WASHINGTON RANKING METHOD

ROUTE SCORES SUMMARY AND RANKING CALCULATION SHEET

Site name: Holden Mine Tailings Region: CRO

City, county: Holden, Chelan

Pathway	Route Score(s)	Quintile Group number(s)
GW-HH	31.4 y	2 ✓
SW-HH	32.0 y	~~4~~ 5 ✓
Air-HH	30.2 y	4
SW-En	44.4 y	4 ✓
Air-En	—	—

25 + 8 + 2 ~~3~~ ~~7/8 = 5~~

~~16~~ + 8 + 2 35/8 = 4.375 = 5 ✓

$\frac{H^2 + 2M + L}{8}$ = 26/8 = 3.25 = 4

16 + 0

$\frac{H^2 + 2L}{7}$ = 16/7 = 2.28 = 3

Matrix Ranking: ~~2~~ 1 ✓

change

8/22/90

MJL

✓

MJL
8/14/90

WORKSHEET 1

SUMMARY SCORE SHEET	
Site Name: Holden Mine Tailings	ID No:
Site Location: (City, County, or Section/Township/Range) Holden Village, Chelan, Section 7, T21N, R17E	
Site Description: (Attach a sketch/map) Eight million tons (80 acres) of mine tailings from copper/zinc/gold/silver mining corporation. Adjacent to Railroad Creek which feeds into Lake Chelan 12 miles to the east. Located at Holden Village. Within the Wenatchee National Forest, elevation 3,200 feet.	
Special Considerations: Railroad Creek is eroding the base of the piles. Especially during high flow. Physical siltation and dissolved copper and zinc (& arsenic) have knocked out aquatic insects for several miles downstream and reduced fish population directly or indirectly. Large flooding/erosion would make this much worse. Railroad Creek feeds Lake Chelan. There is runoff and probably constant seepage through the tailings that enters the creek, and a small stream with high dissolved Cu & Au. An air route. environmental score can be generated and other route scores can be elevated if analyses are performed to document the presence of other metals at the site, including lead, cadmium, and others.	

ROUTE SCORES:

Ground Water/Human:	31.4	Surface Water/Environmental:	44.4
Surface Water/Human:	32.0	Air/Environmental:	---
Air/Human:	30.2		

WORKSHEET 2

SITE WORKSHEET

Site Name: HOLDEN MINE TAILINGS

1. What waste management areas/spills are present at the site?
A 8 MILLION TONS OF MINE TAILINGS, COVERING 80 ACRES

B ± 2CFS STREAM FROM MINE PORTAL FLOWING TO RAILROAD CREEK

1a. How big are they? (Use measure most applicable to type of waste and container, ie., drums = gallons, landfill volume = cubic yds, tanks = gallons, impoundments = gallons)

A. TAILINGS : ESIMATED TOTAL COPPER = 16.5 TONS *
ESTIMATED TOTAL ZINC = 175 TONS *
GUESSTIMATED TOTAL ARSENIC = 100 TONS

B. MINE PORTAL : HIGH LEVELS OF COPPER, ZINC & PROBABLE ARSENIC

2. For each waste management area listed above, what hazardous substances are present/ important for that area? Why?

A. TAILINGS : ZINC, COPPER & PROBABLE ARSENIC ARE HARMFUL TO STREAM FAUNA. SO IS CREEK SILTATION -- INTERFERES WITH GILL FUNCTIONS. HIGH RATES OF RUNOFF/EROSION DURING STORMS.

B. PORTAL STREAM, WITH SAME DISSOLVED MINERALS -- CONSIDERED LESS IMPORTANT BECAUSE LOW FLOW RATE IS DILUTED BY RR CREEK

3. Which areas/substances are to be used to score the ground water route?
COPPER, ZINC (& ARSENIC) FROM TAILINGS

3a. Have releases to ground water occurred? EXTREMELY PROBABLE, ALTHOUGH ARSENIC HAS NOT BEEN TESTED

3b. How are these documented? NOT INVESTIGATED

4. Which areas/substances are to be used to score the air route?
DUST, CONTAINING PROBABLE ARSENIC

4a. Have releases to air occurred? YES, ALTHOUGH ARSENIC HAS NOT BEEN TESTED FOR.

4b. How are these documented? "HOLDEN MINE TAILING REHABILITATION" US FOREST SERVICE, OCT 1975 P. 2-18

5. Which areas/substances are to be used to score the surface water route?
COPPER, ZINC (& ARSENIC) FROM TAILINGS

5a. Have releases to surface water occurred? YES, ALTHOUGH ARSENIC DATA IS INCOMPLETE

5b. How are these documented? "HOLDEN MINE TAILING REHABILITATION" US FOREST SERVICE, OCT 1975 PAGES 2-12 TO 2-14

* DERIVED FROM ASSAY RESULTS IN "HOLDEN MINE TAILINGS ENVIRONMENTAL ANALYSIS REPORT", CHELAN RANGER DISTRICT, 1977:

COPPER = .066 OZ/TON (MEDIAN VALUE)
ZINC = 0.7 OZ/TON (MEAN VALUE)

WORKSHEET 3

ENVIRONMENTAL AND TARGET DATA

Site Name: HOLDEN MINE TAILINGS

Section/Township/Range: SEC 7 T21N R17E

USGS Quadrangle Name: LIBERTY RED TOP MTN.

Name of Soil Conservation Service Soil Survey: CHELAN CO. 8607

Nearest Drinking Water Well (Describe by name section/township/range), include distance:

NONE WITHIN ≈ 12 MILES

Total Population Served by Drinking Water Wells: 0

Nearest Surface Water (Drinking) Intake (Describe by name, section/township/range), include distance:

NONE WITHIN ≈ 12 MILES DOWNSTREAM

Total Population Served by Surface Water Intakes: 0

Acreage Irrigated by Wells: 0

Acreage Irrigated by Surface Water Intakes: 0

Sensitive Environments (List by name, distance/direction from site):

1. RAILROAD CREEK - DIRECTLY ABUTS SITE, FLOWS TO LK. CHELAN
2. LOCATED WITHIN WENATCHEE NATIONAL FOREST
3.

AIR ROUTE TOXICITY MATRIX

Compound	Air Standard	Value	Chronic Toxicity	Value	Acute Toxicity	Value	Carcino-genicity	Value	Highest Value
1. ARSENIC	X			X		X	5	7	7
2.									
3.									
4.									
5.									
6.									

+Bonus Value (2 pts) = 7

WORKSHEET 3 (Continued)

SURFACE WATER ROUTE TOXICITY MATRIX

Compound	Drinking H_2O Standard	Value	Chronic Toxicity	Value	Acute Toxicity	Value	Carcino-genicity	Value	Highest Value
1. COPPER	1mg/l	2	1.3mg	1		1		(1)	2
2. ZINC	5mg/l	2	0.2mg	1		1		(1)	2
3. ARSENIC	20ug	6	1ug	5	770mg	5	15	9	9
4.									
5.									
6.									

+Bonus Value (2 pts) = 9

Environmental Toxicity Acute Standard: ARSENIC ~~2.2mg~~ 300 ug/l Value = ~~10~~ 4

GROUND WATER ROUTE TOXICITY MATRIX

Compound	Drinking H_2O Standard	Value	Chronic Toxicity	Value	Acute Toxicity	Value	Carcino-genicity	Value	Highest Value
1. COPPER		2		1		1			2
2. ZINC		2		1		1			2
3. ARSENIC		6		5		5		9	9
4.									
5.									
6.									

+Bonus Value (2 pts) = 9

Attach the following to this worksheet:

1. Copy of USGS Quadrangle map with site marked
2. Copy of map showing sensitive environments
3. Copy of site-specific soil descriptions, or SCS Soil Survey pages showing site location, and text describing soil types
4. Copy of Washington State Water Rights Information System printouts showing acreage irrigated by wells and surface water intakes.
5. Copy of Washington Public Supply System Listing showing drinking water sources within 2 miles.

WORKSHEET 4

SUBSTANCE CHARACTERISTIC WORKSHEET FOR MULTIPLE UNIT/SUBSTANCE SITES			
	Combination 1	Combination 2	Combination 3
Unit: Substance:			
AIR ROUTE			
Human Toxicity/Mobility Value:			
Environmental Toxicity/ Mobility Value :			
Containment Value:			
Air Human Subscore : (Toxicity/Mobility + 5) • (Containment + 1)			
Air Environmental Score: (Toxicity/Mobility + 5) • (Containment + 1)			
SURFACE WATER ROUTE			
Human Toxicity Value:			
Environmental Toxicity Value:			
Containment Value:			
Surface Water Human Subscore: (Toxicity + 3) • (Containment + 1)			
Surface Water Environmental Subscore: (Toxicity + 3) • (Containment + 1)			
GROUND WATER ROUTE			
Human Toxicity Value:			
Containment Value:			
Ground Water Subscore: (Toxicity + 5) • (Containment + 1)			

WORKSHEET 5

SURFACE WATER ROUTE

1. SUBSTANCE CHARACTERISTICS

Human Toxicity	1 2 3 4 5 6 7 8 9 10 11 12	9
Environmental Toxicity	1 2 3 4 5 6 7 8 9 10	4 ~~10~~
Quantity	1 2 3 4 5 6 7 8 9 10	~~6~~ 10 SRR

2. MIGRATION POTENTIAL

Containment	0 2 4 5 6 7 8 10	8
Surface Soil Permeability	1 3 5 7	7
Total Annual Precipitation	1 2 3 4 5	3
2-Year, 24-Hour Rainfall	1 2 3 4 5	3
Flood Plain	0 1 2	2
Terrain Slope	1 2 3 5	5

3. TARGETS

Distance to Surface Water	0 2 4 7 10	10
Population Square Root ($\sqrt{\text{Popu.}}$-write in nearest whole no.)		0
Area Irrigated ($0.75\sqrt{\text{Area}}$-write in nearest whole no.)		0
Distance to Fishery Resource	0 3 6 9 12	12
Distance to Sensitive Environment	0 3 6 9 12	12

4. RELEASE

RELEASE	0 5	5 ∗

---

1. Substance/containment combination used to score this task: TAILINGS PILES, WITH PROBABLE ARSENIC, ONLY MINOR CONTAINMENT AT TOP.
2. Waste management areas used to score quantity:

8×10^6 TONS OF MINE TAILINGS WITH GUESSTIMATED 100 TONS OF As

use total quantity of waste pile for value assignment - SRR

NOTES: ∗ = ARSENIC FOUND IN RAILROAD CREEK, BUT DATA IS INCOMPLETE.

WORKSHEET 6

AIR ROUTE

1. SUBSTANCE CHARACTERISTICS

Human Health Toxicity/ Mobility Scalar	1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 20 22 24	~~7~~	14
Environmental Toxicity	1 2 3 4 5 6 7 8 9 10	~~X~~	4 need env. tox data
Quantity	1 2 3 4 5 6 7 8 9 10	10	*

2. MIGRATION POTENTIAL

Containment	0 3 4 5 6 8 10	10

3. TARGETS

Nearest Population	0 2 4 6 8 10	10
Nearest Sensitive Environment	0 1 3 5 7	7
Population Sq. Rt. ($\sqrt{\text{Pop.}}$ in ½ mile-write in nearest whole no.)		22

4. RELEASE

RELEASE	0 5	5 ~~0~~	≠

---

1. Substance/containment combination used to score this task: BARE TAILINGS OF FINE PARTICULATE WITH PROBABLE ARSENIC

2. Waste management areas used to score quantity:
TAILINGS PILES

NOTES:

* MAXIMUM USED BECAUSE OF LARGE AREA (80 ACRES) AVAILABLE TO WIND TRANSPORT

≠ = WINDBLOWN DUST IS COMMON IN SURROUNDING AREA, BUT HAS NOT BEEN ANALYZED FOR ARSENIC
Documented release - large windblown particulate problems from tailing piles documented

env. route can not be scored due to lack of env. tox. data

WORKSHEET 7

GROUND WATER ROUTE

1. SUBSTANCE CHARACTERISTICS

		Score
Toxicity	1 2 3 4 5 6 7 8 9 10 11 12	9
Mobility	0 1 2 3	3
Quantity	1 2 3 4 5 6 7 8 9 (10)	~~6~~ 10 SKS

2. MIGRATION POTENTIAL

		Score
Containment	0 1 2 3 4 5 6 7 8 9 10	~~7~~ 10 SKS
Net Precipitation	0 1 2 3 4 5	3
Subsurface Hydr. Cond.	1 2 3 4	4
Depth to Aquifer	1 2 3 4 6 8	8

3. TARGETS

		Score
Aquifer Usage	1 2 3 4 5 9 10	2
Nearest Well	0 1 2 3 4 5	0
Population Square Root ($\sqrt{\text{Pop.}}$-write in nearest whole no.)		0
Area Irrigated (0.75 $\sqrt{\text{Area}}$-write in nearest who no.)		0

4. RELEASE

		Score
RELEASE	0 5	0 ‡

---

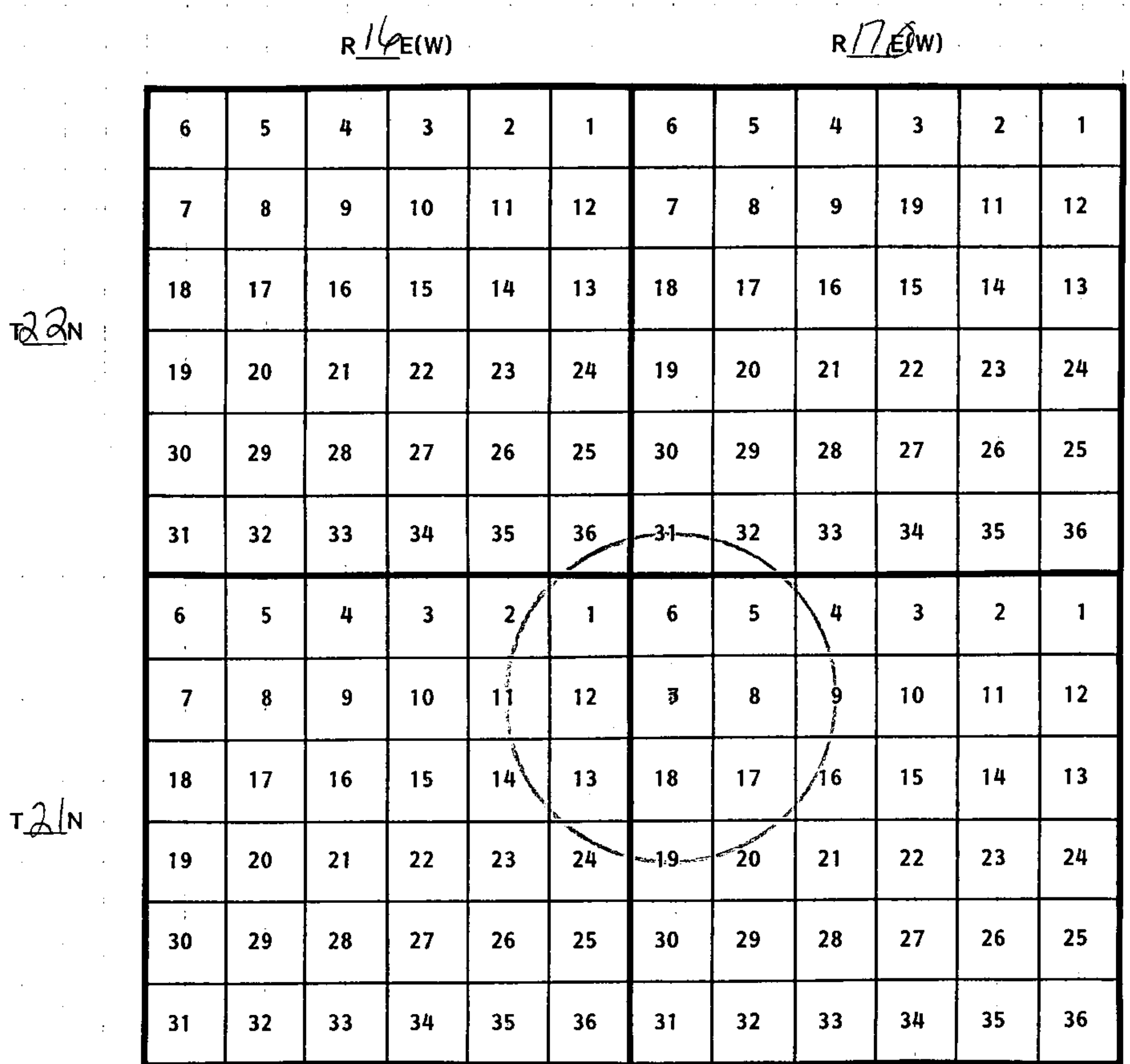
1. Substance/containment combination used to score this task: ARSENIC (PROBABLE), NO LINER, COVER OR LEACHATE COLLECTION
2. Waste management areas used to score quantity:

TAILINGS PILES WITH GUESSTIMATED 100 TONS OF ARSENIC
8 million tons total tailings

NOTES:

‡ = NEAR-CERTAIN RELEASE OF LEACHATE TO GROUNDWATER, BUT NOT YET INVESTIGATED NOR ANALYZED FOR ARSENIC

Containment - waste pile with no leachate collection, no liner, no cover, liquids present



Township, Range, and Section Diagram for Determining Well Data Collection Needs

NW¼NW¼	NE¼NW¼	NW¼NE¼	NE¼NE¼
SW¼NW¼	SW¼NW¼	SW¼NE¼	SE¼NE¼
NW¼SW¼	NE¼SW¼	NW¼SE¼	NE¼SE¼
SW¼SW¼	SE¼SW¼	SW¼SE¼	SE¼SE¼

Well locations guide for designation by sixteenth sections

sect 1, 2, 11-14, 24, T 21N, R16E
4-9, 16-19, T 21N, R17E
36, T 22N, R16E
32-33, T22N, R17E

D	C	B	A
E	F	G	H
L	K	I	J
M	N	O	P

Well locations guide for letter designation within sections

Facility name: Holden Mine Concunully, WA USGS Map

Location: Chelan Co., Holden Village, Washington

EPA Region: 10

Person(s) in charge of the facility: U.S.D.A., Forest Service

Robert E. Hetzer, District Ranger

Name of Reviewer: H. Aldis Date: 8/3/82

General description of the facility:

(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

Abandoned copper, zinc, silver and gold mine. Approx. 8-million tons of mine tailings beside a creek. Eroding and washed down to Lake Chelan. 2 cu.ft./sec. of mine water with copper and zinc.

Scores: S_M = (S_{gw} = 4 S_{sw} = 5 S_a =)

S_{FE} =

S_{DC} =

FIGURE 1
HRS COVER SHEET

Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score	Ref. (Section)
Ground Water Route Work Sheet					
[1] Observed Release	(0) 45	1		45	3.1
If observed release is given a score of 45, proceed to line [4]. If observed release is given a score of 0, proceed to line [2].					
[2] Route Characteristics					3.2
Depth to Aquifer of Concern	0 1 2 (3)	2	6	6	
Net Precipitation	0 (1) 2 3	(1)	1	3	
Permeability of the Unsaturated Zone	0 1 2 (3)	1	3	3	
Physical State	0 (1) 2 3	1	1	3	
	Total Route Characteristics Score		11	15	
[3] Containment	0 1 2 3	1	3	3	3.3
[4] Waste Characteristics					3.4
Toxicity/Persistence	0 3 6 (9) 12 15 18	1	9	18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 (8)	1	8	8	
	Total Waste Characteristics Score		17	26	
[5] Targets					3.5
Ground Water Use	0 1 (2) 3	3	6	9	
Distance to Nearest Well/Population Served	(0) 4 6 8 10 12 16 18 20 24 30 32 35 40	1	0	40	
	Total Targets Score		6	49	
[6] If line [1] is 45, multiply [1] x [4] x [5] If line [1] is 0, multiply [2] x [3] x [4] x [5]				57,330	
[7] Divide line [6] by 57,330 and multiply by 100		S_{gw} = 4 ?			

FIGURE 2
GROUND WATER ROUTE WORK SHEET

Surface Water Route Work Sheet					
Rating Factor	**Assigned Value (Circle One)**	**Multi-plier**	**Score**	**Max. Score**	**Ref. (Section)**
1 Observed Release	0 (45)	1		45	4.1
If observed release is given a value of 45, proceed to line 4. If observed release is given a value of 0, proceed to line 2.					
2 Route Characteristics					4.2
Facility Slope and Intervening Terrain	0 1 2 3	1		3	
1-yr. 24-hr. Rainfall	0 1 2 3	1		3	
Distance to Nearest Surface Water	0 1 2 3	2		6	
Physical State	0 1 2 3	1		3	
	Total Route Characteristics Score			15	
3 Containment	0 1 2 3	1		3	4.3
4 Waste Characteristics					4.4
Toxicity/Persistence	0 3 6 9 (12) 15 18	1	12	18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 (8)	1	8	8	
	Total Waste Characteristics Score		20	26	
5 Targets					4.5
Surface Water Use	0 1 (2) 3	3	6	9	
Distance to a Sensitive Environment	0 1 2 (3)	2		6	
Population Served/Distance to Water Intake Downstream	(0) 4 6 8 10 12 16 18 20 24 30 32 35 40	1	0	40	
	Total Targets Score		6	55	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5			5400	64,350	
7 Divide line 6 by 64,350 and multiply by 100		S_{sw} =	8?		

FIGURE 7
SURFACE WATER ROUTE WORK SHEET

45 x 20 x 6 = 5400

Air Route Work Sheet					
Rating Factor	**Assigned Value (Circle One)**	**Multi-plier**	**Score**	**Max. Score**	**Ref. (Section)**
1 Observed Release	0 45	1		45	5.1
Date and Location:					
Sampling Protocol:					
If line 1 is 0, the S_a = 0. Enter on line 5. If line 1 is 45, then proceed to line 2.					
2 Waste Characteristics					5.2
Reactivity and Incompatibility	0 1 2 3	1		3	
Toxicity	0 1 2 3	3		9	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
	Total Waste Characteristics Score			20	
3 Targets					5.3
Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	1		30	
Distance to Sensitive Environment	0 1 2 3	2		6	
Land Use	0 1 2 3	1		3	
	Total Targets Score			39	
4 Multiply 1 x 2 x 3				35,100	
5 Divide line 4 by 35,100 and multiply by 100		S_a =			

FIGURE 9
AIR ROUTE WORK SHEET

	S	S^2
Groundwater Route Score (S_{gw})	4	16
Surface Water Route Score (S_{sw})	8	64
Air Route Score (S_a)		0
$S^2_{gw} + S^2_{sw} + S^2_a$		80
$\sqrt{S^2_{gw} + S^2_{sw} + S^2_a}$		9
$\sqrt{S^2_{gw} + S^2_{sw} + S^2_a} / 1.73 = S_M =$		5%

FIGURE 10
WORKSHEET FOR COMPUTING S_M

Fire and Explosion Work Sheet					
Rating Factor	**Assigned Value (Circle One)**	**Multi-plier**	**Score**	**Max. Score**	**Ref. (Section)**
1 Containment	1 3	1		3	7.1
2 Waste Characteristics					7.2
Direct Evidence	0 3	1		3	
Ignitability	0 1 2 3	1		3	
Reactivity	0 1 2 3	1		3	
Incompatibility	0 1 2 3	1		3	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
	Total Waste Characteristics Score			20	
3 Targets					7.3
Distance to Nearest Population	0 1 2 3 4 5	1		5	
Distance to Nearest Building	0 1 2 3	1		3	
Distance to Sensitive Environment	0 1 2 3	1		3	
Land Use	0 1 2 3	1		3	
Population Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Buildings Within 2-Mile Radius	0 1 2 3 4 5	1		5	
	Total Targets Score			24	
4 Multiply 1 x 2 x 3				1,440	
5 Divide line 4 by 1,440 and multiply by 100	S_{FE} =				

FIGURE 11
FIRE AND EXPLOSION WORK SHEET

Direct Contact Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
[1] Observed Incident	0 45	1		45	8.1
If line [1] is 45, proceed to line [4] If line [1] is 0, proceed to line [2]					
[2] Accessibility	0 1 2 3	1		3	8.2
[3] Containment	0 15	1		15	8.3
[4] Waste Characteristics Toxicity	0 1 2 3	5		15	8.4
[5] Targets					8.5
Population Within a 1-Mile Radius	0 1 2 3 4 5	4		20	
Distance to a Critical Habitat	0 1 2 3	4		12	
	Total Targets Score			32	
[6] If line [1] is 45, multiply [1] x [4] x [5] If line [1] is 0, multiply [2] x [3] x [4] x [5]				21,600	
[7] Divide line [6] by 21,600 and multiply by 100	S_{DC} =				

FIGURE 12
DIRECT CONTACT WORK SHEET

August 1981

HOLDEN TAILINGS MONITORING PLAN

will be revised for 1989

Region: PNW - 6

Wenatchee National Forest

Chelan Ranger District

INTRODUCTION

The Railroad Creek watershed is situated in North Central Washington (T 31 N, R 17 E, W.M.) and is located on the Chelan Ranger District, Wenatchee National Forest.

The Railroad Creek Basin has a cirque-type formation at the headwaters and trellis-like landform pattern extending to Lake Chelan. The Basin area contains approximately 41,600 acres - 49 percent of which lies within the Glacier Peak Wilderness. Elevations range from 1,112 feet at Lucerne to 9,511 feet at the summit of Bonanza Mountain.

Railroad Creek - the major stream draining the Basin - is 18 miles long and flows from the high elevational Lyman Lake to Lake Chelan. This Stream Class I tributary is one of the major water contributors to Lake Chelan; providing water for downstream uses soch as irrigation, power production, and recreation opportunities for many local residents and thousands from outside the area.

The drainage receives heavy recreational use during the summer months from campers, backpackers traveling to and from the Wilderness, and visitors to the retreat at Holden Village.

The discovery of valuable minerals occurred in the late 1800's as advanced scouting parties attempted to locate a railroad route across the Cascade Range.

In 1937, the Howe Sound Company began major copper and gold mining operations at Holden. Mining continued until 1957. The milled tailing were deposited in three piles adjacent to the mine. As the piles grew and additional waste areas became in short supply; the tailing was placed along the banks of Railroad and Copper Creeks. Upon closing of the mine and operations in 1957, the tailing piles covered an area approximately 80 acres with an average depth of 120 feet.

To protect Railroad Creek, the mining company constructed about 4,500 lineal feet of log crib revetment between the tailings and Railroad Creek. The wooden cribbing has gradually decayed and is being destroyed by periodic heavy discharge. Major flooding would cause significant erosion of tailings into Railroad Creek and subsequently Lake Chelan. Railroad and Copper Creeks annually experience tailing-sediment loading from the now unprotected bases of the tailing slopes that lie adjacent to these streams. The tailings may have toxic levels of cyanide, arsenic, iron, lead, copper, and zinc. Mine portal effluent which discharges directly to Railroad Creek also contains these element and compounds, plus low pH levels.

Peak flow occurrence would result in catastrophic effects to the aquatic subsystems of Railroad/Copper Creeks and Lake Chelan. The potential for damage to other resources and facilities also can be anticipated with high probability.

In 1975, a contract was awarded to ORB Architects of Renton, Washington to acquire additional field data and to develop restoration alternatives. The Chelan District has programmed funding to accomplish the proposed restoration.

Water quality sampling of Railroad and Copper Creeks to evaluate the effects of the tailings - has been on-going for several years. However, evaluation of the collected data was not accomplished. The elements and chemical compounds present are atypical from those encountered in the majority of Forest activities.

In 1981, a contract was awarded to Gordon Snyder and Consultants, Inc. with the objective of evaluating the effects of the eroding tailings, leachate, and mine portal effluent on the water quality to the adjacent streams. The results of this report were heavily relied upon in developing the Railroad Creek Water Quality Monitoring Plan.

OBJECTIVES

1. To determine the impact of sediment and chemical effects of tailing piles 1, 2, and 3 on the water quality of Railroad Creek and Lake Chelan.

2. To determine if the water quality of Railroad Creek exceeds Washington State Class AA Standard Limitations.

3. To determine the effects on water quality of Copper Creek flowing between tailing piles 1 and 2.

4. To determine if the concentrations of the toxic pollutants in the leachate from the tailing piles affects the water quality of Railroad Creek.

5. To determine the contribution of the mine portal effluent to the pollution problem in Railroad Creek.

6. To determine if the concentrations of toxic elements in Railroad Creek are greater below the mine portal tributary than concentrations found above the entrance of the tributary.

7. To determine if the Holden Village sewage lagoon contributes enough bacterial contamination to Railroad Creek to create a health hazard.

RESPONSIBILITIES

The District Watershed Technician will be responsible for data collection. Analysis will be performed as follows:

Parameter	Analysis by:
Temperature, Turbidity, Electrical Conductivity, and pH	District Watershed Technician in the field with portable equipment
Suspended Solids, Alkalinity, Iron, Copper, Lead, Zinc, Fecal Coliform, and Fecal Strep	Forestry Sciences Lab - Wenatchee
Arsenic, Cyanide	Central Washington State University Lab

The District Watershed Technician will be responsible for entry of data into STORET and storing reports in TRI.

The Hydrologist and District Watershed Technician will prepare progress and completion reports.

The Forest Hydrologist will perform required statistical analysis and determine conclusions to be reported.

SAMPLING LOCATIONS (See attached maps)

STATION NAME	STATION NUMBER
1. Railroad Creek at Wilderness Boundary	8103
2. Mine Portal at Holden Mine	8104
3. Railroad Creek below tailings	8106
4. Railroad Creek at Lucerne Bridge	8107
5. Copper Creek below Tailings	8127
6. Copper Creek above Tailings	8128
7. Seepage from Pile 2	8140
8. Seepage from Pile 3	8141

(more)

STATION NAME (Con't)	STATION NUMBER
9. Railroad Creek above Holden Drainfield	8144
10. Railroad Creek below Holden Drainfield	8145
11. Lake Chelan at Mouth of Railroad Creek	8150
12. Lake Chelan uplake of Railroad Creek	8151
13. Railroad Creek at Vehicle Bridge	8152

PARAMETERS

All stations except 8144, 8145

Discharge	Suspended Solids	Copper	Cyanide
Temperature	Turbidity	Lead	
pH	Alkalinity	Zinc	
Conductivity	Iron	Arsenic	

Stations' 8144, 8145

Fecal Coliform
Fecal Strep.

The parameters listed were selected for analysis using the matrix from the 1981 Water Quality Monitoring System for Wenatchee National Forest and recommendations by Dr. Gordon Snyder in his design provided in Holden Mine Tailings Water Quality Monitoring Project. Copies are attached.

SUPPLEMENTAL INTERPRETATIVE DATA

Stream discharge will be measured with each sample taken at each station.

A description of the study area is provided in the Holden Mine Tailings Rehabilitation report prepared by ORB. A copy is on file at the District.

SAMPLING FREQUENCY AND DURATION

Eight samples per station per year will be taken at all stations.

Winter (1) - one sample during peak use of lagoon and drainfield.

Early Spring (1) - one sample on the rising limb sometime between mid-April and mid-May, but before the stream reaches high flow.

Peak Flow (2) - two samples during peak flow. The times may vary but samples should be taken as close to peak flow as possible.

Early Summer (1) - one sample on the recession limb about two to four weeks after peak runoff.

Late Summer (2) - one sample during low flow sometime in late August and one sample in mid-September, but before the cool fall weather sets in.

Late Fall (1) - one sample during low flows of cool weather in late fall, prior to receiving winter precipitation.

These samples will be aimed at sampling the thunderstorms.

Snyder recommends that statistics should not be calculated on less than twelve samples. Also, at least two years of data should be gathered before viewing statistical calculations with a large degree of reliability. The monitoring program should be maintained for a minimum of two years with a review of the data at the end of the two years to determine if enough data has been gathered to provide a sound analysis of the effects of the tailings on Railroad Creek and Lake Chelan.

SAMPLING PROCEDURES AND QUALITY CONTROL

Streamflow - Measurements will be taken in conjunction with other samples. Equipment to be used is: Railroad Creek, a price meter, during heavy flows, suspended from a cable off of the vehicle bridges at Holden and Lucerne with a 75 pound weight and digital reader, and during low flows, from a wading rod; Copper Creek, a Price or pigmy meter with wading rod; Mine Portal, a Price meter or weir.

Turbidity - Grab samples will be taken with one liter containers. Samples will be analyzed with the Hach 2100 Turbidimeter (NTU's).

Water Temperature - Water temperature will be taken with a hand held Fahrenheit scale thermometer.

pH - Grab samples will be analyzed with the portable Corning Model 3 pH meter. Samples will be taken at established frequencies.

Conductivity - Conductivity will be measured in the field with the use of the Beckman Model RA-2A Conductivity Meter. Analysis will be done at established sample frequencies.

Suspended Solids - A USDH-48 sediment sampler will be used to collect samples for analysis. The Forestry Sciences Laboratory will do the analysis according to the Standard Methods for the Examination of Water and Waste Water, 14th Edition, 1975 manual.

Alkalinity - Grab (dip) samples will be taken at planned sampling frequencies. Analysis will be performed by the Forestry Sciences Laboratory according to the Standard Methods for the Examination of Water and Waste Water, 14th Edition, 1975 manual (Standard Methods Manual).

Iron, Copper, Lead, Zinc - Grab (dip) samples will be taken at planned sampling frequencies. Analysis will be performed by the Forestry Sciences Laboratory using the Atomic Absorption method, according to the Standard Methods Manual.

Fecal Coliform and Fecal Streptocci - Grab (dip) samples will be taken at planned sampling frequencies. Analysis will be performed by the Forestry Sciences Laboratory using the membrane technique according to the Standard Methods Manual. Samples shall be iced and transported expeditiously to lab for analysis.

Arsenic - Grab (dip) samples will be taken at planned sampling frequencies. Central Washington State University (CWSU) lab will perform the analysis by the Atomic Absorption method according to the Standard Methods Manual. Methods require a 200 milliliter plastic container be filled, and stabilized with Nitric Acid to a pH of two prior to transporting.

Cyanide - Grab (dip) samples will be taken at planned sampling frequencies. CWSU lab will perform the analysis by the Spectra-photometric method according to the Standard Methods Manual. Methods require a 500 milliliter plastic container be filled, stabilized to a pH of twelve with sodium hydroxide and transported on ice to the lab. Analysis must be completed within 24 hours.

INTERPRETIVE REPORTING PROCEDURE

The Forest Hydrologist will prepare the interpretive reports. A progress report will be prepared at the completion of the first twelve samples to determine if further monitoring will be needed beyond the 16 scheduled samples. A final report will be prepared, interpreting the data collected to answer the seven objectives identified in this plan.

DATA AND REPORT STORAGE

All data collected will be stored in STORET according to the station numbers assigned. All interpretive reports, including summarized water quality data will be entered in the TRI system.

OPERATIONAL COSTS AND NEEDS FOR A TWO YEAR MONITORING PROGRAM

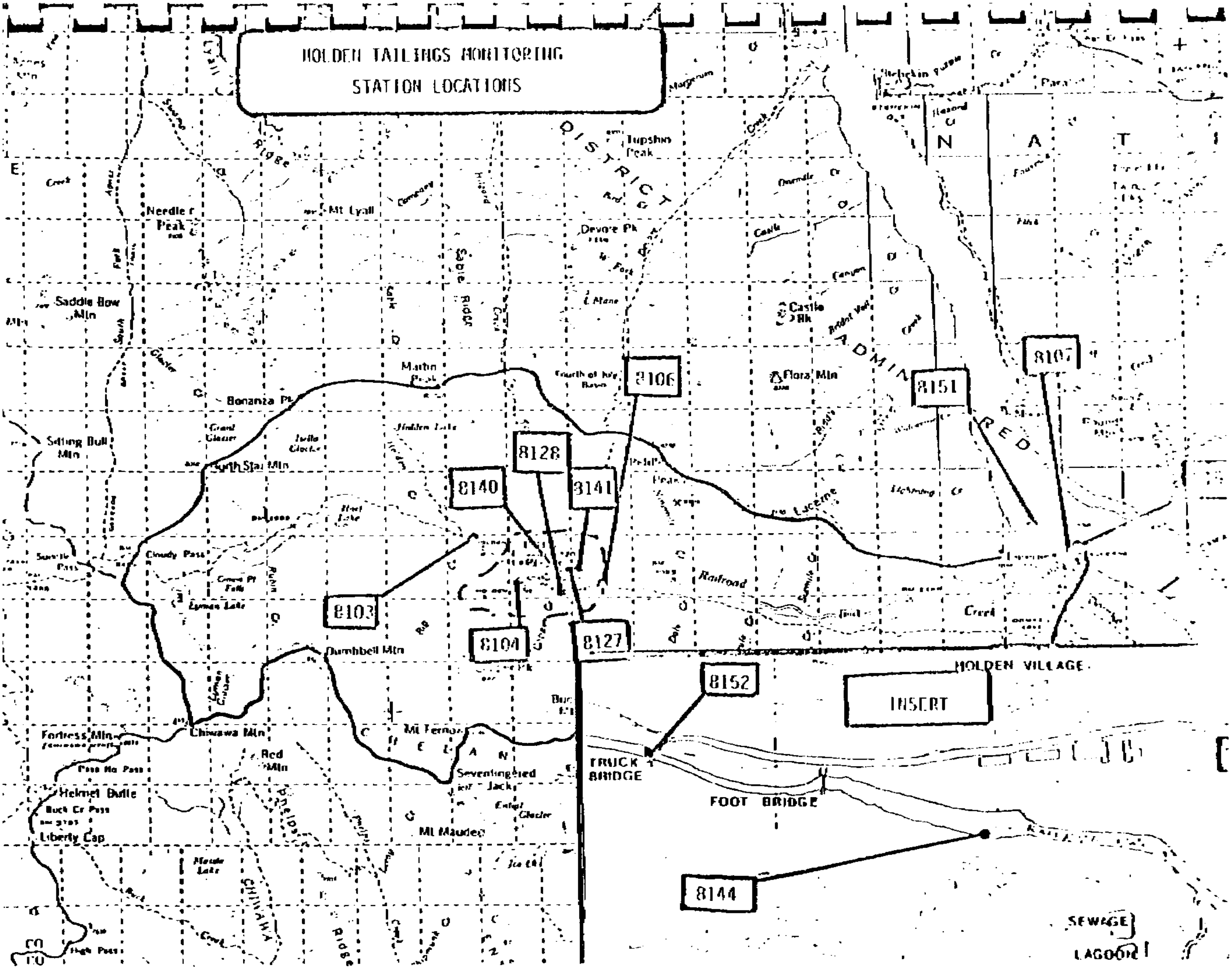
Labor -	Hydrologist: $110/day X 16 days =	$1,760
	Watershed Technician: $87/day X 57 days =	$4,959
	Boat Operator: $90/day X 16 days =	$1,440
	Forestry Technician: $45/day X 16 days =	$ 720
	Resource Clerk: $49/day X 32 days =	$1,568
Subtotal		$10,447
Materials -	Bottles	$30
	Solution (for calibration)	$40
	Ice chests	$40
	Ice	$32
	Miscellaneous supplies (probes, etc.)	$80
Subtotal		$222
Transportation -		
	Half ton rental (FOR) 3 months @ $330/mo =	$990
	Half ton rental (mileage) 16 trips X 224 mi. X .2/mi. =	$717
	Boat use - 16 trips X 3 hrs. X $15/hour =	$720
	Per diem - 16 trips X 2 nights/trip = 32 X $12/night =	$384
Subtotal		$2,811
Laboratory Costs -		
	Central Washington University Lab -	
	Cyanide: 11 samples X 16 collections = 176 X $10 =	$1,760
	Arsenic: 11 samples X 16 collections = 176 X $10 =	$1,760
Subtotal		$3,520
	Forestry Sciences Laboratory -	
	Iron: 11 samples X 16 collections Copper: 11 samples X 16 collections Lead: 11 samples X 16 collections Zinc: 11 samples X 16 collections } =	$1,760
	Alkalinity: 11 samples X 16 collections = 176 samples X $4 =	$704
	Suspended Solids: 11 samples X 16 collections = 176 samples X $5 =	$880
	Fecal Coliform: 1 smp X 16 coll. Fecal Streptocci: 1 smp X 16 coll. } = 16X$9 =	$144
Subtotal		$3,488
GRAND TOTAL		$20,488

Management activity/ water quality parameter matrix.

Management Activity

Water Quality Parameters

Appropriate Hydrologic and Limnologic Parameters	Timber Harvest – Stream	Timber Harvest – Lake	Road Construction – Stream	Road Construction – Lake	Drinking Water Supplies – Stream	Drinking Water Supplies – Lake	Grazing – Stream	Grazing – Lake	Recreation Complex – Stream	Recreation Complex – Lake	Reconnaissance Water Quality Survey – Stream	Reconnaissance Water Quality Survey – Lake	Coop Basin Study – Stream	Coop Basin Study – Lake	Water Quality Management Plan – Stream	Water Quality Management Plan – Lake	Metal Mining – Stream	Metal Mining – Lake	Rehabilitation – Stream	Rehabilitation – Lake	Volcanic Ash – Stream	Volcanic Ash – Lake
Temperature (Temp)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Hydrogen Ion (pH)	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1
Electrical Conductivity (S.C.)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total Dissolved Solids (TDS)	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	2	2	3	3	3	3
Suspended Solids (SS)	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Bedload (BL)	2		2				3				3		2		3		2		2		2	
Sediment Particle Size (SPS)	2	2	2				3	3			3	3	2	2	2		2	2	2	2	2	2
Turbidity (Turb)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Alkalinity (Alk)		1		2	2	2					1	1			1	1	1	1	1	1	1	1
Bicarbonate (HCO_3)		1		2							1	1							2	2	2	2
Carbonate (CO_3)		1		2							2	2										
Nitrate (NO_3)	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1			3	3		
Total Nitrogen (TN)	2	1	3	3			1	1	1	1	1	1	1	1	1	1			3	3		
Ammonia (NH_3)	3	2					2	2	2	2	3	3			3	3						
Orthophosphate (PO_4)	1	1	2	2			1	1	1	1	1	1	1	1	1	1			3	3		
Total Phosphate (TP)	2	1	3	3			1	1	1	1	1	1	1	1	1	1			3	3		
Sulfate (SO_4)											3	3			2	2						
Chloride (Cl)									2	2	3	3										
Boron (B)									3	3												
Calcium (Ca)											3	3			3	3						
Magnesium (Mg)											3	3			3	3						
Sodium (Na)									3	3	3	3			3	3						
Potassium (K)											3	3			3	3						
Iron (Fe)															2	2	1	1				
Arsenic (As)/Cyanide (Cn)															1	1	1	1				
Select Heavy Metals									3	3	3	3			1	1	1	1				
Select Trace Metals									3	3	3	3			1	1	1	1				
Dissolved Oxygen (DO)	1	1	2	1			1	1	1	1	1	1			2	2			2	2		
Biochemical Oxygen Demand (BOD)	3	3	3				3	3	3	3	3	3										
Total Organic Carbon (TOC)	2	1		3			2	2	3	3												
Herbicides													2	2								
Pesticides																						
Petroleum Hydrocarbon			3	3																		
Radionuclides																						
Total Coliform (TC)					1	1					2	2										
Fecal Coliform (FC)					1	1	1	1	1	1	1	1	1	1	1	1						
Fecal Streptocci (FS)					1	1	1	1	1	1	1	1	1	1	1	1						
Algae		2						2			3	3				2					2	2
Macroinvertebrates	3	3	3	3			3	3	3	3	3	3			2						2	2


HOLDEN TAILINGS MONITORING
STATION LOCATIONS
8106
8107
8151
8128
8140
8141
8103
8104
8127
8152
8144
INSERT
HOLDEN VILLAGE
TRUCK BRIDGE
FOOT BRIDGE
SEWAGE LAGOON
DISTRICT
ADMIN
RED
N
A
T
Tupshin Peak
Needle Peak
Mt Lyall
Devore Pk
Saddle Bow Mtn
Castle Rk
Flora Mtn
Martin Peak
Bonanza Pk
Sitting Bull Mtn
North Star Mtn
Cloudy Pass
Lyman Lake
Dumbbell Mtn
Fortress Mtn
Chiwawa Mtn
Red Mtn
Mt Fernow
Seventingered Jack
Helmet Butte
Liberty Cap
Mt Maude
Railroad
Creek
CHIWAWA

HOLDEN MINE TAILINGS

ENVIRONMENTAL ANALYSIS REPORT

CHELAN RANGER DISTRICT
WENATCHEE NATIONAL FOREST

1977

U.S.D.A. FOREST SERVICE ENVIRONMENTAL ANALYSIS REPORT

HOLDEN MINE TAILINGS

SUMMARY SHEET

I. DESCRIPTION:

This report reviews the various means of treating pollutants in Railroad Creek on the Chelan Ranger District, Wenatchee National Forest. The pollutants originate from mine tailings deposited on National Forest land from 1937 until abandonment in 1957 by a copper and gold mining operation.

II. ENVIRONMENTAL IMPACTS:

Impacts associated with the various abandoned mining operations are: contaminated water flowing from the mine portal, leachate flow from the tailing piles, erosion of tailing piles by surface water runoff, erosion of tailing piles by surface water runoff, erosion of tailing piles by Railroad and Copper Creek, erosion of tailing piles by wind action and visual pollution.

III. ALTERNATIVES:

Three alternatives are offered for evaluation:

1. No Action.

2. Action to obtain a nominal reduction in wind and water erosion and provide protection to withstand a 25-year flood.

3. Action to reduce wind and water erosion to meet water and air standards and provide protection to withstand a 50-year flood.

IV. ASSISTANCE & COMMENTS:

Technical assistance and advise have been received from; U.S. Forest Service, Washington Departments of Natural Resources, Game, Ecology & Labor & Industries, National Park Service, Soil Conservation Service, local publics and agencies.

V. ENVIRONMENTAL IMPACT:

The significance of any impact is dependent on the final alternative chosen. Focus on this issue can be best analyzed after evaluation of public response and the subsequent choice of alternatives has been made.

VI. RECOMMENDATION:

The Wenatchee National Forest Management Team requests public and agency response to the three alternatives to assist them in arriving at a decision in regard to future management of the holden mine tailings.

4. Land Management Objectives: Management of National Forests are subject to several laws of which the following are of primary importance:

Organic Act of 1897
Multiple Use Act of 1960
Forest & Range Renewable Resources Planning Act of 1974
National Forest Management Act of 1976

These laws set the stage for resource management designed to provide renewable resources, commodities and services to the public without loss of productivity and/or degradation of the environment.

To safeguard our nation from environmental degradation, several laws have been passed in recent years:

National Environmental Policy Act of 1969
Resource Recovery Act of 1970
Clean Air Act of 1963
Federal Water Pollution Control Act of 1972
Historical Preservation Act of 1966

The Environmental Protection Agency has stated that as long as an abandoned operation remains dormant and inactive, any discharge or resultant runoff from the area would not be covered by the National Pollutant Discharge Elimination System (NPDES) Permit. Water quality standards for streams draining this area would be enforced by the State Department of Ecology. In addition, the National Ambient Air Quality Standards may also apply. There is also the question concerning NPDES implication once rehabilitation commences. Alteration of man made strutures of historical significance is subject to approval by the State Historical Preservation Officer (Washington State Parks & Recreation).

5. Resource Characteristics:

Geology: Holden, Washington, at an elevation of 3,209 feet, is situated in Railroad Creek Valley. The valley floor rises from 1,100 feet at Lucerne on Lake Chelan to 9,500 feet at the summit of Bonanza Peak at the upper end of the valley. Railroad Creek Valley was carved by glacial action and has the typical "U" shape associated with glaciation. Recessional moraines left by the glaciers are irregular deposits of rock. The town of Holden, mill and other mine buildings were located on one of these moraines.

Soils: Three broad categories of soil occur in the Holden Area:

a. Alluvium - Found in the valley bottom, generally more than ten feet deep and are subject to flooding and stream channel erosion.

b. Colluvial - Generally occur at the base of snow chutes, three to ten feet deep and contain a heterogenous mixture of angular rock and soil material.

c. Glacial Till - Soils underlying both the alluvial and colluvial soils and extending well up the valley walls. Generally these soils are more than ten feet deep with the upper layer being less compacted and considered stable.

Water: Railroad Creek drainage encompasses 64.8 square miles. Lyman Lake is fed by Lyman Glacier seven miles upstream from Holden. Railroad Creek contributes 12 percent of the annual discharge into Lake Chelan. The original channel was moved north to provide space for the mine tailings.

Climatology: Prevailing winds are westerly, precipitation averages 35" per year with 77 percent of it in the form of snow, averaging four to eight feet. A season suitable for construction activities is

While the tailing material is highly susceptible to erosion by water, the top oxidized crust prevents rain and snowmelt from eroding and deep cutting the tailings. A velocity of only 30 cm./sec. is needed to start eroding the tailing material.

The tailing piles are relatively stable in their present condition. Susceptibilty of the tailing piles to liquefaction is low.

Ponded water on piles is caused by a settlement of silt and clay sized particles to the bottom of ponds. This results in clogging the inter-granular voids resulting in a reduction of permeability.

Soil Chemistry: Soil pH of the tailings material is 2.9 to 3.5 indicating a highly acidic condition. Plant materials are unable to sustain growth in this soil. Tests have shown that the addition of lime at the rate of 15 tons/acre will raise the pH to a level sufficient to sustain plant establishment. It was also found that a rapid breakdown rate of lime occurred and the soil returned to the original low pH level in two to three years time. These test results show a need for organic matter in the growing media.

Due to droughty soil conditions, irrigation will be necessary for plant establishment. Amounts must be controlled to prevent an increase in leachate rates.

Hydrologic Characteristics: The north slopes of Tailing Piles 1, 2 & 3 abut Railroad Creek. During periods of high runoff, undercutting occurs at the bases of these slopes, eroding tailings material directly into the stream course.

Copper Creek flows north between Tailing Piles 1 and 2 into Railroad Creek. Copper Creek is eroding the base of Tailing Pile No. 1. Holden Village obtains its domestic water supply and hydroelectric power from this creek, approximately 1/4 mile upstream from the tailing piles.

Railroad Creek flow at 50 year flood level is approximately 3000 CFS. This would vary from five to seven feet in depth and using a three foot free-board, the required height of bank protection is ten feet.

Copper and zinc are having a dramatic effect on insect fauna of Railroad Creek. Immediately upstream of Tailings Pile No. 1 a healthy and diverse fauna was observed with a mean of 261 individuals per square meter of creek bottom. Downstream, in the vicinity of Tailing Pile No. 1, the population level dropped to 41 insects/sq. meter and below Tailing Pile No. 3 to a range of five to twelve insects. It appears that insect recovery gradually occurs in the lower six miles of the stream.

Examination of water quality data indicate that the pertinent parameters were copper, zinc, pH and alkalinity. The combination of low pH and low alkalinity enhance the toxicity of heavy metals.

Heavy metal concentrations in Railroad Creek have depleted fish populations due to chronic or acute exposure to copper and zinc ions which lead to any of the following:

1. Rapid Mortalities.

2. Sub-lethal effects and eventual mortality.

3. Avoidance of stream areas due to no aquatic insect food.

Leachate flow into the stream has cemented the stream bottom for several miles downstream. This condition denies a normal aquatic habitat.

Air Quality: Staff and guests at Holden Village have recorded adverse effects to humans attributed to airborne particulate matter from the mine tailings. Associated respiratory problems show a high frequency of occurrence, with persons having asthma often developing severe attacks.

7. Some historical values related to the mine tailings and rock dumps will be lost.

B. ALTERNATIVES TO THE PROPOSED ACTION

The alternatives that follow portray a range of projects from no action to that considered to be optimum rehabilitation.

Alternative 1

No action to be taken which will allow a continuing degradation of air and water quality. Visual and land productivity standards will not be met. Violations of the Federal Water Pollution Control Act and Clean Air Act are a possibility.

Alternative 2

This solution entails rip-rap streambank protection along Railroad Creek to withstand a 25-year flood; a chemical protective covering over all tailing pile slopes; treat contaminated water from the old mine portal prior to its release into Railroad Creek; close existing decanting towers and tailing pile drainage systems; constructing an intercept swale at the base of the hillside area above the tailings to divert runoff away from the pile surfaces. Estimated cost is $787,000 with an annual maintenance cost.

In comparison with complete rehabilitation this alternative is deficient in the following:

1. Does not meet water quality standards; no effort to control leachate flow through the piles.

2. Provides only temporary solution to aerial pollution problem.

3. Does not provide 50-year flood protection to the tailing piles.

4. Does not return the tailing piles or land back into production.

5. Does not meet visual design criteria.

6. Fish and other aquatic life will not be materially improved.

Alternative 3

This alternative is designated to eliminate the deficiencies noted in Alternative 2.

This solution entails treating contaminated water from the mine portal prior to release in Railroad Creek.

Tailing Pile No. 1: Grade the tailing pile slopes and surface and treat to support trees and shrubs on 20 of area and grasses on 80 of area, close decanting towers, construct a lined intercept swale to divert runoff and to collect surface water from the pile. Provide area for retention pond to treat polluted water if required by E.P.A. Sewage lagoons for Holden Village should be located on Pile No. 1;

Tailing Pile No. 2: Close decant tower and drain systems, construct an intercept swale to divert hillside runoff and drain snowmelt and rainfall from the top of the pile, grade east slope only between Piles No. 2 and 3 and place rock and vegetative material over slope area, provide a combination of grass and rock cover on top of pile, relocate Railroad Creek in area of tailing piles to allow planting of trees at toe of slope, provide rock cover on top windward edge of pile, relocate west channel of Copper Creek, provide 50-year flood protection to pile;

Tailing Pile No. 3: Close decant tower and drainage system, construct intercept swale for hillside and pile top drainage, grade east and west slopes and place grass and rock cover on these surfaces, combination rock and grass cover on top, relocate Railroad Creek to permit planting of trees

6. ENVIRONMENTAL PROTECTION AGENCY

7. ORB ARCHITECTS - PLANNERS - ENGINEERS

H. MANAGEMENT RECOMMENDATIONS

The Wenatchee National Forest has no preferred alternative. Public and agency response has been requested to aid the Forest ~~management team~~ in reaching a decision for management of the Holden Mile tailings. Public response received in early 1976 will be considered with current public and agency comment.

I. APPENDIX

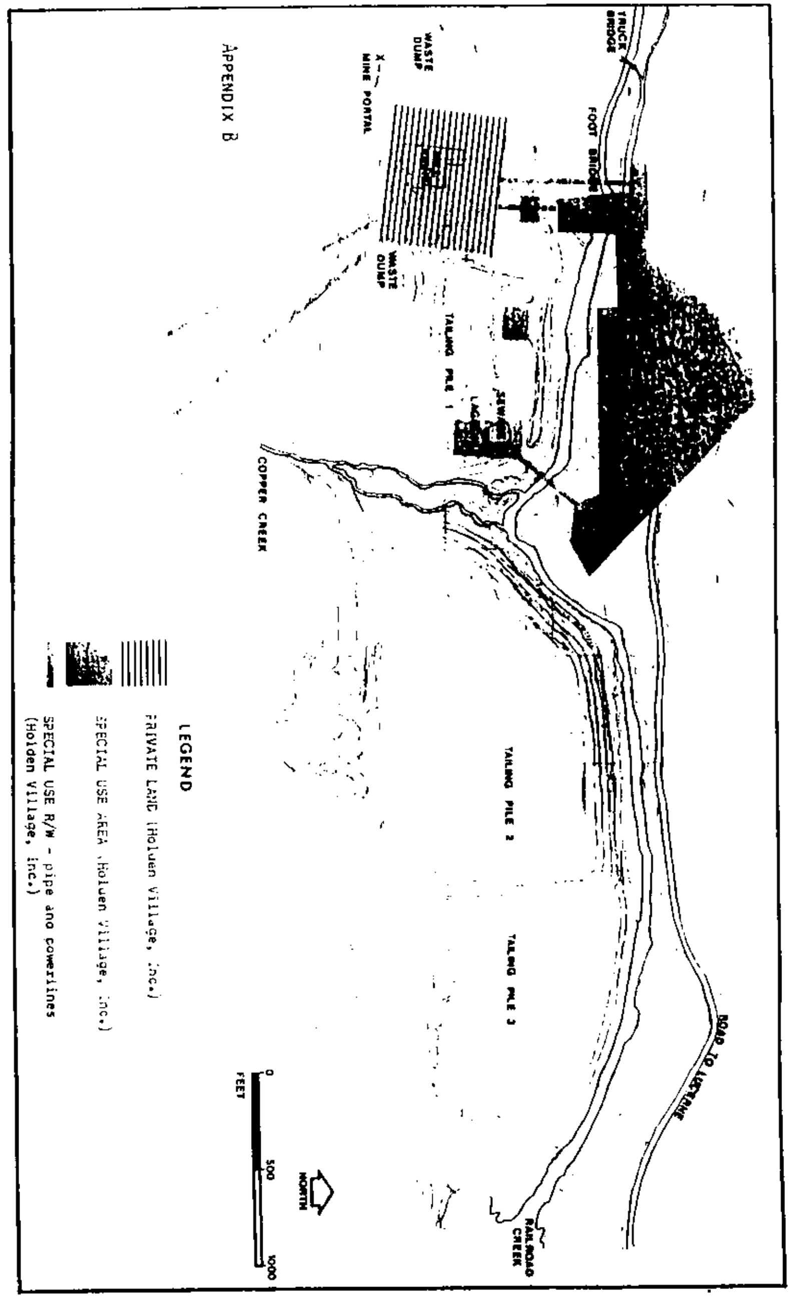
Appendix A - Vicinity Map

Appendix B - Landownership Map

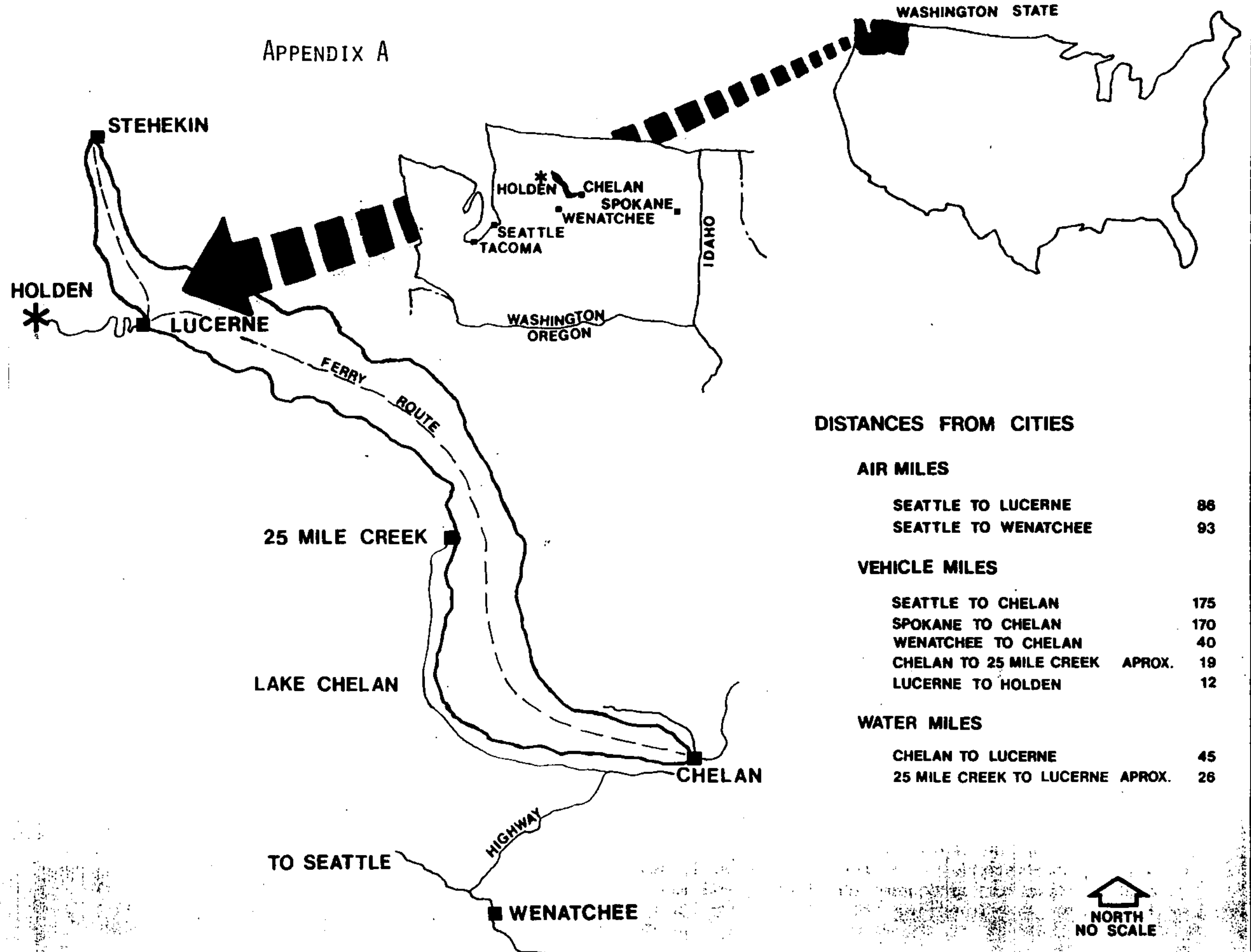
Appendix C - **ORB Report**

Appendix D - Historical Inventory

Appendix E - Mineral Report



APPENDIX A



DISTANCES FROM CITIES

AIR MILES

SEATTLE TO LUCERNE		86
SEATTLE TO WENATCHEE		93

VEHICLE MILES

SEATTLE TO CHELAN		175
SPOKANE TO CHELAN		170
WENATCHEE TO CHELAN		40
CHELAN TO 25 MILE CREEK	APROX.	19
LUCERNE TO HOLDEN		12

WATER MILES

CHELAN TO LUCERNE		45
25 MILE CREEK TO LUCERNE	APROX.	26

Appendix D

VI. Science/Technology
e. Industry

INVENTORY FORM

The Washington State Inventory of Historic Places

NAME

COMMON: Holden Mine

AND/OR HISTORIC:

LOCATION

STREET AND NUMBER: Twelve miles west of Lake Chelan on Railroad Creek

CITY OR TOWN:

COUNTY: Chelan

CLASSIFICATION

CATEGORY (Check One)	OWNERSHIP	STATUS	ACCESSIBLE TO THE PUBLIC
[X] District [ ] Building [ ] Site [ ] Structure [ ] Object	[ ] Public [X] Private [ ] Both; Public Acquisition: [ ] In Process [ ] Being Considered	[X] Occupied [ ] Unoccupied [ ] Preservation work in progress	Yes: [X] Restricted [ ] Unrestricted [ ] No

DESCRIPTION

CONDITION (Check One): [ ] Excellent [X] Good [ ] Fair [ ] Deteriorated [ ] Ruins [ ] Unexposed

(Check One): [ ] Altered [ ] Unaltered

(Check One): [ ] Moved [X] Original Site

DESCRIBE THE PRESENT AND ORIGINAL (if known) PHYSICAL APPEARANCE

Describe briefly on the back; attach a small photo.

SIGNIFICANCE

PERIOD (Check One or More as Appropriate): [ ] Pre-Columbian [ ] 15th Century [ ] 16th Century [ ] 17th Century [ ] 18th Century [ ] 19th Century [X] 20th Century

SPECIFIC DATE(S) (If Applicable and Known): 1938-1957

AREAS OF SIGNIFICANCE (Check One or More as Appropriate): Aboriginal [ ] Prehistoric [ ] Historic [ ] Agriculture [ ] Architecture [ ] Art [ ] Commerce [ ] Communications [ ] Conservation [ ] Education [ ] Engineering [ ] Industry [ ] Invention [ ] Landscape Architecture [ ] Literature [ ] Military [ ] Music [ ] Political [ ] Religion/Philosophy [ ] Science [ ] Sculpture [ ] Social/Humanitarian [ ] Theater [ ] Transportation [ ] Urban Planning [ ] Other (Specify)

STATEMENT OF SIGNIFICANCE

Briefly describe the significance on the back.

FORM PREPARED BY

NAME AND TITLE: Nigel B. Adams (206-ALS-2224)

ORGANIZATION: Green River Community College — 1-206-833-9111

DATE: Oct. 1974

STREET AND NUMBER: 1800 Beacon Way S.E.

CITY OR TOWN: Renton 98055

Washington State Historic Preservation Inventory Project
Washington State University

LES

The inventory of historic places is an attempt to develop a catalog of all properties in the state that demonstrate a contribution to our present by peoples of the past. It is a basic part of the State Historic Preservation Plan that can tell planners, engineers, government officials and others what features in our cities, towns and rural areas they should be aware of as they develop new projects. The inventory form is not a substitute for a nomination to the National or State Registers of Historic Places but it will alert the Office of Archaeology and Historic Preservation staff to potential nominations and their locations; it will enable the Office of Archaeology and Historic Preservation to more effectively assist you in the preparation of actual nominations.

No one knows how many historic sites there are in Washington; that is one of the purposes of the inventory; There are certainly thousands and, consequently, the inventory will be in progress for several years. Eligible properties are those which bear the mark of man: houses, commercial buildings, mines, vessels, archaeological sites and the sites of historic events, transportation facilities -- virtually any evident structure, object or site that has played a part in our collective heritage. Generally, properties less than 50 years will not be a part of the inventory.

Send the completed form to: Office of Archaeology and Historic Preservation
Washington State Parks
P.O. Box 1128
Olympia, Washington 98504

DESCRIPTION:

Gordon Stewart's cabin is a small log structure located next to a fenced g... A number of animal traps and pelts hang from its walls. The design of the buil... was copied from older structures in the Cascades Mountains.

SIGNIFICANCE:

Gordon Stewart, attempting to emulate the style of life of a mountain man ... imater, built his cabin in this remote area in an effort to forget his experie... in the First World War.

APPENDIX E

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Wenatchee N.F.
P.O. Box 811, Wenatchee, Washington 98801

REPLY TO 2540 Water Uses and Development (2800) — January 14, 1976

SUBJECT Economic Evaluation, Holden Tailings Piles

TO Forest Supervisor, Wenatchee N.F.

I have performed the following analyses of the value of the Holden tailings piles at the request of your staff.

The basic data used are assays of split spoon samples from holes drilled in each of the three piles by ORB Architects-Planners-Engineers during the summer of 1975 under a Forest Service contract. The holes used for this analysis were selected on the basis of distribution in three piles. Hole No. B-3 was in Pile 1; hole No. B-11 was in Pile 2; and hole No. B-7 was in Pile 3. The samples within holes were selected at approximate 15-foot intervals to show the vertical distribution of the values. The location of the holes, lithologic logs, and sample thicknesses are shown in the appendix to the ORB report.

All the samples were assayed individually for gold, silver, copper and zinc - the metals formerly produced from the Holden Mine - in order to reveal variations in metal content within individual holes and between the three piles. Additionally, the four samples from hole No. 7 and six samples from hole No. 6 were composited and assayed for sulfur, iron oxide (FeO), and Silica (SiO_2) as an indication of the average content of these substances in Piles 2 and 3.

The assays (certificate attached) show no important trends in metal content vertically within drill holes. The gold, silver and copper assays are within such a narrow range that deviations of individual values have no discernable significance. The zinc assays in Pile 1 and near the bottom of Pile 2 are significantly higher than any others.

It is believed that the higher zinc values are due to the fact that Pile 1 and the bottom of Pile 2 contain tailings from the earliest milling when, it can be supposed, metallurgical efficiency with respect to zinc had not reached the higher degree represented by later tailings.

The average assays restated for each hole are as follows:

Hole No.	Oz. Gold	Oz. Silver	% Copper	% Zinc
B-3	0.025	0.1	0.094	1.45
B-7	0.018	0.13	0.066	0.18
B-11	0.023	0.18	0.061	0.3

Progressively lower average assays from hole No. B-3 through hole No. B-11 to hole No. B-7 suggest either improving metallurgical efficiency chronologically from Pile 1 through Pile 2 to Pile 3, respectively, or progressively lower grade mill feed at the same approximate recovery rate.

Gross Value

Gross value is estimated for the purposes of this evaluation by applying the average November 1975 prices published by Engineering and Mining Journal (McGraw Hill Publications, December 1975) as follows:

Gold, Harmon and Handy, New York	$143.274 per ounce
Silver, U.S. producer	431.902¢ per ounce
Copper, U.S. producer, refinery	63.165¢ per pound
Zinc, U.S., prime western	38.897¢ per pound
Sulfur, elemental, U.S., f.o.b. Gulf ports	$60-63.50 per ton

The gross value of the average assay of each drill hole is estimated as follows:

Hole No.	Gold	Silver	Copper	Zinc	Total
B-3	$3.58	$0.43	$1.19	$11.28	$16.48
B-7	2.58	0.56	0.83	1.40	5.37
B-11	3.30	0.78	0.77	2.33	7.18

The gross value of the contained sulfur at approximately 3¢ per pound is $3.36 per ton in hole No. B-7 and $2.20 per ton in hole No. B-11.

Market Value

Estimates of the value of the tailings in the market place without further concentration take into account the fact that smelters, the obvious purchasers, pay less than the published price by the use of a schedule which allows the smelter to recover the value of metals lost in the smelting process, cover the costs of operations, and generate a return on investment. Schedules vary from smelter to smelter according to their equipmentation and market position.

The two smelters closest to Holden are the ASARCO Smelter at Tacoma, Washington and the Cominco Smelter at Trail, B.C. The ASARCO Smelter is principally a copper smelter while the Cominco Smelter is designed for lead and zinc.

assays well in gold content" (Pearse and Zanadvoroff, 1939), it is probably conservative to assume that at least half of the gold losses were as composite pyrite-fine gold particles. Thus, 5 percent (or half of the estimated 10 percent tailings loss) of 0.06 oz. would be about 0.003 oz. gold per ton of ore or per 120 pounds of pyrite (6 percent) or about 0.05 oz. per ton of pyrite.

The overall gold-silver ratio was 1:3.5 and the ratio for the zinc concentrate was 1:12. As no information regarding silver in the pyrite was found, it is assumed that the content was negligible for purposes of this summary.

No published information on the zinc content of the tailings was found; however, correspondence (J. Fred Williams, Jr., July 1960) shows that the 1947 average tailings loss was 0.20 percent zinc. Although zinc was not recovered until 1943, the older tailings (pile number 1) were largely used later in sand-fill operations and the remainder of this pile is deeply oxidized so it is doubtful that much zinc could be recovered from any of the Holden tailings.

Of the tailings in piles number 2 and 3, at least 1 foot of thickness on the top surfaces and 3 feet or more of the dike faces are oxidized. Thus, this surficial material and probably most of what remains of pile number 1 is not amenable to froth flotation. Although few data are available on which to base calculations, a reasonable estimate of the amount of unoxidized material might be on the order of 6 million tons. Using what would appear to be a conservative figure of 5 percent recoverable pyrite, we obtain a result of 300,000 tons of pyrite concentrate.

While value data for pyrite concentrates in the Northwest are not available, a figure of 10 dollars per ton delivered at Puget Sount ports seems reasonable. This $3 million gross value for pyrite does not include the estimated half million dollars in gold, part of which might be recovered from it.

Summary

Preliminary study (without benefit of sampling) indicates that on the order of 300,000 tons of pyrite concentrate containing possibly 15,000 ounces of gold could be obtained from the Holden Tailings. Positive economic factors are:

1. An extremely simple and therefore cheap recovery cost.
2. A readily measurable, therefore low risk, "ore body".
3. Removal of this acid-forming component would simplify reclamation of the piles.

Negative factors are:

1. A relatively small "ore body".
2. Poor accessibility, making transportation costs high.
3. Low unit value of the end product.

While a recovery operation at the present time would, at best, be marginal, factors such as a gold subsidy or the desire to remove acid-forming minerals prior to reclamation efforts could change this picture.

References Cited

Pearse, H. A. and Zanadvoroff, V. A., 1939, Howe Sound's New Holden Mill: Engineering and Mining Journal, v. 140, no. 11, p. 31-35.

GWT:lb

STATE OF WASHINGT

Department of

Natural Resources

COMMISSIONER
BERT COLE

DON LEE FRASE
SUPERVISOR

BOX 168
OLYMPIA, WASHINGTON
98501

December 8, 1971

U.S. Forest Service
P. O. Box 3026
Portland, OR 97208

Attention: Lloyd Holgren

Dear Mr. Holgren:

In response to our telephone discussion of December 8, I have enclosed a copy of a memo from Gerald W. Thorsen to Marshall T. Huntting. This memo pertains to sulfur-gold values in the Holden Mine tailings. We sent a copy of this memo to Pacific Interior Resources, dated November 11, 1971 in response to an inquiry from them relative to black sand deposits and tailings piles here in Washington.

You indicate that you had received several assays of the tailings piles. We would appreciate receiving a copy of those results if they are available.

If we can be of further service, please do not hesitate to contact us.

Very truly yours,

BERT L. COLE
Commissioner of Public Lands

BY Donald M. Ford
Assistant Supervisor
Division of Mines and Geology

DMF:ja

Enclosure

Telephone 363-3302

Hand Sample Serial 430-443

ASSAY REPORT

UNION ASSAY OFFICE, Inc.

W. C. WANLASS, President
L. G. HALL, Vice President
G. P. WILLIAMS, Treasurer
GERALDINE A. WANLASS, Secretary
P. O. Box 1528
Salt Lake City, Utah 84110

line U.S. Forest Service
Wentachee National Forest
P.O. Box 811

RESULTS PER TON OF 2000 POUNDS

Jan. 7, 1976

NUMBER	GOLD Ozs. per Ton	SILVER Ozs. per Ton	LEAD Wet on Ore	COPPER Per Cent	INSOL. Per Cent	ZINC Per Cent	SULPHUR Per Cent	IRON Per Cent	LIME Per Cent	Per Cent	Per Cent
Project J-203										FeO	SiO2
B-3/S 5	0.030	0.1		0.107		1.6					
" " 6	0.020	0.1		0.081		1.3					
"-7/S 6	0.015	none		0.088		0.4					
" " 10	0.015	0.3		0.044		Trace					
" " 13	0.020	0.2		0.056		0.1					
" " 16	0.020	none		0.075		0.2					
"-11/ S 6	0.015	0.2		0.075		0.3					
" " 10	0.020	0.1		0.056		Trace					
" " 12	0.030	0.2		0.069		Trace					
" " 15	0.020	0.2		0.069		0.1					
" " 18	0.025	0.1		0.044		0.2					
" " 21	0.025	0.3		0.050		1.2					
Composite B-7 /S6 thru B-7/ S 16							5.60			5.53	64.70
Composite B-11 /S6 thru B-11 /S 21							3.66			4.12	66.80

Remarks P.O.# 416-17-76

Charges $. 152.00

[signature]

OME EDITION	TV WORLD	FAMILY WEEKLY	Comics

What's new for the well-groomed bride?

— See special 36-page wedding guide inside

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THE WE[illegible] WORLD

Published in the Apple Capital of the World and the Buckle of the [illegible] Belt of the Great Northwest

Wenatchee, WA 98801

Sunday
Jan. 27, 1985
80th year, No. 178
75¢

ON STUART

Mountain man

Gordon Stuart has lived for 60 years in the high, wild Cascades mount[illegible] an exclusive interview relates his sto[illegible]

DOMKE LAKE: This has been Stuart's home

By HU BLONK
Wenatchee World [illegible]
(Copyright 1985 The [illegible])

DOMKE LAKE [illegible] again, and silence [illegible] around the little [illegible] trees.

Snow has cover[illegible] at the edge of the [illegible] sits. The snow will [illegible] deep by late [illegible]

Gordon Stu[illegible] winter in [illegible] Cascades [illegible] mile trail is [illegible]

[illegible] with a [illegible] wintered [illegible]

Stuart ha[illegible] [illegible] winters. [illegible] Domke Lake [illegible]

He is a stocky man of [illegible] with a round, [illegible] wears a plaid [illegible] worn dark trousers [illegible] brimmed Smok[illegible] cheeks are [illegible] severe years [illegible] Long hair [illegible]

Stuart's [illegible] call him that [illegible] unless you [illegible] growl.

In the past [illegible] interviews with [illegible]

Photo by Kelly Gillin

RAPTOR EXPERT MIKE BRYANT HOLDS EAGLE

Suspect nabbed in wounding of bald eagle

AN PALMER GILLIN
World staff writer

its from the Wenatchee office of the state Department of are considering whether to file charges against an gan County man believed to have shot and wounded a bald near Orondo Friday.

Patrol troopers stopped the man's vehicle near the Olds Bridge in East Wenatchee Friday afternoon. The ed eagle and a loaded .22-magnum rifle were found in the of the car.

car had been described by a witness who notified ities he had seen a man carrying an eagle north of Orondo he Columbia River.

man's name was not released pending the filing of es, said Wildlife Agent Rick Peterson. After being ques- by local game agents, the man and his wife were sent to e to meet with U.S. Fish and Wildlife agents for more oning.

l eagles are a protected species. The federal penalty for ng or killing the birds is a maximum of one year in jail $5,000 fine. Under state law it's a gross misdemeanor.

al game agents kept the bird at their Wenatchee office Mike and Marian Bryant could pick it up for treatment. ryants run the Raptor Rescue Center on Blewett Pass, and a federal permit to rehabilitate endangered and threatened es.

eagle was shot once through the left wing. X-rays taken Cashmere Veterinary Clinic late Friday afternoon showed ken ulna and lead shot in the wing.

wing was badly shattered, Ms. Bryant said. Surgery was uled for Monday morning.

we can get the bird through surgery, pin the wing, we can for a 60 to 70 percent chance to return it to the wild," she

yant said the eagle appeared to be about 3 years old. It does et have the white head, which is a characteristic of fully re bald eagles.

Mountain man Gordon Stuart

Exclusive interview relates his story

From Page 1

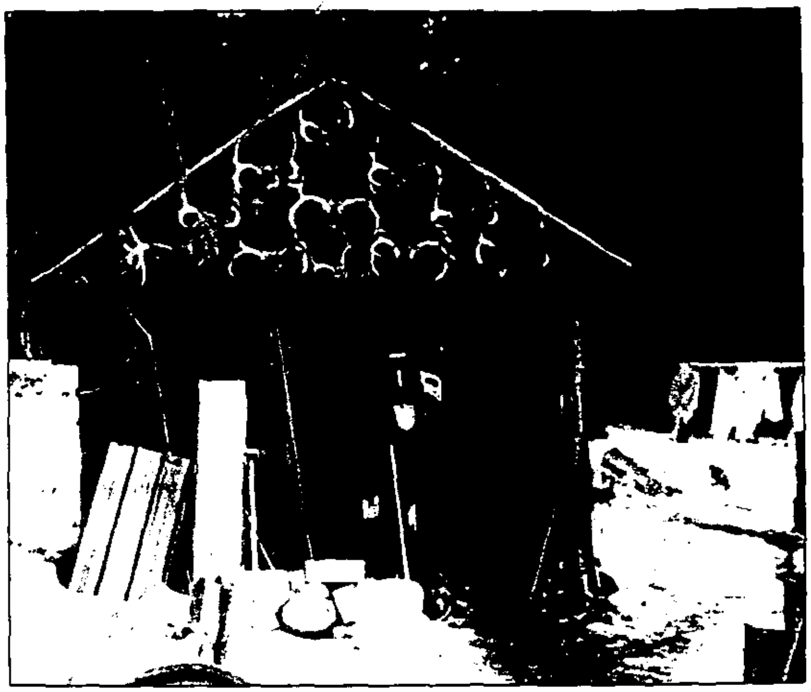
from National Geographic magazine who spent a couple of days at the lake.

Now, in the autumn of his life and after having been repeatedly reminded by friends that his unusual story ought to be preserved for posterity, Stuart agreed to talk.

He did so seated in a comfortable chair in the old wood-frame cottage where he could look through a window to the familiar mountain scene across the lake.

Stuart has a lung condition that makes his words hard to understand, so he spoke with the aid of a person who's taking care of him, almost like a devoted daughter — Sandy Nelson of Minnesota.

The interior of Stuart's confining abode — it has just 250 square feet of living space — provides him with his own brand of comfort. On one side of him was a bed. On the bed lay a couple of dogs, one called "Hopwood," after a Wenatchee brokerage firm run by Stan Bryant, one of Stuart's best friends, and an Airedale named "Sheba." Over the bed hung animal skins and alongside it rested a gun.



GORDON STUART HAS OCCUPIED THIS CABIN AT DOMKE LAKE FOR MANY YEARS

Before Stuart was a table cluttered with, among other things, mail brought up by Sandy from Lucerne via a steep trail that rises 1,100 feet. On a wall to his right were displayed numerous snapshots of bygone days. Above, on exposed roof rafters, personal belongings are stored on a door, providing the place with a sort of ceiling.

Stuart would relate little of his past before coming to Domke Lake, other than to say he was once a cowboy in Nevada and has no relatives that he knows of. Questioned further about his youth, he replied: "None of your business!" He did say he didn't get much schooling.

He came to this high mountain country after being told about trapping marten in Idaho by an old man on a dairy ranch in California where he was working. He ventured to Idaho, but the season was closed. His next stop was Ellensburg, where things looked too dry for trapping, so he came to Wenatchee. He picked apples for four days at Malaga before heading for Lake Chelan, still looking for a place to trap for a living.

Stuart's memory is still sharp, and the old woodsman recalled staying at Campbell's Lodge in Chelan on Oct. 13, 1924. Next day, he boarded the passenger boat "Liberty" for Stehekin. But a Forest Service official told him someone was already trapping marten there. So he got off at Lucerne.

Pioneer resort operator Oscar Getty pointed Stuart in the direction of Domke Lake, where he bedded down in the barn of another trapper, A.L. Cool. Except for Army duty and a few visits "out," he's been here ever since.

Cool, a paymaster for several big corporations in Indiana, had come in 1894 to hunt and trap, and live in a healthy environment after being told by his doctor he had Bright's disease, a kidney ailment, and had six months to live.

Domke Lake proved to be a healthy place, and Cool lived to the ripe old age of 84, renting out boats in his later years. He told Stuart that another man, whose name he did not recall, had preceded him at the lake.

Soon, the young newcomer took over some of Cool's traplines. The latter was happy to get a young partner, being 67 at the time and having lived all by himself for years.

That meant Stuart would go over 6,600-foot-high Milham Pass from Domke Lake (elevation 2,192 feet) and run traps for marten all the way to the Entiat River. That was 12 miles distant, not counting side trips to tend his 150 traps.

The arduous task involved being alone in the vast expanse of deep snow on snowshoes, sometimes in sub-zero weather, for four or five days at a time. He would stay in small cabins enroute.

Stuart said he never felt it was a particularly dangerous occupation, although he admitted that once, while standing about rolling a cigarette, an avalanche nearly engulfed him.

While Cool was there another man named Chambers, from Maine, set up a hunting and fishing camp where Stuart's cabins are now. Shortly after Stuart arrived, Chambers sold the enterprise, not a profitable one, to Mr. and Mrs. Pat Lee, who owned Lucerne Resort. Lee built the large cabin that Stuart later rented out.

The war drew Stuart away from his beloved mountains from 1942 to 1944. Cool died in 1941 while trying to put out a fire that was burning his cabin, and it was understood that Stuart might one day take over Cool's business.

So, Stuart set about getting a permit to operate a resort. He got it in 1950 after a couple of years of squaring away, during which time he built a smaller rental cabin.

Cool had had no government permits for his place, only a "squatter's claim." It was never a patented piece of ground, since it was before national forests were established.

Stuart first called the resort "Emerald Camp." Currently, it is known as "Domke Lake Resort."

He moved to his current site in 1959, building the cabin that he has occupied for many years. Until then, he lived farther south along the lake in an area known now as "Stuart's Camp."

Over the years, Stuart developed a lot of friendships among those who spent time at the resort. They have returned year after year, and say that Stuart is part of the attraction there.

Particularly good friends are Bryant, who visits by float plane in summer and on snowshoes in winter; Sid Burns, a Forest Service employee at Lucerne who keeps in touch with Stuart by means of a crank-type telephone, when it works; Ernie Gibson, a commercial seaplane operator who brings Stuart half his guests; and Archie Mills, now a state game commissioner who was formerly with the Forest Service.

All have played cards with him.

Said Bryant: "He is an avid and savage cribbage player." He went on to appraise his close friend.

"He's one of the most fiercely independent persons I've ever met," Bryant said. "He went to great lengths to maintain his independence, mostly by the way he lived.

"I seriously doubt if there is a man in the Northwest who knows as much about wildlife and habitat. People on the Game Commission might well listen to people like that."

Both Bryant and Mills commented on his knowledge of the outdoors.

"I think he is a most wonderful type," Mills said. "He's one of the few real old woodsman types — people who know the outdoors and live in it with minimal impact. He's a super woodsman who understands about wildlife."

Mills gave an example of the latter. One time Mills suggested burning some willows to enlarge a meadow. But Stuart objected, and pointed out: "That's what keeps ptarmigan alive; they fly in there and feed under the trees. That's the way they survive."

Explained Mills: "He knew all that. He respected wildlife; was absolutely law-abiding."

In no sense is he a hermit or recluse, Mills added.

"He is pretty much self-educated," he said. "He reads rather extensively."

In that regard, Mills said of Stuart:

"He had two cabins in the Entiat that he trapped out of. I went into one — I could barely stand up in it the roof was so low. I found two books.... One was an early-day trapper book and the other was 'The Arabian Nights.' I could just see Gordon holed up in there waiting out a storm, sitting around a wood stove and reading by kerosene lamp."

Besides doing a lot of reading — he has many books around the place — he keeps up with the news via a small radio. And one of the things Sandy Nelson brings up from Lucerne each week are issues of The Wenatchee World.

As for his habits, Mills said that anyone with a dog became a friend of Stuart, who especially liked a Weimaraner he called "Rupert." But he never liked anyone to pet his dogs; he wanted them to guard the place, Mills assumes.

Mills feels his long-time friend "punished his body tremendously, traveling in those severe conditions," and described an incident to denote how tough he is.

One winter Stuart found himself suffering from an excruciating stomach pain. It was so bad he would pass out at times. Yet, as he lay in bed Stuart continued to put wood in the stove to keep warm. Later, a physician found that Stuart had a ruptured appendix.

Stuart was apt "to speak his mind at any time, any place," Mills said, and recalled when he, Mills, gave him a permit to build a cabin by a certain time. When Stuart didn't meet the deadline, Mills asked if he didn't realize his permit was about to run out.

Stuart replied: "Yeah, some stupid son-of-a-bitch put that (time limit) in there."

"You know, Gordon, I put that in there," said Mills.

Stuart answered: "Yeah, I know."

Stuart has always had strong feelings. For a long time, he figured anyone with a motor on his boat at the lake was a sissy, said Gibson, who is a frequent visitor. However, 25 years ago Stuart finally put one on his own boat — quite a concession to modern ways.

Last fall, Stuart made another concession. He had Massey-McCray Associates of Wenatchee build him a 20-by-30-foot Pan Abode log cabin alongside the old one with the 10 deer racks decorating the gable. That involved a noisy helicopter making 20 trips to his otherwise-quiet setting to drop the lumber.

But Stuart has not gone modern all the way. The new cabin, where he now lives, has no electrical wiring, no plumbing for a toilet or drinking water, no covering on the floor. The bathtub has to be filled by bucket. A Coleman lamp provides light.

Stuart likes people, friends say. When asked about that, Stuart qualified his opinion by saying: "Some people." He has been known to order people out of camp.

Asked if he ever got lonely, Stuart said, no, he kept too busy.

Though he is not in the best of health, Stuart has no plans to leave. Asked how much longer he planned to stay there in the forest alongside his beautiful lake, but so far from medical attention, Stuart answered without hesitation:

"'Til my last breath is gone."

His friends worry about that, but they say they understand why Gordon Stuart wants to stay as long as he can where the owls hoot in the dark of night and the deer venture close, rather than in a crowded nursing home or hospital in a noisy distant city.

Huntsville firm charged after river-fish kill

DAYTON, Wash. (AP) — The state Ecology Department has charged a Huntsville company $203,000 for damage from a chemical spill that killed nearly all of the fish in the Touchet River between Waitsburg and Dayton last April.

LABORATORY TEST RESULTS

Water Quality Analysis

Samples for laboratory tests were obtained from the following locations:

	Location	Copper	Iron	Lead	Zinc	Cyanide	Arsenic
*1.	Railroad Creek at Wilderness Boundary (July 1, 1975)	0.003	--	--	--	--	--
**2.	Mine portal drainage (May 17, 1975)	7.060	--	--	--	N.D.	0.10
3.	Outfall pipe, pile No. 1	0.003	--	--	0.006	--	--
4.	Copper Creek upstream, pile Nos. 1 & 2	0.110	N.D.	0.04	--	N.D.	--
*5.	Copper Creek West Branch, pile No. 1	0.003	--	--	0.003	--	--
6.	Railroad Creek at junction Copper Creek	0.080	0.25	0.04	--	N.D.	--
7.	Railroad Creek at pile No. 2	0.120	0.70	0.04	--	--	--
8.	Seepage at pile No. 2	3.760	Trace	0.06	--	--	--
9.	Seepage at pile No. 3 S.W. corner	0.110	N.D.	0.04	--	--	--
10.	Outfall pipe at pile No. 3	2.020	68.70	0.06	--	--	--
*11.	Seepage east of pile No. 3	0.100	--	--	0.309	--	--
*12.	Railroad Creek at junction of Six-Mile Creek	0.009	--	--	--	--	--
13.	Railroad Creek at Lucerne	0.140	--	0.04	--	N.D.	0.02

See Resource Inventory One, Page 2-5, and Resource Inventory Two, Page 2-17 for sample locations.

Water Quality Analysis (continued)

	Copper	Iron	Lead	Zinc	Cyanide	Arsenic
*14. Railroad Creek at Wilderness Boundary (July 17, 1975)	N.D.	--	--	0.007	--	--
15. Railroad Creek at Holden Foot Bridge	0.001	--	--	0.089	--	--
16. Railroad Creek at 600 feet below pile No. 3	0.004	--	--	0.074	--	--
17. Mine portal drainage (July 17, 1975)	1.80	--	--	9.88	--	--

* Samples by ORB team member (S. Martin) on July 1, 1975. Lab Test by Laucks Testing Lab.

** Samples by ORB team members and U.S.F.S. on July 17, 1975. Lab Test by Laucks Testing Lab.

Samples without asterisk were taken by ORB team members and U.S.F.S. on May 17, 1975. Lab Test by C.W.S.C.

N.D. None detected-less than 0.0001

Aquatic Insect Sample Results, Substantiate Previous Data and Conclusions by Pine (1967)

There has been an obvious continuing effect of the tailings material, particularly copper and zinc on the insect fauna of the creek. At Station 1, upstream of the tailings, a healthy and diverse fauna was observed with a mean of 261 individuals per square meter of bottom. However, at Station 2, just above Copper Creek and adjacent to tailing pile No. 1, a mean of only 41.5 insects per square meter (M) were found, with the majority barely mobile or dead. This indicates that these insects had probably been carried from upstream areas into the tailings area and affected by tailings derived pollutants (primarily copper and zinc).

At Station 2, river rocks were coated with a slime material that may be a high concentration of specific bacteria or fungi organisms existing in an area receiving domestic sewage effluent and heavy metal contaminants.

At Stations 3 and 4, downstream from the tailings, very few individuals were found, with mean values of 12 and 5.5 per square meter respectively. However, most individuals were in a healthy condition similar to those observed at Station 1.

Data from Station 5 (Railroad Creek at Lucerne) was not exactly related to the other data, as stream bottom type and rapid currents were not entirely similar to the other stations. However, insects obtained at this station were in a healthy condition, comparable to those found at Station 1.

It is presumed that recovery of the insect population gradually occurs in the distance from River mile 6.0 to River mile 0.1. Pine (1967) did not observe recovery until River mile 3.2, but was unable to sample the distance between River miles 6.3 and 3.2.

Examination of U.S. Forest Service water quality data indicated that the pertinent parameters were copper, zinc, pH, and alkalinity. Ranges for these parameters at each station for the period from 1966 to 1972 are presented below.

Parameter	Below Tailings	At Lucerne	Above Tailings
pH	6.5 - 7.0	6.6 - 7.7	7.3 - 7.7
alkalinity mg/l $CaCO_3$	0.0 - 30.0	0.0 - 30.0	0.0 - 30.0
copper PPM	0.0 - 0.3	0.0 - 0.2	0.0 - 0.036
zinc PPM	0.0 - 0.043	0.0 - 0.042	0.0 - 0.012

These data indicate a relatively high copper level, in combination with relatively low pH and low alkalinity. The latter two conditions enhance the toxicity of heavy metals.

Sources of Pollution:

Copper, zinc, iron, and other heavy metals have been introduced into the creek from a number of waterborne sources, including:

1) Contaminated water from the mine portal.

2) Rain and snowmelt from the tops and slopes of the tailing piles, and the hillside area above the tailings, leaching through the piles.

3) Rain and snowmelt from the same areas listed above, eroding the tailing piles.

4) Erosion of the tailing piles by stream action undercutting their banks (from Copper and Railroad Creeks).

Specific sources of pollutants that may enter Railroad Creek were identified as follows:

1) Drainage from old mine portal, approximately 1/2 mile upstream of the tailings. Drainage is approximately 2 cubic feet per second.

2) Drainage immediately west of tailings pile No. 1, running over lowland areas and joining a small stream which enters Rail-Road Creek. Probable source: upland runoff.

3) Drainage from a small, 10-inch wooden pipe, protruding from east side of tailings pile No. 1 and depositing water on pile slope. Probable source: upland runoff, sewage lagoons, or a combination of these.

4) Copper Creek, both forks, but particularly the smaller west fork which encroaches on tailings pile No. 1.

5) Drainage running down west side of tailing pile No. 2 and joining Copper Creek. Probable source: upland runoff.

6) Large pond on surface of tailings pile No. 2, draining primarily through a decanting tower and old central drainage system within the tailings pile. The drainage system probably allows some water to leach into the tailing pile. Probable source: upland and local runoff.

7) Drainage (leachate) along bases of tailing piles 1, 2, and 3. Probable source: snowmelt from piles and hillside area above piles.

8) Small drainage running northwest off tailings pile No. 3. Probable source: upland runoff.

9) Large pond on surface of tailings pile No. 3, which drains into a decanting tower and through an old central drainage system, exiting via an outfall pipe just east of the pile. Probable source: upland and local runoff.

10) Drainage along base of tailings pond No. 3. Probable source: See No. 7 above.

11) Bank erosion due to occasional flood conditions in Railroad and Copper Creeks.

12) Windborne tailings from all three piles.

13) A concrete weir connected to an internal (pipe) drainage system, which controls the amount of ponded water able to drain off the tailing pile surfaces. The decanting towers, located on tailing piles, were designed to drain surface water directly into Railroad Creek.

Leachate discharge into Railroad Creek is caused by water from upland runoff and precipitation (primarily snowmelt) ponding on the surfaces of tailing pile Nos. 1, 2, and 3, and percolating down into these piles, dissolving mineral elements, and seeping into Railroad Creek in the form of leachate.

ORB originally thought the drainage systems for tailing pile Nos. 2 and 3 were interconnected. However, fluorescein dye placed into the decanting tower on tailing pile No. 2 was not observed at the suspected "common" outflow at the east end of pile No. 3. It must, therefore, be assumed that the drainage system on tailing pile No. 2 is not interconnected with No. 3 and/or it is blocked.

Fluorescein dye tests administrated on tailing pile No. 2 showed only one location where leachate surfaced before flowing into Railroad Creek. This location is just east of a small shack adjacent to the creek, near the junction of pile Nos. 2 and 3. Water quality analysis at this location may be referenced by viewing resource inventory map showing water quality analysis sampling locations.

No tests were made to determine leachate flow through ground water to Railroad Creek.

Conclusions: Contamination of Railroad Creek by the Holden tailings has resulted in a severe depletion of fish and other aquatic life in the creek, extending downstream from the tailings for at least 4 to 5 miles. This condition is primarily due to the presence of heavy metals (copper and zinc) in combination with low pH (6.5 to 7.0) and soft water (less than 45 parts per million as calcium carbonate.

Very low levels of copper and zinc, less than 0.1 PPM are toxic to a variety of aquatic insects. Copper and zinc concentrations as low as 0.048 PPM in combination with soft water have been shown toxic to salmon and trout species.

Chronic exposure to copper and zinc concentrations between 0.025 and 0.050 PPM may result in young salmon and trout exhibiting sub-lethal effects including blood changes, gonadal damage and lowered steroid levels, eventually resulting in death.

Copper concentrations in Railroad Creek vary from 0.003 to 0.14 during the spring and summer of 1975 and zinc concentrations vary from .003 PPM to .089 (during July, 1975). Even if exposure to these heavy metal concentrations are intermittent, it is sufficient to prevent a typical stream community from being re-established in the Creek.

Heavy metal concentrations in Railroad Creek have depleted fish population due to chronic or acute exposure to copper and zinc ions which have lead to any of the following:

- Rapid mortalities
- Sub-lethal effects and eventual mortalities
- Avoidance of stream areas even during times of no pollution (if such periods exist) due to no aquatic insect food.

The entry of tailing fines into stream has also contributed to the unsuitable stream conditions. Sedimentation causes disruption of fish and aquatic insect respiration and fish egg incubation, by interfering with normal gaseous exchange across the gill surface and egg membrane.

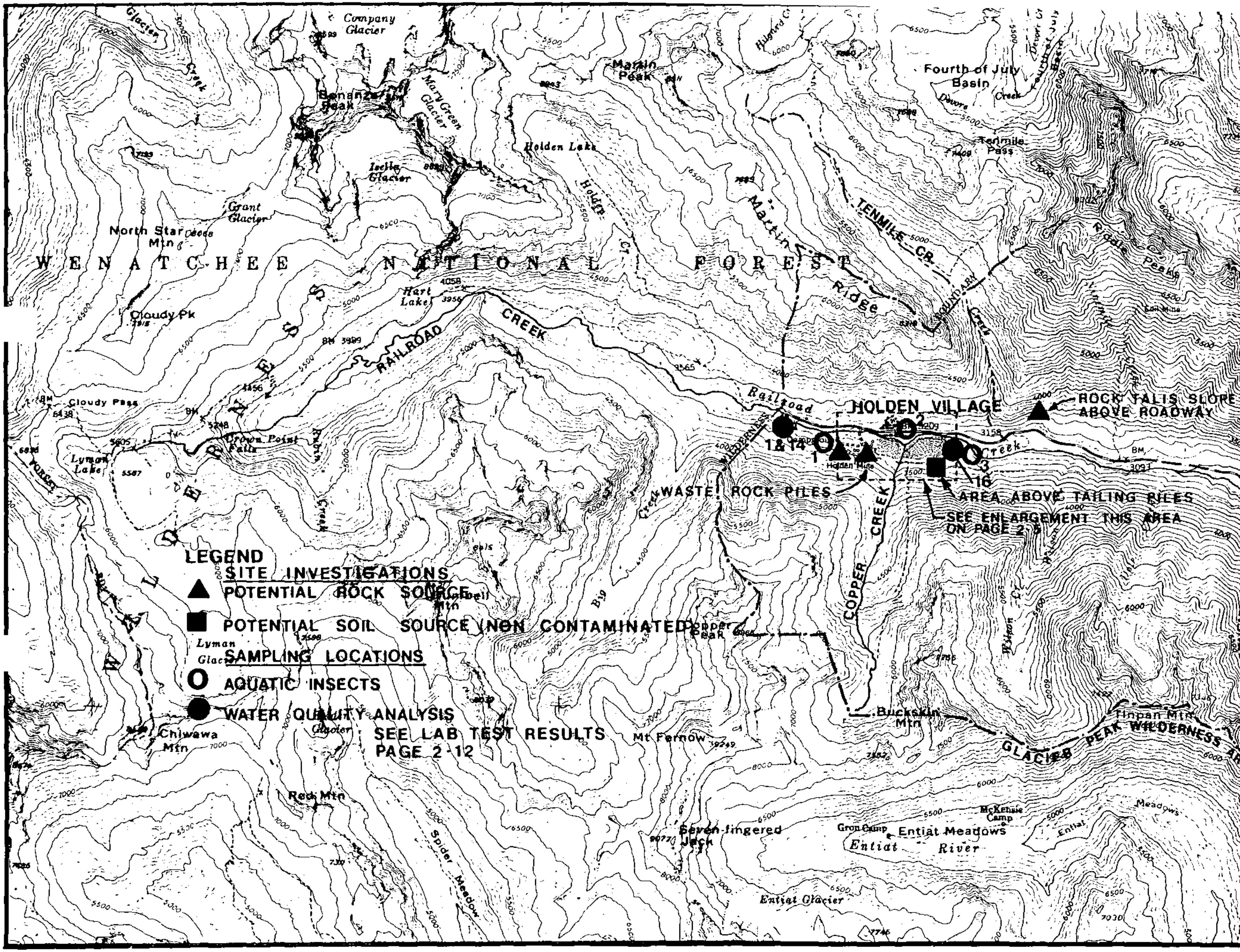
Further damage to aquatic life is caused as a result of leachate flow into the stream which has cemented the stream bottom north of the tailings pile for several miles of the tailing piles. This cemented condition denies a normal aquatic habitat.

Staff members at Holden Village have recorded adverse effects to humans caused by airborne particulate matter originating from the Holden Mine Tailings. Associated respiratory problems show a high frequency of occurrence, with persons having asthma often developing severe attacks. Guests at Holden Village occasionally complain of eye irritation and of allergic reactions. Loggers working in the vicinity of Tenmile Creek (approximately two miles downstream from Holden Village) indicated several workmen contracted eye infections. These were attributed to airborne tailings material.

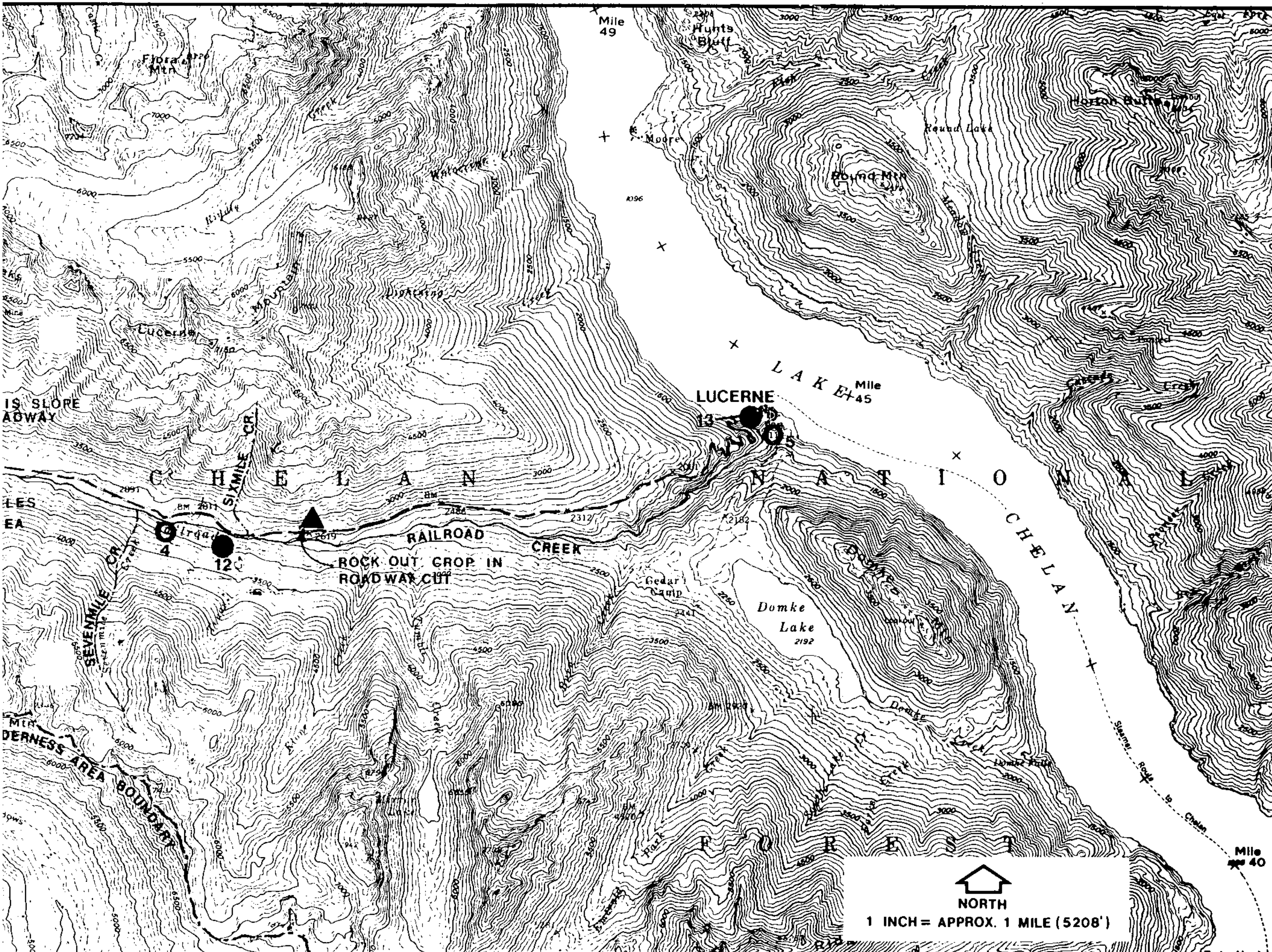
Water Pollution Treatment

Conversations with Jack Sceva, Surveillance Analysis Division Geologist and Dan Bodien, Chief of Water Permits Section, Region 10 office of the Environmental Protection Agency indicate the following:

Since the proposed solution requires that surface water be drained from the tailing piles in a controlled manner, the tailing piles would then become a point source. Such a point source may require an E.P.A. permit. When asked if the E.P.A. would allow time (2 to 3 years) for the proposed vegetative solutions to eliminate the pollution, Mr. Bodien stated that the E.P.A. would not rule on the conditions of the permit until an application from the Forest Service had been received. However, Mr. Sceva indicated that the E.P.A. has issued such delayed permits in the past. It is necessary that the Forest Service apply for a permit before the E.P.A. will make a decision as to the requirement for treatment of runoff.



WENATCHEE NATIONAL FOREST
HOLDEN VILLAGE
ROCK TALUS SLOPE ABOVE ROADWAY
RAILROAD CREEK
COPPER CREEK
TENMILE CR.
Martin Ridge
WASTE ROCK PILES
AREA ABOVE TAILING PILES
SEE ENLARGEMENT THIS AREA ON PAGE 2-5
1&14
1
2
3
16
LEGEND
SITE INVESTIGATIONS
POTENTIAL ROCK SOURCE
POTENTIAL SOIL SOURCE (NON CONTAMINATED)
SAMPLING LOCATIONS
AQUATIC INSECTS
WATER QUALITY ANALYSIS
SEE LAB TEST RESULTS PAGE 2-12
GLACIER PEAK WILDERNESS
North Star Mtn
Cloudy Pk
Cloudy Pass
Lyman Lake
Crown Point Falls
Hart Lake
Holden Lake
Bonanza Peak
Company Glacier
Mary Green Glacier
Isella Glacier
Grant Glacier
Martin Peak
Fourth of July Basin
Tenmile Pass
Riddle Peaks
Buckskin Mtn
Chiwawa Mtn
Red Mtn
Mt Fernow
Seven-fingered Jack
Entiat Meadows
Entiat River
Entiat Glacier
Spider Meadow
Tinpan Mtn



RESOURCE INVENTORY TWO

Dust Bucket test Samples

Dust buckets were placed on our June 7th and 8th trip to Holden area in similar locations to 1974. Test data from 1975 tests are not available at the time of this writing. 1974 data has been used in this analysis. The following data represents a 1 year accumulation (1974). See Dust Bucket location, page 2-19.

Site A - 600 feet east of Tailing Pile No. 3. Buckets at this site collected an average of 3,000 lbs/acre.

Site B - 2,500 feet east of tailings. Buckets at this site collected an average of 350 lbs/acre.

Site C - 5,000 to 6,000 feet east of tailings. Buckets at this site collected an average of 270 lbs/acre.

Site D - Located just west of Holden Village. Buckets at this site collected an average of 70 lbs/acre.

Seasonal variation in the distribution of particulate matter is significant due to local climatic conditions. The maximum air pollution potential is reached during mid summer, when the surfaces of the tailing piles are bare and dry. When tailing surfaces are saturated by rainfall or snowmelt, or covered with a snowpack, particulate matter is effectively "insulated" and protected from wind erosion.

Because the tailing material is predominantly fine sand size or smaller, it is all susceptible to transportation by wind. However, the cemented, oxidized crust material covering the surfaces of the tailing piles appears to limit the extent of wind erosion.

Tailings particulate matter deposited downwind has a yellow buff coloration out of harmony with the environment.

Vegetative Studies

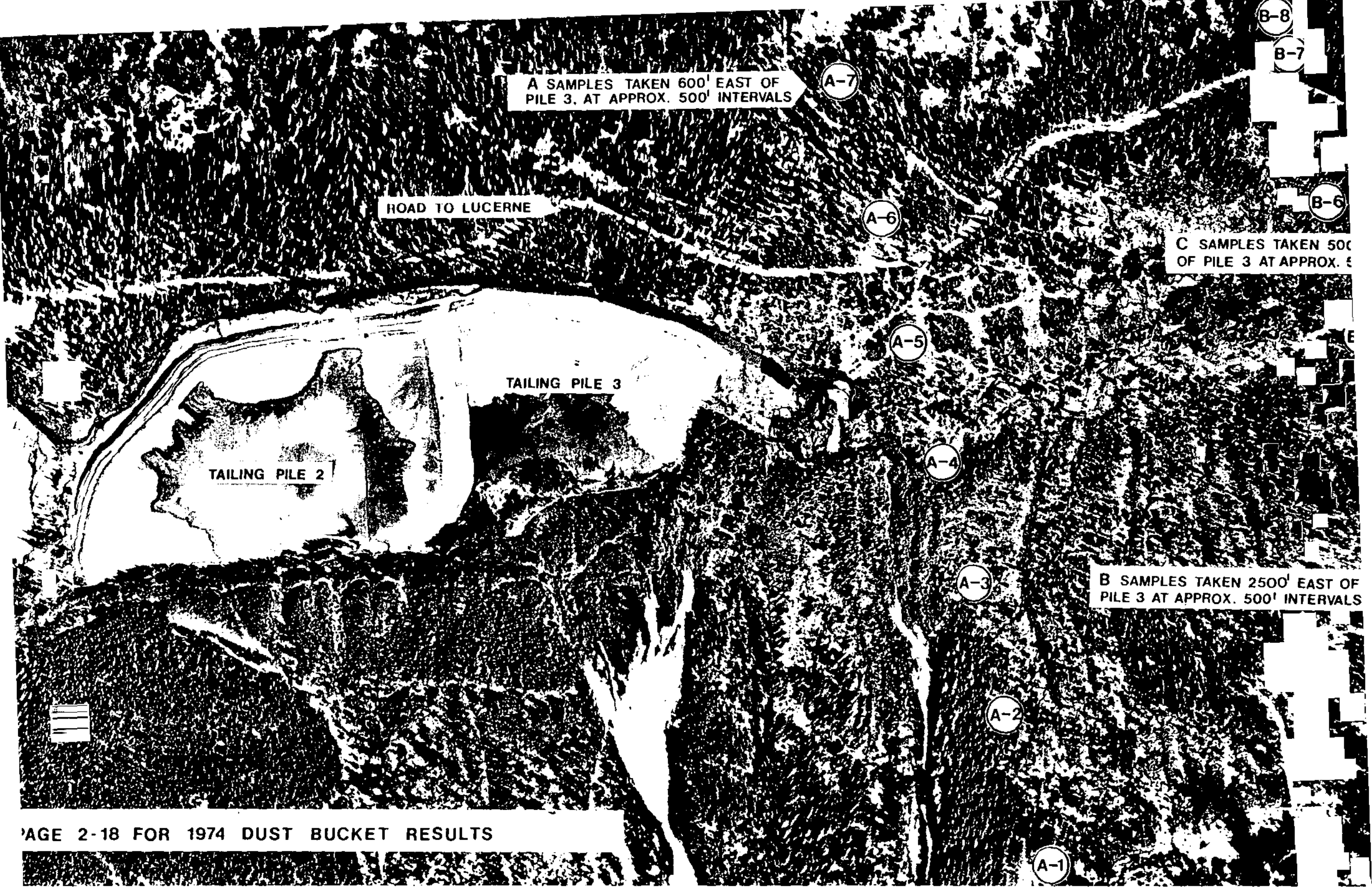
Purpose

- Develop a plant list of suitable species for establishing vegetative cover on tailings.
- Evaluate growth on U.S.B.M. test plots and utilize findings in rehabilitation plan.
- Determine most feasible method of plant establishment to include soil preparation, planting, irrigation, operation and maintenance and design life.
- Investigate native plant material presently growing in highly acid peat bogs to determine which species would grow at Holden in acid conditions.
- Survey existing vegetation in Holden area to assist in development of a suitable plant list.

Field Investigations and Literature Research

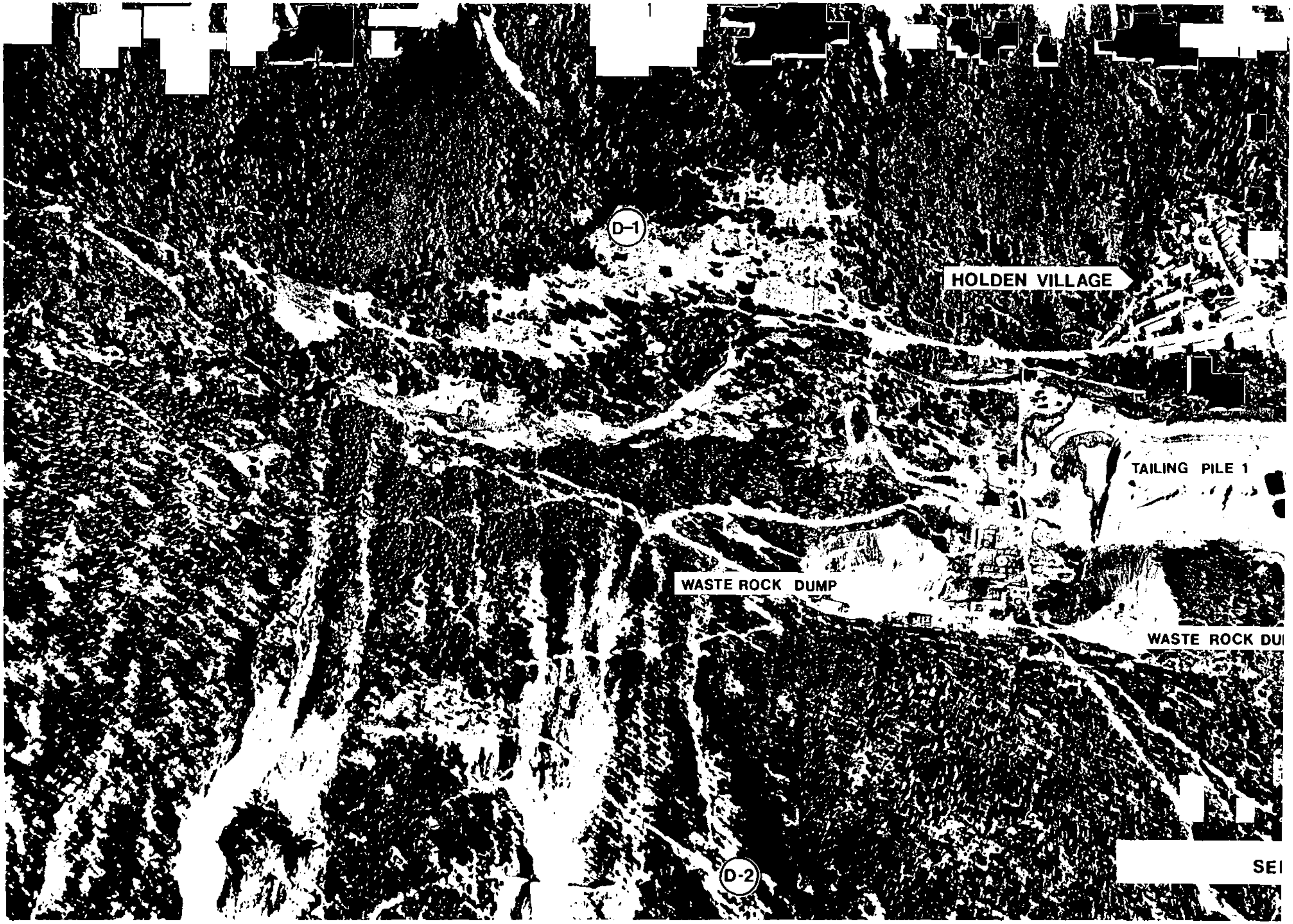
Field inventory of species native to Holden area were made on June 6th and 7th, 1975, and July 1, 1975.

Meetings were held with Wenatchee National Forest Service reforestation personnel to review reforestation practices, and natural succession of varieties which volunteer after fire damage, and the range of usable varieties growing in the Holden area.



SCALE: ONE INCH = 500 FEET

DUST - BUCKET LOC



D-1
HOLDEN VILLAGE
TAILING PILE 1
WASTE ROCK DUMP
WASTE ROCK DU
D-2
SE

Meetings were held with Mr. Ken W. Russell of the Washington State Forest Land Management Center in Olympia. Mr. Russell is an expert on peat bog plant varieties which survive very high acid conditions. ORB obtained list of non-bog plant material which can survive these conditions.

From investigations of species common to both the Holden area and highly acid peat bog material, we found that Lodgepole Pine, Western White Pine, and English Spruce grow in both areas.

Researched tailings rehabilitation work at the Bunker Hill Mine, Kellogg, Idaho, where successful plant establishment on tailings involved hydroseeding adapted grasses with organic mulch, lime and fertilizer. Mini-terraces were used on steep slopes.

Conclusions

A short growing season and continuous wind blowing across the tailings present problems in establishing an overall vegetative cover.

Irrigation will be necessary to provide needed moisture during the initial establishment period and first two summer seasons. The use of low discharge sprinkler heads with close spacing (40 x 40) is necessary in order to get effective coverage without over irrigating the piles.

Organic matter should be added to tailings material to establish a suitable planting bed.

Tree establishment areas should have an uncontaminated soil cover at least 3 feet deep. Amendments should be added to tailings material under the uncontaminated soil to a depth of 2 feet.

Trees and shrub vegetation over the tailing piles should cover from 10 to 25 percent of the pile area.

A fall planting season is possible if done early enough to allow good seeding establishment; and if an early planting deadline is missed, an alternative would be the planting of barley or rye as a cover crop to provide spring erosion control.

Hydroseeding will be necessary on areas inacessible to drill planting and should include Coherex (a chemical used to control surface erosion and prevent "sandblasting" of plant materials) as an additional erosion control measure. Rigorous supervision and coordination of the revegetation program by plant material specialists will be necessary.

Slide Area Alder

Alder from slide area could be chipped and spread over portions of pile. This would not have the severe erosion potential as would removal of soil. Some replanting of alder from seeds contained in chippings could be realized. Alder should be considered for replanting slide slope since the slide area presently maintains alder growth well.

Chemical Cover

Purpose

- Determine suitability of chemical vegetative cover at the Holden Site.

Investigation

- Investigation and conclusions were accomplished by ORB and Consultant, Karl Dean, former U.S.B.M. Mining Engineer.

Conclusion

Chemical stabilization method will not provide a permanent solution.

Chemicals can, however, be applied directly to the steep slope areas without grading.

The U.S.B.M has tested over seventy (70) chemicals and selected materials have been field tested.

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Ligno sulfonates which are produced here in the Pacific Northwest as a by-product of the forest industry and are effective as chemical stabilizers in many areas. They are, however, water soluble and highly susceptible to short life (less than one year) under damp conditions. Water soluble type chemicals should not be used at Holden.

Coherex, TC 1842 (Paracol) Hercules (biobutadiene) Dow M-166 can all be used as a chemical - vegetative stabilizer. Coherex, a resin base material, has been used effectively on several sites and in one application in Colorado the protection is still effective after 5 years. However, chemical stabilization of tailings is not completely proven.

Chemical stabilization requires the transport of large quantities of liquid chemicals to Holden. The logistics are difficult.

Recommendations for Conceptual Design

As a result of our investigations, literature research, laboratory tests, conclusions, and project analysis, we recommend the following:

A. Recommendations on Surface Water Erosion

- Surface water from area above tailing piles should be diverted to Railroad Creek before it flows onto piles.
- Any surface ponding should be sealed to prevent infiltration of water through piles.
- Rainfall and snowmelt on area of piles should be diverted off piles and away from their outer edges in the most expedient manner.

Surface water erosion does not appear to be a major contributor to pollution except during spring runoff. This erosion should be reduced by placing protective covering on the tailing piles.

Existing decant systems provide a route for water to enter tailing piles. This system does not provide a positive method of draining piles. We recommend that the decant towers and drainage system be sealed and that the surface water be either drained as rapidly as practical from the tailing pile surface or provide an impervious cover over the tailing piles. An impervious cover, however, is highly impractical.

B. Recommendations on Tailing Pile Stability

- Slopes of tailing piles may be graded to a flatter slope. However, grading operations should not disturb the toe of piles. (Interface of toe tailing material with original ground). If oxidized crust is removed, positive slope protection must be applied to prevent heavy erosion.
- Construction of revetment structure or grading operations should allow drainage of the tailing pile toe. It is imperative that the phreatic surface not be increased.

  A filter material must be installed between the tailing material and the stream during the construction of stream bank protection piping of the tailing fines through the revetment.
- Protect the toe of tailing piles from undercutting by stream action during a 50-year storm runoff. Provide 3-foot free board. Creek should be kept clear of debris and all over-hanging trees on north side of creek should be cut down and removed.

  Divert west channel of Copper Creek into main channel to prevent undercutting of tailing pile No. 1. This channel carries about 25 percent of the flow in Copper Creek. Stream improvement will be required to keep the main channel in its present location.
- Relocate Railroad Creek at two locations:

  1. at intersection of Railroad Creek and Copper Creek for a distance of 510 feet downstream. The revetment needs to be widened to facilitate access at base of piles and the regrading of the adjacent tailing slopes, and to provide for a

bank protection structure, the channel could be relocated northward. Recommend that the relocation not exceed 40 feet northward and that the resulting channel length equal or exceed the present length.

2. at tailing pile No. 3, move stream over approximately 10 feet to the north to accomodate bank protection.

C. Recommendations on Water Pollution

- o Polluted water should be prevented from entering Railroad Creek.
- o Drainage from the mine portal should be flowed through a channel with crushed limestone to increase pH and alkalinity and precipitate out the heavy metals.
- o Recommend that a long term test be conducted to determine the quantity of limestone required annually to treat polluted water flowing from the mine portal. Also consider use of a retention pond with steel or aluminum added to assist in precipitation process.

(Karl Dean, ORB Consultant, indicates that tests in Lynx Creek, an Arizona stream, have proved successful but no measured values for the quantities of required limestone or metal additives are available. Since logistics for moving limestone to Holden are so great, and because treatment of the mine portal will be required over an indefinite period of time, determinaton of annual limestone costs are particularly important.)

Recommend that Forest Service take required action to obtain an opinion from EPA concerning treatment of polluted water during period of rehabilitation, construction and plant establishment.

D. Recommendations on Aerial Particulate Pollution

Aerial pollutants can be prevented by chemical soil stabilization or vegetation plantings on the tailing piles. Irrigation during the summer months would help insure success. Vegetation would also function well in dissipating rainfall and snowmelt.

E. Recommendations on Vegetative Rehabilitation of Tailings

Planting Media

Recommended Quantities of Fertilizer and Lime on Oxidized Tailings without Organic Material

Material	Quantity/Acre	Total on 90 Acres
Fertilizer		
34-0-0	60 Lbs N	7.95 Tons
0-44-0	125 Lbs P	14.2 Tons
0-0-60	90 Lbs K	6.75 Tons
Lime*	15 Tons	1,350 Tons

Fifty percent of lime should be agriculture grade, 50 percent of lime should be course material. This will allow for both immediate and residual acid neutralization. One ton per acre shall be dolomite or the entire quantity equivalent to amount of magnesium found in one ton of dolomite lime.

F. Recommended Quantities of Fertilizer and Lime on Oxidized Tailings with Rock from Waste Piles 4 - 6 inches Deep over Surface (fines, less than one inch diameter).

Material	Quantity/Acre	Total on 90 Acres
Fertilizer		
34-0-0	60 Lbs N	7.95 Tons
0-44-0	125 Lbs P	14.2 Tons
0-0-60	None	None
Lime*	10 Tons	900.0 Tons

Oxidized tailings with rock fines or coarse rock where no vegetation is desired - apply no fertilizer or lime - apply only on flat areas of site.

G. Recommended quantities of fertilizer and lime on grey tailings on areas where oxidized surface is removed. These areas will be in locations where material excavated below 5 feet is deposited

Material	Quantity/Acre	Total on 90 Acres
Fertilizer		
34-0-0	60 Lbs N	7.95 Tons
0-44-0	125 Lbs P	14.2 Tons
0-0-60	None	None
Lime*	10 Tons	900.0 Tons

*One-half fine material; one-half coarse (grit) as defined above.

H. Annual Fertilization

1st spring after grass is established, apply 150 pounds per acre of 18-46-0. Annual applications during next 2 to 5 years based on visual examination and soil tests.

J. Recommendations on Plant Materials

Plant Materials List: Suitable adapted species for planting at Holden.

Grasses to grow in the mine tailings
The list is based on varieties which are now succeeding, with amendments on the tailings:

Tall Fescue
Crested Wheatgrass
Hard Fescue
Regar Brome
Reubens Canada Bluegrass
Tall Wheatgrass
Intermediate Wheatgrass

Coniferous Trees from Holden Area

Seeds to be collected within the immediate environs of the tailings and grown at an off-site nursery for later transplanting into prepared soil beds on the tailing piles.

Ponderosa Pine
Engleman Spruce
Lodgepole Pine
Western Red Cedar
Western White Pine

Local broadleaf trees and shrubs to add to conifer mix:

Box Wood	Alder species
Ceanothus	Spreading dogbane
Hybrid Poplar	Willow
Caragana	Vine Maple

For added seasonal color, such plants as oxeye daisy, fireweed, honeysuckle, and elderberry may be planted.

Special effort should be made to obtain adapted species. Availability of seed of selected species will govern actual planting. Efforts should be made to collect seed of native tree and shrub species from Holden Village area. Irrigation is essential for any vegetation plan.

K. Recommendations on Stream Rehabilitation

After the pollution problems have been brought under control, it is recommended that a more favorable habitat for cutthroat trout be created. This could be accomplished by the installation of several gabion weirs across the creek in the reach, from above the tailings piles to two or three miles downstream of the tailings. Such structures would significantly increase pool and riffle habitat, which trout prefer, and thereby increase creek carrying capacity.

Gabions could be filled with crushed rock and limestone, the latter aiding significantly in reducing the toxicity of copper that might enter the creek.

(See long term lime test recommended under mine portal pollution).

Several sills could be placed along Railroad Creek to provide resting areas for the fisheries. This could be examined in greater detail in subsequent investigations if such a measure is considered desirable.

L. Recommendations on Sewage Lagoons

Recommend that Holden Village place all sewage lagoons on Pile No. 1, and that the lagoons be placed back from the edge of the pile, approximately 150 feet. Sewage lagoons must be lined to prevent infiltration through tailings but will not interfere with recommended solutions.

Step 2 Holden Brainstorming Session

Purpose:

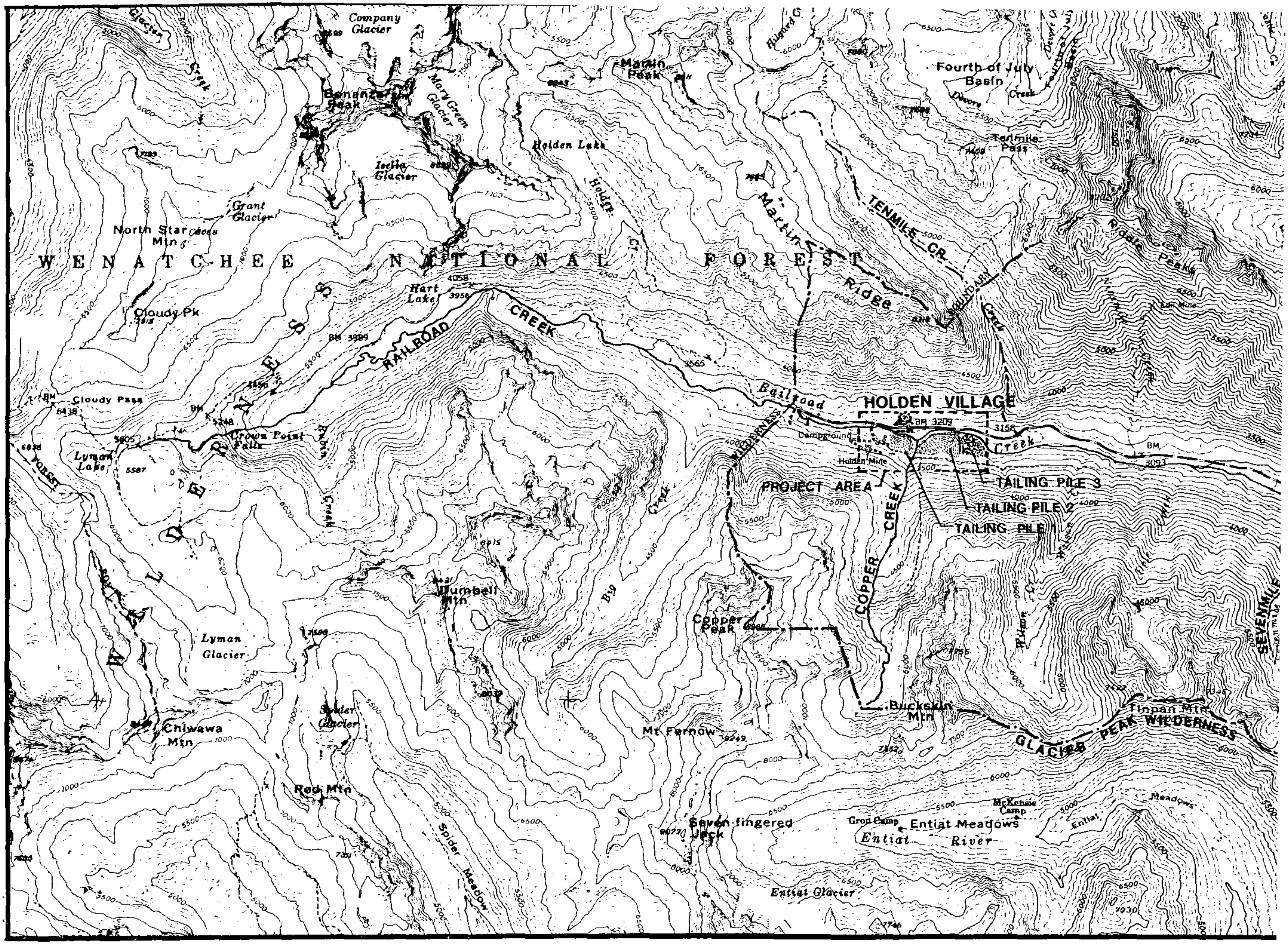
The Holden Brainstorming session was for the purpose of identifying the design teams' conclusions and preliminary recommendations which had been determined during the Step 1 Literature search and field investigations. After each team member had summarized his findings, the team was divided into two groups. One to deal with physical engineering considerations and the second to deal with the vegetative considerations. Each team had the following tasks:

- Identify pollution problems
- Identify pollution sources
- Define solution
- Itemize pros and cons of each solution

During the second day of the team meeting, members of each team exchanged views and discussed the various solutions. The above process provided each specialist with an overall understanding of the entire project.

Step 3 Determine Four Design Alternatives and prepare a presentation to the Forest Service.

In order to communicate the conceptual design and facilitate an understanding of the various complex interrelationships of the pollution problems and proposed solutions, ORB has prepared a network of alternative design solutions for the rehabilitation of the Holden mine tailings. A study of this network will provide the reader with a comprehensive understanding of the pollution problems, the pollution sources, and the


Company Glacier
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TENMILE CR.
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Ridge Peaks
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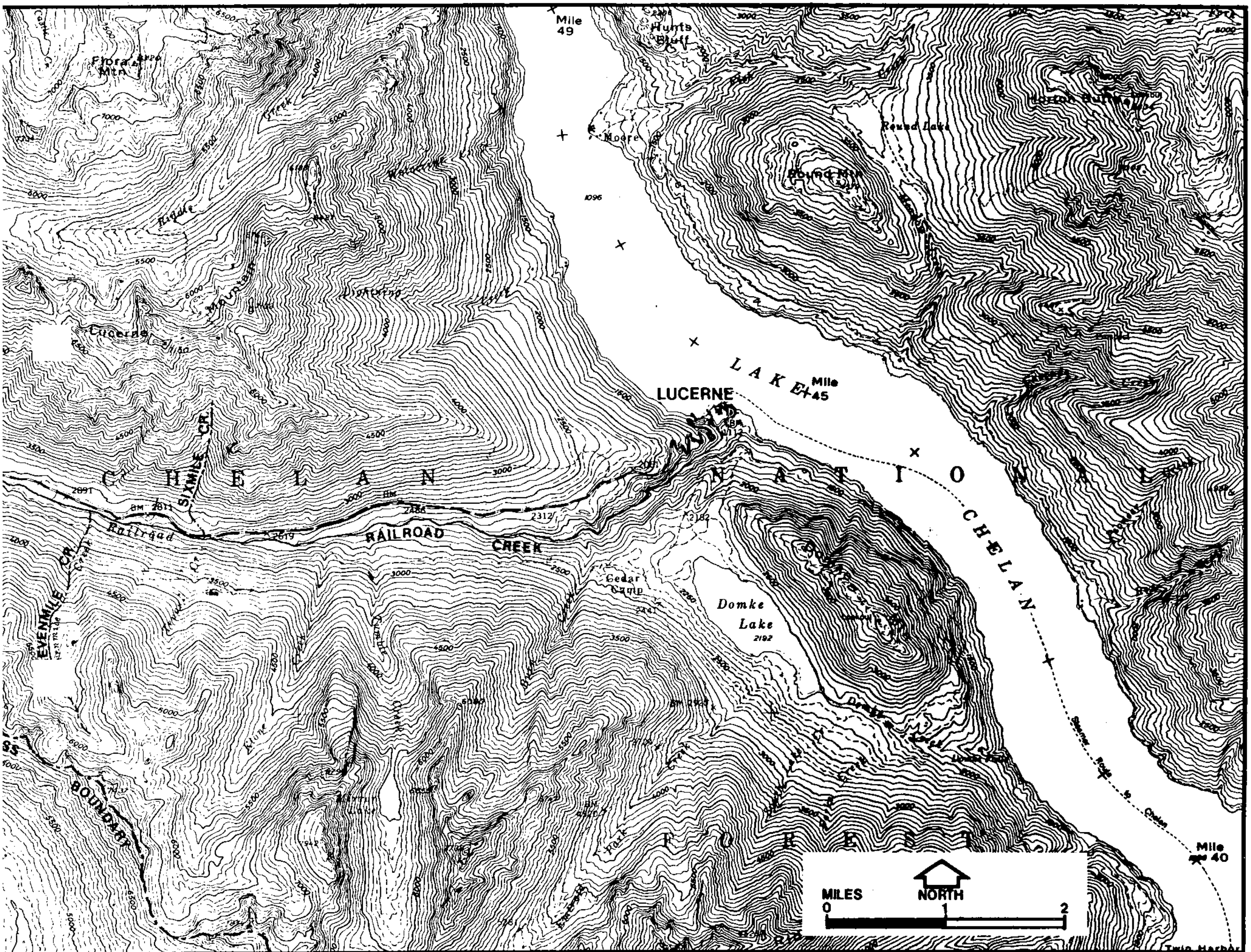
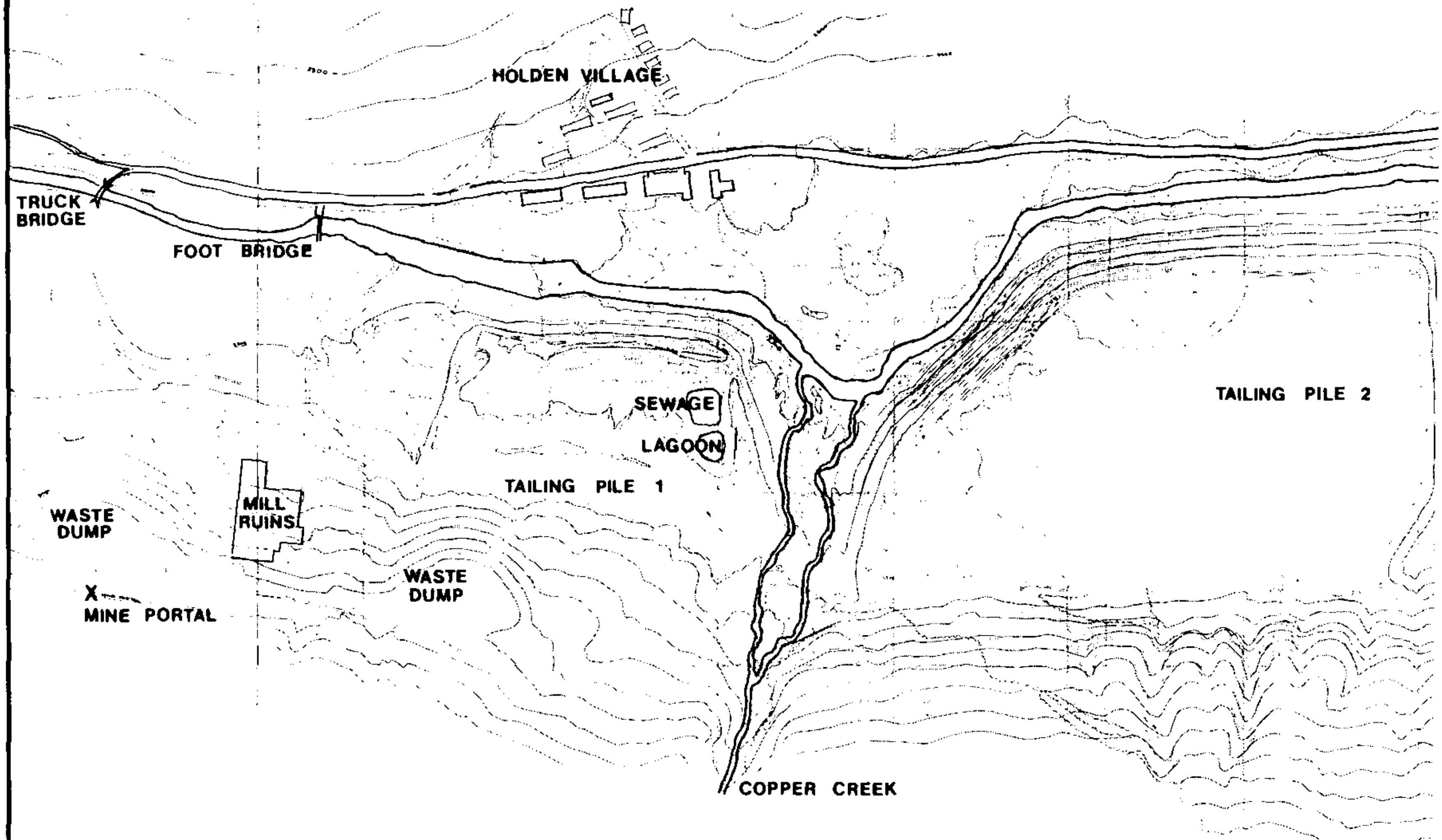
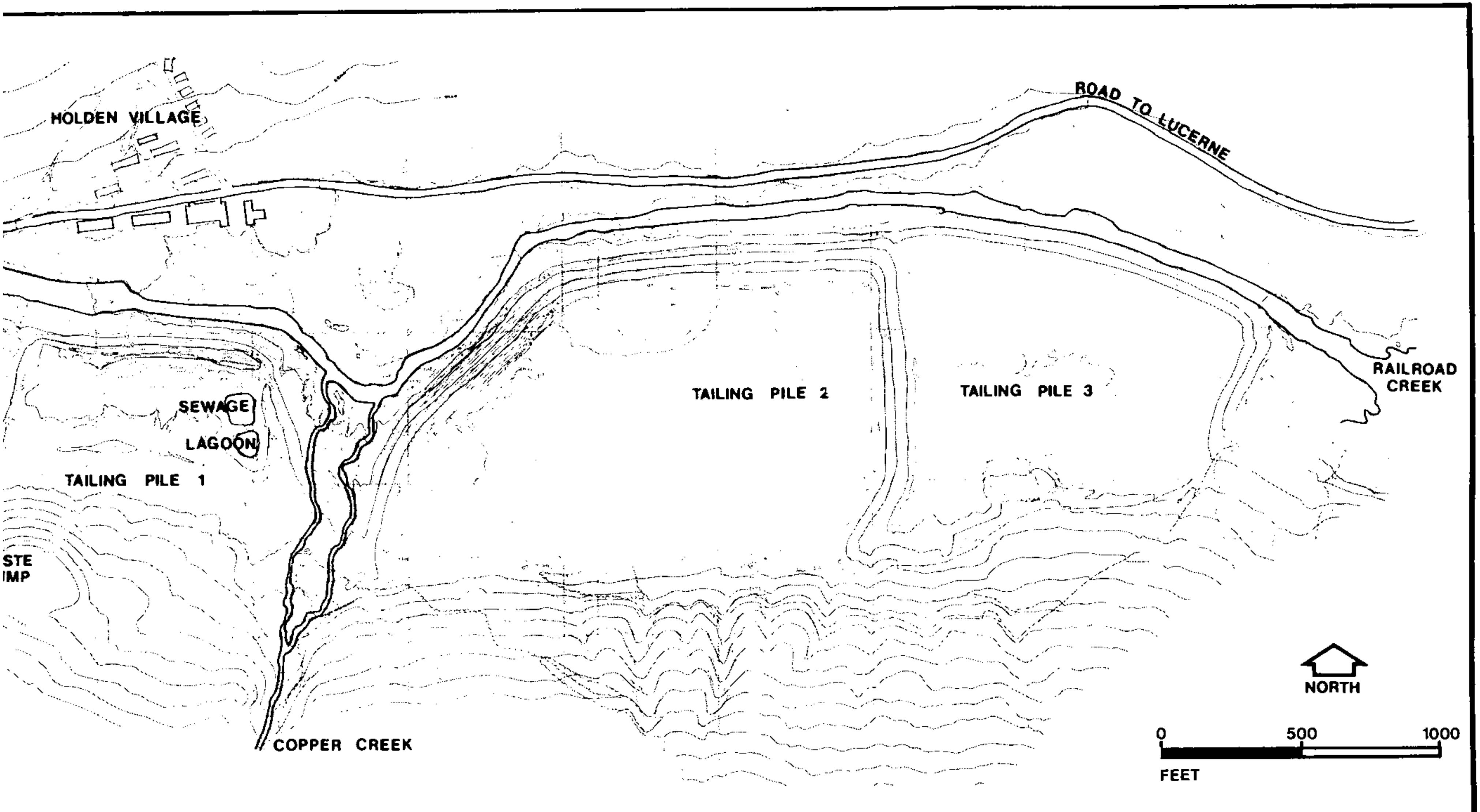
RAILROAD CREEK
Cloudy Pass
Crown Point Falls
Lyman Lake
Railroad Creek
HOLDEN VILLAGE
BM 3209
Campground
Holden Mine
PROJECT AREA
TAILING PILE 3
TAILING PILE 2
TAILING PILE 1
COPPER CREEK
Big Creek
Dumbell Mtn
Copper Peak
Lyman Glacier
Buckskin Mtn
Tinpan Mtn
GLACIER PEAK WILDERNESS
Chiwawa Mtn
Spider Glacier
Mt Fernow
Red Mtn
Seven-fingered Jack
Entiat Meadows
Entiat River
Entiat Glacier
Spider Meadow
SEVENMILE


Mile 49
Hunts Bluff
Flora Mtn
Round Lake
Round Mtn
Moore
Riddle
Mountain
Lightning
Lucerne
LAKE
Mile 45
LUCERNE
SIXMILE CR.
C H E L A N
N A T I O N A L
CHELAN
Railroad
RAILROAD
CREEK
Cedar Camp
Domke Lake
2192
SEVENMILE CR.
BOUNDARY
F O R E S T
MILES
0
1
2
NORTH
Mile 40
Twin Harbor

HOLDEN AREA


HOLDEN VILLAGE
TRUCK BRIDGE
FOOT BRIDGE
SEWAGE
LAGOON
TAILING PILE 2
TAILING PILE 1
WASTE DUMP
MILL RUINS
WASTE DUMP
X
MINE PORTAL
COPPER CREEK



VICINITY MAP

AREA CHARACTERISTICS

Topography: Holden, Washington, at an elevation of 3,209 feet, is situated in Railroad Creek Valley, an east-west valley intersecting the North Cascade Crest. The Valley floor rises from 1,100 feet at Lucerne on Lake Chelan to 9,500 feet at the summit of Bonanza Peak at the northwest end of the valley.

Railroad Creek Valley was carved by glacial action, giving it a long narrow shape with the valley walls flaring up at steep angles. It is approximately 1200 to 1500 feet wide at Holden Village and 16 miles long.

Geology: The Holden Ore Body occurs within a mineralized shear zone in metamorphosed sedimentary rocks. The enclosing rock is a quartz amphibole schist of the Buckskin formation probably of pre-Ordovician age. Mineralization occurred along the shear zone by selective replacement of amphiboles in the host rock and was controlled by structural features. Minerals present in the ore zone include quartz, pyrrhotite, pyrite, chalcopyrite, sphalerite, and gold; the latter three being the important commercial minerals.

A variety of igneous rocks may be observed in the area of the ore body. The mineralizing solutions which account for the ore body probably issued from one or more of the igneous implacements in the general area.

While the absolute geologic age and chronology of the complex central core of the Northern Cascade Mountains is not definitely known, it is reasonable to assume that the host rocks of the Buckskin formation probably are pre-Ordovician and, therefore, roughly 400 to 500 million years old. They were originally deposited as marine sandstone, limestones, and shales. These ancient sediments were deformed into mountainous folds and intruded by granites approximately 150 million years ago. Erosion reduced these ancient mountains to a surface of low relief which gradually sank below sea level and the mountain roots were buried beneath Cretaceous and younger sediments.

In the late Tertiary time (probably Pliocene or Miocene time, less than 15-million years ago) the area was again subjected to mountain building movements. This mountain-building disturbance uplifted the previously folded area and subjected it to a new cycle of erosion exposing the ancient core of the Cascades. During Pliocene and Pleistocene time (perhaps only a million years ago) mountain-building movement concentrated to the west along the present Pacific Coast forming the Coastal Ranges of western Washington and Oregon. The central core of the Cascade Mountains was uplifted and broken by faults. In these areas, crustal adjustment is still taking place as witnessed by the earthquake which disturbed Holden Village in July, 1964.

During the glacial advances of the Pleistocene, ice filled the river valleys and began to flow down the valleys under the force of gravity. Within the last 500,000 years, glaciers formed in the high mountain areas and moved down the valleys three and possibly four times. The intensity of the glacial movement through the canyons of the Northern Cascade Mountains gouged out lakes like Lake Chelan whose fjord-like canyon was deepened to below sea level. Railroad Creek Valley contained a glacier which fed into the ice mass moving through the Lake Chelan trough. This concentrated flow of ice greatly modified the shape of the original stream valleys by sculpturing them into U-shaped canyons with over-steepened walls. Present streams enter along the sides by cascading over the ice-scoured canyon walls.

The last glacier to occupy Railroad Creek Valley probably melted out about 10-thousand years ago. Recessional moraines are irregular deposits of unsorted rock left by the retreating ice mass. One of these crosses Railroad Creek Valley at the position of the Holden town site and was chosen at the building site for the mill and other mine buildings.

Reference: "The Mine, Holden Village", by Rudolph W. Edmund, Augustana College, Rock Island, Illinois, 1967.

Soil Characteristics: Four broad categories of soils occur in the Holden Area, they are: alluvium, colluvium, and glacial till, normally referred to as transported soils, and residuum, a soil formed in place.

Alluvial soils are found in the Railroad Creek Valley bottom. They are composed of stratified gravelly and cobbly loamy sand and sandy loam material. Generally they are more than 10 feet deep and range from excessively welldrained to poorly-drained. They are subject to flooding and stream channel erosion.

The colluvial soils generally occur at the base of snow chutes or below steep exposed rocky areas. Often these soils are underlain by glacial till material. The colluvial soils are characterized by a heterogeneous mixture of angular rock (gravel and cobble size) and soil material. The amount of rock is variable but often is more than 40 percent by volume. These soils are generally 3 to 10 feet deep and are usually well to somewhat poorly drained.

Glacial till soils underlie both the alluvial and colluvial soils and extend well up the valley walls. This material is characterized by being many feet thick (generally more than 10 feet) with a compacted layer 3 to 6 feet below its surface. The upper 3 to 6 feet is reasonably uncompacted. Both the uncompacted and compacted soils have large volumes of rounded and semirounded gravel, cobbles, and stones; the mixture is extremely heterogeneous. The upper uncompacted soils are generally well to excessively well drained sandy loams. This material is considered to be stable; however, lateral water movement does occur between the contact of the two materials, and in some cases, will cause piping if roads are built through this material.

The residual soils are soils formed in place (not transported by ice or water) from bedrock materials. In the Holden area, these soils occur at the higher elevations, above the area affected by glaciation.

Hydrology: Holden, Washington is located in the Railroad Creek Valley Drainage Basin, a geographic area encompassing some 64.8 square miles. Approximately 49 percent of the basin area is in the Glacier Peak Wilderness, although Holden is just outside its eastern boundary.

Railroad Creek, some 18 miles long, is the major stream draining the valley. It flows from Lyman Lake (fed by Lyman Glacier) located 7 miles upstream from Holden. Railroad Creek contributes 12 percent of the annual discharge into Lake Chelan. Lake Chelan is the second deepest lake in the United States, some 1,500 feet deep and 55 miles long.

Climatology: Climatological records were kept at Holden from 1938 to 1957, during operation of the Howe Sound Mining Company, and from 1961 to present by Holden Village Inc.

The climate at Holden, Washington, is directly influenced by its geographic location on the eastern slope of the North Cascades and the prevailing westerly winds. Winters here are moderately cool, with temperatures often staying below freezing for several weeks. Zero and below temperatures are occasionally recorded in January. Coldest temperatures occur when cool air from th Canadian interior spills over the Rocky Mountains into the area.

Precipitation averages 35 inches per year at Holden. Approximately 77 percent of it is in the form of snowfall, generally occurring from early November to mid-March. The first traces of snow normally are recorded in October and occasional snow flurries are recorded as late as May.

Snow depth at Holden generally reaches 1 to 2 feet in November, 2 to 4 feet in December, 3 to 6 feet in January, and 4 to 8 feet plus in February and March. The maximum snow pack recorded was 14 feet-2 inches (170 inches) in early March, 1956. Total snow melt in the Railroad Creek Valley area normally occurs in May, with higher ridges holding snow until early summer. The adjacent mountain peaks remain snowcapped during the entire year. Summer weather is mild with afternoon temperatures ranging in the low and mid 70's. Temperatures in the 80's are frequently recorded in July and August. However, on most summer days, a cool mountain breeze begins blowing down the valley by mid afternoon; by sunset, the breeze generally abates. Accompanying these midafternoon breezes is the frequent formation of cumulus clouds along the crest of the North Cascades, and an occasional thunderstorm.

Average number of clear days per month:

winter	5
spring	10
midsummer	20
early fall	12-15

Visual Characteristics: The area's landscape is a distinctive "Class A" area as classified by the U.S.D.A. Forest Service Visual Management System with a diversity of land forms including sharp exposed ridges, large dominant peaks, outstanding avalanche chutes, talis slopes, and rock outcrops.

The vegetation patterns exhibit a high degree of diversity and scenic value. The area is primarily vegetated with old growth conifers and accented by smaller deciduous trees, shrubs and grasses. Lake Chelan, the longest lake in the State of Washington, is located between vertical rock walls rising many hundreds of feet at the water's edge. Railroad Creek and its tributaries drop rapidly over falls and rapids to Lake Chelan below.

The characteristic landscape in the vicinity of the project is predominantly "natural"; vegetated, scenic, with frequent vistas of lakes and mountain peaks. This area is also one in which the sensitivity level is high; a level 1 as classified by the U.S.D.A. Visual Management System. Certainly the importance of maintaining the characteristic Forest landscape is highly important. Little modification of the characteristic landscape should be tolerated. Railroad Creek has been proposed for classification as a scenic area in the draft environmental statement for the Chelan Use Study on the Wenatchee National Forest.

The Holden mine tailings appear as an obtrusive and foreign element in the characteristic landscape. The form (scale) and color of the tailing piles make them visually dominant when viewed from the Holden Village area, and at best, visually irritating when viewed from upland trails. They are an anachronism in a dominantly distinctive environment. They are a landscape feature; which, because of their location, appearance, and negative characteristics (sources of air and water pollution), are strongly deserving of rehabilitation.

Historic Characteristics: The Railroad Creek drainage was the scene of considerable minerals prospecting around the turn of the century. Holden Mine was the only property developed to an any great extent. The mine has been inventoried as a historic site but has not yet been evaluated for its potential for nomination to the National Register of Historic Places.

Until Holden Mine is evaluated, its potential historic value must be protected. The Historic Preservation Act of 1966 and Executive Order 11593 (1971) direct Federal Agencies to take no action which would destroy or substantially alter a National Register property or a potentially eligible property until the Advisory Council on Historic Preservation has been provided an opportunity to comment on the proposal.

The U.S.F.S. should take immediate action to obtain an opinion from the Advisory Council on Historic Preservation as to the historic value of the Holden Mine and/or the tailing piles. Construction effort on the piles cannot be initiated until this decision is made.

Conceptual Design Analysis: During the preparation of this conceptual design, the ORB team has accomplished their work in six separate steps:

- Step 1 - June 9 through July 16
  Project Familiarization
  Literature Search
  Field Investigation
  Data Analysis

- Step 2 - July 17 and 18
  Holden Brainstorming Session

- Step 3 - July 19 through August 12
  Determine four design alternatives and prepare presentation to U.S.F.S.

- Step 4 - August 12
  Present alternative plans to U.S.F.S.

- Step 5 - August 18 through September 5
  Preparation of preliminary conceptual plan

- Step 6 - September 25 through October 3
  Preparation of final conceptual plan

In order that the U.S.F.S. may gain an insight into the ORB design analysis, we have outlined below the significant events and findings of our investigation which has lead us to the development of the Network of Alternatives Design Solutions and our specific Concept Design recommendations.

Step 1:

Project Familiarization
Literature Review
Field Investigation
Data Analysis

Geotechnical Investigation

Purpose

1. Determine erosivity characteristics of tailings
2. Determine tailing pile dam and slope stability with recommendations concerning grading of piles
3. Determine tailing pile permeability

Field Exploration

12 hollow-stem auger boring were drilled at locations shown on Resource Inventory Map, Page 2-5. Borings ranged in depth from 36 feet to 100 feet. (840 L.F. Total)

Disturbed samples were taken at various intervals using split-spoon sampler.

Undisturbed samples were taking using shelby tube method.

Field classifications determined consistency of fine grained material and relative density of coarse grained material. Water content was estimated and color noted.

Permeability tests were performed near the surface of tailing piles at five (5) of the boring locations.

Four backhoe test pits were excavated between Railroad Creek and the Holden-Lucerne road.

Surface samples of both the wind blown fines and the cemented tailing surface material were taken at 400 foot intervals around the perimeter of the piles.

Logs of the exploratory borings have been prepared and are presented in appendix.

Laboratory Tests Performed

1. Disturbed split spoon samples. Laboratory classification
   191 samples

2. Undisturbed tube samples. Laboratory classification
   14 samples

3. Mechanical analysis minus 5/8" washed samples
   10 tests

4. Hydrometer analysis
   17 tests

5. Consolidation test
   2 tests

6. Direct shear (3 points)
   7 tests

7. Atterberg limits
   10 sample tests

8. Moisture density relationship
   1 test

Conclusions

Grain Size - Stratigraphy of piles reflects layering of coarser grain silty fine sand (approximately 40 percent finer than the No. 200 mesh sieve (0.075 MM) with finer grain sandy silt or silt (approximately 90 percent passing the No. 200 sieve). Borings noted an increased incidence of interlayed silt sized tailing, near center of piles.

Plasticity - Tailing materials are nonplastic.

Density - Average in-situ wet and dry density - 116 pcf and 92 pcf respectively. The determined maximum dry density is 112 pcf at an optimum moisture content of 13 percent (modified proctor procedure ASTM D-1557-70).

Relative density by Standard Penetration Test numbers (N) 0.4 to 0.5 (medium dense material).

Moisture Content - General water content is 15 to 30 percent with a mean value of 25 percent.

Saturated moisture control at maximum dry density is 20 percent assuming a specific gravity of 2.8 (modified proctor - ASTM D-1557-70). Finer grained silt material has an average moisture content 10 percent above coarser silty fine sand.

Shear Strength -

Effective cohesion characteristic tailing material	0.0 to 75 psf
Oxidized layer at surface of pile	240 psf

Angle of internal friction -

coarser material - 34°

finer material - 38°

Consolidation - Average coefficient of consolidation is 2.4 square feet per day. Density of tailings does not significantly increase with depth or time.

Permeability - 1.63 to 4.40×10^{-3} cm/sec. (medium to low permeability.) Finer silt material would restrict downward movement of water but ponded water would infiltrate into tailing materials.

Ponded water on piles is caused by settlement of silt and clay sized particles to the bottom of ponds. Clogging intergranular voids of the tailings. The resulting reduction in permeability causes ponding on surface of piles.

Erosional Characteristics - Tailing material is highly susceptible to erosion by wind and water.

Wind blown material has been measured 500 feet downstream of piles in amounts of over 3,000 pounds per acre. See Page 2-19.

Tailing material moved by saltation on the down valley side of tailing piles has increased considerably during the period from 1963 to 1975.

While the tailing material is highly susceptible to erosion by water, the top oxidized crust prevents rain and snowmelt from eroding and deep cutting the tailings.

Major concern is to eliminate the possibility of drainages forming which would cut the outside slopes of the piles. Any break in pile surface would cause rapid down-cutting of the piles. Tailing ponds are presently drained by decant towers and internal drainage system. A blockage or failure of this system could result in heavy erosion of the piles similar to the 1946 washout of pile No. 3.

Greatest concern for erosion of the tailing piles is from undercutting of the toe of piles by stream action. A velocity of only 30 cm/sec. is needed to start eroding the tailing material.

Stability of Tailing Piles

The phreatic surface (water level) is consistently about two feet above the interface of the tailing with the original ground surface indicating nominal seepage pressure within the piles.

Susceptability of the tailing piles to liquefaction is low.

The tailing piles are relatively stable in their present condition. Flattening of slopes of tailing piles would improve the long term stability of the piles.

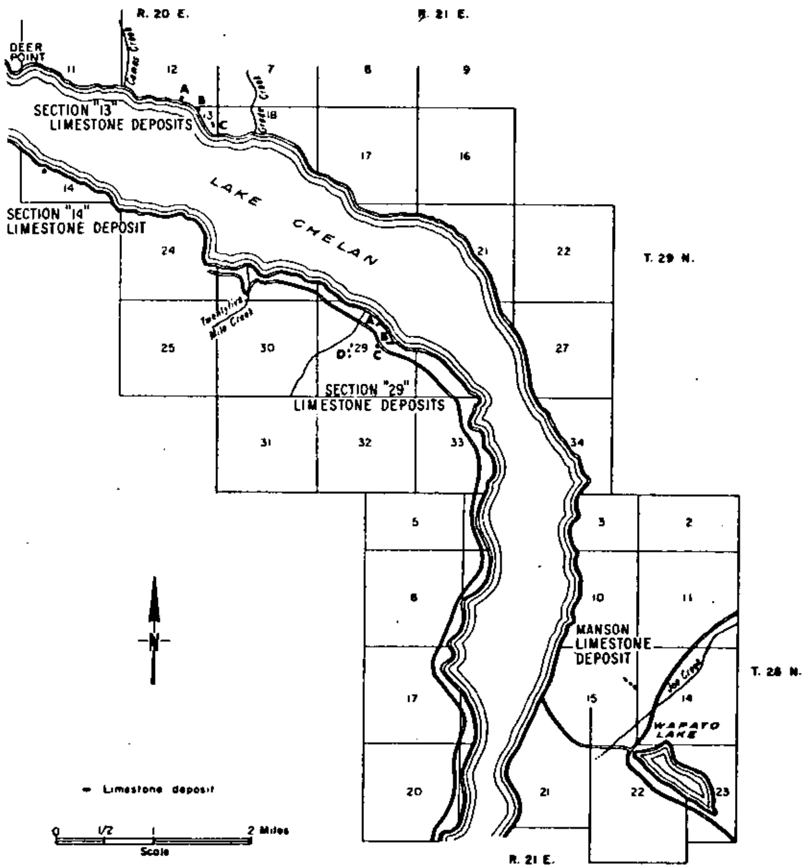
Limestone Deposits

Purpose:

Determine if a source of limestone exists near the Holden area.

Literature Search

Limestone Deposits - A literature search revealed a "Division of Mines and Geology" publication bulletin No. 52, limestone resources of western Washington. This publication identified four (4) limestone deposits in the vicinity of the Holden mine tailings.



Limestone deposits in the Lake Chelan Area.

Holden Area

Limestone has also been reported to occur on the south slopes of Martin Peak two miles northwest of Holden. A similar deposit is reported on north and east slopes of Buckskin Mountain south of Holden. Both areas are within the existing Wilderness.

No field investigation of these limestone sources were made as a part of this study.

ANALYSIS

Soil Chemistry

Purpose:

- Evaluate USBM planting plots
- Evaluate planting media in tailing piles
- Evaluate mine waste piles and slide talus slope for possible borrows area for obtaining uncontaminated soil material.

Field Exploration

On June 7, 1975 through June 9, 1975, Surface Samples ranging in depth from 10 inches to 4 feet were taken at various locations on the tailing piles, the mine waste piles, and the surrounding area. See location map Page 2-5

During the geotechnical subsurface investigations, samples were taken at 2.5 foot intervals for the first 10 feet with additional samples taken at 5-foot intervals to bottoms of holes for later chemical analysis.

During the Step 2, July 17 meeting at Holden, additional samples were taken for analysis.

Laboratory Tests Performed

Laboratory tests were performed by the Washington State University Department of Agronomy and Soils laboratories on the following samples:

Surface Samples taken
June 7 through June 9, 1975

28 Standard Soil Tests
28 Salinity Tests

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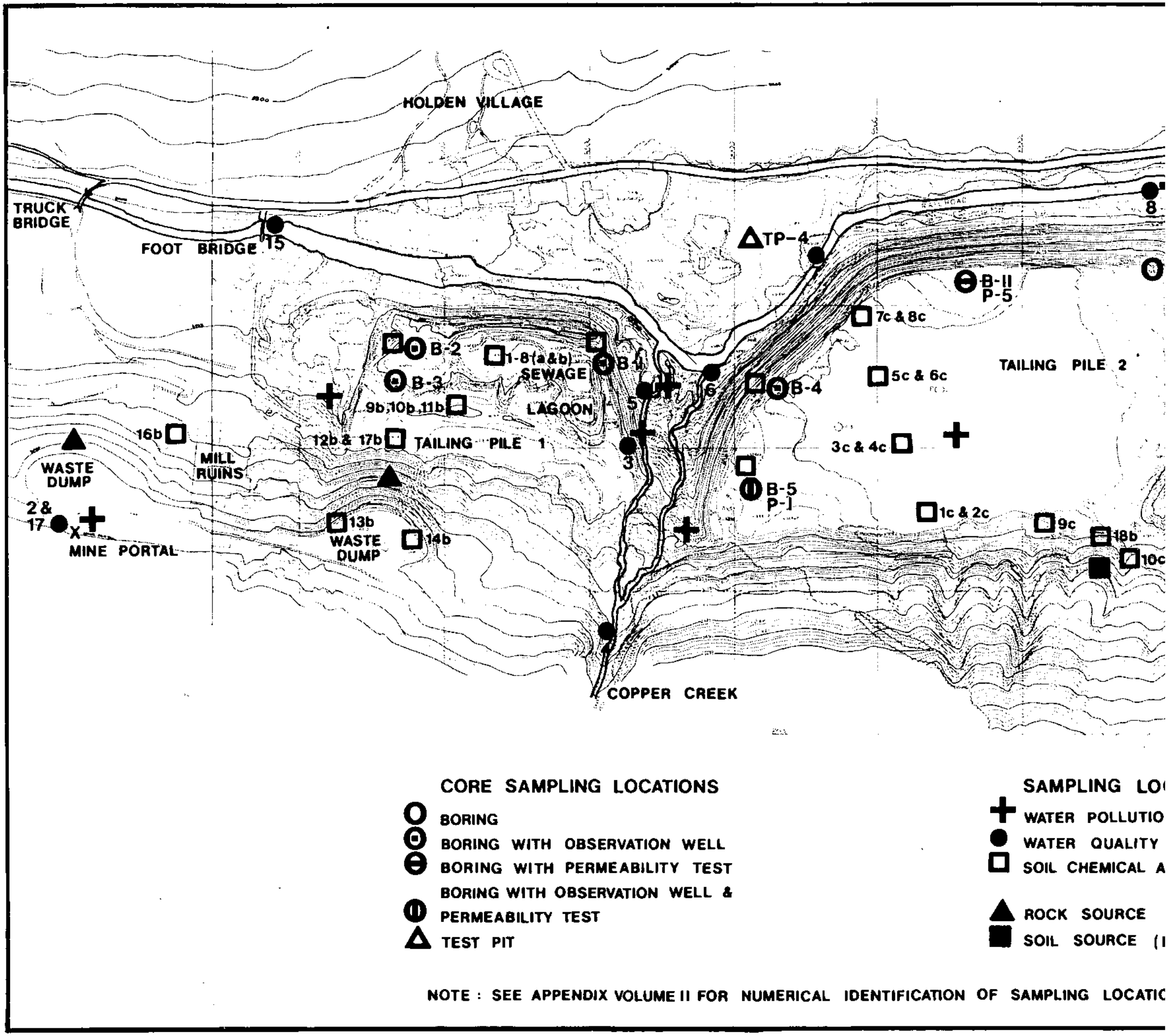

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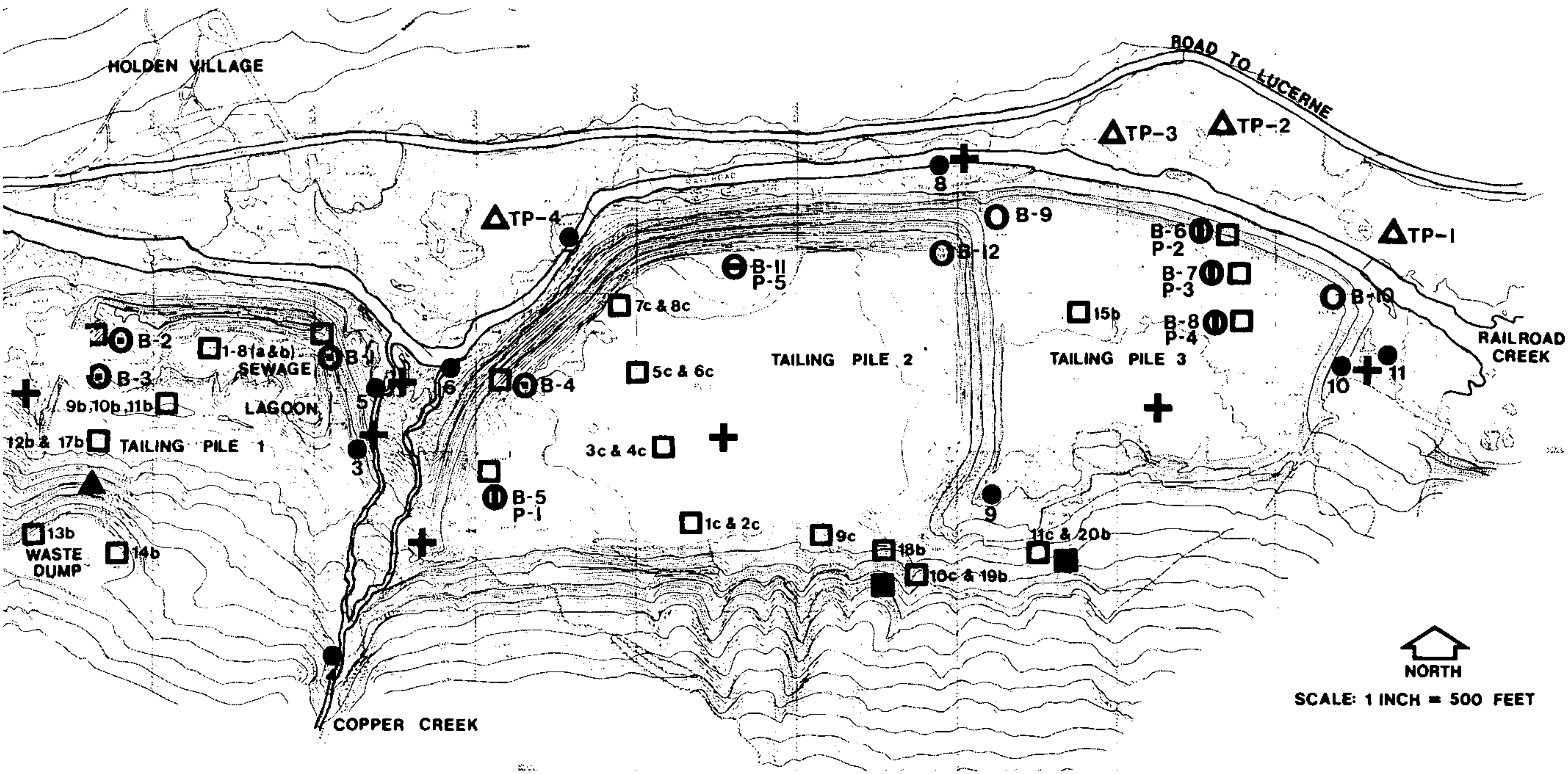


CORE SAMPLING LOCATIONS

- BORING
- BORING WITH OBSERVATION WELL
- BORING WITH PERMEABILITY TEST
- BORING WITH OBSERVATION WELL & PERMEABILITY TEST
- TEST PIT

SAMPLING LOCATIONS

- WATER POLLUTION SOURCES
- WATER QUALITY ANALYSIS
- SOIL CHEMICAL ANALYSIS
- ROCK SOURCE
- SOIL SOURCE (NON CONTAMINATED)

NOTE : SEE APPENDIX VOLUME II FOR NUMERICAL IDENTIFICATION OF SAMPLING LOCATIONS

5 Zinc Tests
5 Copper Tests
5 Manganese Tests
5 Iron Tests

Surface samples taken during
<u>geotechnical subsurface investigations</u>

47 Standard Soil Tests
47 Salinity Tests

Surface samples taken
<u>during July 17th Holden Meeting</u>

11 Standard Soil Tests
11 Salinity Tests
2 Base Saturation Tests

Laboratory tests were also made at the USBM Utah office for total sulfur and sulfate.

11 Sulfur and Sulfate tests

Conclusions

Soil chemistry analysis of USBM test plots using 1974 test data (one year after plant establishment) show the following:

The soil pH of the tailings material is 2.9 to 3.5 indicating a highly acidic condition. Plant materials are unable to sustain growth in this soil.

Highest pH readings were found where 15 Ton/Acre lime was added, all test plots were similar as relates to organic material, P and K. Larger amounts of calcium and salts were found in those plots in which lime was added. The presence of salts indicate that rapid weathering and neutralization of lime had occurred. Soil pH has dropped since 1973.

Soil chemical analysis of USBM test plots were also made from 1975 test samples. These test data indicate that:

Rapid neutralization of lime is occurring. For example, test plot No. 2 treated with 5 tons of lime per acre decreased in pH from 4.4 (1974) to 3.4 (1975); just slightly above original tailing pH.

Test plots where milorganite had been added maintained higher levels of phosphorous and organic material buffered the pH changes from 1974 to 1975. For example, test plot No. 5 showed a slight decrease in pH from 4.8 (1974) to 4.7 and test plot No. 6 showed a slight decrease in pH from 3.9 (1974) to 3.7 (1975). These results show the need for organic matter in the growing media.

The reduction of salts between 1973 and 1975 suggests that there has been leachate action down through the piles.

High extractable copper and Zn may be toxic to plant material if pH is allowed to drop too low. No such problem is anticipated for Mn and Fe.

Samples 1b through 8b were taken at 10 to 20 inches below the surface. These tests show that in areas below 10 inches, the pH of tailings has not raised above the original 2.9 - 3.5 range. Limited root growth below 8 inch depth confirms the low pH. This area is relatively high in salts, and suggests that water action has moved salts downward out of root zone. Samples 9 and 10 taken at 3 feet and 4 feet below the surface respectively, show that calcium and salts are moving down.

In 1974, the U.S.B.M. applied 22 tons/acre of coarse limestone on plots along the road going through tailing pile No. 1. Sample 11 (1975, pH 4.1) was taken in an area of grass growth, whereas sample 12 was bare. It appeared that some benefit was obtained from the coarse material. However, fine material must be added to insure a more rapid increase in pH.

Evaluation of Rock Piles

Samples 13 and 14 were taken from the top of the east mine waste rock pile. These results show that the material is sufficiently high in pH, K, and Ca to consider as planting media on the tailings. The absence of growth on these piles is probably due to the adverse moisture conditions.

Slide Areas

Sample 16 was taken from an alder-growing area below the old mill. (This was not a slide area). Analysis show good pH and organic material. This area would not likely provide any quantity of top soil. Sample 17 is a small slide area on tailings pile No. 1. pH and organic material are adequate. The majority of slide area material above pile No. 2 is represented by Sample 19. Soil pH and uncontaminated soil material are very suitable and would provide a good environment for revegetation is placed at the tailing surface.

Evaluation of Grading Operations

Soil samples from tailing pile Nos. 1, 2 and 3 were taken by Hart Crowser Associates, Inc. between 6-12-75 and 6-17-75. Surface pH of B-1 appears to be unaffected by depth whereas salts increase with depth. Sample B-3 shows a pH increase with depth which is probably due to the decreased rate of weathering at the lower depths. These data suggest no serious salt deposition with depth that could present problems when this area is leveled. However, salts at lower depths (B-1, 22.5 to 24') could present problems if this material were allowed to be deposited at the surface.

High salt values throughout tailing pile No. 2 (B-4 and B-5) raise serious questions as to the suitability of this material for revegetation. It would appear that salt seepage must be coming from other areas on the pile. Boring B-5 has higher pH's at the lower depths with a high salt value at 10 - 11.5 feet.

Leveling of pile No. 2 in the spring would further antagonize the salt problem since salts would move upward during the summer. Fall leveling would be preferred.

In pile No. 3, high salt values at 5 - 12 feet(B-6) suggest a seep area from the pile. Borings B-7 and B-8 have lower values. Salt values in B-7 and B-8 are tolerable for plant growth providing that a minimum of upward movement occurs during the summer. Irrigation would minimize this.

High salt concentrations appear to correspond with fine textured tailings which causes a perched water table preventing salts from draining through piles.

Borings 1-c through 8-c taken July 17, 1975 at a depth of 5 feet show a consistant increase in pH, K and salts with depth. While the deeper material is a more favorable pH for revegetation, total sulphur analysis at this depth is generally higher requiring additional liming material for neutralization. For this reason, the oxidized top surface is a more desirable tailing material for vegetation-planting media as it represents a lower potential for acid production. Total sulfur (S) and Sulfate (SO_4)

indicates that considerable oxidation of sulphur has occurred on the surface of the tailings (see U.S.B.M. test results - Appendix)

The total sulphur from tailing pile No. 2 sample taken from Boring B-3 is higher than samples from piles No. 1 or No. 3. It is not known if this represents a real difference in total sulphur since the pile No. 2 analyses were based on a single sample.

Evaluation of Ponding

Ponding over the years may be causing salt seeps (leachate) out of the tailing piles. This would be reduced by grading and drainage. Holding ponds on the piles for water storage may accumulate undesirable salt. It would be desirable to prevent water flow to the piles from the hillside above pile Nos. 2 & 3. Diverting this local runoff water would reduce the contamination from the tailings and would reduce leachate.

A sedimentation basin below tailing pile No. 3 should be considered for the surface water runoff if chemical stabilization is not used in conjunction with vegetative treatment.

Irrigation

If vegetative cover is selected, irrigation for the first several growing seasons should be considered. Irrigating at slightly less than evaporation transpiration rate will allow for good plant growth without the leaching of salts during the summer. If excessive salts are present at the surface (possibly from lower deposits after leveling), irrigation at a rate greater than evaporation transpiration rate may be necessary.

Hydraulic Studies

Purpose

- Determine water volumes on top of piles, moving on to pile from local drainage above pile and Railroad Creek.
- Determine channel velocities.
- Determine water depths during 50-year flood.
- Determine best method of bank protection.

Basic Data

Precipitation at Holden

Rainfall	5.5 inches
Snowfall	29.9 inches (equiv.)
Snowmelt	27.0 inches on piles
Snowmelt	24.0 inches local drainage above piles

Temperature (mean)

High	62° F July
Low	21° F January
Average	42° F Annual

Discharge Railroad Creek - May 28, 1948

3900 cfs - 50-year flood
3000 cfs estimated 50-year flood for Holden
Main truck bridge across Railroad Creek - 1948 flood - water reached bottom of stringers

Stream slope at Holden - S = 0.02

Area of tailing piles

	Area on top of piles	Area on steep slopes (all sides)	Area at toe between slope and creeks
Tailing Pile #1	15.3 Acres	9.3 Acres	This area included in the first two categories.
Tailing Pile #2	31.1 Acres	11.3 Acres	1.8 Acres
Tailing Pile #3	17.4 Acres	2.9 Acres	.9 Acres
Sub-Totals	63.8 Acres	23.5 Acres	2.7 Acres
	TOTAL AREA	90.0 Acres	

Local drainage onto piles from area above piles 180 acres.

Railroad Creek

(a) Basin Size at Holden - 29 square miles.

(b) Basin Size at Lucerne - 64.8 square miles.

Background

Surface Water to Tailing Piles: The tailing piles receive surface water from two sources:

1. Precipitation (rain and snow) falling directly on the piles

2. Rain and snowmelt draining onto the piles from the hillside area above the tailing piles.

The major portion of this snowmelt occurs in April and May of each year.

Much of this water ponds on the tailing pile surfaces and either evaporates into the atmosphere or percolates down into the pile substrate. A small percentage of this downward moving water flows into Railroad Creek in the form of leachate. Additional water leaves the tailing piles in the form of runoff, causing erosion to pile surfaces and slopes, and introducing tailings material into Copper and Railroad Creeks.

While precise information is not available to determine the exact volume of water reaching the tailing pile surfaces, a good estimate of the volume is:

Surface water from area above the tailings to the tailings piles

15,900,000 cu. ft.

Surface water from area on top of tailing piles

6,253,000 cu. ft.

Surface water from slope areas of tailing piles

2,600,000 cu. ft.

Railroad and Copper Creeks: Railroad Creek is the major stream draining the Railroad Creek Valley basin. It is approximately 18 miles long and has an average gradient of approximately 5 percent (a fall of 250 feet per mile). This gradient is only 2 percent at Holden. The source of Railroad Creek is Lyman Lake (a glacier fed lake) at an elevation of 5,600 feet. The stream flows in an easterly direction and enters Lake Chelan at Lucerne, Washington, elevation 1,100 feet.

The Railroad Creek drainage basin, at Holden, comprises some 29 square miles of surface area. Its basin size at Lucerne, 12 miles downstream from Holden, is 64.8 square miles. Railroad Creek supplies 12 percent of the annual water discharge into Lake Chelan. The United States Geological Survey maintained a water-stage recorder on Railroad Creek approximately one-half mile upstream from Lucerne, from 1911 - 1957. The yearly average stream discharge for that time span was 147,500 acre feet.

The largest monthly runoff for Railroad Creek occurs in June, and the April through July runoff accounts for 12 percent of the total yearly discharge from the drainage basin. The North slopes of tailing piles 1, 2, and 3 abut Railroad Creek. During periods of high creek runoff, undercutting occurs at the bases of these slopes, eroding tailings material directly into the stream course.

Copper Creek, a small stream, flows north (off the south wall of Railroad Creek Valley) and runs between tailing piles 1 and 2, where it joins Railroad Creek. Holden Village obtains its domestic water supply and hydroelectric power from this creek.

Copper Creek divides into two channels just above the tailing piles, the easterly one carrying 75 percent of the stream runoff. The westerly channel flows along the base of tailing pile No. 1 and during high creek flow, undercuts the toe of this pile, washing tailing material into the creek.

Conclusions

Channel Hydraulics

Railroad Creek channel velocities during flows of about 3000 cfs (the estimated 50-year event) are 9 to 14 feet per second depending on the location along Railroad Creek.

Water depths for the 50-year flood would vary from 5 to 7 feet. Using a 3-foot freeboard, the required height of bank protection is 10 feet.

Bank Protection

Riprap

The following riprap bank protection is recommended: Straight alinement 36 inches thick layer with weighted toe Gradation

Maximum	1500 lbs.
75 percent	250 lbs.
30 percent	500 lbs.
10 percent	20 lbs.

Flow along curve and directed toward tailing pile no. 2 48-inch thick layer and weighted toe Gradation

Maximum	1500 lbs.
75 percent	400 lbs.
30 percent	800 lbs.
10 percent	20 lbs.

These riprap layers would be underlayed with either a cloth filter or 12-inch thick gravel filter. In areas immediately adjacent to the tailing pile, the cloth filter would be required. The riprap revetment will be keyed into river bottom and the riprap surface will be tamped with a heavy steel plate to key in the riprap and provide a smooth face to stream flow.

Gabions

Polychloride coated gabion baskets would be ...itable for use for bank protection. These ...bions are acid resistant and would hold up in the water conditions at Railroad Creek. These baskets would use small stone for filler and require about half as much stone as riprap structure.

Vertical Wall Structures or Cribbing

These structures could be constructed of concrete, steel, treated timber, or untreated cedar logs. However, steel will not withstand the chemical action of the tailing piles and a treated timber or log revetment is not as natural appearing as a rock revetment. In addition, the availability of cedar logs in the quantity required would present a logistics problem. ...e life expectancy of untreated or cedar logs ...ld be less and their construction and maintenance cost more than the planned rock revetment.

Interceptor and Drainage Swale

The drainage swale should have a 1 percent grade and 4 to 1 side slopes or flatter. Maximum flows in the ditches are estimated to be 15 cfs.

Ecological Investigation

Purpose

- To identify types and sources of pollution for alleged depletion of fish and other aquatic life in Railroad Creek.
- To study effects of tailings pollutants on aquatic stream life.
- To recommend a means of preventing or at least significantly reducing the introduction of pollutants into Railroad Creek.
- Recommend means of improving fisheries habitat in Railroad Creek after pollution problem is under control.

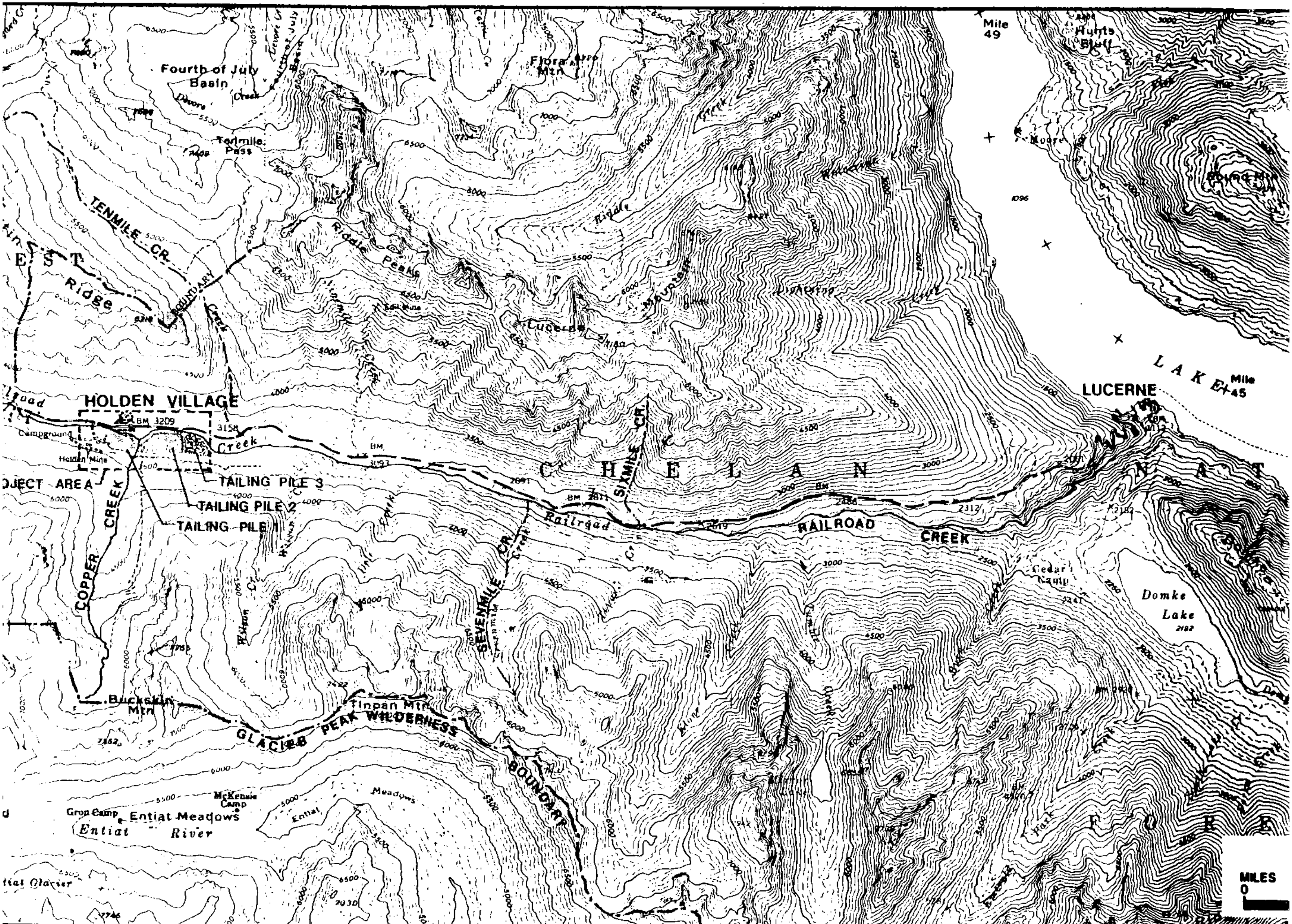
Field Investigation

Samples of aquatic insects found were obtained from five (5) stations in Railroad Creek from River mile 10.2 (upstream tailings) to 0.0 at Lucerne. Sampling methods were the same as used by Pine (1967) so that direct comparisons could be made.

Water samples were collected at various locations on Railroad Creek on three separate occasions.

Sources of Railroad Creek water pollutions that were identified during field investigations are listed under Water Pollution Sources.

See Resource Inventory One, Page 2-5, and Resource Inventory Two, Page 2-17, for sample locations.



Fourth of July Basin
Flora Mtn
Tenmile Pass
TENMILE CR.
BOUNDARY
Ridge
Riddle Peaks
Lucerne
Mile 49
Hunts Bluff
Moore
Round Mtn
LAKE
Mile 45
LUCERNE
HOLDEN VILLAGE
BM 3209
3158
Campground
Holden Mine
Creek
PROJECT AREA
TAILING PILE 3
TAILING PILE 2
TAILING PILE 1
COPPER CREEK
C H E L A N
SIXMILE CR.
Railroad
RAILROAD CREEK
SEVENMILE CR.
Cedar Camp
Domke Lake
Buckskin Mtn
Tinpan Mtn
GLACIER PEAK WILDERNESS
BOUNDARY
McKenzie Camp
Entiat Meadows
Entiat River
Meadows
F O R E
MILES
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S.O. 2510 File

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

State of Washington
Department of Natural Resources
Division of Mines and Geology

HOLDEN TAILINGS

by

Gerald W. Thorsen

March 3, 1970

U.S. GOVERNMENT PRINTING OFFICE : 1973 O—522-184

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STATE OF WASHINGTON

Department of Natural Resources

COMMISSIONER
BERT COLE

DON LEE FRASER
SUPERVISOR

BOX 168
OLYMPIA, WASHINGTON
98501

November 10, 1970

WENATCHEE N. F. REC'D
NOV 12 1970
COPIES

Feigal

Mr. Andrew C. Wright
U. S. Forest Service
3 South Wenatchee Avenue
Wenatchee, Washington 98801

Dear Mr. Wright:

Recently you received from our office a copy of a brief report entitled, "Holden Tailings," by Gerald W. Thorsen. The 53-acre figure given in this report was based on the most recent published information. Later, unpublished information showed the tailings piles had been expanded to cover 80 acres.

Please insert the enclosed corrected pages (2 and 17) into your copy of the report and discard the ones containing the outdated acreage figures.

Very truly yours,

BERT L. COLE
Commissioner of Public Lands

Gerald W. Thorsen

BY Gerald W. Thorsen
Environmental Geologist
Division of Mines and Geology

GWT:oo
(2) Enclosures

STATE OF WASHINGTON

Department of

Natural Resources

COMMISSIONER
BERT COLE

DON LEE FRASE
SUPERVISOR

BOX 168
OLYMPIA, WASHINGTON
98501

March 4, 1970

Mr. E. W. Gano
U. S. Forest Service
Wenatchee National Forest
P. O. Box 811
Wenatchee, Washington 98801

Dear Mr. Gano:

Enclosed is a copy of the report resulting from my 1967 visit to Holden. As it was out of the normal time of my job, it has obviously suffered long periods of neglect during its stages of completion. Hopefully, it is not too late to be of some value to those directly responsible for dealing with this problem. If there is anything we, as "outsiders" can do (officially, or unofficially) to assist in your stream erosion control efforts, please let us know. In the meantime, we would appreciate being kept posted of developments regarding Holden.

Very truly yours,

BERT L. COLE
Commissioner of Public Lands

BY Gerald W. Thorsen
Environmental Geologist
Division of Mines and Geology

GWT:oo
Enclosure

STATE OF WASHINGTON
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES AND GEOLOGY

HOLDEN TAILINGS

By

GERALD W. THORSEN

March 3, 1970

CONTENTS

HOLDEN TAILINGS

By Gerald W. Thorsen

INTRODUCTION

Purpose and Scope

The Division of Mines and Geology of the Department of Natural Resources has long supported the concept of "multiple use." Basic to this concept is the need to minimize the long-term detrimental effects of mining so as to not unnecessarily hinder subsequent uses of the land. The purpose of this study was to investigate the basis for public concern regarding the mill tailings piles left at Holden, Washington after the closing of the copper mine there. This concern has ranged from casual comments by hikers about the appearance of the tailings to published statements such as:

> ".... at the Holden mine where the tailings dump has killed the surrounding vegetation and all the fish in the creek and is now starting to pollute Lake Chelan." (THE MOUNTAINEER, April 1967, p. 12).

> "Hopefully, toxic chemicals will be slowly leached out and the piles of loose debris overgrown before floods send masses of orange mud down to Lake Chelan." (Routes and Rocks, Crowder, D. F. and Tabor, R. W., 1965, p. 188).

I spent two days in June 1967 examining the tailings area. This examination consisted of inspection by walking around and across the piles, taking photographs of various locations of interest, digging shallow exploratory holes with a shovel, and taking samples for further study. A limited amount of soil testing was done on these samples by the Washington State Department of Highways.

A brief summary of the milling process as well as a description of the waste tailings themselves and their method of disposal are included in this report with the hope that these details may help the engineer, forester, or biologist not familiar with ore milling to deal with his particular aspect of the problem.

History of Holden

In 1887 the Great Northern Railway was exploring possible routes across the Cascade Mountains. A route location engineer, Major A. B. Rogers, noticed abundant iron staining on the rocks about 14 miles up a stream, now known as Railroad Creek. On his return to Seattle, he mentioned this to the Denny family, who grubstaked a prospector to examine the area. The prospector, J. H. Holden, staked the first group of claims in 1892.

Numerous unsuccessful attempts to develop a producing mine were made over a period of many years, both by stock groups and major mining companies. In 1938, the Chelan Division of the Howe Sound Company began production from the property. From that time until the closing of the mine in 1957, a total of $66.5 million worth of copper, gold, zinc, and silver was produced from approximately 10.6 million tons of ore. At times, close to 500 employees worked to produce and concentrate as much as 2,000 tons of ore a day.

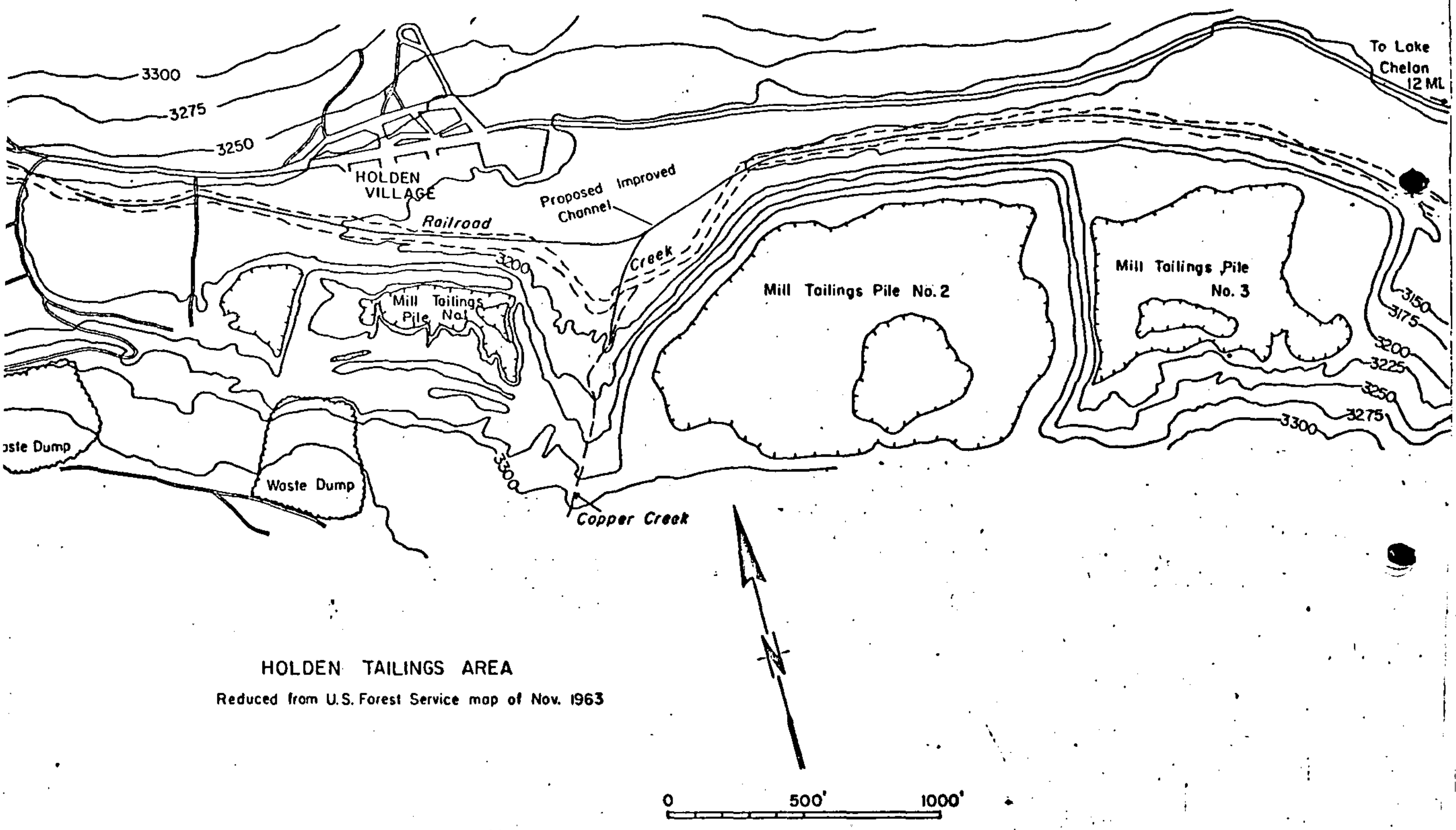
In April 1961 the 15 patented claims were given to the Lutheran Bible Institute of Seattle and were later transferred to Holden Village Incorporated. The latter organization maintains the Holden townsite and runs it as a camp for religious groups of all denominations. The area used for tailings disposal, under "special use permit," reverted back to the U.S. Forest Service after abandonment of the operation.

Setting

The mine, tailings, and townsite of Holden lie about seven miles east of the Cascade Crest on the floor of the steep-sided valley of Railroad Creek. The elevation is 3,200 feet, with peaks of more than 8,000 feet common within a 5-mile radius. Precipitation at Holden ranges from 19 to 45 inches, with a mean of 35 inches, and includes a mean snowfall of approximately 25 feet.

The area is reached by boat from Chelan, to the settlement of Lucerne, a distance of about 40 miles. It is another 11 miles by narrow gravel road from Lucerne to Holden.

The tailings disposal site is located on Federal land, along the south bank of Railroad Creek downstream from the mine area (see map, Fig. 1, and photo No. 1). Over an area of 80 acres, approximately 8 million tons of mill tailings are spread to a maximum depth of about 130 feet.



HOLDEN TAILINGS AREA

Reduced from U.S. Forest Service map of Nov. 1963

FIGURE 1

Photo No. 1.—Mill tailings pile number 1 with mine dumps in background, looking west, up valley of Railroad Creek. This pile was partially hydrauliced (1947), remilled, and pumped underground as sand fill. This operation was apparently responsible for presence of tailings in the creek bank as no such condition exists along the other tailings piles.

Oxidation of iron sulfide minerals has cemented the particles at the surface of the tailings piles to a depth of at least 10 inches and stained them an orangish-brown color (see photo No. 1). While this cemented material is quite erosion resistant, accumulation of windblown material has built up over the years on the lee sides of the piles (see photos 1, 2, and 4).

A small pond is present on tailings area 2 and more than one-fourth the surface of area 3 is covered by a pond. These ponds, accumulating on the gently dished surfaces of the tailings, occupy sites similar to the original settling ponds. They appear to be fed largely by small streams from the hillsides above and drain through the central drainage system around which the tailings were built (see "Construction of tailings").

Photo No. 2.—East face of tailings pile number 2 viewed from surface of pile number 3. Bank is about 75 feet high. Note wind deposited material at angle of repose on this lee slope. Note also the willows and unidentified brush rooted in talus material used as diking near upper level of the dike. Thimble berry and a few conifers are present at this same level on the other side of the pile.

Froth Flotation Milling Process

The following description of the froth flotation treatment of ores to produce concentrates for shipment to a smelter briefly outlines the procedure used at Holden.

To free the metallic sulfide minerals from the enclosing silicate mineral wall rocks, the ore is crushed and ground until 65 percent of it is small enough to pass through a 200-mesh screen (openings of 0.003 inch, or about the size limit between very fine sand and silt). The finely ground rock, now largely a mixture of mineral fragments, comes out of the grinding stage in the form of a very thin mud. This mud is treated with various chemicals and is agitated in tanks with beaters as compressed air raises through the mixture in the form of fine bubbles. Some of the chemicals added are attracted to the metallic minerals but not to the worthless non-metallic minerals. The metallic minerals, coated with this chemically induced water-repellant film, are attracted to the rising air bubbles which carry them to the surface of the tank. Here, they collect in a muddy-looking froth that is skimmed off.

Further chemical treatment and repetition of the "froth flotation" operation is used to separate the various metallic minerals from each other by floating one while depressing the other. The froth is filtered of excess water and the metallic sulfide mineral concentrate at this stage looks like a heavy damp silt. This concentrate is shipped to the smelter for treatment to separate the valuable metals from the sulfur and other waste materials. The bulk of crushed rock in the flotation operation does not float but remains in suspension and is pumped out of the bottom of the tanks, through a long pipeline and into large outdoor settling ponds.

The handling of this waste material or tailings from the mill at Holden is discussed under "Construction of the tailing piles."

Construction of the Tailings Piles *

The disposal of flotation mill tailings resolves basically into a problem of moving (in a slurry form) the finely ground waste rock to a site large enough to permanently store it and there separating the solids from the waste water by settling and decantation. To maintain the settling pond on top of the ever-heightening tailings disposal site it is necessary to continuously build up both the peripheral confining dike and the central drainage system.

Initial preparation of the tailing storage areas at Holden consisted of building an earthern-toe dam around the site about 8 feet high and 10 feet wide at the top, clearing any marketable timber, and constructing central vertical concrete overflow weirs connected by 12-inch steel essentially horizontal drainage pipes to a point outside the tailings storage site. These drainage pipes were covered with 3 to 4 feet of loose earth to prevent their floating during initial tailings deposition.

The concrete weirs or risers are 2 feet by 2 feet 9 inches in cross section and from 10 to 20 feet high. They were initially open on one side for their full height, with this side being "boarded up" with 6 X 6's to regulate the depth of pond water as the tailings built up. The weirs are connected with each other by 10-inch spiral-weld pipe with Victaulic couplings. Before a lower weir was buried by tailings, it was capped by a 3/8-inch steel plate upon which 4 inches of concrete was poured. Thus, tailings pile number 2, the highest, probably has at least 7 concrete risers connected by as many horizontal steel pipes conducting water from the pond on its surface.

*. Most details are from Zanadvoroff, 1946.

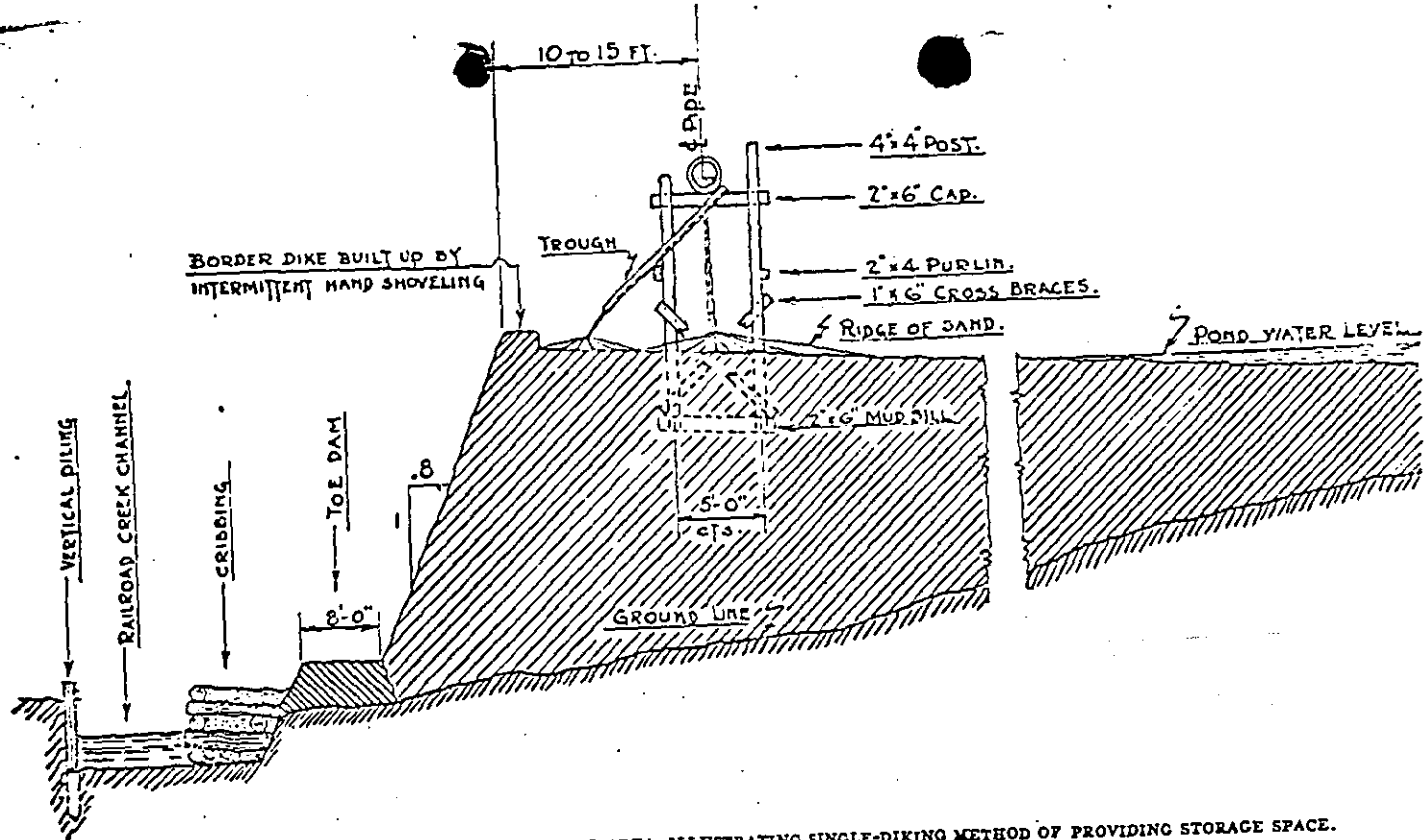


FIG. 2.—IDEALIZED SECTION OF TAILING-DISPOSAL AREA, ILLUSTRATING SINGLE-DIKING METHOD OF PROVIDING STORAGE SPACE.

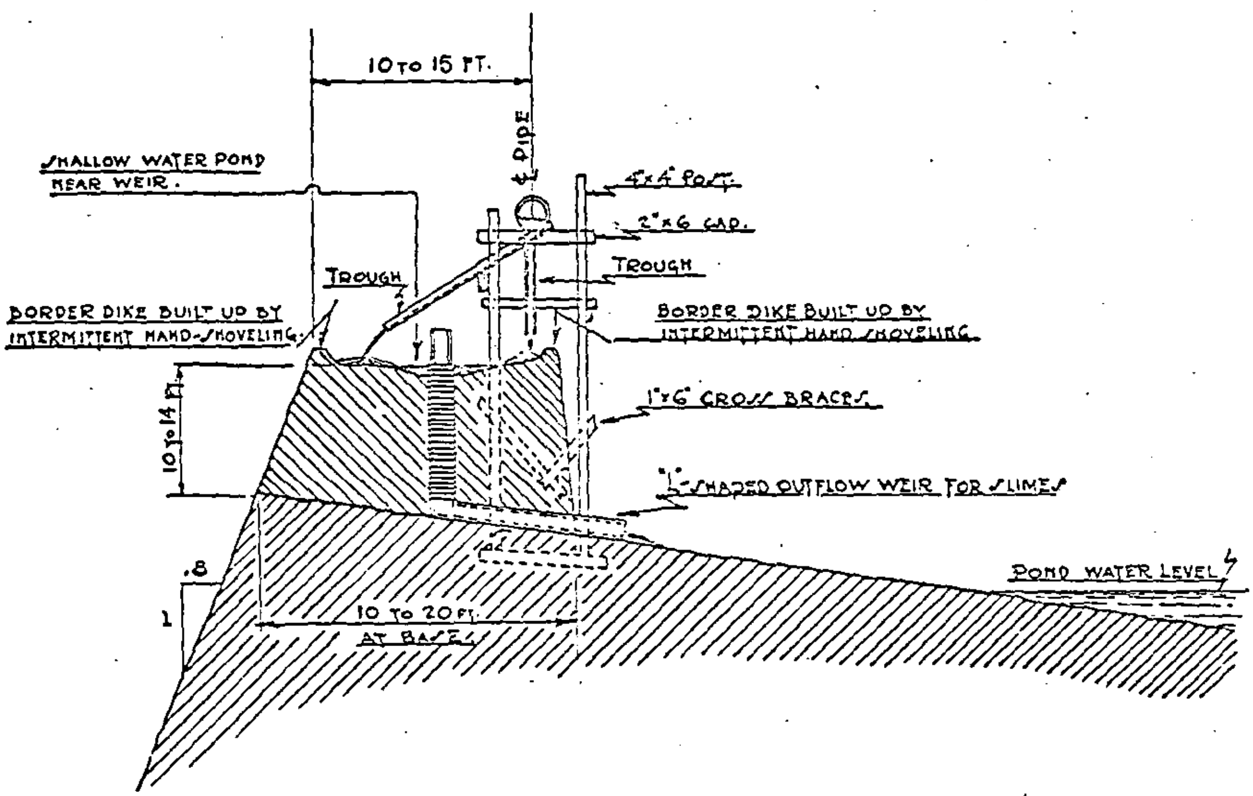


FIG. 3.—IDEALIZED SECTION OF TAILING-DISPOSAL AREA, ILLUSTRATING DOUBLE-DIKING METHOD OF PROVIDING STORAGE SPACE.

Reproduced from: Disposal of Mill Tailings at the Holden Concentrator,
by V. A. Zanadvoroff, A.I.M.E. Transactions, v. 169, 1946, 686-693.

The dikes that maintained the central settling pond, drained by these risers, were built as shown in Figures 2 and 3. The double dike method (Fig. 2) was used to provide extra storage capacity over the winter when it was impossible to build dikes due to the heavy snowfall. Most of the diking was done with "thickened" tailings from which the bulk of the extreme fine mud-size particles were removed (see Physical Characteristics). This enabled construction of a stable dike at slopes averaging 0.8 to 1 or about 52 degrees (Zanadvoroff, p. 690).

During the later stages of use of tailings pile number 2 a dike of bouldery soil (apparently about 10 feet high) was used (see Photo 2). Above this level tailings were again used, but this latter dike appears to have been built by dozing the tailings into a peripheral ridge rather than by the conventional construction previously described.

NATURE OF THE TAILINGS

Physical Characteristics

A report on the disposal of mill tailings at the Holden concentrator was made by Zanadvoroff (1946) during the time the mill was in operation.

Zanadvoroff (1946, p. 690) shows the size distribution of Holden tailings particles to be as follows:

	Percent
+100 mesh (> 0.0058 inch)	8.0
+200 mesh (> 0.0029 inch)	26.9
+325 mesh (> 0.0017 inch)	13.5
-325 mesh (< .0017 inch)	51.6
	100.0

The Holden mill tailings were treated to remove most of the extreme fines (or "slimes" to the extractive metallurgist). The remaining coarser material, which was used for most of the dike construction, was of the following size distribution:

	Percent
+100 mesh	11.8
+200 mesh	47.6
+325 mesh	17.3
-325 mesh	23.3
	100.0
	60.0

The other 40 percent of the tailings were 93.6 percent minus 325 mesh (smaller than 0.0017 inch in diameter).*

The iron sulfide minerals pyrite and pyrrhotite, being hard and brittle, break readily into fine particles. It is these minerals in a finely ground state that make up much of the black pigmentation in the finest grained layers of the unoxidized tailings (see Photo 3). The thicker (as much as 2 inches) layers are light gray and are made up largely of coarser silicate particles.

Photo No. 3.—Test pit dug 4 feet into tailings pile number 2 approximately 20 feet from a small central pond. The finer grained dark layers showed the glisten of surface moisture characteristic of "fat" clays but no water accumulated in the hole after 18 hours. The oxidized layer is about 10 inches thick. Note that there are no loose fines on the tailings surface but a "desert pavement" of iron oxide cemented chips.

* The bulk of this material settled out in the central ponds.

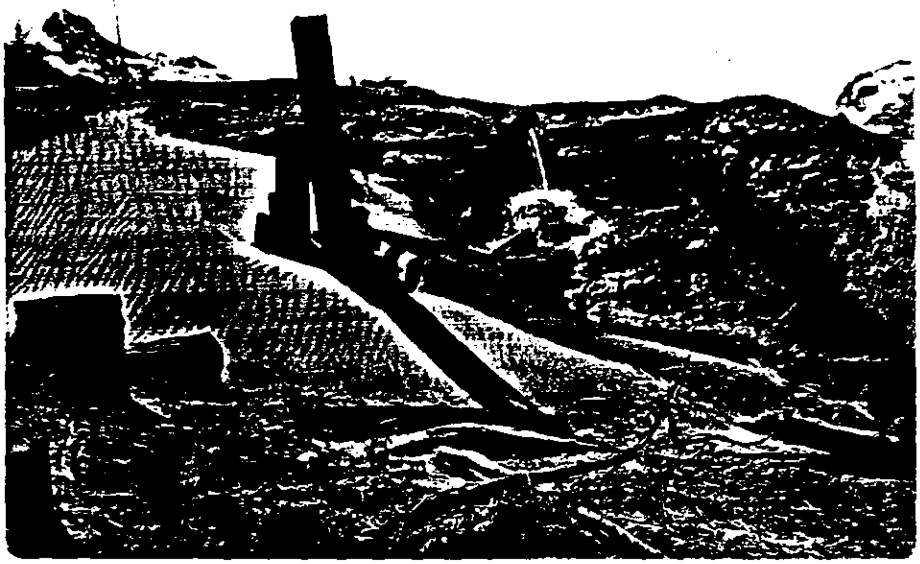


Photo No. 4.—East edge of tailings pile number 1 (photo is "off-color"). This picture shows the relative resistance to erosion of undisturbed oxidized tailings compared to wind deposited tailings. Culvert discharging stream of about 3 square inches in cross section falling 4 feet onto sloping surface of stratified tailings. Note the relatively minor erosion considering that this stream has apparently flowed, at least intermittently, for at least 20 years. No turbidity noticeable in the runoff.

When oxidized the sulfides present cement adjacent particles together with iron oxide. Fragments of this cemented material require considerable pressure to crush with the fingers and thus could be considered to have medium "dry strength" (Earth Manual, 1963, p. 391). The oxidized dike material is practically impossible to penetrate with a shovel and must be first picked to loosen. In climbing the faces of the tailings piles, it was impossible to "kick" steps but instead they had to be hacked with a pick. The effectiveness of this cementation is shown in Photo 4. Walking on "oxidized in place" material, even where underwater, had little effect on it. Wind-deposited oxidized tailings, however, were found to have practically no strength where saturated. Apparently once disturbed the oxidized grains will not bond again and are easily eroded by the wind. This wind-blown material was present only as a veneer on the lee sides of the tailings piles (Photos 1, 2, and 4) and as collars as much as a foot or so thick around the central settling ponds where moisture has stabilized the wind-blown material.

A test hole dug near the center of tailings pile number 2, about 20 feet west of a pond, was started in oxidized material but encountered unoxidized tailings within 10 inches of the surface (Photo 1). The damp unoxidized material in this hole stood up well in a 4-foot vertical face. Despite the nearness of the pond, there was no seepage into the test pit after 18 hours. This may have been due to partial sealing of the pond by wind-blown fines rather than being a true indication of lateral permeability. The tailings in the lower foot or so of the pit were noticeably darker, and the gray-black clay-size layers at this level showed a distinctly wet surface when disturbed; as though they were saturated. Both bulk and undisturbed samples taken from the unoxidized portion of the pit were tested by the Materials Laboratory of the Washington Department of Highways. The following data are representative of the samples, with the moisture content and moisture-dependent properties based on an undisturbed sample taken at the 42 to 46 inch depth interval:

Moisture content	37.6 percent
Liquid limit	25.6
Angle of internal friction	20°
Dry density	78 lb/ft^3

The material as a whole was found to be nonplastic although there are muddy partings, generally less than $\frac{1}{4}$ inch thick, that, by themselves, are plastic. It should be kept in mind that material from this test hole is not representative of the dikes (see Construction of the Tailings Piles); the dikes being practically unstratified and considerably coarser grained.

Four small streams discharged onto tailings pile number 2 at the time of my visit. One of these, about a foot wide and 1 inch deep where it reaches the tailings, meandered across the surface for about 200 feet before it completely disappeared into the oxidized tailings. This seems to indicate very poor permeability, at least vertically, across the stratification. Another pit dug 1 foot from the edge of the pond, in tailings area number 3, began collecting seepage water almost immediately. This suggests fair permeability along the silt layers even within the oxidized zone. A critical factor on tailings pile stability would be the relative permeability of the peripheral dikes and the enclosed tailings. The fact that the coarseness of tailings particles increase outward and the dikes themselves represent the coarsest fraction (see Construction of tailings piles) indicates that, excluding oxidation, permeability should increase outward and there would be no "damming effect" of pore water in the zone of saturation. Oxidation does not seem to adversely effect permeability in the coarser fractions, or at least not enough to compensate for grain size factors.

It would require considerable more lab testing as well as field measurements such as piezometer readings to arrive at quantitative information on the overall stability of the tailings piles. Even then, such factors as the inhomogeneity of the original tailings and the influence of later oxidation on the strength and permeability of the dikes would probably require the making of various assumptions. It appears however that natural settlement of the tailings plus this cementation by oxidation of the dike material would make the tailings more stable now than when originally emplaced.

Chemical Characteristics

The great bulk of material (about 85 percent) in the tailings consists of practically insoluble silicate minerals. The relatively soluble fraction consists largely of sulfide minerals, with only minor and variable amounts of marble ($CaCO_3$). Chemicals added during the flotation process were copper sulfate, hydrated lime, pine oil, Barrett No. 4 oil, either Minerec "B" or Pentasol zanthate, and sodium cyanide. The quantity of sodium cyanide used in the flotation process, at least during the early operations, was about 0.04 pounds per ton of ore (Pearse and Zanadvoroff, p. 34). In addition to this use as a depressant of pyrite, pyrrhotite, and sphalerite during the floation process; cyanide was used on the coarse tailings during the early 1940's and again in the late 1940's in attempts to increase the gold recovery.

The addition of hydrated lime in the amount of 1.2 pounds per ton of ore (Pearse and Zanadvoroff, 1939, p. 34) made the pulp in the flotation process quite alkaline. Probably a good part of this original alkalinity was lost to Railroad Creek by decantation from the tailings ponds. Nevertheless, the tailings were undoubtedly somewhat alkaline when deposited. Once oxidation of the iron sulfides commenced, however, the oxidized zone became acid. A test of the oxidized surficial material showed a high soluble-salt content and a pH of 2.8 (W. R. Rines, Jr., written communication, 1967).

The presence of 4 to 5 percent sulfur, largely in the form of FeS_2 and FeS, indicates a potentially large volume of sulfuric acid to be eventually formed. The slow rate of oxidation means that this large potential of acid will be released over a period of many years, however. An illustration of this is the fact that a test hole dug on the surface of tailings pile number 2 encountered unoxidized tailings within 10 inches of the surface. This indicates an average oxidation rate of on the order of $\frac{1}{2}$ inch per year, although this rate undoubtedly varies with the texture and degree of stratification in the tailings. Oxidation on the banks of the tailings piles has progressed considerably deeper than this however, and may extend the full thickness of the dikes. In one place a 3-foot hole failed to penetrate the oxidized layer.

DISCUSSION OF PROBLEMS

Stability

As suggested under "Physical Characteristics," there seems to be little danger, at the present time, of any mass movement of tailings. Overall stability would be even further ensured however, if surface drainage were guaranteed. (Complete drainage would however aggravate somewhat the summer dust problems.

The central drainage systems (see "Construction of the Tailings Piles") are subject to failure by clogging with floating debris, vandalism, or eventual collapse due to corrosion by acidic water. The drainage system of pond number 2 was functioning normally at the time of my visit in spite of wood jammed in the vertical riser. The pond on tailings area 3 was much larger and it would require a boat to see if the drainage riser was clogged. The scour resistance of the oxidation cemented dike material (see Photo 4) suggests that even if the dikes were to be overtopped due to outlet clogging and an unusually rapid snow melt, that erosion and downcutting probably would not be serious.

Even though the in-place tailings are quite resistant to scour by running water, they should, of course, be protected from undercutting by Railroad Creek. The diversion of the creek, as suggested by the Forest Service engineering consultants (see map), would offer a permanent and, in the long run, probably cheaper solution to this potential hazard than the repair of the existing log cribbing.

Biological Effects

While it was beyond the scope of this investigation to directly study the biological effects, a review of available information may help to evaluate the statements quoted in "Purpose and Scope" and repeated below.

". . . . the tailings dump has killed the surrounding vegetation. . . ."

This was found to be true in one place, along the south edge of tailings pile 2, where several dozen small fir trees were dead. The fact that trees a few feet away looked healthy suggests that the dead trees had been "drowned," as by an encroaching beaver pond, rather than poisoned. In other places, trees and brush of various species were seen growing through several inches of wind-deposited tailings. Nowhere, however was anything seen rooted in tailings, so it appears that they form an effective barrier to the seeding of annual vegetation wherever the tailings completely cover the ground.

". . . . tailings dump has killed. . . all the fish in the (Railroad) creek."

I made no attempt to catch fish during my visit, although former residents of Holden report good fishing downstream from the tailings area during their stays at the mining camp when it was operating (H. A. Pearse, M. E. Defoe, J. S. Mitchell, J. J. Curzon, V. A. Zandon, written communications). Tank tests with trout were conducted by Pearse while milling operations were going but failed to show any difference in fish mortality between "clean" creek water and a creek water-tailings effluent blend (H. A. Pearse, J. J. Curzon, written communications). Although all the details are not known, it would appear that such a test would prove only that the chemical quality of the water used was not toxic to mature trout. Such a test would, of course, yield little or no information on the long-term effects of effluent or tailings particles on the food chain or reproductive cycle of the trout. Apparently the influence of the chemical quality of water on fish can be both subtle and complex. McKee and Wolf (1963, p. 176) state that the "toxicity of cyanides toward fish is effected by the pH, temperature, dissolved oxygen, and concentration of minerals." They cite test results where cyanides in a concentration of 0.005 mg/l were found to be "lethal" to trout and where another study showed a higher concentration (of 0.084 mg/l) to be "not toxic." It is not clear whether this apparent contradiction is due to differences in exposure time, one of the factors mentioned, or some other condition. These authors state further (p. 176), that "toward lower organisms cyanide does not appear to be as toxic as toward fish."

A field study of aquatic insects in the bed of Railroad Creek was made by Roland Pine, a Washington Water Pollution Control Commission Biologist, in September 1967. He found a substantial decrease in creekbed insect fauna at the tailings site and for several miles downstream. He concludes that the "mine tailings at Holden are significantly affecting the already limited productivity of the creek. This is due principally to the deposition of tailing material upon the stream bottom effectively suffocating the aquatic insect fauna" (W.W.P.C.C. Tech. Paper 67091). Assuming that both the testimony of former Holden residents and Pine's findings are true and the fish population has decreased since the closing of the mine, a contributing factor might be that the failure to maintain a year-around settling pond on the tailings surfaces has allowed drying during the summer months resulting in more severe dust conditions and silting than took place while the mine was active. An increase in post-1957 wind erosion plus the normal long-term buildup of dust might result in a cumulative effect that had not yet made itself felt during the years the mine was in operation and the fishing was reportedly good.

". . . the tailings dump . . . is now starting (1967?) to pollute Lake Chelan.."

If pollution is defined as the introduction of a foreign substance, careful analysis of creek water at Lucerne in 1940 probably would have shown more than normal amounts of metals as well as some entirely foreign chemicals from the flotation process. Thus, pollution here is not some new threat nor, as far as Lake Chelan is concerned, does it appear to be a threat at all. The dilution factor is such that pollution would probably not be detectable much beyond the zone of turbidity at the creek mouth.

Sampling of Railroad Creek water on June 15, 1967 by Federal Water Pollution Control Administration personnel yielded the following data (D. B. Krawczyk, written communication, Nov. 20, 1967):

	At Wilderness Boundary	Downstream from tailings pipe	At Lucerne
Copper	0.0036	0.029	0.021
Zinc	0.008	0.016	0.011
Iron	0.2	0.9	0.8
Arsenic	< 0.001	< 0.001	< 0.001
Cyanide	< 0.010	0.056	0.045

All concentrations reported in milligrams per liter

Examination of these data show that the "pollution level" at Lucerne is, for most of the constituents, on the order of 4 times that found at the Wilderness area boundary. For comparison purposes the U.S. Public Health Service Drinking Water Standards (1962) are reproduced below:

	Recommended limit*
Copper	1.0
Zinc	5.0
Iron	0.3
Arsenic	0.01
Cyanide	0.01**

* All values reported as milligrams per liter.

** Mandatory limit for cyanide is set at 0.2 milligrams per liter.

The metal content of the Railroad Creek water, even below the tailings pipe, (with the exception of iron) can be seen to be well within the recommended standards for drinking water. While the iron content at this point is about twice that for municiple wells in the cities of Omak and Okanogan for example (high-iron wells reported by Van Denburgh and Santos, 1965, p. 66). No evidence was found suggesting that such concentrations are any more than a nuisance due to staining effects.

The recommended limit (stated above) for cyanide is apparently a practical one in that it is "easy to attain" and is based more on toxicity to fish than to man. The mandatory limit of 0.2 milligrams per liter gives a "factor of safety of about 100" for drinking water. Thus, even though the recommended limit for cyanide is exceeded at Lucerne, it is still less than one fourth the mandatory limit.

In summary, it appears that while the iron and cyanide levels of Railroad Creek would make it a domestic water source of marginal quality, the water presents no dangers for human consumption such as by campers and hikers. ???

Dust Problems and Possible Solutions

Wind erosion seems to be the most immediate problem but is more in the category of a nuisance than a danger. I saw 35 mm slides taken by the Holden Village management in which portions of the opposite valley wall were obscured by clouds of orangish dust. While riding to Holden from Lucerne on the bus, it was possible to smell and "taste" the tailings at least a half mile downvalley from the tailings area. This was probably due largely to tailings previously deposited by wind along the road.

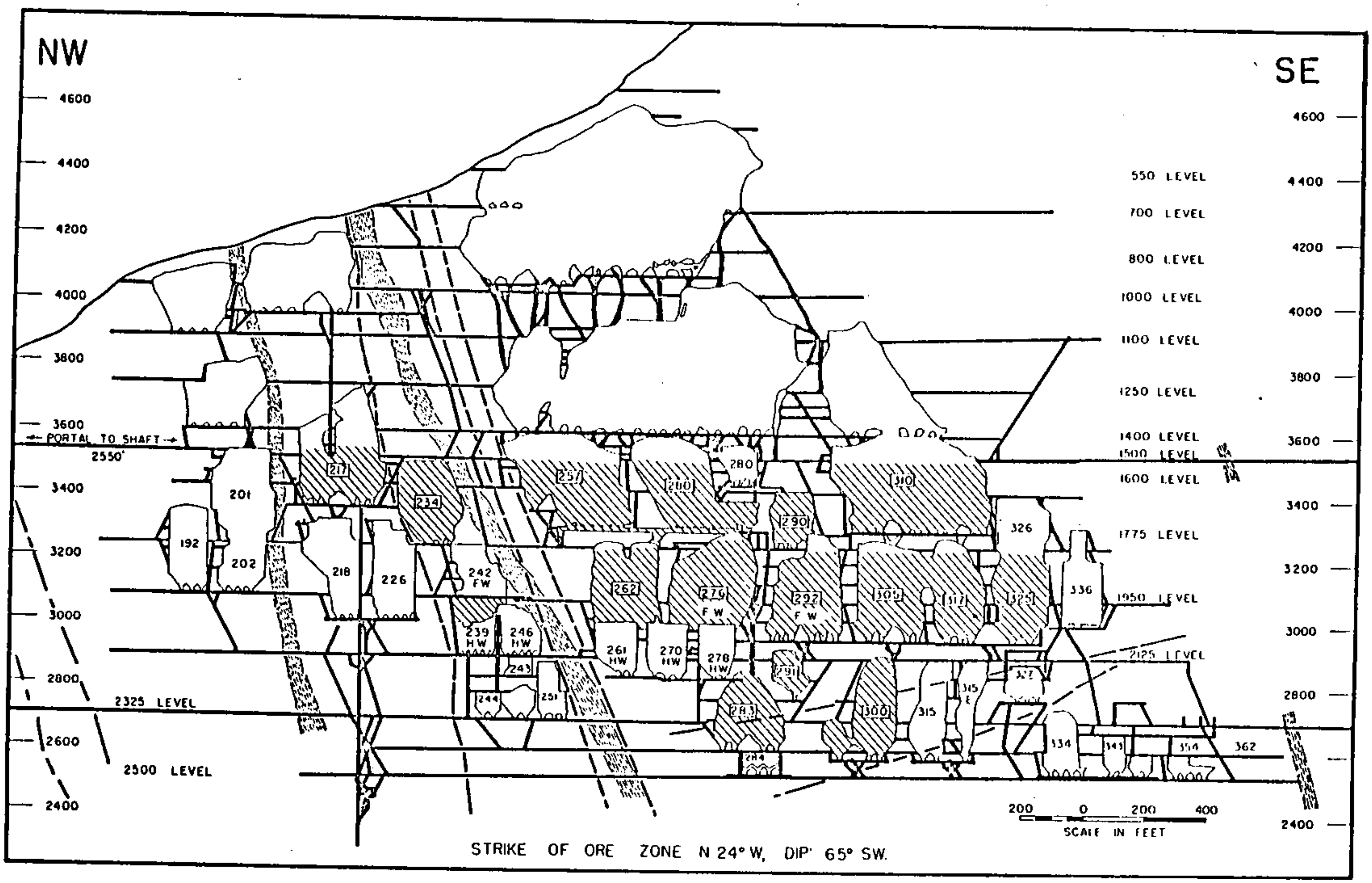
Simply wetting the tailings surface will stop wind erosion and this fact suggests one remedy during the 4 or 5 months when this a problem. The availability of high pressure water from the existing power plant diversion point on Copper Creek might make it feasible, at least on a short term basis, to sprinkle or "fog" the tailings during the summer months. Such an installation could be laid on the surface and drained each winter to avoid freezing. The major shortcoming of such a system is that it would have to be maintained year after year, offering no permanent solution.

Studies have been made of agricultural applications in which a thin layer of asphaltic material is sprayed on the surface of a soil to prevent evaporation of soil moisture. A similar material on the surface of the tailings ponds might not only prevent drying, but act as a binder to further ensure against wind erosion. In tailings stabilization experiments conducted by the U.S. Bureau of Mines, a resinous adhesive, "Coherex", was found to be effective in amounts as low as 0.18 gallons per acre at a dilution of 1 part by volume to 4 parts water (Dean and others, 1969, p. 14). This treatment, at a chemical cost of $34.80 per acre, was combined with seeding of grasses and brush, but it is unlikely that it would be a permanent solution alone. Surface films would be susceptible to puncture and subsequent "blowouts" by wind erosion. The numerous deer tracks on the tailings indicates that this could be a serious problem.

A soil cement might be made by harrowing in a suitable binder. Careful testing would need to be done to select a binder that would be chemically compatible with the oxidized tailings. While this technique might be a permanent solution to erosion, much of the irregular surface of the westernmost pond would need regrading. Also, the technique probably would not be feasible on the steep dike slopes of the tailings piles. Wind scour however appears to be most severe on the top surfaces, probably due to the generally finer grain size of this material. The fact that the tailings cover 80 acres means that a soil cement approach would require a considerable volume of material, all of which would have to be hauled in at great cost.

Probably the most esthetically pleasing approach to the wind erosion problem would be revegetation. The tailings alone, however, would probably not support native vegetation even if planted. Thus, such a method would require either correcting the excessively high soluble salt content and low pH (2.8) (W. R. Rines, Jr., written communication, 1967) or, veneering the tailings with a suitable soil. Both of these approaches would be very expensive. If the veneer approach is considered, it would seem worthwhile to consider the mine waste dumps as a source of "topsoil," thus avoiding the cost and esthetic effects of a large new excavation. It would require on the order of 150,000 cubic yards of material to cover the tailings to a one-foot depth. While metal mine dumps, in the short term, appear to be very sterile, some old mine dumps have tree stands that match or surpass the surrounding natural terrain. The development of a brush and tree cover on such a veneer could, of course, be greatly accelerated by actual planting and by fertilizing.

Revegetation would be relatively simple if the acid-forming iron sulfides were removed from the tailings. While a remilling of the tailings might produce on the order of 3.5 million dollars (gross) worth of gold-bearing pyrite concentrate (assuming a nominal $10/ton for pyrite), the remoteness of the area would almost certainly make it uneconomical at present. Should a form of gold subsidy be introduced, as suggested by some, this otherwise farfetched idea might warrant investigation. Should it prove feasible, not only would the remaining tailings be easier to revegetate but their bulk might be substantially reduced by pumping much of the remaining tailings into mined out areas of the mine above the 1500 level (see Fig. 4).



Mining Methods and Costs
at the Holden Mine . . .
U.S.B.M. Inf. Circ. 7870
John R. McWilliams, 1958

FIGURE 4.—Longitudinal section in plane of ore zone.

SUMMARY

Cementation through oxidation of iron sulfides and settlement appear to have made the tailings piles at least as stable, or possibly even more stable, as when originally implaced. The proposed Railroad Creek diversion should permanently remove any dangers of undermining.

Dust and dust blankets result from wind erosion during the summer. The dust is esthetically displeasing and contributes to stream siltation. The dust blankets do not seem to effect established "woody" vegetation but appear to be a barrier to reproduction by seeding.

Leachates from the tailings are present in Railroad Creek, possibly in concentrations sufficient to adversely effect aquatic life. Stream siltation by tailings particles appears to be responsible for a decreased aquatic insect population downstream from the tailings.

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