WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report Carmacks Copper Project Yukon Territory Volume II Supporting Appendices

Submitted by:

Western Silver Corporation



June 2005

Prepared by:

ACCESS CONSULTING GROUP

accessconsulting.ca

WESTERN SILVER CORPORATION

PROJECT DESCRIPTION AND ENVIRONMENTAL ASSESSMENT REPORT

CARMACKS COPPER PROJECT

YUKON TERRITORY

Volume II – Supporting Appendices

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WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix A

Detailed Project Design Drawings

Appendix A – Detailed Project Design Drawings

The original drawings in Appendix A are from Kilborn, and Knight Piésold, and have been modified/revised slightly from their original format. The original engineering design content for the most part has not been modified.

Modifications to the original drawings include:

- Removing grid lines;
- Removing the water storage area which is no longer included in this project;
- Removing old trails;
- Removing mineral claims;
- Changing the original AutoCAD pen settings;
- Replacing the original title block with the Access Consulting Group title block; and
- All drawings are marked “not for construction”.

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1784_100	Site Investigations Plan
1784_101	Heap Leach Pad Geologic Sections Sheet 1 of 2
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ACG-WS-01.001	Conceptual Heap Leach Facility Closure



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Carmacks Copper Project
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WESTERN SILVER CORPORATION

Aerial Photo of Carmacks Copper Project Area

Drawing Number:

ACG-WS-01.000

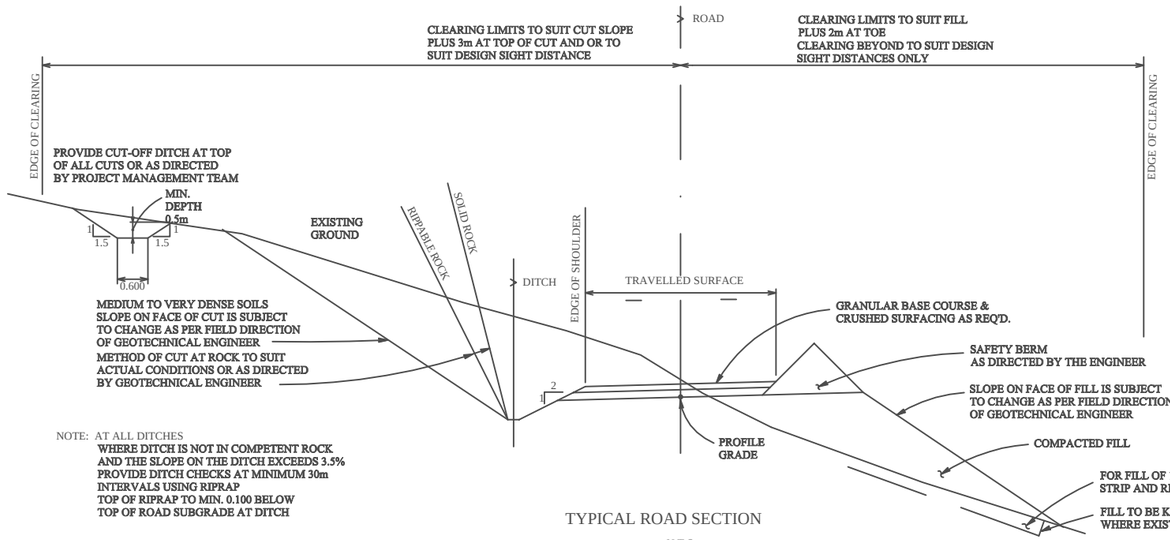
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1:30 000 (Appx)

ACCESS CONSULTING GROUP

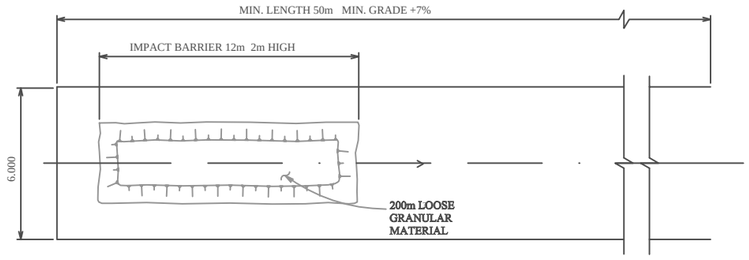
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TYPICAL ROAD SECTION

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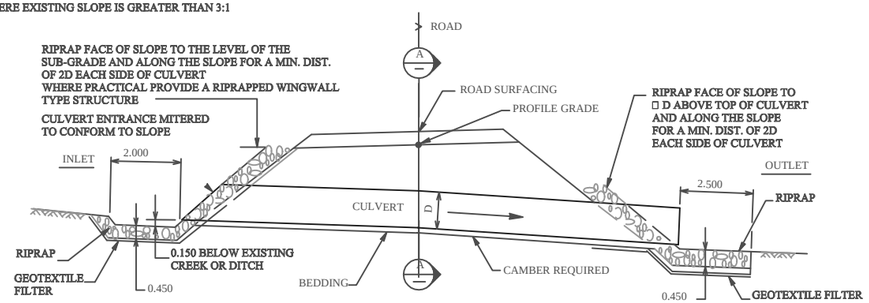


EMERGENCY RUN-OUT LANE

PLAN

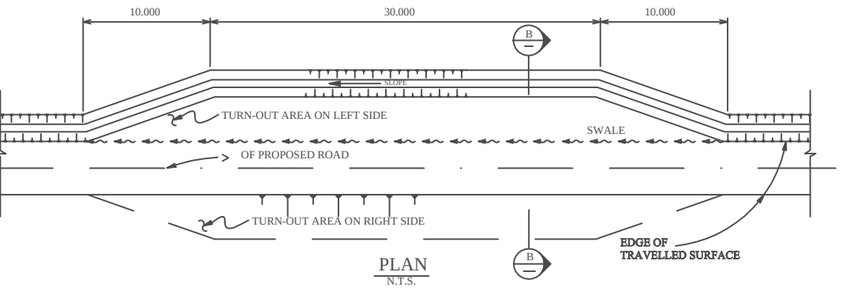
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EMERGENCY RUN-OUT LANES TO BE
FIELD LOCATED BY THE ENGINEER



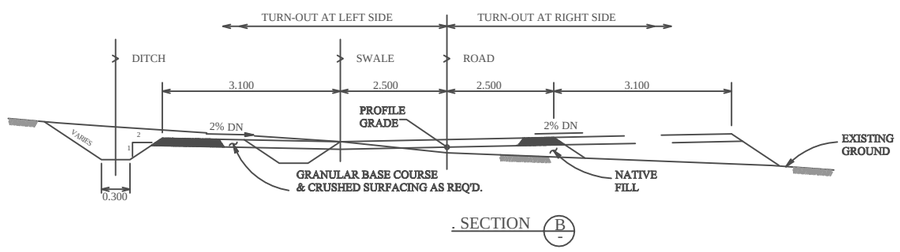
SECTION THROUGH CULVERT

N.T.S.



PLAN

N.T.S.

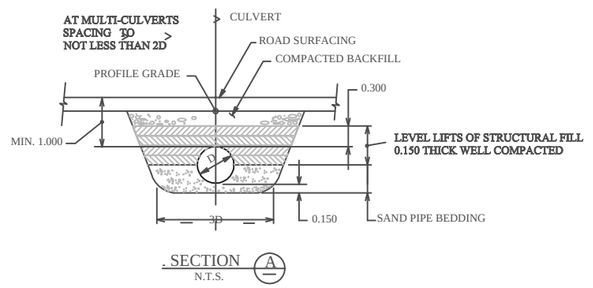


. SECTION B

VIEW LOOKING UP ROAD

N.T.S.

TYPICAL DETAIL AT TURN-OUT
ACCESS ROADS



. SECTION A

N.T.S.

TYPICAL CULVERT DETAIL
(UNLESS NOTED OTHERWISE)

NOTES:
1. DIMENSIONS ARE IN METRES

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
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Drawing #100-13-05

Roads Sections and Details Sheet 1 of 2

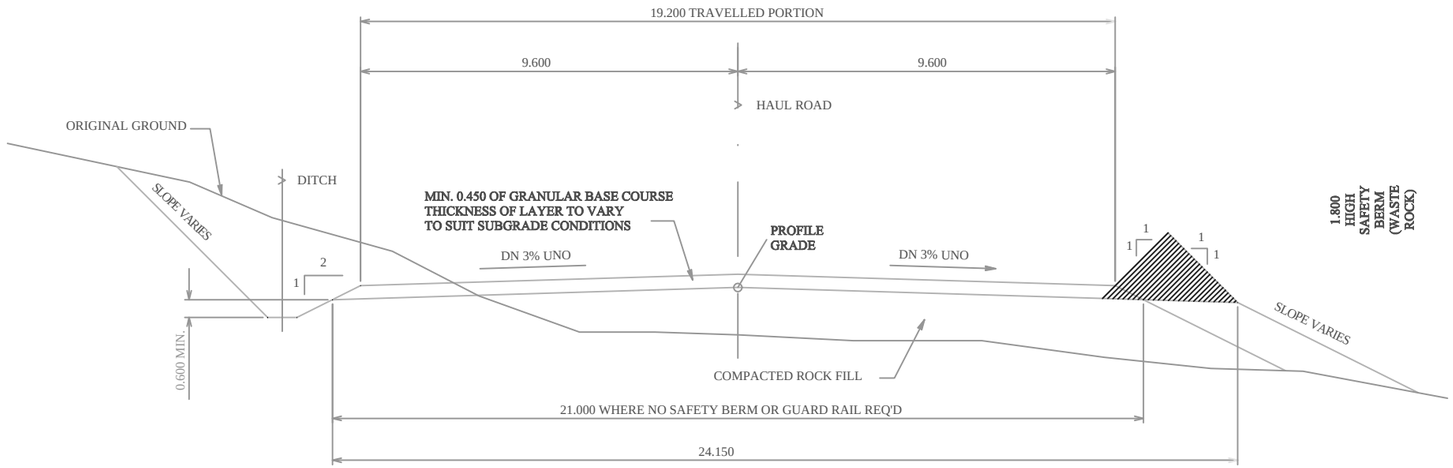
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ACCESS CONSULTING GROUP

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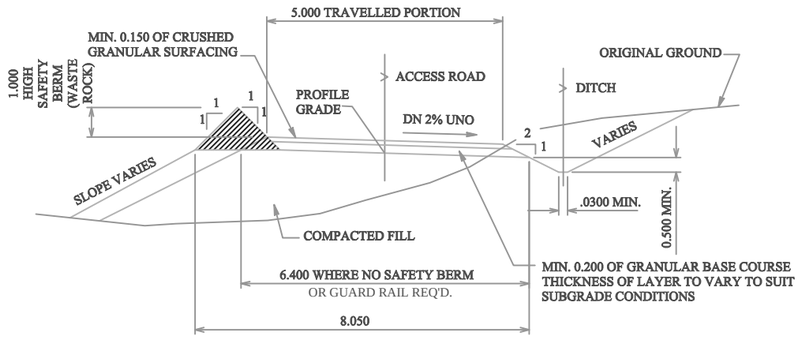
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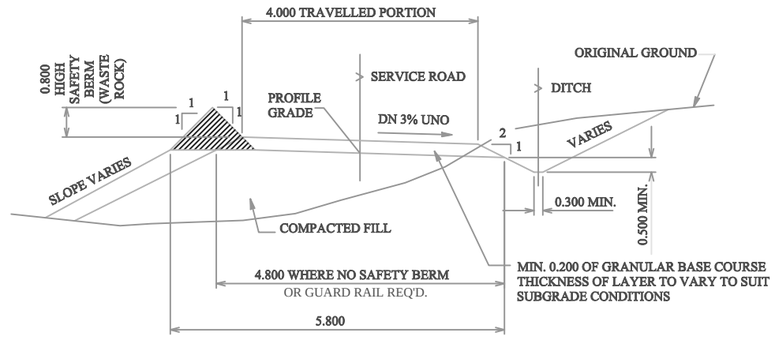
HAUL ROAD SECTION

N.T.S.



ACCESS ROAD SECTION

N.T.S.



SERVICE ROAD SECTION

N.T.S.

NOTES:

1. DIMENSIONS ARE IN METRES

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Carmacks Copper Project
Yukon Territory

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Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
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Drawing #100-13-06

Roads Sections and Details Sheet 2 of 2

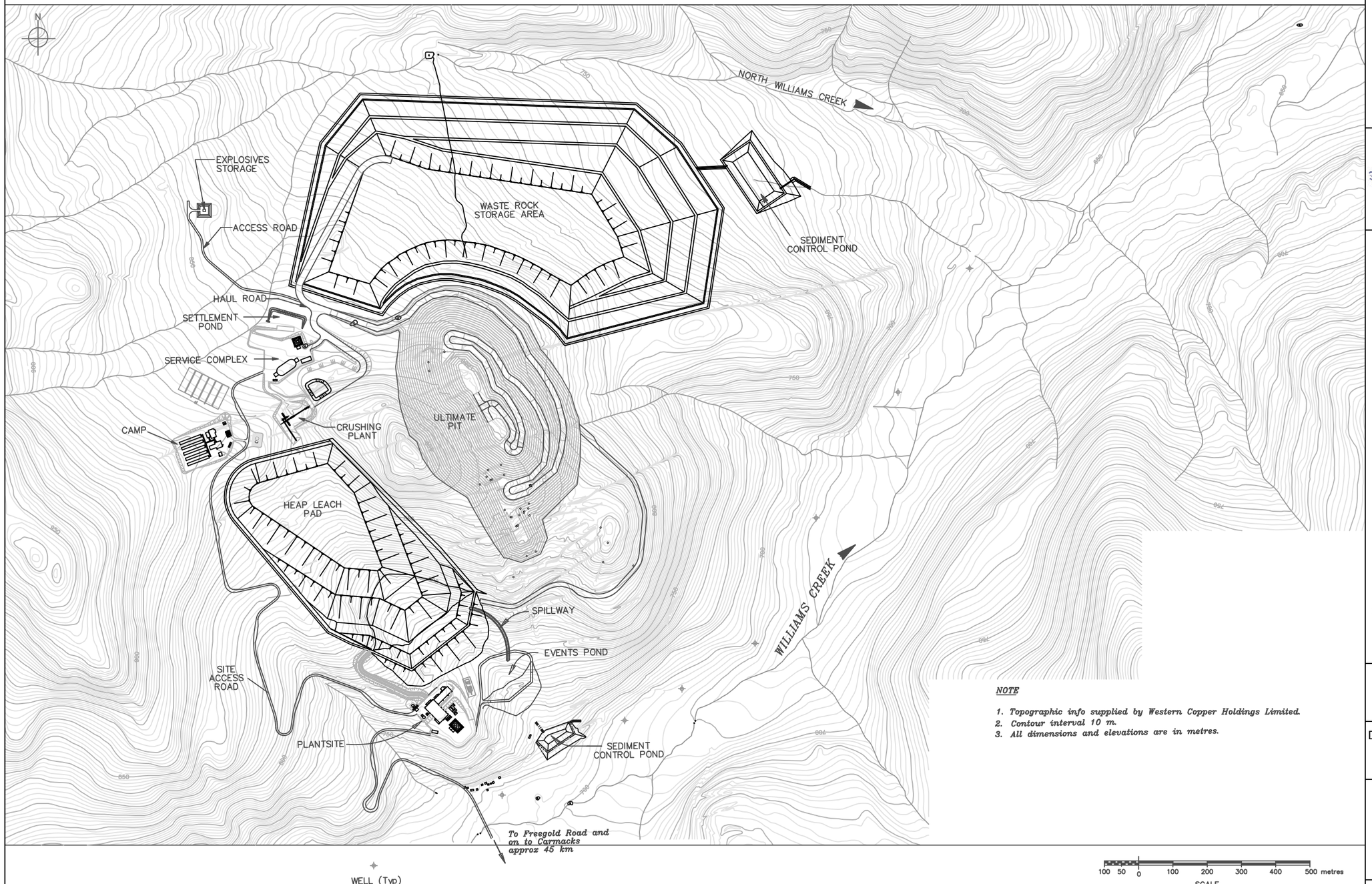
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ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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NOTE

1. *Topographic info supplied by Western Copper Holdings Limited.*
2. *Contour interval 10 m.*
3. *All dimensions and elevations are in metres.*

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Overall Site Plan Ultimate",
Drawing #100-13-08 Rev A

Overall Site Plan Ultimate

Drawing Number:
100-13-08

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

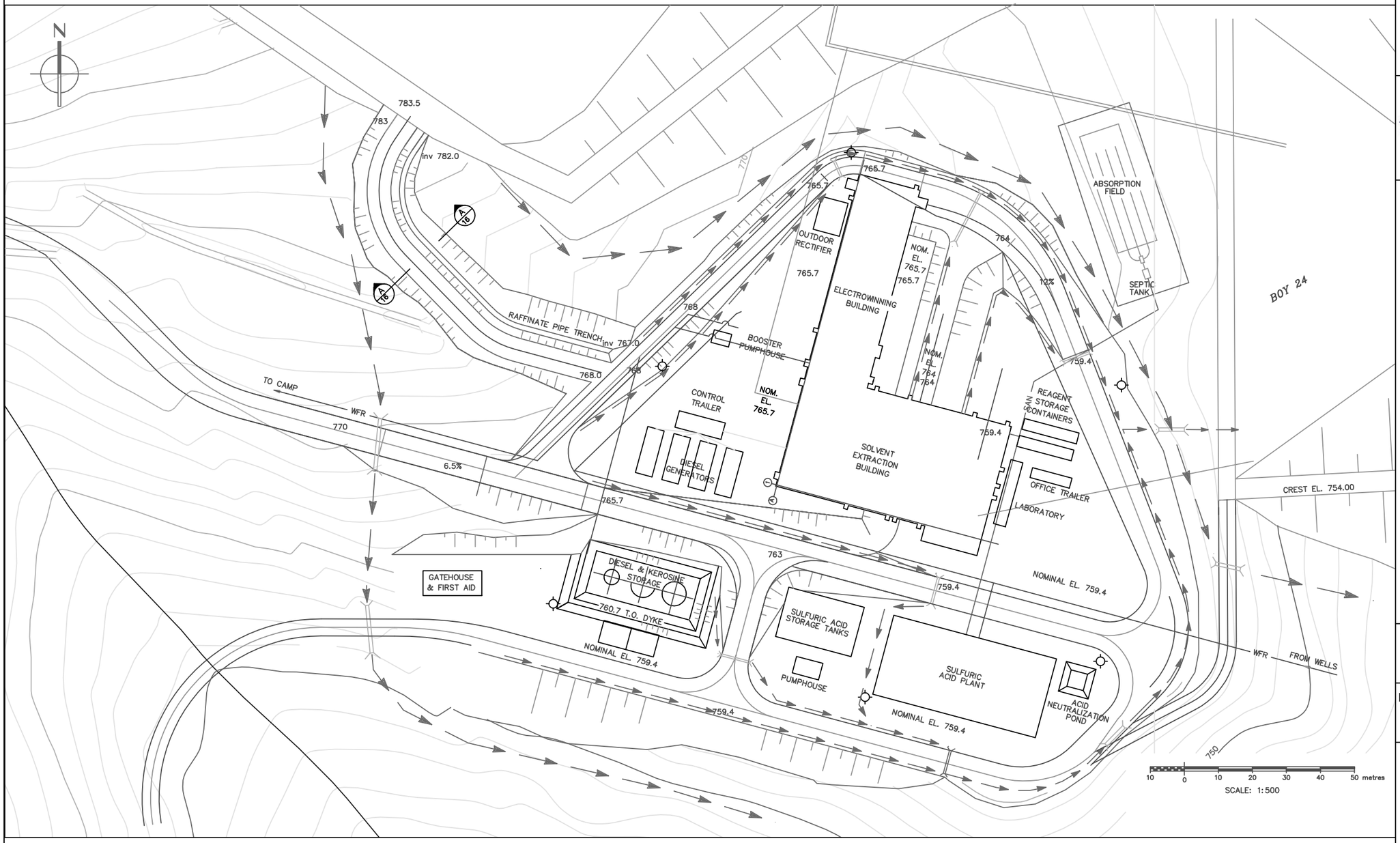
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Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION



Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Plantsite Layout Plan",
Drawing #100-13-09 Rev B

Plantsite Layout Plan

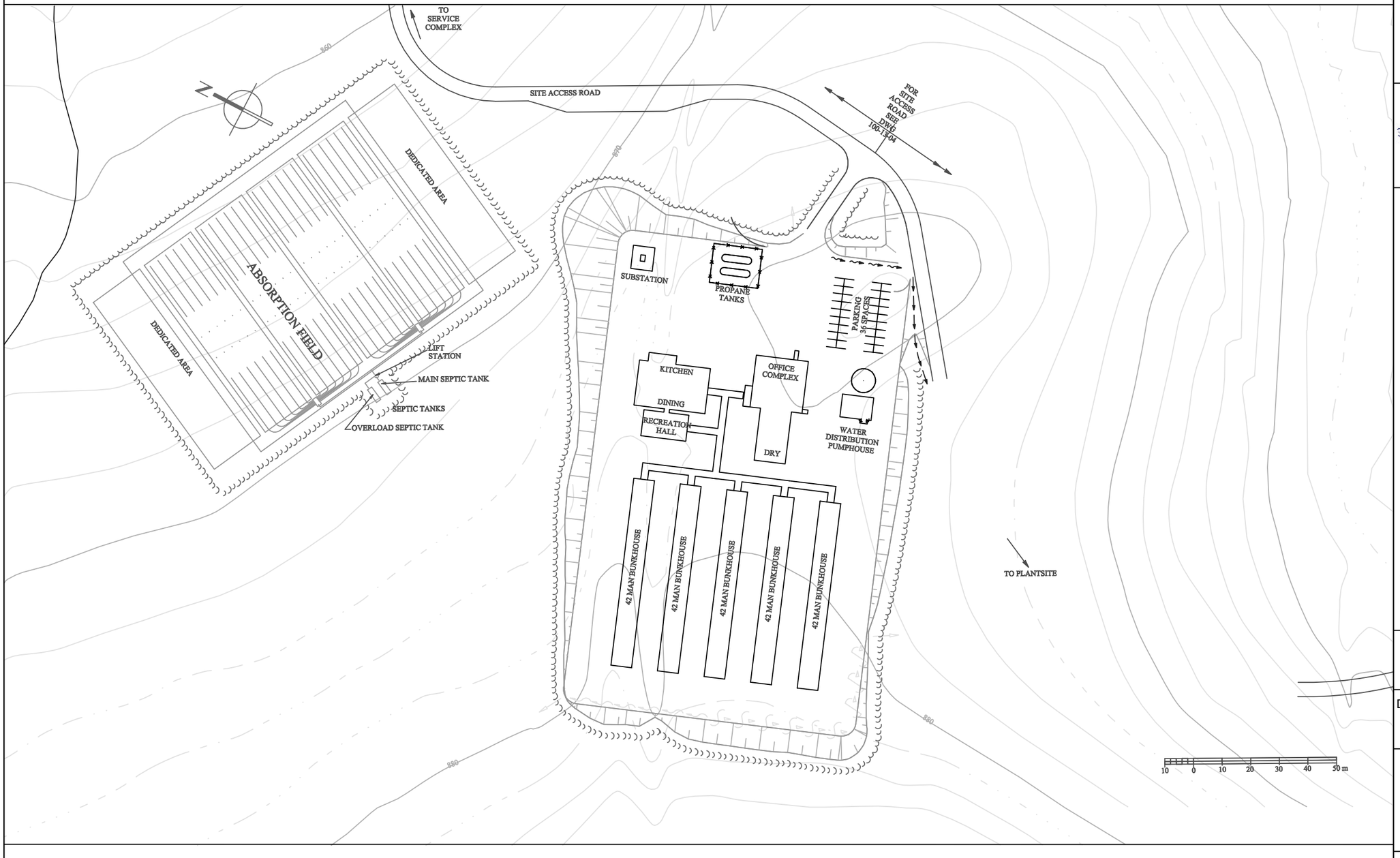
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ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

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Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

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"Camp Layout Plan",
Drawing #100-13-14 Rev B

Camp Layout Plan

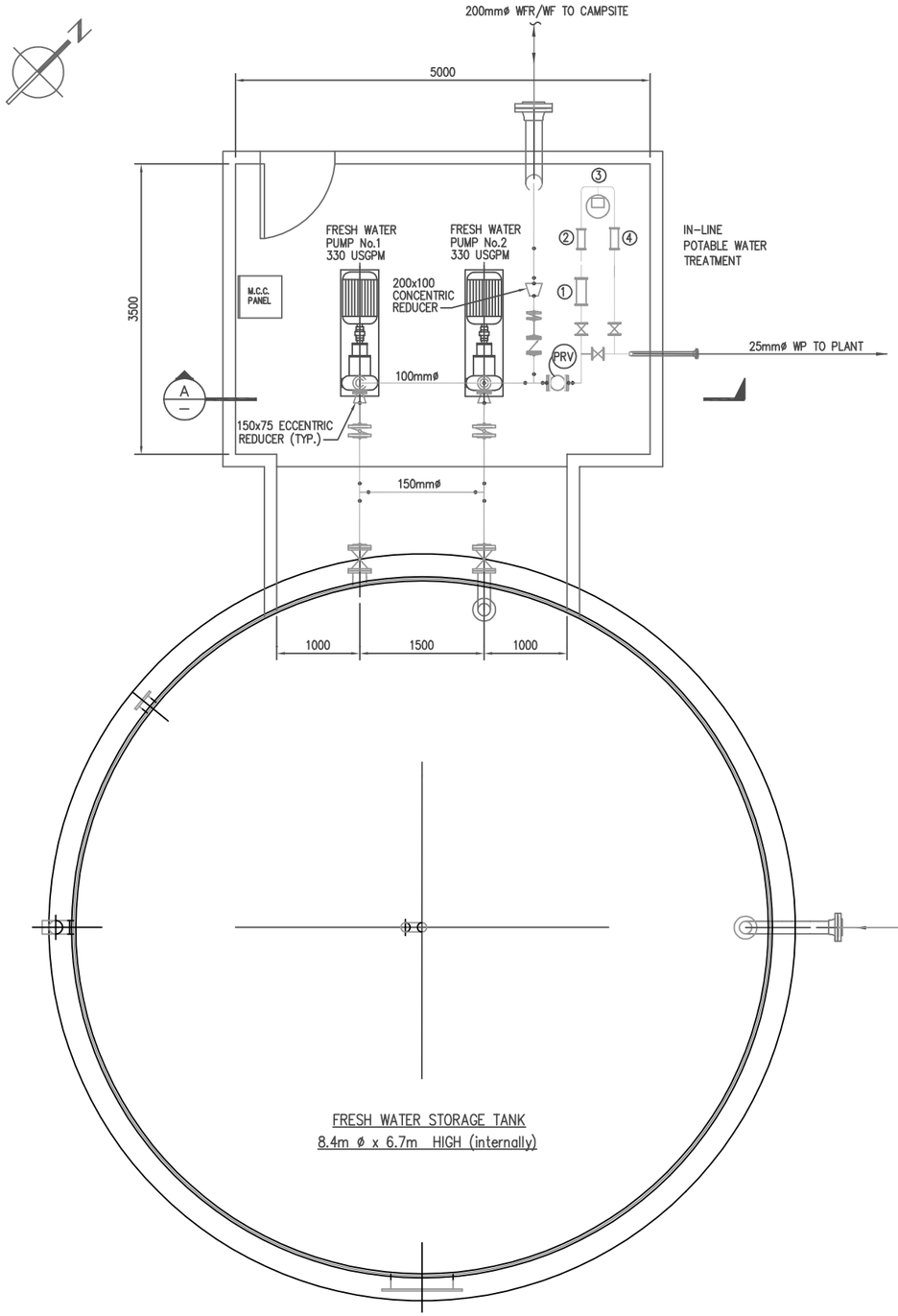
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ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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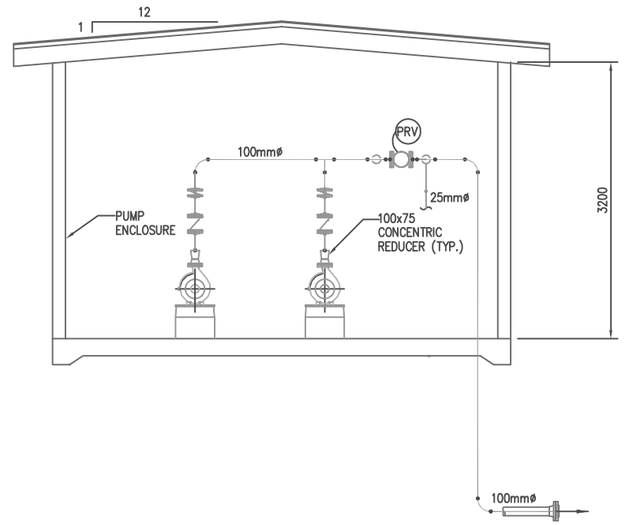
FRESH WATER STORAGE TANK
8.4m ø x 6.7m HIGH (internally)

PLAN
N.T.S.

NOTES:

1.) FOR PUMPHOUSE LOCATION
SEE DWG. 100-13-17.

2.) APPURTENANCES SHOWN ARE AS FOLLOWS:
① – IN-LINE FILTER
② – FLOW METER
③ – HYFLOCHLORINATOR
④ – IN-LINE MIXER



SECTION A
SCALE: N.T.S.

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Carmacks Copper Project Yukon Territory

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Original drawing from Kilborn,
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"Fresh Water Booster Pumphouse Plan and Sections", Drawing #100-13-20 Rev B

Fresh Water Booster Pumphouse Plan and Sections

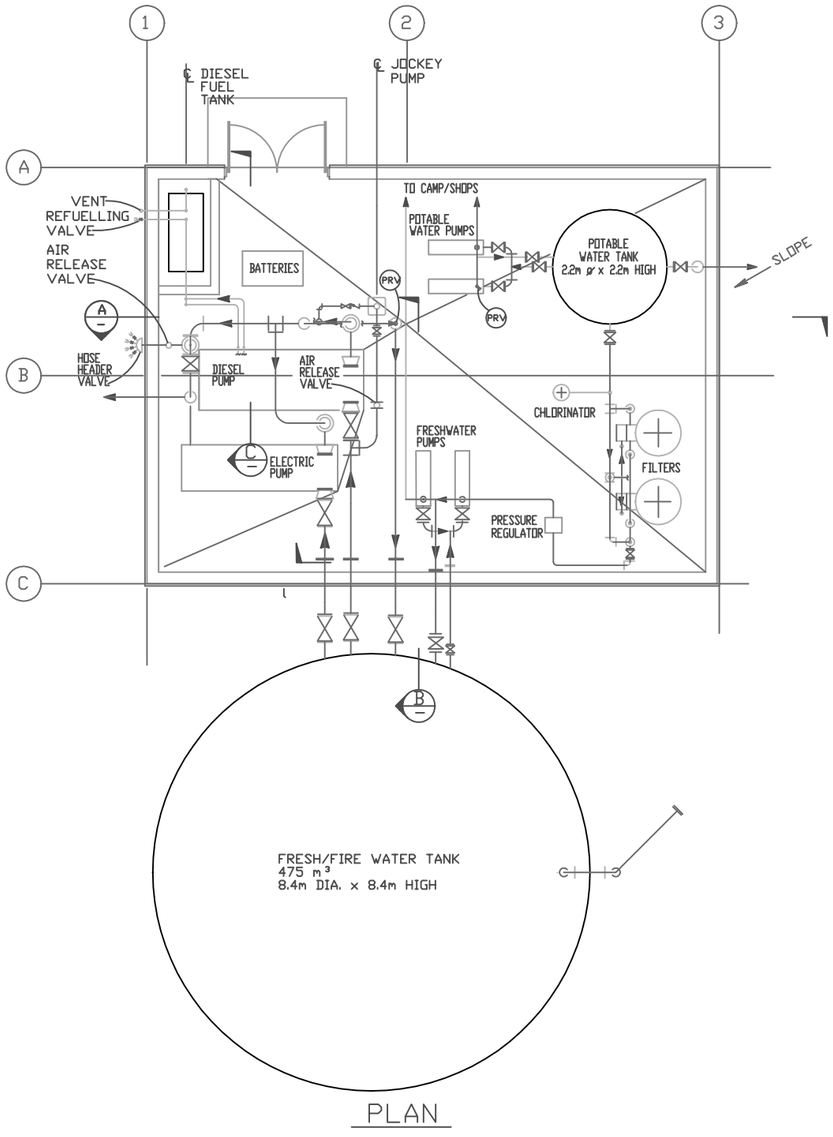
Drawing Number:
100-13-20

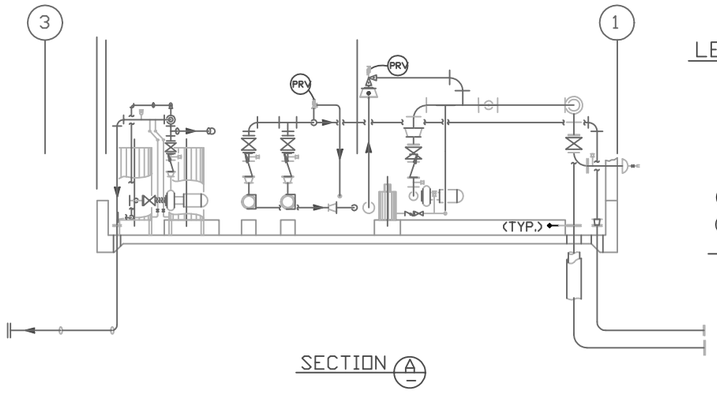
ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

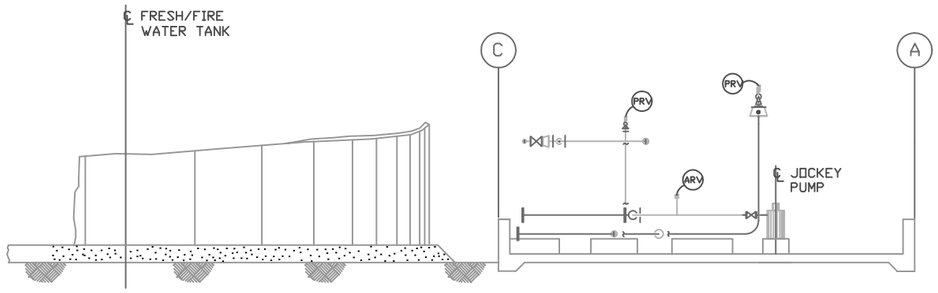
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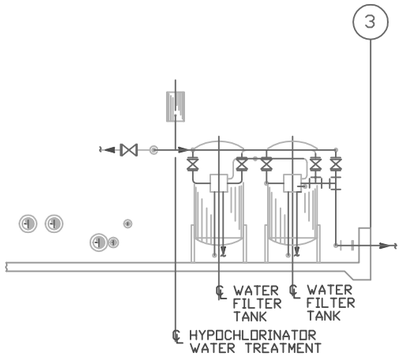


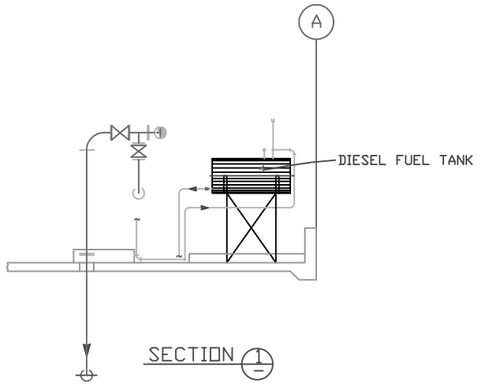


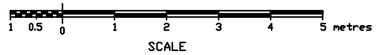
LEGEND:

WF	- FIRE WATER
WFR	- FRESH WATER
WP	- POTABLE WATER
FO	- FUEL OIL
PRV	- PRESSURE RELIEF VALVE
ARV	- AIR RELEASE VALVE
	- CHANGE OF PIPE MATERIAL OR CONTRACT NUMBER









Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Water Distribution Pumphouse Plan, Sections & Details", Drawing #100-13-21 Rev B

Water Distribution Pumphouse Plan, Sections & Details

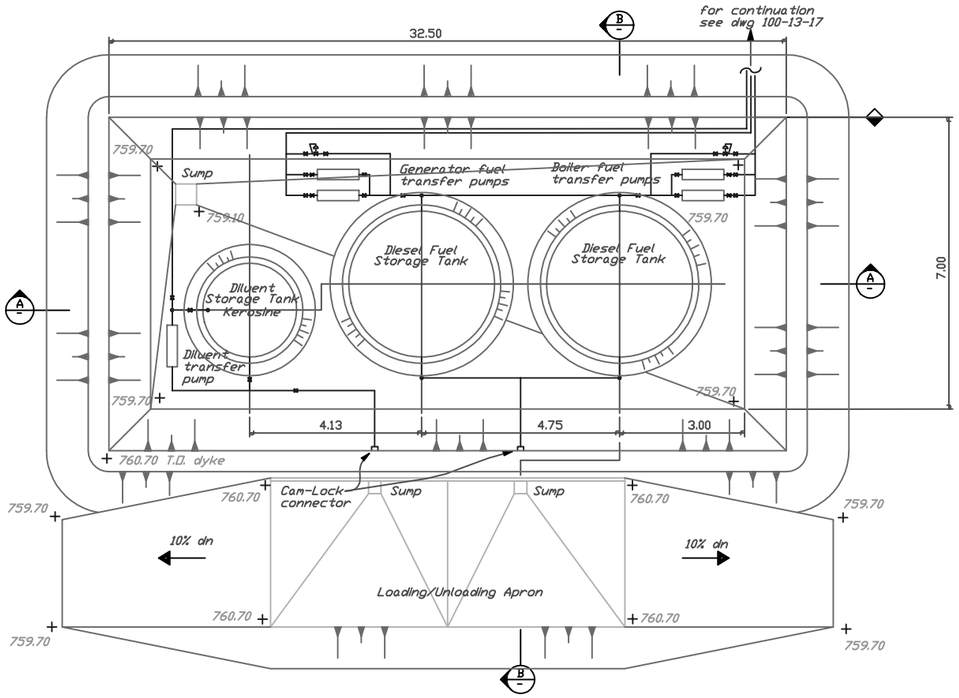
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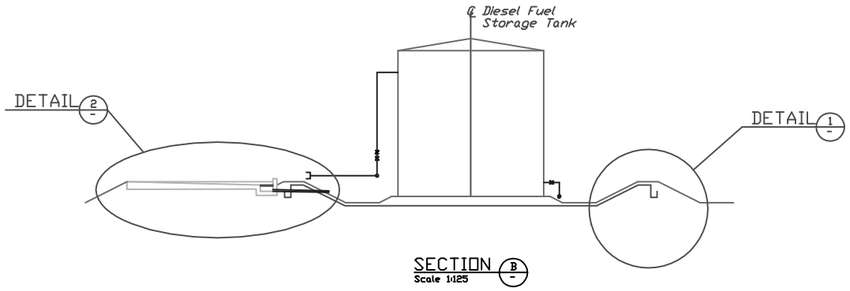
ACCESS CONSULTING GROUP

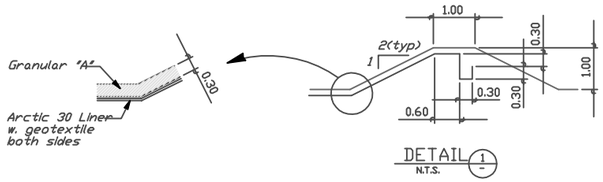
Revised by: HD	Checked by: DDC

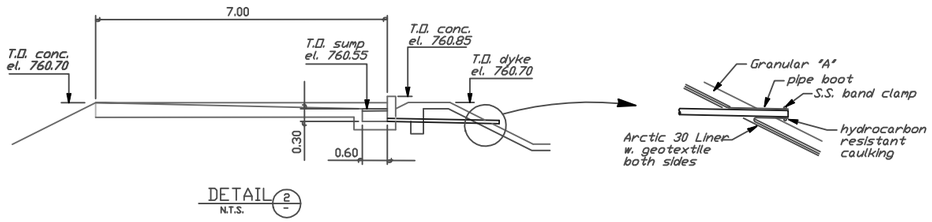
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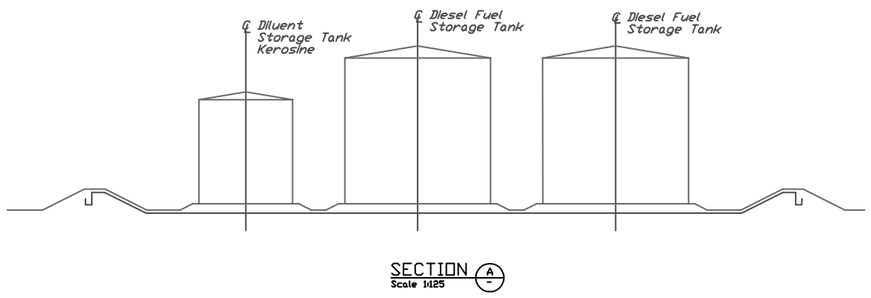
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Notes:

1. All dimensions and elevations in metres U.N.O.
2. Elevations shown are final grade.

5 0 5 10 metres
SCALE: 1:125

Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

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Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
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"Fuel Storage, Diesel Generators Plantsite Plan, Sections, Details",
Drawing #100-13-23 Rev B

Fuel Storage, Diesel Generators Plantsite Plan, Sections, Details

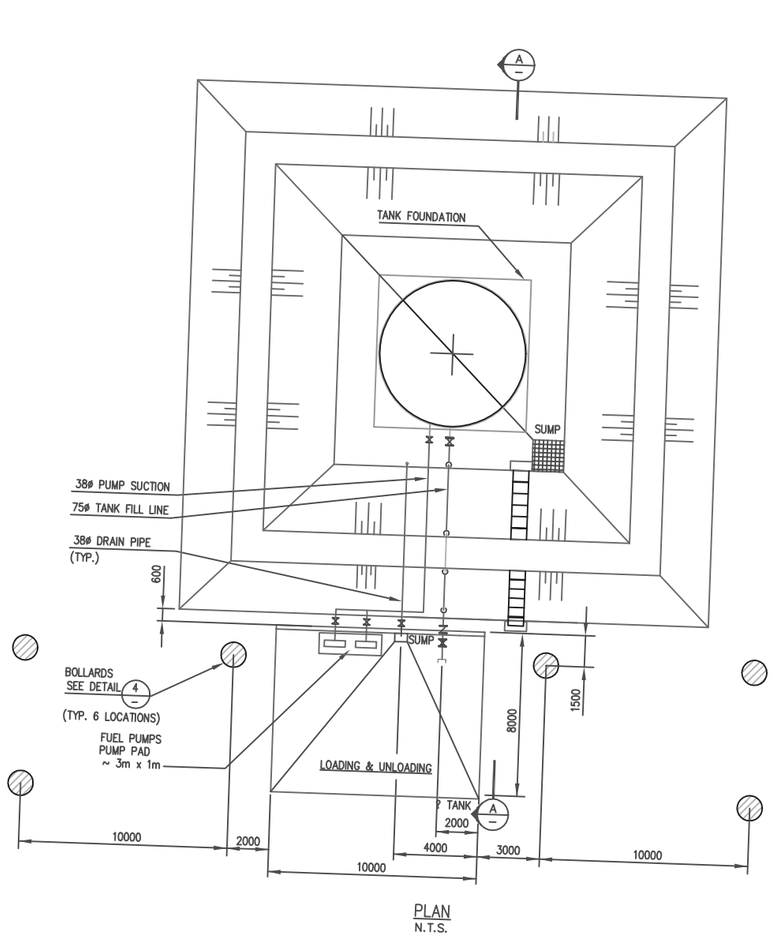
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ACCESS CONSULTING GROUP

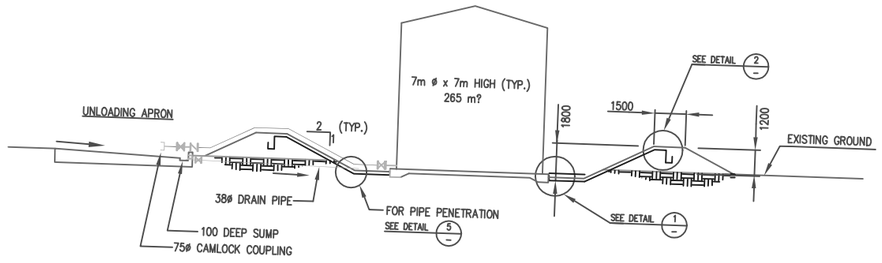
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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PLAN
N.T.S.

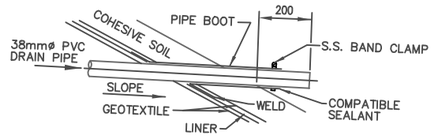


SECTION A
N.T.S.

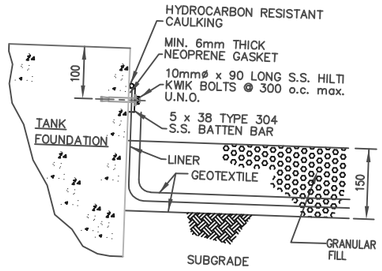
NOTES:

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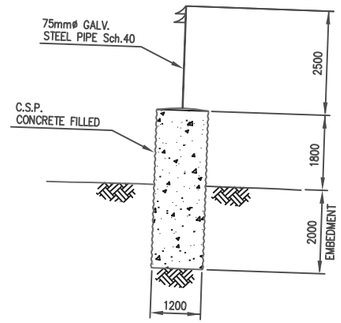
2.) FOR LOCATION SEE DWG. 100-13-11.



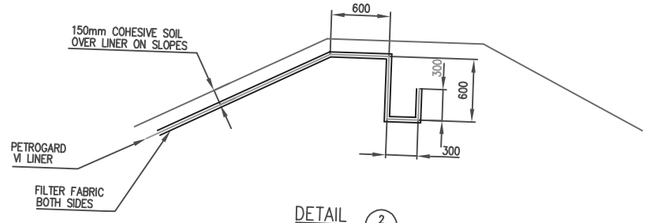
TYPICAL PIPE PENETRATION
DETAIL 5
N.T.S.



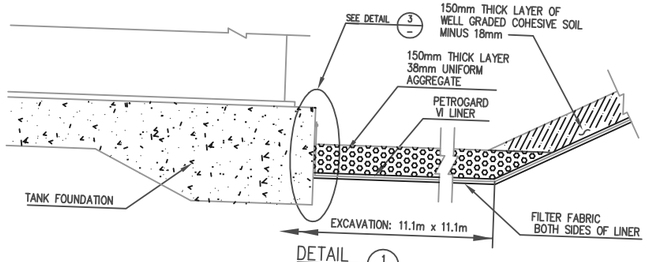
LINER ANCHORAGE AT FOUNDATION WALL
DETAIL 3
N.T.S.



TYPICAL BOLLARD
DETAIL 4
N.T.S.



DETAIL 2
N.T.S.



DETAIL 1
N.T.S.

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Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Fuel Storage Service Complex Plan, Sections & Details", Drawing #100-13-24 Rev B

Fuel Storage Service Complex Plan, Sections & Details

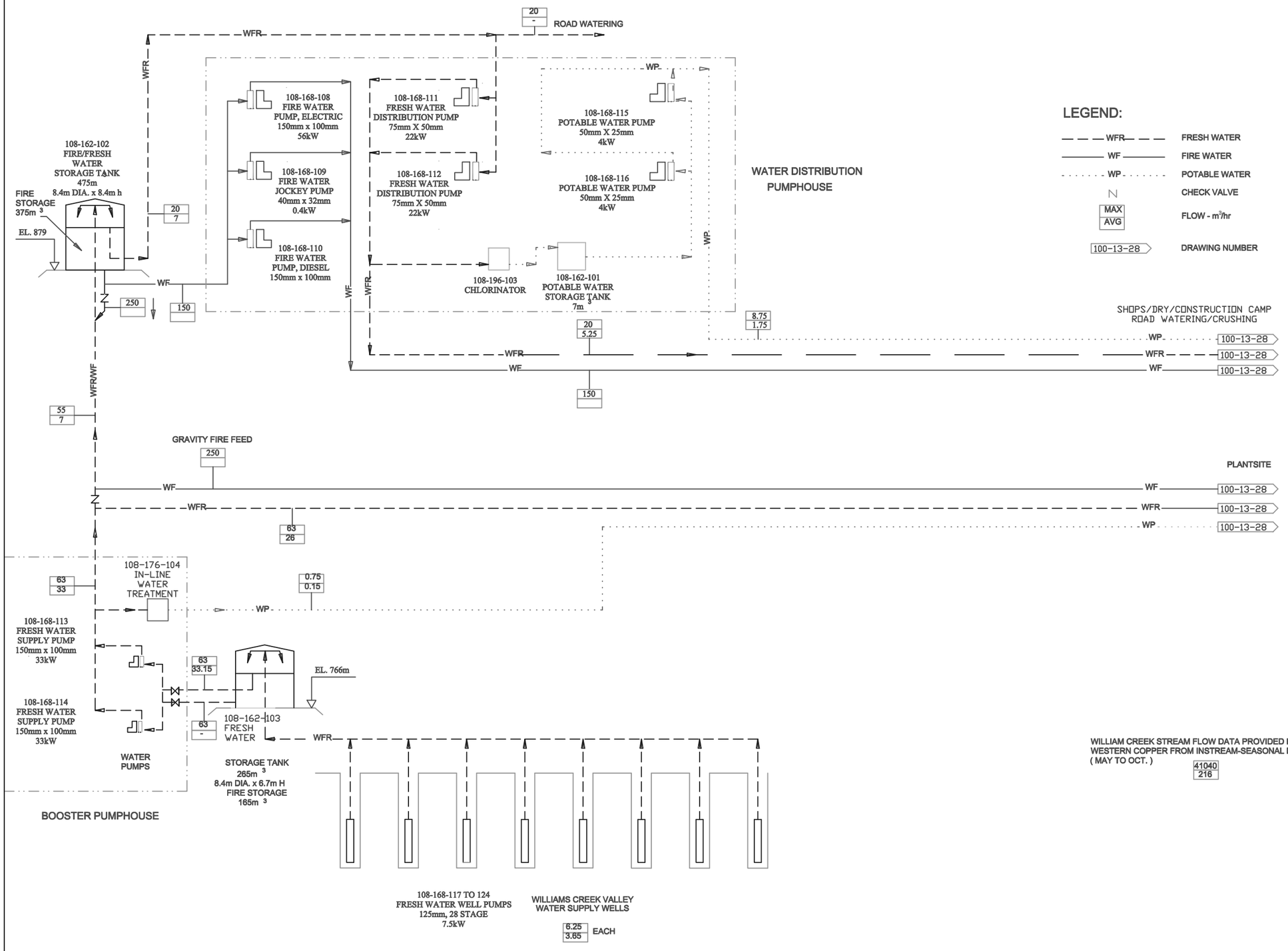
Drawing Number:
100-13-24

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1001324.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Water Supply Diagram",
Drawing #100-13-27 Rev B

Water Supply Diagram

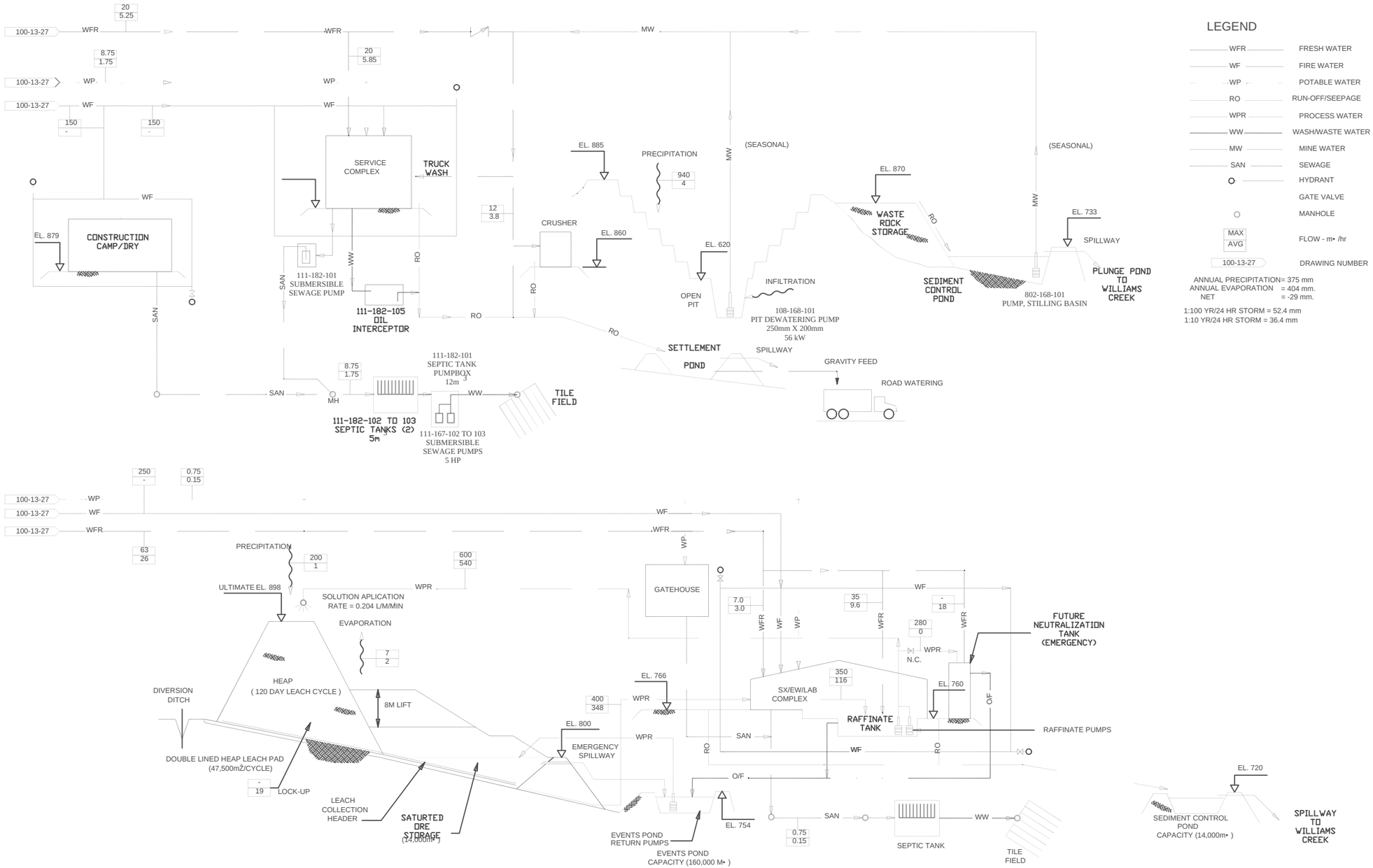
Drawing Number:
100-13-27

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1001327.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Water Distribution Diagram",
Drawing #100-13-28 Rev B

Water Distribution Diagram

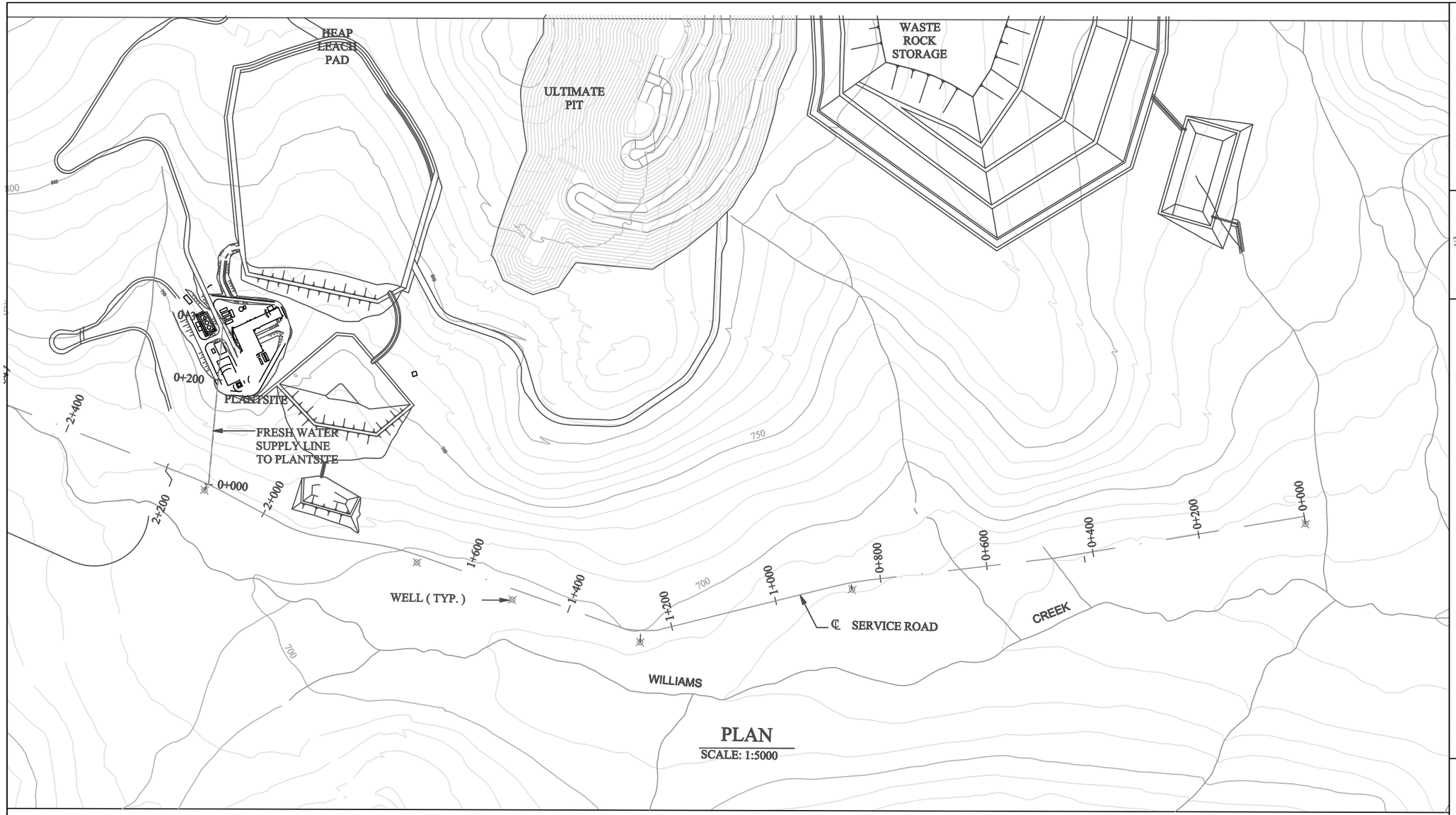
Drawing Number:
100-13-28

ACCESS CONSULTING GROUP

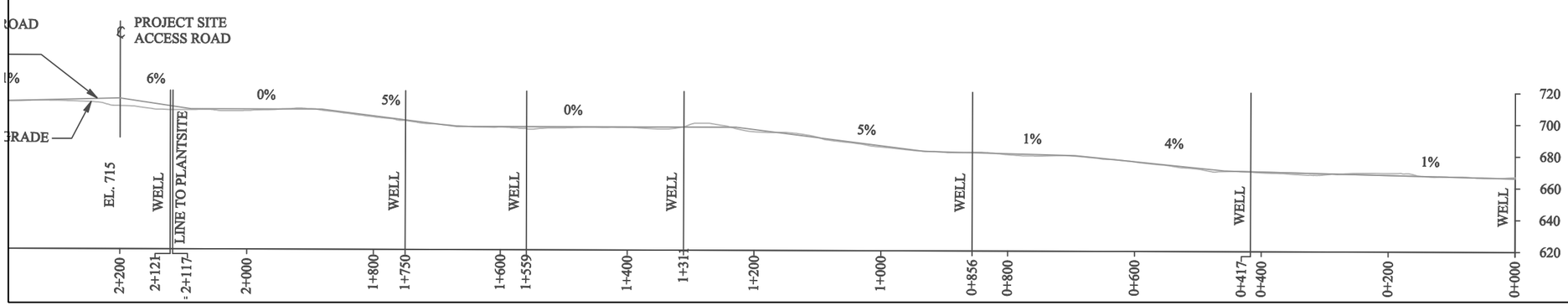
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1001328.dwg



PLAN
SCALE: 1:5000



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Water Supply Pipeline Plan and Profile",
Drawing #100-13-29 Rev A

Water Supply Pipeline Plan and Profile

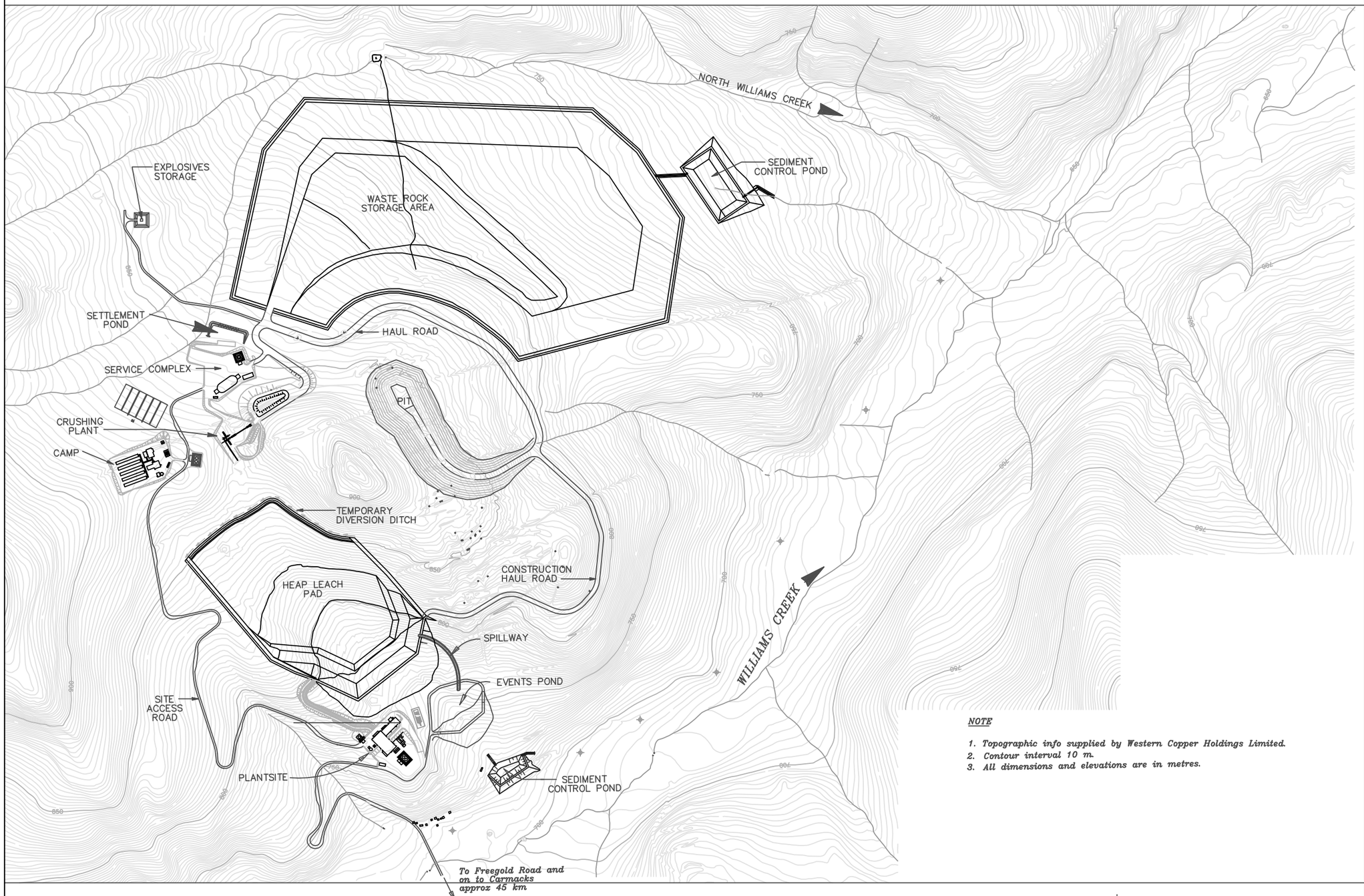
Drawing Number:
100-13-29

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1001329.dwg



NOTE

1. *Topographic info supplied by Western Copper Holdings Limited.*
2. *Contour interval 10 m.*
3. *All dimensions and elevations are in metres.*

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Overall Site Plan Year 2",
Drawing #100-13-45 Rev B

Overall Site Plan Year 2

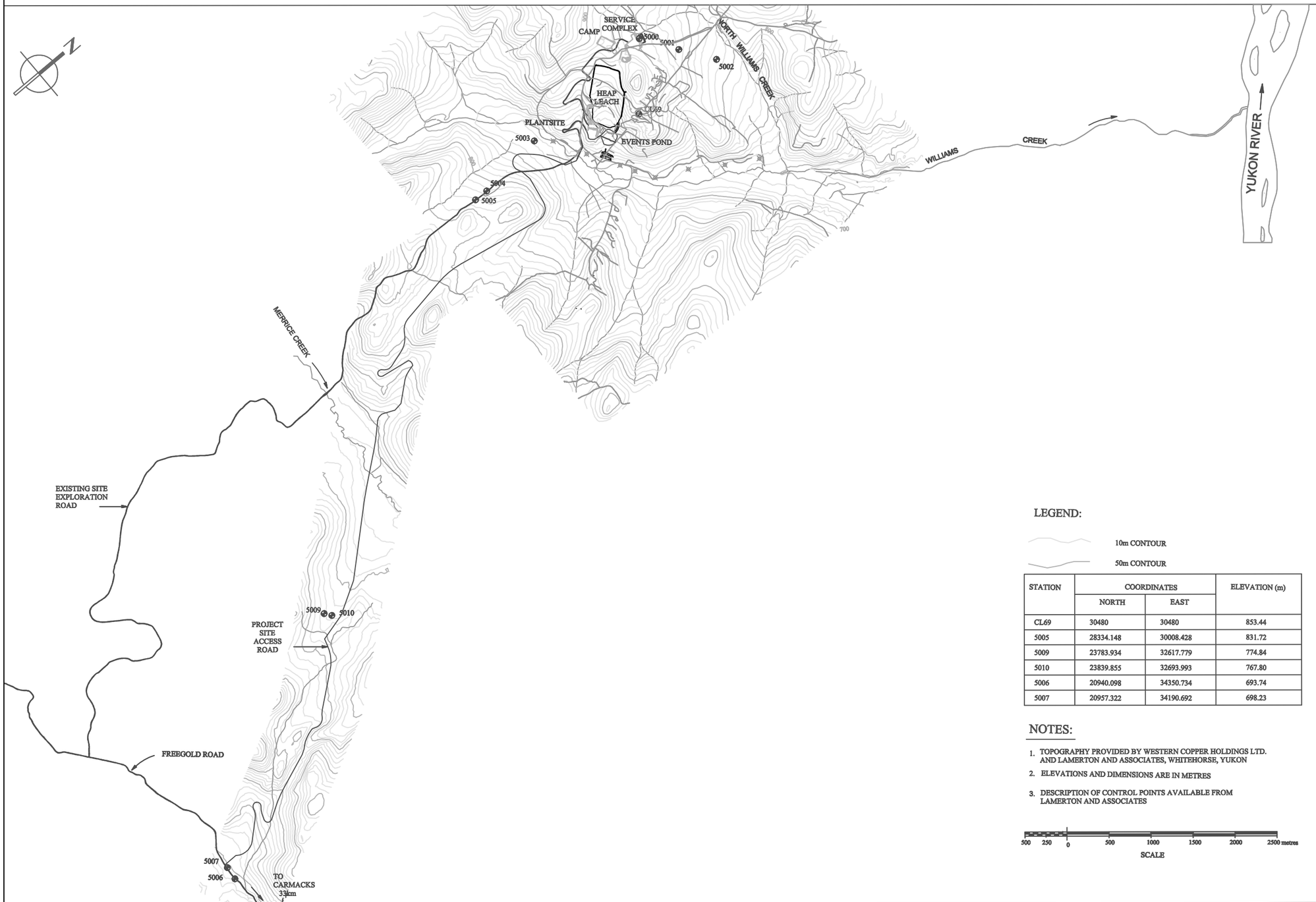
Drawing Number:
100-13-45

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1001345.dwg



LEGEND:

10m CONTOUR

50m CONTOUR

STATION	COORDINATES		ELEVATION (m)
	NORTH	EAST	
CL69	30480	30480	853.44
5005	28334.148	30008.428	831.72
5009	23783.934	32617.779	774.84
5010	23839.855	32693.993	767.80
5006	20940.098	34350.734	693.74
5007	20957.322	34190.692	698.23

NOTES:

1. TOPOGRAPHY PROVIDED BY WESTERN COPPER HOLDINGS LTD. AND LAMERTON AND ASSOCIATES, WHITEHORSE, YUKON
2. ELEVATIONS AND DIMENSIONS ARE IN METRES
3. DESCRIPTION OF CONTROL POINTS AVAILABLE FROM LAMERTON AND ASSOCIATES

500 250 0 500 1000 1500 2000 2500 metres

SCALE

Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Project Site Plan Earthworks Sheet 1",
Drawing #100-13-46

Project Site Plan Earthworks Sheet 1

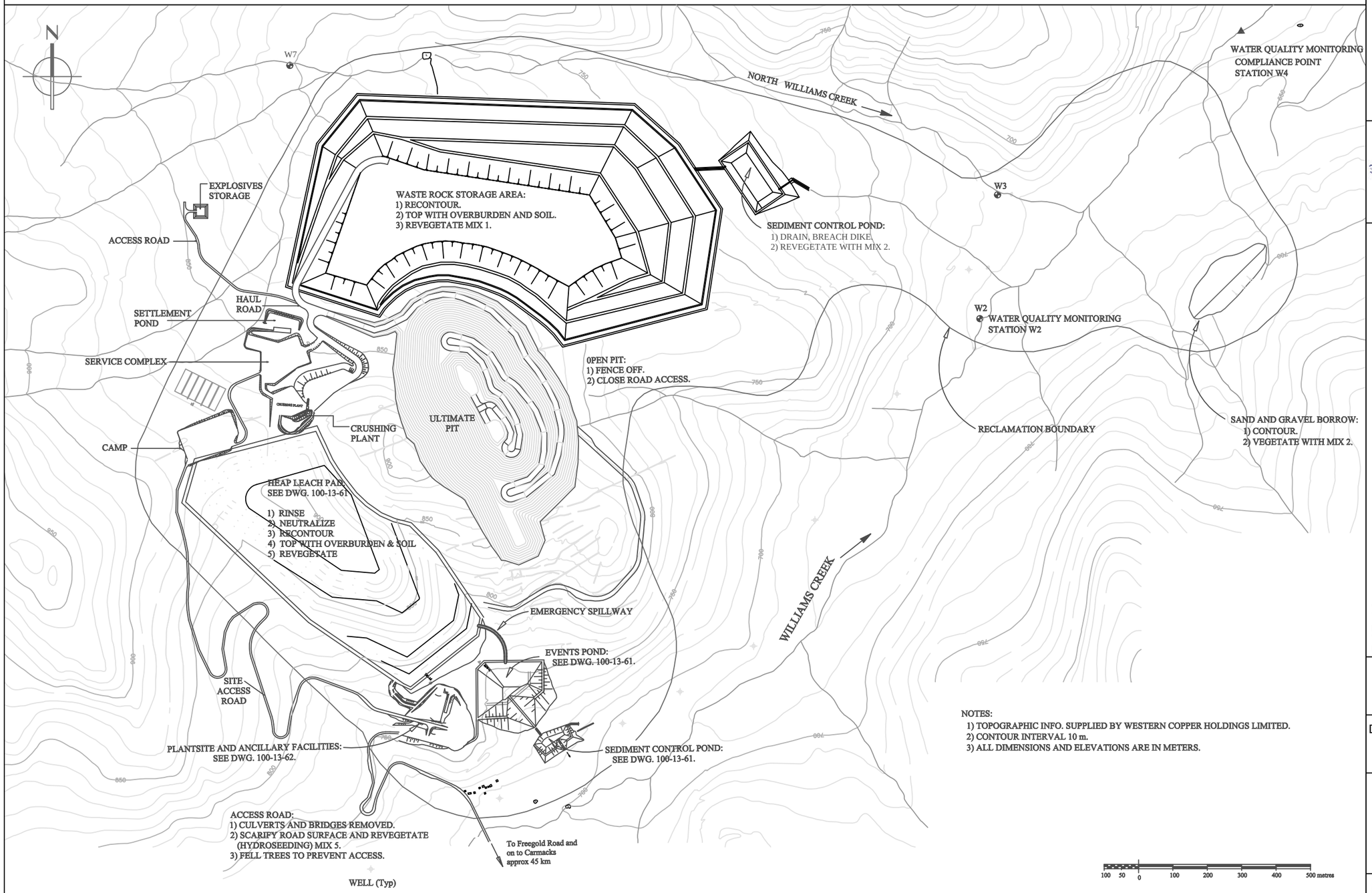
Drawing Number:
100-13-46

ACCESS CONSULTING GROUP

Revised by: HD | Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1001346.dwg



NOTES:
1) TOPOGRAPHIC INFO. SUPPLIED BY WESTERN COPPER HOLDINGS LIMITED.
2) CONTOUR INTERVAL 10 m.
3) ALL DIMENSIONS AND ELEVATIONS ARE IN METERS.

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Overall Site Conceptual Reclamation/Closure Plan", Drawing #100-13-60 Rev B

Overall Site Conceptual Reclamation/Closure Plan

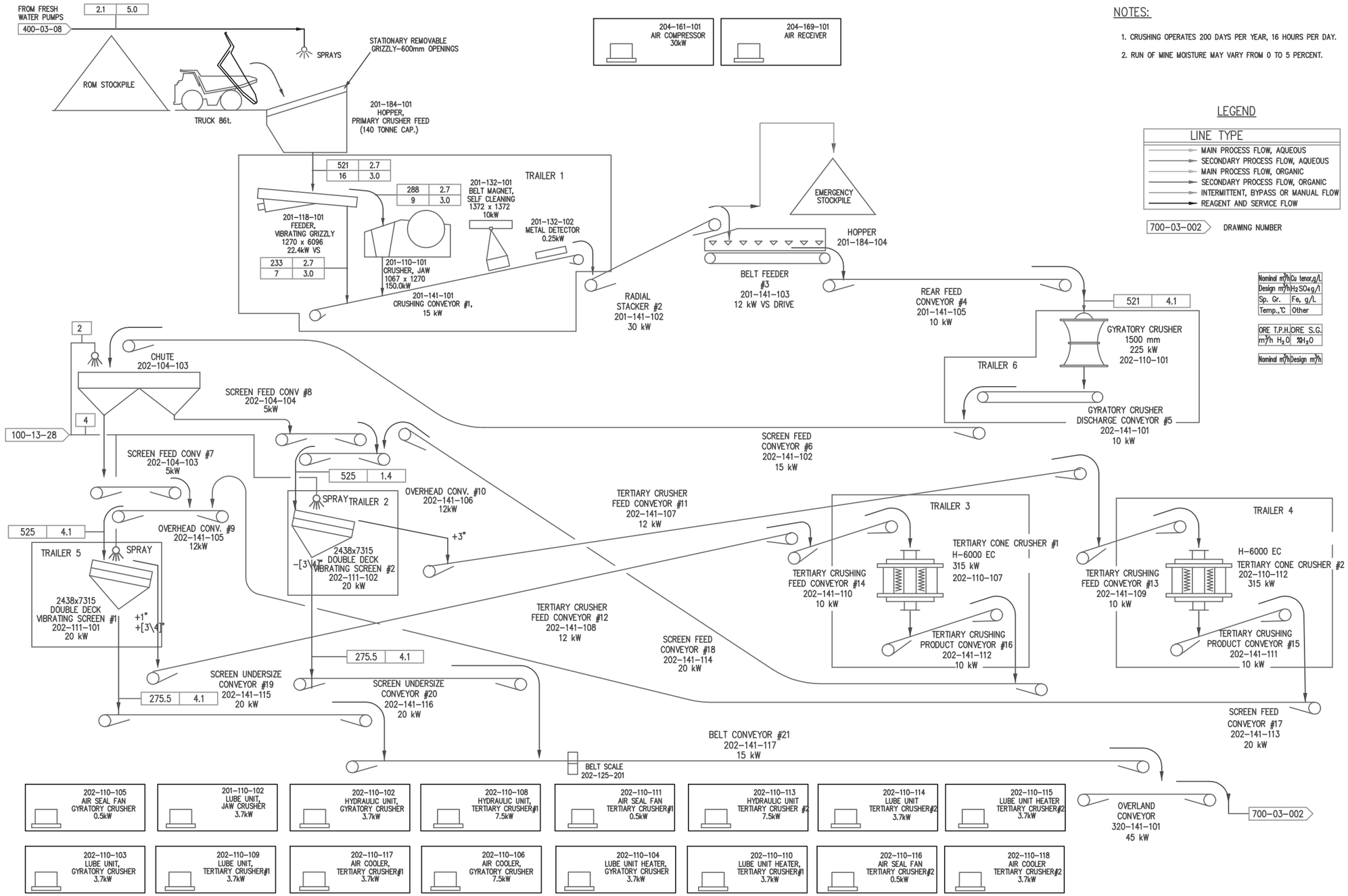
Drawing Number:
100-13-60

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\WCH-01\cad\conceptual_closure_dwgs\1001360.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Crushing and Screening Flowsheet #1",
Drawing #200-03-01 Rev G

Crushing and Screening Flowsheet #1

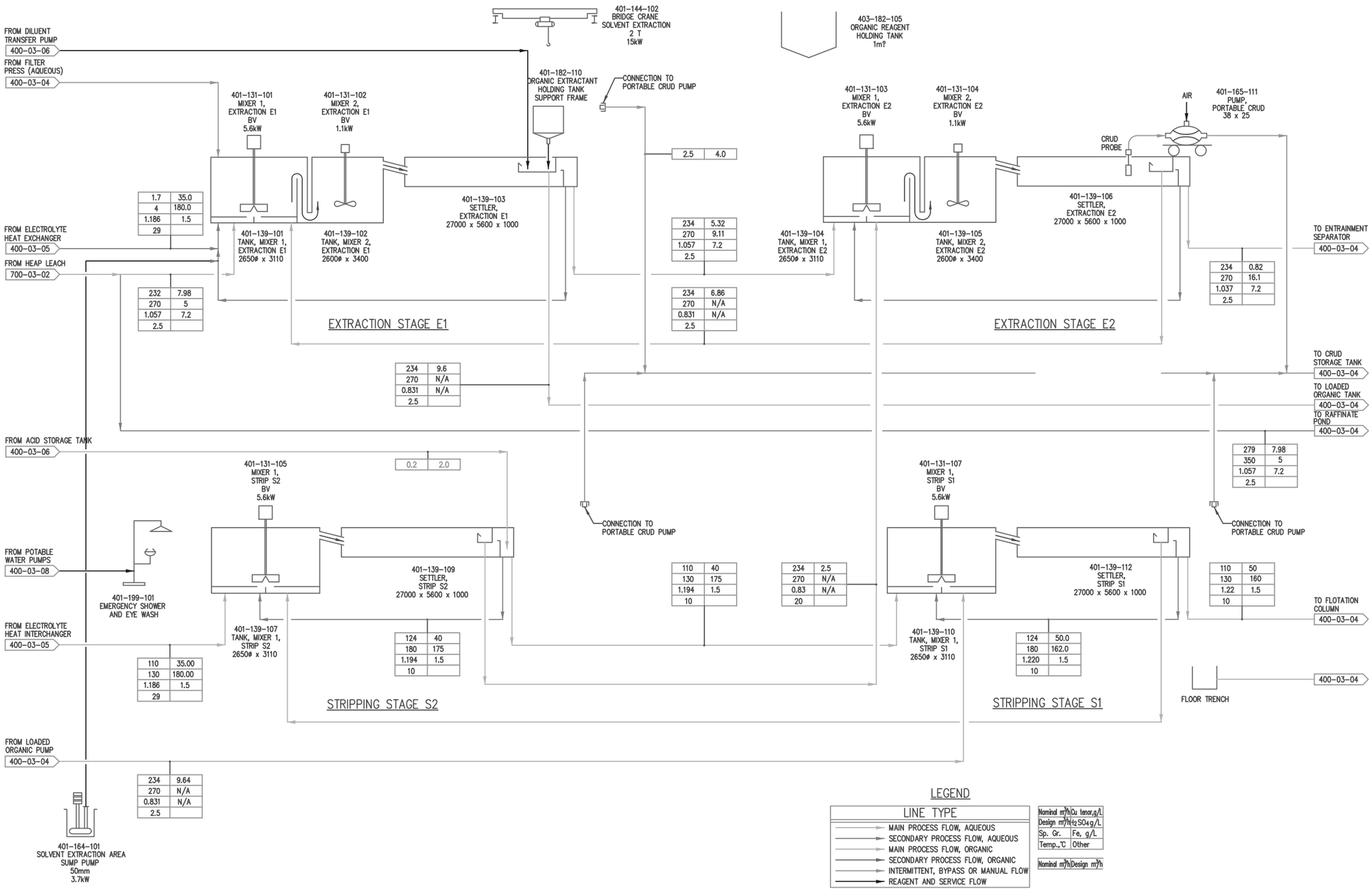
Drawing Number:
200-03-01

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\2000301.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Solvent Extraction & Stripping Flowsheet #3",
Drawing #400-03-03 Rev E

Solvent Extraction & Stripping Flowsheet #3

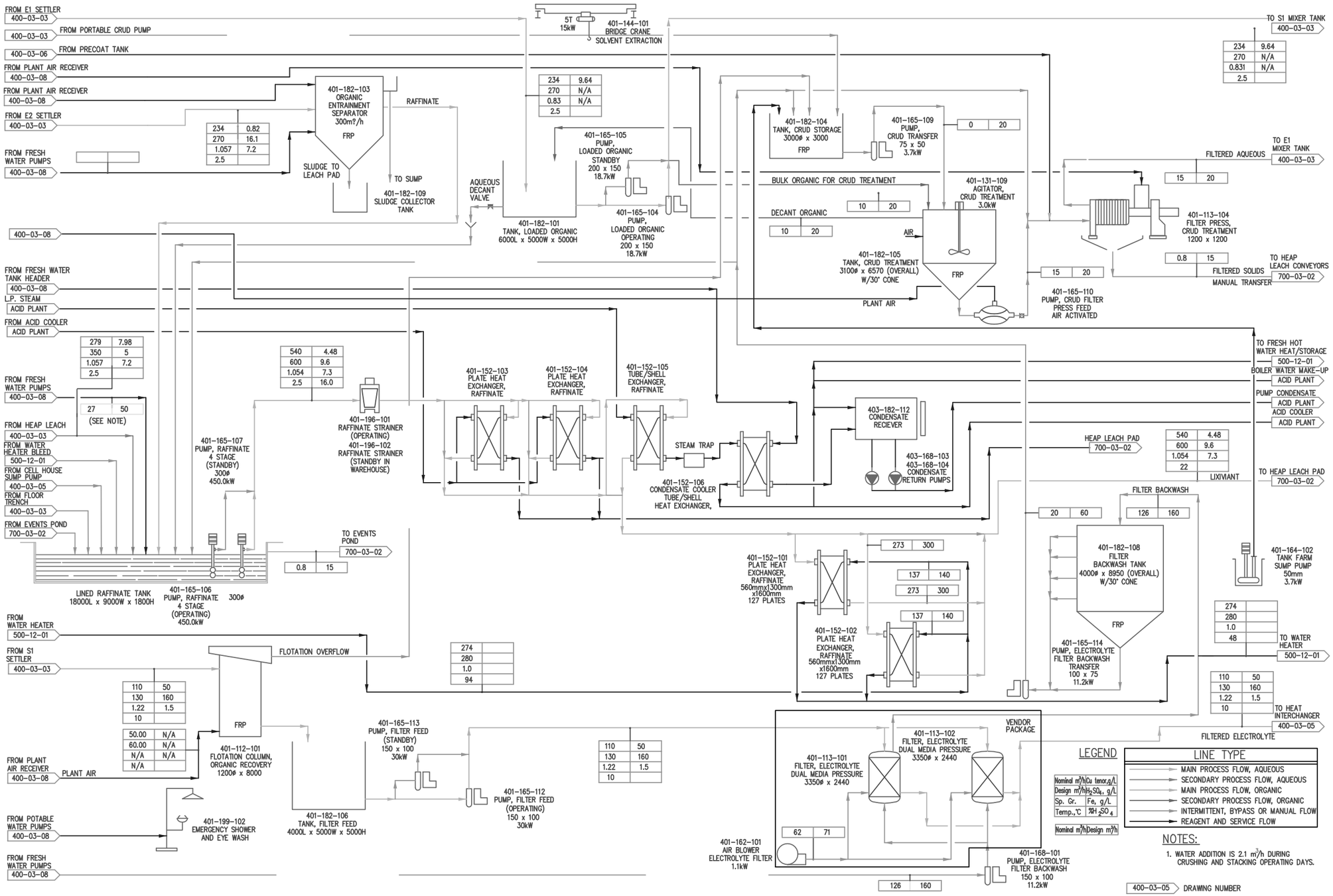
Drawing Number:
400-03-03

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4000303.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Flotation & Organic Treatment Flowsheet #4",
Drawing #400-03-04 Rev E

Flotation & Organic Treatment Flowsheet #4

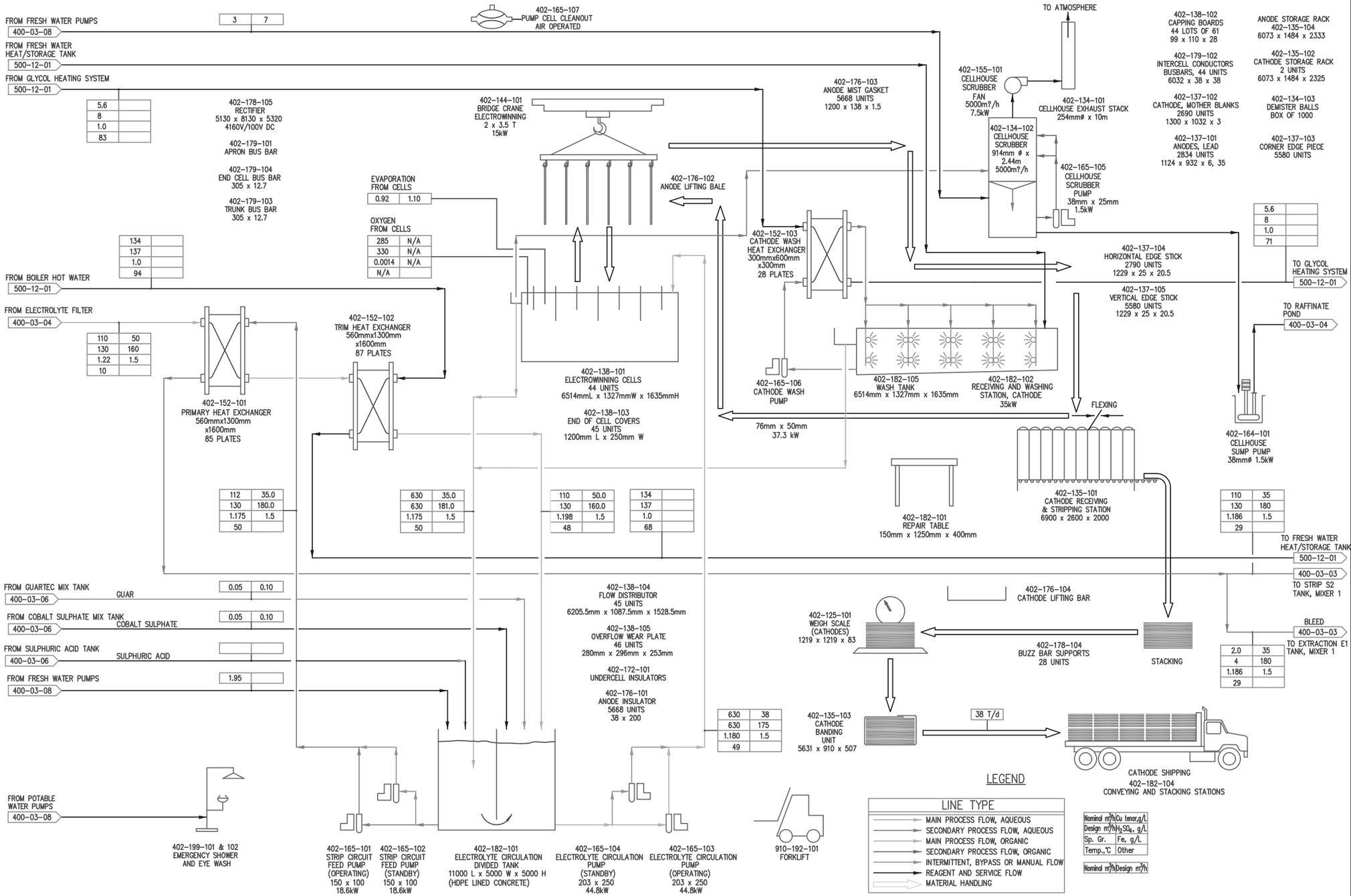
Drawing Number:
400-03-04

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4000304.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Electrowinning Flowsheet #5",
Drawing #400-03-05 Rev E

Electrowinning Flowsheet #5

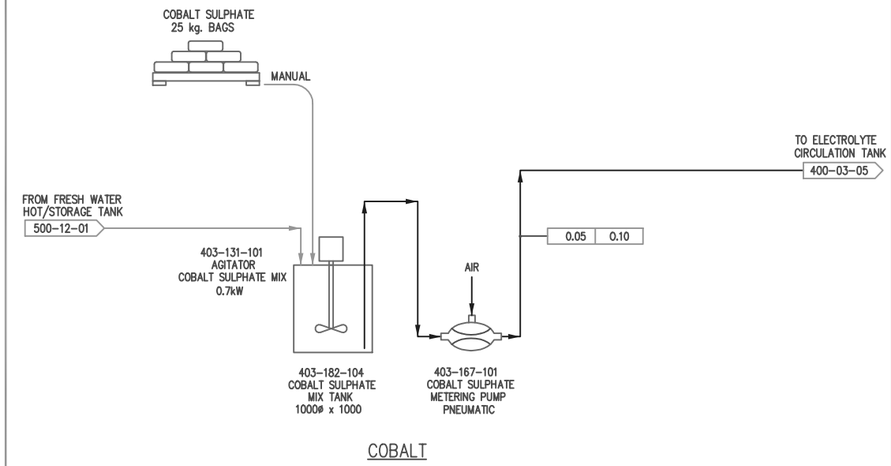
Drawing Number:
400-03-05

ACCESS CONSULTING GROUP

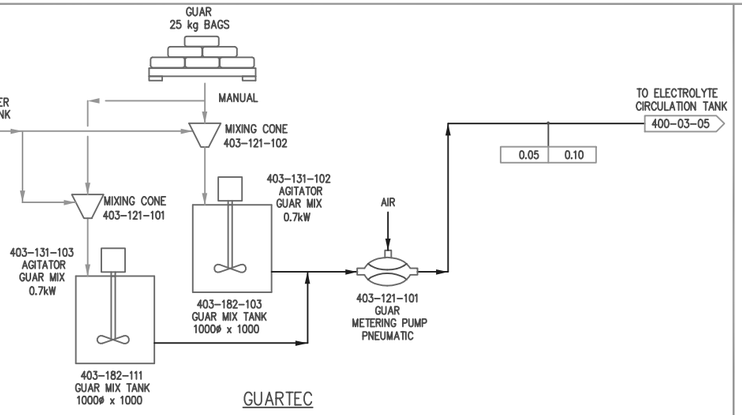
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

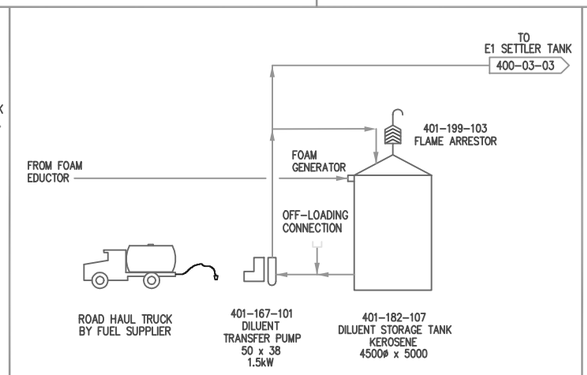
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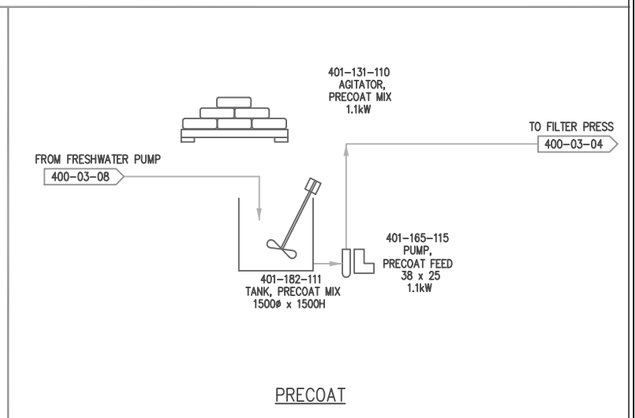
COBALT



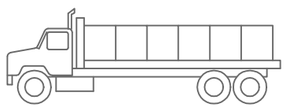
GUARTEC



DILUENT(KEROSENE)



PRECOAT

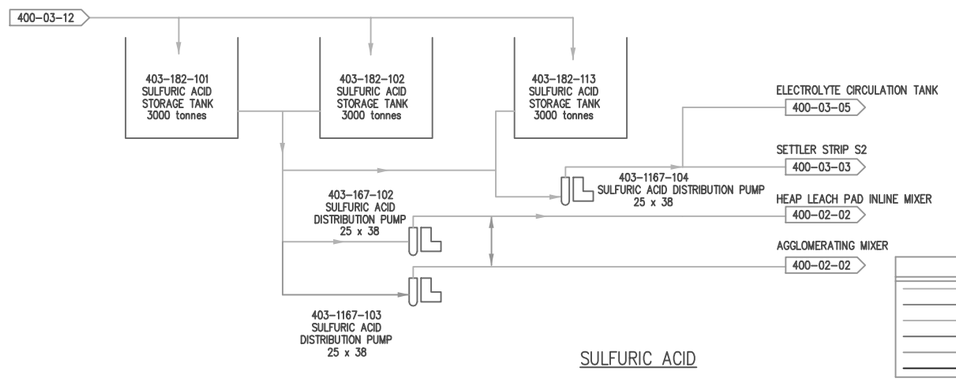




403-182-105
ORGANIC REAGENT
HOLDING TANK
1M?

MECHANICAL TRANSFER TO
E2 SETTLER TANK DWG # 400-03-03

EXTRACTANT REAGENT



SULFURIC ACID

LEGEND

LINE TYPE	Nominal m³/h/Design m³/h
MAIN PROCESS FLOW, AQUEOUS	
SECONDARY PROCESS FLOW, AQUEOUS	
MAIN PROCESS FLOW, ORGANIC	
SECONDARY PROCESS FLOW, ORGANIC	
INTERMITTENT, BYPASS OR MANUAL FLOW	
REAGENT AND SERVICE FLOW	

400-02-02 DRAWING NUMBER

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Reagents Flowsheet #6",
Drawing #400-03-06 Rev D

Reagents Flowsheet #6

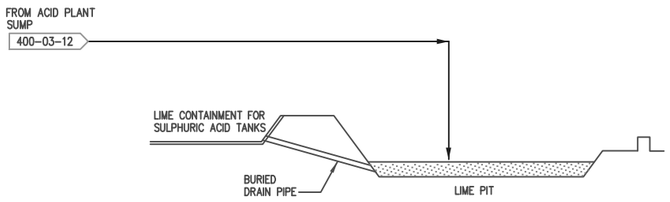
Drawing Number:
400-03-06

ACCESS CONSULTING GROUP

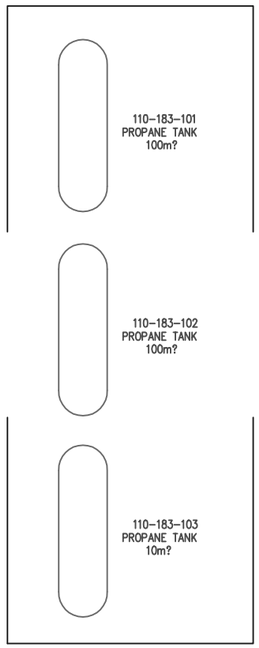
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4000306.dwg

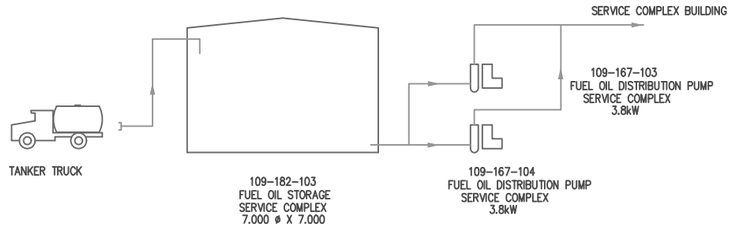


TYPICAL EMERGENCY NEUTRALIZATION LIME PIT
(SULPHURIC ACID PLANT)



PROPANE PACKAGE

PROPANE SYSTEM



LEGEND

LINE TYPE
MAIN PROCESS FLOW, AQUEOUS
SECONDARY PROCESS FLOW, AQUEOUS
MAIN PROCESS FLOW, ORGANIC
SECONDARY PROCESS FLOW, ORGANIC
INTERMITTENT, BYPASS OR MANUAL FLOW
REAGENT AND SERVICE FLOW

Nominal m^3/h	Cu tenor, g/L
Design m^3/h	H_2SO_4 g/L
Sp. Gr.	Fe, g/L
Temp., °C	Other

Nominal m^3/h | Design m^3/h

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Ancillary Facilities Flowsheet #7",
Drawing #400-03-07 Rev C

Ancillary Facilities Flowsheet #7

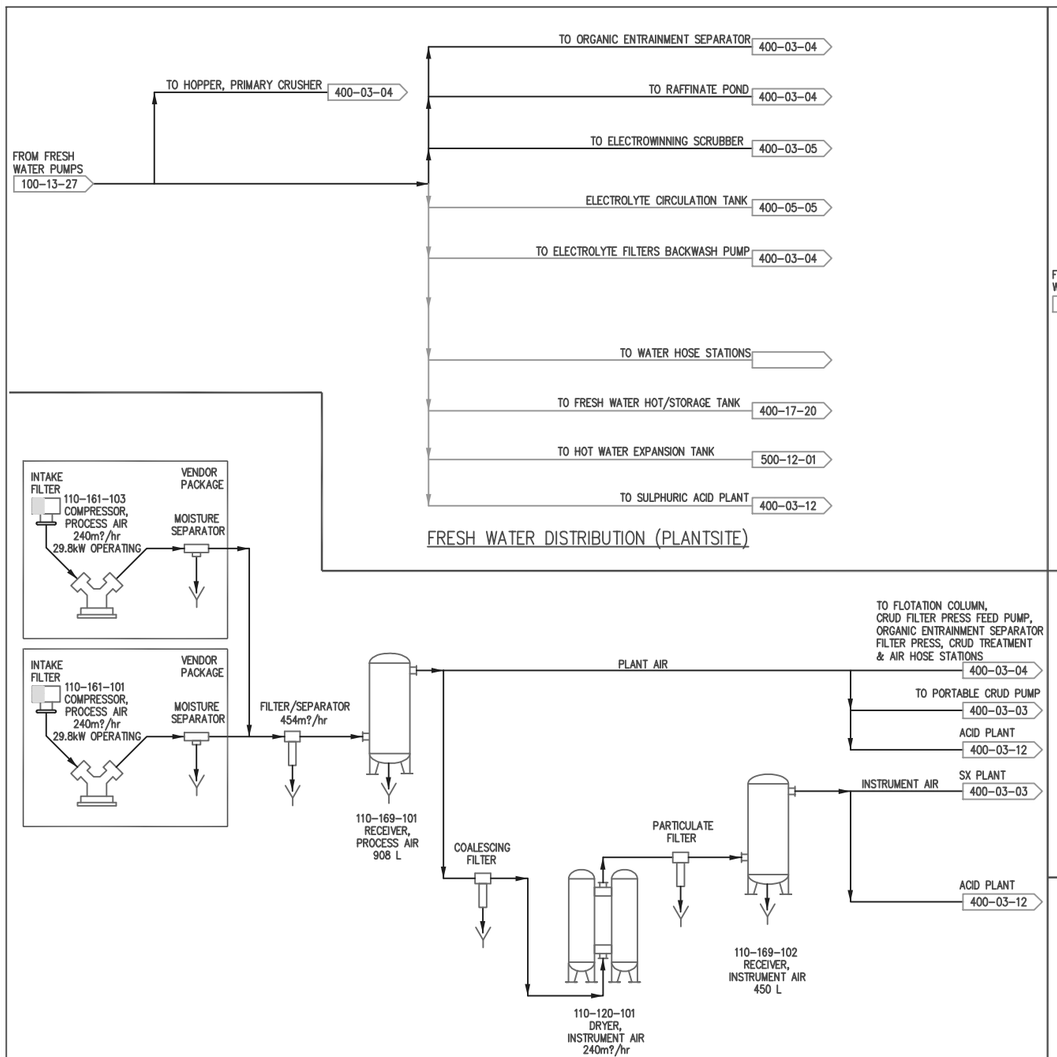
Drawing Number:
400-03-07

ACCESS CONSULTING GROUP

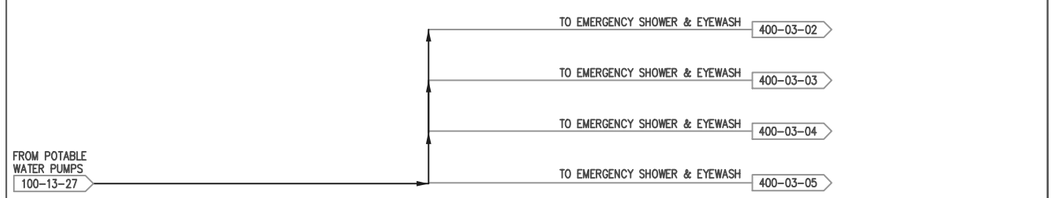
Revised by: HD | Checked by: DDC

Date: Feb. 1, 2005

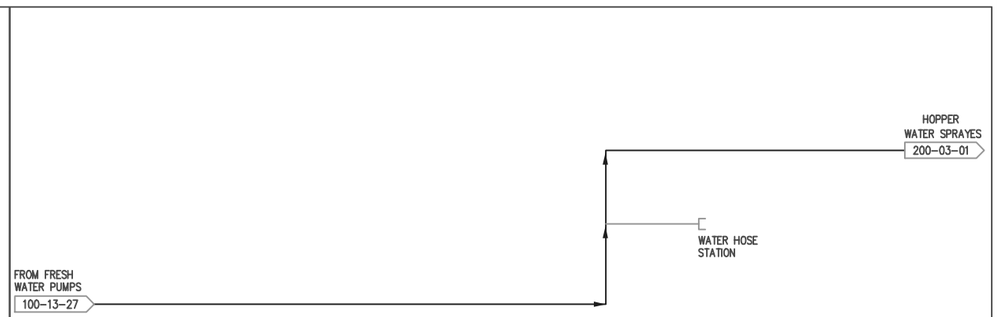
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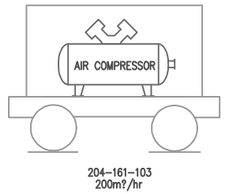
PROCESS AIR/INSTRUMENT AIR (PLANT SIDE)



POTABLE WATER DISTRIBUTION



FRESH WATER DISTRIBUTION (CRUSHER AREA)



PLANT AIR – PORTABLE UNIT(CRUSHER AREA)

LEGEND

LINE TYPE	Nominal m³/h/Design m³/h
MAIN PROCESS FLOW, AQUEOUS	
SECONDARY PROCESS FLOW, AQUEOUS	
MAIN PROCESS FLOW, ORGANIC	
SECONDARY PROCESS FLOW, ORGANIC	
INTERMITTENT, BYPASS OR MANUAL FLOW	
REAGENT AND SERVICE FLOW	

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Water and Air Flowsheet #8",
Drawing #400-03-08 Rev D

Water and Air Flowsheet #8

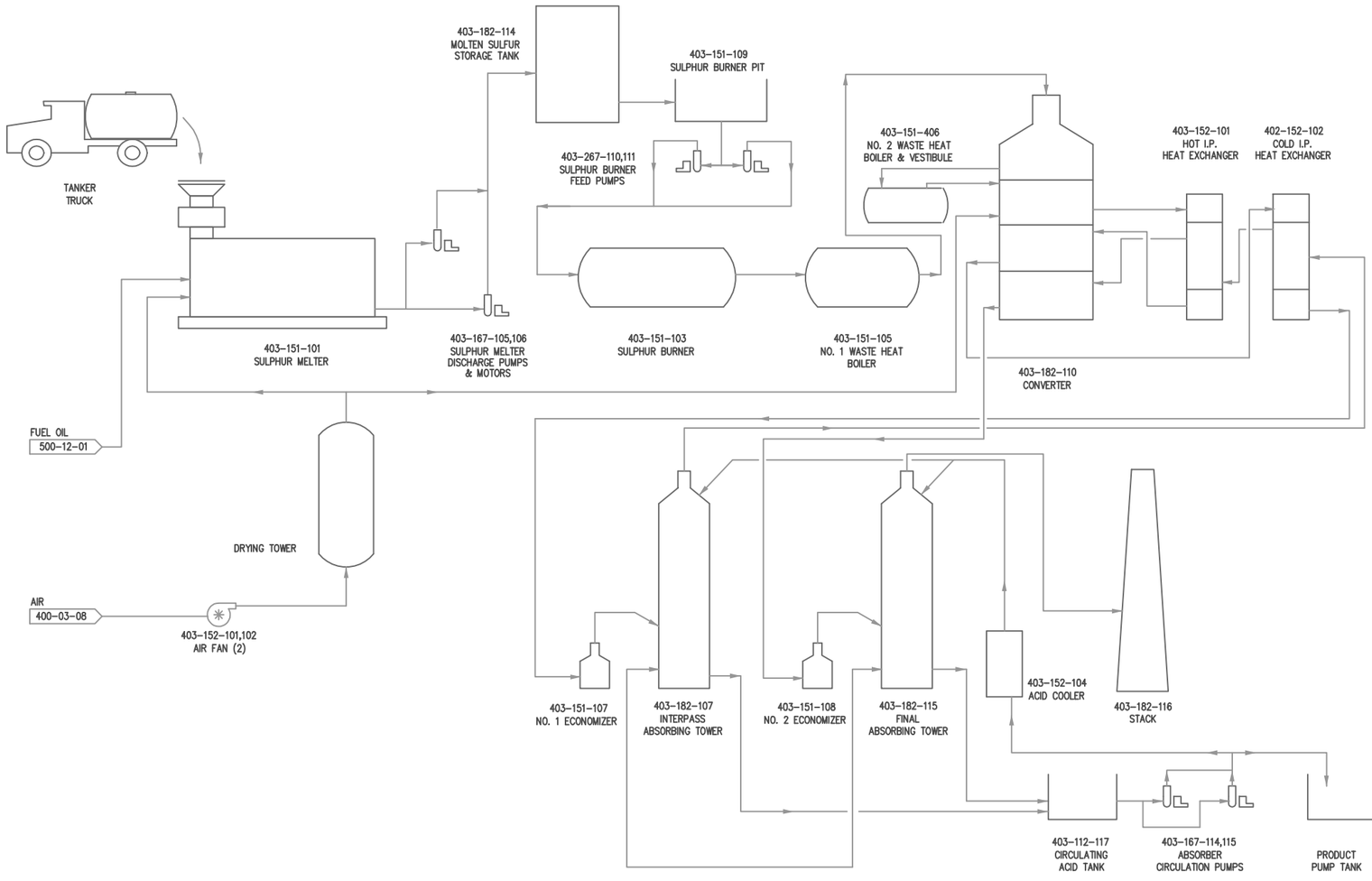
Drawing Number:
400-03-08

ACCESS CONSULTING GROUP

Revised by: HD | Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4000308.dwg



LINE TYPE
MAIN PROCESS FLOW, AQUEOUS
SECONDARY PROCESS FLOW, AQUEOUS
MAIN PROCESS FLOW, ORGANIC
SECONDARY PROCESS FLOW, ORGANIC
INTERMITTENT, BYPASS OR MANUAL FLOW
REAGENT AND SERVICE FLOW

400-03-06 DRAWING NUMBER

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Sulphuric Acid Plant Flowsheet #10",
Drawing #400-03-12 Rev C

Sulphuric Acid Plant Flowsheet #10

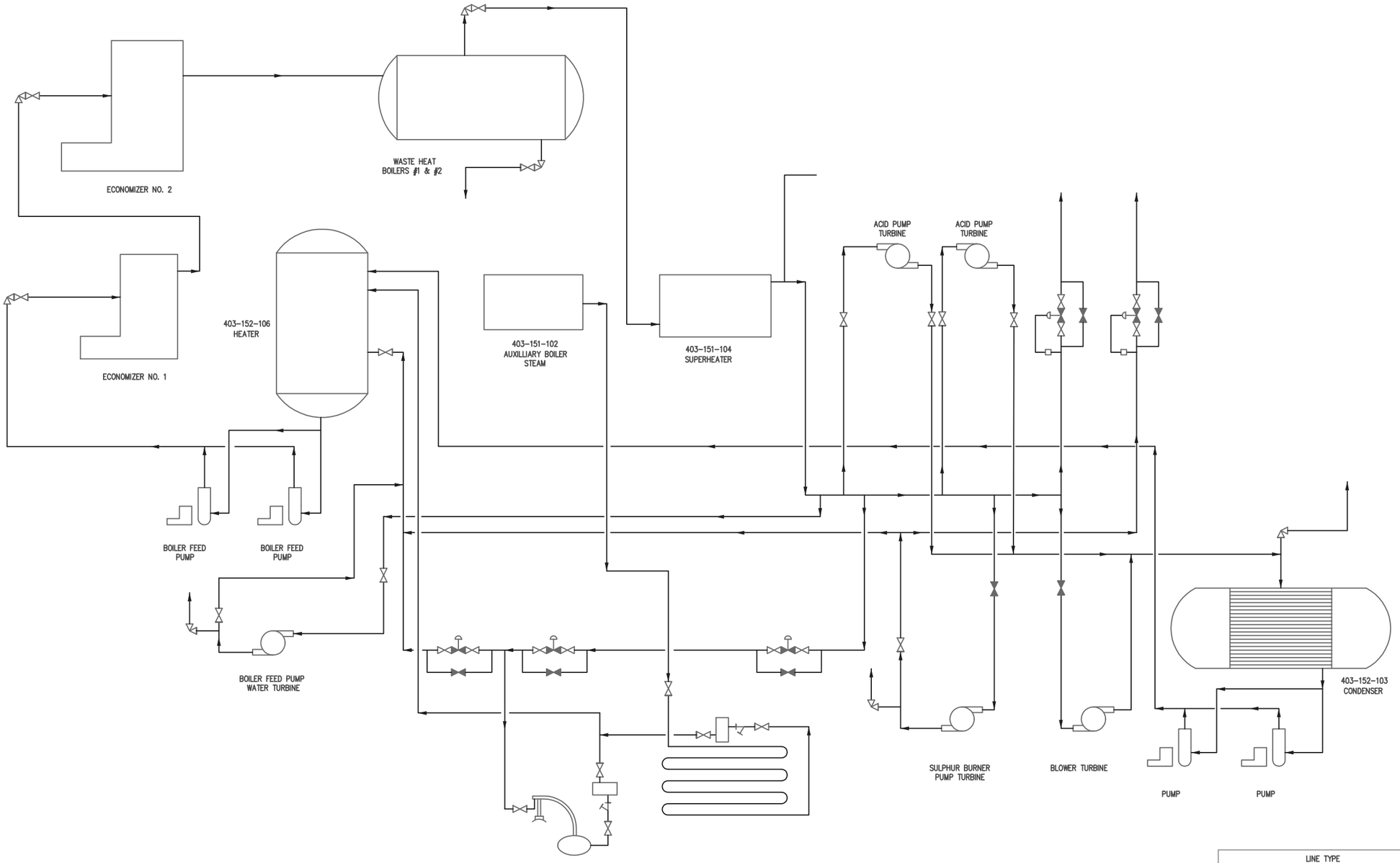
Drawing Number:
400-03-12

ACCESS CONSULTING GROUP

Revised by: HD | Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4000312.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Sulphuric Acid Plant Stream Distribution Diagram",
Drawing #400-03-13 Rev C

Sulphuric Acid Plant Stream Distribution Diagram

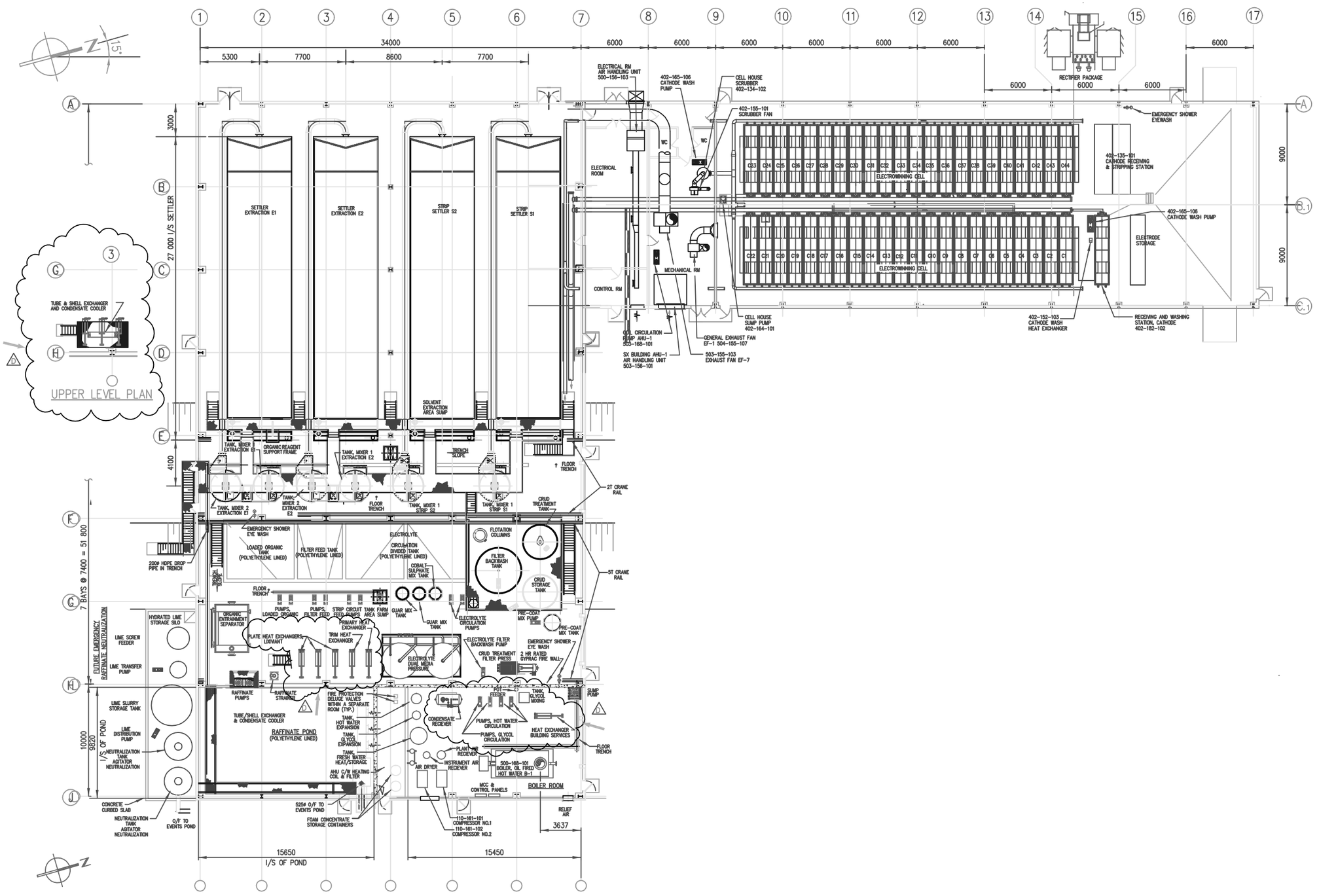
Drawing Number:
400-03-13

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4000313.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Recovery Overall General Arrangement Plan",
Drawing #400-10-06 Rev D

Recovery Overall General Arrangement Plan

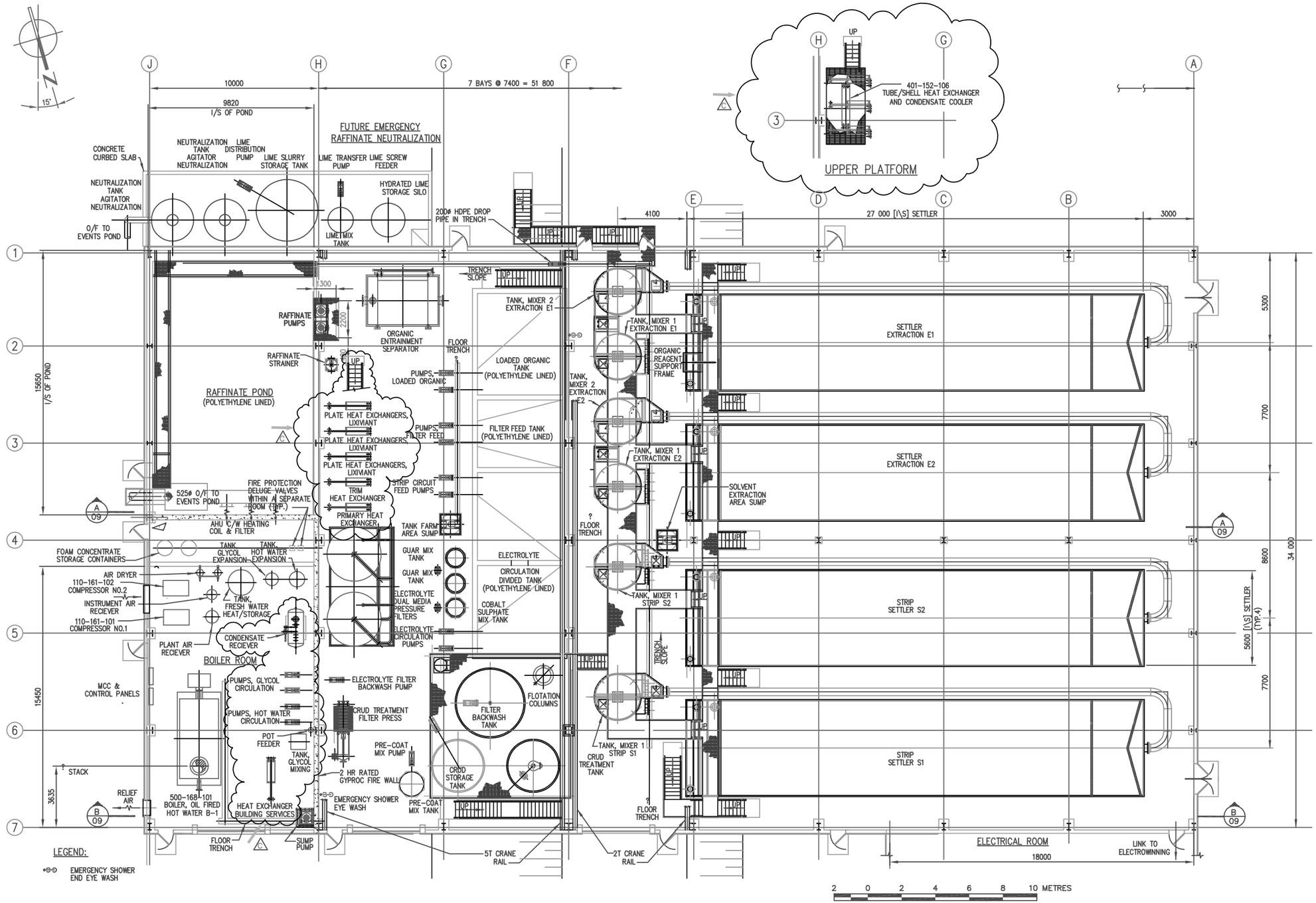
Drawing Number:
400-10-06

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4001006.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Solvent Extraction General Arrangement Plan",
Drawing #400-10-07 Rev C

Solvent Extraction General Arrangement Plan

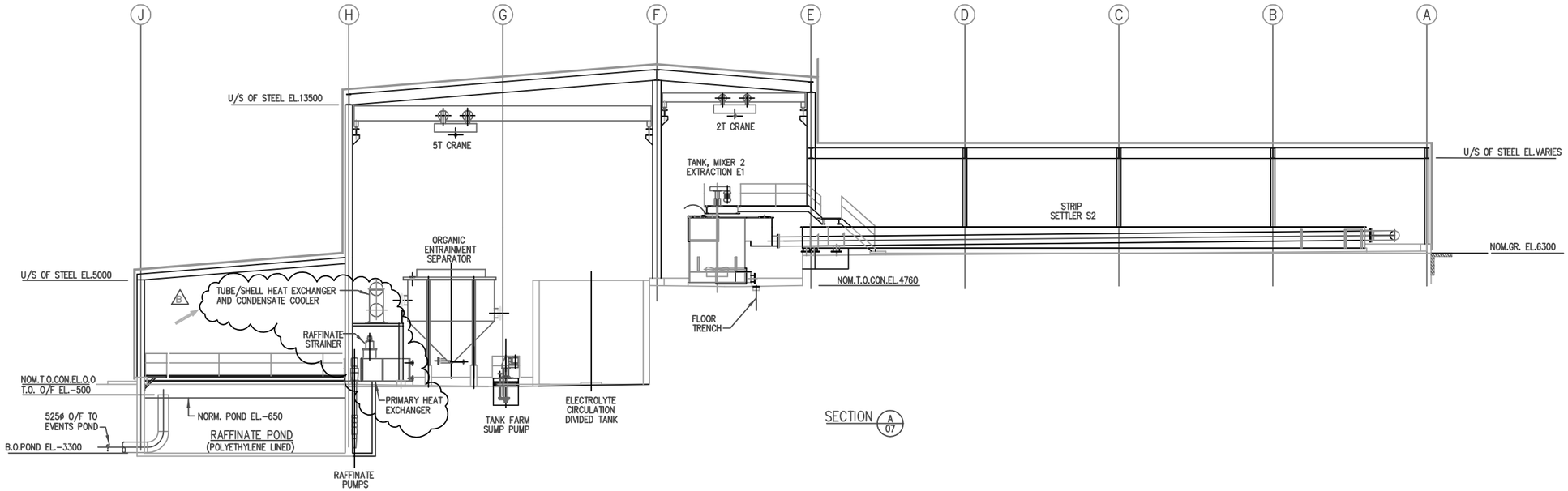
Drawing Number:
400-10-07

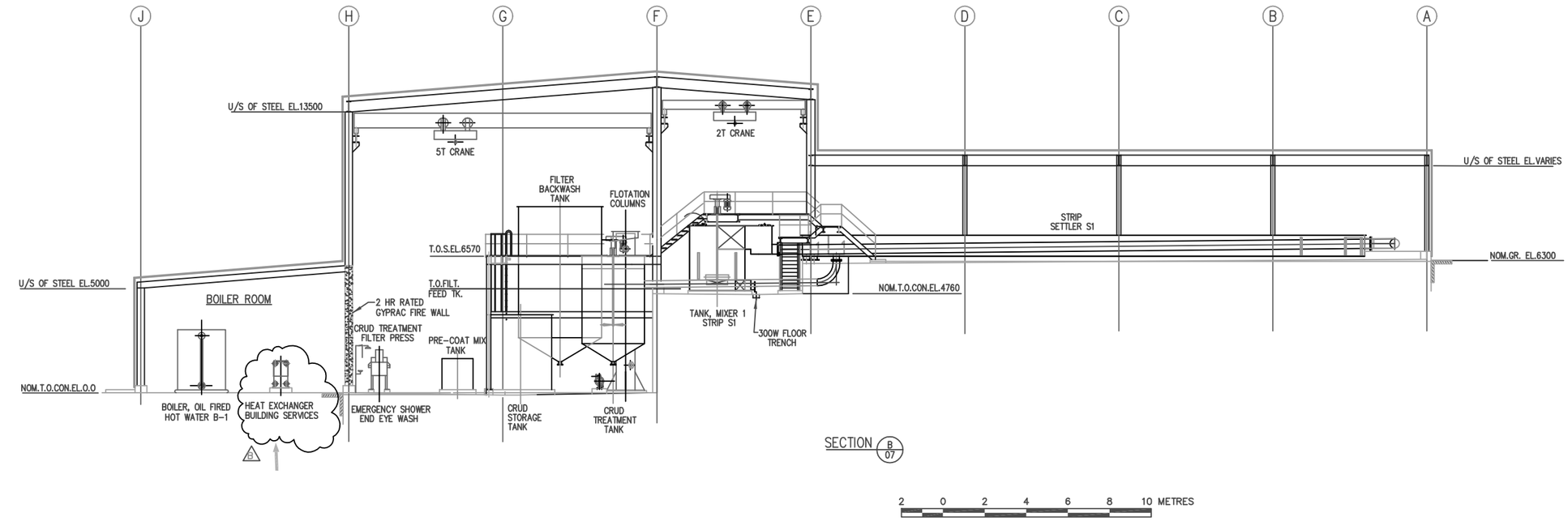
ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4001007.dwg





Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Solvent Extraction General Arrangement Sections",
Drawing #400-10-09 Rev B

Solvent Extraction General Arrangement Sections

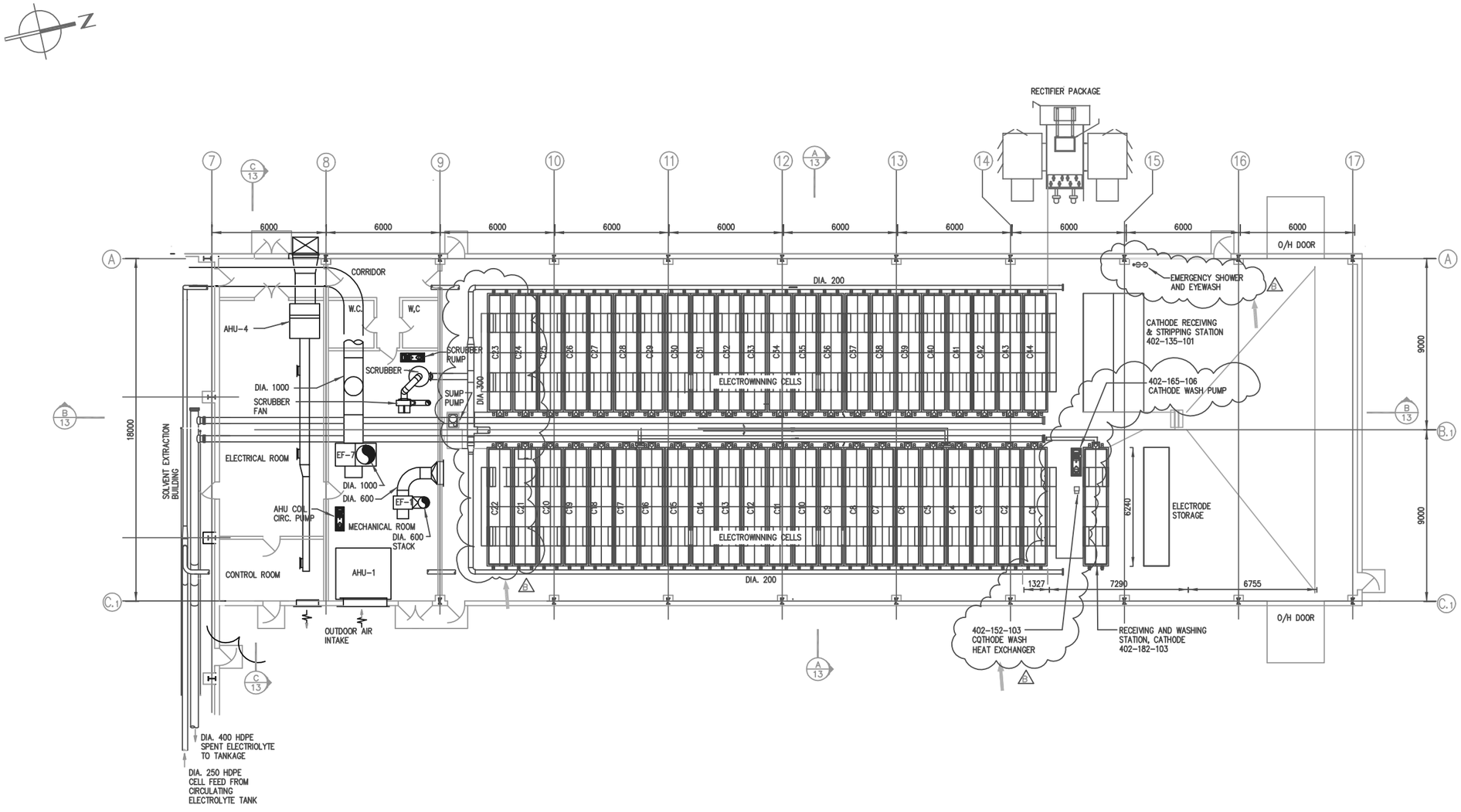
Drawing Number:
400-10-09

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4001009.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Electrowinning Building Plan",
Drawing #400-10-11 Rev C

Electrowinning Building Plan

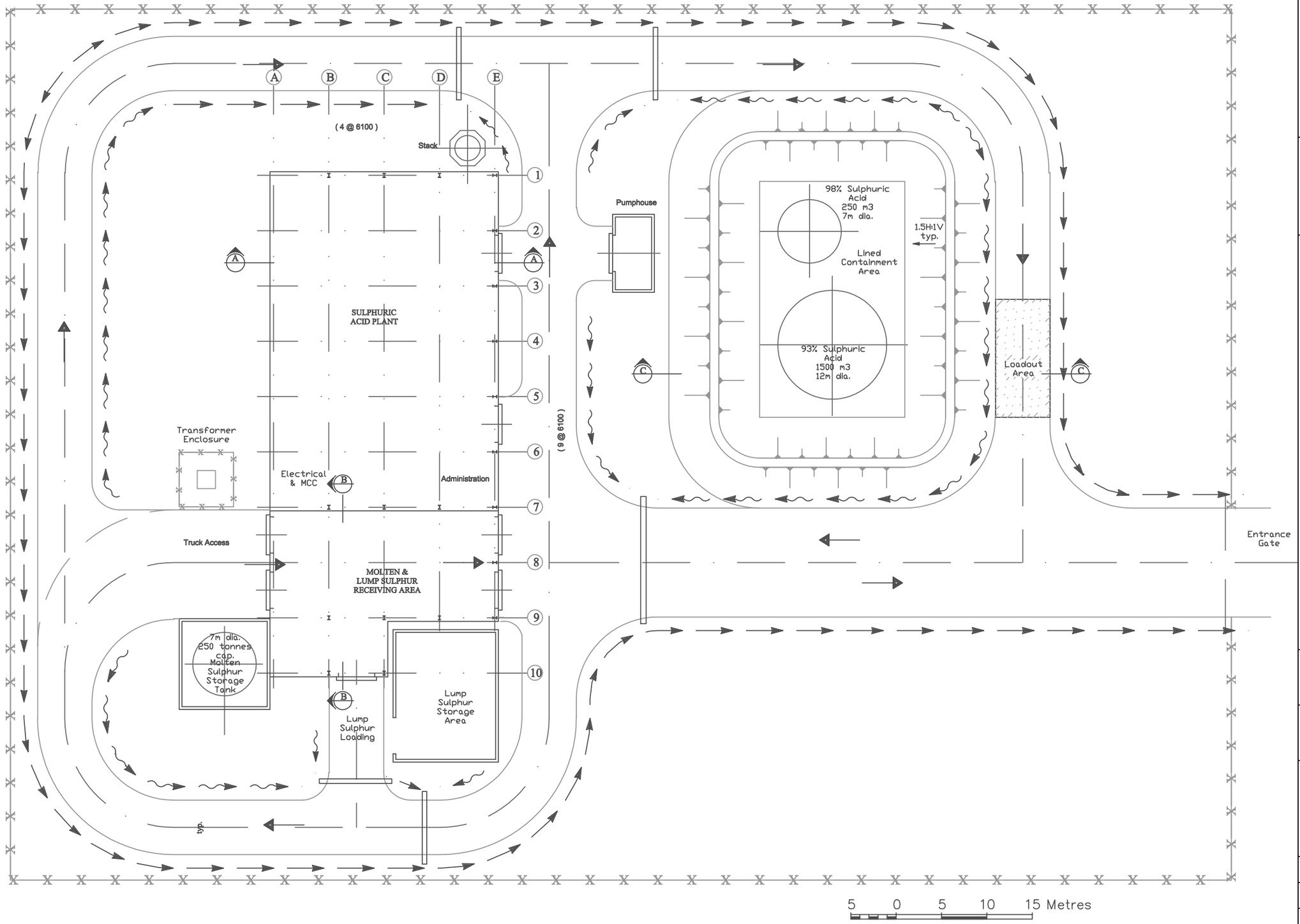
Drawing Number:
400-10-11

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\400101l.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"220 MTPD Sulphuric Acid Plant Site Layout",
Drawing #400-10-16 Rev A

Sulphuric Acid Plant Site Layout

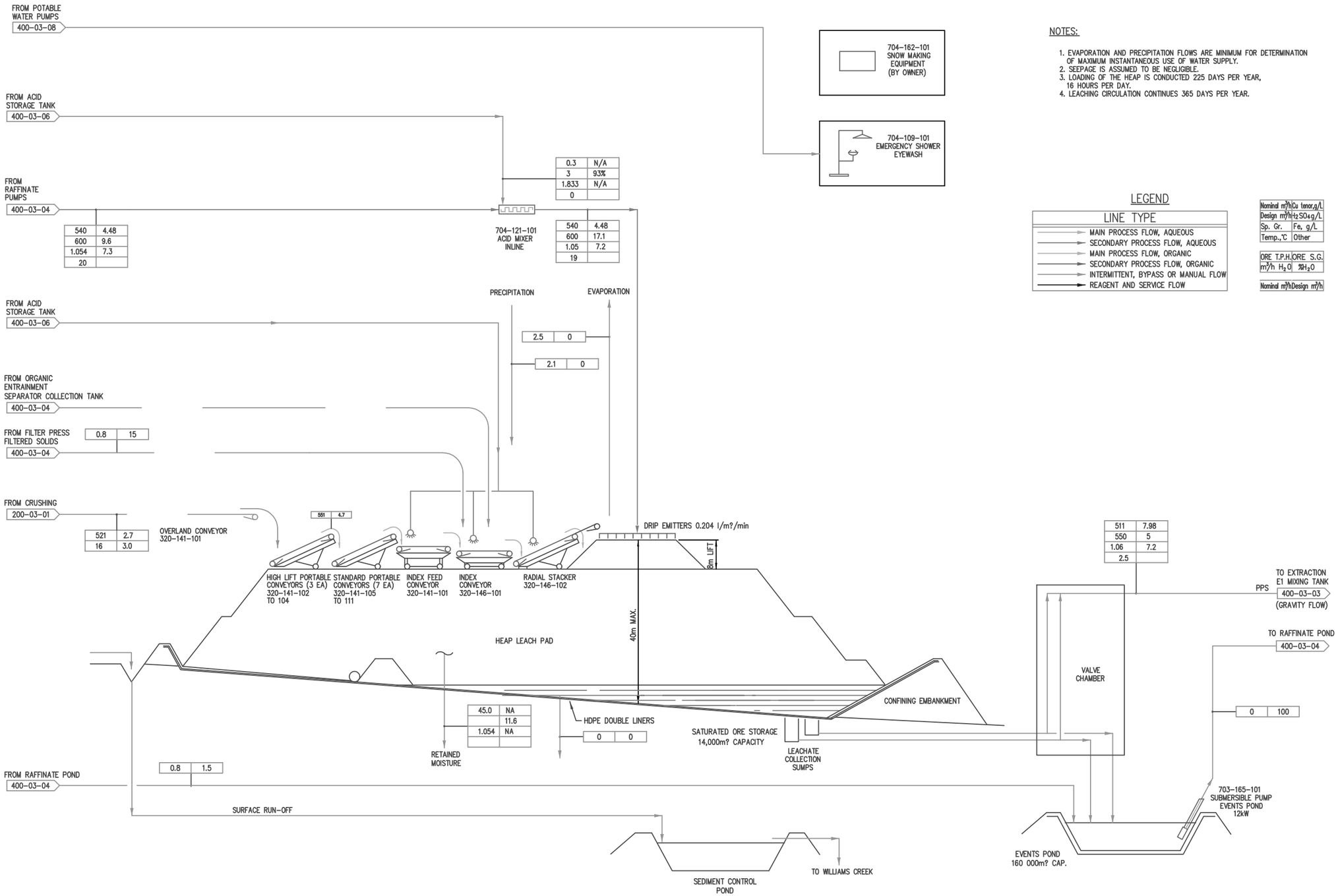
Drawing Number:
400-10-16

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\4001016.dwg



NOTES:

1. EVAPORATION AND PRECIPITATION FLOWS ARE MINIMUM FOR DETERMINATION OF MAXIMUM INSTANTANEOUS USE OF WATER SUPPLY.
2. SEEPAGE IS ASSUMED TO BE NEGLIGIBLE.
3. LOADING OF THE HEAP IS CONDUCTED 225 DAYS PER YEAR, 16 HOURS PER DAY.
4. LEACHING CIRCULATION CONTINUES 365 DAYS PER YEAR.

LEGEND

LINE TYPE
MAIN PROCESS FLOW, AQUEOUS
SECONDARY PROCESS FLOW, AQUEOUS
MAIN PROCESS FLOW, ORGANIC
SECONDARY PROCESS FLOW, ORGANIC
INTERMITTENT, BYPASS OR MANUAL FLOW
REAGENT AND SERVICE FLOW

Nominal m^3/h	Cu tenor, g/L
Design m^3/h	H_2SO_4 g/L
Sp. Gr.	Fe, g/L
Temp.,°C	Other

ORE T.P.H.	ORE S.G.
m^3/h H_2O	%H_2O

Nominal m^3/h	Design m^3/h

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Leaching Flowsheet #2",
Drawing #700-03-02 Rev F

Leaching Flowsheet #2

Drawing Number:
700-03-02

ACCESS CONSULTING GROUP

Revised by: HD | Checked by: DDC

Date: Feb. 1, 2005

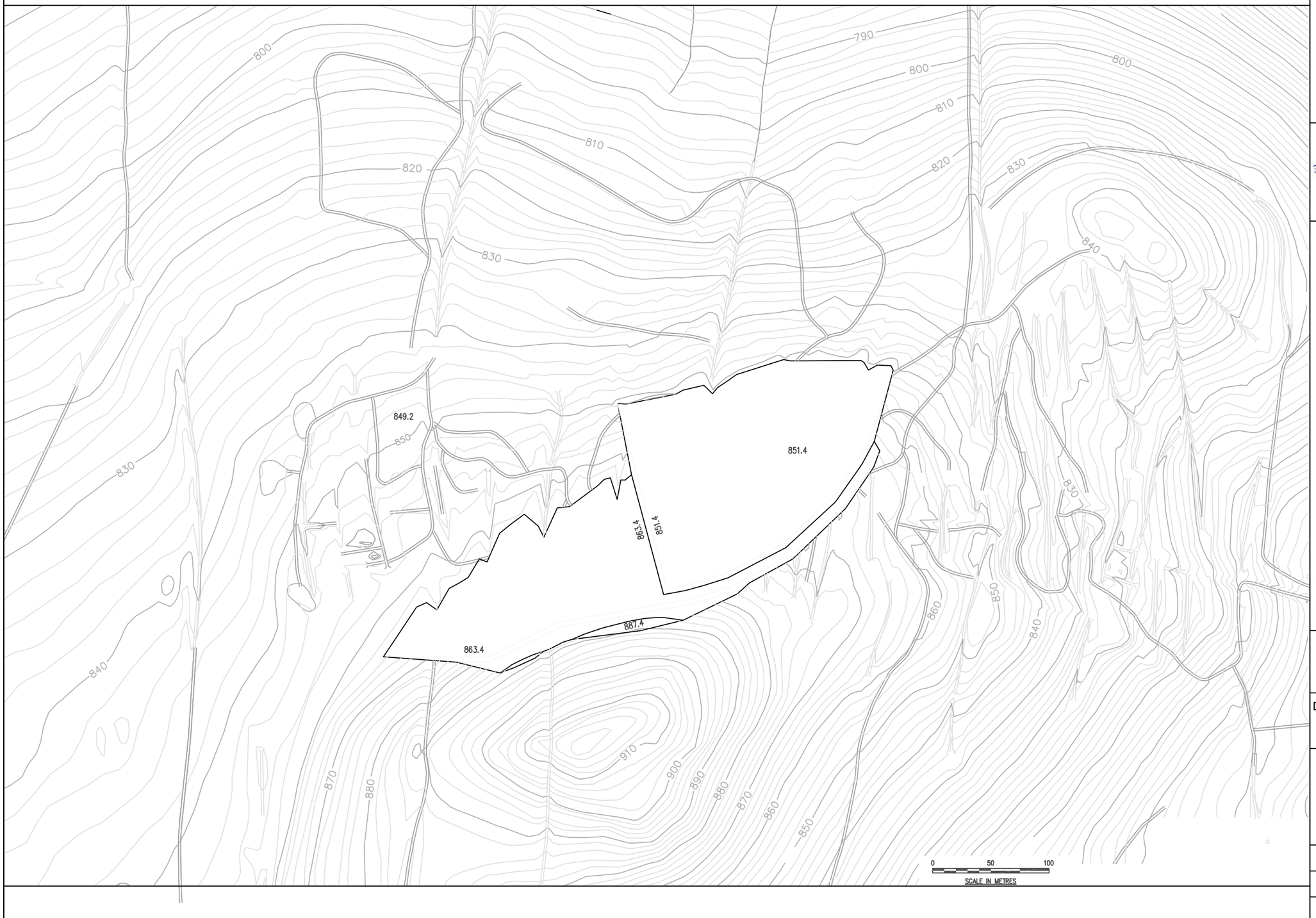
File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\7000302.dwg

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION



Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Open Pit Plan Pre-Production Stripping",
Drawing #800-05-13 Rev B

Open Pit Plan Pre-Production Stripping

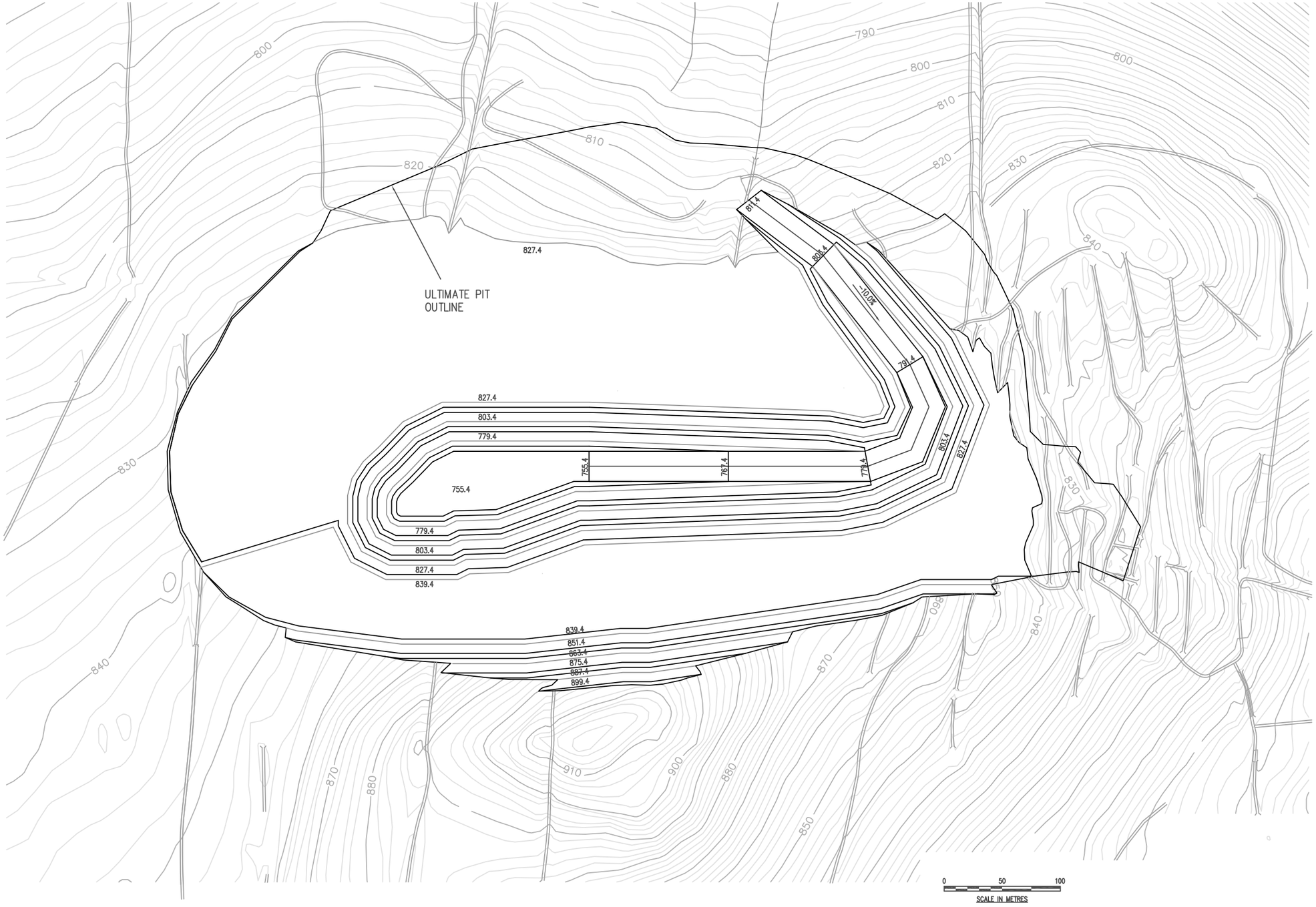
Drawing Number:
800-05-13

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\8000513.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Open Pit Plan End of Year 2",
Drawing #800-05-14 Rev C

Open Pit Plan End of Year 2

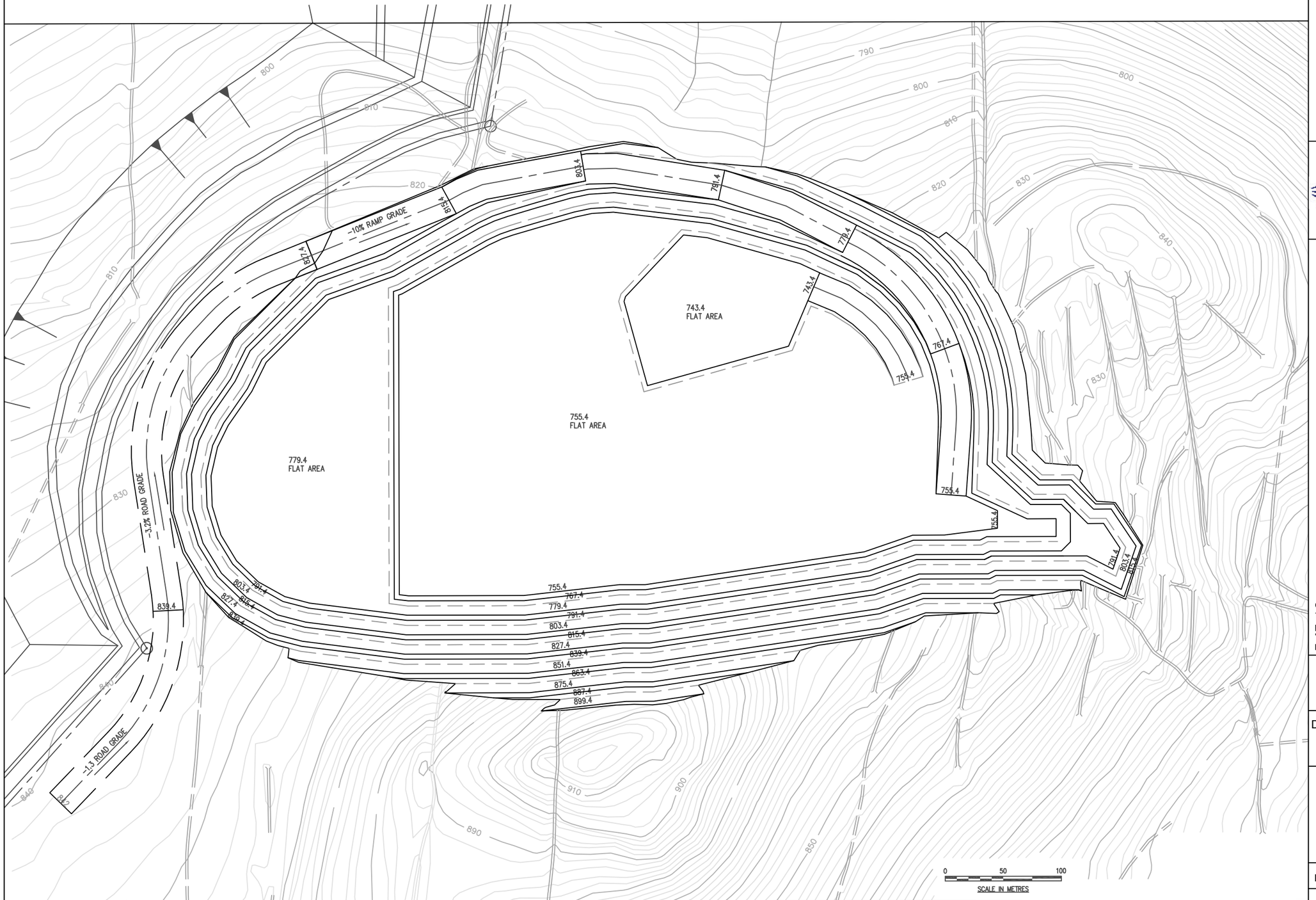
Drawing Number:
800-05-14

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\8000514.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Open Pit Plan End of Year 4",
Drawing #800-05-15 Rev C

Open Pit Plan End of Year 4

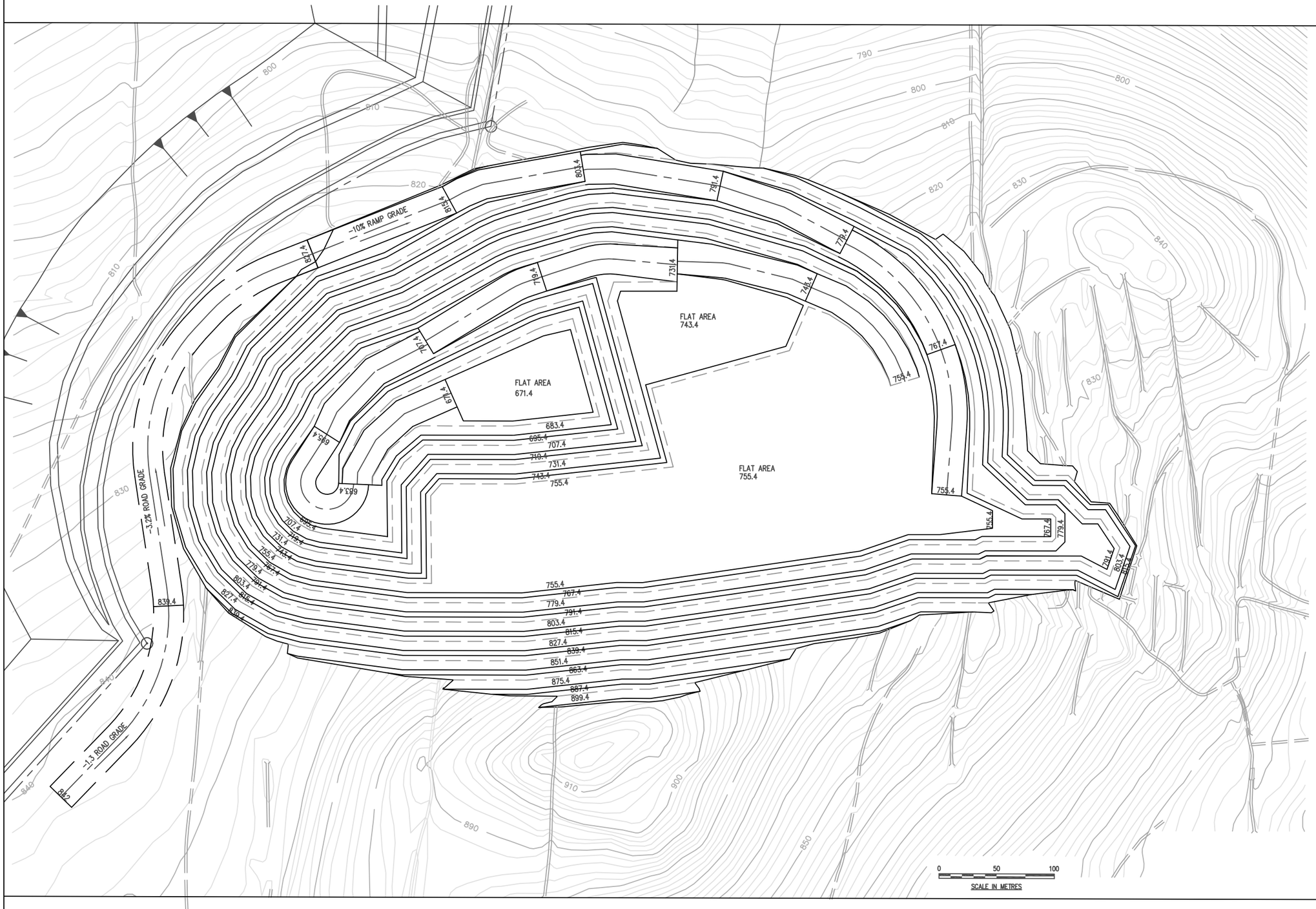
Drawing Number:
800-05-15

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\8000515.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Open Pit Plan End of Year 6",
Drawing #800-05-16 Rev C

Open Pit Plan End of Year 6

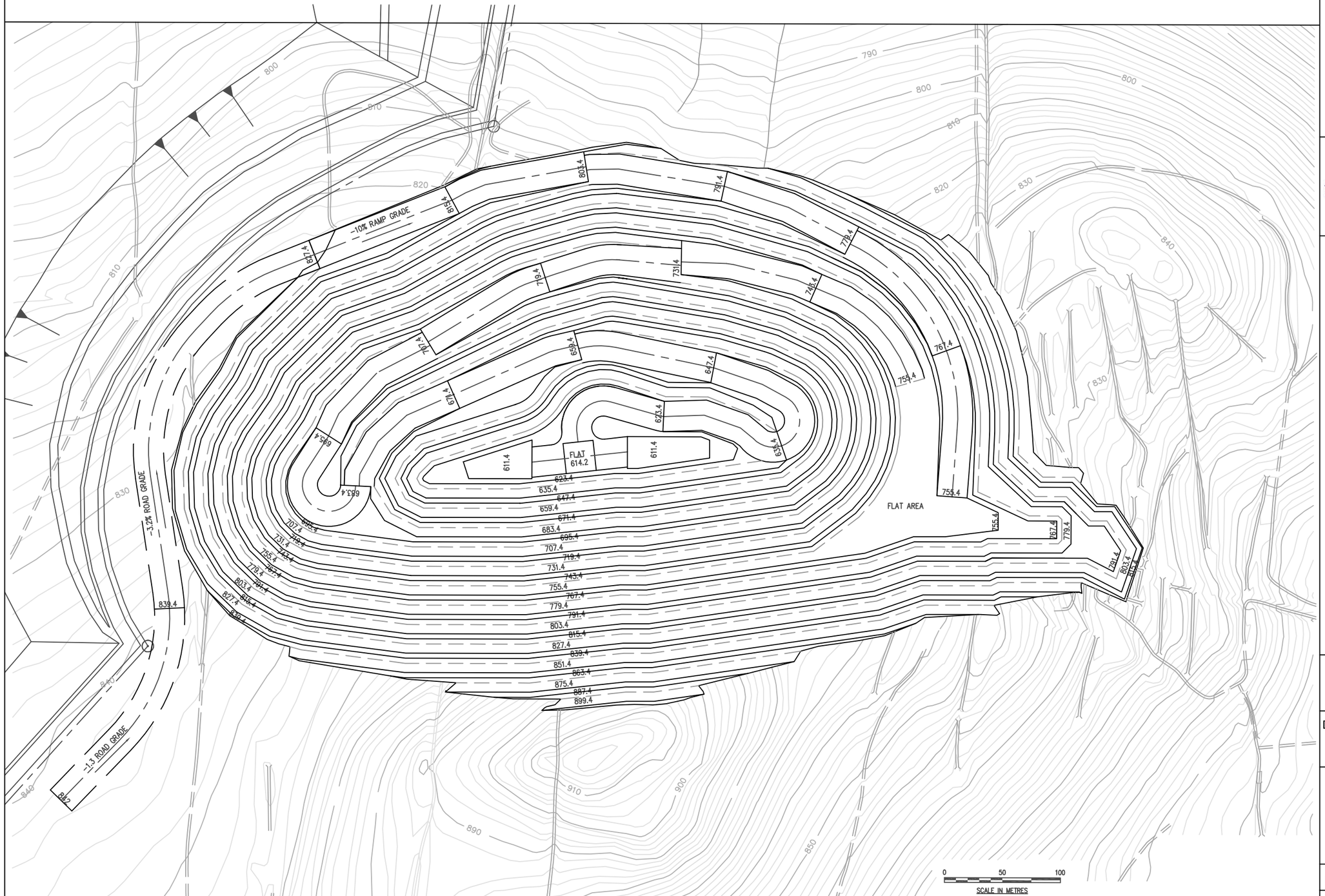
Drawing Number:
800-05-16

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\8000516.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Open Pit Plan End of Year 8 Ultimate Pit",
Drawing #800-05-17 Rev C

Open Pit Plan End of Year 8 Ultimate Pit

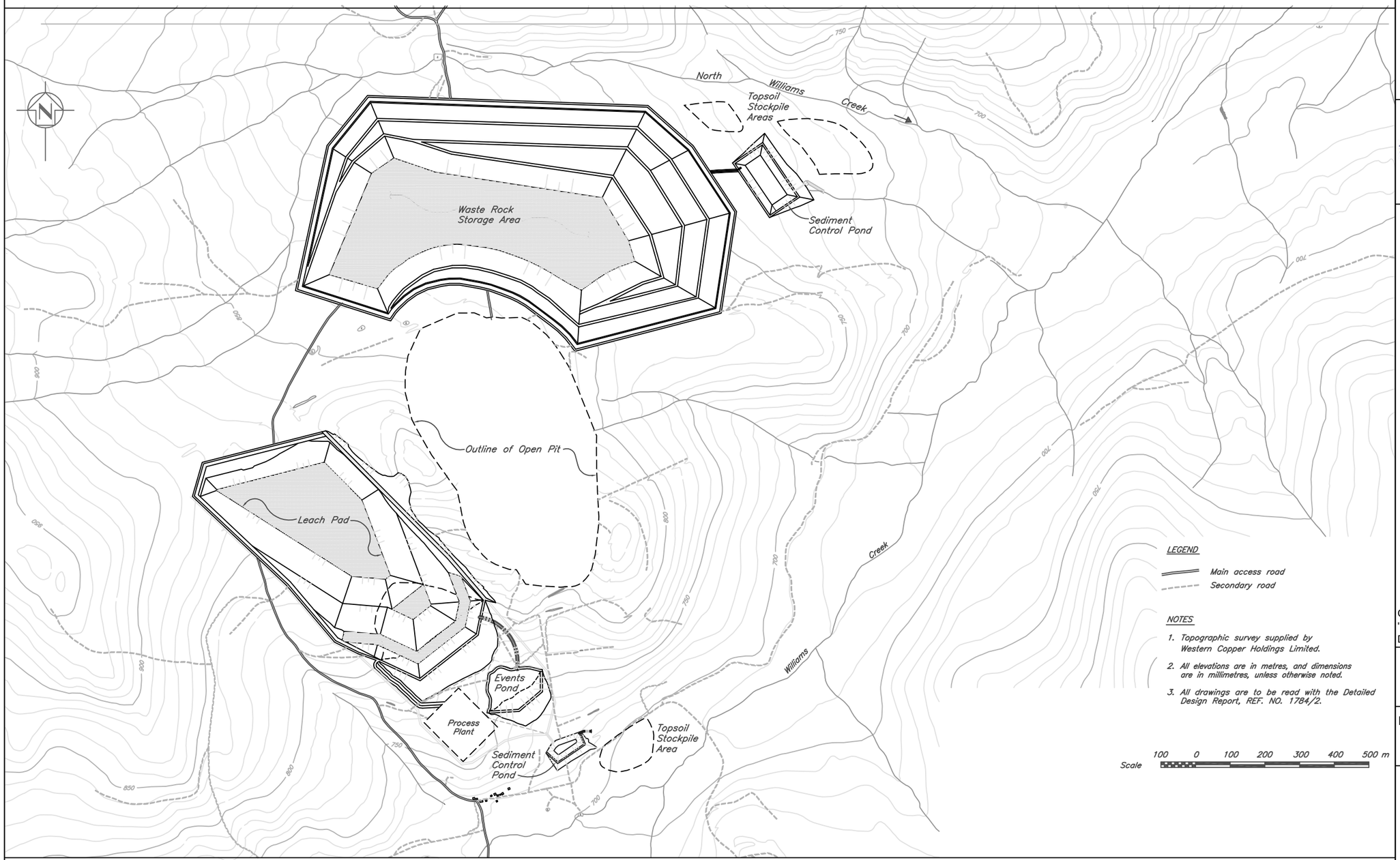
Drawing Number:
800-05-17

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\8000517.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "General Arrangement", Drawing #1784.000

General Arrangement

Drawing Number:
1784.000

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

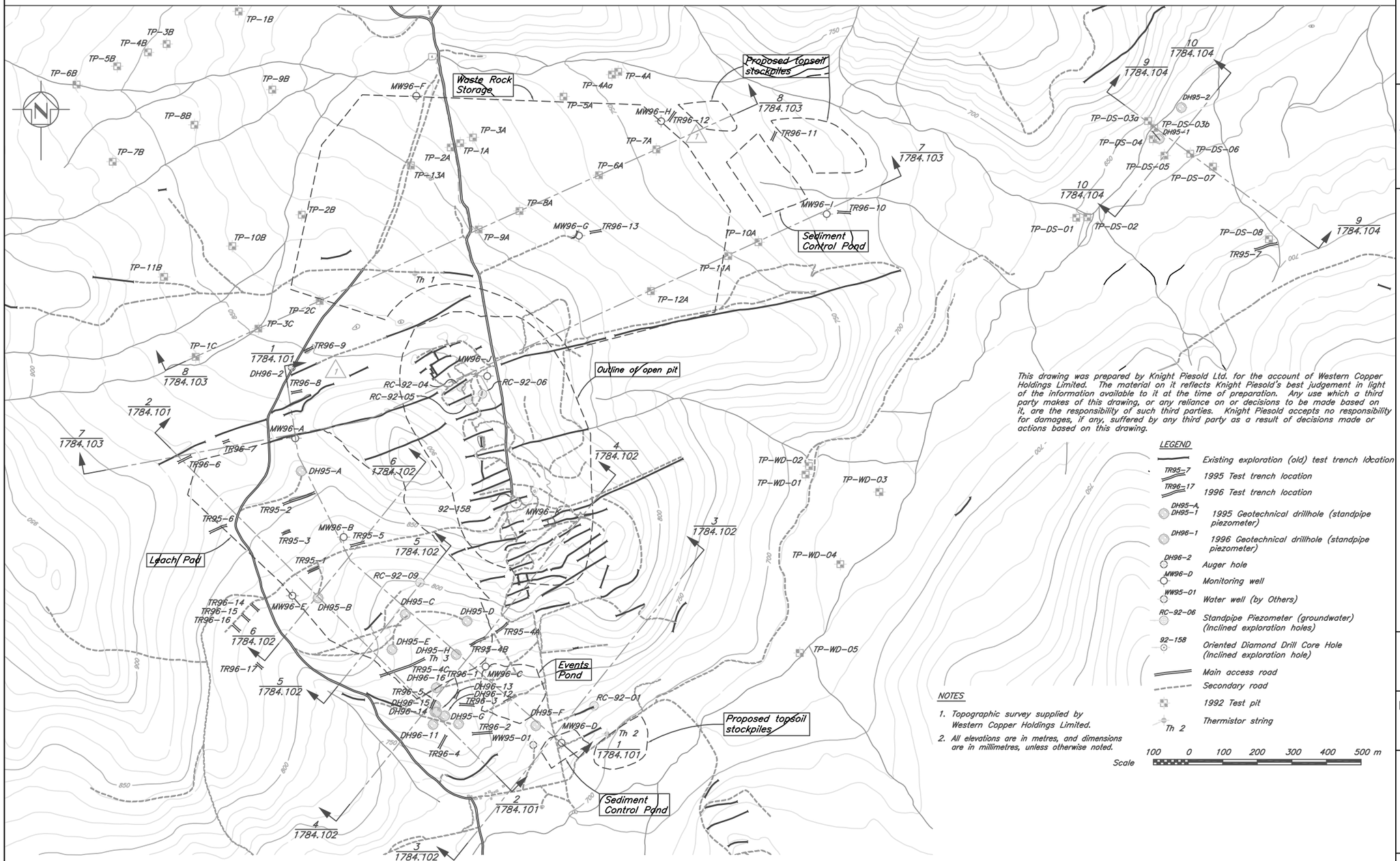
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Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION



This drawing was prepared by Knight Piesold Ltd. for the account of Western Copper Holdings Limited. The material on it reflects Knight Piesold's best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this drawing, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Knight Piesold accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this drawing.

LEGEND

- Existing exploration (old) test trench location
- TR95-7 — 1995 Test trench location
- TR96-17 — 1996 Test trench location
- DH95-A, DH95-1 — 1995 Geotechnical drillhole (standpipe piezometer)
- DH96-1 — 1996 Geotechnical drillhole (standpipe piezometer)
- DH96-2 — Auger hole
- MW96-D — Monitoring well
- WW95-01 — Water well (by Others)
- RC-92-06 — Standpipe Piezometer (groundwater) (Inclined exploration holes)
- 92-158 — Oriented Diamond Drill Core Hole (Inclined exploration hole)
- Main access road
- Secondary road
- 1992 Test pit
- Th 2 — Thermistor string

NOTES

1. Topographic survey supplied by Western Copper Holdings Limited.
2. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.

Scale 100 0 100 200 300 400 500 m

Original drawing from Knight Piesold Limited, "Site Investigations Plan" Drawing #1784.100 Rev 1

Site Investigations Plan

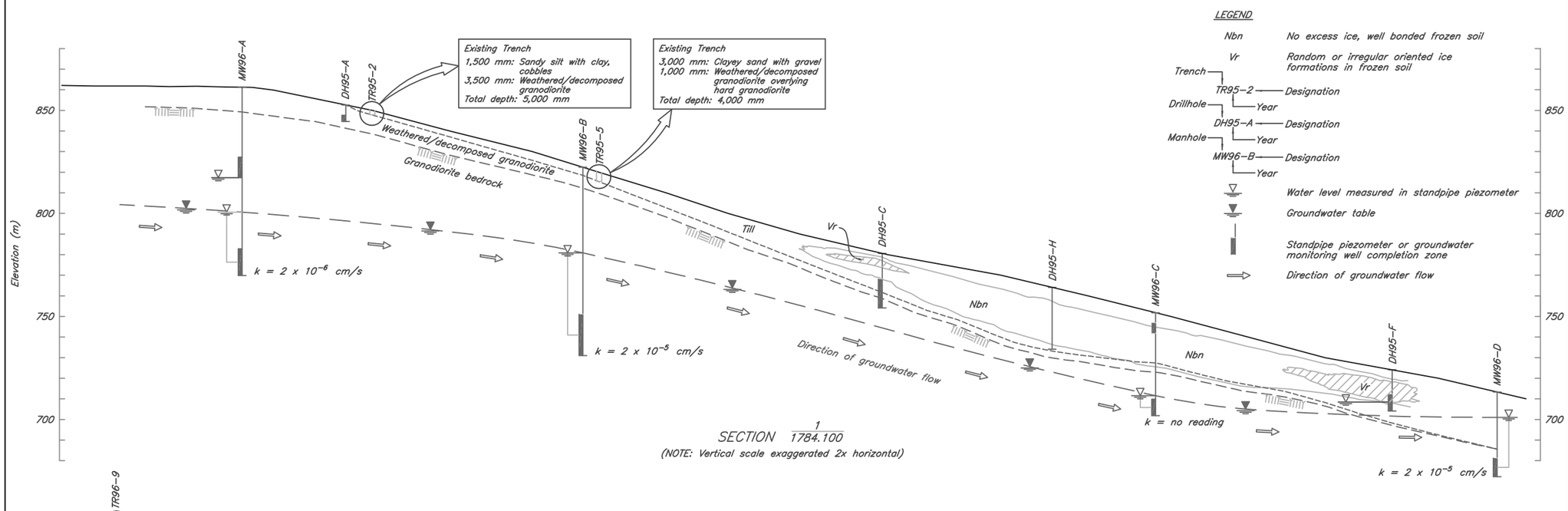
Drawing Number:
1784.100

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1784_100.dwg



NOTES

1. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.
2. 1995 Geotechnical drillholes DH95-C, E and F standpipe piezometers have measured water levels from water introduced from diamond drilling.

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Heap Leach Pad Geologic Sections Sheet 1 of 2" Drawing #1784.101 Rev 0

Heap Leach Pad Geologic Sections Sheet 1 of 2

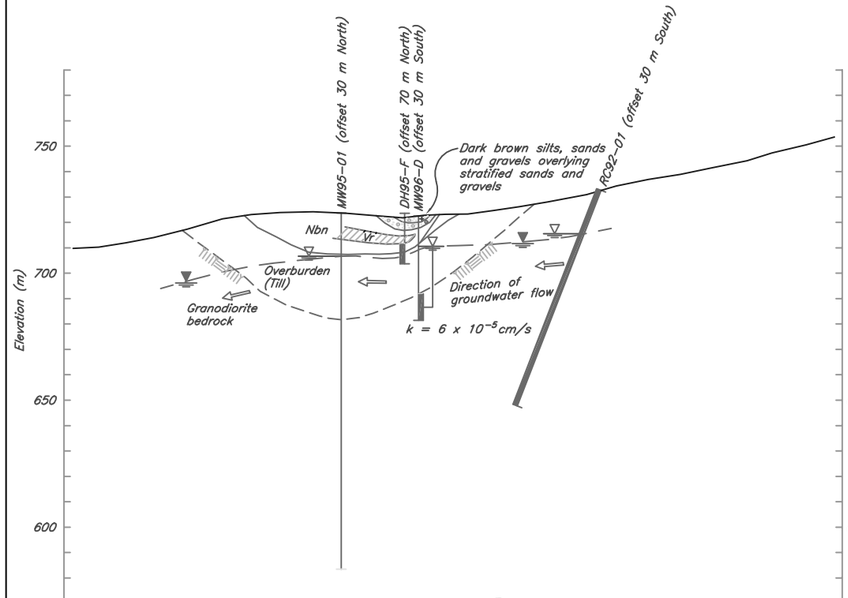
Drawing Number: 1784.101

ACCESS CONSULTING GROUP

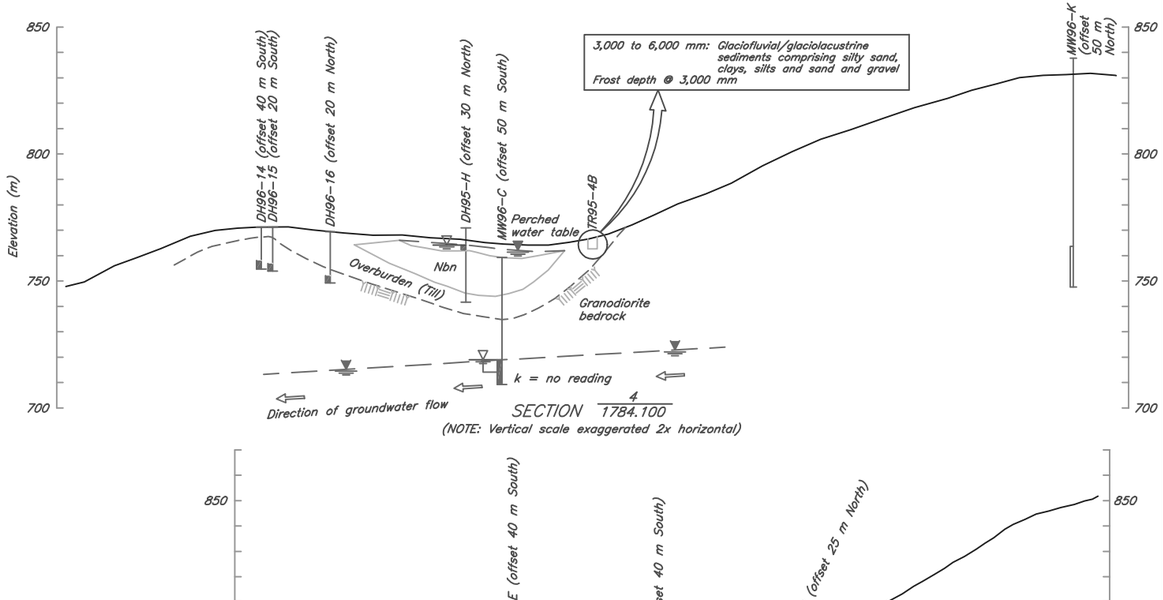
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

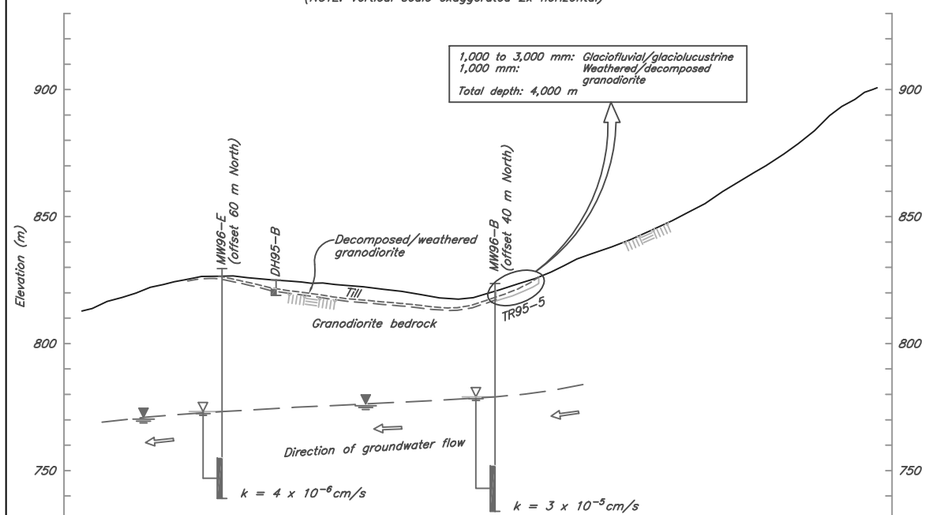
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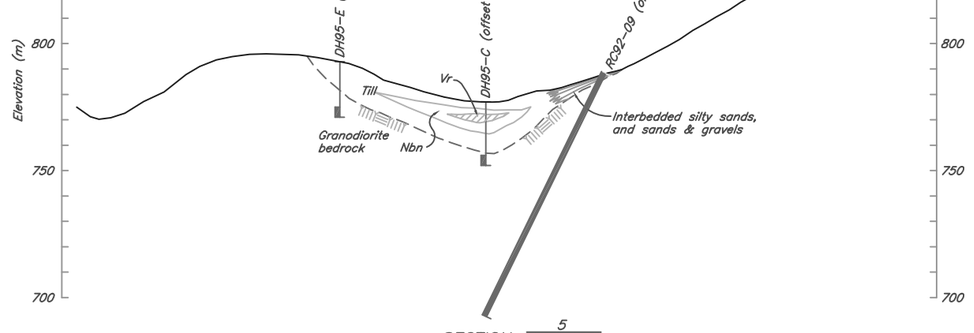
3
SECTION 1784.100
(NOTE: Vertical scale exaggerated 2x horizontal)



4
SECTION 1784.100
(NOTE: Vertical scale exaggerated 2x horizontal)



6
SECTION 1784.100
(NOTE: Vertical scale exaggerated 2x horizontal)



5
SECTION 1784.100
(NOTE: Vertical scale exaggerated 2x horizontal)

LEGEND

Nbn	No excess ice, well bonded frozen soil
Vr	Random or irregular oriented ice formations in frozen soil
Trench — TR95-4B — Year	Designation
Drillhole — DH95-H — Year	Designation
Manhole — MW96-C — Year	Designation
	Water level measured in standpipe piezometer
	Groundwater table
	Standpipe piezometer or groundwater monitoring well completion zone
	Direction of groundwater flow

NOTES

1. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.
2. 1995 Geotechnical drillholes DH95-C, E and F standpipe piezometers have measured water levels from water introduced from diamond drilling.

Vert. Scale 20 0 20 40 60 80 100 metres

Horiz. Scale 100 50 0 100 200 metres

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited,
"Heap Leach Pad Geologic Sections Sheet 2 of 2"
Drawing #1784.102 Rev 0

Heap Leach Pad Geologic Sections Sheet 2 of 2

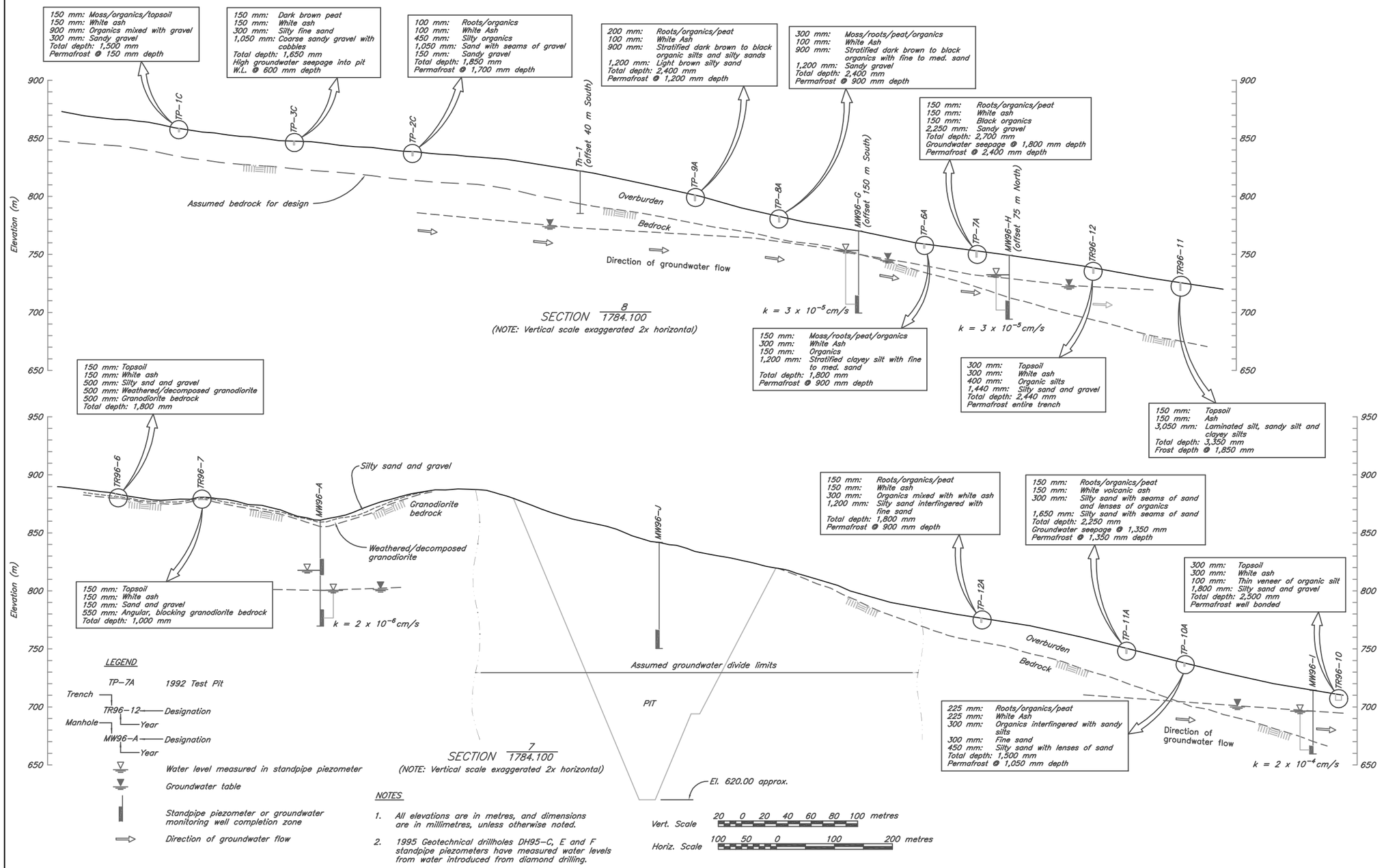
Drawing Number:
1784.102

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Revised by: HD | Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1784_102.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Waste Rock Storage Geologic Sections" Drawing #1784.103 Rev 0

Waste Rock Storage Geologic Sections

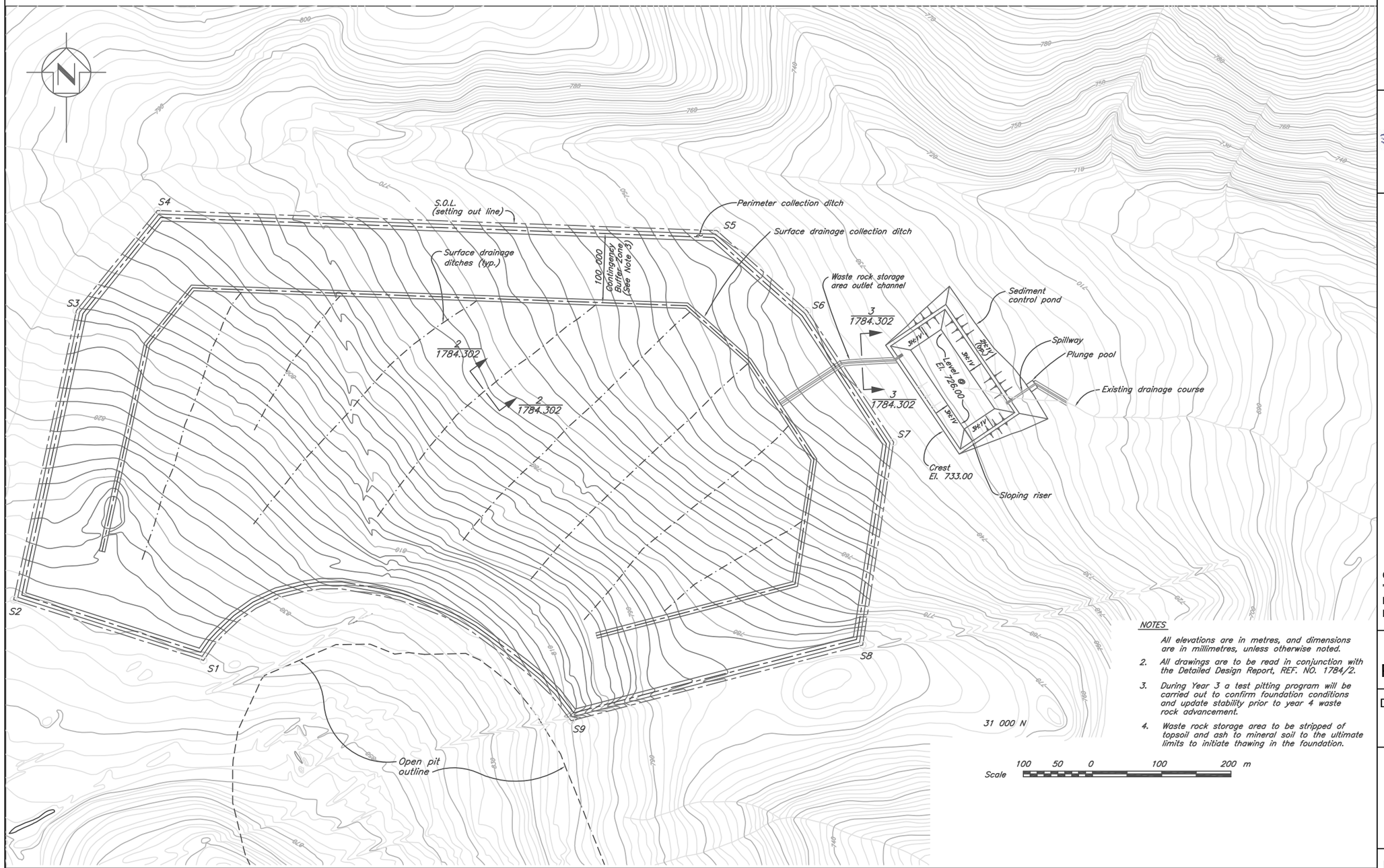
Drawing Number:
1784.103

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1784_103.dwg



NOTES

1. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.
2. All drawings are to be read in conjunction with the Detailed Design Report, REF. NO. 1784/2.
3. During Year 3 a test pitting program will be carried out to confirm foundation conditions and update stability prior to year 4 waste rock advancement.
4. Waste rock storage area to be stripped of topsoil and ash to mineral soil to the ultimate limits to initiate thawing in the foundation.

Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Waste Rock Storage Area Foundation Preparation Plan", Drawing #1784.301 Rev 0

Waste Rock Storage Area Foundation Preparation Plan

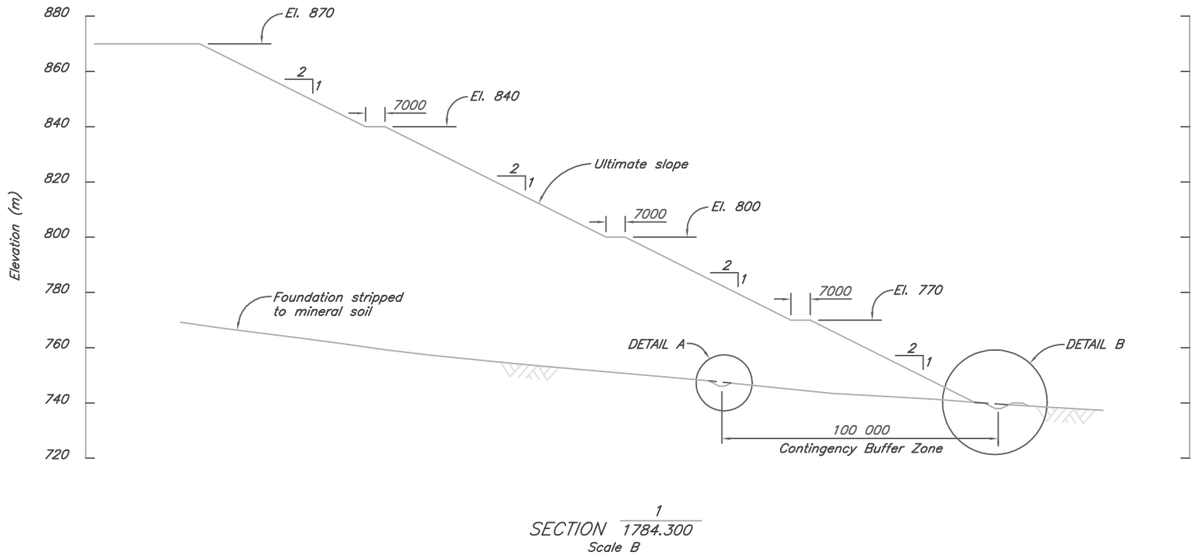
Drawing Number:
1784.301

ACCESS CONSULTING GROUP

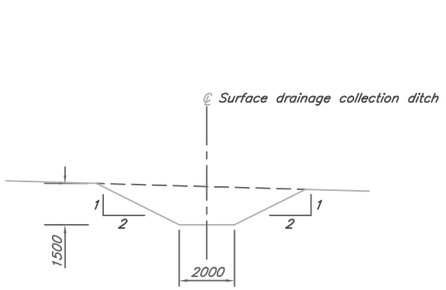
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

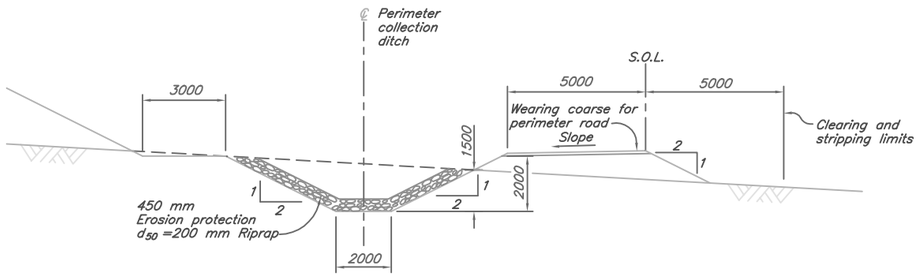
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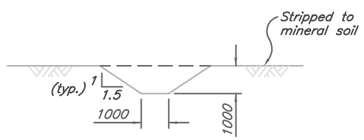
1
SECTION 1784.300
Scale B



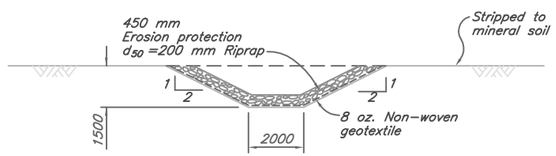
DETAIL A
Scale A



DETAIL B
Scale A



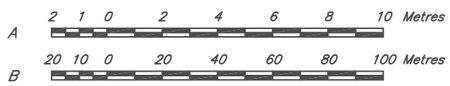
2
SECTION 1784.301
TYPICAL SURFACE DRAINAGE DITCH
Scale A



3
SECTION 1784.301
WASTE ROCK STORAGE AREA
OUTLET CHANNEL
Scale A

NOTES

1. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.
2. All drawings are to be read in conjunction with the Detailed Design Report, REF. NO. 1784/2.
3. S.O.L. – Setting out line.



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Waste Rock Storage Area Sections and Details", Drawing #1784.302 Rev 0

Waste Rock Storage Area Sections and Details

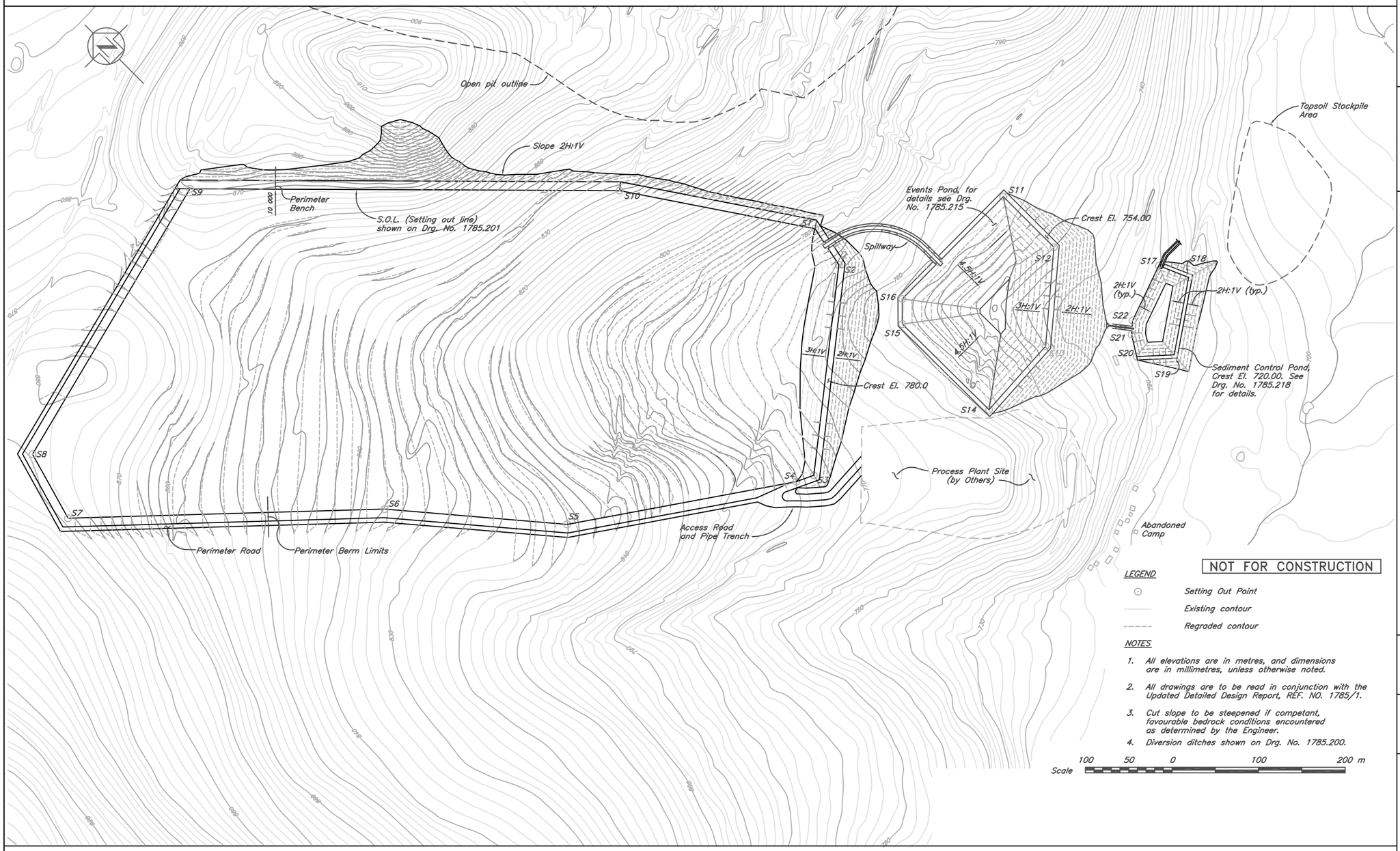
Drawing Number:
1784.302

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1784_302.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Heap Leach Facility Overall Rough Grading Plan", Drawing #1785.202 Rev 0

Heap Leach Facility Overall Rough Grading Plan

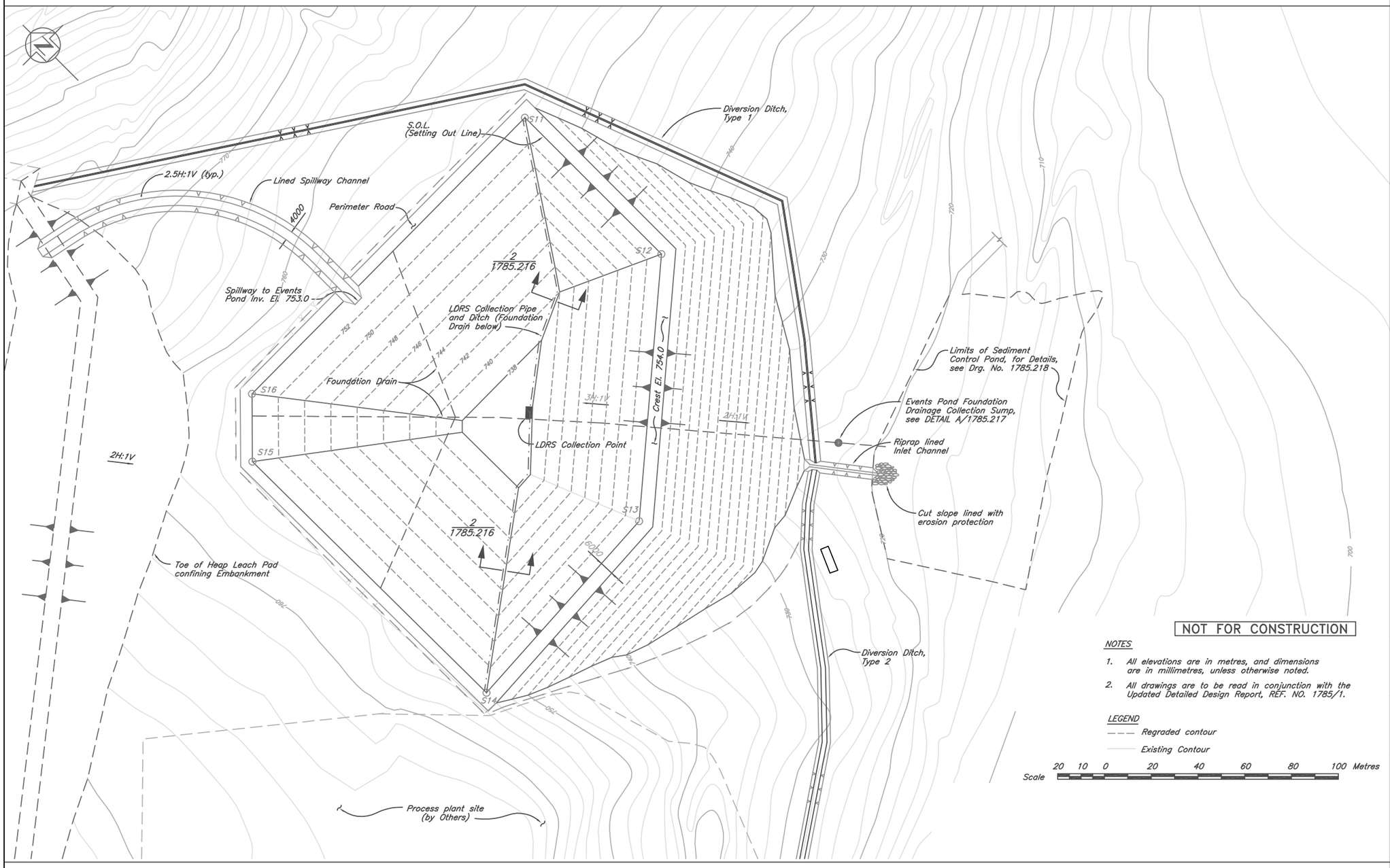
Drawing Number:
1785.202

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\1785_202.dwg



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Events Pond Foundation Drainage and Grading Plan", Drawing #1785.215 Rev 0

Events Pond Foundation Drainage and Grading Plan

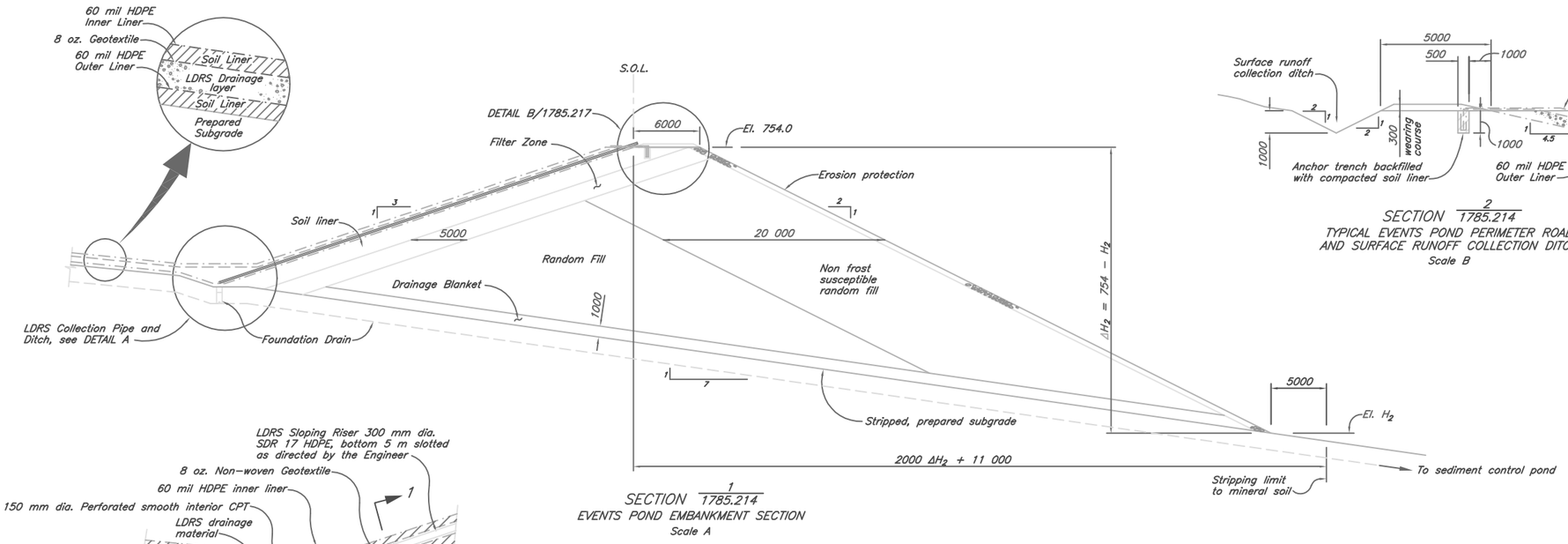
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ACCESS CONSULTING GROUP

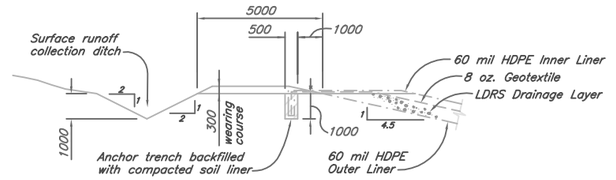
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Date: Feb. 1, 2005

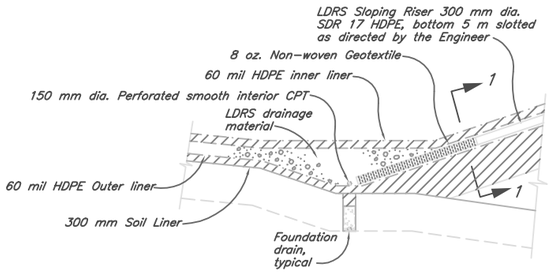
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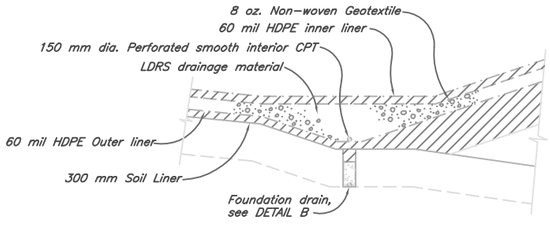
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EVENTS POND EMBANKMENT SECTION
Scale A



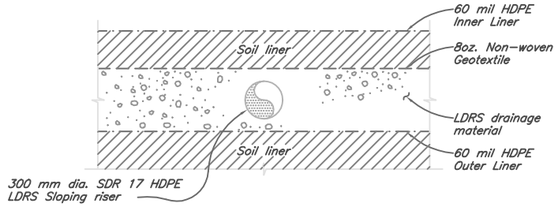
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TYPICAL EVENTS POND PERIMETER ROAD
AND SURFACE RUNOFF COLLECTION DITCH
Scale B



DETAIL A
LEAK DETECTION AND RECOVERY SYSTEM (LDRS)
COLLECTION PIPE AND DITCH
Scale B



SECTION 2/1785.215
LEAK DETECTION AND RECOVERY SYSTEM (LDRS)
COLLECTION PIPE AND DITCH
WITHOUT LDRS SLOPING RISER
Scale B



SECTION 1
LDRS SLOPING RISER
NTS

NOTES

1. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.
2. All drawings are to be read in conjunction with the Updated Detailed Design Report, REF. NO. 1785/1.
3. S.O.L. – Setting out line.

NOT FOR CONSTRUCTION



Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Events Pond Sections and Details Sheet 1 of 2", Drawing #1785.216 Rev 0

Events Pond Sections and Details Sheet 1 of 2

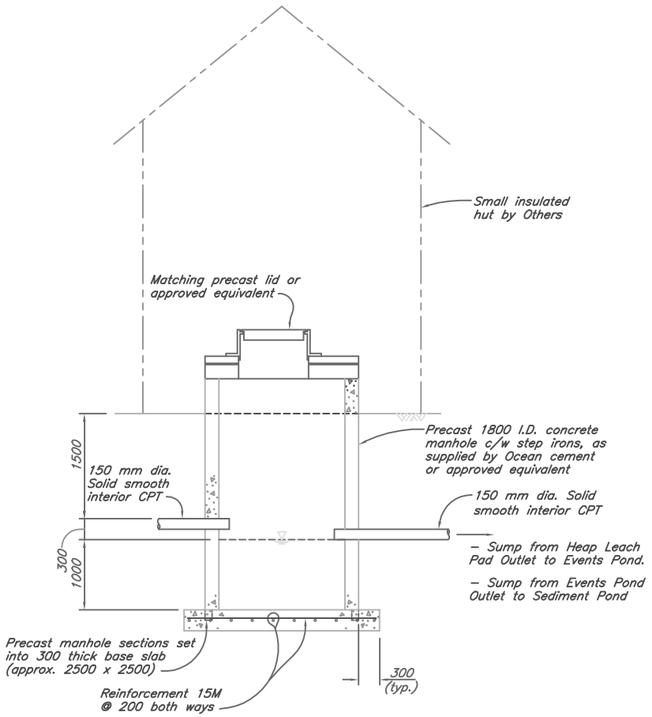
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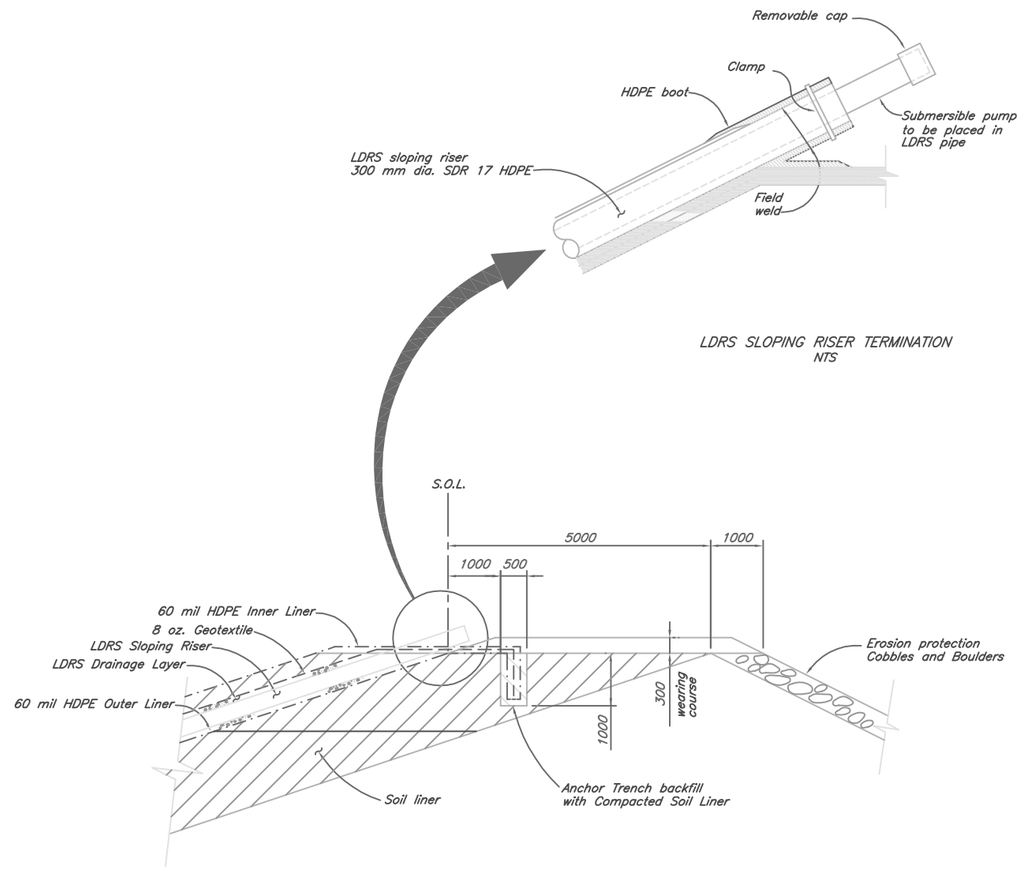
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DETAIL A 1785.203 , A 1785.215
TYPICAL FOUNDATION DRAINAGE SUMP
Scale A



DETAIL B 1785.216
EVENTS POND EMBANKMENT CREST
Scale B

NOTES

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3. S.O.L. – Setting out line.

B 1 0 1 2 3 4 5 m

A 1 0 1 2 3 m

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Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

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Events Pond Sections and Details Sheet 2 of 2

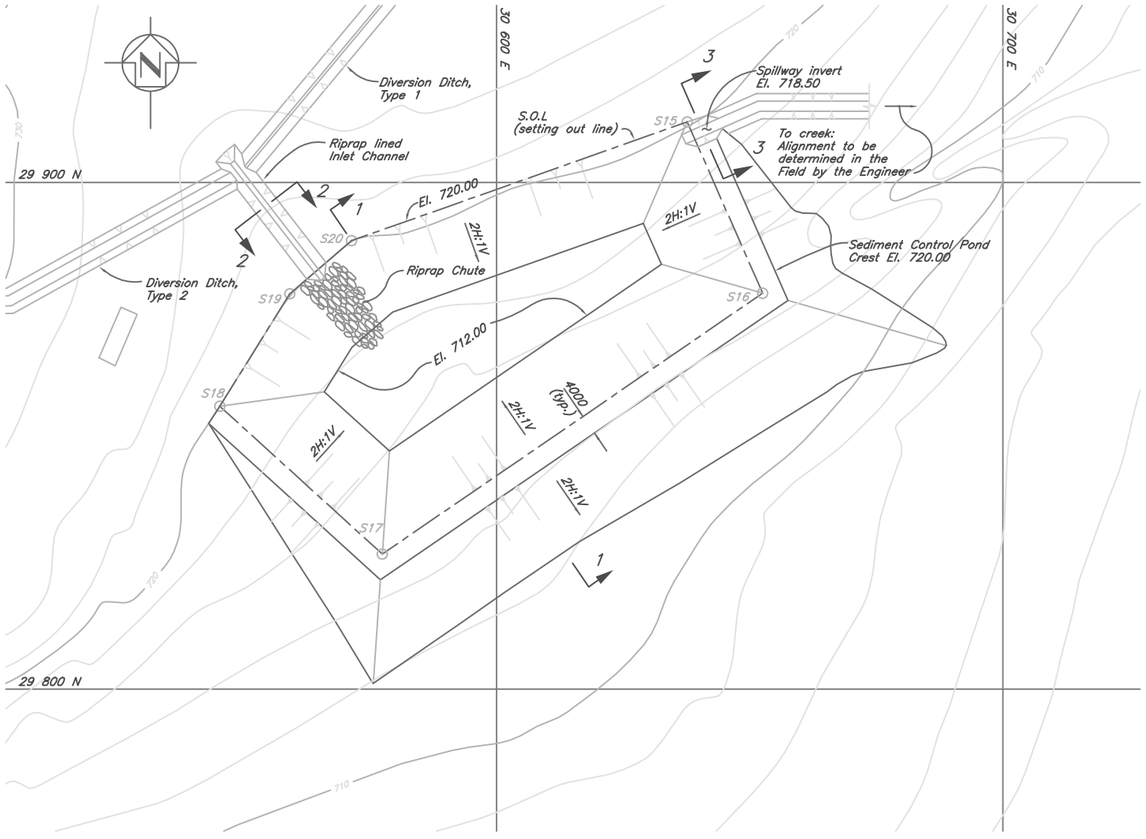
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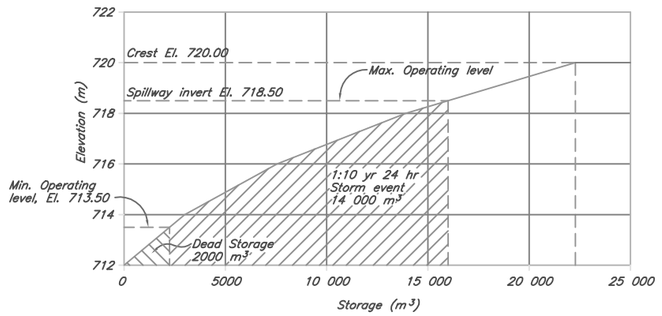
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

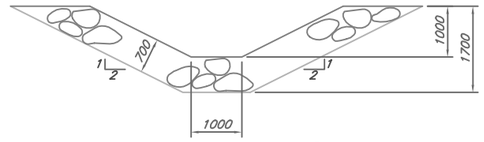
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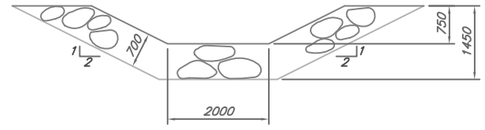
PLAN
Scale A



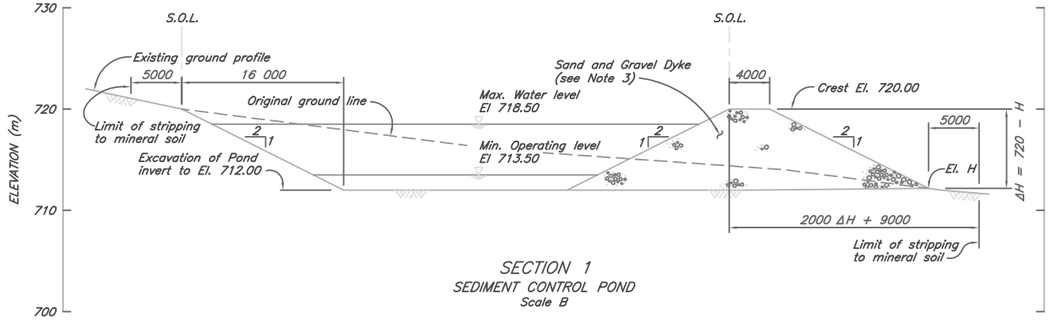
SEDIMENT CONTROL POND DEPTH/CAPACITY RELATIONSHIP



SECTION 2, SECTION 2 / 1785.214
RIPRAP LINED INLET CHANNEL
Scale C



SECTION 3
SPILLWAY
Scale C



SECTION 1
SEDIMENT CONTROL POND
Scale B

NOTES

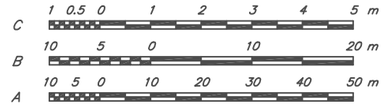
1. All elevations are in metres, and dimensions are in millimetres, unless otherwise noted.
2. All drawings are to be read in conjunction with the Updated Detailed Design Report, REF. NO. 1785/1.
3. Dyke to be constructed from locally derived granular sand and gravel or rockfill, raked towards the downstream slope in increasing lift thickness. Oversize particles to be moved downslope until less than 3/4 the lift thickness. Compaction with a vibratory smooth drum compactor.
4. For Setting Out Point coordinates, see Drg. 1785.201.

LEGEND

⊙ Setting Out Point (S.O.P.)

S.O.L. Setting Out Line.

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Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Knight Piesold Limited, "Sediment Control Pond Plan, Sections and Details", Drawing #1785.218 Rev 0

Sediment Control Pond Plan, Sections and Details

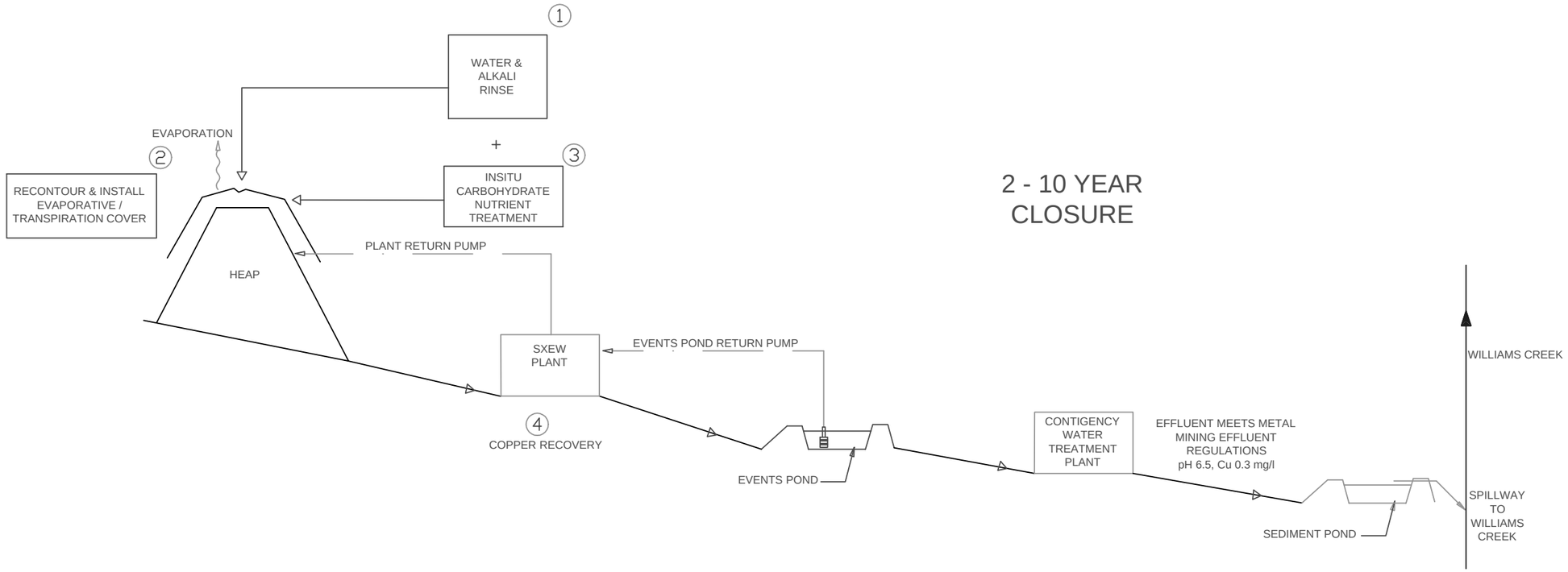
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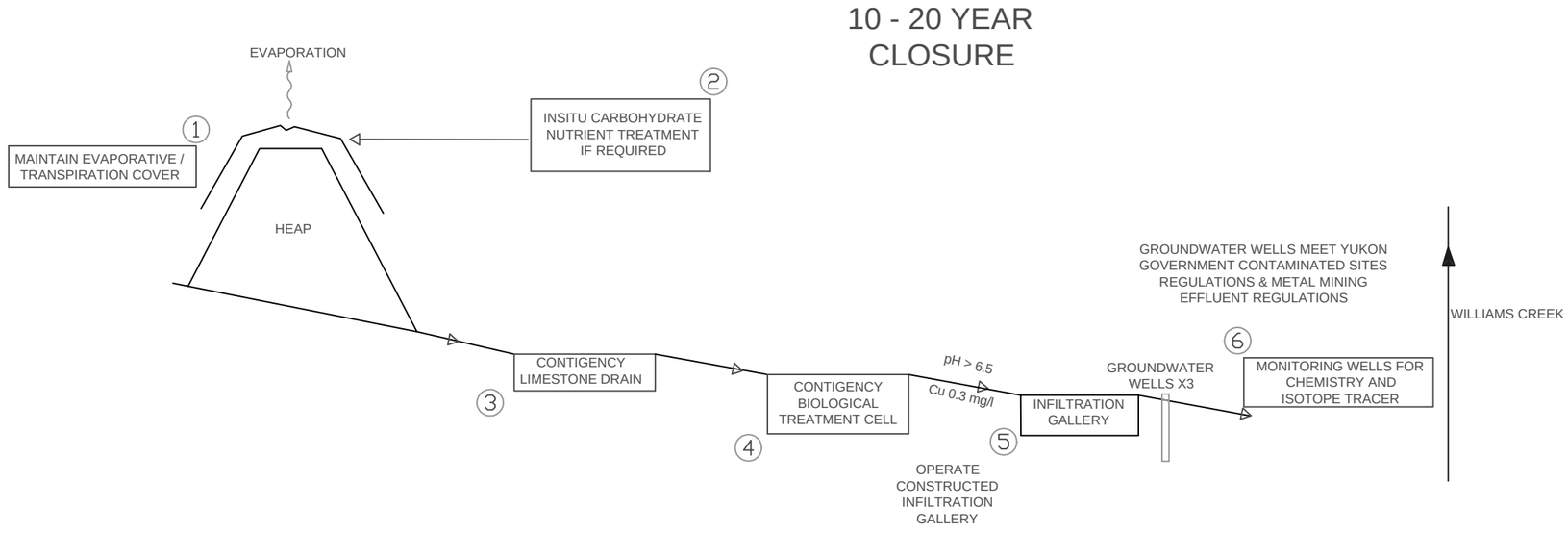
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Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Conceptual Heap Leach Facility Closure

Drawing Number:
ACG-WS-01.001

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Drawn by: HD | Checked by: DDC

Date: Feb. 1, 2005

File: D:\Project\AllProjects\DEV-04-02\dwg\drawings\ACG_WS_1_1.dwg

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix B

Western Silver Corporation
Safety and Environmental Policy

WESTERN SILVER CORPORATION

Safety And Environmental Policy

Western Silver Corporation recognizes that maintenance of environmental quality is vital to the Corporation's existence, progress, and continued development. The Corporation will maintain high environmental standards limited only by technical and economic feasibility. The Corporation will take positive action to protect the safety of its workers, conserve natural resources, and minimize the impact of its activities on the environment through diligent application of appropriate technology and responsible conduct at all stages of exploration, mine development, mining, mineral processing, decommissioning, and reclamation.

The purpose of Western Silver Corporation's Safety and Environmental Policy is to provide a measurable framework for the performance of the Corporation's activities in an environmentally responsible manner, ensuring compliance by the Corporation and its employees with all applicable environmental regulations and commitments.

Implementation

Western Silver Corporation will:

1. Obey the law and conduct all business in an ethical manner.

2. Evaluate, plan, construct, and operate all projects and facilities to reduce adverse environmental impacts and to meet or exceed applicable environmental laws, regulations, and standards. In the absence of applicable regulations, the Corporation will apply cost effective best management practices to protect the environment. Require managers of all projects and operations to adhere to the Corporation Environmental Policy and to identify, evaluate, and minimize risks to the environment.

3. Continuously review environmental achievements and technology to seek and implement methods for further improvement.

4. Require all operations to have site specific emergency response plans which meet or exceed all applicable regulations.

5. Conduct regular environmental, health and safety preparedness and emergency response plans to verify compliance with the Corporation's policy and applicable regulations. Identify revisions or improvements to current practices in order to minimize environmental impacts. Report findings regularly to the Board of Directors.

6. Educate employees in environmental matters and responsibilities relating to performance of their assigned tasks. Entrust all employees to maintain necessary environmental performance for their activities.

7. Foster communication with shareholders, the public, employees, indigenous people and government to enhance understanding of environmental issues affecting the Corporation's activities.

8. Work pro-actively with government and the public to define environmental priorities. Participate in the development of responsible laws for the protection of the environment.

9. Allocate sufficient resources to meet the Corporation's environmental goals. Annually assess the projected costs of decommissioning and reclamation while funding "off balance sheet" an appropriate amount to ensure that there will be sufficient cash reserves to pay for these costs upon closure.

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix C

Carmacks Copper Project Performance Standards and Design Criteria Parameters

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Western Silver Corporation

Carmacks Copper Project

Performance Standards and Design Criteria Parameters

April 2005

CONTEXT OF THIS DOCUMENT

This document, prepared by Western Silver Corporation, is a revised version of a report prepared by Western Copper Holdings Ltd. entitled "*Carmacks Copper Project Design Criteria and Parameters*" (October, 1998) and subsequently presented to Yukon Government (YG), Energy, Mines and Resources in August 2004. The rationale for the selection of project design criteria and parameters is not presented in this document. The reader is referred to the Carmacks Copper Project listing of reports for further details and information.

The purpose of this document is to provide a summary of project performance standards and objectives, and engineering design objectives and criteria. The project performance standards and design criteria are being presented for discussion with government authorities to ensure that regulatory requirements are being met.

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Appendix A YG Performance Standards for Carmacks Copper Project

1.0 INTRODUCTION

1.1 GENERAL

The Carmacks Copper Project is a proposed open pit copper mine and solvent extraction and electro winning (SXEW) processing facility being developed by Western Silver Corporation (formerly Western Copper Holdings Ltd.). It is located in the Yukon Territory, approximately 38 km northwest of the town of Carmacks. The project will include an open pit, acid heap leach and copper extraction facility, waste rock storage area, soil stockpiles, events pond, drainage ditches, sediment control ponds, roads, and miscellaneous facilities to support mining operations. A crushing plant may also be constructed for ore and fill processing.

This document is being presented as part of the Project Description for discussion with Yukon regulators to determine the overall performance standards and design criteria that will guide the construction operation and decommissioning of the project. The standards and criteria presented here are intended to support a Yukon Environmental Assessment Act Screening and Water License Application. It presents performance standards and objectives for environmental protection consistent with industry best practices, and the design criteria and parameters that will be used to update the analysis and design of the mine facilities for presentation to the review and regulatory committees. These criteria and parameters consider primarily the geotechnical and operational aspects of the design of the mine facilities, and do not address the SX/EW plant processing plant or its associated infrastructure. More detailed information will be presented in the project description and design reports.

The definition of a performance standard is a numerical limit or narrative statement adopted from criteria or objectives in a legally enforceable form, such as in a regulation, statute, contract or other legally binding document (Environment Canada, 1991). The distinction between design criterion and a design parameter is the difference between the intended output and input.

1.2 PROJECT DESCRIPTION

Active mining at the Carmacks Copper project is estimated to be for eight years, producing about 60 million tonnes of waste rock, and 13.3 million tonnes of copper ore. Using shovels and trucks, the mine will remove an overall average of about 20,500 tonnes per day of waste rock and overburden year round from the open pit to the appropriate stockpiles. For about 300 days each

year, the mine will use haul trucks (run of mine ore) or a series of mobile conveyors to place up to 9,872 tonnes per day of ore on a 31.5 ha lined heap leach pad in 8-m lifts. Studies are underway to consider the possibility of crushing the ore before it is conveyed to the leach pad.

Once on the heap, 540 m^3/hr of raffinate (a barren acid solution) from the process plant will be applied to the surface of the ore at rate of 0.204 L/min/m^2 by a system of buried drip emitters. After leaching through the ore, the pregnant leachate solution (PLS) will be collected in a network of pipes on top of the leach pad liner and flow either directly to the process plant or to the events pond below the heap.

After mining ceases, the heap will be leached for about two more years. When the leaching is no longer economical, the heap will be rinsed for about three years then decommissioned. *In-situ* biological treatment will be undertaken in the heap to neutralize and stabilize metals. Active water treatment may be required for a period of time to reach effluent performance standards; however, a long-term passive treatment (infiltration gallery) is proposed for final closure. Preliminary metallurgical test work indicates that the heap can be rinsed and neutralized.

1.3 DESIGN OBJECTIVES

The principal objectives of the design for the various mine facilities are to:

- Use industry best management practices to meet existing environmental laws and regulations;
- Ensure protection of the regional groundwater and surface water quality and flows both during operations and in the long-term;
- Stage the development to minimize the environmental disturbance at any one time during operations, and to distribute capital expenditures over the life of the facility;
- Monitor the operation to check that the design objectives are met and that environmental impacts are predictable and acceptable; and
- Reclaim the facilities to a condition compatible with the original land use, ensuring long-term stability under extreme precipitation and design seismic events.

The principal objectives of defining performance standards are as follows:

- The protection of health and safety of public and area fauna by the elimination of unacceptable health hazards;

- Reclaiming for future use the areas where infrastructures (buildings, chemical and fuel storage, roads, sediment ponds, solution treatment facilities, tailings facilities, waste rock storage areas (WRSA), heap leach pads, open pits) are located;

- Absence or mitigation in the production and circulation of substances that could damage the receiving environment;

- The restoration of the site to a condition that is visually acceptable to the community; and

- In the long term, eliminating the need for monitoring and maintenance.

Performance standards will be established for effluent quality, receiving water quality, groundwater quality, and revegetation.

2.0 GENERAL DESIGN CRITERIA AND PARAMETERS

2.1 DESIGN LIFE AND CONSEQUENCE CATEGORIES

The design life of the mine facilities is approximately 12 years, (8 year mine life; 2 years residual leaching; 2 years heap detoxification and decommissioning) with long-term closure monitoring following. It is expected that the site would be monitored for a further period of time after decommissioning to demonstrate the effectiveness of closure measures.

The embankments at the Carmacks Copper site will not impound fluids for long periods during operations. The following measures will achieve this:

- Low-level outlets within the heap confining embankment will prevent fluid impoundment during normal operations.

- Solution in the events pond and sediment ponds will be used as makeup water in the heap.

- Water in the sediment ponds will drain through decant structures in the abutments.

According to the classification method proposed by the Canadian Dam Safety Association (CDSA, 1999), the consequence category for the heap leach and events pond embankments is "high".

2.2 SITE HYDROLOGY

Details of the site hydrology are presented in the Clearwater Consultants Ltd. Design Memoranda CCL-CC2 (March 13, 1998) and CCL-CC2A (April 28, 1998). Average values for key hydrologic parameters are summarized in the table below for a typical elevation of 850 m at the Williams Creek site. Values for extreme wet and dry conditions are presented in the source documents.

Parameter	Average Value, mm
Total Annual Precipitation	372
Total Annual Precipitation – 100 year return period wet year	541
Annual Rainfall	205
Annual Snowfall	168
Wet Period Precipitation	
One-Month Rainfall	78.8
Two Month Rainfall	124
Three Month Rainfall	159
Four Month Rainfall	183
Five Month Rainfall	196
Six Month Snowfalll	165
Seven Month Precipitation	181
Eight Month Precipitation	209
Maximum Snowpack, mm water	145
Annual Lake Evaporation	
Low	400
Average	460
High	520

2.3 SPILLWAYS

Emergency overflow spillways will be provided for all water and solution storage reservoirs to prevent uncontrolled overtopping of embankments. The heap and event pond spillways will be sized to pass the peak flow from a 100-yr return period storm. Embankment crest elevations will be determined by adding 500 mm of freeboard to the maximum routed water elevation.

2.4 DIVERSION CHANNELS

Surface water diversion channels will be provided around key project facilities to divert natural runoff water away from the structures. The channels will be designed with 250 mm freeboard above the peak flows from a 100-yr return period storm event. Diversion channels will be consistent with the design hydraulic capacity of the structure and will be based on the maximum flow velocities expected in the local channel.

2.5 SEDIMENT CONTROL

Sedimentation below the leach pad and events pond areas, waste dumps and plant site will be controlled with conventional settling ponds. The settling ponds will be sized to remove inflowing suspended sediments down to fine silt sizes for events up to a 10-yr return period 24-hr duration storm. Emergency spillways will be provided for each pond as described in Section 2.3.

2.6 SEISMIC CRITERIA

2.6.1 Maximum Credible and Design Basis Earthquakes

The heap confining embankment and events pond dam have a "high" consequence category as described by CDSA. Accordingly, these two embankments will be designed to withstand accelerations resulting from the greater of 50 percent of the Maximum Credible Earthquake (MCE) from a deterministic analysis or the acceleration from an earthquake with a 1000-yr return period from a probabilistic analysis. The sediment control pond embankments and the waste rock storage area have " very low" to "low" consequence categories, and will also be designed to withstand earthquake accelerations with a 475-yr return period.

From probabilistic analyses conducted by the Pacific Geoscience Centre the maximum ground accelerations associated with the 475-yr and 1000-yr return period earthquake is estimated to be 8.5 percent and 10.3 percent of gravity, respectively. Using deterministic methods, the maximum credible design acceleration is 13.2 percent of gravity and will be used for stability analysis purposes with a corresponding factor of safety greater than 1.

The heap confining embankment and events pond dam will be designed to withstand horizontal accelerations of 10.3 percent of gravity and satisfy a minimum factor of safety of 1.15 or greater. Similarly, the other embankments and waste rock storage area will be designed for 8.5 percent of gravity.

2.6.2 Allowable Deformations and Seismic Coefficients

For lined waste impoundments in the U.S., Seed and Bonaparte (1992) describe the current practice as using an allowable seismic displacement of 150 to 300 mm. A displacement of 150 mm will be allowed at the crest of the heap confining embankment and the events pond dam.

The following table summarizes project allowable crest displacements.

Embankment	Consequence Category	CDSA Max ground Accel, %g	Allowable Disp, m
Heap confining embankment	High	10.3	0.15
Events pond dam	High	10.3	0.15
Sediment pond dam	V. low-low	8.5	1.0
Waste rock pile	V. low-low	8.5	3.0

2.7 GEOTECHNICAL STABILITY

For the steady-state static loading condition at the "high" consequence structures-the heap confining embankment and events pond dam-the factor of safety will be at least 1.5 for all failure mechanisms.

For the seismic loading condition, the factor of safety for the heap confining embankment and events pond dam will be greater than 1.0 at the maximum credible earthquake and at least 1.15 using the maximum design earthquake seismic coefficients.

For the end of construction static loading condition, all structures will have a factor of safety of at least 1.3, regardless of consequence category.

2.8 PERMAFROST

Where the soils are unfrozen, or frozen but with a moisture content not greater than 17 percent, construction can proceed without any special foundation treatment. Prior to construction in the heap and extent ponds area, test holes will be drilled in a 50-m grid pattern to bedrock or a maximum depth of 25 m, whichever is shallower. In the waste rock storage area, test holes will be drilled in a grid pattern prior to construction. A construction quality assurance and quality control (QA/QC) manual will be developed and submitted prior to construction.

2.9 EFFLUENT WATER QUALITY

All effluent, which is discharged from the project, both during operation and at final decommissioning, shall meet the following effluent quality standards, which are provided in Schedule IV of the *Metal Mining Effluent Regulations*.

Authorized Limits of Deleterious Substances (as stated in the Metal Mining Effluent Regulations)

Item	Column 1 Deleterious Substances	Column 2 Maximum Authorized Monthly Mean Concentration	Column 3 Maximum Authorized Concentration in a Composite Sample	Column 4 Maximum Authorized Concentration in a Grab Sample
1	Arsenic	0.50 mg/L	0.75 mg/L	1.00 mg/L
2	Copper	0.30 mg/L	0.45 mg/L	0.60 mg/L
3	Cyanide	1.00 mg/L	1.50 mg/L	2.00 mg/L
4	Lead	0.20 mg/l	0.30 mg/L	0.40 mg/L
5	Nickel	0.50 mg/L	0.75 mg/L	1.00 mg/L
6	Zinc	0.50 mg/L	0.75 mg/L	1.00 mg/L
7	Total Suspended Solids:	15.00 mg/L	22.50 mg/L	30.00 mg/L

NOTE: All concentrations are total values.

2.10 RECEIVING WATER QUALITY

The project shall be operated and decommissioned in such a manner that the long-term water quality of lower Williams Creek shall meet the objectives of the Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life, prepared by the Canadian Council of Minister of the Environment, 1999, updated 2002.

2.11 GROUNDWATER QUALITY

The project shall be operated and decommissioned in such a manner that the long-term groundwater quality down gradient of the heap and WRSA shall meet the objectives of the Yukon Environment Act, *Contaminated Sites Regulations,* Aquatic Life criteria (Schedule 3).

2.12 REVEGETATION

General standards that will be followed with respect to revegetation are as follows:

- Vegetation is self sustaining and comprises native seed mixes;
- The vegetative cover is capable of self-regeneration without continued dependence on fertilizer or re-seeding;
- The establishment of a vegetative cover with sufficient density and species diversity to stabilize the surface against the effects of long term erosion;

- The successive vegetation must be similar to naturally occurring habitats in the surrounding area;
- Plant material does not show detrimental uptake of metals; and
- Points of compliance for revegetation will ensure that:
  - -fertilizing/seeding completed;
  - -vegetation established; and
  - -vegetation accepted.

Refer to Appendix A for the performance standards and criteria that YG has set as the minimum standards for the project.

3.0 HEAP LEACH FACILITY

3.1 DESIGN BASIS

The heap will be designed to store approximately 13.3 million tonnes of ore at a dry density of 1.9 tonnes/m^3. The ore density may be higher in the later years of operation due to consolidation under load, possibly reducing the size of the final pad expansion. The leach pad could be expanded beyond this capacity to the west or the height could be increased. Ore will be placed for eight years at an approximate rate of 9,872 tonnes per day for up to 300 days per year. Periods of higher or lower loading rates are expected due to operational considerations. The 31.5 ha leach pad will be constructed in three stages ahead of ore placement. Ore will be placed in 8-m lifts at an overall slope of 2½h: 1v using either haul trucks or conveyor. It is anticipated that approximately two years of residual leaching, three years of heap rinsing and eventual decommissioning will follow the eight years of ore placement.

The raffinate will be applied through a system of drip emitters at a rate of 0.204 litres/min/m^2. The total raffinate flow to the heap will be 540 m^3/hr for a design leaching cycle of 120 days. Solution will not be stored within the heap but will drain through perimeter piping and a low-level outlet to the process plant or the events pond.

3.2 GENERAL ARRANGEMENT

The ore will be placed on the valley-fill heap in 8-m lifts by conveyors and leached in subsequent lifts, progressing up slope for the first lift and atop previously leached lifts. Storage for excess solution and extreme precipitation events will be provided in an events pond located down gradient from the heap.

The proposed leach pad will be lined with a double composite liner system with a leak detection and recovery system (LDRS). The pad will be surrounded by a 2-m high perimeter berm on the north and west sides and a perimeter bench on the east side. A confining embankment will form the lower limit of the leach pad to support the heap. With a crest elevation of approximately 780 m, it will be about 22 m high and 350 m long.

There will be no in-heap solution storage behind this confining embankment. Solution from the heap will be collected by a network of corrugated polyethylene tubing (CPT) above the leach pad liner and conveyed by gravity flow to the process plant. There will a double lined spillway over the heap confining embankment to the events pond to convey solution during extreme precipitation events. Diversion ditches will collect and convey runoff from upslope of the heap leach facility to a sediment control pond, thereby reducing the quantity of water reporting to the heap and minimizing PLS dilution.

3.3 GEOTECHNICAL AND HYDROGEOLOGICAL PROPERTIES

The following documents form the basis for selecting the principal geotechnical and hydrogeological properties for final design of the leach pad, heap confining embankment, waste rock storage area, events pond dam and other foundation structures:

- Knight Piésold, Ref. No. 1783/1, May 1995 'Report on Preliminary Design' – Laboratory test work and index test results, including foundation materials, pre- and post-leach ore, geosynthetic/soil interfaces, and geosynthetic/geosynthetic interfaces.

- Knight Piésold, Ref. No. 1784/1, June 1996 'Report on 1996 Geotechnical and Hydrogeological Site Investigations' – Laboratory test work and index test results, including permeability, coefficient of consolidation, coefficient of volume compressibility, and uniaxial compressive strength of bedrock.

The table below provides a list of materials and interfaces to be considered during design and the principal geotechnical and hydrogeological parameters adopted for each.

Zone	Material Requirements	Placement and Compaction
Drainage Blanket Filter Zone	Sand and gravel or rockfill from designated borrow areas or required excavations. Selected or processed material.	Placed in maximum 500 mm lift thickness and compacted with a vibrating smooth drum roller.
Random Fill Zone A	Selected earthfill or rockfill from designated borrow areas, required excavations and/or from preproduction stripping of the ore body.	Placed in maximum 500 mm lift thickness and compacted to a minimum 95% modified Proctor maximum dry density.
LDRS Drainage Layer	Sand and gravel from designated borrow areas or required excavations. Processed material.	Placed in one lift to a uniform density, free from excess voids.

3.4 LINER SYSTEM

The entire leach pad and the uphill face of the confining embankment will be lined with a double composite liner with an integral LDRS. Three separate designs are envisioned with protection for the environment appropriate to the potential for leakage in any given zone: we have designated these zones upper works, lower works and trenches.

The upper works comprise the upper portion of the heap leach pad, at elevations greater than 830 m. In this zone, the base slope exceeds 7:1 with a consequence that PLS flow velocities are high and hydraulic heads are low.

The lower works comprise the lower portion of the heap leach pad adjacent to the confining embankment. In this zone, PLS velocities are low and the hydraulic head will approach 1.0 m. Therefore, there is a potential for higher leakage rates through the primary liner in this area.

The liner system will be comprised of the following components:

<u>Upper Works</u>

The upper works liner system comprises (listed from the top down):

- High-permeability, durable overliner cushion layer with solution collection piping;
- 60 mil textured HDPE upper liner;

- Leak detection and recovery system (LDRS) comprising a high transmissivity tri-planar geocomposite;
- 60 mil textured HDPE lower liner; and
- Subgrade (with foundation drains).

Lower Works

The lower works liner system comprises (listed from the top down):

- High-permeability, durable overliner cushion layer with solution collection piping;
- 60 mil textured HDPE upper liner;
- Leak detection and recovery system (LDRS) comprising a high transmissivity tri-planar geocomposite;
- 60 mil textured HDPE lower liner;
- Compacted lower soil liner with a permeability not greater than 10^{-8} m/s; and
- Subgrade (with foundation drains).

Trenches

The trench design profile comprises (listed from the top down):

- High-permeability, durable overliner cushion layer with solution collection piping;
- 60 mil textured HDPE upper liner;
- 12 oz nonwoven polypropylene geotextile;
- Drainage layer comprising durable crushed ore or sand and gravel with permeability of at least 5×10^{-4} m/s and solution recovery piping;
- Leak detection and recovery system (LDRS) comprising a high transmissivity tri-planar geocomposite;
- 12 oz nonwoven polypropylene geotextile;
- 60 mil textured HDPE lower liner; and
- Subgrade.

3.5 LEAKAGE CRITERIA

For the valley leach pad, leakage through the upper composite liner system, which will be collected and monitored through the LDRS; will be estimated. The permeability of the various layers used in the design is as follows:

- Overliner: $k > 5 \times 10^{-4}$ m/s
- Textured HDPE liners: $k < 1 \times 10^{-10}$ m/s (permeability controlled by construction defects)
- LDRS: $k > 1 \times 10^{-4}$ m/s
- Soil liner: $k < 1 \times 10^{-8}$ m/s

Using the methods described by Giroud and Bonaparte (1989b), the allowable leakage rate into each cell of the LDRS is 100 L/day averaged over a 12-month period, and 300 L/day averaged over a 3-month period. The estimated leakage rates will be achieved by placing solution recovery pipes in the overliner and the LDRS layers to reduce the hydraulic heads on, and thus the flow through, the underlying liners. The collection pipe systems within the overliner and LDRS layers will flow by gravity to the perimeter of the pad and then to the plant. Flow rates from individual cells of the LDRS will be monitored daily during operations.

3.6 LINER TERMINATIONS

All HDPE liners will be terminated in anchor trenches. These trenches will be either permanent trenches along the perimeter berm, bench and embankment, or temporary trenches on the edges of pad extensions. The design criteria for the trenches are:

- To ensure water cannot enter drainage systems by seeping through the trench backfill.
- To provide adequate anchoring resistance to withstand the pullout forces generated by gravity and thermal expansion and contraction of the HDPE geomembranes.

3.7 FROST PROTECTION

To protect the soil portion of the leach pad liner from frost damage, the liner will be covered with at least 4.5 m of ore and overliner prior to winter.

4.0 EVENTS POND

4.1 DESIGN BASIS

Active solution storage will not be within the heap, but in the events pond below the heap confining embankment. The events pond will have a capacity of approximately 160, 000 m^3 to store the following combinations of events:

- The operating solution volume, plus
- Excess runoff inflows from the critical duration 100-yr return period event occurring at the most critical point in time, plus,
- An allowance for heap draindown as follows:
  - During the first year of operation, 100% of the total potential heap draindown volume, or
  - During subsequent years of operation, 48 hours of draindown at the full rate of solution application. For a solution application rate of 540 m^3/hr this volume is 26 000 m^3; and
- Redundant systems (i.e. pumps, power, spare parts).

This capacity will be available each year at the start of the winter season.

Details of the leach pad water balance and the determination of design solution storage volumes will be presented in the Clearwater Consultants Ltd. Design Memorandum CCL-CC4.

4.2 GENERAL ARRANGEMENT

Normally, solution will flow directly from the heap to the plant. When there is a high-rainfall or high-precipitation event, or when the plant cannot accept solution, the flow can be directed from the heap to the events pond.

Immediately below the heap confining embankment toe, the events pond will have a lined area of about 62,000 m^2 and a storage capacity of about 160,000 m^3. This storage will be created by a dam across the valley at the lower end of the pond about 30 m high, 380 m long with a crest elevation of about 754 m.

The events pond will incorporate two HDPE geomembrane liners with a high-transmissivity geonet drainage layer placed in between. There will be an emergency spillway in the dam crest as described in Section 2.3.

4.3 LINER SYSTEM

The entire events pond will have a double liner with an integral LDRS. From the bottom up, the liner system will be comprised of the following components:

- Subgrade – areas of suitable *in-situ* material and areas that will be covered by borrow material backfilling excavations of unsuitable material;
  - random fill as defined in the technical specifications;
  - maximum particle size of three quarters of the approved layer thickness;

- HDPE Liner – the lower geomembrane liner will be 40 mil smooth HDPE and the top geomembrane liner will be 60 mil;
  - random fill as defined in the technical specifications;

- Leak Detection and Recovery System – high transmissivity polyethylene geonet placed between the two geomembranes;
  - leakage into the LDRS layer will be conveyed back to the pond via a sump at the low point of the events pond accessed by an inclined riser and submersible pump.

4.4 LEAKAGE CRITERIA

Using the methods described by Giroud and Bonaparte (1989b), the allowable leakage rate into the events pond LDRS is 200 L/day averaged over a 12-month period, and 600 L/day averaged over a 3-month period.

5.0 WASTE ROCK STORAGE

5.1 DESIGN BASIS

The waste rock storage area will cover an area of 70 ha and have a storage capacity of about 60 million tonnes. Waste rock will be placed year round at an annual rate of approximately 7.5 million tonnes.

Designs for the waste rock storage area will conform to the British Columbia Mine Waste Rock Pile Research Committee Investigation and Design Manual Interim Guidelines, May 1991.

5.2 GENERAL ARRANGEMENT

The waste rock storage area will be developed in horizontal lifts by trucks and bulldozers. The waste rock will be dumped in 25 m high lifts with intermediate benches wide enough to maintain an overall slope of approximately 2½ h: 1v. A 100-m wide stripped buffer will be maintained below the toe of the waste rock pile until the final configuration is achieved.

Most of the upper limit of the waste rock storage area is either immediately below the open pit or on a local drainage divide, so there is no need to divert upslope runoff. Ditches around the lower perimeter will collect surface runoff and seepage from the waste rock pile and drain to a sediment control pond. The sediment control pond will be routinely monitored for effluent quality.

6.0 OPEN PIT

The proposed open pit is approximately 800 by 400 m at the existing ground surface and will be approximately 275 m deep at its deepest point. Based on preliminary estimates, the layout of the pit calls for ultimate inter-ramp angles of 55 degrees with overall angles of 41 degrees in the northwest and southeast sectors and 45 degrees and 55 degrees in the northeast and southwest sectors respectively. Double benching will be used, with the bench height and catchment berm width being 12 m and 8 m respectively. Bench face angles will be blasted to 70 degrees. A study of pit optimization factors may alter the internal design and sequencing of the pit operation.

In developing these slope angles, various failure mechanisms, including failure along local structural discontinuities and deep-seated failures through the surrounding rock mass have been considered. Further open pit details are provided in Report on Pit Slope Stability (Knight Piesold Ref. No. 1782/3, January, 1993).

Water from the open pit will be used for process makeup water to the fullest possible extent. Any excess pit water will be discharged to the environment in full compliance with the discharge performance standards (see Section 2.9).

7.0 HAUL ROADS

Haul roads within and around the open pit, waste rock storage area and heap leach facility will have an overall width of approximately 26 m, including an allowance for ditches and safety berms. The maximum grade will be approximately 10 percent on all main roads and approximately 12 percent on bench access roads.

All haul roads will be protected from flooding or washout at stream crossings. In general, culverts will be sized to convey peak flows from a 25-year return period event without water surcharge above the culvert crown. Extreme peak flows with return periods of up to 100 years may be considered for critical road sections. Small stilling basins will be excavated at the intake of all culverts to prevent sedimentation and blocking within the culverts and to improve water quality.

Bridges will be sized to convey peak flows from a 100-year return period event. Riprap and other erosion protection measures for culverts and bridges will be designed for the same event as the culvert or bridge.

8.0 CLOSURE REQUIREMENTS AND RECLAMATION

8.1 HEAP LEACH FACILITY

Closure requirements for all facilities will be planned to satisfy the requirements of the performance standards and licences issued under the Quartz Mining Act and Yukon Waters Act and Regulations.

In-situ neutralization of the spent ore pile is planned and to be complemented with a passive infiltration gallery. Once the last ore is loaded and the full leach cycle is complete there will be a period when acid is no longer applied but copper recovery continues (Stage IV, Years 8 and 9). This stage will end when copper recovery is no longer economical.

At that time, the heap will be rinsed with water for a period yet to be determined but for the current analysis is assumed to be 3 years (Stage V). *In-situ* biological heap neutralization may follow using alcohols, sugars, and bacteria. The length of the rinsing and *in-situ* neutralization period will depend on economic and chemical criteria, focusing on the cost to achieve effluent that can be directly discharged and then subsequently treated using a passive system (infiltration gallery).

Following Stage V, the heap will be fully drained down, excess solutions will be neutralized, treated and released, and an evapotranspiration cover will be placed. At closure, the heap will be a stable rock pile that will not impound water except temporarily during high-precipitation or high-runoff events.

The evapotranspiration soil cover will cover the ore to reduce the volume of precipitation entering the heap and enhance water evaporation. The permeability of the cover will be finalized after further testing and analysis of the results. To allow placement of the cover, the heap slopes will be re-contoured to a continuous 2 ½ h:lv slope by regrading the intermediate benches and angle of reposes slopes. Runoff interception ditches will cross the final surface of the cover to prevent surface erosion. These ditches will be designed to convey peak flows from a 100-yr return period storm event of critical duration, and will be armored to prevent erosion.

Diversion channels surrounding the heap will be left intact and stabilized for closure to reduce the volume of upslope runoff entering the heap. Diversion channels will be designed to convey peak flows from a 100-year return period storm event of critical duration.

Spillways will be sized to accommodate a peak flow consistent with a CDSA 'moderate' consequence category structure with allowances for freeboard.

8.2 EVENTS POND

The events pond will be retained and used for storing spent ore seepage at closure. Spent ore seepage will be treated if required, in the water treatment plant and released to the sediment pond or allowed to evaporate seasonally in the events pond. Alternatively and in the longer term, neutralized heap seepage would be directed to an infiltration gallery. The events pond design criteria for solution storage will remain the same as the operational design criteria. These design criteria also consider the criteria for sizing the contingency water treatment plant. Physical stability criteria will be as those for operations. The pond spillway will be sized to pass the peak flow from a critical duration event of an approximately 475-yr return period. Since the solution volume will be less than during operations and the solution will be diluted, there will be no leakage criteria specified after closure.

When the spent ore seepage meets effluent discharge criteria and is suitable for direct release to the environment, the events ponds will be decommissioned by draining all fluids, sampling and testing any sediment, and disposing the sediment in a manner consistent with the regulations then in effect. Liners will be folded over, covered and the dikes breached to prevent water accumulation.

8.3 WASTE ROCK STORAGE AREA

The overall dump geometry will not be modified at closure. Surface water ditches and the sediment pond will remain until water quality, as a minimum, meets the *Metal Mining Liquid Effluent Regulations* effluent discharge criteria and is suitable for direct release. Diversions and the sediment pond will be stabilized with the closure design criteria remaining the same as during operations.

8.4 OPEN PIT

Preliminary calculations estimate that it will take over 300 years to flood the open pit from direct precipitation alone, assuming no exfiltration to ground water. Based on the current understanding of the ground water regime, ground water contributions to mine water are expected to be negligible. Consequently it is unlikely that the open pit can be flooded.

Criteria for measures to close the pit will include the public safety. Steep slopes will be blocked with fences or large rocks to prevent inadvertent access.

8.5 PLANT SITE

Criteria for closure includes a chemically and physically stable land surface, land use capability consistent with the surrounding area, public health and safety, minimal hazards to wildlife and self-sustaining vegetation

It will be important to maintain access as required by the closure plan. Once safety issues have been dealt with, a significant criterion for road closures will be the desires of the Little Salmon/Carmacks First Nation and the local community. Where necessary, mine haul roads will be stabilized, scarified to minimize future erosion, and revegetated.

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Western Silver Corporation

Carmacks Copper Project

Performance Standards and Design Criteria Parameters

Appendix A

YG Performance Standards for Carmacks Copper Project

APPENDIX A

Performance Standards for Carmacks Copper Project

- Work should be conducted by properly qualified professionals
- Where possible, progressive reclamation will be part of the plan

DESIGN STANDARDS

Issues	Performance Objective	YG Guideline/Standard
CRITICAL		
ML/ARD Concerns with Heap -Heap detoxification -Acid drainage - Operational and post-closure	Prevent significant impacts to downstream terrestrial and aquatic resources Prevent significant post-mining ecological and human health impacts on the mine site Minimize liability and environmental risk both during operation and after mine closure Adequate understanding and commitment from proponent to conduct required work No requirement for perpetual treatment	• Meet CCME guidelines in fish bearing waters • MMER last point of control • Assess the ML/ARD potential of all affected geological materials. ie excavated (mine wastes), exposed (mine walls) and post-leach (heap) • When necessary, develop plans for impact prevention (mitigation), operational material characterization, material handling, waste disposal, site reclamation, water management, monitoring and maintenance. • Identify the required work including the time frame, risks, liabilities, and post-mining alienation of resources. • Follow design requirements and conduct the work outlined in the **Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia** and Draft **Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at**

Issues	Performance Objective	YG Guideline/Standard
		Minesites in British Columbia.
Solution Control -Process Waters	Prevent discharge of noncompliant waters	• Provide storage capacity to contain normal operating levels + 10 year snowmelt + 100 year 24hr storm event **+** sufficient draindown capacity. (Proponent must substantiate their proposed draindown containment capacity based on sound reasoning and a risk assessment utilizing accepted methodology) • Leak detection and recovery system with contingency plans
Liner Design	Prevent discharge of noncompliant waters	• Liner System (including materials; conceptual construction methods and conditions; operation and maintenance procedures) achieving a permeability at least equivalent to a synthetic liner over a 12" soil liner with permeability of 10^{-6} cm/sec • Leak detection and recovery system with contingency plans
Physical Stability of heap and associated earth works, such as berms constructed to constrain leachate	Minimize risk of liner damage	• Suitable design, criteria based on Canadian **Dam Association's "Dam Safety Guidelines" (1999)**
Waste Rock Dump Stability	Physical Stability	• **BC Mine Waste Rock (1991) Interim guidelines**
Waste Rock ML/ARD Concerns	Prevent significant impacts to downstream terrestrial and aquatic resources Prevent significant post-mining ecological and human health impacts on	• Meet CCME guidelines in fish bearing waters • MMER last point of control • Assess the ML/ARD potential of all affected geological materials. ie excavated (mine wastes), exposed (mine walls) and

Issues	Performance Objective	YG Guideline/Standard
	the mine site Minimize liability and environmental risk both during operation and after mine closure Adequate understanding and commitment from proponent to conduct required work No requirement for perpetual treatment	post-leach (heap) • When necessary, develop plans for impact prevention (mitigation, operational material characterization, material handling, waste disposal, site reclamation, water management, monitoring and maintenance, and • Identify the required work including the time frame, risks, liabilities, and post-mining alienation of resources. • Follow design requirements and conduct the work outlined in the **Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia** and Draft **Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia.**
OTHER		
Terrestrial Reclamation Standards	As per attached Terrestrial Reclamation Standards	As per attached Terrestrial Reclamation Standards

Note:

1. Project proposal must be based on sound technical design and Industry Best Management Practices.

Terrestrial Reclamation Standards

Global Objectives

1. The protection of health and safety of public and area fauna by the elimination of unacceptable hazards.
2. Reclaiming for productive future use the areas where infrastructures (e.g., buildings, chemical and fuel storage, roads, sediment ponds, solution treatment facilities, tailings facilities, waste rock storage areas, heap leach pads) are located.
3. Prevent significant exposure to or release of substances that could damage the receiving environment.
4. Minimize liability and environmental risk.

Terrain Stability

Objective: Protection of health and safety through measures to prevent or otherwise protect from terrain hazards.

General Standards

1. Access to areas of unsafe drop-offs are blocked
2. Internal and external waste rock storage are re-contoured to a stable configuration

Erosion Control

Objective: Prevent erosion that significantly impacts drainage quality or impedes productivity of reclaimed site.

General Standards

1. Slopes are stabilized by contouring and leveling to provide land forms which conform to the surrounding terrain and provide suitable seedbeds
2. Lack of erosion features on re-sloped surfaces such as gullies and rills
3. Diversion ditches are constructed to guide drainage away from pit walls, where necessary
4. Vegetative mat is sufficient to control erosion
5. Adequate growth media (fines) is present to sustain re-vegetation
6. Appropriate pit ponds and decants are in place

Re-vegetation

Objective: To protect wildlife habitat through the reestablishment of a vegetation mat (food source, cover, hide etc,..) and self sustaining native vegetation.

General Standards

1. Vegetation is self sustaining and comprises native seed mixes
2. The vegetative cover is capable of self-regeneration without continued dependence on fertilizer or re-seeding.
3. The establishment of a vegetative cover with sufficient density and species diversity to stabilize the surface against the effects of long term erosion
4. The successive vegetation must be similar to naturally occurring habitats in the surrounding area
5. Plant material does not show environmentally significant uptake of metals
6. Points of Compliance
   -fertilizing/seeding completed
   -vegetation established
   -vegetation accepted
   - Vegetation must be self-sustaining for an appropriate period
   - if vegetation is not acceptable, measures will be taken to re-seed or apply further growth media where necessary

Roads and Trails

Objective: Decommissioning of access corridors when they are no longer required

General Standards

1. Removal of bridges, culverts & pipes. Streambeds re-established with appropriate stabilization of banks.
2. Stabilization of banks, road fills and cuts
3. Installation of diversion berms on steep slopes
4. Reclamation of the surface and seeding
5. Ensure road cuts are stable and access is restricted where there is a safety hazard
6. Access to be restricted with appropriate signage for areas posing a safety risk

Buildings and Infrastructure

Objective: Removal of all structures and re-establishment of vegetation mat.
Removal of all hazardous material

General Standards

1. Structures removed
2. Waste from dismantling is removed from the site and reused or stored in an authorized waste disposal site
3. All buried support infrastructures (tanks, pipes, underground services, etc.) should be removed or decommissioned in a safe, acceptable manner. All buried infrastructure remaining will be identified on site closure maps.
4. All non-toxic waste may be disposed of in an approved waste disposal site. The location and contents of disposal sites will be identified and recorded

5. In all areas where fuel and chemicals were stored and handled at the site, the soil has been tested for contaminants, and treated if required
6. Mining equipment, ore processing equipment, and heavy machinery has been removed from the site
7. After being emptied, decommissioned septic tanks are either removed or completely filled with gravel, sand, earth or inert material
8. Foundations covered with soil and self sustaining vegetation established.
9. Contaminated soils remediation will conform to the Yukon Contaminated Sites Regulations.
10. No hazardous materials remaining on site

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix D

EBA Engineering Consultants
Carmacks Copper Mine
Heap Leach Pad Liner Design Report

Heap Leach Pad Liner Design
Carmacks Copper Project
near Williams Creek, YT

EBA Project No. 1200133

May 2005

Heap Leach Pad Liner Design
Carmacks Copper Project
near Williams Creek, YT

Submitted To:

Western Silver Corporation
Vancouver, BC

Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE, YUKON TERRITORY

EBA Project No. 1200133

May 2005

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APPENDIX A – Manufacturer's Literature

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) have carried out a review of the existing Heap Leach Pad design for the Carmacks Copper Project, and prepared an alternative conceptual design for submission with the Project Description. Authorization to carry out this work was provided by Mr. Dan Cornett of Access Consulting Group (ACG) on behalf of Mr. Jonathan Clegg of Western Silver Corporation (Western Silver).

The purpose of this work was to assist Western Silver with the development of specific engineering components of the heap leach pad in support of the environmental assessment and permitting for the Carmacks Copper Project. The Carmacks Copper Project is located approximately 28 km northwest of Carmacks, Yukon at Latitude 62.35˚ North and Longitude 136.70˚ West.

Western Silver intends to submit their Project Description to the Yukon Government in early 2005.

2.0 AVAILABLE INFORMATION

Several key documents were either contained in EBA files, or forwarded to EBA for use in this study – they include:

- EBA Engineering Consultants Ltd., *Testpit and Laboratory Test Results – Heap Leach Pad Area, Carmacks Copper Project, NW of Carmacks YT.* EBA Report to Western Copper Holdings Ltd., December, 1997.

- Hallam Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Detailed Report on Hydrogeological Summary and Preliminary Impact Assessment (Ref. No. 1783/3);* IEE Addendum No. 3, October 1995

- Hallam Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Detailed QA/QC Program and Construction Specifications (Ref. No. 1783/5);* IEE Addendum No. 3, October 1995

- Hallam Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Detailed Report on Initial Leach Pad Settlement Assessment (Ref. No. 1783/6);* IEE Addendum No. 3, October 1995

- Hallam Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Detailed Terrain Hazard Mapping;* IEE Addendum No. 3, October 1995

- Hallam Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Detailed Carmacks Copper Operating Plans;* IEE Addendum No. 3, October 1995

- Kilborn SNC·Lavalin, *Western Copper Holdings Limited, Carmacks Copper Project, Report on Detailed Design (Ref. No. 1784/2);* Revised 14 August 1996

- Kilborn SNC·Lavalin, *Western Copper Holdings Limited, Carmacks Copper Project, Report on Updated Detailed Design Criteria (Ref. No. 1784/5);* 3 July 1996

- Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Report on Updated Detailed Design of the Heap Leach Pad and Events Pond (Ref. No. 1785/1);* 23 April 1997

- Knight Piesold Ltd., *Western Copper Holdings Limited, Carmacks Copper Project, Report on 1996 Geotechnical and Hydrogeological site Investigations (Ref. No. 1784/1);* June 1996

- Sitka Corp, *Carmacks Copper Project Design Criteria and Parameters*, October 1998 -

- Western Copper Holdings Limited, *Carmacks Copper Project, Hydrogeological and Water Management Issues*; IEE Addendum No. 4, December 1997

- Western Copper Holdings Limited, *Carmacks Copper Project, Basic Engineering Reports and Definitive Cost Estimate; IEE Addendum No. 4*, December 1997

- Western Copper Holdings Limited, Carmacks Copper Project, Technical Issue Response Document; 30 June 1997

3.0 YUKON GOVERNMENT GUIDELINES

EBA's conceptual design was prepared to comply with the Yukon Government guidelines and referenced standards. Table 1 below presents performance standards dated April 8, 2005 that were provided by Mr. Bill Dunn of the Department of Energy Mines and Resources.

Table 1
April 2005 Performance Standards for the Carmacks Copper Project

Issues	Performance Objective	Yukon Government Guideline/Standard
Liner Design	Prevent discharge of noncompliant waters	• Liner System (including materials; conceptual construction methods and conditions; operation and maintenance procedures) achieving a permeability at least equivalent to a synthetic liner over a 12" soil liner with permeability of 10^{-6} cm/sec • Leak detection and recovery system with contingency plans
Physical Stability of heap and associated earth works, such as berms constructed to constrain leachate	Minimize risk of liner damage	• Suitable design, criteria based on **Canadian Dam Association's "Dam Safety Guidelines" (1999)**

4.0 METHODS

Knight Piesold Ltd (KP) prepared a design of the Heap Leach Pad in 1997 using the factual information identified in Section 2.0. EBA has undertaken a review of the 1997 design and KP reports in an effort to adequately understand the site, plans, resources and commitment by Western Silver. The primary purpose of this initial review was to identify any fatal flaws that may preclude the use of a lined heap leach pad system. The KP heap leach pad layout and design was used as the baseline work for EBA's analyses.

EBA have reviewed the information and identified pertinent events and information that post-dates the April 23, 1997 report by KP. This new information includes:

- The Heap Leach pad site was cleared of forest and vegetation cover in 1996 and has been inactive since that time.
- Canadian Dam Association's "Dam Safety Guidelines" (1999) were issued.
- 1998 Draft Report by Sitka
- Advancement in the design and manufacture of geosynthetic liner systems and geocomposites

In 2005 new seismic hazards will be introduced as part of the revised National Building Code of Canada. Further review of the influence of these new standards will be required, however, based on a cursory review of the information the assumptions made with respect to seismic loading are

expected to satisfy the new code requirements. Further seismic analyses using the new guidelines will be necessary to confirm this.

5.0 DESIGN LIFE AND CONSEQUENCE CATEGORIES

The design life of the mine facilities is approximately 12 years, with long-term decommissioning, reclamation, and monitoring following.

The embankments at the Carmacks Copper site will not impound fluids for long periods during operations. The following measures will achieve this:

- Low-level outlets within the heap confining embankment will prevent fluid impoundment during normal operations.
- Solution in the events pond will be used as makeup water in the heap.
- Water in the sediment ponds will drain through decant structures in the abutments.

The Canadian Dam Safety Association (CDSA, 1999) categorizes the failure of a dam or similar impoundment structure using a consequence scale of Very High, High, Low or Very Low. The CDSA classification method requires that the project components be rated in terms of consequence to safety and/or failure hazard to socioeconomic, financial and environment in the event of a failure. EBA have reviewed terrain hazard mapping prepared by KP, subsurface soil conditions, seismic criteria and the proposed construction and operational plan. It is apparent that under static conditions conventional engineered measures can be implemented to address containment and overall stability. Under seismic loading the stability of the heap pile and impoundment has been shown to be feasible within ordinarily acceptable ranges of parameters and seismic criteria. Seismic loading magnitudes and overall influence are statistically based parameters for which the resulting loads can vary widely. Seismic events occur with little or no warning and therefore it is possible that a statistically low likelihood event might trigger a failure that could lead to a high consequence.

6.0 SEISMIC CRITERIA

6.1 General

Selection of appropriate seismic criteria is key to acceptable engineering design and analysis for the heap leach pad. The CDS guidelines provide the means for regulators and owners to choose an appropriate range of ground accelerations based on the available statistical information and for agreed upon consequences of a failure. Using the CDSA criteria, a corresponding range of seismic related forces acting on all forms of structures can be prescribed based on the estimated seismic generated horizontal ground accelerations. These forces are added to the static forces used in conventional slope stability analyses and the resulting analyses are termed pseudostatic.

To analyze the stability of an embankment under seismic load, Seed (1979) states that a pseudostatic analysis is appropriate provided that potentially liquefiable materials do not make up a significant portion of the structure or foundation. From the site investigations to date, there are few materials on site that could liquefy during an earthquake, making pseudostatic analysis appropriate. Furthermore, foundation treatment methods such as foundation drains are proposed by Western Silver to further reduce the possibility of liquefiable foundation soils.

For the pseudostatic analysis, Hynes-Griffin and Franklin (1984) describe another method to evaluate the appropriate seismic criteria prescribed by the CDSA Consequence based approach. The Hynes-Griffin and Franklin (1984) method determines the appropriate seismic coefficient from the maximum ground acceleration and the allowable displacement. This allowable displacement varies with the type of embankment or structure.

The following sections outline the approach that has been used to selecting the appropriate seismic design criteria for this project.

6.2 Maximum Credible and Design Basis Earthquakes

The heap confining embankment and events pond dam have a "high" consequence category as described by CDSA. According to the CDSA guidelines, these two embankments will be designed to withstand accelerations resulting from the greater of 50 percent of the Maximum Credible Earthquake (MCE) from a deterministic analysis or the acceleration from an earthquake with a 1000-yr return period from a probabilistic analysis. The lower end of the range of design criteria suggested by CDSA has been selected due to the relatively short design life of these two embankments and the resulting reduced risk exposure.

From the probabilistic analyses conducted by the Pacific Geoscience Centre (the maximum ground accelerations associated with the 475 and 1000-yr return period earthquakes are estimated to be 8.5 percent and 10.3 percent of gravity, respectively.

Using deterministic methods, the MCE is associated with the Fairweather-Yakutat source zone, with a maximum magnitude of 8.5. At an epicentral distance of 250 km, it is estimated to generate a maximum ground acceleration of 13.2 percent of gravity. Despite their shorter epicentral distances, three other potential source zones (Northern B.C., Denali-Shakwak, and Mackenzie) all generate lower maximum accelerations of 8.8 percent, 3.9 percent, and 2.1 percent of gravity, respectively. Thus, the maximum credible design acceleration from the deterministic analysis is 13.2 percent of gravity. EBA suggests that a design acceleration of 13.2 percent of gravity be used for stability analysis purposes, and that the corresponding Factor of Safety be greater than 1.

Using CDSA criteria, the heap confining embankment and events pond dam should be designed to withstand horizontal accelerations of 10.3 percent of gravity and satisfy a minimum factor of Safety of 1.15 or greater.

6.3 Allowable Deformations and Seismic Coefficients

For the pseudostatic analysis, Hynes-Griffin and Franklin (1984) describe a method for determining the appropriate seismic coefficient from the maximum ground acceleration and the allowable displacement from seismic activity. This allowable displacement varies with the type of embankment or structure.

For a conventional dam, Seed (1979) suggests that about one metre of crest displacement is usually acceptable.

Where geomembrane liners form a component of an embankment, such as in the heap confining embankment and events pond dam, a smaller crest displacement is allowed to reduce the possibility of influencing the integrity of the liner system during the design seismic event. For lined waste impoundments in the U.S., Seed and Bonaparte (1992) describe the current practice as using an allowable seismic displacement of 150 to 300 mm. A displacement of 150 mm will be allowed at the crest of the heap confining embankment and the events pond dam.

The following table summarizes the seismic coefficients from Hynes-Griffin and Franklin (1984) using the allowable crest displacements described above.

Table 2
Seismic Design Criteria

Embankment	Consequence Category	CDSA Max ground Accel., %g	Allowable Displ., m	Hynes-Griffin and Franklin (1984)Seismic Coef., %g
Heap confining Embankment	High	10.3	0.15	6.7
Events pond dam	High	10.3	0.15	6.7

Based on the above, the design seismic ground accelerations chosen in Section 6.2 satisfy CDSA (1999) guidelines and a strict interpretation of Hynes-Griffin and Franklin (1984).

7.0 GEOTECHNICAL STABILITY

The targeted minimum factor of safety of embankments depends on the loading condition and the assigned consequence category of the embankment. The three primary loading conditions are steady-state static, seismic, and end of construction.

For the steady-state static loading condition at the “high” consequence structures-the heap confining embankment and events pond dam-the factor of safety will be at least 1.5 for all failure mechanisms.

For the seismic loading condition, the factor of safety for the heap confining embankment and events pond dam will be greater than 1.0 at the maximum credible earthquake and at least 1.15 using the maximum design earthquake seismic coefficients provided in Section 6.2.

For the end of construction static loading condition, all structures will have a factor of safety of at least 1.3, regardless of consequence category.

8.0 PERMAFROST

8.1 Regional Overview

The project site is in the southern region as defined by Brown (1970). In this region, the permafrost is discontinuous and its character is varied. Testholes across the site confirm this, with slightly more than half the holes drilled in the early and mid-1990's encountering permafrost. The upper and lower limits of the permafrost vary significantly, but the onsite thermistor instrumentation data suggest that in 1997 the permafrost did not extend deeper than about 25 m below ground surface and that its temperature was only a few tenths of a degree below freezing. Brown (1970) indicates the active layer-the zone subject to annual freeze-thaw cycles-usually ranges from about 1.5 m to 4 m depending on the thickness and character of the organic ground cover, slope aspect, and elevation.

8.2 Review of KP Subsurface Information (to 1996)

Of the 191 samples collected on the entire Carmacks Copper (Williams Creek) Project Site and tested, only 15 that were frozen had moisture contents greater than 17 percent. Of these, only 5 were deeper than 5 m, 2 were from a single test hole in the proposed heap area (DH95-C), 2 were from test holes on the north side of the proposed waste rock storage area (MW96-F and H), and 1 was east of the proposed development area (DH95-2).

8.3 Influence of Permafrost on Design and Construction

In 1996 the entire heap leach pad site was cleared of vegetation in preparation for subgrade preparation work. The removal of the insulating effect of the vegetative ground cover will undoubtedly have had a positive effect by causing the permafrost to degrade. These measures and other proposed measures would reduce the influence of thaw-unstable soils and the residual effects of the permafrost.

Thaw-unstable soils within the permafrost will be addressed. These soils contain sufficient ground ice to possibly cause unacceptable settlement or loss of shear strength as they melt. Without specific tests on individual soils to determine their thaw-instability, the natural moisture content can sometimes be used as an indicator. On other Yukon projects where foundation soils exhibit moisture contents greater than 17 percent of the dry soil weight, the foundation soils have been deemed potentially thaw-unstable. Site specific testing will be required to verify the applicable moisture content at this site, as it is dependant upon soil gradation and composition.

For the purposes of this report, however, it has been assumed that 17 percent moisture is an acceptable cutoff.

Prior to construction in an area, test holes will be drilled in a 50-m grid pattern through the soil cover to either the top of bedrock or to the base of permafrost estimated to be at maximum depth of 25 m, whichever is shallower. In the test holes, the upper 1.5 m will be sampled continuously to check for moisture content and suitable soil liner material. Below 1.5 m, samples will be collected approximately every 1.5 m or as required by material changes, and tested for moisture content. Where the soils are unfrozen, or frozen but with a moisture content not greater than 17 percent, construction can proceed without any special foundation treatment. Where there are frozen soils with a moisture content greater than 17 percent within 5 m of the ground surface, the potentially thaw-unstable soils will be excavated and the excavation backfilled with durable rock. This program and procedures will be described in more detail in the construction quality assurance plan.

It has been reported by others that less than 10 percent of the samples tested to 1997 have been frozen with moisture contents greater than 17 percent. Because of the advanced stripping and thawing, this proportion should have decreased significantly and thereby reduce the required amount of pad foundation preparation.

Also as noted above, there have been only three locations in the areas currently proposed for development where there have been frozen soils deeper than 5 m with water contents greater than 17 percent. Because these are below the active zone, the advanced stripping likely will not cause thawing in a single year at these depths. Also, because of their depth, they cannot simply be excavated.

Each area where there are deep soils that are potentially thaw-unstable will require further engineering analysis and/or testing to determine the proper treatment. For example, drill hole DH95-C in the proposed leach pad area encountered deep potentially thaw-unstable soil at depths of 6.1 m and 12.2 m. Surrounding drill holes did not encounter these soils, so for this example, the problem area could be considered to be local. In this case, a potential reduction in soil shear strength would not be critical to successful performance because the surrounding soils are stable and because the ore will be loaded in an uphill direction. However, without special treatment, local differential settlement could be enough to unacceptably strain the liner system. By subexcavating the subgrade several metres in this area and constructing a raft of heavily compacted durable rock fill, these potential differential settlements can be spread over a wider area to reduce the liner strains to an acceptable amount. For higher ice contents, the raft could be made more rigid to better spread the settlement by reinforcing it with geogrid or high-strength geotextile.

9.0 HEAP LEACH FACILITY

9.1 Design Basis

The heap will be designed to store approximately 13.3 million tonnes of ore at a dry density of 1.6 tonnes/m^3. The ore density may be higher in the later years of operation due to consolidation under load. The leach pad could be expanded beyond this capacity to the west or the height could be increased. Ore will be placed for eight years at a maximum rate of 9872 tonnes per day for up to 200 days per year. The 31.5 ha leach pad will be constructed in three stages ahead of ore placement. Ore will be placed in 8 m lifts at an overall slope of 2½h:1v using conveyors. It is anticipated that two years of residual leaching, three years of heap rinsing and eventual decommissioning will follow the eight years of ore placement.

The raffinate will be applied through a system of drip emitters at a rate of 0.204 litres/min/m^2. The total raffinate flow to the heap will be 540 m^3/hr for a design leaching cycle of 120 days. Solution will not be stored within the heap but will drain through perimeter piping and a low-level outlet to the process plant or the events pond.

9.2 General Arrangement

The ore will be placed on the valley-fill heap in 8-m lifts by haul trucks and leached in subsequent lifts, progressing up slope and atop previously leached lifts. Storage for excess solution and extreme precipitation events will be provided in an events pond located down gradient from the heap.

The proposed leach pad will be lined with a double composite liner system with a leak detection and recovery system (LDRS). The pad will be surrounded by a two metre high perimeter berm on the north and west sides and a perimeter bench on the east side. A confining embankment will form the lower limit of the leach pad to support the heap. With a crest elevation of 780 m, it will be about 22 m high and 350 m long.

There will be no in-heap solution storage behind this confining embankment. Solution from the heap will be collected by a network of corrugated polyethylene tubing (CPT) above the leach pad liner and conveyed by gravity flow to the process plant. There will a double lined spillway over the heap confining embankment to the events pond to convey solution during extreme precipitation events. Diversion ditches will collect and convey runoff from upslope of the heap leach facility to a sediment control pond, thereby reducing the quantity of water reporting to the heap and minimizing the pregnant leachate solution (PLS) dilution.

9.3 Geotechnical and Hydrogeological Properties

The geotechnical and hydrogeological properties of the foundation, zoned earthfill, liner, waste rock, ore, drainage layer, and overliner materials have been estimated from drilling and test pitting, site-specific laboratory results, published literature, and professional experience. The following documents form the basis for selecting the principal geotechnical and hydrogeological properties for final design of the leach pad and heap confining embankment:

- Knight Piésold, Ref. No. 1783/1, May 1995 'Report on Preliminary Design' – Laboratory test work and index test results, including foundation materials, pre- and post-leach ore, geosynthetic/soil interfaces, and geosynthetic/geosynthetic interfaces.

- Knight Piésold, Ref. No. 1784/1, June 1996 'Report on 1996 Geotechnical and Hydrogeological Site Investigations' – Laboratory test work and index test results, including permeability, coefficient of consolidation, coefficient of volume compressibility, and uniaxial compressive strength of bedrock.

- EBA Engineering Consultants Ltd. December 5, 1997. Submission of Testpit & Laboratory Test Results- Heap Leach Pad Area.

The complete site-specific test results are not repeated in this report. Table 3, on the next page, provides a list of all materials and interfaces to be considered during design and the principal geotechnical and hydrogeological parameters adopted for each. Where available, the range of test results is provided in parentheses. In general where test data are available, the selected parameters are at or near the lower bound of the test data. In the few exceptions to this, the parameters were selected after considering the variability of the data and experience in similar circumstances.

Table 3: Summary of Hydrogeological and Geotechnical Properties - Carmacks Copper Heap Leach Pad

Material	Bulk Unit Weight, γ_{bulk} (kN/m3)	Friction Angle, φ' (degrees)	Cohesion, c (kPa)	Permeability, k (m/s)	Coefficient of Consolidation, C_v (m^2/year)	Uniaxial Compressive Strength, UCS (MPa)
Ore Materials						
Crushed Ore (saturated)	19.6	37	0	1 x 10^{-8}	-	-
Crushed Ore (unsaturated)	16.7	37	0	1 x 10^{-8}	-	-
Foundation Materials						
Sands and gravels	21 (20.9 to 21.8)	36 (36 to 44)	0	1x10^{-5} (1x10^{-5} to 1x10^{-7})	150	-
Finer grained sand, silt and clay mixtures	21 (17.5 to 23.2)	33 (36 to 41)	0 (0 to 151)	1x10^{-7} (1x10^{-7} to 1x10^{-9})	20 (6 to 35)	-
Plastic clays	14 (14)	10 (10)	61 (61)	-	7 (3 to 13)	-
Frozen soils	21.7 (20.4 to 23.0)	-	-	1 x 10^{-15}	-	-
Weathered granodiorite	21 (21)	37 (37 to 44)	-	1 x 10^{-6}	-	5
Fresh granodiorite	25	45	15,000	2 x 10^{-7}	-	40 (35 to 75)
Fresh to weathered biotite gneiss	25	37 to 40	-	1 x 10^{-6} to 2 x 10^{-7}	-	56 (35 to 92)
Construction Materials						
Zoned earthfill	22.4	40 (36 to 44)	0	-	-	-
Waste rock	19.6	37	0	-	-	-
Overliner	-	-	-	1 x 10^{-4}	-	-
Soil liner	-	-	-	1x10^{-8} (1x10^{-9} to 1x10^{-11})	-	-
LDRS drain rock	-	-	-		-	-
Textured Geomembrane / Geonet		21*				
T. Geomembrane / Ore or overliner interface	-	26 (26 to 26)	0	-	-	-
Smooth Geomembrane / Geonet interface	-	n/a (6 to 25)	0	-	-	-

Notes:
1. Plastic clays not considered in hydrogeological modelling.
2. Sources: Site-specific laboratory testwork, references provided in Section 3.1, Knight Piésold Ref. No. 10178/6-1, professional experience, and external review comments.
3. Range of site-specific laboratory results presented in parentheses.
4. Omitted values not relevant to design analyses or not applicable to material.
5. Ore and overliner permeabilities to be confirmed, including stress dependancy and degradation during leaching.
6. * verification required

9.4 Foundation Preparations

9.4.1 Pad Grading

Most of the organics and topsoil were stripped from the foundation area in 1996. At the start of construction, any remaining windrows or piles will be removed and the area will be rough graded. Site preparation activities at this time will include:

- completion of the a drilling investigation to delineate any potential unstable soil (see Section 8.3) and assess suitability for soil liner material,
- removal or treatment of the unstable/unsuitable soils and controlled fill placement to subgrade elevation;
- in areas cut to subgrade elevation - scarification, moisture conditioning, and compaction of the subgrade level soils to depth of at least 300 mm,
- proof-roll of prepared subgrade
- construction of the liner

As part of the pre-construction investigation soil samples representative of the subgrade will be taken and tested for particle size, plasticity indices, and natural moisture content. There will also be enough control tests to relate the index properties and visual characteristics of the subgrade soils to the expected permeabilities. From the test results, the subgrade soils to be classified as follows:

- Soil Liner Material - permeability of 10^{-8} m/s or lower. This materials will satisfy the grading requirements for soil liner material, and will be suitable for compaction;

- Random fill – permeability greater than 10^{-8} m/s. These materials will be used selectively for site grading below the depth of any proposed soil liner or uses as appropriate in zoned earthfills based on grading requirements.

- Waste Materials – waste materials will include organic rich materials, potentially unstable materials or any other materials deemed deleterious. These materials will be excavated and hauled to a designated waste stockpile.

As described in Section 8.3, all potentially thaw-unstable materials within 5 m of the ground surface that are identified during the delineation program will be excavated. Excavations deeper than 1 m below final subgrade will be filled to 1 m below final subgrade with acceptable rock fill, then filled with soil liner material. These materials will be placed and compacted as subgrade. Further details will be provided in the QA/QC Manual.

Areas where potentially thaw-unstable materials are deeper than 5 m will be assessed individually and specific treatments developed.

9.4.2 Foundation Drainage

A foundation drainage system will be installed beneath the leach pad to intercept and remove near-surface and seasonal groundwater flows, to reduce the possibility of uplift pressures beneath the liner, and to provide another LDRS. The foundation drains will be installed at least 1.5 m below the prepared subgrade surface and will comprise perforated CPT surrounded by select drain gravel and wrapped in geotextile. The select drain gravel will provide continued foundation drainage in the event of blockage or collapse of the CPT. The drains will be located in the natural drainage swales and extended to intercept any springs, seeps, or damp spots identified during pad grading and mapping. These drains will convey any intercepted groundwater seepage under the embankment to a foundation drainage collection sump located at the toe of the confining embankment. Flow into the sump will be tested periodically for pH and conductivity. If its quality is acceptable, it will be discharged below the events ponds; otherwise, it will be discharged into the events pond.

Once the foundation drains are installed they will be covered by compacted soil liner material and the double composite liner system. The upslope ends of the main collection pipes extend beyond the limits of the pad area through solid CPT pipe so that they will remain accessible. The ends of the pipes will be capped to prevent animals from entering the pipe and to prevent icing. If blockage of the CPT is suspected an attempt will be made to pressure clean with water or mechanically clean the tubing. Given the redundant drainage provided by the surrounding drain gravel, no further attempt to recover the CPT installation will be made if cleaning is unsuccessful.

9.4.3 Perimeter Berm and Bench

The perimeter bench on the east side of the leach pad will be wide enough for the access road perimeter diversion ditch, perimeter piping and sumps, and the liner anchor trench. The perimeter berm on the north and west sides of the pad will incorporate the liner anchor trench and perimeter piping and sumps. The perimeter road and diversion ditch will be outside of this berm. The berm and bench will separate the surrounding diverted areas and the heaped ore. A channel, formed by the depression between the perimeter berm or bench and the sloping ore, will convey surface runoff from the heaped ore to the perimeter sumps. From there, it will be piped to the plant or events pond.

10.0 LINER SYSTEM

10.1 General

The entire leach pad and the uphill face of the confining embankment will be lined with a double composite liner with an integral LDRS. Three separate designs are envisioned with protection for the environment appropriate to the potential for leakage in any given zone: these zones have been designated as the upper works, lower works and trenches.

The upper works comprise the upper portion of the heap leach pad, at elevations greater than 830 m. In this zone, the base slope exceeds 7:1 with a consequence that pregnant leachate solution (PLS) flow velocities are high and hydraulic heads are low.

The lower works comprise the lower portion of the heap leach pad adjacent to the confining embankment. In this zone, PLS velocities are low and the hydraulic head will approach 1.0 m. Therefore, there is a potential for higher leakage rates through the primary liner in this area.

The trenches are constructed in the LDRS to move PLS laterally. In the trenches, PLS velocities will be high but, because these are the collector system for the LDRS, the hydraulic head will also be high. There is therefore a higher potential for leakage of the primary liner in this area.

Subject to the results of product specific laboratory testing of the liner system, the components of the liner system for the upper and lower works will generally comprise the following:

10.2 Upper Works:

The upper works liner system comprises (listed from the top down):

- High-permeability, durable overliner cushion layer with solution collection piping.
- 60 mil textured HDPE upper liner;
- Leak detection and recovery system (LDRS) comprising a high transmissivity tri-planar geocomposite;
- 60 mil textured HDPE lower liner;
- Subgrade (with foundation drains);

10.3 Lower Works:

The lower works liner system comprises (listed from the top down):

- High-permeability, durable overliner cushion layer with solution collection piping.
- 60 mil textured HDPE upper liner;

- Leak detection and recovery system (LDRS) comprising a high transmissivity tri-planar geocomposite;
- 60 mil textured HDPE lower liner;
- Compacted lower soil liner with a permeability not greater than 10^{-8} m/s;
- Subgrade (with foundation drains);

10.4 Trenches

The trench design profile comprises (listed from the top down):

- High-permeability, durable overliner cushion layer with solution collection piping.
- 60 mil textured HDPE upper liner;
- 12 oz nonwoven polypropylene geotextile
- Drainage layer comprising durable crushed ore or sand and gravel with permeability of at least 5 x 10^{-4} m/s and solution recovery piping;
- Leak detection and recovery system (LDRS) comprising a high transmissivity tri-planar geocomposite;
- 12 oz nonwoven polypropylene geotextile
- 60 mil textured HDPE lower liner;
- Subgrade;

The components of the various liner designs are further described as follows:

10.5 Subgrade

The subgrade will be suitable in-situ material that has been scarified and recompacted, or borrow material imported to backfill excavations of unsuitable material as described above. The design criteria for subgrade are:

- Random fill as defined in the technical specifications
- Maximum particle size equal to 75% of the approved layer thickness.

10.6 Soil Liner

Lower Works

Laboratory tests and correlations with index properties will confirm that the liner material meets the required permeability criterion of 10^{-8} m/s. These will be described in the QA/QC manual.

The soil liners will be compacted with a smooth drum vibratory roller in lifts of less than 150 mm, with careful inspection of the soil surface to ensure the removal of any stones larger than 10 mm under strict quality control. The liner installer will certify acceptance of the final surface as part of the QC and warranty process.

Upper Works

Beneath the upper works, subgrade preparation will require sufficient effort to remove any organic materials, provide a competent base and prevent rock fragments and gravel from puncturing the lower geomembrane liner. Product-specific laboratory testing under expected loads will dictate the maximum allowable particle size and final methods of subgrade preparation for the upper works

10.7 Textured HDPE Liner

Both geomembrane liners will be 60 mil textured HDPE. Careful manufacturing quality control and construction quality assurance will confirm the specifications are achieved.

10.8 Leak Detection and Recovery System

An LDRS will be constructed using a high flow triplanar geocomposite. The geocomposite utilizes a tri-planar structure with rigid vertical ribs that significantly increase the tensile strength and compressive resistance of the geocomposite. These ribs are also supported by structural planar ribs that reduce intrusion into the high flow drainage core. The LDRS will be subdivided into cells of appropriate size to allow for solution management in each pad area.

10.9 Geotextile

A 12 oz, non-woven, needle punched geotextile will be used as a separation and filtration layer in the trenches ("French drain").

10.10 Overliner

A maximum 1.0 m thick layer of processed, durable crushed ore or sand and gravel will cover the upper HDPE liner to protect it from puncture under ore loading and to promote the effective under-drainage and collection of PLS from the ore. The design criteria for the overliner are as follows:

- Maximum particle size of 19 mm to prevent liner puncture, unless specific testing shows a larger size is acceptable.
- Durable, hard rock resistant to acid degradation.
- Permeability of at least 5 x 10^{-4} m/s to enhance PLS recovery and to minimize hydraulic head on the upper liner.

Within the overliner, there will be a network of pipes to collect the solution within the overliner and transfer it to either the process plant or the events pond. This system of solution recovery piping also will reduce the hydraulic head on the upper liner. As within the LDRS, the overliner will be subdivided into cells of appropriate size to allow solution management above the liner.

10.11 Leakage Criteria

Previous leakage criteria used in the Yukon were reviewed to develop the liner design. These criteria require an allowable leakage rate into the LDRS of 100 L/day averaged over a twelve-month period, with a maximum of 300 L/day averaged over a 3-month period. Initially, because of the lack of a defined area in the criteria, we used the leakage rate to define the largest detection "cell" that could be allowed in the design.

At the outset of EBA's design, it was our belief that the design criteria could be accommodated with a conventional double-lined geomembrane system, commonly used in hazardous waste impoundments in low precipitation situations. However, when we apply accepted design standards for the geomembrane as proposed by Giroud and Bonaparte (1989) and updated by Maxxon and Feeney (1993), the leakage into the LDRS required a large number of cells to be constructed to remain below the leakage criteria.

The permeability of the various layers used in the design is as follows:

- Overliner: $k > 5 \times 10^{-4}$ m/s
- Textured HDPE liners: $k < 1 \times 10^{-10}$ m/s (permeability controlled by construction defects)
- LDRS: $k > 1 \times 10^{-4}$ m/s
- *Soil liner: $k < 1 \times 10^{-8}$ m/s

**There may be some issues with the performance of soil liners in a highly acidic permeant. A review of the literature indicates that between one and two orders of magnitude increase in permeability could be expected when soil is exposed to acid. In one case, despite some buffering of the acid by the soil itself, the permeability increased two orders of magnitude with a permeant of pH 2.3. To account for this potential impact, the permeability of the soil liner has been modelled using an increased k.*

10.12 Liner Terminations

All HDPE liners will be terminated in anchor trenches. These trenches will be either permanent trenches along the perimeter berm, bench and embankment, or temporary trenches on the edges of pad extensions. The design criteria for the trenches are:

- To ensure water cannot enter drainage systems by seeping through the trench backfill.
- To provide adequate anchoring resistance to withstand the pullout forces generated by gravity and thermal expansion and contraction of the HDPE geomembranes.

10.13 Frost Protection

To protect the soil portion of the leach pad liner from frost damage, the liner will be covered with at least 4.5 m of ore and overliner prior to winter. Additional frost protection may be provided by exothermally-generated heat from the leaching process, solution heating, and natural snow insulation.

10.14 Geotechnical Instrumentation

Geotechnical instruments will be used to monitor and confirm design assumptions and performance of the solution collection system, perimeter berms and heap confining embankments. They will include permanent surface movement monuments on the system embankment crest, and piezometers within the pad foundation, overliner and confining embankment. All piezometers will be monitored regularly but will not form a requirement for continued operation of the facility should they cease to function.

10.15 Leach Pad Settlement

Leach pad settlement could potentially result from several sources – thaw of ground ice in permafrost, and subsequent consolidation of thawed soils from overburden pressure; and elastic compression of coarser-grained soils, and consolidation of fine-grained soils due to vertical loads imposed by the heap.

The design criteria for the leach pad settlement are as follows:

- Differential settlements will not compromise the integrity of the liner system.
- Tensile strains of less than five percent in the synthetic and soil liner systems will be maintained.
- Positive drainage of foundation drains and LDRS and PLS collection pipes will be maintained by "overbuilding". All drainage grades and locations will be determined with an allowance for settlements of the foundations.
- Pipe joints will be capable of sustaining settlement-induced tensions without separation.

The initial Knight-Piesold settlement estimates of up to 1.2 m under the heap leach pad have been reviewed and are considered reasonable at this time. However, permafrost conditions have likely changed significantly over the past nine years – additional boreholes will be required to verify existing conditions, and to collect data to re-assess settlement potential from thawing permafrost. It is expected that some permafrost thaw has occurred, and therefore the estimates of total and differential settlements under the leach pad might be lower than initially predicted.

Mitigative measures include the potential use of (more flexible) PVC liners in specific areas, based on the results of an additional site assessment.

11.0 LIMITATIONS

The recommendations provided in this report have provided fundamental geotechnical parameters and recommendations for one conceptual design of the heap leach pad facility for the Carmacks Copper Project. A double geomembrane liner system is being considered at the current time as the only configuration that would satisfy a permitting process in this setting. Alternative development concepts are being considered, the final design will reflect the impacts of capital and operating costs, leakage rates, stability under seismic loading, laboratory tests of the liner system, and constructability; among others. Additional geotechnical data and specific analyses will be required to finalize the design.

Respectfully submitted,
EBA Engineering Consultants Ltd.

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PROFESSIONAL ENGINEER YUKON TERRITORY

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PERMIT TO PRACTICE
Signature
Date May 5/05 EBA Engineering
PERMIT NUMBER: PP003
Association of Professional Engineers of Yukon

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

3.0 LOGS OF TEST HOLES

The test hole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

4.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

5.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

6.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

7.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

8.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

9.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

10.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

11.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

12.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

13.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

14.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

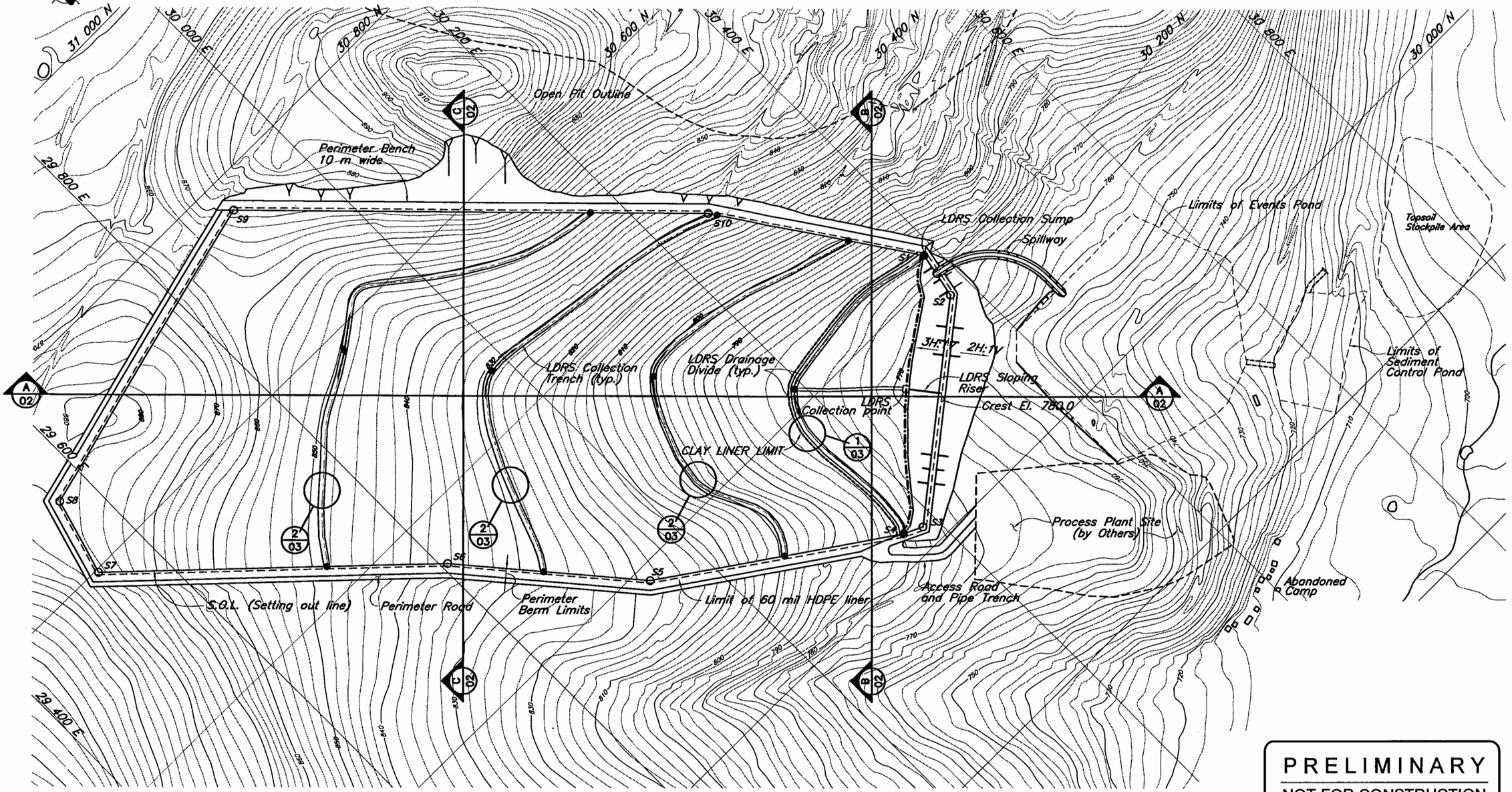
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Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

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FIGURES



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Carmacks, Yukon

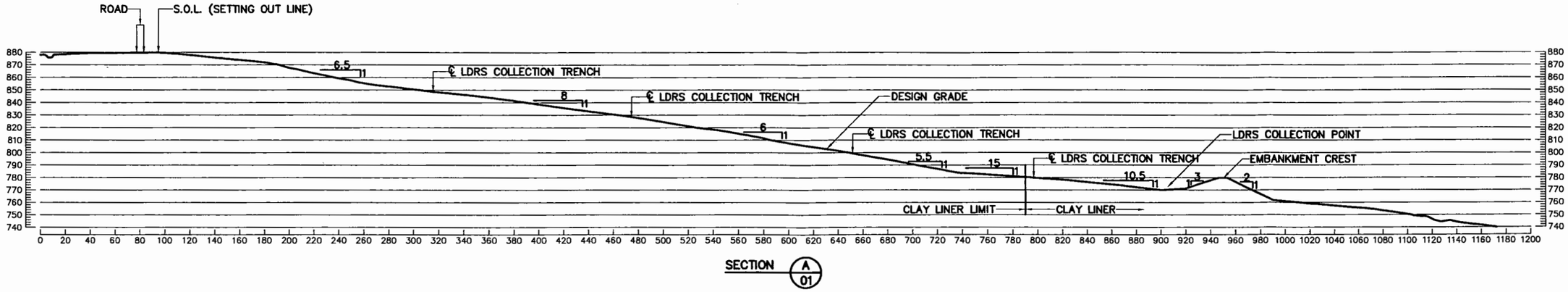
HEAP LEACH PAD

SITE PLAN

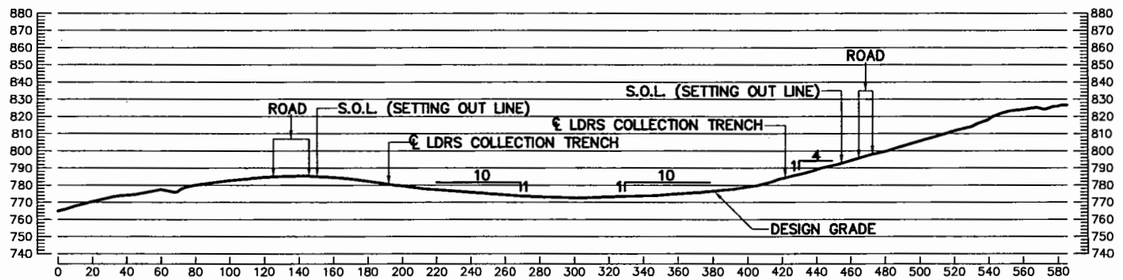
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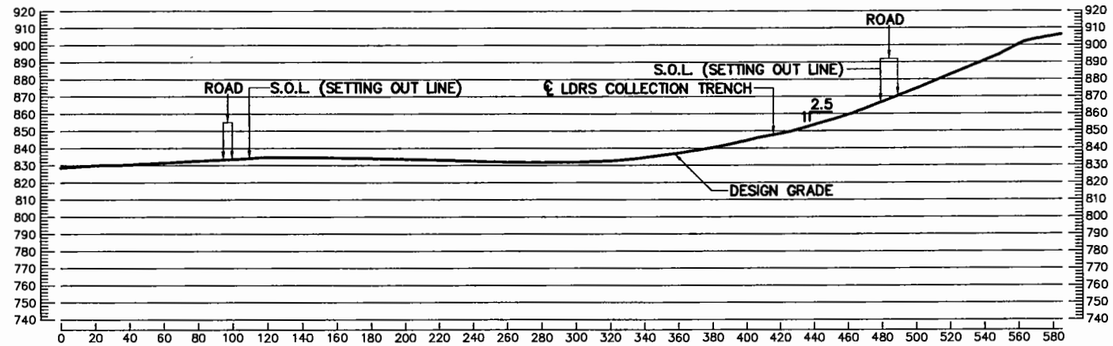
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SECTION A 01



SECTION B 01



SECTION C 01

PRELIMINARY
NOT FOR CONSTRUCTION

0.5 0 0.5 1 2 metres

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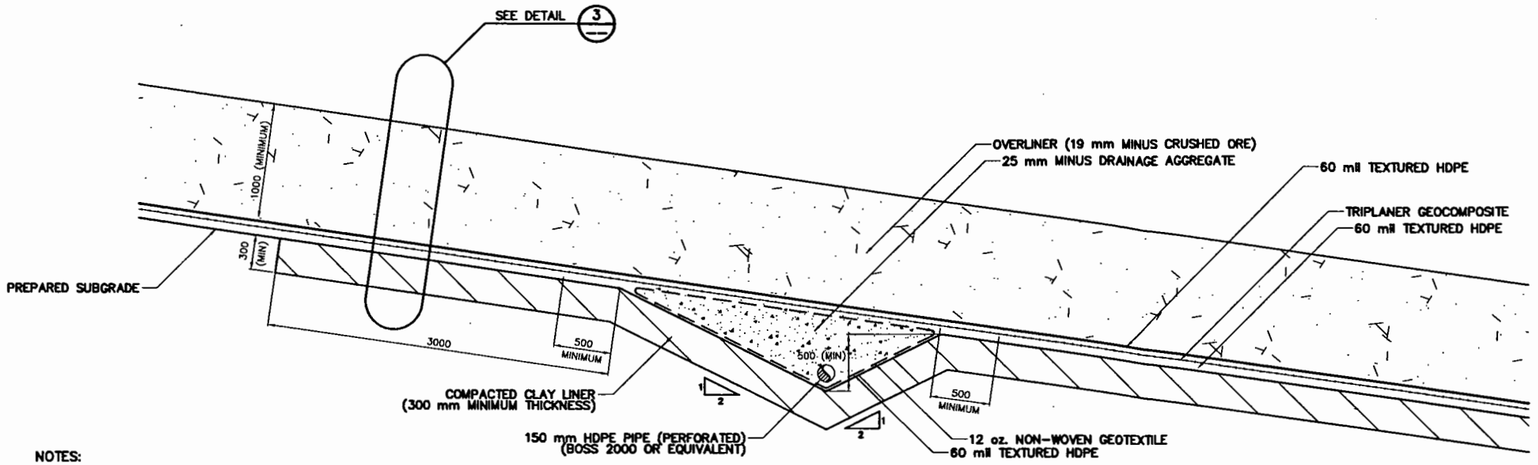
HEAP LEACH PAD

SECTIONS

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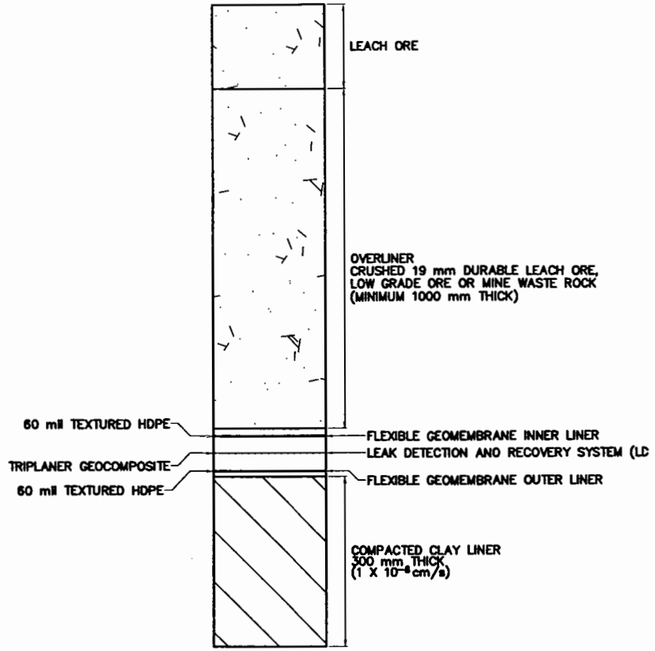
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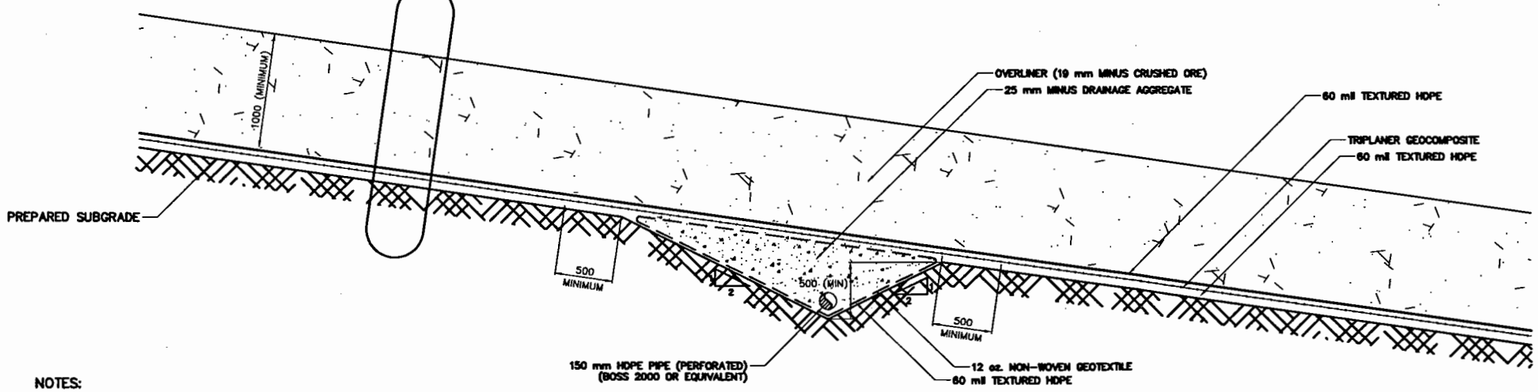
NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.
2. MATERIAL AND LINER LAYER ARE SHOWN SEPARATED FOR CLARITY.
3. CROSS-SLOPE VARIES BETWEEN 3 (HORIZONTAL) AND 15 (HORIZONTAL) TO 1 (VERTICAL) APPROXIMATELY.

LOWER LDRS COLLECTION DITCH 1/01



TYPICAL LINER SYSTEM – LOWER LDRS COLLECTION DITCH 3
SCALE: N.T.S.



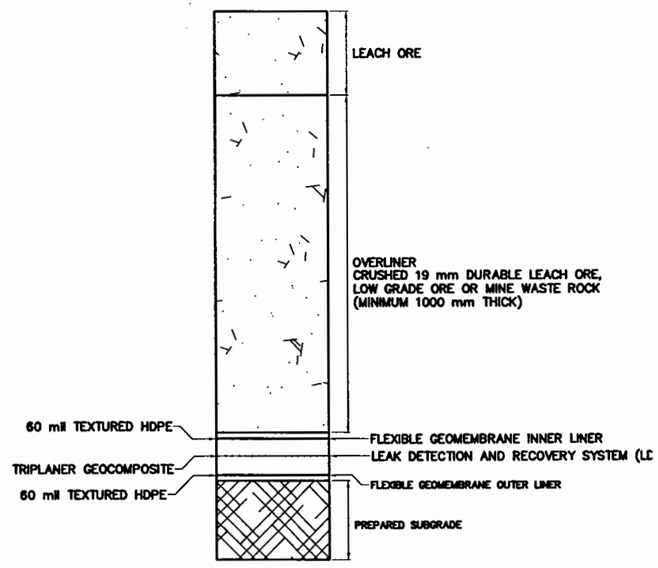
NOTES:

1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE NOTED.
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3. CROSS-SLOPE VARIES BETWEEN 3 (HORIZONTAL) AND 15 (HORIZONTAL) TO 1 (VERTICAL) APPROXIMATELY.

UPPER LDRS COLLECTION DITCH 2/01

0.5 0 0.5 1 2 metres

PRELIMINARY
NOT FOR CONSTRUCTION



TYPICAL LINER SYSTEM – UPPER LDRS COLLECTION DITCH 4
SCALE: N.T.S.

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Carmacks, Yukon

HEAP LEACH PAD

SECTIONS and DETAILS

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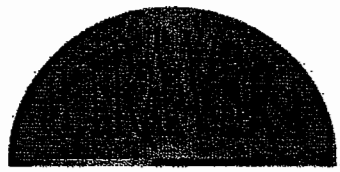
APPENDIX A

High Flow Geocomposite

TENDRAIN™ CLASS 1

AASHTO Class 1 Highly UV Stable Double-Sided Geocomposite

TENDRAIN™ C1 geocomposite is comprised of a tri-axial geonet structure consisting of thick supporting ribs with diagonally placed top and bottom ribs and with thermally bonded, nonwoven highly UV resistant, AASHTO Class 1 Ultra-Vera™ geotextiles on both sides. The product is capable of providing high Transmissivity in a soil environment under high normal loads and will have properties conforming to the values and test methods listed below.



Property	Test Methods	Units	Value	Qualifier	Test Frequency
Resin					
• Density	ASTM D 1505	g/cm3	0.94	MAV	lot
• Melt Flow Index	ASTM D 1238	g/10min	1.0	MAX	lot
Geonet Core[4]					
Structure	Tri-axial				
• Tensile Strength - MD	ASTM D 4595	lb/ft (kN/m)	1200 (17.5)	MAV	50,000 sf
• Creep Reduction Factor[1] @ 20°C	GRI-GC8	-	1.2		
• Retained thickness[2] @ 40°C	ASTM D1621	%	65		
• Thickness[3]	ASTM D 5199	mil (mm)	300 (7.6)	MAV	50,000 sf
• Carbon Black	ASTM D 4218	%	2-3	Range	50,000 sf
Top Filter Geotextile[4,5]					
• U.V. Resistance (500 hrs)	ASTM G 154	%	95	MAV	Per formula
• Color			Orange		
• Serviceability Class	AASHTO M-288		Class 1		
• Grab Tensile	ASTM D 4632	lbs (N)	202 (900)	MARV	100,000 sf
• Tear Strength	ASTM D 4533	lbs (N)	79 (350)	MARV	100,000 sf
• Puncture Resistance	ASTM D 4833	lbs (N)	79 (350)	MARV	100,000 sf
• CBR Puncture Strength	ASTM D 6241	lbs (N)	449 (2000)	MARV	100,000 sf
• AOS	ASTM D 4751	US Std. Sieve (mm)	80 (0.18)	MaxARV	500,000 sf
• Permittivity	ASTM D 4491	Sec-1	0.5	MARV	500,000 sf
Bottom Friction Geotextile[4,5]					
• U.V. Resistance (500 hrs)	ASTM G 154	%	95	MAV	Per formula
• Color			Orange		
• Serviceability Class	AASHTO M-288		Class 1		
• Grab Tensile	ASTM D 4632	lbs (N)	202 (900)	MARV	100,000 sf
• Tear Strength	ASTM D 4533	lbs (N)	79 (350)	MARV	100,000 sf
• Puncture Resistance	ASTM D 4833	lbs (N)	79 (350)	MARV	100,000 sf
• CBR Puncture Strength	ASTM D 6241	lbs (N)	449 (2000)	MARV	100,000 sf
Geocomposite					
• Peel Adhesion[6] - MD	F904 Modified	lb/in (g/in)	1.0 (454)	MAV	100,000 sf
• Labeling	Product code, geotextile type, roll dimensions, finished product lot and roll number.				
Hydraulic Behavior of Geocomposite					
• Transmissivity[7] - MD					
Gradient / Load			26,000 psf (1200 kPa)		
0.33	ASTM D 4716		5.0*10-4		
0.1	GRI - GC8	m2/sec	7.5*10-4	MAV	200,000 sf
0.02			1.0*10-3		

Qualifiers:
MARV = Minimum Average Roll Value (MARV)
MAV = Minimum Average Value
MAX = Maximum Value
MaxARV = Maximum average roll value

NOTES:
1. Creep Reduction Factor is based on 10,000 hour test duration, extrapolated to 30 years and using a compressive load of 25,000 psf.
2. Retained thickness is measured through 5,000 hours duration, under a compressive load of 15,000 psf and temperature of 400C.
3. Thickness measured by manufacturer per ASTM D5199 with a 2.22 in. diameter presser foot and 2.9 psi pressure.
4. Geotextile and geonet properties listed are prior to lamination.
5. Geotextiles meet AASHTO Standard Specification M 288-00 strength requirements of class 1, and filter geotextile meets the highest filter requirements.
6. Peel adhesion is tested by the manufacturer per modified ASTM F904, with a 2-inch wide (5 longitudinal ribs) by 10-inch long strip. The geotextile bonded to either side of the geonet is pulled apart at a peeling rate of 12 in/min., for at least 4 inches of peeling distance. The reported value for each laminated side is the average of the "peak" values from 5 tested samples. The 5 samples are cut evenly distributed along the roll width with a 1-foot margin from both edges of the roll.
7. Geocomposite transmissivity measured by manufacturer per ASTM D4716 with testing boundary conditions as follows: steel plate / uniform sand / geo composite / 60 mil HDPE geomembrane / steel plate, and sealing period of 100 hours according to GRI-GC8.

Engineered for Life
Sales/Technical Service
4800 East Monument Street o Baltimore, Maryland 21205
• 410.522.7000 (Phone) • 410.522.7015 (Fax) • 800.356.8495 (Toll-Free)
www.tenaxus.com E-Mail:info@us.tenax.com

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2/2004 DRSAM003

TENAX® Corporation

TENAX TENDRAIN GEONET (TD7)

HIGH PERFORMANCE TRI-PLANAR GEONET

TENAX TD7 is an innovative high performance tri-planar geonet consisting of thick supporting ribs with diagonally placed top and bottom ribs. The three sets of intersecting strands form unique flow conduits that provide extremely high flow capacity, high compressive resistance and enhanced tensile properties. TENAX TD7 is manufactured from the extrusion of high density polyethylene resin and carbon black. TENAX TD7 is inert to chemical and biological attack and is stabilized against UV degradation.

Typical applications:

- leachate collection/detection systems in landfills - landfill cap drainage layer - gas venting media

TECHNICAL CHARACTERISTICS	TEST METHOD	UNIT	Value	QUALIFIER
MD TENSILE STRENGTH	ASTM D4595	lb/ft (kN/m)	1200 (17.5)	a, Note 1
COMPRESSION BEHAVIOR				
% retained thickness				
@50,000 psf (short term)	ASTM D1621	%	50	a, Note 2
@25,000 psf (10,000 hours)		%	65	
Creep Reduction Factor	GRI-GC8	-	1.2	Note 3
DENSITY	ASTM D1505	g/cm^3	0.94	a
MELT FLOW INDEX	ASTM D1238	g/10 min	1.0	b
CARBON BLACK CONTENT	ASTM D4218	%	2.0 ~ 3.0	c
THICKNESS	ASTM D5199	mils (mm)	300 (7.6)	a, Note 4
TRANSMISSIVITY-MD @ i = 0.1 at 15,000 psf	ASTM D4716	m^2/sec	4.0×10^{-3}	a, Note 5
ROLL WIDTH	-	ft	6.7	c, Note 6
ROLL LENGTH	-	ft	200	c, Note 6
ROLL AREA	-	ft^2	1340	c

QUALIFIER:
a) Minimum Average Value b) Typical value c) Maximum

NOTES:

1. Tensile properties tested by manufacturer every 50,000 square feet of product per ASTM D4595 with a specimen width of 8.0 in. and cross-head speed of 0.4 in/min.
2. Short term compression behavior tested by manufacturer every 50,000 square feet of product per ASTM D1621 with a 4 in.x4 in. specimen and a constant rate of strain of 0.04 in./min.
3. Creep Reduction Factor is based on 10,000-hour test duration, extrapolated to 30 years and using a compressive load of 25,000 psf.
4. Thickness measured by manufacturer every 50,000 square feet of product per ASTM D5199 with a 2.22 in. diameter presser foot and 2.9 psi pressure.
5. Geonet transmissivity measured by manufacturer every 200,000 square feet of product as per ASTM D4716 with testing boundary conditions as follows: steel plate / geonet / 60 mil HDPE geomembrane / steel plate and seating period of 100 hours.
6. Roll dimensions are measured at the time of manufacture.

TENAX Engineered for Life

Sales/Technical Service
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1/26/04

Technical Note

Determining Creep Reduction Factor for Tri-Planar Geonets

In this technical note, the Creep Reduction Factor, RF_{cr} is determined to account for the creep that takes place in a tri-planar geonet between the seating period of 100 hours and two time periods. The first case is to represent the initial phase of waste placement, and the second case is to represent the stage of the landfill prior to final closure where waste thickness reaches its maximum height. The reduction factor for creep is then applied to the transmissivity value determined from performance test with a 100-hour seating to account for the creep deformation.

The attached Figure shows the results of 10,000-hour compressive creep tests on tri-planar geonets under normal loads of 2,000psf and 25,000psf respectively. The creep curve under 2,000psf load is used to determine the creep reduction fact for the first case (initial phase of waste placement), and the creep curve under 25,000psf is used for the second case (landfill prior to final closure). The following Equation[1] is used to determine the Creep Reduction Factor, RF_{cr}

$$RF_{cr} = \left[\frac{(t_{CO}/t_{virgin}) - (1 - n_{virgin})}{(t_{cr}/t_{virgin}) - (1 - n_{virgin})}\right]^3$$

Where:

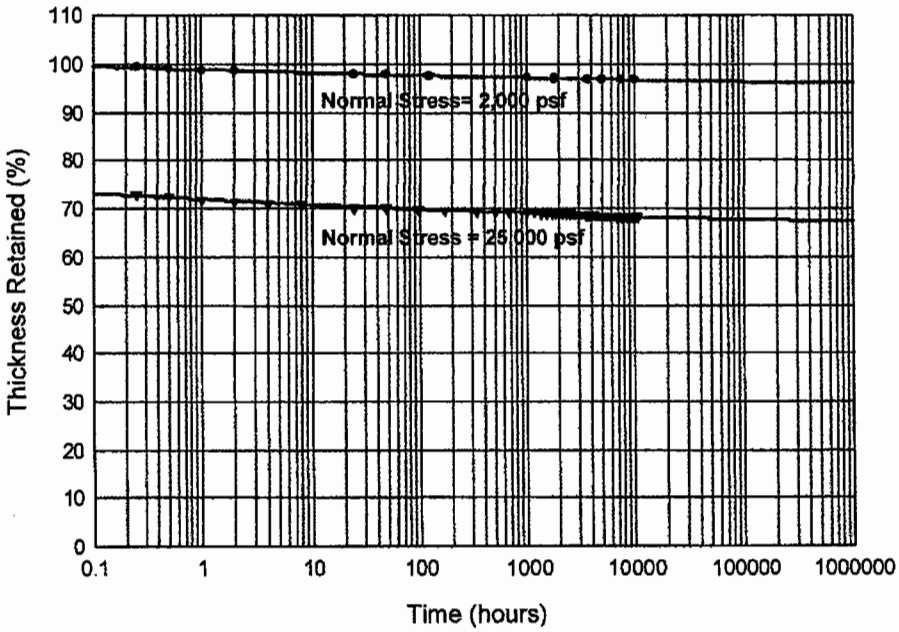
T_{CO} = thickness after load application for 100 hours

t_{virgin} = initial thickness under 2.9 psi (ASTM D5199)

---

[1] Giroud, J.P., Zhao, A., and Richardson, G., 2000, "Effect of Thickness Reduction on Geosynthetic Hydraulic Transmissivity", Special Issue on Liquid Collection Systems, *Geosynthetics International*, Vol.7, Nos. 4-6, pp. 433-452.

Compressive Creep Data on Tendrain



t_{CR}= thickness at the time period of interest

n_{virgin} = initial porosity

Case 1: Using the compressive creep curve under 2000psf load (Initial Phase of Waste Placement):

t_{CO} = t_{100h} = 7.62*0.975 = 7.43 mm

t_{vingin} = 7.62 mm (300 mils)

t_{CR} (use 4,000 hours) = t_{4000h} = 7.62*0.965 = 7.35 mm

n_{virgin} = 0.75 (calculated)

Substituting these values in the above Equation:

RC_{CR} = **1.05**

Case 2: Using the compressive creep curve under 25,000psf load (Landfill Prior to Final Closure):

t_{CO} = t_{100h} = 7.62*0.7 = 5.32 mm

t_{vingin} = 7.62 mm (300 mils)

t_{CR} (use 17,000 hours) = t_{17000h} = 7.62*0.675 = 5.14 mm

n_{virgin} = 0.75 (calculated)

Substituting these values in the above Equation:

RC_{CR} = **1.20** (for landfill prior to final closure)

GSE

GSE STANDARD PRODUCTS

Product Data Sheet

GSE Nonwoven Geotextiles

GSE Nonwoven Geotextiles is a family of polypropylene, staple fiber, nonwoven needle punched geotextiles. Manufactured using an advanced manufacturing and quality system, these products are the most uniform and consistent nonwoven needle punched geotextile currently available in the industry. GSE combines a fiber selection and approval system with in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications. The company has performed extensive performance testing to evaluate suitability of its nonwovens for various applications. GSE Nonwoven Geotextiles are available in a range of weights to meet your specific project needs. *These product specifications meet or exceed GRI GT12.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	NW4	NW6	NW8	NW10	NW12	NW16
Product Code			GEO 0408002	GEO 0608002	GEO 0808002	GEO 1008002	GEO 1208002	GEO 1608002
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	90,000 ft²	4 (135)	6 (200)	8 (270)	10 (335)	12 (405)	16 (540)
Grab Tensile Strength, lb (N)	ASTM D 4632	90,000 ft²	120 (530)	170 (755)	220 (975)	260 (1,155)	320 (1,420)	390 (1,735)
Grab Elongation, %	ASTM D 4632	90,000 ft²	50	50	50	50	50	50
Puncture Strength, lb (N)	ASTM D 4833	90,000 ft²	60 (265)	90 (395)	120 (525)	165 (725)	190 (835)	240 (1,055)
Trapezoidal Tear Strength, lb (N)	ASTM D 4533	90,000 ft²	50 (220)	70 (310)	95 (420)	100 (445)	125 (555)	150 (665)
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	540,000 ft²	1.50	1.50	1.50	1.20	0.80	0.70
Permeability, cm/sec	ASTM D 4491	540,000 ft²	0.22	0.30	0.30	0.30	0.29	0.27
Water Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	540,000 ft²	120 (4,885)	110 (4,480)	110 (4,480)	85 (3,460)	60 (2,440)	50 (2,035)
UV Resistance (% retained after 500 hours)	ASTM D 4355	per formulation	70	70	70	70	70	70
Roll Length, ft (m)			600 (182)	600 (182)	600 (182)	300 (91)	300 (91)	300 (91)
Roll Width, ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Area, ft² (m²)			9,000 (836)	9,000 (836)	9,000 (836)	4,500 (418)	4,500 (418)	4,500 (418)

NOTES:

- The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values (MARV) except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.

DS037 R04/17/03

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Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

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GSE

Application Sheet

GSE Nonwoven Geotextiles

GSE NONWOVEN NEEDLEPUNCHED GEOTEXTILES

GSE nonwoven needlepunched geotextiles are manufactured at our state-of-the-art needlepunching plant in Kingstree, South Carolina. The plant has been certified according to ISO 9002 quality system.

GSE manufactures 4 to 20 oz/yd² geotextiles designated as NW4, NW6, NW8, NW10, NW12, NW16 and NW20. The most common function and usage of these products is indicated in Figure 1 below. However, the actual selection of the product depends on the specific needs of a project. For example, while NW16 is commonly used for geomembrane protection, it can also be used in filtration and separation because of specific design needs.

ASPHALT OVERLAY

It is common for asphalt pavements to crack prematurely because of design flaws, material limitations or environmental reasons. A fresh layer of asphalt is the most common remedy for this problem. However, reflective cracking – the propagation of cracks from old cracked surface into the new surface – limits the performance of the fresh asphalt overlay. To prevent reflective cracking, a nonwoven needlepunched geotextile must be placed above the cracked surface before placing the new layer. The geotextile works as a sealant and stress-absorbing layer. There are comprehensive design and construction methods available for this purpose. GSE NW4 is ideal for preventing reflective cracking. Figure 2 shows the use of geotextiles to prevent reflective cracking.

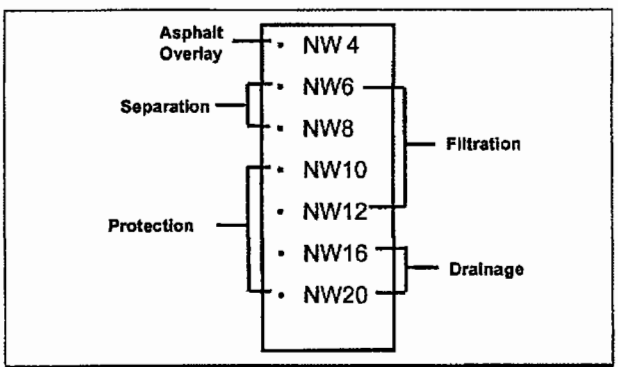


Figure 1 - Most common usage of GSE nonwoven needlepunched geotextiles

SEPARATION

Intermixing of two dissimilar materials always leads to the deterioration of their engineering performance. For example, contamination of aggregate by fine particles always leads to a decrease in the permeability of the aggregate. The separation function refers to the use of geotextiles to maintain physical separation between two adjacent materials. This is demonstrated graphically in Figure 3. GSE geotextiles are ideal for this purpose because of their strength, durability, flexibility and a highly porous structure.

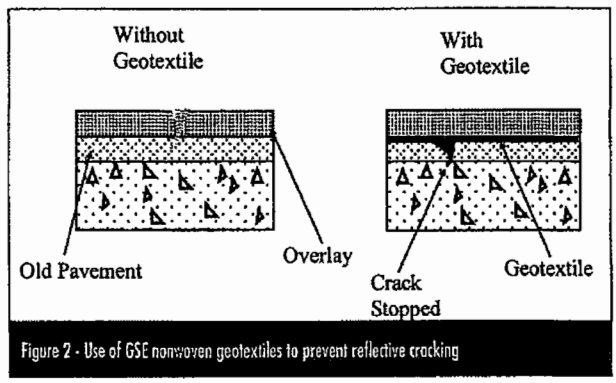


Figure 2 - Use of GSE nonwoven geotextiles to prevent reflective cracking

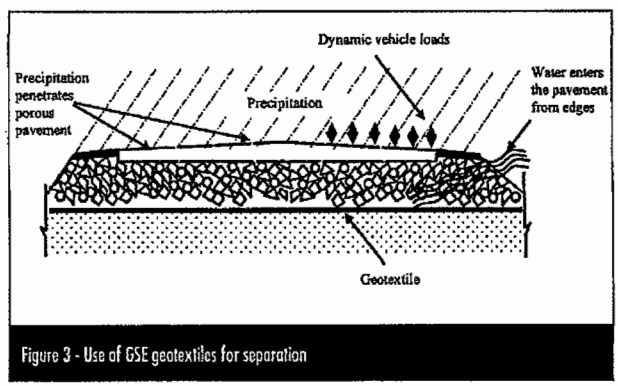


Figure 3 - Use of GSE geotextiles for separation

FILTRATION

When used as filters, GSE nonwoven needlepunched geotextiles allow the passage of liquid while preventing the loss of soil particles. GSE offers a range of products with opening size to meet filtration needs for different types of soils. For relatively coarse soils, lower mass products – NW4, NW6 and NW8 are recommended. For fine soil particles, it is better to use heavier mass geotextiles such as NW10, NW12 or NW16. Depending on the needs of a specific project, GSE has a geotextile available which will perform the intended design function.

- Continued -

PROTECTION

Geomembrane liners are very sensitive to damage and puncture during construction as well as over the life of a project. Therefore, geomembranes must be protected both from top and bottom. GSE nonwoven needlepunched geotextiles are ideal for this purpose because of their cushioning ability. Depending on soil size and overburden loads, one of the many geotextiles offered by GSE can be selected to ensure that geomembrane performance is not compromised.

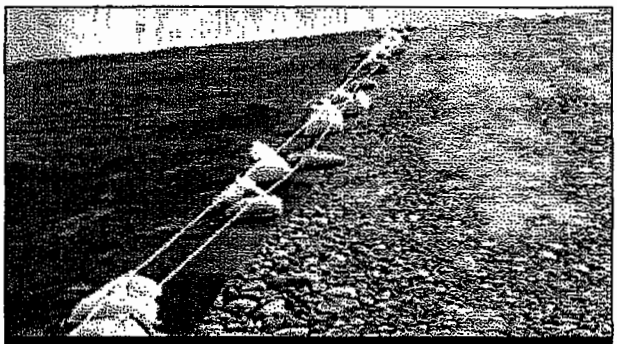


Figure 4 - Use of GSE geotextiles for geomembrane protection

DRAINAGE

Liners are used typically to prevent infiltration of liquids into environmentally sensitive areas. In certain cases, trapped gases and vapors must be vented to prevent uplifting of the liner. GSE nonwoven needlepunched geotextiles are ideal for gas and vapor drainage from under the liners. The high porosity of GSE geotextiles facilitates drainage while providing added benefit of cushion for the liners. A general configuration of this application is provided in Figure 5 below.

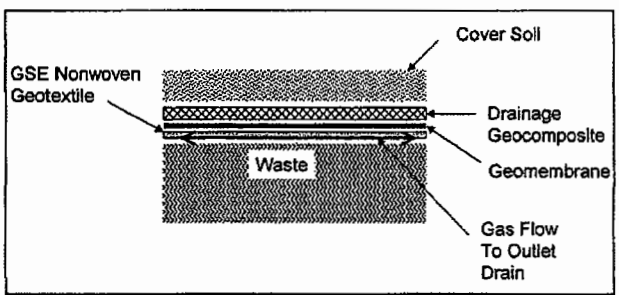


Figure 5 - Use of GSE geotextiles for geomembrane protection

ADDITIONAL INFORMATION

If you have an upcoming project please give us a call. We will prepare a scope of work outlining the necessary materials and construction support for the effective completion of a specific project. GSE has a staff of product managers, estimators, and project managers to assist with your project from conception through project completion.

AP029 R11/25/02

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www.gseworld.com

GSE®

GSE STANDARD PRODUCTS

Product Data Sheet

GSE HD Textured

GSE HD Textured is the textured version of GSE HD. It is a high quality, high density polyethylene (HDPE) geomembrane with one or two coextruded, textured surfaces, and consisting of approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. The resin used is specially formulated, virgin polyethylene and is designed specifically for flexible geomembrane applications. GSE HD Textured has excellent resistance to UV radiation and is suitable for exposed conditions. This product allows projects with greater slopes to be designed since frictional characteristics are enhanced. *These product specifications meet or exceed GRI GM13.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDT 030A000	HDT 040A000	HDT 060A000	HDT 080A000	HDT 100A000
Thickness, mil (mm) or per project specs	ASTM D 5994	every roll	27 (0.69)	36 (0.91)	54 (1.4)	72 (1.8)	90 (2.3)
Density, g/cm³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)[1]	ASTM D 6693, Type IV	20,000 lb					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm		45 (8)	60 (11)	90 (16)	120(21)	150 (27)
Strength at Yield, lb/in-width (N/mm)			63 (11)	84 (15)	130 (23)	173 (30)	216 (38)
Elongation at Break, %	G.L. = 2.0 in (51 mm)		150	150	150	150	150
Elongation at Yield, %	G.L. = 1.3 in (33 mm)		13	13	13	13	13
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	54 (240)	72 (320)	108 (480)	144 (641)	150 (667)
Carbon Black Content, %	ASTM D 1603	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Asperity Height	GRI GM 12	second roll	+Note 2	+Note 2	+Note 2	+Note 2	+Note 2
Notched Constant Tensile Load[2], hrs	ASTM D 5397, Appendix	200,000 lb	400	400	400	400	400
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**				
Oxidative Induction Time, minutes	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length (approximate), ft (m)	Standard Textured		830 (253)	700 (213)	520 (158)	400 (122)	330 (101)
Roll Width, ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft² (m²)			18,674 (1,735)	15,750 (1,463)	11,700 (1,087)	9,000 (836)	7,425 (690)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- +Note 2: 10 mil average. 8 of 10 readings ≥7 mils. Lowest individual ≥ 5 mils.
- GSE HD Standard Textured is available in rolls weighing about 4,000 lb (1,800 kg).
- [1]The combination of stress concentrations due to coextrusion texture geometry and the small specimen size results in large variation of test results. Therefore, these tensile properties are minimum average values.
- [2]NCTL for HD Textured is conducted on representative smooth membrane samples.
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <-77° C when tested with ASTM D 746.

DS006 R12/08/04

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GSE

Application Sheet

GSE HD Geomembranes

GSE HD and GSE HD Textured geomembranes are high quality HDPE geomembranes that provide the following benefits:

- **Excellent chemical resistance**
- **Outstanding stress crack resistance**
- **Lowest permeability**
- **History of proven performance**
- **Meet or exceed all aspects of GRI GM 13**

GSE HD is available with either a black or white upper surface. GSE HD Textured is available as either single or double sided textured geomembrane with either a black or white upper surface.

CHEMICAL RESISTANCE

The chemical resistance of HDPE is the best of any available geomembranes. GSE HD is chemically resistant to a wide variety of chemicals including aromatic and halogenated hydrocarbons. They have been used successfully for years as primary and secondary landfill liners, in secondary containment applications and as liners for mining leach pads.



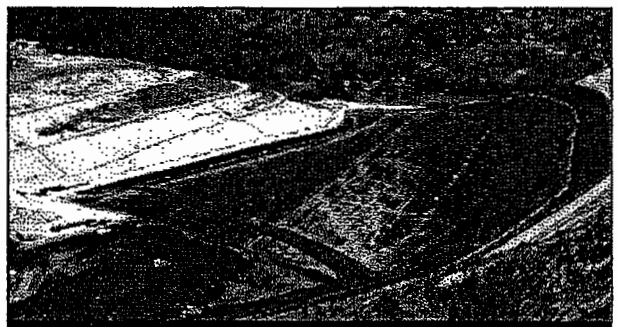
GSE HD can be used to line decorative ponds.

STRESS CRACK RESISTANCE

GSE HD is manufactured from resins specially designed to provide outstanding resistance to stress cracking. The appendix to ASTM D 5397, Single Point Notched Constant Tensile Load, is the test method most commonly specified for determination of stress crack resistance. GRI GM 13 requires a minimum of 300 hours to failure. GSE requires that every lot of resin used to manufacture GSE HD geomembranes has a minimum of 400 hours.

PERMEABILITY

Permeability of HDPE geomembranes is the lowest of any available geomembranes. This coupled with outstanding chemical and stress crack resistance combine to maximize the integrity of containment for any application.



GSE HD textured is used on slopes to increase the capacity of a landfill.

BENEFITS OF A ROUGHENED SURFACE

Perhaps the most important attribute textured geomembranes offer is the ability to improve geosynthetic profile stability which ultimately maximizes the available volume that can be contained by the geomembrane. The ability to line steeper slopes allows increases in design capacity providing cost savings. Further, the white upper surface of GSE White has the same physical properties as the black with the added benefit of a light reflective layer. This light reflective layer reduces heat gain, thereby reducing wrinkling, subgrade desiccation and worker fatigue.

IN-LINE TEXTURING DECREASES LEAD TIME

GSE HD Textured is manufactured using coextrusion technology – the same technology used by GSE for over fifteen years to produce GSE UltraFlex, GSE Conductive and GSE White geomembranes. GSE HD Textured meets the increasing need for textured HDPE geomembranes because it is an in-line one-step texturing process. Availability to GSE customers is increased and lead times are minimized.

PROVEN RELIABILITY

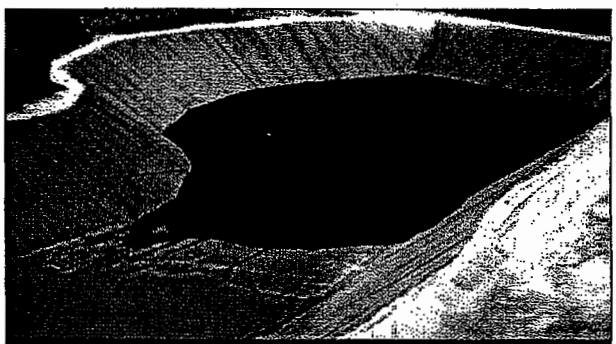
GSE HD geomembranes have a long history of reliability and proven performance. Hundreds of millions of square feet of GSE HD and GSE HD Textured have been sold and

- Continued -

installed. They have been used in wide ranging containment applications including potable water, decorative ponds, animal waste containment, landfills, canal linings and secondary containment. In addition to their exceptional performance, GSE HD products have excellent weldability under a variety of conditions. Extrusion and fusion welding can be performed with ease and confidence.

PREMIUM RAW MATERIAL

GSE HD products are made from high quality high density polyethylene resins. To these resins, carbon black, antioxidants and UV stabilizers are added to assure long term performance and UV resistance even in exposed conditions. The absence of leachable additives to all GSE geomembranes allows them to maintain excellent resistance to brittleness that may occur over time when plasticizers are used.



GSE HD can be used to line pregnant solution ponds in mining applications.

GSE QUALITY ASSURANCE SYSTEMS

All GSE geomembrane production involves three levels of quality assurance. First, raw material suppliers must comply with GSE specifications on incoming resin. Before the resin is unloaded from the railcar, GSE verifies the raw material test results that are submitted by our suppliers by performing selected conformance tests. The second level of QA begins during actual production. As each roll is produced it is electronically monitored for pinholes. Finally, GSE HD products undergo a rigorous Quality Assurance program after production to ensure the mechanical properties are intact and meet or exceed GSE current quality standards. All GSE laboratories are certified to both ISO and GAI-LAP standards.

ADDITIONAL INFORMATION

If you have an upcoming project, please give us a call. We will provide you with recommendations, an estimate for material and installation and contacts for a GSE approved installer.

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WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix E

Beattie Consulting Ltd. Report on Leaching and Decommissioning of Samples from Carmacks Oxide Copper Project

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LEACHING AND DECOMMISSIONING OF SAMPLES FROM CARMACKS OXIDE COPPER PROJECT

WESTERN COPPER HOLDINGS
FEBRUARY 2001

BEATTIE CONSULTING LTD
VANCOUVER, BC CANADA

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February 28, 2001

Western Copper Holdings Limited
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V6E 4E6

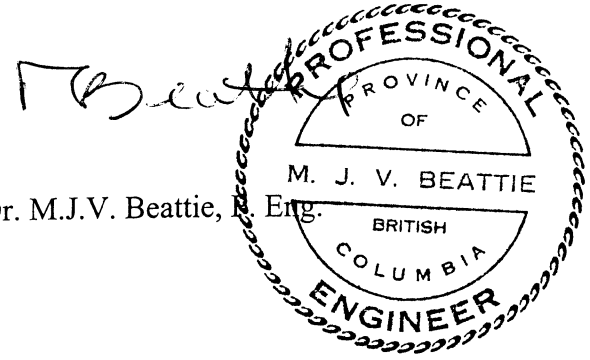
Attention: Mr. Dale Corman

Dear Dale,

Enclosed please find our report entitled *Leaching and Decommissioning of Samples from Carmacks Oxide Copper Project*. The reports compiles the testwork done for the project since early 1998 and draws conclusions based on this work within the context of all previously completed work.

The work completed to date provides a sound basis for predicting copper recovery requirements and neutralization requirements. We would be pleased to discuss any aspects of this project with you at any time.

Yours truly,
BEATTIE CONSULTING LTD



Dr. M.J.V. Beattie, P. Eng.

CARMACKS COPPER PROJECT
LEACHING AND DECOMMISIONING

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Appendix 1 Sample Collection Report

Appendix 2 Leach Column Test Details

Appendix 3 Waste Neutralization Batch Test Report

Appendix 4 Waste Column Neutralization Test Details

Appendix 5 Column C Neutralization Details

1.0 SUMMARY

The most recently completed test program on samples from the Carmacks oxide copper deposit has confirmed the following:

- The copper is readily leachable by means of crushing to minus ¾ inch followed by heap leaching. A copper extraction of just over 85% was achieved over a leach period of 187 days. Over the design leach time of 120 days the column achieved a copper extraction of 83%, corresponding to a commercial extraction of about 78%. For a multiple lift leach configuration it is recommended that the primary leach cycle be ended when about 70% copper extraction has been achieved in order to minimize acid consumption. For the current sample the primary leach cycle would be about 60 days.

- The predicted acid consumption for Carmacks is 22 kg/tonne. It is recommended that 20 kg/tonne be added to the cure stage with the balance being added to solution for control of feed pH.

- The recirculation of leach solutions through the column results in a gradual build-up of dissolved Al, Fe, Mg and Si. The presence of these constituents in solution indicates attack on the gangue minerals.

- Leaching of the Carmacks material at a Run of Mine size results in a significant loss in copper extraction of about 20% unless very long leach times, in excess of 1000 days are utilized. The test was conducted with a top size of 10 inches and some additional loss in copper extraction can be expected with the presence of even coarser material. The present test operated for 360 days and has not demonstrated the ultimate copper extraction achievable at a Run of Mine size.

- Even after extended leach times, the bulk sample was found to consume any free acid present in feed solutions. Following the completion of active leaching, a partial neutralization is achieved by continued circulation of the solutions through the heap. On this basis the leached material does not pose a threat for continued acid rock drainage.

- Previous column testwork indicated that the leached solids could be readily neutralized to result in an effluent of pH 4, which was buffered at this pH. Additional tests have indicated that when leached solids are freely mixed with solution containing an excess of base, the solution readily achieves a neutral pH and this pH is stable. Subsequent column tests have shown that sodium carbonate is effective at altering the leached solids so that effluents have a neutral pH. This condition appears to be stable over extended time periods.

- One effective rinsing procedure for the spent heaps appears to be to recirculate the solutions until the free acid is consumed and the copper concentration in solution becomes uneconomic to recover. At this point the leach solution should be neutralized with lime to precipitate sulphate and other deleterious constituents before being discharged. The heap should then be rinsed with groundwater (pH 7) in a series of pulses alternating with rest periods to allow dissolved sulphate, copper etc to diffuse from the rock particles. An effluent pH near pH 4 can be expected with this procedure. To achieve higher pH values, the addition of a base is required and sodium carbonate added as a pH 10.5 solution appears to be the most effective addition. The use of lime as a neutralizing agent will likely only be effective if the lime can be intimately mixed with the solids.

  Alternatively, if an on-off leaching pad scenario is adopted, lime could be mixed with the spent ore as it is removed from the pad in order to achieve permanent neutralization.

- It has been observed that the leached solids tend to become less permeable due to both decrepitation and precipitation of secondary mineral phases. This loss of permeability will minimize the quantity of effluent to be treated with time. Consideration should be given to installing collection piping at least every few lifts to optimize the flow of solution from the heap during leaching and to minimize the inventory of dissolved copper in the heap.

- The alternative of using an on-off pad leach should be considered as an alternative to the multiple lift scenario contemplated to date. As well as facilitating the neutralization of the spent ore, this approach would provide for the possibility of gold recovery in a second process step.

2.0 INTRODUCTION

The leaching of oxide copper from Carmacks samples has been studied over a number of years and the results have been reported previously:

Metallurgy of the Williams Creek Oxide Copper Deposit
Beattie Consulting Ltd
May 1994

Pilot Scale Column Testing of the Williams Creek Oxide Deposit
Beattie Consulting Ltd
February 1996

The previous testwork demonstrated that copper can be leached successfully from Carmacks materials by crushing to minus ¾ inch followed by heap leaching with a weak sulphuric acid solution. Such a process is practiced widely for the recovery of copper from oxide copper ores and the parameters required for the Carmacks deposit are consistent with general practice in the industry.

The leaching testwork summarized in the present report was initiated to evaluate the potential for leaching of the Carmacks deposit at a Run-of Mine size. A parallel test on a portion of the same sample crushed to minus ¾ inch was conducted to enable the results for this sample to be compared to those obtained previously with drill core composites.

Previous decommissioning testwork had consisted of rinsing of test columns with water followed by solutions containing base additions to various pH levels. Those tests had demonstrated that the pH of the effluent from the columns could be raised quite readily to a value of about pH 4 but appeared to be buffered at this value and was resistant to further increases. The present program therefore included various tests to improve the understanding of what was controlling the effluent pH and to investigate alternatives for effective decommissioning of the leach pads.

All testwork included in this report was conducted at the laboratories of Process Research Associates Ltd of Vancouver.

3.0 DISCUSSION

3.1 Sample Description

Two sources of material were used for the work included in this report. The primary sample consisted of a bulk sample taken from a series of surface trenches under the supervision of representatives of Kilborn Engineering Pacific Ltd. The Kilborn report describing the bulk sample collection is included as Appendix 1 to this report. The second sample consisted of trench material which had previously been crushed to minus ¾ inch and used for a crib test at the site. This material had been partially leached of copper.

3.1.1 Bulk ROM Sample

The bulk sample was obtained by taking samples from four separate trenches and coning and quartering these samples to provide a sub sample of each one. These sub-samples were combined into an overall composite which was then loaded into 18 bulk bags having an approximate moist weight of 1 tonne each for shipment to Vancouver.

At the laboratory, the entire sample was screened into a series of size fractions as summarized in Table 3.1.1. Sufficient material was available of all size fractions below 6 inches to take portions for assay. Fractions between 6 inches and 1 inch were sampled by coning and quartering while all finer fractions were sampled by means of riffling. The results of these assays are included in Table 3.1.1 and they indicate a general enrichment of copper into the finer fractions. The distribution of both total and soluble copper was obtained by assuming that the fractions coarser than 6 inches had the same copper content as the –6+4 inch fraction.

It was recognized during the sample collection that the removal of a bulk sample from a surface trench would result in a somewhat different size distribution than would be expected for an industrial-scale blast. Furthermore, even though the trenches were as deep as 11 meters in places, the near surface material could be somewhat weathered and therefore result in the generation of excessive fines during blasting and handling. The size distribution of the material placed in the ROM column was therefore adjusted to be closer to an expected size distribution so that the extraction would not be overstated. The size distribution of the bulk sample is summarized in Figure 3.1.1, together with the size distribution of the material placed in the column. Also included in this figure are the size distributions for several full-scale blast of oxide copper ores. It can be seen that the distribution of the material placed in the column has been adjusted to be similar to these other materials through the reduction of the fines content.

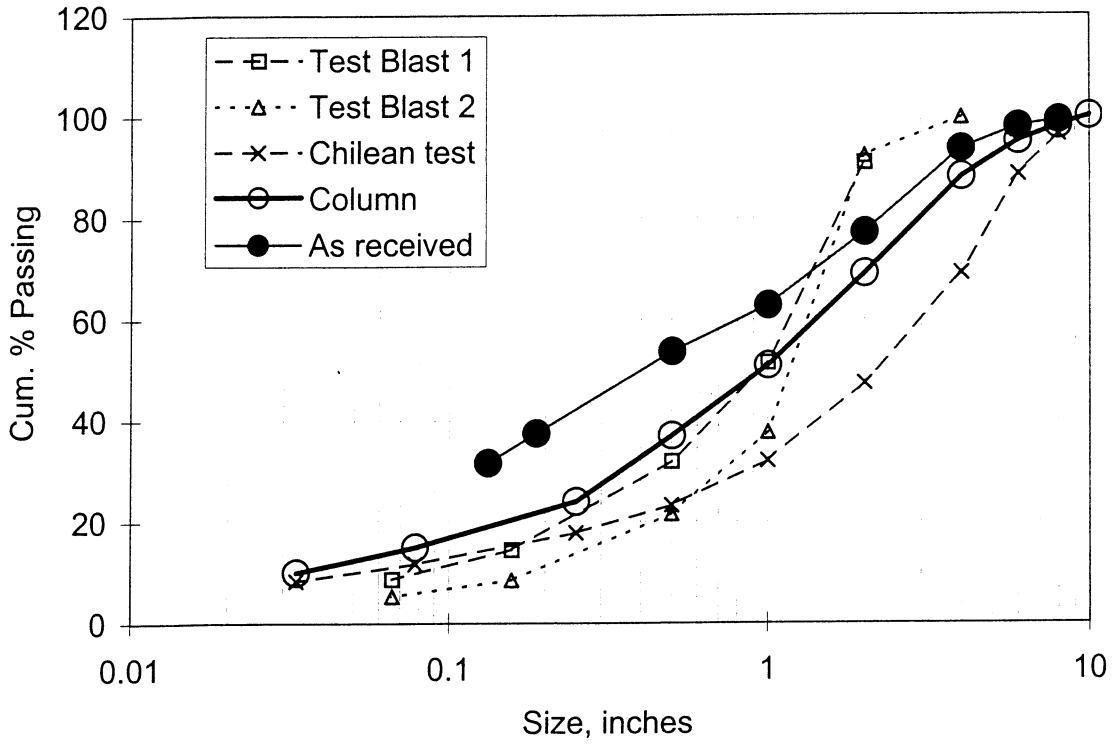


Figure 3.1.1 Size Distribution for Bulk Sample and Other ROM Samples.

Table 3.1.1
Assay by Size Fraction for ROM Sample

Fraction	Weight %	Assay, %		Distribution, %	
		Cu_T	Cu_{AS}	Cu_T	Cu_{AS}
+12"	0.4	-	-	0.3	0.3
-12+8"	0.5	-	-	0.4	0.4
-8+6"	1.2	-	-	0.9	0.9
-6+4"	4.4	0.78	0.72	3.3	3.4
-4+2"	16.4	0.80	0.74	12.5	12.8
-2+1"	14.3	0.82	0.74	11.2	11.2
-1+1/2"	9.1	0.82	0.74	7.1	7.1
-1/2+ 4 mesh	16.2	0.94	0.84	14.6	14.4
-4+6	5.9	1.04	0.96	5.8	6.0
-6+10	3.5	0.82	0.76	2.7	2.8
-10+20	5.4	1.14	1.06	5.9	6.1
-20	22.7	1.62	1.50	35.2	36.2
Total		1.03	0.94		

A sub-sample of the bulk sample was taken and crushed to minus ¾ inch in order to conduct a column test on the sample at this crush size. The sample was taken by sampling each of the size fractions into which the bulk sample had been screened and then crushing the plus ¾ inch fractions to minus ¾ inch. The size analysis and assays for the crushed sample are summarized in Table 3.1.2.

Table 3.1.2
Assay by Size Fraction of Crushed Sample

Fraction	Weight %	Assay, %		Distribution, %	
		Cu_T	Cu_{AS}	Cu_T	Cu_{AS}
-3/4 + ½	8.0	0.60	0.50	4.7	4.3
- ½ + 3/8	17.0	0.72	0.66	12.1	12.2
- 3/8 + ¼	18.0	0.76	0.72	13.5	14.1
- ¼ + 6m	15.9	0.86	0.76	13.5	13.1
-6m	41.1	1.38	1.26	56.1	56.3
Total		1.01	0.92		

Additional analyses for the bulk sample are summarized in Table 3.1.3. Process Research Associates conducted an acid-base accounting of the bulk sample by the Modified Sobek Method. The results of this analysis are summarized in Table 3.1.4 and show the material to be a net acid consumer.

Table 3.1.3
Analysis of Bulk Sample (Column C Head)

	%
Cu_T	1.02
Cu_{AS}	0.90
Fe_T	4.59
Fe_{AS}	1.53
Al_2O_3	17.13
BaO	0.18
CaO	4.20
Fe_2O_3	8.03
K_2O	2.55
MgO	2.78
MnO	0.12
Na_2O	4.12
P_2O_5	0.43
SiO_2	55.15
TiO_2	0.86
LOI	4.00

Table 3.1.4
Acid Base Accounting of Bulk Sample

Parameter	Value
Paste pH	8.1
24 Hour pH	1.82
S (T), %	0.12
S (SO4), %	0.05
AP	2.2
NP	12.4
Net NP	10.2
NP/AP	5.7

3.1.2 Waste Sample

The sample of previously leached ore (designated by the laboratory as Sample L1 Waste) consisted of one bulk bag which was sampled at the laboratory by coning and quartering. This sample was analyzed to determine the extent of copper leaching and the overall make-up of the sample. The analysis summarized in Table 3.1.5 indicates a high total and soluble copper content. Assuming an initial copper content similar to that of the bulk sample, the copper appears to have been only about 50% leached in terms of copper extraction.

Table 3.1.5
Analysis of Sample L1 Waste

	%
Cu_T	0.58
Cu_{AS}	0.42
Fe_T	3.84
Fe_{AS}	1.20
Al_2O_3	16.98
BaO	0.22
CaO	3.43
Fe_2O_3	6.21
K_2O	2.43
MgO	2.24
MnO	0.07
Na_2O	4.59
P_2O_5	0.30
SiO_2	57.27
TiO_2	0.68
LOI	5.64

3.2 Leaching Testwork

Additional column leach tests were conducted as part of the most recent program. One test (Column AB) was conducted on Run of Mine sized material to observe the leaching response of this material. A second test (Column C) was conducted on a portion of the same sample but crushed to the same size as the feed used for previous tests. The results of these column tests are discussed in this section. The details of the column tests are included in Appendix 2.

3.2.1 Crushed Sample Leaching

A column test (designated as Column C) was conducted on a portion of the composite sample crushed to minus ¾ inch. This crush size had been selected previously as being appropriate for the Carmacks deposit. While determining the viability of conducting a ROM leach was a significant objective of the current program, testing of the sample crushed to minus ¾ inch provided a basis of comparing the behaviour of the composite to previously tested materials and provided material for decommissioning studies. The following discussion compares the results for the current sample to the results obtained for previous samples.

Prior to being loaded in the column the material was mixed with an addition of 15 kg/tonne sulphuric acid and 19.9 kg/tonne water and tumbled to simulate the degree of agglomeration that the material would achieve through several stages of transfer on a grasshopper type stacking system. The material was placed in the column and allowed to cure for 5 days before leaching was started. Leaching was commenced with a 10 gpl sulphuric acid solution for the first 6 days of operation. After this time the feed was raffinate which had been blended to maintain a feed acid concentration of about 13 gpl acid. The balance of the test was a closed circuit test with the PLS (Pregnant Leach Solution) being processed through solvent extraction before being returned to the column feed. Further acid additions were made to the column feed from time to time to achieve specific objectives.

For the purpose of discussion, the results for column C are compared to those obtained previously for columns PC2 and FH. Column PC2 was conducted in 1992-1993 on sample material obtained from surface trenches while column FH was conducted on a drill core composite.

Figure 3.2.1 summarizes the copper extraction as a function of leach time for column C and Figure 3.2.2 shows the copper extraction as a function of time for samples C, FH and two tests on the PC sample. It can be seen in this figure that sample FH gave the same results as one of the PC tests while the other PC test gave a slower initial leach rate. Sample C on the other hand leached faster than any of the other test samples. The leaching rate can be influenced by several factors including particle size and rate of acid addition.

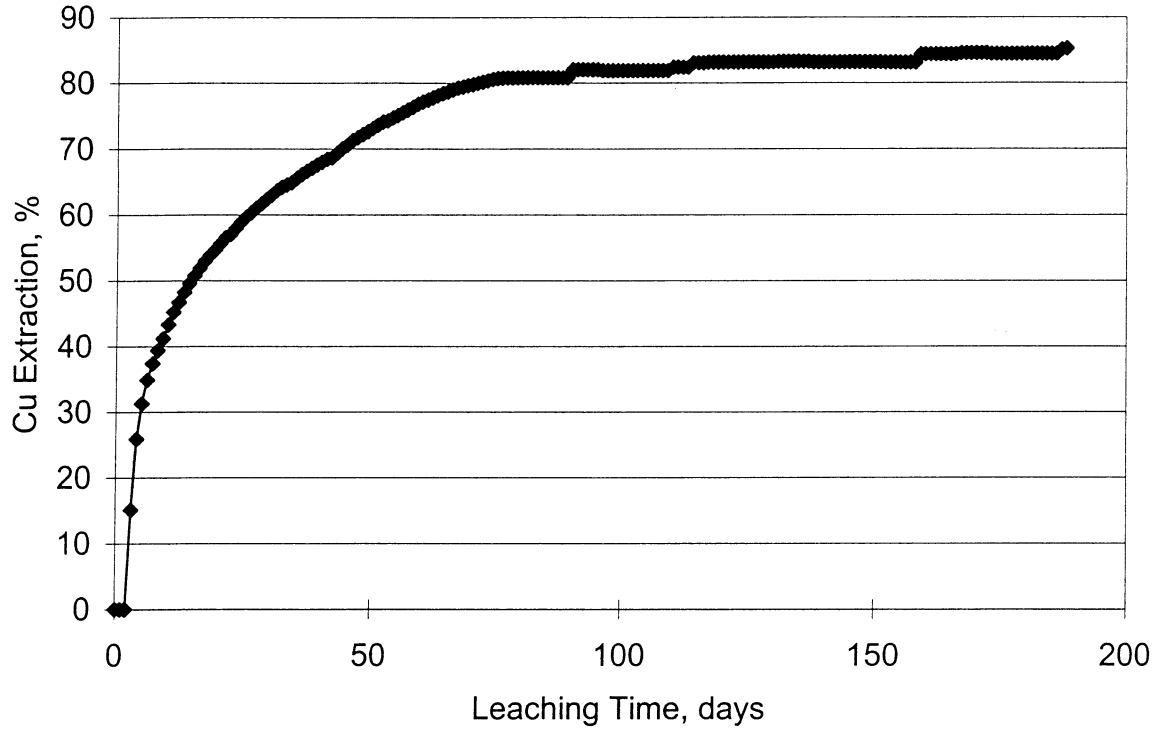


Figure 3.2.1 Extraction as a Function of Leach Time for Column C.

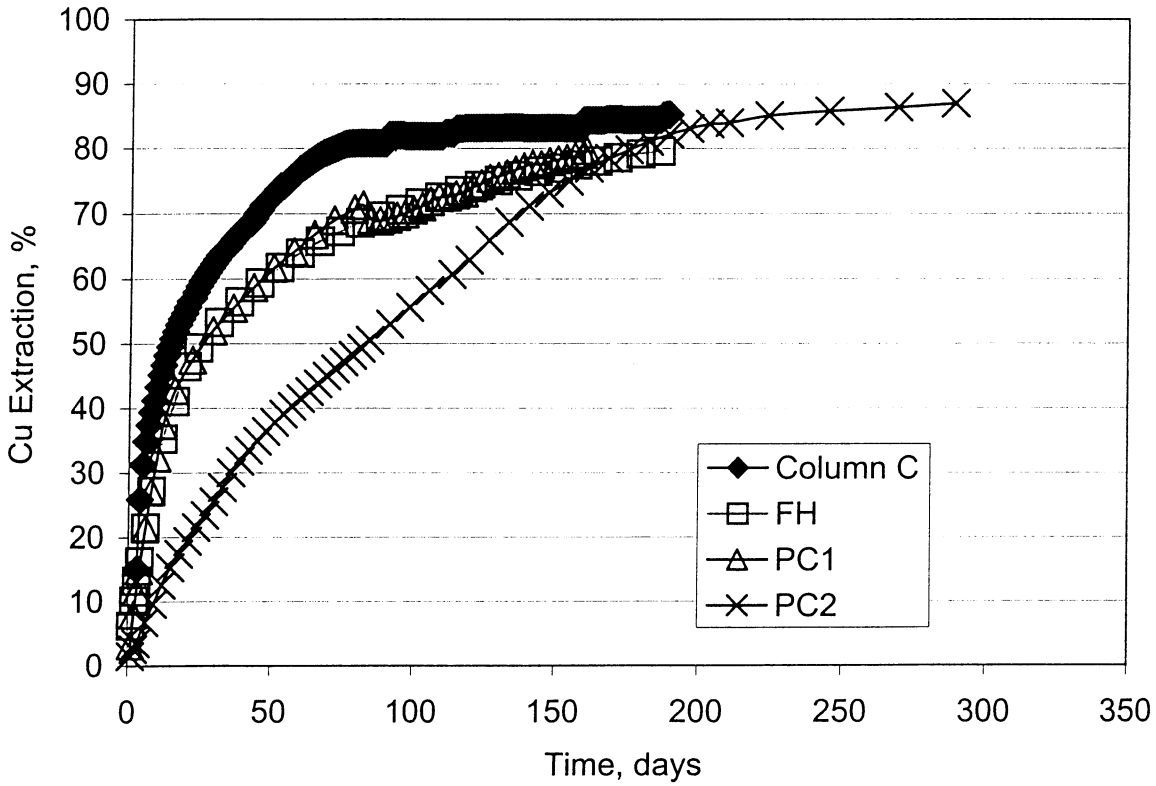


Figure 3.2.2 Copper Extraction Profiles for Various Carmacks Tests.

Figure 3.2.3 shows the size distribution of the three samples used for the various tests. The three samples have similar distributions at the coarse particle sizes but FH contains fewer fines than the other two samples and sample C is the finest of all. Sample FH likely has somewhat less fines than would be obtained when mining this material since much of the fines observed in mine products originate during blasting while the FH composite was produced by crushing drill core. However, it is expected that more fines will be experienced during the initial stages of mining, similar to the content of the PC and C samples and the presence of these fines would be expected to result in faster leach kinetics as well as increased acid consumption.

The slow initial rate experienced for column PC2 compared to PC1 can be explained in terms of the acid additions made to this column. Figure 3.2.4 shows the copper extraction as a function of acid addition for all the ¾ inch columns. It can be seen that column PC2 achieved comparable copper extraction (when adjusted for leach time) as the other columns but with much less acid. Column FH on the other hand maintained high acid concentrations, and therefore high acid consumption, throughout the test but obtained no benefit in terms of copper leaching for this extra acid. These results show that while it is very important to establish the correct conditions in terms of acid at the start of the leaching cycle, there is no benefit to maintaining aggressive conditions after the initial leaching period of 50 to 100 days. It does appear from Figure 3.2.2 combined with Figure 3.2.4 that sample C leaches somewhat more quickly than the other samples tested at similar acid additions. The slight increase in rate for sample C could be related to the fact that this is the finest sample tested, together with the fact that the sample has a lower head grade (1.0 vs 1.2% Cu).

The acid consumption expected for sample C is similar to that established for the other samples that were tested. While the current test (Column C) indicates a high acid consumption of 34.4 kg/t, consideration of Figure 3.2.4 shows this figure to be misleading. During the initial part of the test, the acid consumption for sample C was similar to that for PC2. However, while the consumption for column PC2 was held at about 22 kg/t, the consumption for column C continued to increase. The reason for the excessive acid consumption observed in column C is apparent from Figure 3.2.6. While most copper heap leach operations maintain a PLS pH in the range of 1.8 to 2.0, it has previously been established that for the Carmacks ore, the PLS pH should be at least 2.2. The initial PLS pH for Column C was well over pH 3 and acid was added over the period of 50 to 100 days to bring this value down to a more normal range. It appears that the target value of 2.2 is still too low for this material and based on a comparison of the pH profiles for the various tests as summarized in Figure 3.2.7, a more appropriate target appears to be pH 2.5 to 2.7. In order to achieve this target efficiently a cure acid addition of 20 kg/t, rather than the 15 kg per tonne used in Column C, is indicated.

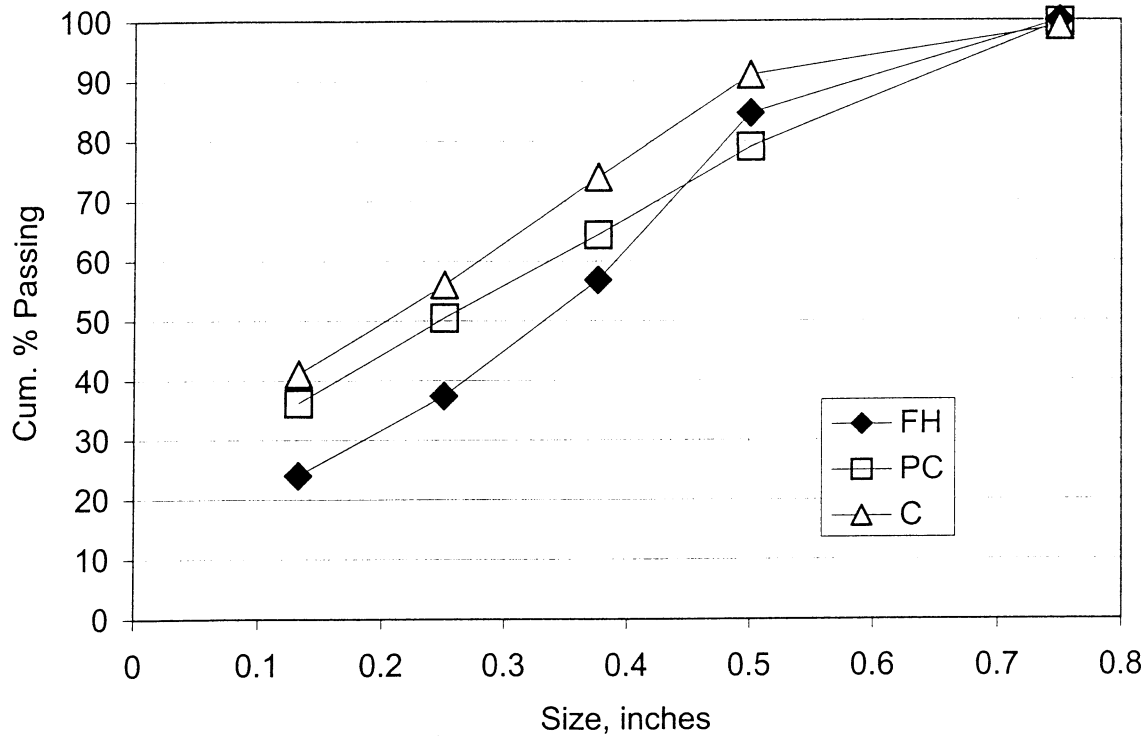


Figure 3.2.3 Size Distribution for Carmacks Test Samples.

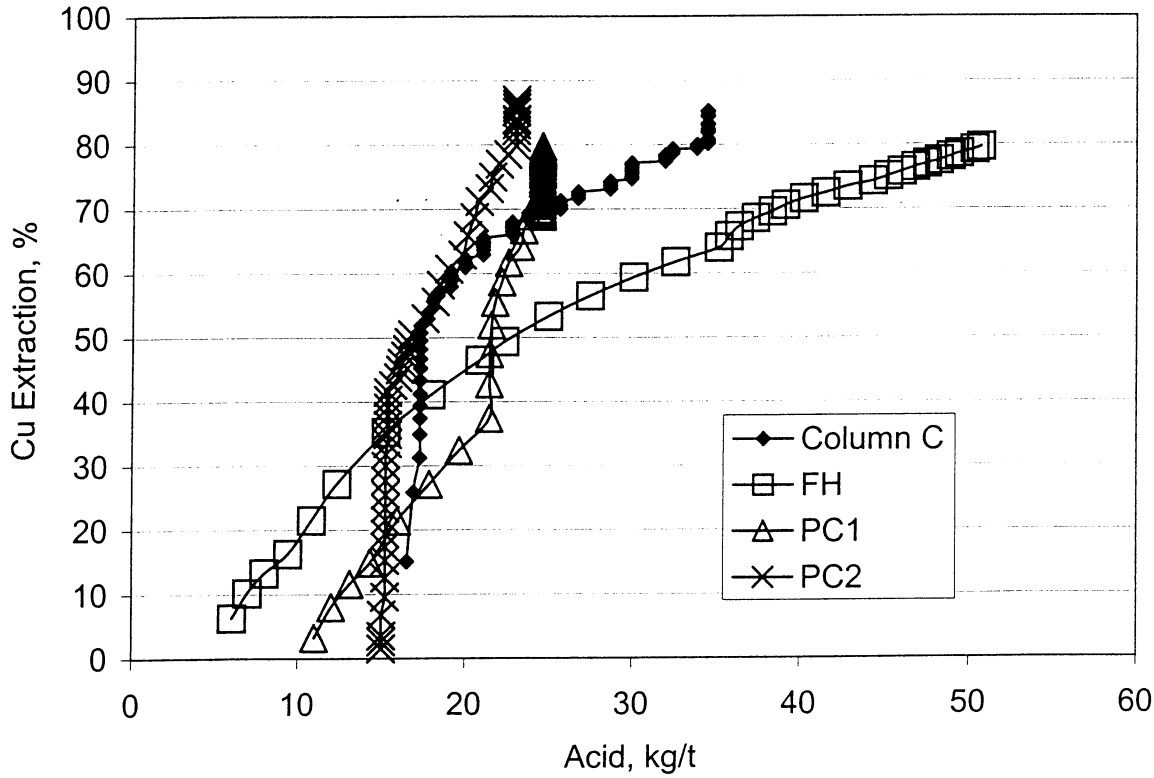


Figure 3.2.4 Copper Extraction as a Function of Acid Addition.

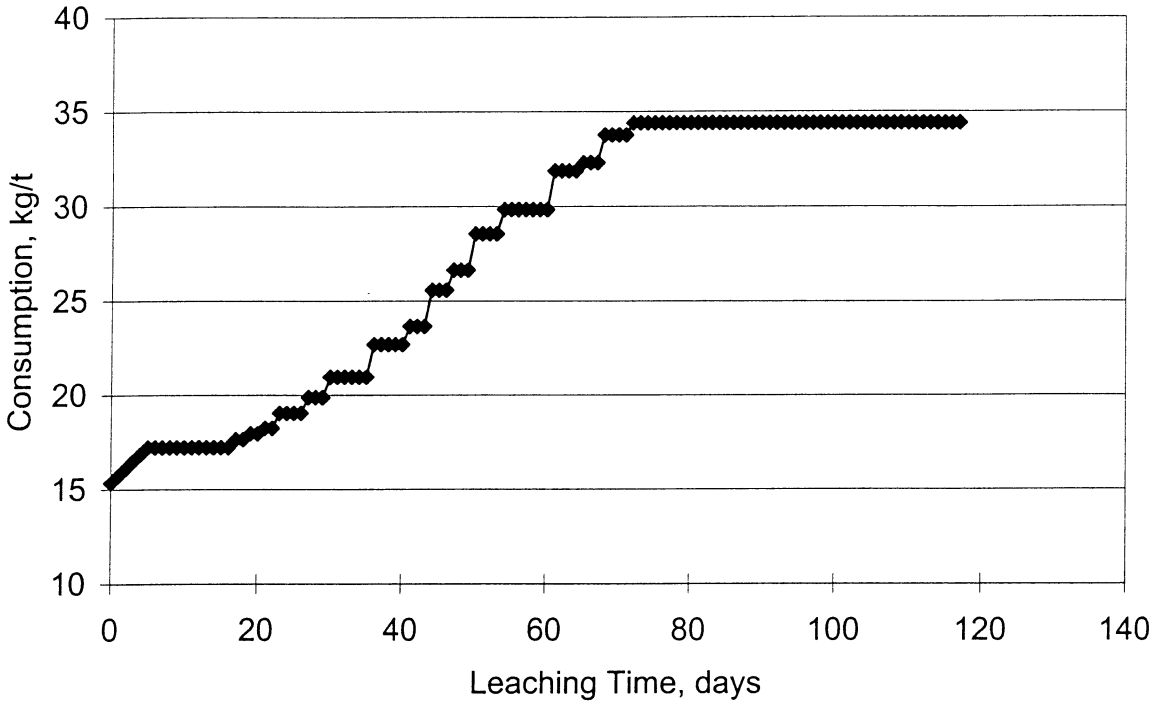


Figure 3.2.5 Acid Consumption for Column C.

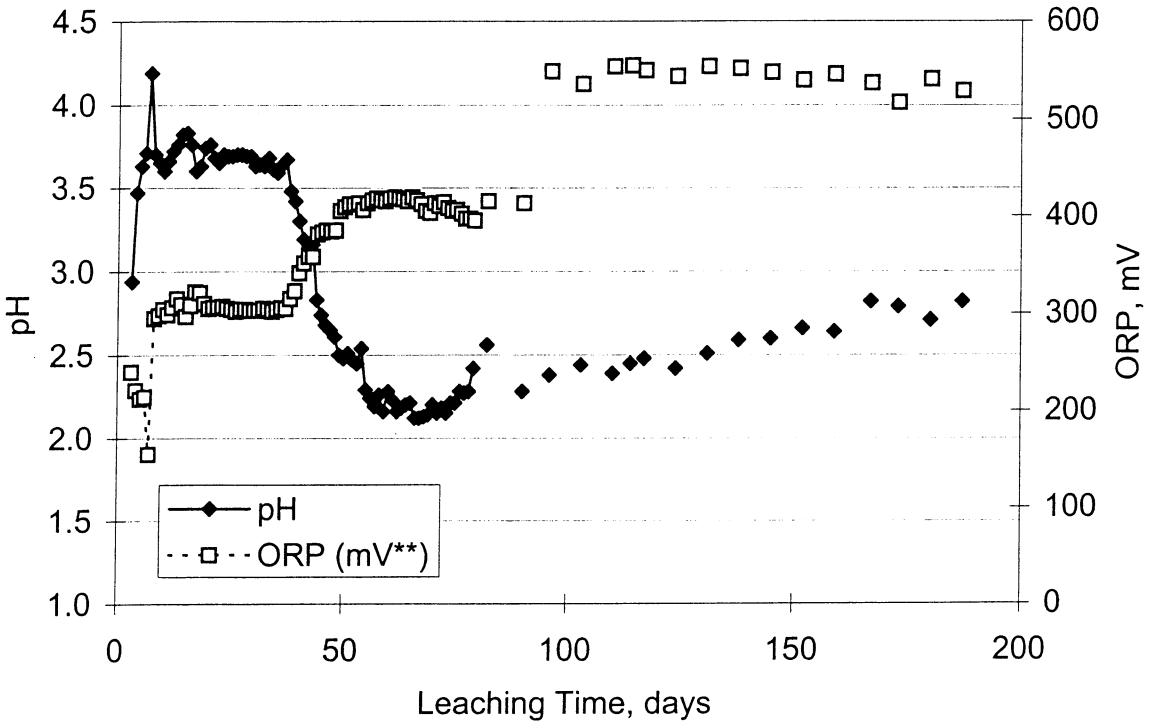


Figure 3.2.6 pH and ORP Profile for Column C.

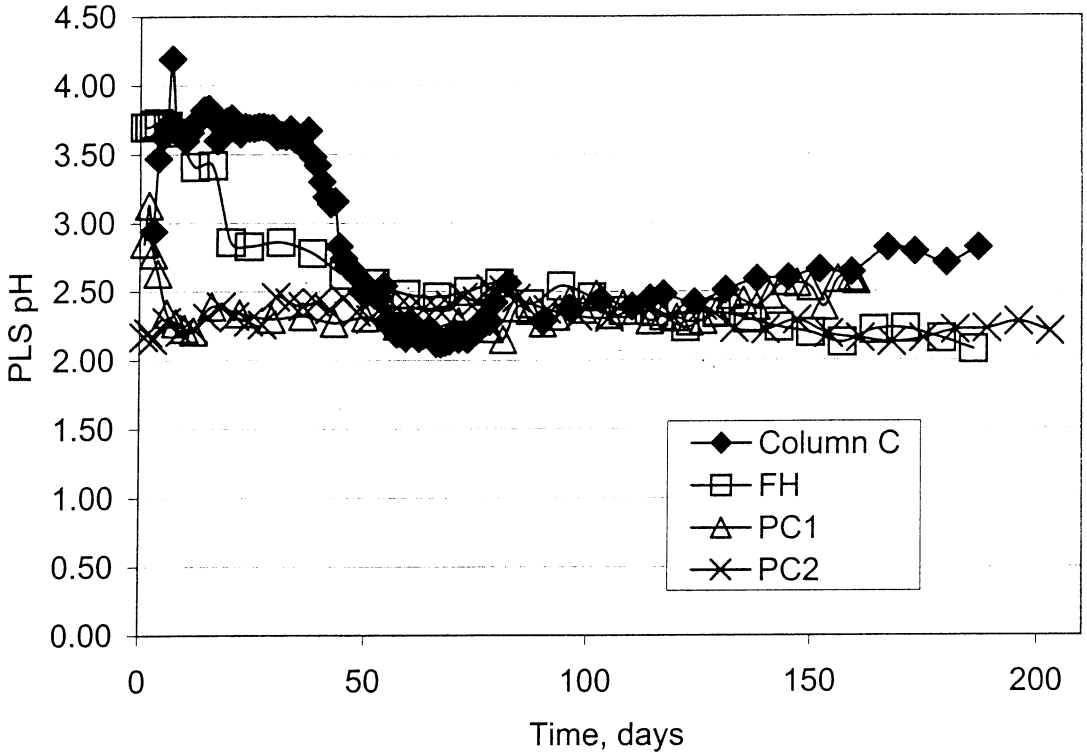


Figure 3.2.7 PLS pH Profiles for Carmacks Column Tests.

After the interval from day 72 to day 75, no further acid additions were made to this test. The solution was allowed to drain down from the column for eight days to provide an indication of the drain down characteristics as discussed in Section 3.2.2. After the drain down test was completed the PLS solution was continuously recirculated through the material until the copper grade reached about 0.5 gpl Cu. At this point solvent extraction was performed to remove the copper and the solution was then recycled again. As is summarized in Figure 3.2.8, the pH of both the feed and PLS increased over this period as the free acid was consumed. The downward spikes in the feed pH in this figure show the points where solvent extraction was carried out, resulting in a temporary increase in the feed acid concentration. The acid added through solvent extraction was consumed quickly by the ore each time.

The net conclusion is that Sample C leaches somewhat more readily than the other materials tested and requires a high PLS pH in order to minimize acid consumption. The copper extraction of about 83% achieved for the column test over the design leaching period of about 120 days would translate into a commercial copper extraction of about 76 to 78%, depending on operating efficiencies. When processing materials with a leaching profile such as that observed for column C, the primary leach cycle should be reduced to about 60 days. About 70% copper extraction (column) would be achieved during this period with the remaining extraction achieved during subsequent leaching of overlying lifts. The acid consumption will be minimized in this manner.

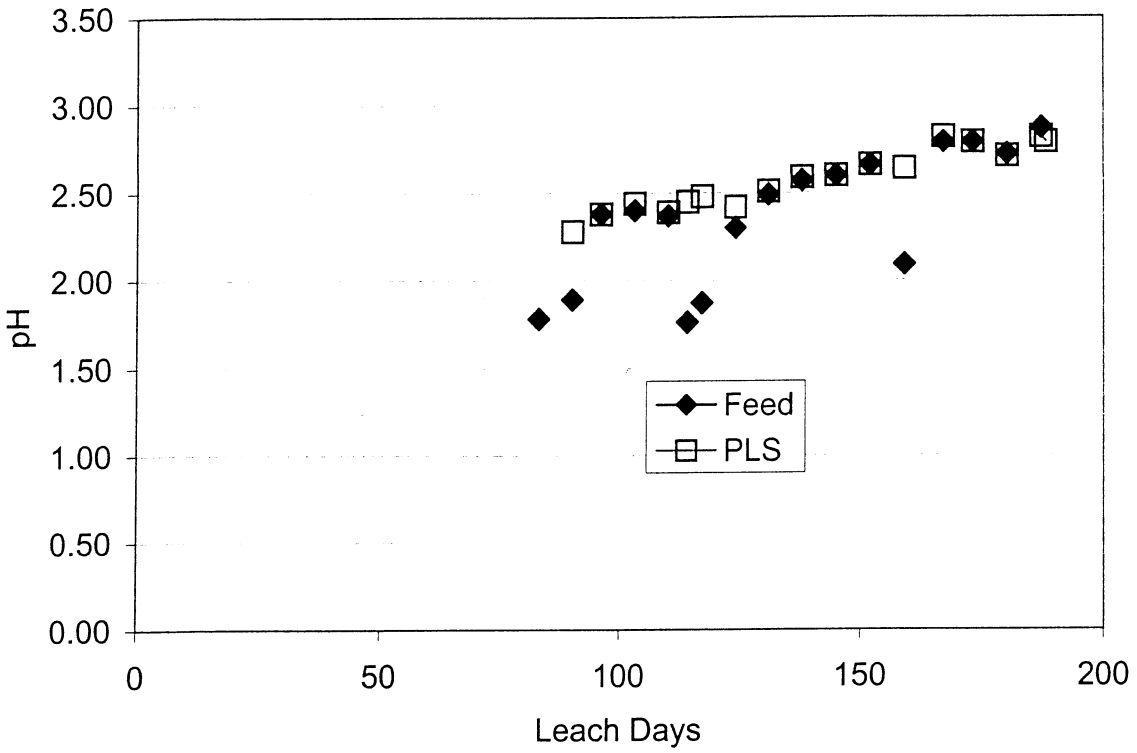


Figure 3.2.8 pH of Feed and PLS During Solution Recirculation.

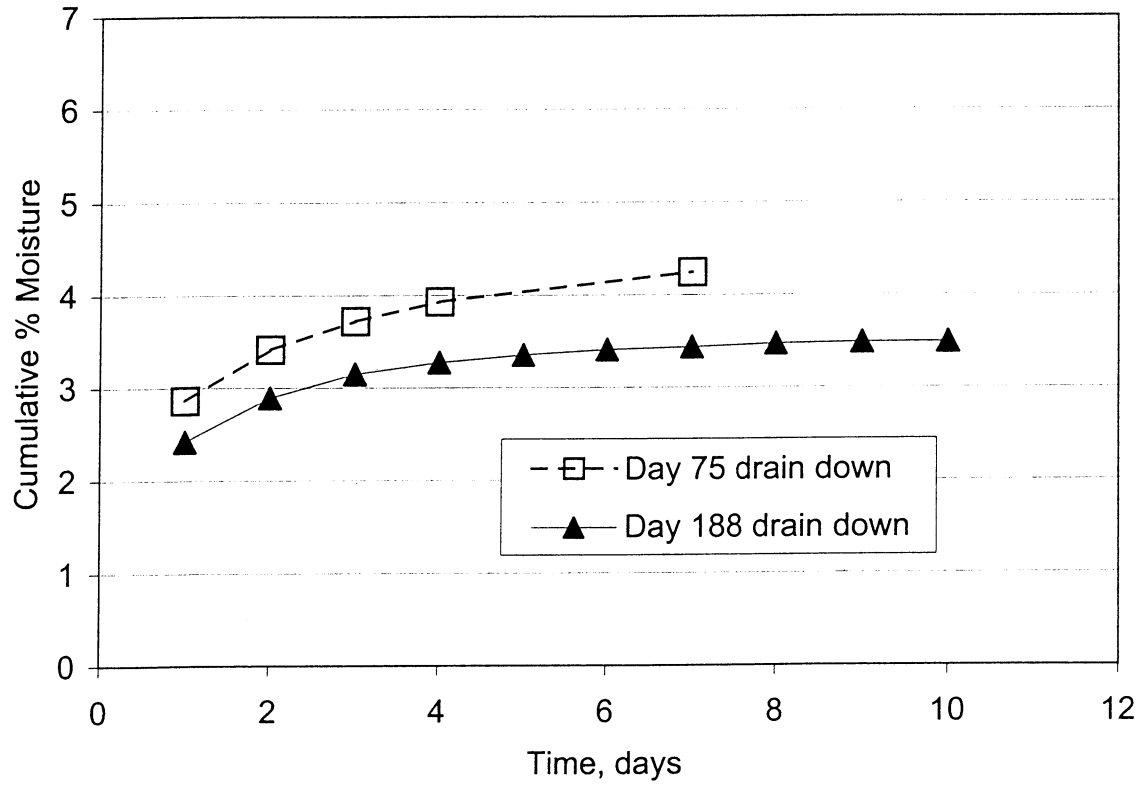


Figure 3.2.9 Drain Down Curves for Column C.

The recovery by size fraction for column C is summarized in Table 3.2.1. The recovery is seen to be quite uniform for all fractions below about ½ inch. Above this size there is a slight loss in copper extraction. It would be expected that the coarsest particles would continue to leach but at a very slow rate. Similarly, even larger particles than included in this test would be expected to achieve an even lower copper extraction in a given leach time.

Table 3.2.1
Recovery of Copper by Size Fraction at ¾ Inch Crush Size

Fraction	Final Residue			Recovery
	Wt. %	Cu_T, %	Cu_{AS}, %	Cu_T %
- ¾ + ½	5.5	0.18	0.17	79.5
- ½ + 3/8	13.5	0.12	0.12	86.8
- 3/8 + ¼	14.7	0.11	0.09	88.2
- ¼ + 6m	14.1	0.10	0.09	89.7
- 6m	52.3	0.12	0.11	88.9
Total		0.12	0.11	87.8

The trace element concentration for the Column C PLS for a number of days is summarized in Table 3.2.2 and for the Raffinate is summarized in Table 3.2.3. It is apparent that the gangue mineral constituents are being leached by the solution as evidenced by the increase in dissolved Al, Mg, Fe, and Si. It is likely that the biotite in the sample is undergoing significant leaching and accounts for much of the acid consumption.

Table 3.2.2
ICP Analysis of Pregnant Leach Solution

Element	Unit	Column C PLS					
		Day 5	Day 12	Day 19	Day 26	Day 33	Day 40
$SO_4^=$	g/L	39.97	16.46	16.22	19.88	22.12	26.98
Al	mg/L	1502.2	814.0	1175.7	1485.2	1950.2	2417.4
Sb	mg/L	0.1	< 0.1	0.1	< 0.1	< 0.1	0.1
As	mg/L	2.7	1.0	1.5	1.7	1.6	2.4
Ba	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bi	mg/L	< 0.1	< 0.1	< 0.1	0.9	0.2	< 0.1
Cd	mg/L	< 0.01	0.16	0.20	0.21	0.24	0.27
Ca	mg/L	497.9	466.4	463.9	467.0	470.0	496.1
Cr	mg/L	0.21	< 0.01	0.01	0.23	0.50	0.83
Co	mg/L	9.80	4.51	5.02	5.42	5.98	6.68
Cu	mg/L	15.78 g	5083.31	2720.73	2194.03	1722.71	1270.35
Fe	mg/L	503.13	667.70	740.58	1176.52	1443.16	1787.69
La	mg/L	2.17	1.50	1.30	1.26	1.31	1.38
Pb	mg/L	0.48	0.14	< 0.05	< 0.05	< 0.05	< 0.05
Mg	mg/L	1325.5	765.1	911.2	1171.8	1453.1	1588.1
Mn	mg/L	359.61	153.19	173.98	175.80	199.37	206.85
Hg	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mo	mg/L	0.33	0.17	0.16	0.13	0.24	0.17
Ni	mg/L	2.03	1.04	1.22	1.58	1.72	2.15
P	mg/L	187.9	59.4	31.0	26.5	24.6	21.4
K	mg/L	17	11	18	22	13	5
Sc	mg/L	0.73	0.27	0.28	0.84	1.31	1.60
Si	mg/L	49.9	58.7	62.4		107.61	
Ag	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Na	mg/L	39	< 1	22	21	17	15
Sr	mg/L	2.28	1.51	1.15	0.82	0.59	0.61
Th	mg/L	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Ti	mg/L	0.6	0.2	0.1	< 0.1	< 0.1	< 0.1
W	mg/L	3.7	0.7	0.4	0.7	0.5	0.3
V	mg/L	0.10	0.03	0.02	0.02	0.03	0.53
Zn	mg/L	45.23	19.68	18.91	20.34	22.21	25.70
Zr	mg/L	0.02	0.02	< 0.01	< 0.01	< 0.01	0.06

Element	Unit	Column C PLS					
		Day 47	Day 54	Day 61	Day 68	Day 103	Day 246
$SO_4^=$	g/L	33.06	42.53	36.47	44.42		
Al	mg/L	2935.3	3705.5	2935.4	3778.7	3424.8	3596
Sb	mg/L	< 0.1	<0.1	<0.1	0.1	0.2	0.3
As	mg/L	1.7	2.2	1.0	1.7	6.6	12.9
Ba	mg/L	< 0.01	<0.01	<0.01	< 0.01	<0.01	<0.01
Bi	mg/L	< 0.1	<0.1	<0.1	< 0.1	<0.1	<0.1
Cd	mg/L	0.26	0.34	0.22	0.28	0.25	0.41
Ca	mg/L	508.9	474.9	481.9	491.2	497.5	493.2
Cr	mg/L	1.48	2.14	1.84	2.50	2.19	0.86
Co	mg/L	7.26	9.15	5.80	7.01	6.74	7.65
Cu	mg/L	797.00	932.20	484.80	323.90	427.44	271.54
Fe	mg/L	3537.02	4616.31	4291.79	5015.75	1608	28.6
La	mg/L	1.54	1.69	1.07	1.32	0.60	<0.05
Pb	mg/L	< 0.05	<0.05	<0.05	< 0.05	<0.05	0.35
Mg	mg/L	1966.0	2449.8	1952.5	2574.1	2458	3629
Mn	mg/L	224.68	265.10	167.52	217.77	189.7	341.5
Hg	mg/L	< 0.05	<0.05	<0.05	< 0.05	<0.05	0.16
Mo	mg/L	0.94	1.55	3.43	2.99	0.54	0.26
Ni	mg/L	2.36	2.84	1.83	2.90	2.75	3.06
P	mg/L	160.7	209.2	219.9	210.6	88.5	6.9
K	mg/L	106	92.	154.	236	41	12
Sc	mg/L	1.90	2.17	1.68	2.12	1.76	0.45
Si	mg/L	279.42	261.05	264.96	284.13	211.9	
Ag	mg/L	< 0.02	<0.02	,0.02	< 0.02	<0.02	0.04
Na	mg/L	6	8.	<1.	< 1	16	40
Sr	mg/L	0.99	1.04	1.05	1.12	0.29	0.06
Th	mg/L	< 0.1	<0.1	<0.1	< 0.1	<0.1	0.2
Ti	mg/L	0.3	0.5	1.1	3.0	0.6	<0.1
W	mg/L	0.4	<0.1	0.6	< 0.1	<0.1	<0.1
V	mg/L	8.16	12.81	12.37	16.05	1.52	<0.01
Zn	mg/L	27.97	31.46	23.27	29.62	31.43	37.42
Zr	mg/L	0.05	0.09	0.06	0.08	<0.01	0.01

Table 3.2.3
ICP Analysis of Column C Raffinate

Element	Unit	Column C SX Raffinate					
		Day 5	Day 12	Day 19	Day 26	Day 33	Day 40
$SO_4^=$	g/L	46.02	19.42	17.60	20.77	24.62	27.68
Al	mg/L	1655.0	822.2	1151.1	1532.4	1937.1	2402.0
Sb	mg/L	0.3	< 0.1	< 0.1	< 0.1	< 0.1	0.2
As	mg/L	2.3	0.9	1.1	1.6	1.7	2.3
Ba	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bi	mg/L	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1
Cd	mg/L	0.42	0.18	0.19	0.22	0.23	0.27
Ca	mg/L	505.1	466.8	463.8	472.5	463.2	495.1
Cr	mg/L	0.28	< 0.01	< 0.01	0.24	0.52	0.91
Co	mg/L	10.71	4.47	5.02	5.39	5.93	6.67
Cu	mg/L	235.70	6.55	12.70	9.11	9.58	7.42
Fe	mg/L	586.58	678.84	740.20	1213.93	1426.50	1831.20
La	mg/L	2.32	1.49	1.32	1.20	1.31	1.38
Pb	mg/L	0.11	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	mg/L	1413.6	756.9	890.5	1127.4	1399.7	1563.7
Mn	mg/L	385.20	152.11	170.16	179.91	197.54	205.64
Hg	mg/L	< 0.05	< 0.05	< 0.05	0.17	< 0.05	< 0.05
Mo	mg/L	0.09	0.08	0.09	0.07	0.04	0.15
Ni	mg/L	2.33	1.06	1.17	1.55	1.73	2.08
P	mg/L	15.4	0.3	1.1	1.4	2.8	8.0
K	mg/L	19	12	20	15	18	5
Sc	mg/L	0.69	0.22	0.25	0.83	1.28	1.66
Si	mg/L	56.6	57.9	62.5		108.75	
Ag	mg/L	< 0.02	< 0.02	0.04	< 0.02	< 0.02	0.05
Na	mg/L	41	< 1	21	21	16	16
Sr	mg/L	2.36	1.52	1.16	0.83	0.58	0.61
Th	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Ti	mg/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
W	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	< 0.1
V	mg/L	0.10	< 0.01	< 0.01	< 0.01	0.03	1.01
Zn	mg/L	27.70	13.38	15.34	17.66	19.83	23.95
Zr	mg/L	0.03	< 0.01	0.02	< 0.01	0.03	0.03

Element	Unit	Column C SX Raffinate					
		Day 47	Day 54	Day 61	Day 68		
$SO_4^{=}$	g/L	32.07	40.53	41.11	46.36		
Al	mg/L	2765.7	3426.5	3304.5	3868.0		
Sb	mg/L	< 0.1	<0.1	<0.1	< 0.1		
As	mg/L	2.0	2.4	1.6	1.7		
Ba	mg/L	< 0.01	<0.01	<0.01	< 0.01		
Bi	mg/L	< 0.1	<0.1	<0.1	< 0.1		
Cd	mg/L	0.25	0.33	0.28	0.28		
Ca	mg/L	503.4	479.4	494.1	488.8		
Cr	mg/L	1.32	1.96	2.10	2.52		
Co	mg/L	7.05	7.80	7.07	7.18		
Cu	mg/L	3.81	4.98	6.09	2.67		
Fe	mg/L	3061.59	4203.01	4344.62	4974.65		
La	mg/L	1.46	1.60	1.36	1.38		
Pb	mg/L	< 0.05	<0.05	<0.05	< 0.05		
Mg	mg/L	1881.6	2252.7	2197.9	2615.2		
Mn	mg/L	219.39	254.99	209.25	224.90		
Hg	mg/L	< 0.05	<0.05	<0.05	< 0.05		
Mo	mg/L	0.25	0.70	1.50	0.64		
Ni	mg/L	2.27	2.92	2.37	2.91		
P	mg/L	117.4	207.8	232.1	241.7		
K	mg/L	80	87.	147.	241		
Sc	mg/L	1.83	2.14	2.07	2.15		
Si	mg/L	259.23	243.53	267.58	305.63		
Ag	mg/L	< 0.02	<0.02	<0.02	< 0.02		
Na	mg/L	9	10.	4.0	2		
Sr	mg/L	0.97	1.06	1.06	1.12		
Th	mg/L	< 0.1	<0.1	<0.1	< 0.1		
Ti	mg/L	0.2	0.5	1.1	3.2		
W	mg/L	< 0.1	<0.1	0.5	< 0.1		
V	mg/L	7.05	11.34	13.17	15.74		
Zn	mg/L	25.97	28.53	27.16	29.75		
Zr	mg/L	0.01	0.07	0.05	0.09		

3.2.2 Drain Down Testwork

Based on the solution balance during the first 6 days of column operation, the total solution hold-up in the column was calculated to be equivalent to 14.8% by weight. Two drain down tests were conducted on this column, one after 75 days leaching and the other at the end of the test. The results are summarized in Figure 3.2.9. The drain down at the end of the test showed a moisture release of about 3.5%. The moisture content of the column residue was determined to be 10.8%, which is in reasonable agreement with the hold-up moisture less the drain down. The decrease in drain down from day 75 to day 188 could be the result of decrepitation with time, resulting in increased moisture content of the leached solids.

A drain down test was also conducted on the ROM leach column. The solution hold-up in this column was determined to be equivalent to 10.2% moisture. Over 7 days the drain down moisture was 1.8% by weight and extending these results to 30 days indicates a drain down of 2.4%.

3.2.3 Run of Mine Leaching

A run of mine leaching test (Test AB) was conducted with the bulk sample, using two column sections each 36 inches (~0.9m) in diameter and 4 meters tall. The sample was loaded in each section to a height of about 3.5 meters. All solutions were pumped to the top of the first section of column (Column A) and the PLS from this section became the feed to the second section (Column B) resulting in an effective overall height for the test of 7 meters. Solvent extraction was conducted on the PLS from column B before the solution was recirculated to column A. All results for this test will be discussed on the basis that the two sections together comprised one test. The details for this test are included in Appendix 2.

Once the sample had been placed in the columns, a solution containing 235 gpl sulphuric acid was pumped onto Column A and advanced through B just until solution appeared at the bottom of B. This acid addition, amounting to 12.58 kg/t H_2SO_4, was the cure acid addition. Curing was allowed to proceed for 7 days before the column was irrigated with leach solution.

Leaching was initiated by pumping an approximately 8 gpl sulphuric acid solution onto column A at a rate of 7 $l/h/m^2$ for the first four days of operation. After this time the raffinate was recycled to the feed and was initially diluted with water to maintain the target acid concentration in the feed. Over the course of the test the feed acid concentration was varied as reflected by the feed pH as summarized in Figure 3.2.12, in order to achieve specific objectives. Since the determination of free acid in the leach solutions is quite unreliable the feed conditions are best judged on the basis of the feed pH.

The progress of leaching of the ROM test is summarized on a linear time scale in Figure 3.2.10 and on a log time scale in Figure 3.2.11. In both Figures the results for column C are included for the purpose of comparison. It is apparent from the outset of the tests that the crushed sample leaches much faster than the ROM sample as would be expected. It also appears that the ROM test will have an ultimate copper extraction that is significantly lower than that of the crushed sample. Specific aspects of the ROM test need to be considered to determine whether a ROM leach could achieve higher extractions under different conditions or with an extended leach time.

The extraction curve is flat across the period from day 84 to 91 since no feed solution was being added at this time. The column was allowed to drain down during this period to provide drain down data as discussed in Section 3.2.2. Following the drain down, the feed pH was allowed to increase so that no acid additions were made over the period from day 83 to day 164. The copper extraction curve is therefore somewhat flatter than prior to this period. Following day 164 the feed acid concentration was increased as is apparent from the drop in both the feed pH as shown in Figure 3.2.12 and PLS pH, summarized in Figure 3.2.13. No significant benefit other than a slight increase in the leach rate resulted from this increase in acid concentration and it was therefore gradually allowed to decrease as is apparent from the acid consumption as a function of leach time as summarized in Figure 3.2.14. After day 304, no further acid additions were made to the column and the pH was allowed to increase naturally.

The copper extractions as a function of acid addition for both the ROM and ¾ inch tests are summarized in Figure 3.2.15. It can be seen that in the range of 40 to 65% Cu extraction, the two samples gave very similar results. The shapes of the two curves are consistent with the variations in operating conditions used for the column tests. It is apparent from these results that there is no benefit in terms of copper extraction derived from the use of high acid additions once the initial leach period which achieves somewhere in the range of 50% copper extraction is complete. It also appears that since increased acid consumption for the ROM column was resulting in low incremental copper extraction, a very long leach time of more than 1000 days (with the attendant increase in acid consumption) would be required to achieve a copper extraction similar to that achieved at a ¾ inch crush size.

The residue from the ROM test was not screened into size fractions for assay but it is expected that there would be a significant decrease in copper extraction for the coarser particle sizes.

Tables 3.2.4 and 3.2.5 summarize the dissolved element concentrations for the PLS and raffinate from column AB respectively. As for the column containing crushed sample, the build up of dissolved trace elements is consistent with the leaching process.

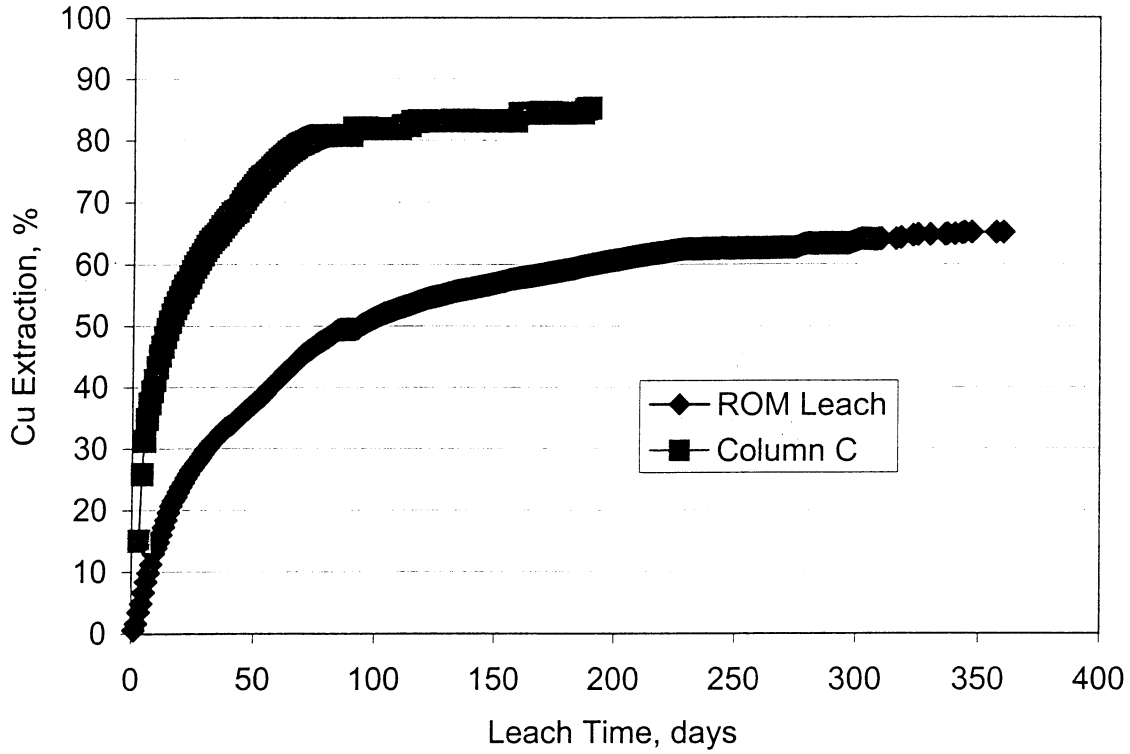


Figure 3.2.10 Cu Extraction Versus Time for Columns C and AB.

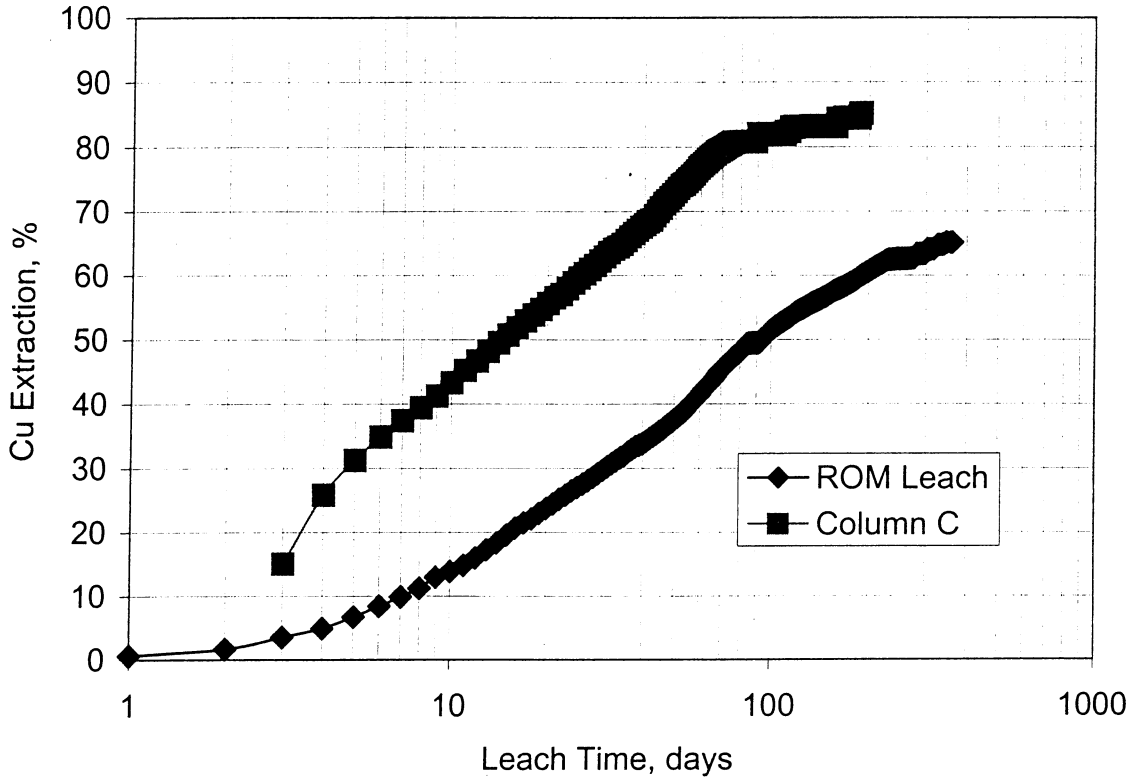


Figure 3.2.11 Cu Leaching vs Log Time for Columns C and AB.

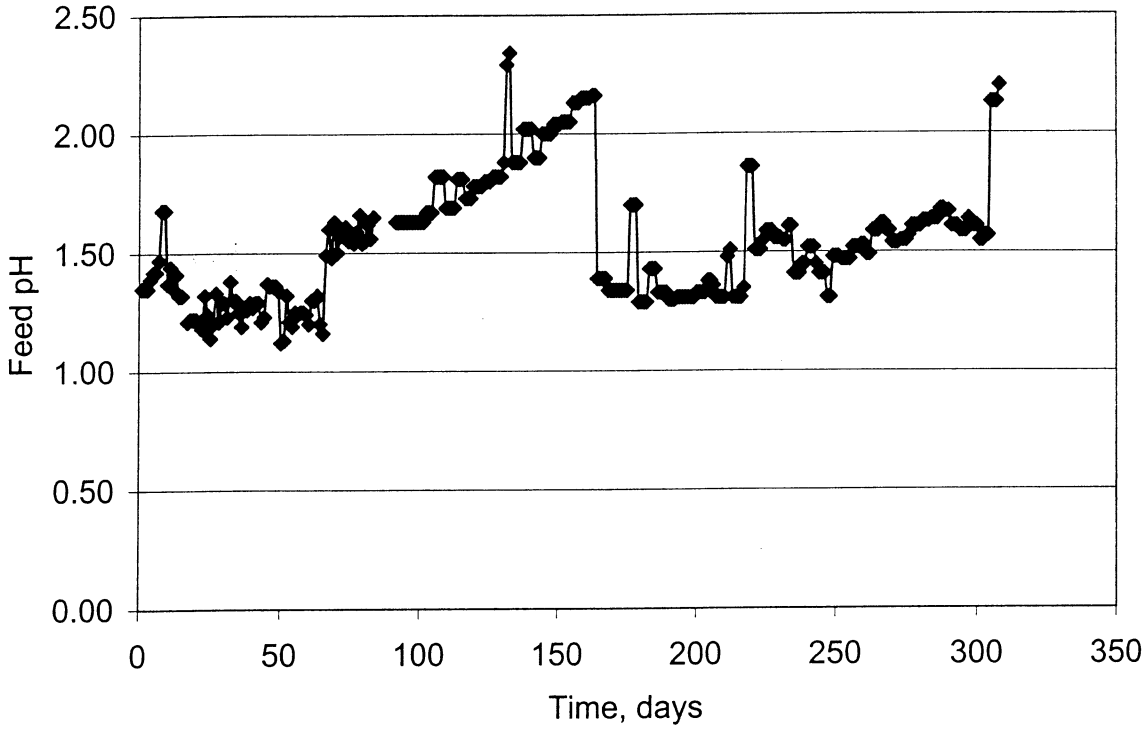


Figure 3.2.12 Feed pH for Column AB.

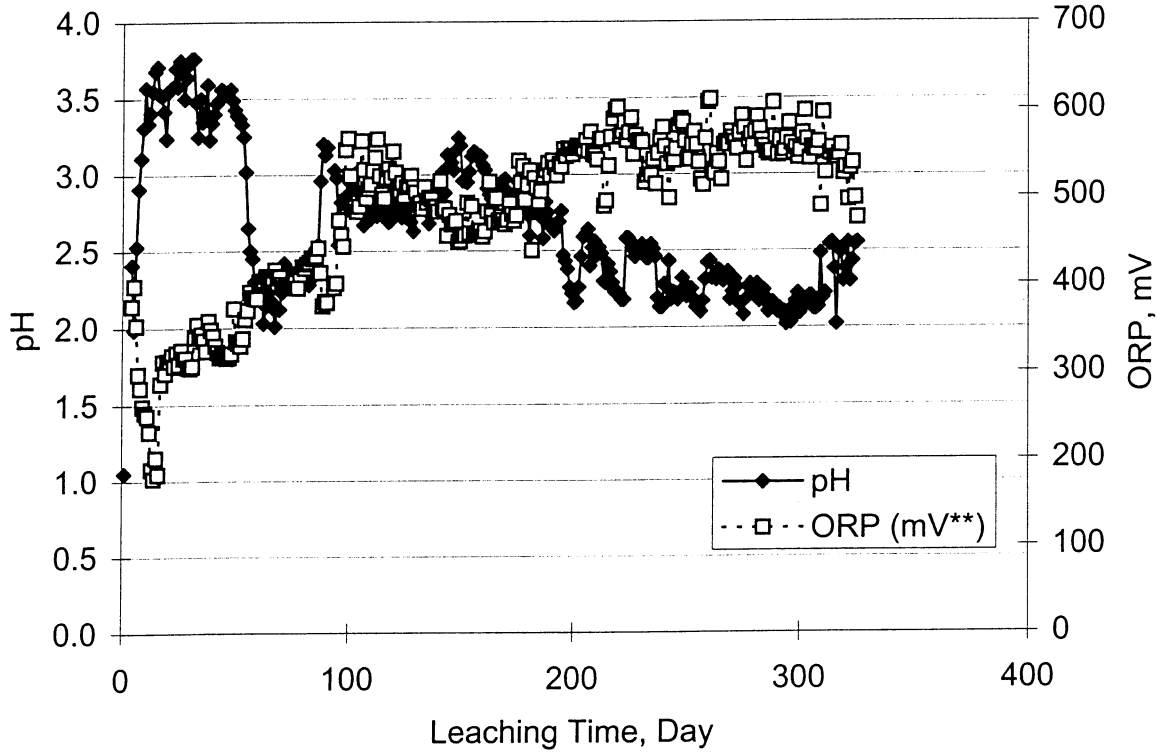


Figure 3.2.13 pH and ORP for Column AB PLS.

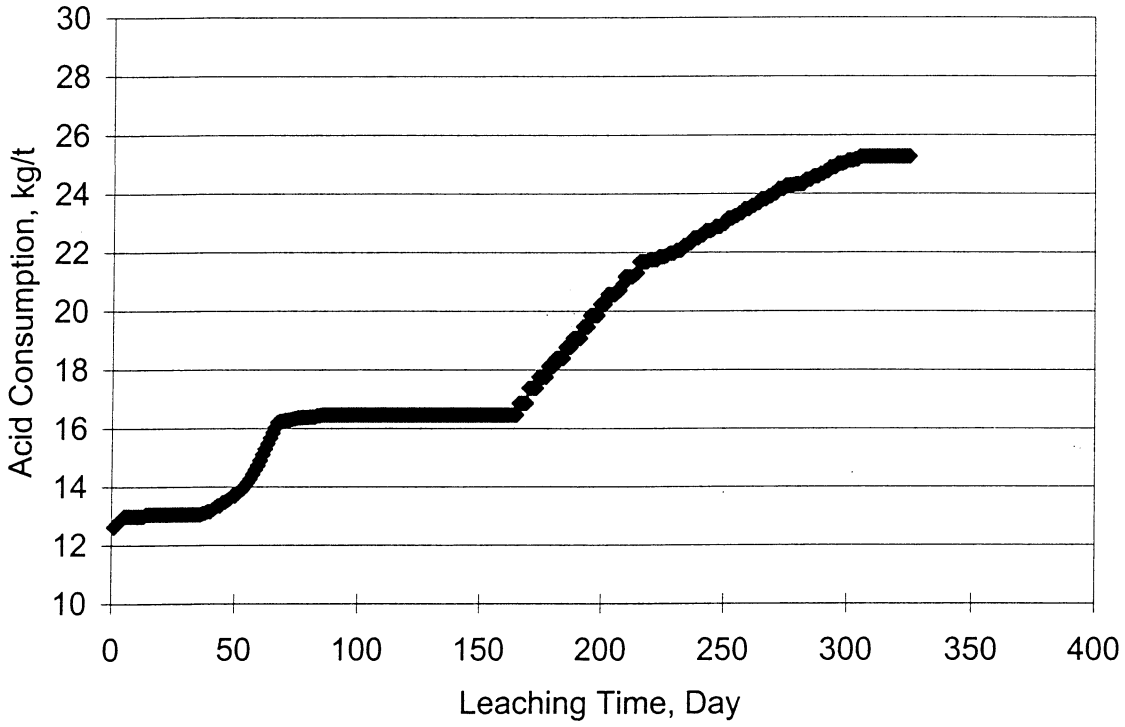


Figure 3.2.14 Acid Consumption vs Time for Column AB.

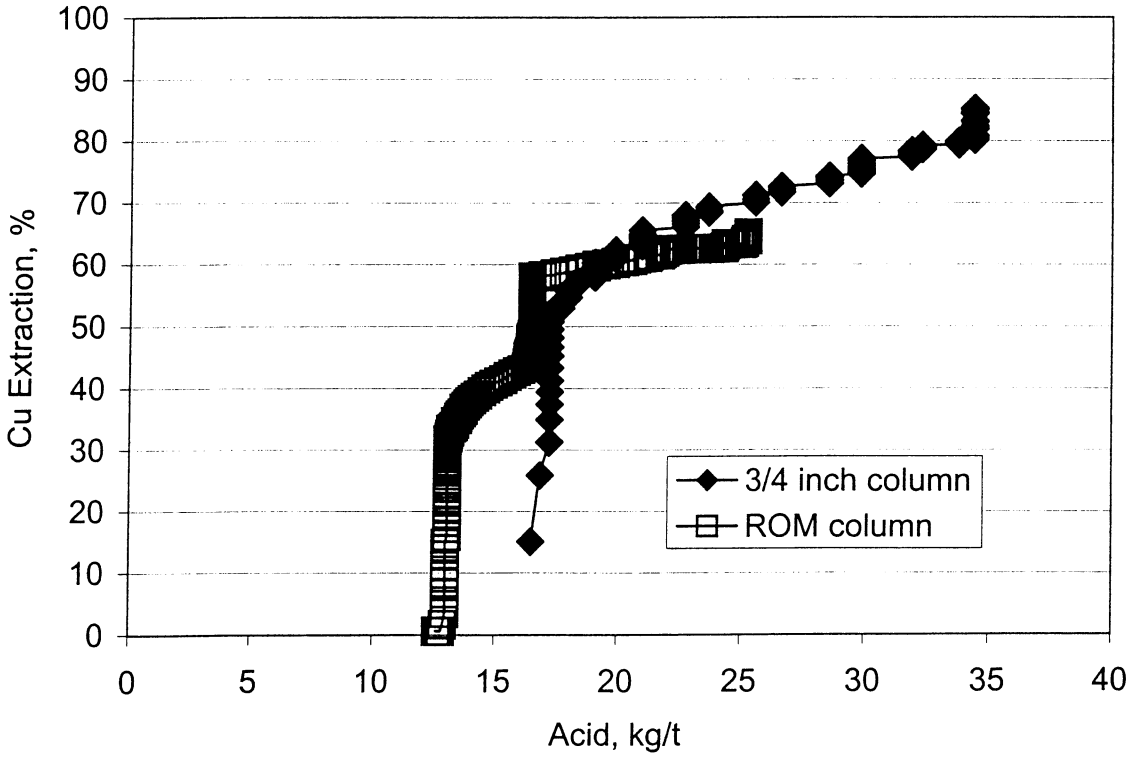


Figure 3.2.15 Cu Extraction vs Acid Consumption for Columns C and AB.

Table 3.2.4
ICP Analysis of Column B PLS

Element	Unit	Column B PLS					
		Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
$SO_4^{=}$	g/L	65.76	39.86	28.38	23.38	25.55	26.38
Al	mg/L	3912.9	2037.3	1389.6	1299.3	1413.9	1750.0
Sb	mg/L	< 0.1	0.2	< 0.1	< 0.1	< 0.1	0.1
As	mg/L	4.0	2.6	2.1	1.6	2.1	1.7
Ba	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bi	mg/L	< 0.1	0.6	< 0.1	0.6	2.6	1.7
Cd	mg/L	< 0.01	0.32	0.27	0.24	0.26	0.31
Ca	mg/L	482.2	470.2	459.3	455.9	467.7	463.9
Cr	mg/L	0.92	0.20	0.04	0.03	0.05	0.11
Co	mg/L	13.34	9.86	7.37	6.33	7.33	7.96
Cu	g/L	15.69	10.04	6734.65	5005.51	4703.37	3924.04
Fe	mg/L	3075.71	1493.27	1013.21	1025.27	1093.43	1290.37
La	mg/L	2.01	1.32	1.08	0.89	0.87	0.91
Pb	mg/L	< 0.05	< 0.05	< 0.05	0.24	< 0.05	0.10
Mg	mg/L	3496.8	2301.7	1748.2	1616.6	1775.9	2149.5
Mn	mg/L	505.18	368.08	266.33	233.77	260.13	290.49
Hg	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	0.11	< 0.05
Mo	mg/L	1.69	0.35	0.12	0.15	0.21	0.25
Ni	mg/L	3.28	2.26	1.79	1.53	2.04	2.15
P	mg/L	217.8	96.2	87.5	55.6	49.8	49.3
K	mg/L	213	125	70	66	54	61
Sc	mg/L	1.49	0.77	0.46	0.42	0.48	0.65
Si	mg/L	125.6	79.6	72.9	70.2	C0251	85.66
Ag	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Na	mg/L	29	26	14	23	30	26
Sr	mg/L	1.36	0.96	0.77	0.69	0.64	0.57
Th	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Ti	mg/L	1.7	0.5	0.3	0.2	0.2	0.2
W	mg/L	3.4	2.2	1.0	0.7	1.6	1.6
V	mg/L	3.85	0.69	0.09	0.13	0.39	0.47
Zn	mg/L	57.44	39.66	29.39	25.19	27.10	28.80
Zr	mg/L	0.10	0.02	0.03	0.03	< 0.01	< 0.01

		Column B PLS					
Element	Unit	Day 49	Day 56	Day 63	Day 70	Day 77	Day 112
$SO_4^=$	g/L	27.68	30.94	36.04	38.58	39.75	
Al	mg/L	1842.8	2274.4	2737.9	3120.1	3319.9	3783
Sb	mg/L	< 0.1	< 0.1	0.3	<0.1	0.3	0.2
As	mg/L	2.6	2.3	2.4	3.0	2.9	9.0
Ba	mg/L	< 0.01	< 0.01	<0.01	<0.01	< 0.01	<0.01
Bi	mg/L	1.0	0.2	<0.1	1.2	< 0.1	<0.1
Cd	mg/L	0.34	0.34	0.38	0.41	0.43	0.54
Ca	mg/L	500.9	517.2	482.0	491.1	479.8	515.2
Cr	mg/L	0.15	0.46	0.72	0.79	0.82	0.52
Co	mg/L	8.59	9.02	9.01	9.78	10.00	12.32
Cu	g/L	3207.61	1915.31	1661.69	1442.53	1222.32	1080
Fe	mg/L	1391.77	2044.03	2576.85	2677.90	2273.35	267.3
La	mg/L	0.88	1.13	1.12	1.13	1.13	0.52
Pb	mg/L	< 0.05	< 0.05	<0.05	<0.05	< 0.05	0.80
Mg	mg/L	2025.7	2354.4	2589.1	2772.0	2917.8	3320
Mn	mg/L	281.31	299.20	318.25	321.35	350.77	394.6
Hg	mg/L	< 0.05	< 0.05	<0.05	<0.05	< 0.05	<0.05
Mo	mg/L	0.26	0.91	1.57	1.86	1.05	0.25
Ni	mg/L	2.46	2.45	2.77	2.82	3.15	4.15
P	mg/L	44.3	80.0	92.8	71.4	70.7	26.1
K	mg/L	69	152	117.	104.	71	6
Sc	mg/L	0.68	1.04	1.35	1.55	1.66	1.60
Si	mg/L	C0302	204.68	177.9	171.99	147.63	99.36
Ag	mg/L	< 0.02	< 0.02	<0.02	<0.02	< 0.02	<0.02
Na	mg/L	26	26	25.	26.	28	37
Sr	mg/L	0.52	0.83	0.80	0.73	0.54	0.13
Th	mg/L	< 0.1	< 0.1	<0.1	<0.1	< 0.1	<0.1
Ti	mg/L	0.2	2.4	4.4	2.7	2.5	0.4
W	mg/L	0.9	1.1	<0.1	0.4	< 0.1	0.2
V	mg/L	0.68	3.67	4.67	4.71	3.46	<0.01
Zn	mg/L	31.56	31.22	31.09	33.32	35.25	45.48
Zr	mg/L	< 0.01	< 0.01	0.04	0.02	0.07	<0.01

Table 3.2.5
ICP Analysis of Column B Raffinate

Element	Unit	Column B SX Raffinate					
		Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
$SO_4^=$	g/L	67.50	39.93	28.37	23.73	25.48	26.99
Al	mg/L	3879.9	2054.3	1420.7	1291.7	1391.1	1775.8
Sb	mg/L	< 0.1	< 0.1	0.3	0.1	< 0.1	< 0.1
As	mg/L	2.9	2.3	1.5	1.5	1.6	1.6
Ba	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bi	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cd	mg/L	0.50	0.36	0.29	0.26	0.29	0.31
Ca	mg/L	493.4	472.9	463.0	462.6	469.7	465.6
Cr	mg/L	0.94	0.22	0.07	0.03	0.07	0.09
Co	mg/L	13.54	9.93	7.35	6.47	7.32	8.02
Cu	mg/L	1561.49	2299.47	49.27	184.54	71.37	52.15
Fe	mg/L	3056.49	1487.32	1067.34	998.51	1078.72	1284.69
La	mg/L	2.05	1.40	1.00	0.87	0.94	0.93
Pb	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	mg/L	3531.4	2321.5	1751.3	1566.5	1750.9	2052.7
Mn	mg/L	499.30	368.77	268.84	233.30	256.84	289.32
Hg	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mo	mg/L	1.44	1.22	0.20	0.21	0.15	0.13
Ni	mg/L	3.18	2.38	1.71	1.71	1.75	2.06
P	mg/L	41.4	29.1	1.5	3.0	2.2	3.2
K	mg/L	227	99	59	59	132	61
Sc	mg/L	1.38	0.69	0.40	0.38	0.44	0.63
Si	mg/L	130.6	78.6	73.8	71.2	C0251	87.16
Ag	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Na	mg/L	27	26	15	24	31	28
Sr	mg/L	1.36	0.96	0.78	0.70	0.64	0.58
Th	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Ti	mg/L	1.2	0.2	< 0.1	< 0.1	< 0.1	< 0.1
W	mg/L	< 0.1	0.2	< 0.1	< 0.1	< 0.01	< 0.1
V	mg/L	3.85	0.53	0.31	0.16	0.39	0.44
Zn	mg/L	40.11	29.65	20.71	19.12	21.24	24.21
Zr	mg/L	0.09	0.03	0.01	0.03	< 0.01	< 0.01

Element	Unit	Column B SX Raffinate					
		Day 49	Day 56	Day 63	Day 70	Day 77	Day 112
$SO_4^=$	g/L	27.89	30.92	36.46	38.72	39.33	
Al	mg/L	1850.7	2282.0	2797.4	3051.9	3317.1	3804
Sb	mg/L	< 0.1	< 0.1	0.2	<0.1	< 0.1	0.1
As	mg/L	2.2	2.3	3.0	2.8	3.2	8.1
Ba	mg/L	< 0.01	< 0.01	<0.01	<0.01	< 0.01	<0.01
Bi	mg/L	< 0.1	< 0.1	<0.1	0.1	< 0.1	<0.1
Cd	mg/L	0.36	0.34	0.39	0.41	0.43	0.56
Ca	mg/L	497.0	517.4	489.1	487.8	485.5	509.5
Cr	mg/L	0.16	0.49	0.71	0.78	0.84	0.56
Co	mg/L	8.51	9.05	9.15	9.71	10.12	12.21
Cu	mg/L	36.02	14.07	12.03	11.89	6.00	3.39
Fe	mg/L	1388.87	2019.78	2549.83	2580.55	2131.68	170.2
La	mg/L	0.92	1.11	1.08	1.11	1.08	0.59
Pb	mg/L	< 0.05	0.21	<0.05	<0.05	< 0.05	0.78
Mg	mg/L	2049.9	2375.6	2605.4	2790.5	2957.9	3347
Mn	mg/L	281.62	301.58	322.29	317.63	351.93	396.4
Hg	mg/L	< 0.05	< 0.05	0.16	<0.05	0.11	<0.05
Mo	mg/L	0.13	0.21	0.45	1.32	0.69	0.21
Ni	mg/L	2.41	2.54	2.83	2.82	3.14	3.97
P	mg/L	2.9	54.9	73.3	51.2	57.6	14.5
K	mg/L	67	222	107.	102.	63	15
Sc	mg/L	0.75	1.03	1.39	1.51	1.67	1.60
Si	mg/L	C0302	203.66	183.59	169.90	148.07	99.12
Ag	mg/L	< 0.02	< 0.02	<0.02	<0.02	< 0.02	<0.02
Na	mg/L	27	27	27.	26.	29	38
Sr	mg/L	0.52	0.83	0.84	0.71	0.54	0.14
Th	mg/L	< 0.1	< 0.1	<0.1	<0.1	< 0.1	<0.1
Ti	mg/L	< 0.1	2.4	4.3	2.4	2.3	0.3
W	mg/L	< 0.1	< 0.1	<0.1	0.2	< 0.1	<0.1
V	mg/L	0.94	3.68	4.70	4.48	3.35	<0.01
Zn	mg/L	26.86	29.10	29.72	31.46	34.26	43.69
Zr	mg/L	< 0.01	0.03	0.02	0.03	0.05	0.01

Table 3.3.1
Neutralization Tests on Carmacks Waste Sample AL1.

Test No.	Neutralizing Agent
AL1 – T1	NaOH
AL1 – T2	Lime
AL1 – T3	Na_2CO_3
AL1 – T4	Water

The test results indicate that while the solution with no base added remained at about pH 4, with the addition of lime, sodium carbonate or sodium hydroxide, the pH could be adjusted quite readily to about pH 7 and was stable once this value was achieved. These test results suggest that when a basic solution is in free contact with leached solids, a neutralizing effect is achieved and there is not unlimited release of acid. These results are somewhat at odds with the results of the pilot column neutralization where even the top section of column material remained at about pH 4 after considerable basis solution had passed through. It is likely that the large volume of solution available in the present titration tests is overwhelming the surface reactions that are detected under percolation conditions.

3.3.2 Column Neutralization of Leached Solids

Several column tests were conducted to study the neutralization of the waste sample (L1) under different conditions. Two columns, N1 and N2, were conducted initially using 15 cm x 5.5 meter (6" x 216") columns filled with the waste sample. Test N1 was conducted by feeding a sodium carbonate solution to the column while test N2 was conducted with sodium hydroxide. The test details are attached in Appendix 4. In each case, the feed rate of the solution was comparable to that used during leaching of the copper. The feed pH to column N1 was varied over the course of the test, in response to the effluent pH while the feed pH to test N2 was fairly constant.

The feed pH and resulting effluent pH for these two tests are summarized in Figures 3.3.1 and 3.3.2. The response of the waste to the two neutralizing agents was drastically different. For test N2, with sodium hydroxide the effluent pH remained near 4.0 over the period of the test. Although the feed pH was about 9 throughout the test, this feed pH translates to a very low cumulative addition of sodium hydroxide of 0.013 kg/tonne. For test N1 using a 5% solution of sodium carbonate, the effluent pH increased very rapidly to values over pH10. After 20 days irrigation the column was rested for one week and when irrigation resumed the feed was changed to a pH near 7, representing a very low rate of sodium carbonate addition. A feed pH of 7 was selected as being near the groundwater pH in the area of the deposit. The effluent pH remained high following the rest and the decrease in feed pH. The volume of pH 7 water pumped through the column was far greater than the amount of moisture which would have been held in the column following the rest

period so that the continued high effluent pH is not simply the result of flushing out the high pH solution which had been pumped into the column initially.

Based on the observed results, together with information in the published literature it appears that the presence of sodium carbonate in solution converts the surface of the alteration products formed during leaching so that they become stable and cease releasing their constituents such as aluminum into solution. This observation is supported by the analysis of the day 20 effluent for column N1compared to the day 4 effluent as summarized in Table 3.3.2.

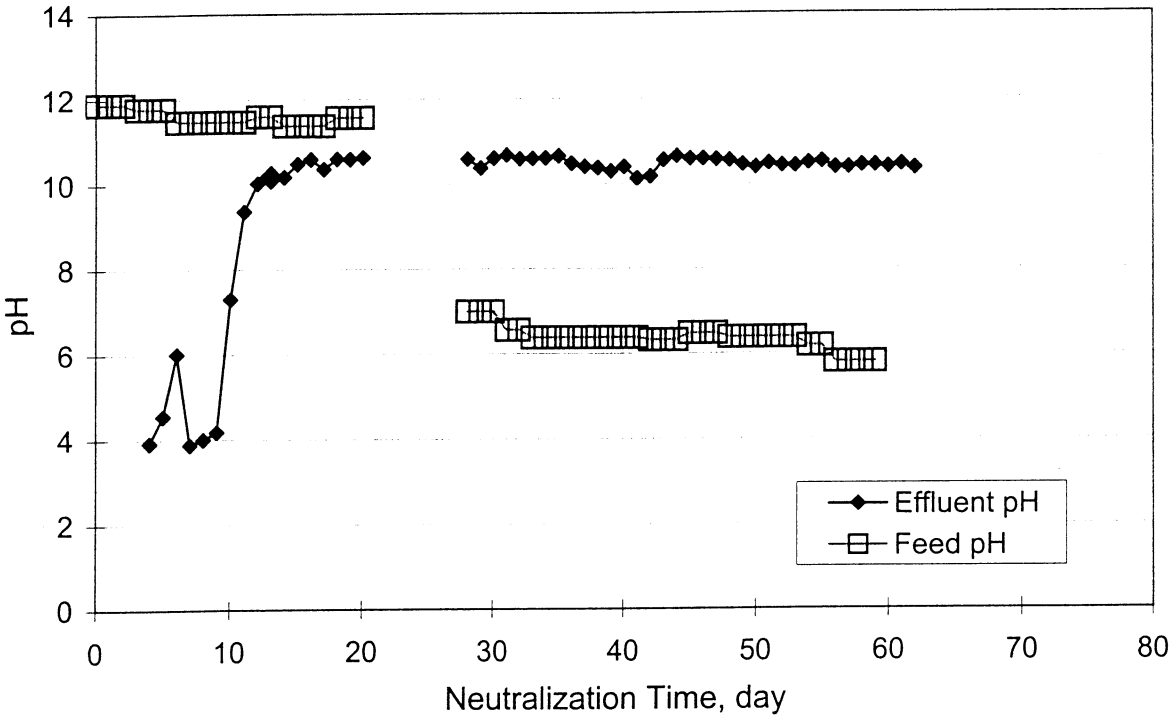


Figure 3.3.1 pH of Feed and Effluent for Neutralization Column N1.

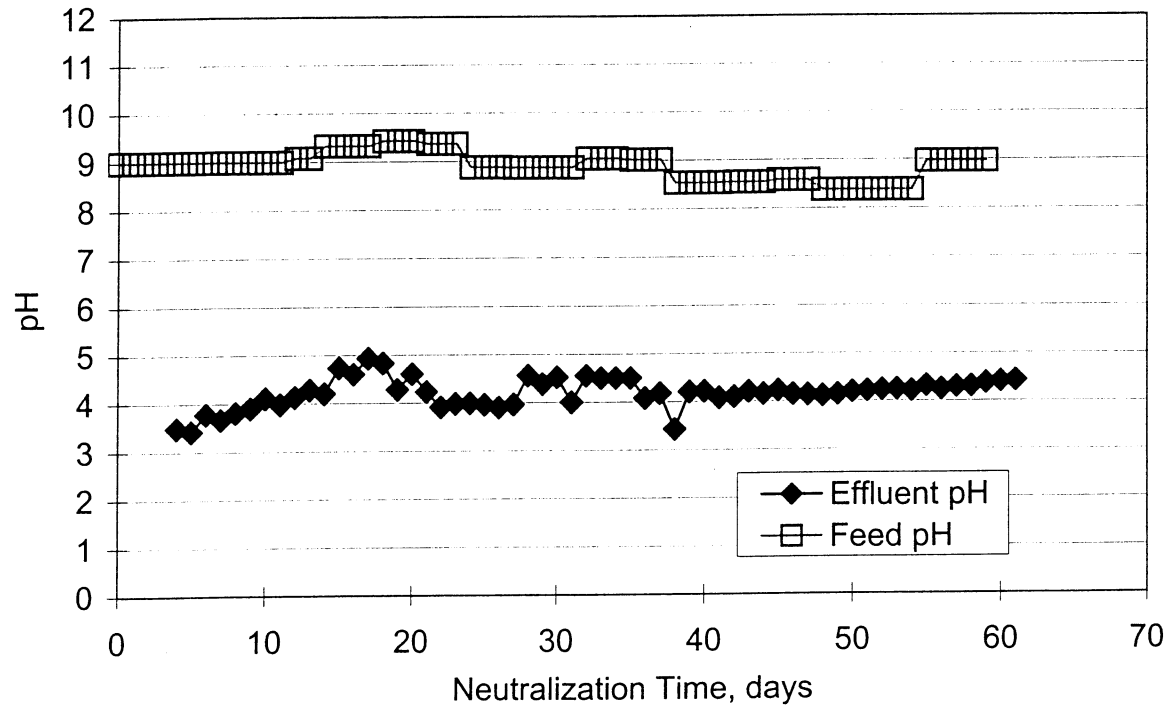


Figure 3.3.2 Feed and Effluent pH for Neutralization Test N2.

Table 3.3.2
Multi-element ICP Analysis of Column N1 Effluent, mg/L

Element	Day 4	Day 20
Al	2213.8	<0.2
Sb	0.5	0.1
As	6.9	0.3
Ba	<0.01	<0.01
Bi	<0.1	<0.1
Cd	0.08	<0.01
Ca	481.2	2.1
Cr	<0.01	<0.01
Co	13.59	<0.01
Cu	25180	5.86
Fe	28.48	0.23
La	0.09	<0.05
Pb	0.76	<0.05
Mg	5155.2	<0.1
Mn	755.04	0.02
Hg	<0.05	0.10
Mo	0.05	4.29
Ni	7.18	0.94
P	334.0	88.3
K	33	49
Sc	0.47	<0.01
Ag	<0.02	<0.02
Na	1077	18000
Sr	0.18	<0.01
Th	0.5	<0.1
Ti	0.9	<0.1
W	6.1	0.2
V	0.08	1.11
Zn	82.99	<0.01
Zr	0.01	0.04
SO_4	70800	600
CO_3	<1	9000
HCO_3	<1	37000

The consumption of sodium carbonate is not apparent from this test. While the day 4 effluent analysis indicates that the feed carbonate is being entirely consumed at this point, the day 20 effluent contains 45 gpl combined carbonate and bicarbonate, representing most of the feed carbonate. Since analyses are not available for all the effluents a balance is not possible.

A third column test was conducted on the waste material under more moderate additions of sodium carbonate to establish the sodium carbonate consumption required to achieve a neutral effluent pH and to observe the effects of aging of the neutralized solids. This test, N3, was conducted in a smaller 10 cm x 1.5 meter (4" x 60") column since limited sample material remained at this point. The test was started by feeding a solution of water adjusted to pH 7 with sodium carbonate to the top of the column at a rate comparable to that used during leaching of copper, of 14.8 l/h/m^2.

The feed and effluent pHs for test N3 are summarized in Figure 3.3.3. Since the effluent pH remained near pH 4 initially, the feed pH was increased in stages until a significant increase in effluent pH was observed. The effluent pH increased above about pH 4 once the feed pH had been increased to pH 10 and increased above pH 6 once the feed pH was increased to pH 10.5. The reason for the lack of response at the lower feed pH is likely that it required an insignificant amount of sodium carbonate to increase the pH of the feed water to these levels. The sodium carbonate addition as a function of time is summarized in Figure 3.3.4. It can be seen that the consumption started to increase after day 32 when the feed pH was increased to pH 10.

Over the period where the feed pH was at 10.5, a somewhat erratic behaviour is apparent for the effluent pH. This variation is believed to result from channeling of the solution through the column. Both columns N1 and N2 had become essentially impermeable over the course of the test, likely (at least in part) as a result of the high fines content and weathered nature of the waste sample used for this testwork.

Towards the end of the initial test period the feed pH was dropped at first to pH 7 and then to pH 5.3 to observe whether the effluent pH would respond in a downward manner. The variation in the effluent pH is within the order of variation, which had been observed previously under steady feed conditions. Irrigation was stopped to this column and it was allowed to rest for 20 days before being irrigated again with pH 7 solution. The effluent pH following this rest period is comparable to that observed prior to the rest.

Following the initial test period above, column N3 was allowed to rest for 509 days before being irrigated again with pH 7 solution for one week. As shown in Figure 3.3.5, the effluent pH over this week varied from an initial value of 5.9 to an average value of 6.3. The sulphate concentration in the effluent decreased from a value of 160 mg/L on day 1 to a value of 8 mg/L on day 7 and the copper concentration decreased from 2.85 ppm on day 1 to 0.69 ppm on day 7. It appears that during the extended rest period, a small amount of sulphuric acid and copper migrated out of the rock fragments. Once the surface concentration of weak acid and copper was removed from the column, a stable discharge situation was achieved.

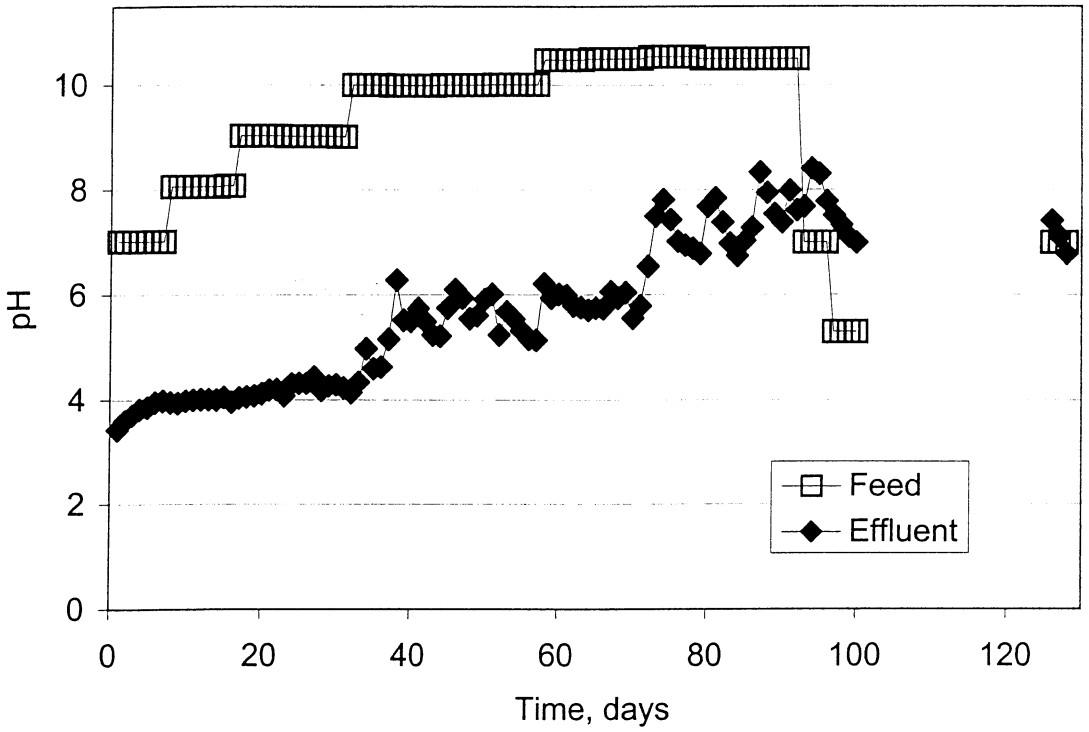


Figure 3.3.3 Feed and Effluent pH for Neutralization Test N3.

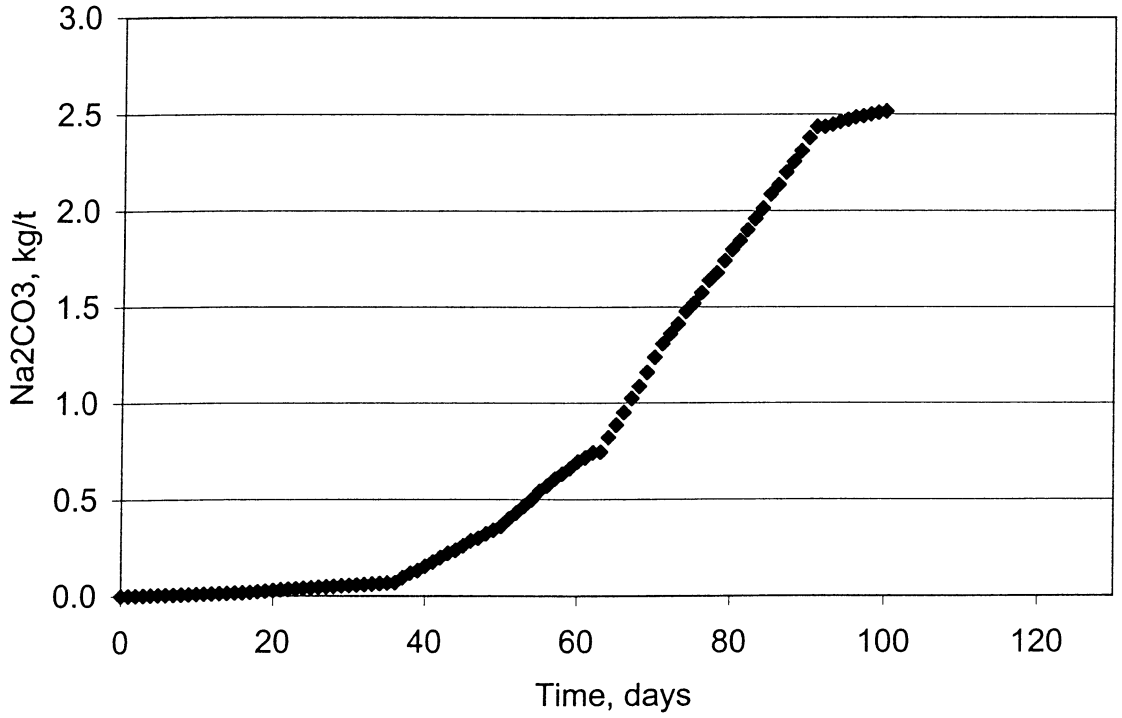


Figure 3.3.4 Sodium Carbonate Addition vs Time for Test N3.

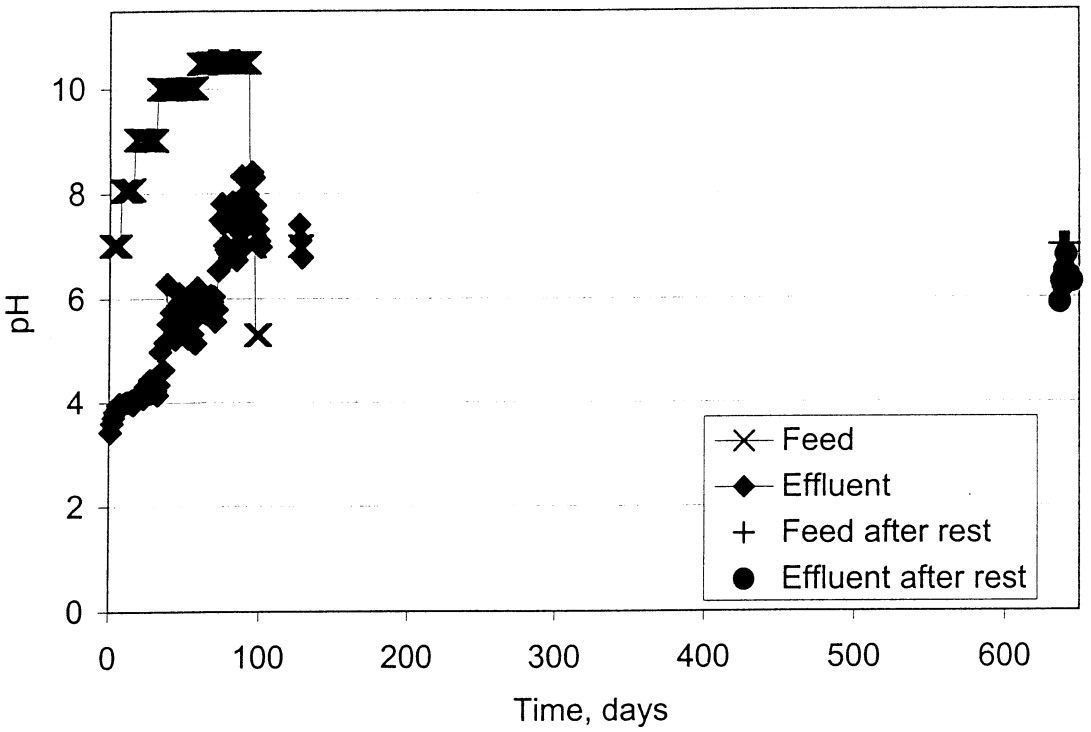


Figure 3.3.5 Test N3 pH Profiles Over Extended Time.

3.3.3 Decommissioning of Column C Leach Residue

As discussed in Section 3.2, once copper leaching of the ¾ inch crushed material in Column C had achieved target levels, acid addition to this test was stopped and the pH was allowed to increase naturally. The solution was recirculated continuously with periodic solvent extraction to remove the dissolved copper. This procedure resulted in an increase in PLS pH from a value of 2.28 to 2.79 over a period of about 100 days. Although the feed pH spiked downwards several times over this period, the effluent pH maintained an upward trend showing that even after prolonged leaching with acid, the Carmacks material has a tendency to consume free acid.

After the leach solution had been allowed to drain from the column for one week, a rinsing test was undertaken. The details of this test are included as Appendix 5. Initially, the column was rinsed with a total of 9 liters of water adjusted to pH 7 with minor additions of sodium carbonate. This volume is estimated at about 1/3 pore volume. The effluent from this initial rinse had a pH of 3.43 – 3.12. After this initial rinse the column was irrigated with a solution of sodium carbonate having a pH of 10.5. The pH of the feed and effluent with time is summarized in Figure 3.3.6. Over the test period of 141 days the effluent pH just achieved a value of pH 4. Consideration of the results summarized in Figure 3.3.7 together with those in Figures 3.3.8 and 3.3.9 reveals the reason for a lack of increase in the effluent pH during the initial rinse procedure. The initial rinse with pH 7 solution involved insufficient solution to rinse out the sulphate from the leached ore. The rinsing with pH 10.5 solution involved greater volumes of solution per day and the rate of rinsing of sulphate, aluminum and magnesium from the spent ore increased. However, the sulphate in the effluent over the first 22 days of the test period initially remained near 5 gpl. By day 111 the sulphate concentration in the effluent had decreased to about 1 gpl. The aluminum in the effluent decreased from over 4000 ppm at the start of the rinse to about 200 ppm after 22 days rinsing. It would appear that rinsing with much greater volumes of pH 7 solution than used in the present test is warranted in order to rinse out sulphate and other impurities before any attempt is made to add sodium carbonate for neutralization purposes. Groundwater would be suitable for the initial rinse. The most effective rinse procedure will likely involve a series of pulses so that sulphate is able to diffuse out of the rock between flushes.

Following the initial rinse test, the column was allowed to rest for 425 days prior to additional rinsing being undertaken. The objective of the later rinse was to determine if any rebound to lower pH would be observed. The results summarized in Figure 3.3.10 indicate that after the rest, the effluent pH, even when irrigating with only pH 7 solution, remained at about pH 4. As noted previously, in the absence of intentional neutralization the Carmacks material appears to buffer at about pH 4. The initial effluent to be obtained from the column after the rest contained 13.7 ppm Cu and the concentration dropped to 5.81 ppm after 5 days rinsing. Following the extended rest period the effluent contained 4.2 ppm Al with 22.5 ppm Mg on day 3 and 1.2 ppm with 9.7 ppm Mg on day 7 of the second rinse period.

The apparent reason that column C did not achieve comparable discharge pH to that achieved for column N3, is that sulphate rinsing was not complete before sodium carbonate addition was started. Comparing Figure 3.3.3 with 3.3.6 and Figure 3.3.4 with 3.3.7 supports this conclusion. The carbonate addition made to column C of about 1.2 kg/t would be expected to achieve an effluent pH of just below pH 6 if flushing of impurities including sulphate removal was more complete prior to carbonate addition.

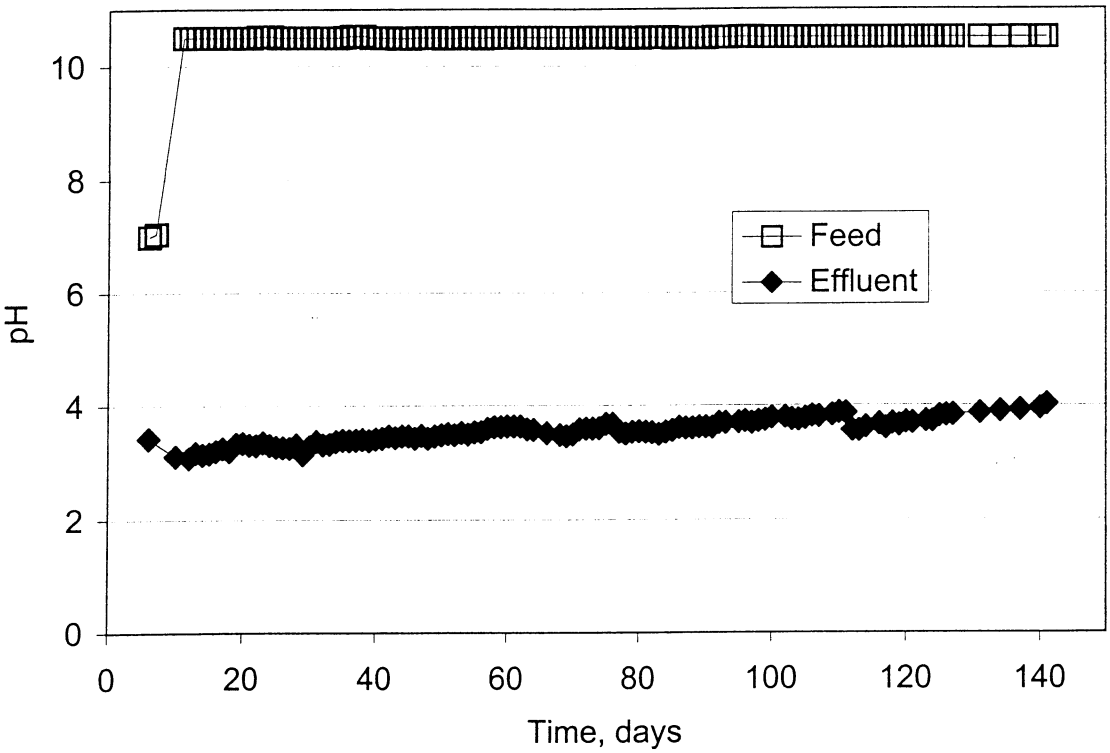


Figure 3.3.6 pH as a Function of Rinse Time for Column C.

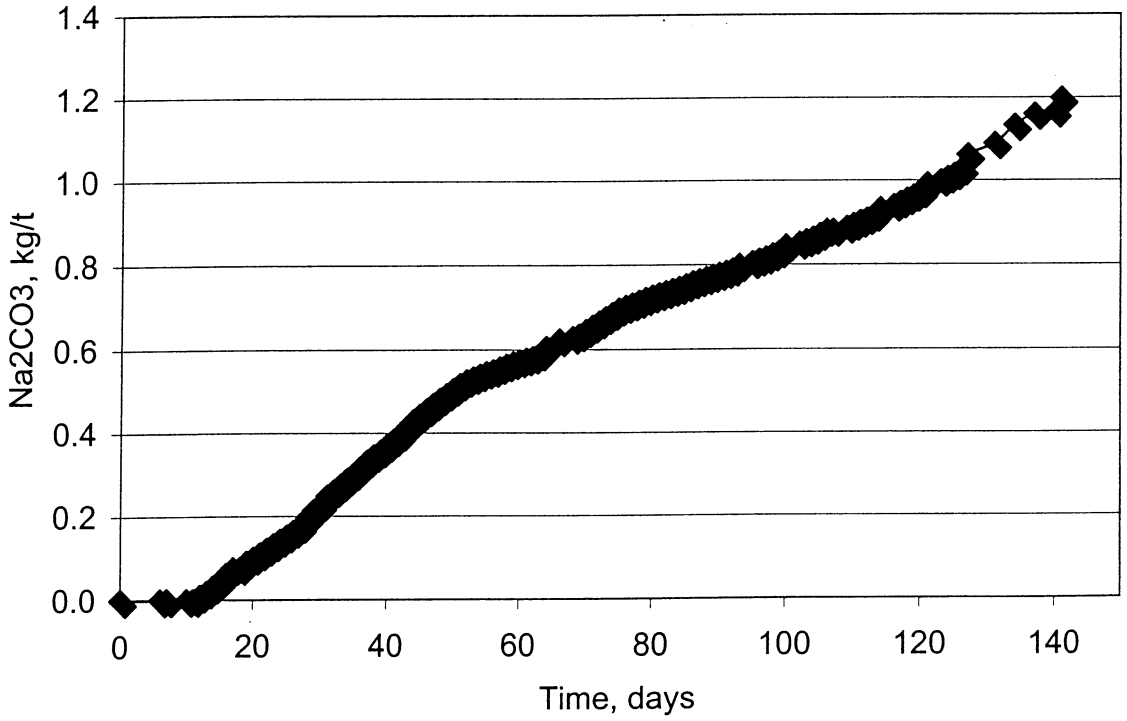


Figure 3.3.7 Sodium Carbonate Consumption for Rinsing of Column C.

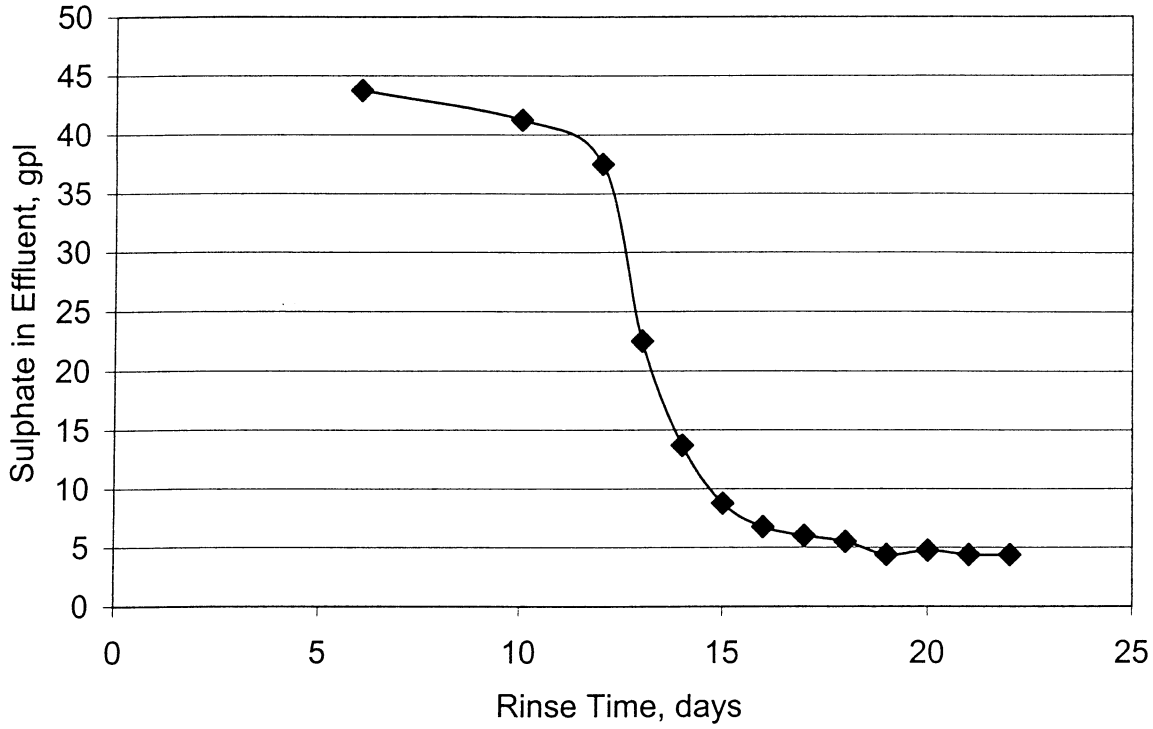


Figure 3.3.8 Sulphate in Effluent as a Function of Rinse Time.

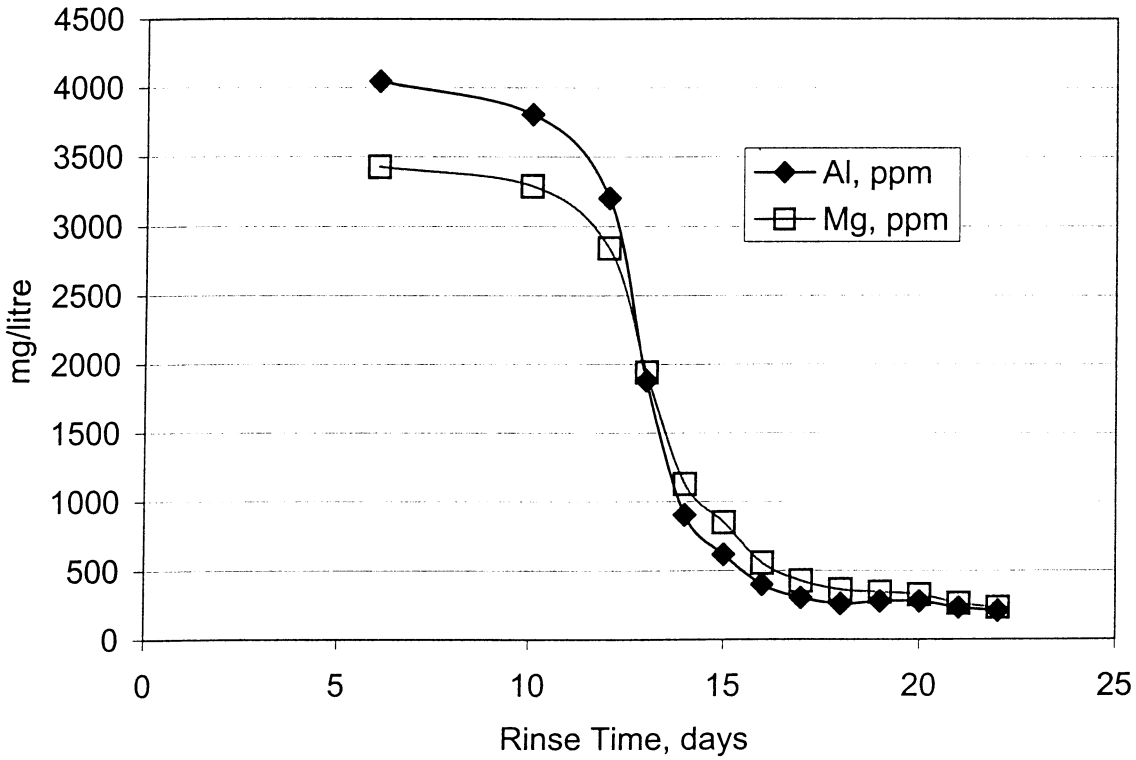


Figure 3.3.9 Al and Mg in Effluent as a Function of Rinse Time.

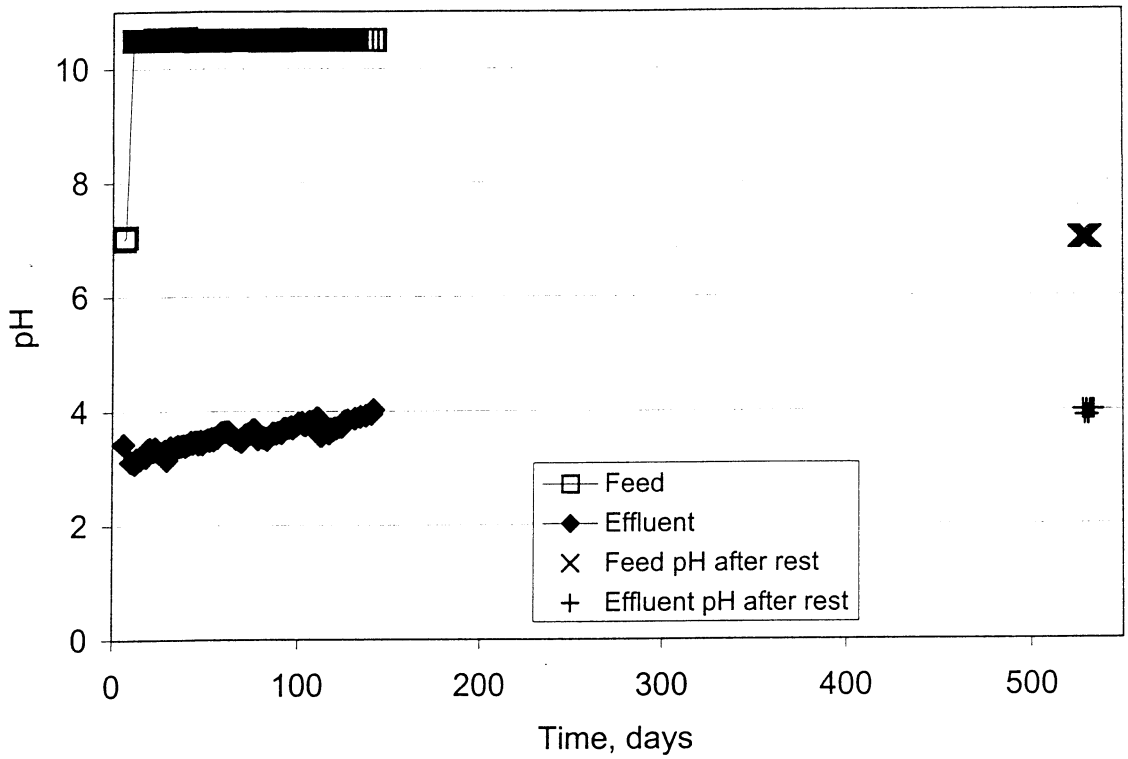


Figure 3.3.10 Feed and Effluent pH After Extended Rest Period.

3.3.4 Rinsing of Run of Mine Column

No active neutralization of the column AB contents was undertaken. At the end of the leach period the solution was recirculated through this column and the pH was allowed to increase naturally. The PLS pH at the end of the test was about pH 2.5. After sitting from February 1999 until May 2000, the column was rinsed for 6 days with water having a pH of 7.0. The details of this rinse are included in Appendix 5. The effluent pH from this rinse was 3.0 to 3.2, indicating that some neutralization of the retained solution had occurred. Since leaching of this material had not been taken to its ultimate level the retained acid resulted in additional copper leaching with the day 1 effluent containing 2.4 grams per litter copper. By day 3 of the rinse this concentration had decreased to 1.5 grams per litter. Subsequent to the rinse period the column remained in place for more than six months. At the end of this period the contents were emptied and it was found that the bottom section had become cemented by iron precipitates.

Appendix 1

Sample Collection Report

WESTERN COPPER HOLDINGS LIMITED

CARMACKS, YUKON TERRITORY

CARMACKS COPPER PROJECT

Project No. 8555-25

RUN-OF-MINE BULK SAMPLE COLLECTION

KILBORN ENGINEERING PACIFIC LTD.
400 - 1380 Burrard Street
Vancouver, B.C.
V6Z 2B7

JANUARY 1998

WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
RUN-OF-MINE BULK SAMPLE COLLECTION

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1.0 INTRODUCTION

1.0 INTRODUCTION

1.1 SCOPE OF WORK

Western Copper (Western) requested Kilborn to obtain a bulk composite sample from the Carmacks Copper Project located at Williams Creek near Carmacks, Yukon (Kilborn letter March 10, 1997). The 18,000 kg bulk sample is to be used for copper heap leach metallurgical testing for run-of-mine ore.

The bulk sample was to be taken from four trenches and blended at the proportions as listed in Table 1.1-1. The material taken from the each trench was designed to obtain a representative sample from the near surface mineralization at the Carmacks Copper Mine Zone 1 deposit. Kilborn has relied on Max Holtby's detailed knowledge of the deposit to select the trenches to be sampled and determined the proportion of sample to be taken from each trench. Trench locations are shown on Drawing No. 1.1-1.

Table 1.1-1
Trench Sample Proportions

Trench	Proportion
T91-22	30
T91-20	30
T92-68	20
T91-18	20

1.2 GEOLOGY

The Carmacks Copper deposit occurs as a gneissic roof pendant within the Upper Triassic Granite Mountain Batholith. This Batholith is principally of granodioritic composition including rocks of diorite, tonalite and quartz monzonite composition. The mineralized roof pendant consist of a feldspathic-biotite-hornblende-quartz gniesses. The gniesses are generally quartz deficient. Gneiss compositions vary from basaltic to

granodioritc. The gniesses are well foliated with coarse to fine grained textures. Aplite and pegmatite dykes intrude both the batholitic rocks and the gniesses. Rocks of this deposited are oxidized to a depth of 260 m (Holtby and McNoughton, 1993).

Copper and gold mineralization occurs in the Carmacks Copper deposit. Holtby and McNaughton (1993) indicate that 86% of the deposit consists of secondary copper minerals mainly malachite, cuprite, azurite and tenorite. Unoxidized mineralization consist of bornite and chalcopyrite. Gold mineralization is commonly associated with limonite but is also associated with malachite, plagioclase, chlorite and quartz. Gold occurs as native grains rarely greater than 5 μm in size.

The geological resources for Zone 1 of the deposit has been estimated at 20.7 mt at a grade of 0.98% copper, using a cut off grade of 0.20% copper (Kilborn, 1994).

1.3 DISCLAIMER

Kilborn has followed standard professional procedures in preparing the contents of this report, but it is based in part on details, information and assumptions provided by others. Kilborn, therefore cannot guarantee the correctness of all the information, but to the extent of its investigation and within the scope of the work delegated to it, Kilborn believes that the report is substantially correct.

2.0 PROCEDURES

2.0 PROCEDURES

2.1 IDENTIFICATION OF TRENCHES AND MINERALIZED ZONES

Trenches 91-18, 92-68, 91-20 and 91-22 were previously marked by Lamerton & Associates. Kilborn confirmed trench locations by locating nearby drill holes and other marked trenches.

Discussions with Silver Standard (Holtby, per. com) indicated that the footwall contact in each trench could be readily located. It was suggested that the hanging wall contact could be located approximately by measuring from the foot wall. The distance to be measured could be obtained from trench plans or sections.

Kilborn was readily able to identify footwall contacts in each of the trenches. Hangingwall contacts were determined by measuring distances from trench footwall contact and by identifying the geological contact based on examination of other trenches where hangingwall contacts were marked with pickets. A comparison of mineralized trench intersections from Holtby and McNaughton (1993) sections and Kilborn's determinations is shown in Table 2.1-1. The distance between footwall and hangingwall determined by Kilborn was from 0.3 to 9.1 m shorter than distances determined from sections. These differences are believed to be within the accuracy of the 1" to 100' map scale of the sections used to determine the distances.

Table 2.1-1
Comparison of Trench Mineralization Distances

	Length of Mineralized Intersection		
Trench	Sections*	Sampled	Difference
91-18	39.6	39.3	0.3
92-68	73.1	66.1	7
91-20	36.6	33.9	2.7
91-22	33	23.9	9.1

* Mineralization distances from cross-sections in appendix 1 of the Holtby and McNaughton (1993) report.

2.2 EQUIPMENT

The following equipment was used:

- 1 Cat 225LC excavator;
- 1 Cat D7G bulldozer;
- 2 Dump trucks, tandem axle, 29 t gvw;
- 1 Air track percussion drill;
- 1 450 compressor for drill; and
- 1 Flat deck truck with Hiab crane.

As a contractor based in Carmacks was not available, a contractor from Whitehorse was chosen. The contractor chosen to supply the equipment and personnel was H. Coyne & Sons Ltd. The contractor set up a camp for equipment operators beside the Freegold Road on the access road to Williams Creek. The camp was established to reduce travel time for equipment operators to and from the site.

The excavator and bulldozer were used to deepen and widen trenches. Dump trucks were necessary to move excavated ground from trench 91-20 as the trench was too deep to pile ground on trench sides. Ground removed from trench 91-20 was stock piled in a nearby pit. Care was taken to pile waste (footwall and hangingwall rock) material separately. The dump trucks were also used to move the bulk sample out of trenches to mixing sites.

Additionally a Hiab-crane truck was used for weighing bulk sample bags, loading bulk sample bags and loading equipment.

2.3 TRENCH DEVELOPMENT

Trenches selected by Western were widened to approximately 6 m to allow rotation of the excavator for loading of bulk sample on to dump trucks. Initially existing trenches were about 2 to 4 m deep. Generally these trenches were deepened an additional 2 to 3 m to ensure that the ground was below previous blast fragmentation (Figures 2.3-1, 2.3-2, 2.3-3). Trench 91-20 was deepened from the original 3-4 m from surface to 9 to 11 m from the surface (Figure 2.3-4). This trench was deepened to confirm an unexpected footwall contact that paralleled the trench direction for 15 to 20 m. This contact was excavated to ensure that sampling began at the proper contact. The trench was deepened to a depth where rocks were more competent and therefore more representative of run-of-mine material.

The side walls of trenches, in particular trench 91-20, were benched to prevent rock falls into the trench and to allow clearance for the excavator bucket. Ground removed from trench 91-20 was stockpiled in a nearby pit. Care was taken to pile waste (hangingwall and footwall rock) material separately.



Figure 2.3-1 Trench 91-18 after excavation, before blasting.

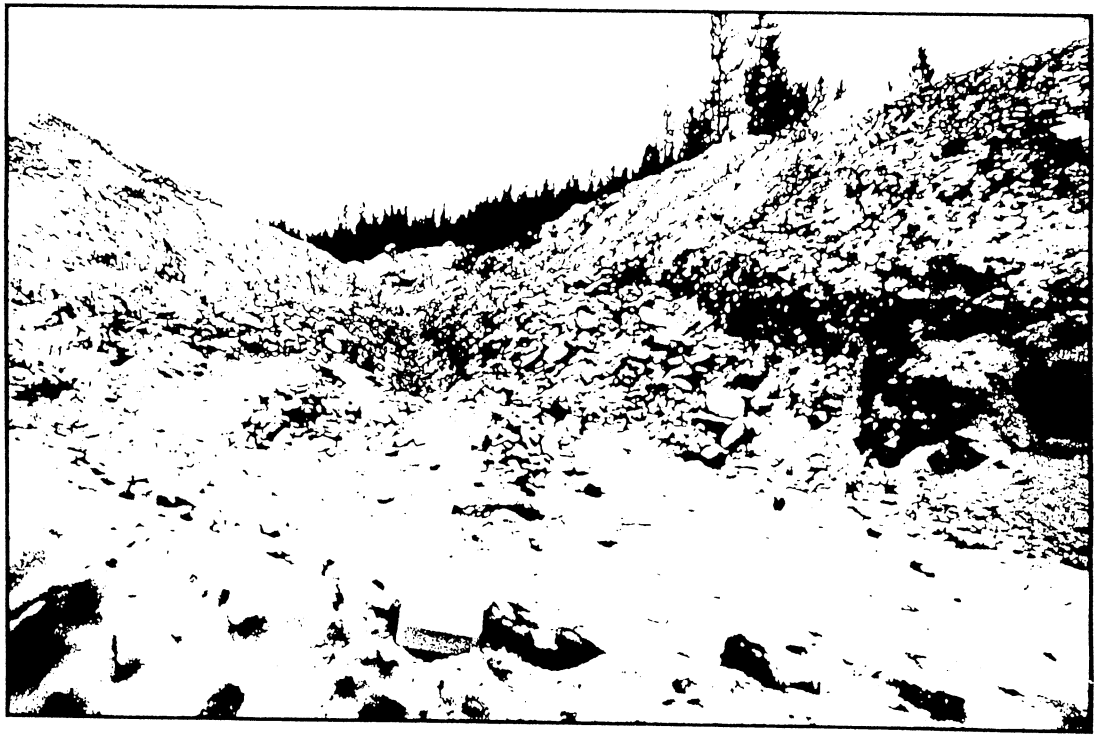


Figure 2.3-2 Trench 92-68 after bulk sampling.



Figure 2.3-3 Trench 91-22. After bulk sampling.

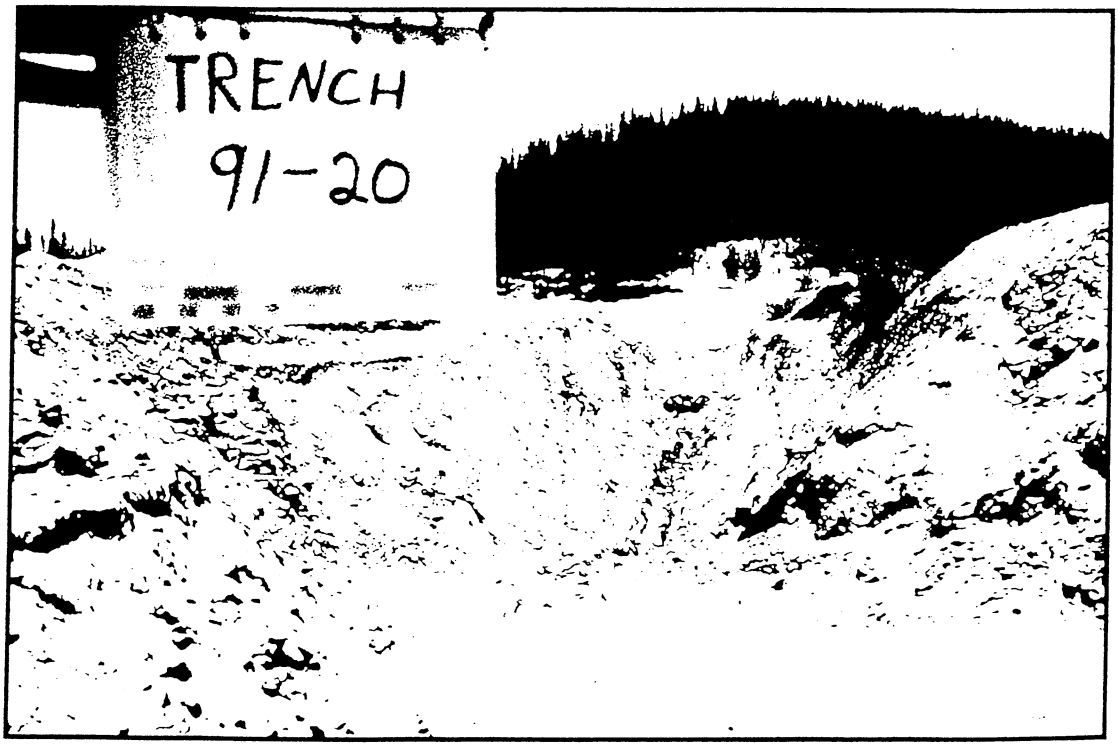


Figure 2.3-4 Trench 92-20. After bulk sampling.

2.4 BLASTING

The bulk sample was obtained by drop cut blasting of the trench floor. The blast was designed to ensure that blasted material was slightly wider than the excavator bucket (.95 m wide, 1.2 m deep). Blast holes were initially drilled by a Mini Air Track drill which was replaced by an Air Track drill because of break downs. Blast holes were drilled vertically at a depth of 1.5 m and a diameter of 0.05 m. A three blast hole pattern was drilled centered across the width of the trench at a hole spacing of 0.75 m. This three hole pattern was spaced along the length of the trench at 1.5 m.

Inclined blasted hole fans were drilled over the eastern end of trench 91-18 over a hill of competent rock.

92-68

In areas where the rock was highly friable no blast holes were drilled. In trench 91-68 an intervening 4.5 m section of granodiorite waste rock was not blasted.

Blast holes were charged with a half stick of Unimax Yellow TS (32 mm x 40 mm) powder and loaded 0.6 m from the collar with anfo. Holes were then stemmed to the collar with drill cuttings and fine grained ground. Non-electric detonators with 25 ms delays were used. The blasting pattern schematic is shown in Figure 2.4-1.

2.5 BULK SAMPLING

2.5.1 Sampling

Each trench was sampled using the excavator. A continuous sample about 1.0 m wide and 1.0 m deep was taken from each trench. The sample was taken from the footwall contact to the hangingwall contact and in the case of trench 91-68 the intervening granodiorite was excluded. Each bucket near these contacts was inspected to ensure that no waste rock was included.

The following steps were taken to ensure that contamination from trench side walls was excluded from the bulk sample:

- The top 0.15 m to 0.2 m from blasted material was scraped off before sampling to ensure that no debris from the trench walls was included;

- Material that fell into the trench from sidewalls was moved aside before the next bucket of sample was taken. This ensured no contamination from sidewall material. Unblasted very friable sections of the trenches were sampled in the same manner.

Each excavator bucket of sample was loaded directly into a dump truck. The bulk sample was then transported to and dumped at a mixing site nearby each trench.

In addition to the bulk sample weathered previously leached ore from trench 91-20 was collected. Approximately 800 lbs of this material was placed separately in a bulk sample bag.

2.5.2 Mixing and Blending

The bulk sample from each trench was rolled, moved and repiled for one-half hour. A new pile was made from this material by moving the material bucket load by bucket load on to a new pile. Care was taken to keep the new pile in a regularly shaped cone, this process is called coning. A skin of 3 to 5 cm of bulk sample was left on the mixing pad surface to reduce dilution from introduction of ground material.

The mass of the bulk sample was estimated from the volume of sample moved out of the trench multiplied by a density of 2.68 (ore density (Holtby and McNaughton, 1993)). The masses of bulk samples from each trench were reduced to masses which when combined would maintain the mixing ratio suggested by Western/Silver Standard:

Trench	Ratio
91-18	20%
92-68	20%
91-20	30%
91-22	30%

The estimated masses were obtained by physically splitting the pile in quarters or multiples of quarters. Each successive split was re-coned for further splitting. The final mass from each trench was loaded into one dump truck and dumped on to a new mixing pad. This sample containing a proportion from other trenches was then mixed by rolling, moving and repiling for about half an hour. The bulk sample was then coned twice to ensure good mixing. This bulk sample was then loaded into bulk sample bags with two 3 mil thick polyethylene liners. The plastic liners ensure that fines were not lost during transport and to ensure that the sample did not get wet during transport. Each bag was then weighed to ensure that approximately one tonne of material was loaded in each bag.

Despite a calculated bulk sample excess of 5 tonnes a shortfall of three tonnes of bulk sample was discovered upon weighing bulk sample material. This shortfall was made up by blending and mixing excess sample material from each trench. The same relative proportions from each trench was maintained.

Bulk sample bags were sealed, loaded onto the dump trucks and transported to Whitehorse. The bulk samples were then trans-shipped to Vancouver by truck.

2.6 CHANNEL-CHIP SAMPLES

Two meter channel-chip samples were taken along each trench. A channel-chip sample is a continuous sample of rock similar to a channel sample. The channel-chip sample is different from a channel sample because the width and depth of the channel-chip sample is roughly the same. In a channel sample the width and depth of the sample is exactly uniform as equipment such as a diamond saw would be used to cut the sample from rock. Kilborn channel-chip sampled the side walls of the trenches. All samples consisted in-situ blasted rock and in place unblasted rock. Only the portions of the trench used in the bulk sample were channel-chip sampled. Geological notes on the channel-chip samples are attached.

TRENCH 92-68 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.
Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
588820	0.0	2.0	Biotite+feldspar gneiss, fine to medium grained, rusty brown, mod. weathered, mod foliated, tr-0.5% malachite, 2-5% ?tenorite+lim., minor granodiorite dyke
588821	2.0	4.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-2%malachite, minor pegmatite dykes
588822	4.0	6.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-2%malachite, minor pegmatite dykes
588823	6.0	8.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-2%malachite, minor pegmatite dykes
588824	8.0	10.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, 5% ?tenorite+lim., 1-3%malachite, some pegmatite dykes
588825	10.0	12.0	Bt+fspar gneiss, m-c. gr. rusty brown, mod. weathered, very friable, 3-6% ?tenorite+lim., 1-2%malachite, tr. azurite
588826	12.0	14.0	Bt+fspar gneiss, f-c. gr. rusty brown, mod. weathered, very friable, 3-6% ?tenorite+lim., 1-2%malachite, tr. azurite
588827	14.0	16.0	Bt+fspar gneiss, f-c. gr. rusty brown, mod. weathered, very friable, 3-6% ?tenorite+lim., 1-2%malachite, tr. azurite
588828	16.0	18.0	Bt+fspar gneiss, f-c. gr. rusty brown, mod. weathered, friable, 3-6% ?tenorite+lim., 1-3%malachite, mod. competant
588829	18.0	20.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod. weathered, friable, 3-6% ?tenorite+lim., 1-2%malachite, mod. competant
588830	20.0	22.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod. weathered, friable, 3-6% ?tenorite+lim., 1-2%malachite, mod. competant
588831	22.0	24.0	Bt+fspar gneiss, f-m. gr. rusty brown, mod. weathered, friable, 3-6% ?tenorite+lim., 2-3%malachite, mod. competant
588832	24.0	26.9	Bt+fspar gneiss, f-m. gr. rusty brown, mod-v. weathered, mod-very friable, 3-6% ?tenorite+lim., 2-3%malachite, minor granodiorite dykes, contact with granodiorite unit
588833	31.4	34.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 5% ?tenorite+lim., 1-2%malachite, contact with granodiorite unit
588834	34.0	36.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 5% ?tenorite+lim., 2-3%malachite, contact with granodiorite unit
588835	36.0	38.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 2-5% ?tenorite+lim., 2-4%malachite
588836	38.0	40.0	Bt+fspar gneiss, f-m. gr. rusty brown-yellow, mod-v. weathered, mod-very friable, 2-5% ?tenorite+lim., 2-3%malachite
588837	40.0	42.0	Bt+fspar gneiss, m-c. gr. rusty brown, mod-v. weathered, mod friable to mod competant, 5% ?tenorite+lim., 1-2%malachite
588838	42.0	44.0	Bt+fspar gneiss, m-c. gr. rusty brown, mod. weathered, mod competant, 5% ?tenorite+lim., 1-2%malachite
588839	44.0	46.0	Bt+fspar gneiss, f-c. gr. rusty brown-yellow, mod. weathered, 7% ?tenorite+lim., 2-3%malachite
588840	46.0	48.0	Bt+fspar gneiss, f-c. gr, rusty brown-yellow, mod. weathered, 4-50% ?tenorite+lim., 2-3%malachite
588841	48.0	50.0	Bt+fspar gneiss, f-c. gr, rusty brown-yellow, mod. weathered, 3-7% ?tenorite+lim., 2-3%malachite
588842	50.0	52.0	Bt+fspar gneiss, f-c. gr, rusty brown-yellow, mod-v. weathered, 3-7% ?tenorite+lim., 2-3%malachite
588843	52.0	54.0	Bt+fspar gneiss, c. gr, rusty brown-yellow, v. weathered, mod-v. friable, 5-6% ?tenorite+lim., 3-4%malachite
588844	54.0	56.0	Bt+fspar gneiss, c. gr, rusty brown-yellow, v. weathered, mod-v. friable, 5-6% ?tenorite+lim., 3-4%malachite
588845	56.0	58.0	Bt+fspar gneiss, c. gr, rusty brown-yellow, v. weathered, mod-v. friable, 5-6% ?tenorite+lim., 3-4%malachite
588846	58.0	60.0	Bt+fspar gneiss, c. gr, rusty brown-yellow, v. weathered, mod-v. friable, 4-6% ?tenorite+lim., 2-3%malachite, 1-2%azurite
588847	60.0	62.0	Bt+fspar gneiss, c. gr, rusty brown-yellow, v. weathered, mod-v. friable, 4-6% ?tenorite+lim., 2-4%malachite, 2-3%azurite, transitional change from gneissic to massive igneous texture
588848	62.0	64.0	Bt+fspar gneiss, c. gr, rusty brown-yellow, v. weathered, mod-v. friable, 4-6% ?tenorite+lim., 2-4%malachite, 2-3%azurite, transitional change from gneissic to massive igneous texture
			End of Sampling

TRENCH 91-22 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.
Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
586568	0.0	2.0	Biotite+feldspar gneiss, fine to medium grained, rusty brown-yellow, v. oxidized, mod. friable, 2-3% ?tenorite+lim, 3-4%malachite 1-2%azurite,
586269	2.0	4.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, blocky, 3-6%malachite, 2-3 ?tenorite+lim,
586270	4.0	6.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, blocky, 2-3%malachite, 2-3 ?tenorite+lim, minor pegmatite dyke
586271	6.0	8.0	Bt+fspar gneiss, m-c. grained, rusty brown-yellow, v. oxidized, blocky, 3-4%malachite, 2-3 ?tenorite+lim, 2-3%azurite
586272	8.0	10.0	Bt+fspar gneiss, m-c. grained, rusty brown-yellow, v. oxidized, mod. friable, 2-3%malachite, 2-4% ?tenorite+lim, tr-13%azurite
586273	10.0	12.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3%malachite, 2-4% ?tenorite+lim, tr-13%azurite, clayey-texture, intense hematite staining
586274	12.0	14.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3%malachite, 2-4% ?tenorite+lim, tr-13%azurite, clayey-texture, intense hematite staining
586275	14.0	16.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3%malachite, 4-6% ?tenorite+lim, tr %azurite, mod. hematite staining
586276	16.0	18.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3%malachite, 4-6% ?tenorite+lim, tr %azurite, mod. hematite staining
586277	18.0	20.0	Bt+fspar gneiss, m-c. grained, rusty brown, v. oxidized, v. friable, 2-3%malachite, 3-5% ?tenorite+lim, 1-2%azurite, mod. hematite staining
586278	20.0	22.0	Bt+fspar gneiss, f-c. grained, rusty brown, v. oxidized, blocky wk. friable, 1-3%malachite, 2-3% ?tenorite+lim, 1%azurite
586279	22.0	23.5	Bt+fspar gneiss, f-c. grained, rusty brown, v. oxidized, blocky mod.. friable, mod. hematization, increasing abundance of grnodiorite dykes, hanging wall contact.
			End of Sampling

TRENCH 91-20 CHANNEL-CHIP SAMPLING

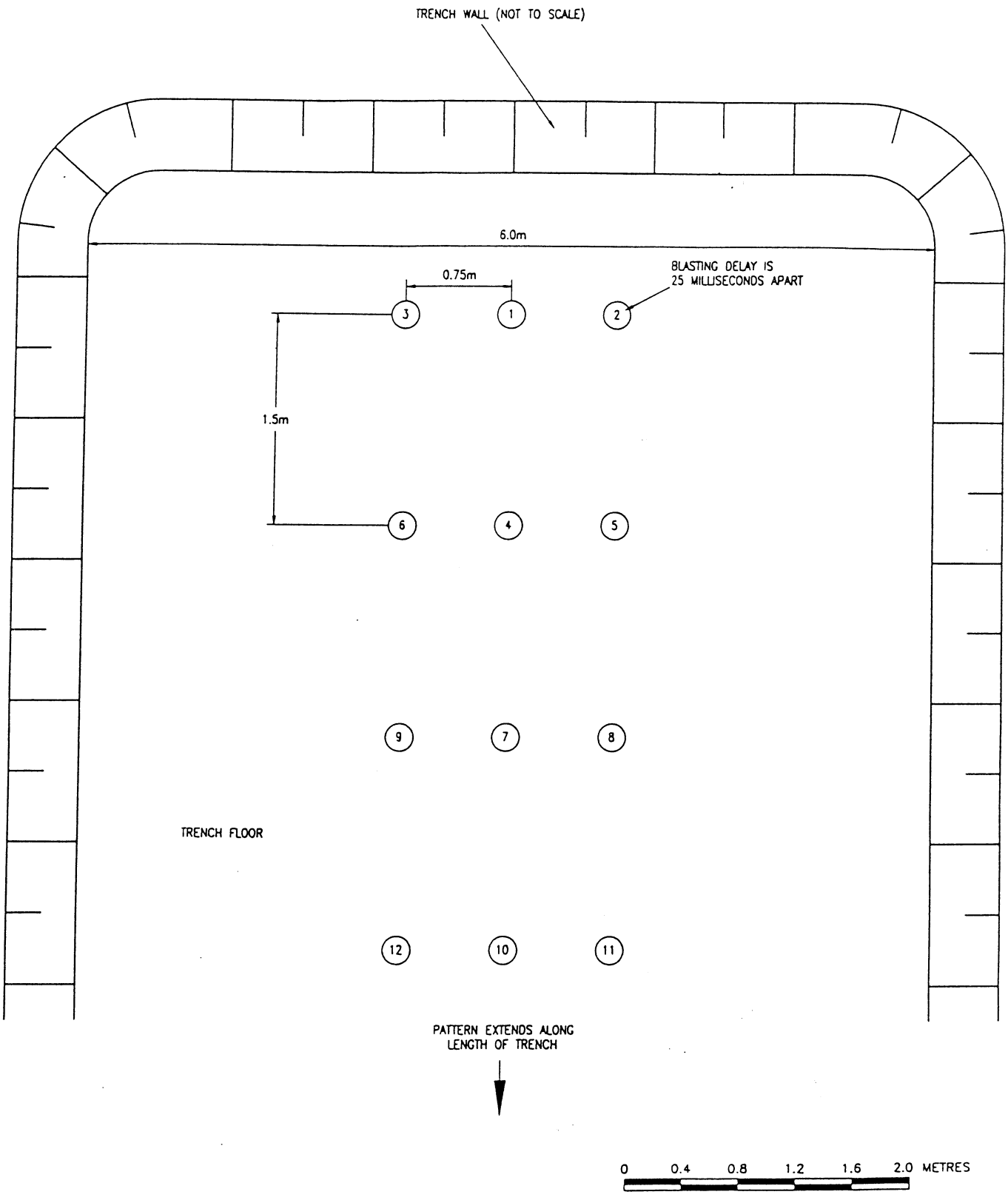
Samples taken from footwall contact to hangingwall.
Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
586251	0.0	2.0	Biotite+feldspar gneiss, fine grained, rusty brown-yellow, v. oxidized, very friable, 2-5% ?tenorite+lim, well foliated
586252	2.0	4.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, very friable, 2-5% ?tenorite+lim, locally 2-3%chalcocite
582563	4.0	6.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, mod. friable, 2-5% ?tenorite+lim, tr-2%malachite
582654	6.0	8.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, weakly friableto blocky, 2-53% ?tenorite+lim, tr-2%malachite
586255	8.0	10.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, blocky, mod fractured, 10-13% ?tenorite+lim, 1-3%malachite,
586256	10.0	12.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, blocky, mod fractured, 3-5% ?tenorite+lim, 3-54%malachite, minor granodiorite dykes
586257	12.0	14.0	Bt+fspar gneiss, fine grained, rusty brown-yellow, v. oxidized, blocky, mod fractured, 3-5% ?tenorite+lim, 2-4%malachite, pegmatite dykes 20cm wide
586258	14.0	16.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, mod-v. friable, 2-4%malachite, 3-5 ?tenorite+lim,
586259	16.0	18.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, mod-v. friable, 1-3%malachite, 1-3 ?tenorite+lim,
586260	18.0	20.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, mod-v. friable, 1-3%malachite, 1-3 ?tenorite+lim,
586261	20.0	22.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, v. friable, 1-3%malachite, 1-3 ?tenorite+lim,
586262	22.0	24.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, mod-v. friable, clayey texture, 2-4%malachite, 6-7% ?tenorite+lim,
586263	24.0	26.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, v. friable, clayey texture, 1-3%malachite, 3-5% ?tenorite+lim
586264	26.0	28.0	Bt+fspar gneiss, f. grained, rusty brown-yellow, v. oxidized, v. friable, clayey texture, 1-3%malachite, 3-5% ?tenorite+lim
586265	28.0	30.0	Bt+fspar gneiss, f-c. grained, rusty brown-yellow, v. oxidized, v. friable, clayey texture, 2-3%malachite, 3-5% ?tenorite+lim
586266	30.0	32.0	Bt+fspar gneiss, c. grained, rusty brown-yellow, v. oxidized, mod. friable, 2-3%malachite, 3-5% ?tenorite+lim
586267	32.0	33.9	Bt+fspar gneiss, c. grained, rusty brown-yellow, v. oxidized, mod. friable, 3-4%malachite, 2-3% ?tenorite+lim, contact with granodiorite hanging wall
			End of Sampling

TRENCH 91-18 CHANNEL-CHIP SAMPLING

Samples taken from footwall contact to hangingwall.
Sample start marked with picket.

SAMPLE NUMBER	FROM [m]	TO [m]	DESCRIPTION
588801	0.0	2.0	Biotite+feldspar gneiss, fine grained, rusty brown, mod. weathered, foliated at 128o 84oNE, tr-1% malachite, 2-5% ?tenorite+lim.
588802	2.0	4.0	Bt+fspar gneiss, f. gr. rusty brown, mod. weathered, 2-5% ?tenorite+lim., minor granodiorite dykes
588803	4.0	6.0	Bt+fspar gneiss, f.gr., rusty brown-yellow, mod. to intense clay weathering, 2-5% ?tenorite+lim.
588804	6.0	8.0	Bt+fspar gneiss, f.gr., rusty brown, very friable, tr-1% malachite(locally 2-3%), 5% ?tenorite+lim.
588805	8.0	10.0	Bt+fspar gneiss,m-f gr., rusty brown, mod-very friable, 1-2% malachite, 5% ?tenorite+lim., minor pegmatite veins
588806	10.0	12.0	Bt+fspar gneiss,m gr., rusty brown, mod. friable, tr-1% malachite, 2-3% ?tenorite+lim., biotite bands
588807	12.0	14.0	Bt+fspar gneiss,m gr., rusty brown-yellow, friable, highly fractured, tr-1% malachite, 2-3% ?tenorite+lim., biotite 20-30%
588808	14.0	16.0	Bt+fspar gneiss, m gr., intense to mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 5-10% ?tenorite+lim., tr-1% malachite,
588809	16.0	18.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 2-5% ?tenorite+lim., 1-2% malachite
588810	18.0	20.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 2-5% ?tenorite+lim., 1-2% malachite
588811	20.0	22.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown-yellow, v. friable, clayey to bt sand texture, 2-5% ?tenorite+lim., 1-2% malachite
588812	22.0	24.0	Bt+fspar gneiss, f-m gr., mod. weathering, rusty brown, mod competant and v. friable sections, 2-5% ?tenorite+lim., 2-3% malachite, minor pegmatite (?qtz veins) dykes
588813	24.0	26.0	Bt+fspar gneiss, c-f gr., mod. weathering, rusty brown, mod foliated, mod fractured, 5% ?tenorite+lim., 2-4% malachite
588814	26.0	28.0	Bt+fspar gneiss, f gr., mod. weathering, rusty brown, mod foliated, mod competant fractured, 5% ?tenorite+lim., 2-3% malachite(locally 4%)
588815	28.0	30.0	Bt+fspar gneiss, f gr., mod. weathering, grey- brown, mod foliated, mod competant, fractured, 2% ?tenorite+lim., 3-4% malachite, minor pegmitite
588816	30.0	32.0	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 3-4% malachite, forms resistant outcrop, mineralizatiom occurs along fracture planes, weakly foliated
588817	32.0	34.0	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 3-5% malachite, resistant, wk foliated
588818	34.0	36.0	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 3-5% malachite, resistant, wk. foliated
588819	36.0	39.3	Bt+fspar gneiss, c gr., wk weathered, grey-black, mod foliated, competant, mod. fractured, 2-3% malachite, resistant, wk. foliated
			End of Sampling



SECTION: MINING		CLIENT: WESTERN COPPER HOLDINGS LTD.
SCALE:AS SHOWN	DATE	
DESIGNED: D.K.	23OCT97	LOCATION: CARMAKS, YUKON TERRITORY
DRAWN: T.M.	23OCT97	THE ENGINEERING DATA ON THIS DRAWING IS SOLELY FOR THE PURPOSE AND PROJECT FOR WHICH THIS DRAWING IS ISSUED
CHECKED: D.K.	23OCT97	
APPROVED: D.K.	23OCT97	

KILBORN SNC•LAVALIN

CARMAKS COPPER PROJECT

FIG 2.4-1

TRENCH BLASTING SCHEMATIC

FIG 2.4-1.DWG

EQUIP/UNIT/LOOP No.

PROJECT No.	DIVISION No.
8555	25

JMG P.A.H. JOAUG93

3.0 PROGRAM SCHEDULE

3.0 PROGRAM SCHEDULE

Removal of the bulk sample commenced on September 23, 1997 and was completed October 9, 1997. The sample was received at Process Research's Vancouver Laboratory on October 27, 1997. Activities during collection of samples are outlined in Table 3.0-1.

Table 3.0-1
Activity Schedule for Bulk Sampling Program

DATE	EVENT
September 22	Mobilization to Carmacks.
September 23	Equipment and operators on site.
	Start excavation of trench 91-18.
September 25	Excavation of trench 91-18 complete.
	Start excavation of trench 92-68.
September 28	Excavation of trench 92-68 complete.
September 29	Final work on trench 91-22 completed by excavator.
	Start excavation of trench 91-20.
	Dump trucks and Mini-Air Trac drill arrive on site.
September 30	Blast hole drilling started on trench 91-18.
October 02	Blast hole drilling on trench 91-18 complete.
	Trench 91-18 loaded and blasted.
October 04	Blast hole drilling for trench 92-68 started. Drill break down.
	Channel-chip sampling completed for trench 91-18.
October 06	Blast hole drilling for trench 92-68 completed.
	Blast hole drilling for trench 91-20 completed.
	Blast hole drilling for trench 91-22 completed.
	Trenches 92-68, 91-20, and 91-22 loaded and blasted.
October 07	Bulk sample taken from trenches 92-68, 91-20 and 91-22.
	Bulk sample from trench 92-68 mixed.
October 08	Bulk sample from trenches 91-20 and 91-22 mixed.
	Composite bulk sample blended and mixed.
	Composite bulk sample loaded into ore bags.
	Channel-chip sampling of trench 92-68 complete.
October 09	Additional composite bulk sample blended and mixed.
	Additional composite bulk loaded into ore bags.
October 10	Channel-chip sampling of trenches 91-20 and 91-22.
	Demobilization from Carmacks to Whitehorse.
October 11	Demobilization from Whitehorse.

4.0 COMMENTS

4.0 COMMENTS

Mineralization

Kilborn observed that malachite azurite and chalcocite mineralization occurred principally along rock fractures and as small aggregates in fine grained highly friable zones. Some malachite mineralization was observed along mineral grains in coarse grained gneisses that were moderately to weakly friable. In resistant competent coarse grained gneisses malachite appeared to occur only along fracture planes.

Run-of-Mine Simulation

Fine grained material from coarse sand size to fine silt size and smaller particles appeared to dominate the bulk sample material. The main source of this fine material is probably in-situ. This is evidenced by some sections in trenches 91-18 and 91-20 which were not blasted because the material was fine grained and could be excavated without blasting. It was also observed that much of the trench material was moderately to very friable and broke into small particles with a minimum of force. This fine grained material was observed to a depth of 11 m in trench 91-20. It was not possible for Kilborn to determine to what depths this fine grained friable rock extends.

Trench blasting compared to production blasting can generate finer material. Blasting in a trench confines the blast and typically results in finer fragmentation. A production blast that is less confined typically results in coarser fragmentation. Since all material for the bulk sample was necessarily extracted from trenches, the size of blast fragments may be expected to be finer than from a production blast.

The bulk sample extracted from trenches may be biased towards finer grained material. Blast fragmentation from trenches and possibly finer and more friable ore material in the upper portion of the deposit may contribute to higher amounts of fine materials than would be expected from a run-of-mill production blast.

5.0 REFERENCES

5.0 REFERENCES

1. Holtby, M. and K. McNaughton. Williams Creek Project; Yukon Territory, Silver Standard Resources Inc. February 1993.

2. Kilborn Engineering Pacific Ltd. Wester Copper Holdings Limited, Carmacks Copper Project; Feasibility Study. October 1994.

3. Holtby, M. Personal Communication. September 9, 1997.

APPENDIX A

FIELD REPORTS

From: David Keller
To: WACHT
Date: 10/2/97 6:01pm
Subject: Carmacks Bulk Sampling

Tony,

Just a short note. Production today on trench 20 is stalled because of excavator break down. However trench 18 was loaded and blasted this morning.

Due to this delay I expect that work will be finished around the middle of next week.

Dave

From: David Keller
To: WACHT
Date: 10/5/97 2:39pm
Subject: Carmacks Bulk Sampling

Tony,

More delays with regard to the air track drill. Replacement parts for the drill were broken. A new drill had to be arranged and transported to site. Drilling resumed at noon on Saturday. We have lost 2.5 days due to drilling problems. Trench 19 (not 18) has been sampled (chip and bulk) and mixed. Digging of trench 20 was completed Saturday.

Since equipment work is completed as far as possible, I have sent the operators home until drilling and blasting is near completion. Taking the bulk sample from a trench and mixing the sample takes about four hours.
I expect drilling to continue until Wednesday. Operators are scheduled to be back Tues.

I have changed my flight to Thurs morning but I think that may be a bit optimistic.

Attached is my final estimate of costs up to the end of September. Jim has charged us the transport costs for the camp and is charging $78.00/day/man room and board.

Jim has also sent out an invoice for September to the client. There are some errors which Jim needs to fix.

From: David Keller
To: WACHT
Date: 9/30/97 8:02pm
Subject: Carmacks Bulk Sampling -Reply -Reply

Tony,

I have talked to Jim Coyne about leaving the Cat (D7) at site for the next program. Jim is quite happy to leave the Cat until the next program starts up.

Trenches 19, 68 and 22 are ready for blasting and removing the sample. Work on trench 20 is progressing. Trench 20 needs to be cleaned out and widened for equipment. As this was a previous bulk sample trench the trench has to be deepened. Rock can be only removed using dump trucks. Benching of trench sides is necessary to reduce slumping of trench sides. I expect this trench to be completed in about two days.

Two dump trucks arrived at site yesterday afternoon with the air-track drill and compressor for drill. Blasting\Drilling was delayed today for about 8 hours today because the drill was broken. Late in the afternoon the drill was fixed and drilling on trench 19 started.

I expect bulk sampling to be completed early next week.

Jim Coyne has organized a camp for his men just off of the main road. He will give the cost per man shortly.

Last weekend Access Mining Consultants from Whitehorse did piezometer testing. The brushing crew started about Wednesday last week.

The 500kg sample of the previous bulk sample needs some clarification. The only material in one of the trenches appears to be leached ore. Ken and one or two other people have indicated that the material is from the leach pad set up in Carmacks. I concur with this as plastic sheets and plastic pipes are buried with this material. It was my understanding that the material wanted was weathered crushed ore not weathered crushed and leached material. There does not appear to be any crushed unleached ore available. Please confirm if a sample of this material should be sampled.

I seem to have misplaced the address for Process Research Associates (PRA). Could you please send me their address and phone number.

Jim Coyne has made preliminary inquiries concerning shipping about 20 tonnes to Vancouver. The cost will be around $1000.00.

Are the trench channel samples to be sent to PRA also or to another lab such as Chemex?

Regards,

Dave

From: David Keller
To: WACHT
Date: 9/27/97 10:11am
Subject: Carmacks Bulk Sampling

Carmacks Bulk Sampling

Tony,

Trench 18 is completed ready for blasting and sampling. A good portion of the trench won't need blasting as the rock is very friable.

Work on trench 68 is still in progress. A large amount of ground has to be moved to get access for excavator and mini-air track. At the moment this is holding up progress. This trench should be completed by tomorrow.

Trench 22 has been enlarged by the bulldozer and will need only minor work before blasting/sampling.

Trench 20 will need dump trucks to clean out trench. The trench (including muck piles beside trench) is 5-6m deep.

Bulk sample bags were in Whitehorse the same day I arrived.

Contractor recommends some minor road work so that dump trucks can access site and take out bulk samples. I will try to minimize road work as much as possible.

Please find attached a summary of men and equipment hours up to the 24. Further update Sunday evening.

Dave

From: David Keller
To: WACHT
Date: 9/24/97 6:20pm
Subject: Hi Tony,

Hi Tony,

The trenching is progressing. The first trench number 18 will probably be complete tonight. Initial work on trench 68 has started today. Ken Roberts equipment is was working on another site so he arranged for another contractor to do the work. The contractor is Jim Coyne, he is based out of Whitehorse. Jim's equipment is essentially the same as Ken's, possibly newer. The blaster was at site and advised of what was needed. I will get him to start blasting when at least three trenches have been cleaned out.

Trenches may need more work than I expected because equipment about six feet wide and trench sides are piled high from previous work. So far progress is good. Operators were at site yesterday afternoon.

Otherwise things are okay. The equipment operators seem to be quite competant.

Dave

APPENDIX B

SAMPLE DESCRIPTION MEMO

KILBORN
SNC·LAVALIN

KILBORN ENGINEERING PACIFIC LTD.
Suite 400, 1380 Burrard Street
Vancouver, B.C.
Canada V6Z 2B7

Telephone: (604) 669-8811

FAX
(604) 669-0847

TO:	Morris Beattie	**COPY TO:**
COMPANY:	Beattie Consulting Ltd.	
FAX NO.:	(604) 263-0895	**COPY TO:**
FROM:	Dave Keller	
DATE:	October 19, 1997	
SUBJECT:	Carmacks Samples	
PROJECT #:	8555-25	

NUMBER OF PAGES SENT: **3 (INCLUDING TRANSMITTAL PAGE)**

MESSAGE:

Morris Beattie:

Samples from the Carmacks bulk sampling program should arrive in Vancouver this week.

There are 18 bulk sample bags numbered 1-18 containing a blended ore from four trenches. Each bag weighs about 1 tonne. Also there is 1 bulk sample bag containing the previously leached ore which was left to weather in one of the trenches. This bag is marked as L1 and weighs approximately 800lbs.

Additionally each trench was sampled by channel-chip sampling along each trench wall. Nineteen samples are in one bulk sample bag, sample numbers 588801 to 588819. Additionally 109 samples are in another bulk sample bag, sample numbers 588820 to 588850 and 586251 to 586279.

I have attached a list of channnel-chip samples indicating trench number and distance from the footwall contact.

G. David Keller

The content of this communication is confidential. If you are not the intended recipient, please notify us immediately. Be advised that the unauthorized use or disclosure of this communication or of its content, meaning, purpose, or the mere disclosure of its existence, is unlawful.

CARMACKS CHANNEL-CHIP SAMPLES

SAMPLE NO.	F/W CONTACT DISTANCE		TRENCH
	FROM	TO	
588801	0.0	2.0	91-18
588802	2.0	4.0	91-18
588803	4.0	6.0	91-18
588804	6.0	8.0	91-18
588805	8.0	10.0	91-18
588806	10.0	12.0	91-18
588807	12.0	14.0	91-18
588808	14.0	16.0	91-18
588809	16.0	18.0	91-18
588810	18.0	20.0	91-18
588811	20.0	22.0	91-18
588812	22.0	24.0	91-18
588813	24.0	26.0	91-18
588814	26.0	28.0	91-18
588815	28.0	30.0	91-18
588816	30.0	32.0	91-18
588817	32.0	34.0	91-18
588818	34.0	36.0	91-18
588819	36.0	39.3	91-18
588820	0.0	2.0	92-68
588821	2.0	4.0	92-68
588822	4.0	6.0	92-68
588823	6.0	8.0	92-68
588824	8.0	10.0	92-68
588825	10.0	12.0	92-68
588826	12.0	14.0	92-68
588827	14.0	16.0	92-68
588828	16.0	18.0	92-68
588829	18.0	20.0	92-68
588830	20.0	22.0	92-68
588831	22.0	24.0	92-68
588832	24.0	26.9	92-68
588833	26.9	31.4	92-68
588834	31.4	34.0	92-68
588835	34.0	36.0	92-68
588836	36.0	38.0	92-68
588837	38.0	40.0	92-68
588838	40.0	42.0	92-68
588839	42.0	44.0	92-68
588840	44.0	46.0	92-68
588841	46.0	48.0	92-68
588842	48.0	50.0	92-68

588843	50.0	52.0	92-68
588844	52.0	54.0	92-68
588845	54.0	56.0	92-68
588846	56.0	58.0	92-68
588847	58.0	60.0	92-68
588848	60.0	62.0	92-68
588849	62.0	64.0	92-68
588850	64.0	66.1	92-68
586251	0.0	2.0	91-20
586252	2.0	4.0	91-20
586253	4.0	6.0	91-20
586254	6.0	8.0	91-20
586255	8.0	10.0	91-20
586256	10.0	12.0	91-20
586257	12.0	14.0	91-20
586258	14.0	16.0	91-20
586259	16.0	18.0	91-20
586260	18.0	20.0	91-20
586261	20.0	22.0	91-20
586262	22.0	24.0	91-20
586263	24.0	26.0	91-20
586264	26.0	28.0	91-20
586265	28.0	30.0	91-20
586266	30.0	32.0	91-20
586267	32.0	33.9	91-20
586268	0.0	2.0	91-22
586269	2.0	4.0	91-22
586270	4.0	6.0	91-22
586271	6.0	8.0	91-22
586272	8.0	10.0	91-22
586273	10.0	12.0	91-22
586274	12.0	14.0	91-22
586275	14.0	16.0	91-22
586276	16.0	18.0	91-22
586277	18.0	20.0	91-22
586278	20.0	22.0	91-22
586279	22.0	23.9	91-22

APPENDIX C

DRAWINGS

Appendix 2

Leach Column Test Details

COPPER COLUMN LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6"x216"
Initial Charge Height: 214 inch
Final Charge Height: inch
Sample Weight: 164.2 kg
Bulk Density: 1.656 tonne/m^3

Starting Date: February 18, 1998

Ore Sample: Carmacks ROM crushed to -3/4"
Head Assay $Cu_{(T)}$: 1.02 %
Head Assay $Cu_{(acid\ soluble)}$: 0.90 %
Calculated $Cu_{(T)}$: 0.99 %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: 23.15 Litre
Drain Volume: 5.46 Litre

Report Date: February 19, 2001

Curing Period: 5 days
Curing Water Addition: 19.9 kg/tonne
Curing Acid Concentration: 95 % H_2SO_4
Curing Acid Consumption: 15.00 kg/tonne
Leach H_2SO_4 Solution Concentration: 10.0 g/L
Leach H_2SO_4 Solution Feed Rate: 14.0 $L/m^2/h$
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: 10.8 % by weight

Day	COLUMN																	SX							Cu		H_2SO_4	
	Feed									PLS								Raffinate							Leached		Consumption	
	H_2SO_4 added*	Start Weight	End Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	ORP	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cum. Weight	Cum. Extraction	Cum. vs. feed	Cum. vs. Cu
	(g)	(kg)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(mV**)	(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g)	(%)	(kg/t ore)	(kg/t Cu)
0	57.26	15.00	9.24	1.0060	5.73	1.12	0.00	0.00	10.00																#VALUE!	#VALUE!	15.35	
1	61.38	15.00	8.83	1.0060	6.14	1.12			10.00																0.0	0.0	15.72	
2	60.31	15.00	8.93	1.0060	6.03	1.12			10.00																0.0	0.0	16.09	
3	65.21	15.00	8.44	1.0060	6.52	1.12			10.00	5.57	1.2332	4.51	2.94	240	56.0	6.13	27.30	3.45	1.1466	3.00	0.83	1.49		108.60	252.7	15.1	16.49	10,712.6
4	59.89	15.00	8.98	1.0060	5.99	1.12			10.00	6.69	1.1111	6.02	3.47	221	30.0	1.07	19.55	4.78	1.0680	4.48	0.77	0.61		62.50	433.3	25.9	16.85	6,385.4
5	60.69	14.00	7.90	1.0060	6.07	1.12			10.00	5.99	1.0601	5.65	3.63	212	16.00	0.53	13.90	5.91	1.0384	5.69	0.80	0.23		36.70	523.7	31.3	17.22	5,399.0
6		15.00	9.06	1.0132	5.87	1.34	0.11	3.76	13.05	6.06	1.0385	5.83	3.71	214	10.50	3.76	9.93	6.00	1.0247	5.85	1.05	0.045		22.90	584.3	34.9	17.22	4,839.3
7		15.00	8.96	1.0141	5.96	1.31	0.14	0.49	12.90	5.75	1.0274	5.60	4.19	155	7.70	0.30	6.03	5.13	1.0174	5.04	1.04	0.018		16.90	626.6	37.4	17.22	4,512.9
8		15.00	8.90	1.0156	6.01	1.25	0.16	0.05	13.05	5.85	1.0213	5.72	3.70	295	6.00	0.03	5.00	5.82	1.0136	5.74	0.99	0.011		14.30	660.0	39.4	17.22	4,284.5
9		25.00	17.90	1.0145	7.00	1.32	0.13	0.36	12.66	5.80	1.0204	5.68	3.65	298	5.50	0.35	4.82	5.66	1.0126	5.59	1.04	0.008		12.70	690.3	41.2	17.22	4,096.2
10		17.90	11.80	1.0145	6.01	1.32			12.66	6.53	1.0217	6.39	3.60	304	5.50	0.47		6.31	1.0140	6.22	1.26	0.010			725.5	43.3	17.22	3,897.7
11		11.80	6.55	1.0145	5.17	1.32			12.66	6.07	1.0233	5.93	3.66	299	5.40	0.61		5.93	1.0165	5.83	1.23	0.008			757.5	45.2	17.22	3,733.0
12		23.00	16.88	1.0131	6.05	1.45	0.09	0.24	11.77	5.35	1.0237	5.22	3.72	306	4.80	0.65	4.76	5.04	1.0167	4.96	1.25	0.004		12.42	782.0	46.7	17.22	3,616.0
13		25.00	18.81	1.0126	6.11	1.25	0.07	0.24	12.91	6.11	1.0226	5.97	3.76	315	4.30	0.67	4.61	5.87	1.0168	5.77	1.26	0.004		11.11	807.3	48.2	17.22	3,502.9
14		18.81	12.67	1.0126	6.07	1.25	0.07	0.24	12.91	6.01	1.0219	5.88	3.82	309	3.90	0.72	4.02	5.92	1.0160	5.83	1.39	0.016		8.43	829.7	49.5	17.22	3,408.0
15		12.67	6.55	1.0126	6.04	1.25	0.07	0.24	12.91	6.04	1.0214	5.91	3.83	297	3.50	0.71	4.07	5.93	1.0160	5.83	1.48	0.013		7.72	850.0	50.8	17.22	3,326.7
16		27.00	20.52	1.0140	6.40	1.26	0.03	0.34	16.80	6.19	1.0210	6.06	3.76	308	3.10	0.67	3.75	6.00	1.0155	5.90	1.44	0.014		7.81	868.6	51.9	17.22	3,255.4
17	70.00	21.00	14.74	1.0170	6.15	1.12	0.03	0.34	16.80	6.38	1.0199	6.25	3.60	322	2.90	0.69	6.10	6.24	1.0158	6.14	1.45	0.012		9.09	886.6	52.9	17.65	3,268.4
18		14.74	9.35	1.0170	5.30	1.12	0.03	0.34	16.80	5.88	1.0199	5.77	3.63	321	2.75	0.70	6.17	5.74	1.0151	5.65	1.49	0.012		8.86	902.3	53.9	17.65	3,211.5
19	50.00	21.45	15.45	1.0175	5.90	1.14	0.02	0.44	16.71	5.23	1.0207	5.12	3.74	310	2.75	0.72	6.28	5.08	1.0161	5.00	1.39	0.009		9.65	916.3	54.7	17.95	3,217.1
20		15.45	9.56	1.0175	5.79	1.14	0.02	0.44	16.71	5.90	1.0218	5.77	3.76	305	2.75	0.79	5.87	5.81	1.0176	5.70	1.60	0.009		9.27	932.0	55.7	17.95	3,162.6
21	47.13	27.60	20.84	1.0178	6.64	1.19	0.01	0.59	14.47	5.89	1.0235	5.75	3.68	306	2.70	0.92	6.32	5.74	1.0193	5.63	1.46	0.012		9.49	947.5	56.6	18.24	3,160.8
22		20.84	14.76	1.0178	5.97	1.19	0.01	0.59	14.47	6.24	1.0240	6.09	3.65	306	1.35	1.0		6.14	1.0200	6.01	1.60	0.008			955.7	57.1	18.24	3,133.8
23	130.00	32.10	24.90	1.0198	7.06	1.23	0.01	0.65	14.56	6.00	1.0241	5.86	3.70	307	2.60	0.96	6.22	5.91	1.0204	5.79	1.60	0.012		9.09	970.8	58.0	19.03	3,218.9

COPPER COLUMN LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6"x216"
Initial Charge Height: 214 inch
Final Charge Height: inch
Sample Weight: 164.2 kg
Bulk Density: 1.656 tonne/m^3

Starting Date: February 18, 1998

Ore Sample: Carmacks ROM crushed to -3/4"
Head Assay $Cu_{(T)}$: 1.02 %
Head Assay $Cu_{(acid\ soluble)}$: 0.90 %
Calculated $Cu_{(T)}$: 0.99 %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: 23.15 Litre
Drain Volume: 5.46 Litre

Report Date: February 19, 2001

Curing Period: 5 days
Curing Water Addition: 19.9 kg/tonne
Curing Acid Concentration: 95 % H_2SO_4
Curing Acid Consumption: 15.00 kg/tonne
Leach H_2SO_4 Solution Concentration: 10.0 g/L
Leach H_2SO_4 Solution Feed Rate: 14.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: 10.8 % by weight

Day	COLUMN																	SX							Cu		H_2SO_4	
	Feed									PLS								Raffinate							Leached		Consumption	
	H_2SO_4 added*	Start Weight	End Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	ORP	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cum. Weight	Cum. Extraction	Cum. vs. feed	Cum. vs. Cu
	(g)	(kg)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(mV**)	(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g)	(%)	(kg/t ore)	(kg/t Cu)
24		24.90	20.19	1.0198	4.62	1.23	0.01	0.65	14.56	6.55	1.0247	6.39	3.69	305	2.40	1.01	6.17	6.37	1.0216	6.24	1.59	0.010		8.75	986.1	58.9	19.03	3,169.0
25		20.19	14.81	1.0198	5.28	1.23	0.01	0.65	14.56	5.93	1.0240	5.79	3.69	304	2.25	1.05	6.04	5.81	1.0205	5.69	1.58	0.008		8.63	999.0	59.6	19.03	3,127.9
26		14.81	8.82	1.0198	5.87	1.23	0.01	0.65	14.56	5.18	1.0244	5.06	3.70	302	2.20	1.11	6.22	5.07	1.0214	4.96	1.52	0.007		9.18	1,010.1	60.3	19.03	3,093.7
27	137.00	31.46	25.25	1.0221	6.08	1.29	0.01	0.78	14.18	5.84	1.0257	5.69	3.70	304	2.00	1.15	5.96	5.70	1.0221	5.57	1.54	0.008		7.79	1,021.4	61.0	19.87	3,193.6
28		25.25	18.94	1.0221	6.17	1.29	0.01	0.78	14.18	6.08	1.0254	5.93	3.69	304	1.90	1.18	5.96	6.00	1.0226	5.86	1.61	0.006		7.59	1,032.6	61.7	19.87	3,158.9
29		18.94	12.80	1.0221	6.00	1.29	0.01	0.78	14.18	6.17	1.0258	6.01	3.69	303	1.85	1.18	6.04	6.08	1.0231	5.94	1.65	0.007		7.50	1,043.6	62.3	19.87	3,125.5
30	178.40	35.83	29.49	1.0248	6.19	1.28	0.01	0.85	15.11	6.02	1.0265	5.86	3.63	303	1.85	1.18	6.20	5.94	1.0241	5.80	1.67	0.006		7.64	1,054.4	63.0	20.95	3,262.7
31		29.49	24.39	1.0248	4.98	1.28	0.01	0.85	15.11	6.28	1.0276	6.11	3.64	303	1.85	1.33		6.12	1.0246	5.97	1.66	0.007		7.55	1,065.7	63.6	20.95	3,228.3
32		24.39	23.13	1.0248	1.22	1.28	0.01	0.85	15.11	5.00	1.0274	4.86	3.63	305	1.80	1.34		4.89	1.0257	4.77	1.67	0.006		7.98	1,074.4	64.1	20.95	3,202.0
33		23.13	17.35	1.0248	5.65	1.28	0.01	0.85	15.11	3.48	1.0286	3.38	3.68	304	1.80	1.39		3.35	1.0258	3.27	1.60	0.010		8.84	1,080.4	64.5	20.95	3,184.1
34		17.35	11.36	1.0248	5.85	1.28	0.01	0.85	15.11	3.43	1.0288	3.33	3.61	302	1.90	1.39	5.47	3.31	1.0264	3.22	1.67	0.008		8.61	1,086.7	64.9	20.95	3,165.8
35		11.36	5.16	1.0248	6.05	1.28	0.01	0.85	15.11	5.87	1.0299	5.69	3.59	304	1.90	1.45	5.39	5.74	1.0270	5.58	1.67	0.007		7.85	1,097.5	65.5	20.95	3,134.7
36	285.40	39.59	33.35	1.0283	6.07	1.27	0.01	1.20	15.32	6.27	1.0308	6.08	3.64	306	1.60	1.54	5.95	6.23	1.0287	6.05	1.74	0.005		7.80	1,107.1	66.1	22.69	3,365.1
37		33.35	27.30	1.0283	5.88	1.27	0.01	1.20	15.32	6.06	1.0307	5.87	3.67	305	1.45	1.63	5.58	5.94	1.0295	5.76	1.77	0.006		7.37	1,115.6	66.6	22.69	3,339.6
38		27.30	20.30	1.0283	6.81	1.27	0.01	1.20	15.32	6.34	1.0310	6.15	3.48	315	1.32	1.60	5.87	6.24	1.0290	6.06	1.70	0.004		7.71	1,123.7	67.1	22.69	3,315.6
39		20.30	14.73	1.0283	5.41	1.27	0.01	1.20	15.32	6.43	1.0319	6.23	3.42	323	1.31	1.67	6.33	6.34	1.0310	6.14	1.71	0.002		7.71	1,131.8	67.6	22.69	3,291.8
40		14.73	8.22	1.0283	6.33	1.27	0.01	1.20	15.32	5.43	1.0334	5.25	3.30	342	1.30	1.74	6.56	5.33	1.0320	5.16	1.63	0.003		7.82	1,138.6	68.0	22.69	3,272.2
41	157.60	26.60	24.06	1.0315	2.47	1.16	0.008	1.39	14.94	6.32	1.0348	6.11	3.19	351	1.28	1.78	7.18	6.20	1.0321	6.00	1.66	0.004		7.22	1,146.4	68.4	23.65	3,387.5
42		24.06	13.08	1.0315	10.64	1.16	0.008	1.39	14.94	3.37	1.0339	3.26	3.14	358	1.24	1.89	6.75			#DIV/0!					1,150.3	68.7	23.65	3,375.8
43		13.08	0.00	1.0315	12.68	1.16	0.008	1.39	14.94	10.04	1.0344	9.70	3.16	358	1.19	1.94	6.99	13.22	1.0321	12.80	1.81			6.91	1,161.8	69.4	23.65	3,342.6
44	315.70	40.90	30.70	1.0345	9.86	1.32	0.003	1.73	13.89	13.37	1.0370	12.89	2.83	381	0.88	2.82	6.99			#DIV/0!		0.002			1,173.1	70.0	25.57	3,579.4
45		30.70	17.20	1.0345	13.05	1.32	0.003	1.73	13.89	10.18	1.0393	9.80	2.74	383	0.93	3.02	6.39			#DIV/0!					1,182.1	70.6	25.57	3,552.0
46		17.20	5.95	1.0345	10.88	1.32	0.003	1.73	13.89	13.56	1.0408	13.02	2.68	385	0.87	3.36	6.68			#DIV/0!					1,193.4	71.3	25.57	3,518.4
47	174.40	49.00	38.10	1.0410	10.47	1.30	0.035	2.72	13.51	10.13	1.0419	9.72	2.65	384	0.79	3.52	6.90	47.01	1.0383	45.28	1.90	0.002			1,200.8	71.7	26.63	3,642.2

COPPER COLUMN LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6"x216"
Initial Charge Height: 214 inch
Final Charge Height: inch
Sample Weight: 164.2 kg
Bulk Density: 1.656 tonne/m^3

Starting Date: February 18, 1998

Ore Sample: Carmacks ROM crushed to -3/4"
Head Assay $Cu_{(T)}$: 1.02 %
Head Assay $Cu_{(acid\ soluble)}$: 0.90 %
Calculated $Cu_{(T)}$: 0.99 %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: 23.15 Litre
Drain Volume: 5.46 Litre

Report Date: February 19, 2001

Curing Period: 5 days
Curing Water Addition: 19.9 kg/tonne
Curing Acid Concentration: 95 % H_2SO_4
Curing Acid Consumption: 15.00 kg/tonne
Leach H_2SO_4 Solution Concentration: 10.0 g/L
Leach H_2SO_4 Solution Feed Rate: 14.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: 10.8 % by weight

Day	COLUMN																	SX							Cu		H_2SO_4	
	Feed									PLS								Raffinate							Leached		Consumption	
	H_2SO_4 added* (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
48		38.10	25.80	1.0410	11.82	1.30	0.035	2.72	13.51	11.70	1.0421	11.23	2.61	385	0.75	3.52	6.93			#DIV/0!					1,208.8	72.2	26.63	3,618.0
49		25.80	13.40	1.0410	11.91	1.30	0.035	2.72	13.51	11.60	1.0439	11.11	2.50	405	0.72	3.71	6.18			#DIV/0!					1,216.3	72.6	26.63	3,595.5
50	316.00	45.80	33.20	1.0468	12.04	1.23	0.011	3.25	15.60	11.90	1.0463	11.37	2.48	409	0.74	4.05	7.61	34.70	1.0440	33.24		0.002		8.04	1,224.6	73.1	28.56	3,829.2
51		33.20	21.10	1.0468	11.56	1.23	0.011	3.25	15.60	12.70	1.0483	12.11	2.51	412	0.71	4.05	7.14			#DIV/0!					1,233.1	73.6	28.56	3,802.9
52		21.10	19.50	1.0468	1.53	1.23	0.011	3.25	15.60	11.90	1.0514	11.32	2.47	412	0.70	4.45	7.52			#DIV/0!					1,241.0	74.1	28.56	3,778.7
53		19.50	8.50	1.0468	10.51	1.23	0.011	3.25	15.60	4.50	1.0539	4.27	2.45	413	0.72	5.35	7.90			#DIV/0!					1,244.0	74.3	28.56	3,769.7
54	210.00	37.40	26.80	1.0527	10.07	1.30	0.005	4.10	15.08	8.00	1.0553	7.58	2.54	406	0.95	4.75	8.28	36.80	1.0506	35.03	1.82	0.003		8.56	1,251.1	74.7	29.84	3,916.0
55		26.80	14.40	1.0527	11.78	1.30	0.005	4.10	15.08	10.20	1.0547	9.67	2.29	413	0.65	5.00	7.96			#DIV/0!					1,257.3	75.1	29.84	3,896.6
56		14.40	2.20	1.0527	11.59	1.30	0.005	4.10	15.08	12.10	1.0559	11.46	2.24	416	0.64	5.34	8.13			#DIV/0!					1,264.6	75.5	29.84	3,874.2
57		52.90	40.10	1.0379	12.33	1.23	0.003	2.92	14.73	11.90	1.0584	11.24	2.19	418	0.62	5.84	8.00	34.20	1.0542	32.44		0.003		9.32	1,271.6	75.9	29.84	3,853.0
58		40.10	26.50	1.0379	13.10	1.23	0.003	2.92	14.73	12.40	1.0589	11.71	2.26	416	0.60	5.89	8.95			#DIV/0!					1,278.5	76.3	29.84	3,832.0
59		26.50	15.10	1.0379	10.98	1.23	0.003	2.92	14.73	14.50	1.0529	13.77	2.16	415	0.57	5.34	8.16			#DIV/0!					1,286.4	76.8	29.84	3,808.7
60		15.10	4.40	1.0379	10.31	1.23	0.003	2.92	14.73	11.20	1.0470	10.70	2.28	418	0.52	4.64	7.09			#DIV/0!					1,291.9	77.1	29.84	3,792.4
61	333.00	49.40	36.40	1.0532	12.34	1.40	0.005	4.59	14.63	10.60	1.0460	10.13	2.23	419	0.51	4.79	5.97	48.70	1.0477	46.48		0.040		7.53	1,297.0	77.4	31.87	4,034.2
62		36.40	23.40	1.0532	12.34	1.40	0.005	4.59	14.63	11.80	1.0459	11.28	2.16	418	0.48	4.64	5.44			#DIV/0!					1,302.4	77.8	31.87	4,017.6
63		23.40	11.30	1.0532	11.49	1.40	0.005	4.59	14.63	12.30	1.0509	11.70	2.18	417	0.48	4.98	8.38			#DIV/0!					1,307.9	78.1	31.87	4,000.5
64		11.30	0.00	1.0532	10.73	1.40	0.005	4.59	14.63	11.70	1.0576	11.06	2.20	415	0.47	5.69	8.77			#DIV/0!					1,313.1	78.4	31.87	3,984.9
65	70.00	43.50	30.60	1.0531	12.25	1.63	0.002	5.20	9.87	11.70	1.0592	11.05	2.21	419	0.43	5.95	8.75	47.50	1.0515	45.17	1.83	0.002		8.80	1,317.8	78.7	32.29	4,023.7
66		30.60	16.40	1.0531	13.48	1.63	0.002	5.20	9.87	12.10	1.0598	11.42	2.12	416	0.42	5.90	8.70			#DIV/0!					1,322.6	79.0	32.29	4,009.2
67		16.40	7.50	1.0531	8.45	1.63	0.002	5.20	9.87	13.80	1.0601	13.02	2.12	412	0.38	5.50	8.65			#DIV/0!					1,327.5	79.3	32.29	3,994.3
68	241.00	58.30	46.40	1.0377	11.47	1.51	0.002	3.30	8.99	8.10	1.0566	7.67	2.13	405	0.32	5.25	7.97	34.00	1.0572	32.16	1.74	0.002		8.84	1,329.9	79.4	33.76	4,168.2
69		46.40	34.50	1.0377	11.47	1.51	0.002	3.30	8.99	11.80	1.0555	11.18	2.14	403	0.29	5.30	8.65			#DIV/0!					1,333.1	79.6	33.76	4,158.1
70		34.50	21.90	1.0377	12.14	1.51	0.002	3.30	8.99	12.70	1.0511	12.08	2.20	413	0.26	4.70				#DIV/0!					1,336.2	79.8	33.76	4,148.4
71		21.90	9.00	1.0377	12.43	1.51	0.002	3.30	8.99	12.40	1.0434	11.88	2.15	410	0.26	4.85				#DIV/0!					1,339.3	80.0	33.76	4,139.0

COPPER COLUMN LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6"x216"
Initial Charge Height: 214 inch
Final Charge Height: inch
Sample Weight: 164.2 kg
Bulk Density: 1.656 tonne/m^3

Starting Date: February 18, 1998

Ore Sample: Carmacks ROM crushed to -3/4"
Head Assay $Cu_{(T)}$: 1.02 %
Head Assay $Cu_{(acid\ soluble)}$: 0.90 %
Calculated $Cu_{(T)}$: 0.99 %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: 23.15 Litre
Drain Volume: 5.46 Litre

Report Date: February 19, 2001

Curing Period: 5 days
Curing Water Addition: 19.9 kg/tonne
Curing Acid Concentration: 95 % H_2SO_4
Curing Acid Consumption: 15.00 kg/tonne
Leach H_2SO_4 Solution Concentration: 10.0 g/L
Leach H_2SO_4 Solution Feed Rate: 14.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: 10.8 % by weight

Day	COLUMN																	SX							Cu		H_2SO_4	
	Feed								PLS									Raffinate							Leached		Consumption	
	H_2SO_4 added* (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
72	104.50	55.30	40.80	1.0461	13.86	1.52	0.002	4.00		12.80	1.0418	12.29	2.18	414	0.26	4.05		49.70	1.0462	47.51	1.62	0.001			1,342.5	80.2	34.40	4,207.0
73		40.80	28.30	1.0461	11.95	1.52	0.002	4.00		13.50	1.0423	12.95	2.15	408	0.28	3.96	5.70			#DIV/0!					1,346.0	80.4	34.40	4,196.0
74		28.30	18.00	1.0461	9.85	1.52				12.00	1.0450	11.48	2.21	405	0.27	4.12	6.23			#DIV/0!					1,349.1	80.5	34.40	4,186.5
75		0.00	0.00	1.0000	0.00					10.00	1.0485	9.54	2.21	406	0.25	4.32	6.43			#DIV/0!					1,351.4	80.7	34.40	4,179.1
76		0.00	0.00	1.0000	0.00					4.70	1.0495	4.48	2.28	402	0.26	4.32	6.20			#DIV/0!					1,352.6	80.8	34.40	4,175.6
77		0.00	0.00	1.0000	0.00					0.90	1.0509	0.86	2.27	397	0.37	4.15	6.45			#DIV/0!					1,352.9	80.8	34.40	4,174.6
78		0.00	0.00	1.0000	0.00					0.50	1.0522	0.48	2.28	397	0.47	4.30	6.80			#DIV/0!					1,353.1	80.8	34.40	4,173.9
79		0.00	0.00	1.0000	0.00					0.35	1.0517	0.33	2.42	395	0.52	4.10	6.37			#DIV/0!					1,353.3	80.8	34.40	4,173.4
82		0.00	0.00	1.0000	0.00					0.52	1.0512	0.49	2.56	415	0.60	3.35	6.70	42.50	1.0454	40.65	1.78	0.006		7.65	1,353.6	80.8	34.40	4,172.5
83		60.10	19.20	1.0460	39.10	1.78	0.005	3.55	8.92											#DIV/0!					1,353.4	80.8	34.40	4,173.1
90		54.10	27.40	1.0469	25.50	1.89	0.245	3.30	7.57	34.90	1.0476	33.31	2.28	413	0.80	3.20	6.02			#DIV/0!					1,373.8	82.0	34.40	4,111.1
96		52.60	16.70	1.0462	34.31	2.38	0.285	2.95		25.20	1.0449	24.12	2.38	549	0.31	2.23				#DIV/0!					1,371.4	81.9	34.40	4,118.4
103		51.90	10.80	1.0435	39.39	2.40	0.380	1.90	7.45	35.20	1.0423	33.77	2.44	536	0.44	1.50	7.45			#DIV/0!					1,371.3	81.9	34.40	4,118.7
110		50.10	28.60	1.0416	20.64	2.37	0.470	1.27	7.93	39.30	1.0413	37.74	2.39	554	0.49	1.12	7.99			#DIV/0!					1,379.9	82.4	34.40	4,093.0
114		48.60	30.50	1.0460	17.30	1.76	0.002	0.65	9.66	21.50	1.0418	20.64	2.45	555	0.54	0.83	8.18	50.10	1.0460	47.90	1.76	0.003		9.56	1,391.0	83.1	34.40	4,060.3
117		48.00	7.40	1.0419	38.97	1.87	0.196	0.67	8.94	17.50	1.0424	16.79	2.48	550	0.55	0.69	8.19								1,392.6	83.1	34.40	4,055.7
124		46.30	6.70	1.0420	38.00	2.30	0.275	0.63	8.88	38.90	1.0421	37.33	2.42	544	0.30	0.61	8.56								1,393.1	83.2	34.40	4,054.1
131		42.30	8.40	1.0422	32.53	2.49	0.330	0.47	8.39	35.60	1.0422	34.16	2.51	554	0.35	0.46	8.39								1,394.4	83.3	34.40	4,050.5
138		44.10	1.10	1.0432	41.22	2.57	0.385	0.38	8.11	35.70	1.0432	34.22	2.59	552	0.42	0.37	8.20								1,392.7	83.2	34.40	4,055.4
145		42.30	2.00	1.0441	38.60	2.60	0.440	0.26	0.29	41.20	1.0440	39.46	2.60	548	0.45	0.26	0.31								1,393.3	83.2	34.40	4,053.7
152		40.20	0.00	1.0443	38.49	2.66	0.485	0.20	0.30	38.20	1.0442	36.58	2.66	540	0.49	0.20	0.28								1,392.3	83.1	34.40	4,056.4
159		51.30	1.90	1.0350	47.73	2.09	0.003	0.08	1.49	41.50	1.0434	39.77	2.64	546	0.53	0.17	0.28	41.30	1.0419	39.64	2.00	0.003		1.86	1,413.3	84.4	34.40	3,996.3
167		46.10	9.00	1.0417	35.61	2.79	0.320	0.14	0.29	44.20	1.0415	42.44	2.82	537	0.34	0.16	0.23								1,416.1	84.6	34.40	3,988.3
173		43.80	0.70	1.0403	41.43	2.79	0.225	0.14	0.23	34.80	1.0399	33.46	2.79	517	0.22	0.14	0.23								1,414.0	84.4	34.40	3,994.3

COPPER COLUMN LEACH TEST DATA

Carmacks Project

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Day	COLUMN																	SX							Cu		H_2SO_4	
	Feed									PLS								Raffinate							Leached		Consumption	
	H_2SO_4 added* (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
180		42.20	0.00	1.0435	40.44	2.72	0.317	0.14	0.22	41.50	1.0421	39.82	2.71	541	0.33	0.13	0.22								1,414.3	84.4	34.40	3,993.4
187		49.50	43.60	1.0350	5.70	2.87	0.250	0.08		39.50	1.0443	37.82	2.82	529	0.33	0.10									1,425.2	85.1	34.40	3,963.0
188										6.80	1.0434	6.52	2.79	483	0.36	0.09									1,427.5	85.2	34.40	3,956.5
189										3.10		2.92													1,427.5	85.2	34.40	3,956.5
190										0.80		0.74																
191										0.41		0.40																
192										0.21		0.20																
193										0.22		0.13																
194										0.09		0.09																
195										0.04		0.04																
196										0.01		0.05																
197										0.00		0.03																
198										0.00		0.00																
199																												
200																												
201																												
202																												
203																												
204																												

Process Research Associates Ltd.

SIZE-ASSAY ANALYSIS REPORT

Client: Western Copper **Date:** 30-Jan-98
Project: 97-084

Sample: Carmacks Column C Head Sample

Size Fraction	Weight (%)	Assay (%)		Distribution (%)	
		$Cu_{(T)}$	$Cu^*_{(a.s.)}$	$Cu_{(T)}$	$Cu_{(a.s.)}$
-3/4 +1/2"	8.0	0.60	0.50	4.7	4.3
-1/2 +3/8"	17.0	0.72	0.66	12.1	12.2
-3/8 +1/4"	18.0	0.76	0.72	13.5	14.1
-1/4 +6 mesh	15.9	0.86	0.76	13.5	13.1
-6 mesh	41.1	1.38	1.26	56.1	56.3
Total	**100.0**	**1.01**	**0.92**	**100.0**	**100.0**

Sample: Carmacks Column C Final Residue

Size Fraction	Weight (%)	Assay (%)		Distribution (%)	
		$Cu_{(T)}$	$Cu^*_{(a.s.)}$	$Cu_{(T)}$	$Cu_{(a.s.)}$
-3/4 +1/2"	5.5	0.18	0.17	8.3	8.5
-1/2 +3/8"	13.5	0.12	0.12	13.6	14.9
-3/8 +1/4"	14.7	0.11	0.09	13.5	12.1
-1/4 +6 mesh	14.1	0.10	0.09	11.8	11.6
-6 mesh	52.3	0.12	0.11	52.7	52.8
Total	**100.0**	**0.12**	**0.11**	**100.0**	**100.0**

* Acid soluble (a.s.) copper assays were obtained by digesting 1 g sample in 50mL 10% H_2SO_4 at room temperature for 2 hours.

SIZE-ASSAY ANALYSIS REPORT

Test: SA3 **Date:** May 14, 1998
Sample: Carmacks Column C Top Residue **Project:** 97-084

Size Fraction	Weight (%)	Assay (%)		Distribution (%)	
		Cu	Fe	Cu	Fe
-3/4 +1/2"	4.1	0.080	3.45	4.9	5.0
-1/2" + 4 mesh	25.6	0.036	2.19	13.8	19.6
-4 +10 mesh	13.5	0.036	2.15	7.3	10.2
-10 +20 mesh	8.0	0.044	2.23	5.3	6.3
-20 mesh	48.8	0.094	3.45	68.7	59.0
Total	**100.0**	**0.067**	**2.85**	**100.0**	**100.0**

SIZE-ASSAY ANALYSIS REPORT

Test: SA1
Sample: Carmacks Head Sample

Date: December 24, 1997
Project: 97-084

Size Fraction	Weight (%)	Assay (%)		Distribution (%)	
		$Cu_{(T)}$	$Cu^{*}_{(acid\ soluble)}$	$Cu_{(T)}$	$Cu_{(acid\ soluble)}$
+12"	0.37	0.78	0.72	0.3	0.3
-12 +8"	0.53	0.78	0.72	0.4	0.4
-8 +6"	1.21	0.78	0.72	0.9	0.9
-6 +4"	4.40	0.780	0.720	3.3	3.4
-4 +2"	16.38	0.800	0.740	12.5	12.8
-2 +1"	14.33	0.820	0.740	11.2	11.2
-1 +1/2"	9.07	0.820	0.740	7.1	7.1
-1/2" +4 mesh	16.23	0.940	0.840	14.6	14.4
-4 +6 mesh	5.87	1.04	0.960	5.8	6.0
-6 +10 mesh	3.46	0.820	0.760	2.7	2.8
-10 +20 mesh	5.41	1.14	1.06	5.9	6.1
-20 mesh	22.75	1.62	1.50	35.2	36.2
Total	**100.00**	**1.05**	**0.94**	**100.0**	**101.6**

* Acid soluble copper assays were obtained by digesting 1 g sample in 50 mL 10% H_2SO_4 at room temperature for 2 hours.

** These fractions were not sampled for assay due to difficulties in sampling.

Process Research Associates Ltd.

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m³

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m²/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B									SX							Cu	H_2SO_4
		Feed									PLS			PLS									Raffinate							Leached	Consumption
		H_2SO_4 added*	Start Weight	End Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cu	Fe	pH	Weight	s.g.	Volume	pH	ORP	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cum. Weight	Cum. Extraction	Cum. vs. feed	Cum. vs. Cu
		(kg)	(kg)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g/L)	(g/L)		(kg)	(g/mL)	(L)		(mV**)	(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g)	(%)	(kg/t ore)	(kg/t Cu)
	Cure	111.04				472.1		0.00	0.00	235.21				19.70	1.3020	15.1	1.05		36.00	30.50	22.76								544.7	0.6	12.63	203,860.5
9-Feb-98	0	0.87	201.10	87.30	1.0053	113.2	1.35	0.00	0.00	7.70																			544.7	0.6	12.72	205,460.7
10-Feb-98	1	0.79	288.40	184.70	1.0053	103.2	1.35	0.00	0.00	7.70	20.0	20.5	1.68																544.7	0.6	12.82	206,918.9
11-Feb-98	2	0.70	184.70	93.10	1.0053	91.1	1.35	0.00	0.00	7.70	17.0	25.5	1.40	26.27	1.2570	20.9	2.41	375	43.5	16.0	16.85								1,453.7	1.6	12.89	78,014.9
12-Feb-98	3	0.79	103.20	0.00	1.0053	102.7	1.35	0.00	0.00	7.70	10.0	8.00	1.99	76.50	1.1953	64.0	1.99	398	26.0	14.0	17.67	87.00	1.1828	73.6	0.72	5.90	17.0	56.50	3,117.7	3.5	12.98	36,629.6
13-Feb-98	4		205.30	72.60	1.0209	130.0	1.39	0.83	2.67	7.85	6.60	3.50	2.06	72.50	1.1584	62.6	2.53	353	21.4	8.70	14.18	70.00	1.1256	62.2	0.60	2.80	8.70	41.92	4,349.2	4.9	12.98	26,258.0
14-Feb-98	5		205.30	116.50	1.0263	86.5	1.42			7.55	7.00	2.08	2.22	92.10	1.1252	81.9	2.91	298	19.60	5.14	12.06	89.20	1.0967	81.3	0.86	2.25	5.74	34.60	5,953.5	6.7	12.98	19,182.2
15-Feb-98	6		116.50	22.10	1.0263	92.0	1.42			7.55	7.00	2.08	2.22	105.00	1.0963	95.8	3.11	282	15.80	3.56	10.23	102.50	1.0723	95.6	0.94	1.39	3.76	29.30	7,466.8	8.4	12.98	15,294.6
16-Feb-98	7		205.60	91.00	1.0278	111.5	1.47	0.87	2.47	7.65	6.70	2.28	2.21	92.60	1.0951	84.6	3.31	261	16.40	3.17	10.11	91.60	1.0709	85.5	0.90	1.49	3.36	30.52	8,756.5	9.9	12.98	13,041.8
17-Feb-98	8		204.90	153.10	1.0246	50.6	1.68	0.70	1.98	7.45	6.10	2.47	2.14	80.90	1.0939	74.0	3.57	254	16.80	2.97	10.73	79.00	1.0680	74.0	0.85	0.98	2.97	31.23	9,963.6	11.2	12.98	11,461.8
18-Feb-98	9		153.70	55.50	1.0246	95.8	1.68			7.45	7.40	2.30	2.13	119.90	1.0776	111.3	3.34	250	14.00	2.40	8.01	117.50	1.0576	111.1	0.90	1.34	2.50	25.84	11,521.3	13.0	12.98	9,912.2
19-Feb-98	10		205.30	94.20	1.0263	108.3	1.37	0.67	2.00	8.63	6.60	2.30	2.27	61.20	1.0814	56.6	3.41	232	15.40	2.60	8.63	59.50	1.0587	56.2	0.95	0.35	2.50	28.32	12,320.3	13.9	12.98	9,269.3
20-Feb-98	11		205.10	101.70	1.0225	101.1	1.44	0.56	1.70	8.92	5.60	2.30	2.18	64.10	1.0832	59.2	3.55	189	15.30	2.30	11.00	62.40	1.0597	58.9	0.96	0.43	2.30	33.03	13,169.1	14.8	12.98	8,671.9
21-Feb-98	12	0.60	212.60	95.70	1.0258	114.0	1.35	0.61	1.60	11.47	5.20	2.10	2.21	86.60	1.0766	80.4	3.68	178	13.90	2.00	10.87	85.10	1.0543	80.7	1.00	0.69	2.00	30.52	14,217.6	16.0	13.05	8,074.5
22-Feb-98	13		204.60	76.80	1.0258	124.6	1.41	0.54	1.40	10.69	4.70	2.10	2.06	112.00	1.0635	105.3	3.71	202	11.20	1.70	9.98	109.80	1.0469	104.9	1.09	0.55	1.80	25.81	15,329.9	17.3	13.05	7,488.7
23-Feb-98	14		205.10	105.40	1.0254	97.2	1.32	0.51	1.39	10.54	4.20	2.08		105.60	1.0575	99.9	3.53	183	10.30	1.58	4.92	104.80	1.0416	100.6	0.94	0.16	0.13	23.92	16,308.8	18.4	13.05	7,039.2
24-Feb-98	15		105.40	0.00	1.0254	102.8	1.32			10.54	3.90	1.98	1.94	93.10	1.0527	88.4	3.52	287	12.30	1.98	9.21	91.40	1.0389	88.0	1.08	0.11	0.12	21.55	17,396.6	19.6	13.05	6,599.0
25-Feb-98	16		205.20	92.70	1.0260	109.6		0.52	1.19	11.32	3.30	1.78	1.73	131.20	1.0468	125.3	3.42	312	8.20	1.48	7.45	128.10	1.0362	123.6	1.10	0.18	0.12	19.73	18,367.4	20.7	13.05	6,250.3
26-Feb-98	17		205.20	98.90	1.0230	103.9	1.21	0.42	0.89	11.56	3.30	1.37	1.66	108.10	1.0465	103.3	3.24	299	7.50	1.15	8.25	107.30	1.0348	103.7	1.10	0.07		18.93	19,098.4	21.5	13.05	6,011.0
27-Feb-98	18		204.30	93.50	1.0213	108.5	1.22	0.36	0.92	11.61	3.50	1.50	1.91	80.10	1.0441	76.7	3.55	313	7.60	1.11	8.39	78.60	1.0340	76.0	1.09	0.04		19.76	19,642.4	22.1	13.05	5,844.5
28-Feb-98	19		204.50	95.20	1.0288	106.2	1.22	0.46	0.87	11.40	3.30	1.36	1.79	119.10	1.0427	114.2	3.57	313	7.10	1.01	7.31	117.30	1.0355	113.3	1.13	0.06		14.81	20,404.5	23.0	13.05	5,626.2
1-Mar-98	20		95.20	2.00	1.0228	91.1	1.22	0.00	0.00	11.40	3.00	1.29	1.88	98.00	1.0415	94.1	3.58	319	7.40	0.98	6.96	95.60	1.0310	92.7	1.23	0.05		15.20	21,100.8	23.8	13.05	5,440.6
2-Mar-98	21		205.00	81.10	1.0227	121.1	1.21	0.50	0.88	10.78	2.80	1.23	1.75	102.10	1.0403	98.1	3.70	307	7.00	0.97	6.59	100.70	1.0301	97.8	1.24	0.05		14.86	21,727.3	24.5	13.05	5,283.7
3-Mar-98	22		204.30	102.40	1.0218	99.7	1.18	0.28	0.90	11.47	2.60	1.31	1.72	115.10	1.0368	111.0	3.58	322	6.30	1.01	5.27	113.90	1.0286	110.7	1.22	0.05		13.34	22,398.7	25.2	13.05	5,125.3
4-Mar-98	23		204.10	79.20	1.0204	122.4	1.32	0.22	0.80	11.25	3.00	1.40	2.03	105.50	1.0367	101.8	3.75	309	5.90	1.02	5.39	104.30	1.0288	101.4	1.25	0.23		11.28	22,972.2	25.9	13.05	4,997.4
5-Mar-98	24		203.70	95.80	1.0181	106.0	1.24	0.23	0.69	9.96	2.90	1.35	1.99	108.21	1.0363	104.4	3.69	325	5.90	0.96	5.10	107.40	1.0261	104.7	1.21	0.23		11.14	23,563.9	26.5	13.05	4,871.9
6-Mar-98	25		205.40	85.60	1.0271	116.6	1.14	0.29	0.81	14.60	2.70	1.29	2.21	89.00	1.0360	85.9	3.50	316	5.80	0.91	5.12	86.90	1.0262	84.7	1.20	0.25		11.23	24,028.4	27.0	13.05	4,777.7
7-Mar-98	26		205.30	90.40	1.0264	111.9	1.20	0.32	0.92	14.44	2.50	1.30	1.98	97.70	1.0347	94.4	3.64	316	5.50	0.92	7.79	97.40	1.0269	94.8	1.39	0.20		10.73	24,511.9	27.6	13.05	4,683.5
8-Mar-98	27		205.50	76.90	1.0273	125.2	1.33	0.22	0.96	14.21	2.40	1.40	1.88	89.50	1.0347	86.5	3.73	306	5.30	0.93	7.55	89.30	1.0261	87.0	1.34	0.16		12.06	24,942.8	28.1	13.05	4,602.6
9-Mar-98	28		205.40	88.40	1.0280	113.8	1.21	0.14	0.97	15.45	2.30	1.55	1.90	105.60	1.0323	102.3	3.76	305	5.00	0.92	7.66	104.10	1.0242	101.6	1.37	0.17		11.88	25,438.3	28.6	13.05	4,512.9

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 $L/m^2/h$
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4
		Feed									PLS			PLS								Raffinate							Leached	Consumption
		H_2SO_4 added*	Start Weight	End Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cu	Fe	pH	Weight	s.g.	Volume	pH	ORP	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cum. Weight	Cum. Extraction	Cum. vs. feed	Cum. vs. Cu
		(kg)	(kg)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g/L)	(g/L)		(kg)	(g/mL)	(L)		(mV**)	(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g)	(%)	(kg/t ore)	(kg/t Cu)
10-Mar-98	29		205.30	117.70	1.0267	85.3	1.29	0.15	0.95	14.85	2.10	1.59	1.85	110.80	1.0324	107.3	3.76	307	4.80	0.96	7.57	110.70	1.0258	107.9	1.44	0.13		11.24	25,940.7	29.2	13.05	4,425.5
11-Mar-98	30		117.70	2.20	1.0267	112.5	1.29	0.15	0.95	14.85	2.05	1.67	1.87	129.70	1.0332	125.5	3.48	340	4.10	1.13	7.39	128.50	1.0256	125.3	1.53	0.087		10.58	26,438.5	29.8	13.05	4,342.2
12-Mar-98	31		201.90	80.40	1.0308	117.9	1.23	0.06	1.05	15.67	2.10	1.56	1.93	111.90	1.0336	108.3	3.25	354	4.20	1.05	7.33	110.00	1.0269	107.1	1.51	0.085		10.59	26,886.1	30.3	13.05	4,269.9
13-Mar-98	32		176.00	29.90	1.0310	141.7	1.38	0.06	1.09	16.06	2.35	1.66	2.18	104.70	1.0328	101.4	3.50	341	4.40	1.03	7.08	103.70	1.0264	101.0	1.58	0.077		10.42	27,323.7	30.8	13.05	4,201.5
14-Mar-98	33		205.70	108.60	1.0284	94.4	1.30	0.06	1.00	15.01	2.10	1.67	1.93	95.70	1.0338	92.6	3.35	343	4.40	1.07	7.05	95.10	1.0262	92.7	1.49	0.075		10.47	27,725.3	31.2	13.05	4,140.7
15-Mar-98	34		108.60	31.50	1.0284	75.0	1.30	0.06	1.00	15.01	1.95	1.73	1.91	98.90	1.0345	95.6	3.41	336	4.20	1.05	7.17	98.70	1.0326	95.6	1.41	0.086		10.90	28,122.3	31.7	13.05	4,082.2
16-Mar-98	35	0.34	211.30	110.80	1.0277	97.8	1.25	0.18	0.99	14.92	1.85	1.74	1.87	72.80	1.0350	70.3	3.59	324	4.60	1.03	7.18	71.80	1.0277	69.9	1.44	0.068		11.57	28,428.3	32.0	13.09	4,050.0
17-Mar-98	36	0.21	202.08	91.20	1.0279	107.9	1.19	0.21	0.98	14.19	1.60	1.74	1.78	140.50	1.0364	135.6	3.23	358	3.70	1.23	7.16	137.00	1.0308	132.9	1.43	0.086		10.48	28,907.2	32.5	13.11	3,990.0
18-Mar-98	37	0.37	205.60	125.60	1.0278	77.8	1.26	0.21	0.97	14.54	1.95	1.72	2.00	101.50	1.0366	97.9	3.34	348	3.90	1.20	7.18	100.40	1.0303	97.4	1.44	0.054		10.16	29,272.8	33.0	13.16	3,952.7
19-Mar-98	38		125.60	37.80	1.0278	85.4	1.26	0.21	0.97	14.54	2.45	1.66	2.19	95.40	1.0369	92.0	3.40	341	4.00	1.18	7.35	94.50	1.0304	91.7	1.42	0.053		10.18	29,622.8	33.3	13.16	3,906.0
20-Mar-98	39	0.63	198.08	87.20	1.0270	108.0	1.29	0.20	0.92	14.90	2.40	1.63	2.23	61.20	1.0366	59.0	3.47	330	4.20	1.13	6.91	60.70	1.0304	58.9	1.46	0.036		10.77	29,849.2	33.6	13.23	3,897.6
21-Mar-98	40	0.58	203.74	102.10	1.0267	99.0	1.27	0.19	0.97	15.26	1.90	1.89	1.87	53.80	1.0373	51.9	3.49	323	4.70	1.17	6.93	53.10	1.0295	51.6	1.34	0.038		11.23	30,074.2	33.9	13.29	3,887.9
22-Mar-98	41	0.52	200.00	134.80	1.0268	63.5	1.29	0.17	0.98	15.22	1.75	1.86	1.79	73.50	1.0374	70.9	3.56	317	4.50	1.21	7.09	72.80	1.0305	70.6	1.45	0.056		10.77	30,382.2	34.2	13.35	3,865.5
23-Mar-98	42		134.80	40.10	1.0268	92.2	1.29	0.17	0.98	15.22	2.20	1.74	1.86	101.00	1.0372	97.4	3.55	320	4.10	1.27	7.15	99.90	1.0306	96.9	1.47	0.051		10.39	30,765.8	34.6	13.35	3,817.3
24-Mar-98	43	0.93	200.00	98.80	1.0286	98.4	1.21	0.11	1.10	15.28	1.85	1.94	1.80	78.00	1.0372	75.2	3.53	317	4.20	1.24	6.78	77.10	1.0310	74.8	1.41	0.040		10.26	31,070.8	35.0	13.46	3,809.8
25-Mar-98	44	0.24	160.00	49.40	1.0283	107.6	1.23	0.10	1.09	14.84	1.80	1.85	1.86	81.40	1.0375	78.5	3.52	316	4.10	1.24	7.61	80.70	1.0314	78.2	1.41	0.036		10.18	31,381.7	35.3	13.49	3,779.6
26-Mar-98	45	0.51	160.00	51.60	1.0290	105.3	1.37	0.09	1.08	14.55	1.70	1.89	2.01	96.30	1.0372	92.8	3.56	317	3.90	1.24	7.42	95.30	1.0313	92.4	1.54	0.040		9.99	31,734.3	35.7	13.54	3,753.7
27-Mar-98	46	0.61	160.00	39.90	1.0290	116.7	1.36	0.09	1.12	15.12	1.70	2.01	1.99	86.10	1.0367	83.1	3.49	321	3.90	1.29	7.58	84.70	1.0314	82.1	1.57	0.04		9.81	32,047.7	36.1	13.61	3,736.0
28-Mar-98	47	0.68	208.80	105.60	1.0286	100.3	1.36	0.08	1.10	14.41	1.50	1.94	1.90	106.10	1.0355	102.5	3.43	372	3.40	1.34	6.07	104.10	1.0329	100.8	1.59	0.036		8.94	32,388.1	36.5	13.69	3,717.9
29-Mar-98	48		105.60	5.60	1.0286	97.2	1.36	0.08	1.10	14.41	1.50	1.89	1.83	101.80	1.0361	98.3	3.39	335	3.50	1.37	6.21	100.30	1.0314	97.2	1.42	0.036		9.06	32,724.2	36.8	13.69	3,679.7
30-Mar-98	49	0.82	160.00	48.50	1.0315	108.1	1.34	0.08	1.25	14.52	1.50	1.89	1.74	92.80	1.0363	89.5	3.37	333	3.40	1.37	6.29	92.10	1.0311	89.3	1.39	0.029		8.94	33,020.0	37.2	13.78	3,671.7
31-Mar-98	50	0.66	160.00	57.70	1.0340	98.9	1.12	0.06	1.24	15.15	1.40	1.95	1.75	105.60	1.0372	101.8	3.33	330	3.30	1.36	6.34	104.80	1.0325	101.5	1.42	0.028		8.98	33,350.1	37.5	13.86	3,655.2
1-Apr-98	51	0.62	206.40	12.90	1.0321	187.5	1.13	0.05	1.19	14.42	1.40	1.98	1.76	103.80	1.0376	100.0	3.25	338	3.20	1.38	6.54	103.20	1.0319	100.0	1.41	0.030		8.98	33,660.8	37.9	13.93	3,639.9
2-Apr-98	52	0.91	212.30	20.50	1.0324	185.8	1.32	0.05	1.16	14.10	0.85	1.78	1.60	119.70	1.0369	115.4	3.02	360	2.70	1.45	6.35	116.80	1.0322	113.2	1.58	0.031		8.47	33,963.2	38.2	14.03	3,634.3
3-Apr-98	53	1.03	216.10	22.10	1.0331	187.8	1.21	0.04	1.21	14.37	0.90	1.98	1.68	137.90	1.0550	130.7	2.65	370	2.50	1.60	8.01	137.30	1.0335	132.8	1.58	0.021		8.53	34,282.5	38.6	14.15	3,630.3
4-Apr-98	54	1.08	218.80	0.00	1.0328	211.9	1.19	0.04	1.25	14.66	0.60	1.75	1.41	163.40	1.0385	157.3	2.50	391	2.20	1.73	7.65	163.40	1.0340	158.0	1.54	0.018		8.45	34,620.2	39.0	14.27	3,626.1
5-Apr-98	55	1.39	216.10	3.00	1.0330	206.3	1.25	0.04	1.32	15.34	0.80	1.96		257.40	1.0384	247.9	2.45	385	2.00	1.86	8.01	254.90	1.0360	246.0	1.62	0.010			35,107.7	39.5	14.43	3,615.4
6-Apr-98	56	1.33	211.00	1.00	1.0355	202.8	1.24	0.03	1.32	14.70	0.68	1.81	1.47	220.90	1.0399	212.4	2.30	384	1.85	2.03	6.52	217.70	1.0363	210.1	1.54	0.008		8.09	35,494.6	40.0	14.58	3,613.5
7-Apr-98	57	1.24	221.90	26.30	1.0344	189.1	1.25	0.02	1.48	13.65	0.78	2.03	1.51	182.90	1.0398	175.9	2.23	383	2.00	2.08	6.90	176.20	1.0358	170.1	1.53			8.28	35,842.6	40.3	14.72	3,613.0
8-Apr-98	58	1.59	225.40	0.00	1.0372	217.3	1.25	0.02	1.58	14.96	0.71	1.94	1.51	191.80	1.0399	184.4	2.28	403	1.85	2.08	6.95	190.20	1.0382	183.2	1.68	0.008		8.66	36,179.4	40.7	14.91	3,623.4

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m³

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m²/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4
		Feed									PLS			PLS								Raffinate							Leached	Consumption
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
9-Apr-98	59	1.73	222.90	4.50	1.0398	210.0	1.24	0.01	1.80	15.03	0.68	2.14	1.52	189.20	1.0407	181.8	2.33	401	1.90	2.10	6.36	186.80	1.0376	180.0	1.61	0.008		8.32	36,522.3	41.1	15.10	3,636.7
10-Apr-98	60	1.70	231.20	0.00	1.0398	222.4	1.20	0.01	1.90	15.98	0.61	2.21	1.49	171.90	1.0413	165.1	2.03	404	1.90	2.15	7.65	171.50	1.0388	165.1	1.59	0.01		8.28	36,833.8	41.5	15.30	3,652.1
11-Apr-98	61	1.65	223.20	0.00	1.0415	214.3	1.30	0.01	1.90	15.13	0.70	2.36	1.51	291.70	1.0442	279.4	2.14	409	1.60	2.35	7.89	287.90	1.0421	276.3	1.56	0.008		8.66	37,278.8	42.0	15.48	3,652.7
12-Apr-98	62	1.65	216.90	0.00	1.0420	208.2	1.30	0.01	1.96	15.08	0.65	2.42	1.57	219.60	1.0452	210.1	2.23	407	1.75	2.45	7.75	219.00	1.0433	209.9	1.64	0.009		8.71	37,644.8	42.4	15.67	3,661.0
13-Apr-98	63	1.60	215.70	6.10	1.0429	201.0	1.32	0.01	1.95	14.65	0.50	2.27	1.51	214.70	1.0470	205.1	2.18	407	1.70	2.50	8.22	212.20	1.0440	203.3	1.57	0.009		8.85	37,991.6	42.8	15.85	3,669.7
14-Apr-98	64	1.65	217.10	0.00	1.0440	208.0	1.20	0.01	2.07	15.40	0.45	2.37	1.37	164.60	1.0470	157.2	2.13	407	1.70	2.52	7.84	163.70	1.0450	156.7	1.57	0.008			38,257.0	43.1	16.04	3,687.2
15-Apr-98	65	1.52	219.50	0.00	1.0446	210.1	1.16	0.01	2.23	15.13	0.59	2.67	1.45	239.30	1.0474	228.5	2.01	416	1.45	2.77	8.42	234.70	1.0458	224.4	1.56	0.007		9.07	38,586.4	43.4	16.21	3,695.2
16-Apr-98	66	0.31	219.00	0.00	1.0428	210.0	1.49	0.01	2.52	10.52	0.63	3.07	1.56	207.10	1.0487	197.5	2.13	409	1.65	2.92	8.42	206.00	1.0461	196.9	1.63	0.007		9.37	38,910.2	43.8	16.25	3,672.4
17-Apr-98	67		226.00	0.00	1.0438	216.5	1.60	0.03	2.57	10.38	0.64	3.02	1.67	252.40	1.0490	240.6	2.12	408	1.60	2.92	7.82	249.10	1.0464	238.1	1.72	0.009		8.71	39,288.2	44.2	16.25	3,637.0
18-Apr-98	68	0.27	224.40	15.40	1.0434	200.3	1.48	0.01	2.67	8.94	0.63	2.92	1.73	235.20	1.0490	224.2	2.23	400	1.90	2.77	7.57	234.90	1.0466	224.4	1.61	0.015		8.76	39,712.4	44.7	16.28	3,604.9
19-Apr-98	69		221.80	0.00	1.0405	213.2	1.63	0.01	2.73	9.18	0.47	2.73	1.74	196.60	1.0489	187.4	2.42	396	1.80	2.64	8.30	189.40	1.0465	181.0	1.64	0.010		9.18	40,047.9	45.1	16.28	3,574.7
20-Apr-98	70	0.19	209.80	16.60	1.0448	184.9	1.50	0.01	2.73	10.10	0.62	2.83	1.80	228.30	1.0485	217.7	2.36	399	1.50	2.78	8.35	227.90	1.0460	217.9	1.74	0.008		8.76	40,371.9	45.4	16.30	3,550.7
21-Apr-98	71	0.19	232.30	25.10	1.0459	198.1	1.57	0.02	2.78	10.49	0.52	2.88	1.80	187.80	1.0482	179.2	2.38	397	1.55	2.69	8.45	187.80	1.0455	179.6	1.75	0.008		8.74	40,646.6	45.8	16.32	3,531.5
22-Apr-98	72	0.16	237.70	12.20	1.0460	215.6	1.60	0.016	2.95	10.20	0.55	2.95	1.82	196.90	1.0485	187.8	2.27	399	1.30	2.74	8.68	193.90	1.0462	185.3	1.80	0.005		8.72	40,887.3	46.0	16.34	3,514.6
23-Apr-98	73	0.24	241.60	0.00	1.0455	231.1	1.61	0.022	2.74	10.14	0.50	3.00	1.86	178.00	1.0486	169.8	2.32	401	1.35	2.74	8.29	177.40	1.0466	169.5	1.74	0.005		8.58	41,111.4	46.3	16.37	3,501.2
24-Apr-98	74		220.40	0.00	1.0449	210.9	1.55	0.049	2.55	9.46	0.47	2.90	1.83	226.60	1.0489	216.0	2.36	402	1.30	2.65	8.46	221.80	1.0469	211.9	1.75	0.006		8.51	41,381.9	46.6	16.37	3,478.3
25-Apr-98	75	0.13	233.90	0.00	1.0483	223.1	1.57	0.073	2.90	9.60	0.45	2.80	1.77	244.40	1.0487	233.1	2.37	395	1.30	2.55	8.47	244.30	1.0473	233.3	1.71	0.006		8.38	41,668.6	46.9	16.38	3,457.4
26-Apr-98	76		212.90	16.50	1.0474	187.5	1.54	0.091	2.80		0.43	2.85	1.71	238.60	1.0496	227.3	2.36	411	1.30	2.50		236.70	1.0469	226.1	1.75	0.005		9.13	41,947.0	47.2	16.38	3,434.5
27-Apr-98	77		208.70	0.00	1.0478	199.2	1.59	0.106	2.75		0.43	2.90	1.74	190.10	1.0495	181.1	2.36	420	1.20	2.45		186.10	1.0467	177.8	1.82	0.005			42,143.3	47.4	16.38	3,418.5
28-Apr-98	78	0.09	232.00	0.00	1.0492	221.1	1.66	0.097	2.67		0.50	2.92	1.88	202.40	1.0498	192.8	2.38	418	1.20	2.42		200.20	1.0469	191.2	1.75	0.006			42,353.2	47.7	16.39	3,403.6
29-Apr-98	79		223.10	0.00	1.0505	212.4	1.54	0.170	2.67	10.30	0.49	2.82	1.83	226.10	1.0490	215.5	2.32	423	1.15	2.37	8.48	224.60	1.0465	214.6	1.65	0.004		9.13	42,565.0	47.9	16.39	3,386.7
30-Apr-98	80		244.70	0.00	1.0490	233.3	1.55	0.114	2.37	9.95	0.51	2.87	1.88	226.30	1.0494	215.6	2.28	425	1.15	2.32	8.33	225.20	1.0470	215.1	1.68	0.004		8.84	42,786.4	48.2	16.39	3,369.1
1-May-98	81	0.40	236.70	21.00	1.0460	206.2	1.62	0.010	2.37	8.98	0.54	2.82	1.88	216.70	1.0494	206.5	2.32	430	1.20	2.13	8.56	210.10	1.0480	200.5	1.73	0.004		9.37	43,032.1	48.4	16.44	3,359.2
2-May-98	82		254.60	18.80	1.0453	225.6	1.56	0.074	2.26	10.05	0.54	2.62	1.97	211.20	1.0503	201.1	2.35	429	1.27	2.06	8.59	191.00	1.0491	182.1	1.78	0.009		9.56	43,270.8	48.7	16.44	3,340.7
3-May-98	83	0.22	243.40	54.10	1.0470	180.8	1.65	0.006	2.21	Volume (L)	0.52	2.47	2.00	221.70	1.0496	211.2	2.52	432	1.46	1.70	8.78	220.10	1.0478	210.1	1.82	0.009		9.56	43,578.1	49.1	16.46	3,322.2
4-May-98	84		0.00	0.00	1.0000	0.0				174.9	0.51	2.32	2.03	174.90	1.0492	166.7	2.54	441	1.45	1.54	8.78	170.20	1.0468	162.6	1.82	0.009		9.78	43,819.8	49.3	16.46	3,303.8
5-May-98	85		0.00	0.00	1.0000	0.0				45.35	0.96	2.06	2.27	48.00	1.0498	45.7	2.96	413	1.90	1.13				#DIV/0!					43,906.7	49.4	16.46	3,297.3
6-May-98	86		0.00	0.00	1.0000	0.0				13.70	1.66	1.50	2.66	9.70	1.0533	9.2	3.20	375	2.50	0.60				#DIV/0!					43,929.7	49.5	16.46	3,295.6
7-May-98	87		0.00	0.00	1.0000	0.0				8.37	1.90	1.15	2.67	5.70	1.0547	5.4	3.13	380	2.80	0.65				#DIV/0!					43,944.8	49.5	16.46	3,294.4
8-May-98	88		0.00	0.00	1.0000	0.0				5.79	2.13	1.00	2.80	4.00	1.0578	3.8	3.18	379	3.00	0.70				#DIV/0!					43,956.2	49.5	16.46	3,293.6

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4	
		Feed									PLS			PLS								Raffinate							Leached	Consumption	
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
11-May-98	91		475.10	374.22	1.0445	96.6	1.63	0.017	1.85	10.14	0.85	2.10	1.79	6.80	1.0633	6.4	3.03	396	2.50	0.70	8.37	74.20	1.0482	70.8	1.73	0.011		11.04	43,970.5	49.5	16.46	3,292.5
12-May-98	92		374.22	273.72	1.0445	96.2	1.63	0.017	1.85	9.87	1.57	0.75	2.51	45.30	1.0503	43.1	2.98	401	2.60	0.75	7.27	44.80	1.0454	42.9	1.68	0.008		11.29	44,081.0	49.6	16.46	3,284.3
13-May-98	93		273.72	160.53	1.0445	108.4	1.63	0.017	1.85	9.87	1.17	0.95	2.36	216.40	1.0485	206.4	2.54	473	1.85	1.00		214.30	1.0461	204.9	1.78	0.009		10.20	44,461.0	50.1	16.46	3,256.2
14-May-98	94		160.53	48.53	1.0445	107.2	1.63	0.017	1.85	9.87	0.99	1.22	2.18	105.70	1.0495	100.7	2.82	456	1.98	0.71		104.80	1.0460	100.2	1.60	0.009		10.45	44,658.6	50.3	16.46	3,241.8
15-May-98	95		437.23	314.80	1.0481	116.8	1.63	0.009	1.88	9.80	0.87	1.37	2.03	89.70	1.0485	85.6	2.82	443	2.00	0.56		88.00	1.0453	84.2	1.68	0.005		10.51	44,828.6	50.5	16.46	3,229.5
16-May-98	96		314.80	203.92	1.0481	105.8	1.63	0.009	1.88	9.80	0.93	1.65	2.00	102.10	1.0483	97.4	2.86	554	2.09	0.26		101.20	1.0455	96.8	1.59	0.007		10.58	45,031.2	50.7	16.46	3,214.9
17-May-98	97		203.92	88.42	1.0481	110.2	1.63	0.009	1.88	9.80	0.76	1.40	2.12	98.30	1.0485	93.8	2.98	567	2.04	0.26		95.30	1.0450	91.2	1.54	0.007		10.49	45,221.5	50.9	16.46	3,201.4
18-May-98	98		88.42	0.00	1.0481	84.4	1.63	0.009	1.88	9.80	0.70	1.35	2.13	103.30	1.0483	98.5	2.98	524	1.96	0.29		100.70	1.0441	96.4	1.78	0.006		10.29	45,413.9	51.1	16.46	3,187.9
19-May-98	99		440.80	328.80	1.0471	107.0	1.63	0.011	1.30	9.81	0.70	1.25	2.08	95.70	1.0476	91.4	2.97	486	1.88	0.28		95.00	1.0446	90.9	1.78	0.011		10.50	45,584.4	51.3	16.46	3,175.9
20-May-98	100		328.80	212.15	1.0471	111.4	1.63	0.011	1.30	9.81	0.71	1.15	2.18	116.80	1.0476	111.5	2.91	488	1.68	0.34		110.00	1.0454	105.2	1.79	0.006		10.29	45,770.5	51.5	16.46	3,163.0
21-May-98	101		212.15	105.85	1.0471	101.5	1.63	0.011	1.30	9.81	0.69	1.02	2.29	98.80	1.0482	94.3	3.02	483	1.67	0.33		98.30	1.0454	94.0	1.80	0.003			45,926.8	51.7	16.46	3,152.3
22-May-98	102		424.95	277.10	1.0462	141.3	1.67	0.009	0.91		0.69	0.93	2.18	105.20	1.0487	100.3	2.88	489	1.65	0.32		100.20	1.0454	95.8	1.86	0.004			46,091.1	51.9	16.46	3,141.0
23-May-98	103		277.10	205.00	1.0462	68.9	1.67	0.009	0.91		0.80	1.06	2.20	112.10	1.0499	106.8	2.82	564	1.55	0.37		107.80	1.0470	103.0	1.85	0.005			46,255.9	52.1	16.46	3,129.8
24-May-98	104		205.00	68.70	1.0462	130.3	1.67	0.009	0.91		0.71	0.92	2.28	72.00	1.5050	47.8	2.67	531	1.33	0.48		71.90	1.0481	68.6	1.83	0.003			46,318.4	52.1	16.46	3,125.6
25-May-98	105		453.90	361.20	1.0455	88.7	1.82	0.009	0.38		0.63	0.80	2.33	130.10	1.0499	123.9	2.81	498	1.40	0.40		129.60	1.0479	123.7	1.88	0.004			46,491.1	52.3	16.46	3,114.0
26-May-98	106		361.20	249.20	1.0455	107.1	1.82	0.009	0.38		0.59	0.74	2.36	102.00	1.0497	97.2	2.76	509	1.27	0.40		100.30	1.0476	95.7	1.83	0.003			46,613.5	52.5	16.46	3,105.8
27-May-98	107		249.20	139.20	1.0455	105.2	1.82	0.009	0.38		0.54	0.68	2.33	100.10	1.0501	95.3	2.71	514	1.19	0.42		99.10	1.0490	94.5	1.91	0.002			46,726.0	52.6	16.46	3,098.3
28-May-98	108		139.20	28.20	1.0455	106.2	1.82	0.009	0.38		0.53	0.61	2.28	103.70	1.0487	98.9	2.83	530	1.32	0.30		103.50	1.0463	98.9	1.82	0.003			46,855.6	52.7	16.46	3,089.8
29-May-98	109		431.70	325.20	1.0447	101.9	1.69	0.007	0.26		0.51	0.58	2.25	94.50	1.0487	90.1	2.80	545	1.29	0.28		93.90	1.0457	89.8	1.68	0.003			46,971.1	52.9	16.46	3,082.2
30-May-98	110		325.20	191.20	1.0447	128.3	1.69	0.007	0.26		0.60	0.69	2.13	105.20	1.0484	100.3	2.73	566	1.19	0.27	8.73	104.80	1.0463	100.2	1.84	0.004		10.33	47,089.6	53.0	16.46	3,074.4
31-May-98	111		191.20	96.00	1.0447	91.1	1.69	0.007	0.26		0.53	0.52	2.16	106.30	1.0483	101.4	2.80	524	1.20	0.24	8.64	106.10	1.0460	101.4	1.86	0.002		10.31	47,210.7	53.1	16.46	3,066.5
1-Jun-98	112		96.00	2.00	1.0447	90.0	1.69	0.007	0.26		0.50	0.43	2.27	109.20	1.0480	104.2	2.77	503	1.13	0.25	8.47	108.40	1.0458	103.7	1.79	0.003		10.09	47,327.8	53.3	16.46	3,058.9
2-Jun-98	113		409.60	269.60	1.0456	133.9	1.81	0.005	0.31	10.63	0.46	0.41	2.29	92.20	1.0476	88.0	2.86	498	1.15	0.22	8.42	91.60	1.0455	87.6	1.81	0.002		10.02	47,428.3	53.4	16.46	3,052.5
3-Jun-98	114		269.60	154.60	1.0456	110.0	1.81	0.005	0.31	10.63	0.39	0.43	2.16	110.70	1.0473	105.7	2.75	522	1.10	0.21	8.27	108.50	1.0469	103.6	1.82	0.002		10.09	47,544.1	53.5	16.46	3,045.0
4-Jun-98	115		154.60	15.00	1.0456	133.5	1.81	0.005	0.31	10.63	0.38	0.41	2.19	144.50	1.0473	138.0	2.69	532	1.03	0.23	8.42	144.10	1.0453	137.9	1.86	0.002		10.33	47,685.5	53.7	16.46	3,036.0
5-Jun-98	116		416.30	277.30	1.0455	133.0	1.73	0.004	0.25	10.49	0.41	0.40	2.18	141.30	1.0479	134.8	2.70	522	1.01	0.21	8.27	140.50	1.0458	134.3	1.88	0.002		9.96	47,821.2	53.8	16.46	3,027.4
6-Jun-98	117		277.30	168.30	1.0455	104.3	1.73	0.004	0.25	10.49	0.48	0.44	2.17	130.30	1.0479	124.3	2.74	552	1.01	0.20	8.29	130.30	1.0460	124.6	1.84	0.003		9.93	47,946.3	54.0	16.46	3,019.5
7-Jun-98	118		168.30	30.30	1.0455	132.0	1.73	0.004	0.25	10.49	0.44	0.42	2.10	121.80	1.0485	116.2	2.77	528	0.99	0.19	8.37	121.40	1.0461	116.1	1.87	0.002		10.03	48,060.8	54.1	16.46	3,012.3
8-Jun-98	119		445.90	330.40	1.0451	110.5	1.78	0.003	0.15	10.49	0.37	0.33	2.13	124.90	1.0478	119.2	2.79	510	1.00	0.17	8.34	124.50	1.0460	119.0	1.86	0.002		9.95	48,179.7	54.2	16.46	3,004.9
9-Jun-98	120		330.40	224.40	1.0451	101.4	1.78	0.003	0.15	10.49	0.43	0.31	2.28	128.60	1.0479	122.7	2.83	507	1.00	0.16	8.40	128.40	1.0462	122.7	1.87	0.002		10.09	48,302.1	54.4	16.46	2,997.2

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4
		Feed									PLS			PLS								Raffinate							Leached	Consumption
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
10-Jun-98	121		224.40	103.10	1.0451	116.1	1.78	0.003	0.15	10.49	0.50	0.28	2.34	129.30	1.0489	123.3	2.72	516	0.89	0.20	8.84	126.30	1.0468	120.7	1.87	0.002		10.44	48,411.5	54.5	16.46	2,990.5
11-Jun-98	122		103.10	0.30	1.0451	98.4	1.78	0.003	0.15	10.49	0.42	0.27	2.20	84.40	1.0489	80.5	2.79	501	0.95	0.17	8.79	83.60	1.0469	79.9	1.88	0.002		10.35	48,487.6	54.6	16.46	2,985.8
12-Jun-98	123		415.20	306.20	1.0454	104.3	1.80	0.003	0.13	10.43	0.38	0.25	2.17	94.90	1.0488	90.5	2.77	511	0.92	0.17	8.60	93.50	1.0471	89.3	1.89	0.003		10.43	48,570.5	54.7	16.46	2,980.7
13-Jun-98	124		306.20	195.20	1.0454	106.2	1.80	0.003	0.13	10.43	0.53	0.27	2.16	89.60	1.0499	85.3	2.71	514	0.89	0.16	8.84	89.20	1.0487	85.1	1.90	0.003		10.34	48,646.2	54.8	16.46	2,976.0
14-Jun-98	125		195.20	88.00	1.0454	102.5	1.80	0.003	0.13	10.43	0.53	0.26	2.38	91.80	1.0502	87.4	2.69	524	0.81	0.17	8.71	90.90	1.0485	86.7	1.90	0.002		10.29	48,716.7	54.8	16.46	2,971.7
15-Jun-98	126		462.30	369.90	1.0468	88.3	1.82	0.002	0.10	10.46	0.45	0.23	2.33	104.50	1.0497	99.6	2.63	511	0.81	0.17	8.68	103.70	1.0480	99.0	1.87	0.002		10.30	48,797.1	54.9	16.46	2,966.8
16-Jun-98	127		369.90	258.90	1.0468	106.0	1.82	0.002	0.10	10.46	0.43	0.22	2.45	106.80	1.0494	101.8	2.86	505	0.93	0.14	8.53	106.00	1.0473	101.2	1.89	0.002		10.01	48,891.6	55.0	16.46	2,961.1
17-Jun-98	128		258.90	128.90	1.0468	124.2	1.82	0.002	0.10	10.46	0.40	0.22	2.38	97.50	1.0496	92.9	2.87	491	0.97	0.13	8.49	96.90	1.0482	92.4	1.89	0.002		9.96	48,981.4	55.1	16.46	2,955.7
18-Jun-98	129		128.90	50.00	1.0468	75.4	1.82	0.002	0.10	10.46	0.40	0.22	2.36	110.30	1.0497	105.1	2.86	493	0.92	0.12	9.35	109.60	1.0481	104.6	1.91	0.002		10.21	49,077.9	55.2	16.46	2,949.9
19-Jun-98	130		442.60	273.80	1.0478	161.1	1.88	0.002	0.09	10.89	0.38	0.21	2.40	117.10	1.0499	111.5	2.84	486	0.87	0.13	9.34	116.80	1.0484	111.4	1.89	0.001		10.11	49,174.7	55.4	16.46	2,944.1
20-Jun-98	131		273.80	150.00	1.0478	118.2	2.29	0.002	0.09	10.89	0.39	0.21	2.28	108.00	1.0500	102.9	2.86	511	0.84	0.12	9.32	107.30	1.0482	102.4	1.93	0.002		10.26	49,260.8	55.5	16.46	2,938.9
21-Jun-98	132		150.00	59.30	1.0478	86.6	2.34	0.002	0.09	10.89	0.37	0.20	2.29	140.40	1.0495	133.8	2.76	493	0.80	0.13	9.52	140.20	1.0479	133.8	1.96	0.002		10.40	49,367.7	55.6	16.46	2,932.5
22-Jun-98	133		456.80	368.70	1.0474	84.1	1.88	0.002	0.07	10.81	0.35	0.19	2.34	110.20	1.0491	105.0	2.68	499	0.73	0.14	9.12	108.50	1.0483	103.5	1.95	0.002		10.15	49,444.2	55.7	16.46	2,928.0
23-Jun-98	134		368.70	260.10	1.0474	103.7	1.88	0.002		10.81	0.36	0.19	2.37	81.20	1.0499	77.3	2.75	497	0.76	0.13	9.24	80.70	1.0488	76.9	1.90	0.002		9.95	49,502.4	55.7	16.46	2,924.6
24-Jun-98	135		260.10	147.10	1.0474	107.9	1.88	0.004		10.81	0.37	0.18	2.35	84.30	1.0508	80.2	2.81	489	0.82	0.11	9.16	84.10	1.0499	80.1	1.89	0.002		11.45	49,567.3	55.8	16.46	2,920.7
25-Jun-98	136		147.10	37.90	1.0474	104.3	1.88	0.002		10.81	0.37	0.17	2.52	92.20	1.0509	87.7	2.86	488	0.72	0.12	9.24	92.10	1.0494	87.8	2.03	0.002		9.92	49,629.8	55.9	16.46	2,917.1
26-Jun-98	137		452.30	357.60	1.0485	90.3	2.02	0.002		10.50	0.34	0.17	2.57	92.00	1.0506	87.6	2.91	483	0.71	0.12	9.21	91.30	1.0492	87.0	2.03	0.002		9.94	49,691.8	55.9	16.46	2,913.4
27-Jun-98	138		357.60	172.80	1.0485	176.3	2.02	0.001		10.50	0.43	0.22	2.38	94.80	1.0506	90.2	2.93	518	0.76	0.11	8.75	93.90	1.0492	89.5	2.04	0.002		10.31	49,759.8	56.0	16.46	2,909.4
28-Jun-98	139		172.80	106.50	1.0485	63.2	2.02	0.002		10.50	0.34	0.17	2.49	91.20	1.0512	86.8	3.02	487	0.79	1.02	8.78	90.50	1.0493	86.2	2.02	0.002		10.01	49,827.8	56.1	16.46	2,905.5
29-Jun-98	140		106.50	17.60	1.0485	84.8	2.02	0.002		10.50	0.33	0.17	2.44	95.20	1.0500	90.7	2.88	486	0.73	0.11	8.78	94.50	1.0490	90.1	2.02	0.002		9.97	49,893.3	56.2	16.46	2,901.7
30-Jun-98	141		442.50	327.00	1.0481	110.2	1.90	0.002	0.07	10.72	0.33	0.17	2.47	56.90	1.0508	54.1	3.13	455	0.93	0.07	8.64	56.80	1.0486	54.2	1.99	0.002		10.22	49,943.2	56.2	16.46	2,898.8
1-Jul-98	142		327.00	232.30	1.0481	90.4	1.90	0.002	0.07	10.72	0.37	0.18	2.47	110.30	1.0510	104.9	3.06	479	0.88	0.08	8.82	109.90	1.0493	104.7	2.07	0.002		9.70	50,034.8	56.3	16.46	2,893.4
2-Jul-98	143		232.30	133.00	1.0481	94.7	1.90	0.002	0.07	10.72	0.34	0.17	2.49	89.80	1.0511	85.4	3.08	468	0.86	0.08	8.69	89.30	1.0496	85.1	2.00	0.002		9.83	50,108.1	56.4	16.46	2,889.2
3-Jul-98	144		408.70	288.70	1.0490	114.4	2.00	0.002	0.06	10.22	0.36	0.17	2.51	97.70	1.0511	93.0	3.03	469	0.85	0.09	8.79	97.00	1.0485	92.5	2.02	0.002		9.98	50,186.4	56.5	16.46	2,884.7
4-Jul-98	145		288.70	243.70	1.0490	42.9	2.00	0.002	0.06	10.22	0.44	0.19	2.53	99.20	1.0522	94.3	3.16	472	0.89	0.08	8.89	99.10	1.0506	94.3	2.08	0.001		10.08	50,269.8	56.6	16.46	2,879.9
5-Jul-98	146		243.70	121.30	1.0490	116.7	2.00	0.002	0.06	10.22	0.40	0.16	2.62	58.70	1.0529	55.8	3.24	448	0.92	0.07	8.79	58.20	1.0514	55.4	2.06	0.001		10.17	50,320.6	56.6	16.46	2,877.0
6-Jul-98	147		121.30	26.60	1.0490	90.3	2.00	0.002	0.06	10.22	0.34	0.14	2.57	63.60	1.0525	60.4	3.19	449	0.88	0.07	8.79	62.70	1.0523	59.6	2.07	0.002		10.22	50,373.6	56.7	16.46	2,874.0
7-Jul-98	148		474.10	367.80	1.0497	101.3	2.04	0.002	0.04	10.12	0.33	0.14	2.54	113.60	1.0516	108.0	2.96	455	0.72	0.09	8.99	112.80	1.0509	107.3	2.08	0.002		9.93	50,451.1	56.8	16.46	2,869.6
8-Jul-98	149		367.80	256.80	1.0497	105.7	2.04	0.002	0.04	10.12	0.30	0.15	2.51	130.40	1.0519	124.0	2.96	455	0.70	0.09	0.00	129.80	1.0498	123.6	2.08	0.001		1.21	50,537.1	56.9	16.46	2,864.7
9-Jul-98	150		256.80	145.80	1.0497	105.7	2.04	0.002	0.04	10.12	0.30	0.15	2.51	131.50	1.0509	125.1	2.95	493	0.69	0.09	0.00	129.90	1.0507	123.6	2.07	0.001		1.26	50,623.2	57.0	16.46	2,859.8

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX Raffinate							Cu Leached		H_2SO_4 Consumption	
		Feed									PLS			PLS																			
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
10-Jul-98	151		478.60	358.60	1.0501	114.3	2.05	0.002	0.04	2.89	0.34	0.14	2.58	123.60	1.0521	117.5	3.02	458	0.75	0.08	0.00	111.90	1.0508	106.5	2.08	0.001		1.26	50,711.1	57.1	16.46	2,854.9
11-Jul-98	152		358.60	247.60	1.0501	105.7	2.05	0.002	0.04	2.89	0.39	0.16	2.54	121.80	1.0538	115.6	3.12	489	0.74	0.08	0.00	121.60	1.0521	115.6	2.12	0.001		1.21	50,796.4	57.2	16.46	2,850.1
12-Jul-98	153		247.60	117.60	1.0501	123.8	2.05	0.002	0.04	2.89	0.35	0.14	2.63	94.10	1.0536	89.3	3.15	456	0.76	0.08	0.00	93.30	1.0521	88.7	2.10	0.001		1.26	50,864.0	57.3	16.46	2,846.3
13-Jul-98	154		117.60	11.30	1.0501	101.2	2.05	0.002	0.04	2.89	0.34	0.13	2.62	97.30	1.0537	92.3	3.14	458	0.76	0.07	0.00	96.80	1.0527	92.0	2.16	0.001		1.26	50,933.6	57.3	16.46	2,842.4
14-Jul-98	155		382.90	295.10	1.0509	83.5	2.13	0.002	0.04	1.40	0.28	0.13	2.65	208.50	1.0535	197.9	3.11	461	0.69	0.08	0.00	108.00	1.0524	102.6	2.15	0.001		1.21	51,069.0	57.5	16.46	2,834.9
15-Jul-98	156		295.10	181.90	1.0509	107.7	2.13	0.002	0.04	1.40	0.30	0.13	2.68	98.00	1.0532	93.0	3.12	461	0.66	0.08	0.00	97.40	1.0525	92.5	2.16	0.001		1.21	51,130.2	57.6	16.46	2,831.5
16-Jul-98	157		181.90	64.10	1.0509	112.1	2.13	0.002	0.04	1.40	0.26	0.11	2.58	110.00	1.0536	104.4	3.06	454	0.62	0.08	0.00	107.00	1.0520	101.7	2.15	0.001		1.16	51,194.1	57.6	16.46	2,827.9
17-Jul-98	158		483.80	368.30	1.0515	109.8	2.15	0.002	0.04	1.35	0.24	0.12	2.54	104.00	1.0533	98.7	3.03	460	0.60	0.08	0.00	103.10	1.0524	98.0	2.22	0.001		1.07	51,253.2	57.7	16.46	2,824.7
18-Jul-98	159		368.30	257.30	1.0515	105.6	2.15	0.002	0.04	1.35	0.31	0.14	2.51	130.00	1.0544	123.3	2.91	483	0.51	0.09	0.05	128.10	1.0529	121.7	2.22	0.001		1.02	51,315.8	57.8	16.46	2,821.2
19-Jul-98	160		257.30	144.30	1.0515	107.5	2.15	0.002	0.04	1.35	0.29	0.13	2.53	108.90	1.0545	103.3	2.87	517	0.48	0.09	0.11	108.10	1.0534	102.6	2.15	0.001		1.12	51,364.7	57.8	16.46	2,818.5
20-Jul-98	161		144.30	42.30	1.0515	97.0	2.15	0.002	0.04	1.35	0.24	0.11	2.53	109.40	1.0533	103.9	2.84	479	0.47	0.09	0.12	108.30	1.0535	102.8	2.16	0.001		1.10	51,413.3	57.9	16.46	2,815.9
21-Jul-98	162		477.90	385.50	1.0520	87.8	2.16	0.001	0.03	1.10	0.25	0.11	2.55	96.30	1.0542	91.3	2.83	470	0.45	0.09	0.18	95.50	1.0532	90.7	2.18	0.001		1.15	51,454.3	57.9	16.46	2,813.6
22-Jul-98	163		385.50	267.70	1.0520	112.0	2.16	0.001	0.03	1.10	0.25	0.11	2.56	118.30	1.0538	112.3	2.86	498	0.49	0.09	0.10	117.30	1.0529	111.4	2.24	0.001		1.16	51,509.0	58.0	16.46	2,810.6
23-Jul-98	164	3.54	487.80	389.80	1.0577	92.7	1.39	0.002	0.03	9.18	0.26	0.11	2.58	96.30	1.0538	91.4	2.89	473	0.53	0.09	0.07	95.10	1.0527	90.3	2.18	0.001		1.27	51,556.8	58.0	16.86	2,876.6
24-Jul-98	165		389.80	264.50	1.0577	118.5	1.39	0.002	0.03	9.18	0.29	0.11	2.58	112.00	1.0540	106.3	2.85	477	0.49	0.08	0.11	111.30	1.0533	105.7	2.16	0.001		1.40	51,608.5	58.1	16.86	2,873.7
25-Jul-98	166		264.50	120.50	1.0577	136.1	1.39	0.002	0.03	9.18	0.35	0.20	2.38	99.90	1.0553	94.7	2.96	473	0.61	0.06	0.00	99.20	1.0536	94.2	2.17	0.001		1.26	51,666.0	58.2	16.86	2,870.5
26-Jul-98	167		120.50	0.00	1.0577	113.9	1.39	0.002	0.03	9.18	0.33	0.30	2.23	109.30	1.0550	103.6	2.97	468	0.62	0.07	0.00	108.80	1.0537	103.3	2.21	0.001		1.21	51,730.1	58.2	16.86	2,867.0
27-Jul-98	168	4.53	467.07	360.77	1.0597	100.3	1.34	0.001	0.02	11.37	0.29	0.34	2.15	119.90	1.0653	112.6	2.89	473	0.61	0.09	0.05	119.30	1.0547	113.1	2.19	0.001		1.40	51,798.4	58.3	17.38	2,950.7
28-Jul-98	169		360.77	270.70	1.0597	85.0	1.34	0.001	0.02	11.37	0.30	0.47	2.04	109.80	1.0571	103.9	2.84	492	0.62	0.14	0.09	108.70	1.0555	103.0	2.15	0.001		1.49	51,862.2	58.4	17.38	2,947.0
29-Jul-98	170		270.70	159.70	1.0597	104.7	1.34	0.001	0.02	11.37	0.30	0.50	1.95	101.90	1.0578	96.3	2.83	480	0.66	0.13	0.05	101.50	1.0564	96.1	2.15	0.002		1.40	51,925.7	58.5	17.38	2,943.4
30-Jul-98	171		159.50	48.50	1.0597	104.7	1.34	0.001	0.02	11.37	0.35	0.54	2.11	91.10	1.0594	86.0	2.87	472	0.70	0.14	0.00	91.00	1.0594	85.9	2.12	0.002		1.54	51,985.8	58.5	17.38	2,940.0
31-Jul-98	172	3.32	508.00	404.00	1.0602	98.1	1.34	0.002	0.04	8.67	0.39	0.55	2.15	105.90	1.0623	99.7	2.86	478	0.72	0.15	0.07	105.60	1.0613	99.5	2.08	0.002		1.58	52,056.9	58.6	17.76	2,999.8
1-Aug-98	173		404.00	288.50	1.0602	108.9	1.34	0.002	0.04	8.67	0.50	0.69	1.94	93.10	1.0630	87.6	2.95	541	0.73	0.15	0.05	92.00	1.0622	86.6	2.16	0.003		1.66	52,120.3	58.7	17.76	2,996.1
2-Aug-98	174		288.50	173.00	1.0602	108.9	1.34	0.002	0.04	8.67	0.56	0.69	2.09	84.60	1.0671	79.3	2.95	516	0.76	0.18	0.06	83.90	1.0642	78.8	2.37	0.002		1.56	52,180.3	58.7	17.76	2,992.7
3-Aug-98	175		173.00	45.90	1.0602	119.9	1.34	0.002	0.04	8.67	0.46	0.61	2.21	91.00	1.0669	85.3	2.91	535	0.75	0.18	0.10	90.20	1.0654	84.7	2.18	0.002		1.96	52,244.1	58.8	17.76	2,989.0
4-Aug-98	176	3.23	456.60	278.80	1.0660	166.8	1.70	0.002	0.05	9.69	0.39	0.49	2.29	91.40	1.0665	85.7	2.92	496	0.77	0.18	0.06	90.30	1.0664	84.7	2.21	0.002		1.75	52,309.8	58.9	18.12	3,047.0
5-Aug-98	177		378.80	273.00	1.0660	99.2	1.70	0.002	0.05	9.69	0.38	0.46	2.28	94.50	1.0673	88.5	2.74	513	0.67	0.26	0.33	92.10	1.0665	86.4	2.17	0.003		1.74	52,368.9	59.0	18.12	3,043.6
6-Aug-98	178		273.00	162.00	1.0660	104.1	1.70	0.002	0.05	9.69	0.36	0.47	1.93	91.80	1.0682	85.9	2.60	530	0.72	0.27	0.31	91.20	1.0670	85.5	1.98	0.003		2.08	52,430.6	59.0	18.12	3,040.0
7-Aug-98	179	2.36	471.40	360.40	1.0687	103.9	1.29	0.003	0.08	9.55	0.43	0.44	2.20	85.20	1.0687	79.7	2.82	438	0.81	0.19	0.06	84.70	1.0677	79.3	2.12	0.003		1.68	52,494.5	59.1	18.39	3,081.3
8-Aug-98	180		360.40	237.90	1.0687	114.6	1.29	0.003	0.08	9.55	0.51	0.74	2.12	88.80	1.0719	82.8	2.75	521	0.81	0.21	0.17	87.20	1.0694	81.5	2.13	0.002		1.90	52,561.3	59.2	18.39	3,077.4

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4	
		Feed									PLS			PLS								Raffinate							Leached	Consumption	
		H_2SO_4 added*	Start Weight	End Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cu	Fe	pH	Weight	s.g.	Volume	pH	ORP	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cum. Weight	Cum. Extraction	Cum. vs. feed	Cum. vs. Cu
		(kg)	(kg)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g/L)	(g/L)		(kg)	(g/mL)	(L)		(mV**)	(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g)	(%)	(kg/t ore)	(kg/t Cu)
9-Aug-98	181		237.90	120.10	1.0687	110.2	1.29	0.003	0.08	9.55	0.42	0.72	2.07	93.60	1.0722	87.3	2.82	510	0.80	0.22	0.12	91.60	1.0708	85.5	2.19	0.002		1.71	52,630.9	59.2	18.39	3,073.3
10-Aug-98	182		120.10	7.00	1.0687	105.8	1.29	0.003	0.08	9.55	0.35	0.64	2.16	86.80	1.0713	81.0	2.96	494	0.81	0.20	0.05	96.20	1.0689	90.0	2.16	0.002		1.75	52,696.2	59.3	18.39	3,069.5
11-Aug-98	183	3.33	424.40	332.00	1.0718	86.2	1.43	0.002	0.09	9.92	0.35	0.64	2.06	102.80	1.0719	95.9	2.72	506	0.75	0.28	0.11	102.20	1.0697	95.5	2.05	0.002		1.71	52,768.0	59.4	18.77	3,128.3
12-Aug-98	184		332.00	218.80	1.0718	105.6	1.43	0.002	0.09	9.92	0.38	0.69	2.05	134.00	1.0733	124.8	2.58	524	0.71	0.34	0.28	132.60	1.0717	123.7	1.93	0.002		2.05	52,856.4	59.5	18.77	3,123.1
13-Aug-98	185		218.80	117.20	1.0718	94.8	1.43	0.002	0.09	9.92	0.33	0.68	1.95	105.60	1.0736	98.4	2.82	530	0.87	0.22	0.07	105.10	1.0711	98.1	2.10	0.004		1.66	52,941.3	59.6	18.77	3,118.1
14-Aug-98	186	2.73	459.80	321.20	1.0748	129.0	1.33	0.002	0.10	9.78	0.32	0.69	1.89	104.30	1.0745	97.1	2.75	538	0.78	0.25	0.11	103.40	1.0729	96.4	2.00	0.002		2.32	53,016.3	59.7	19.08	3,165.1
15-Aug-98	187		321.20	208.00	1.0748	105.3	1.33	0.002	0.10	9.78	0.36	0.79	1.67	119.70	1.0780	111.0	2.68	524	0.78	0.28	0.15	118.00	1.0755	109.7	2.01	0.003		1.72	53,102.1	59.8	19.08	3,160.0
16-Aug-98	188		208.00	108.60	1.0748	92.5	1.33	0.002	0.10	9.78	0.33	0.69	1.70	110.00	1.0784	102.0	2.65	541	0.76	0.30	0.22	107.00	1.0770	99.4	2.03	0.003		1.71	53,179.5	59.9	19.08	3,155.4
17-Aug-98	189		108.60	0.00	1.0748	101.0	1.33	0.002	0.10	9.78	0.36	0.66	1.75	111.00	1.0795	102.8	2.63	533	0.73	0.32		110.40	1.0771	102.5	1.98	0.003		2.05	53,253.8	60.0	19.08	3,151.0
18-Aug-98	190	3.43	438.80	332.70	1.0816	98.1	1.30	0.002	0.10	9.90	0.33	0.71	1.93	96.40	1.0803	89.2	2.68	524	0.71	0.33		95.10	1.0780	88.2	2.02	0.002		1.86	53,317.0	60.0	19.47	3,211.7
19-Aug-98	191		332.70	208.00	1.0816	115.3	1.30	0.002	0.10	9.90	0.32	0.70	1.81	91.50	1.0814	84.6	2.69	537	0.70	0.33	0.20	91.00	1.0788	84.4	2.00	0.003		2.05	53,376.0	60.1	19.47	3,208.1
20-Aug-98	192		208.00	106.40	1.0816	93.9	1.30	0.002	0.10	9.90	0.30	0.68	1.87	75.70	1.0825	69.9	2.76	534	0.69	0.33	0.21	74.00	1.0812	68.4	2.02	0.003		2.33	53,424.0	60.1	19.47	3,205.3
21-Aug-98	193	3.37	489.20	371.40	1.0843	108.6	1.31	0.003	0.20	10.46	0.29	0.70	1.87	142.30	1.0832	131.4	2.47	554	0.61	0.46	0.61	138.20	1.0806	127.9	2.02	0.003		2.28	53,503.9	60.2	19.85	3,263.4
22-Aug-98	194		371.40	260.40	1.0843	102.4	1.31	0.003	0.20	10.46	0.37	0.86	1.81	119.70	1.0854	110.3	2.43	546	0.65	0.45	0.70	119.60	1.0842	110.3	1.96	0.003		2.45	53,574.8	60.3	19.85	3,259.1
23-Aug-98	195		260.40	149.40	1.0843	102.4	1.31	0.003	0.20	10.46	0.35	0.87	1.83	114.20	1.0864	105.1	2.38	555	0.61	0.50	0.84	111.80	1.0840	103.1	1.99	0.004		2.33	53,638.7	60.4	19.85	3,255.2
24-Aug-98	196		149.40	38.00	1.0843	102.7	1.31	0.003	0.20	10.46	0.33	0.76	1.95	112.90	1.0866	103.9	2.26	554	0.54	0.57	1.14	112.50	1.0849	103.7	1.88	0.003		2.85	53,694.5	60.4	19.85	3,251.8
25-Aug-98	197	3.31	488.70	378.20	1.0879	101.6	1.31	0.003	0.35	10.11	0.32	0.75	1.88	107.50	1.0883	98.8	2.22	548	0.53	0.61	1.30	106.80	1.0867	98.3	1.93	0.003		2.79	53,746.6	60.5	20.23	3,310.2
26-Aug-98	198		378.20	262.60	1.0879	106.3	1.31	0.003	0.35	10.11	0.28	0.79	1.69	106.00	1.0890	97.3	2.16	555	0.53	0.68	1.53	104.70	1.0870	96.3	1.85	0.003		3.49	53,797.8	60.6	20.23	3,307.1
27-Aug-98	199		262.60	141.80	1.0879	111.0	1.31	0.003	0.35	10.11	0.26	0.77	1.67	97.10	1.0896	89.1	2.17	558	0.60	0.59	1.96	97.00	1.0887	89.1	1.87	0.003		3.49	53,851.0	60.6	20.23	3,303.8
28-Aug-98	200	2.97	531.30	434.30	1.0771	90.1	1.33	0.003	0.32	10.15	0.34	0.82	1.88	108.10	1.0902	99.2	2.26	556	0.67	0.55	1.58	107.80	1.0875	99.1	1.87	0.002		3.20	53,917.2	60.7	20.57	3,354.9
29-Aug-98	201		434.30	294.80	1.0771	129.5	1.33	0.003	0.32	10.15	0.40	1.06	1.90	87.60	1.0910	80.3	2.46	556	0.72	0.52	0.45	87.30	1.0906	80.0	1.92	0.025		2.58	53,974.3	60.8	20.57	3,351.3
30-Aug-98	202		294.80	180.30	1.0771	106.3	1.33	0.003	0.32	10.15	0.44	0.93	2.03	97.60	1.0922	89.4	2.59	554	0.77	0.50	0.33	94.80	1.0917	86.8	2.04	0.002		2.11	54,042.3	60.8	20.57	3,347.1
31-Aug-98	203		180.30	31.00	1.0771	138.6	1.33	0.003	0.32	10.15	0.35	0.93	1.94	61.90	1.0937	56.6	2.61	564	0.80	0.48	0.31	60.50	1.0932	55.3	1.91	0.003		2.80	54,087.0	60.9	20.57	3,344.3
1-Sep-98	204	1.18	224.90	122.90	1.0909	93.5	1.38	0.003	0.32	8.90	0.33	0.90	1.82	76.50	1.0937	69.9	2.64	552	0.82	0.45	0.30	74.80	1.0904	68.6	2.01	0.003		2.36	54,144.1	61.0	20.70	3,362.5
2-Sep-98	205		122.90	0.00	1.0909	112.7	1.38	0.003	0.32	8.90	0.36	0.89	2.02	129.90	1.0890	119.3	2.40	574	0.68	0.64	0.62	124.80	1.0882	114.7	1.99	0.004		2.18	54,224.2	61.0	20.70	3,357.6
3-Sep-98	206	1.78	261.90	160.20	1.0951	92.9	1.36	0.005	0.34	9.22	0.36	0.87	2.02	93.60	1.0901	85.9	2.52	548	0.76	0.52	0.40	91.20	1.0886	83.8	1.94	0.003		2.54	54,288.7	61.1	20.90	3,386.4
4-Sep-98	207	2.33	488.70	387.10	1.0691	95.0	1.31	0.003	0.23	11.13	0.38	0.86	2.04	98.20	1.0922	89.9	2.56	547	0.73	0.53	0.39	95.00	1.0905	87.1	1.92	0.004		2.50	54,353.6	61.2	21.17	3,425.2
5-Sep-98	208		387.10	276.10	1.0691	103.8	1.31	0.003	0.23	11.13	0.41	0.99	1.73	78.00	1.0928	71.4	2.47	542	0.73	0.53	0.49	77.90	1.0924	71.3	1.88	0.004		2.74	54,405.1	61.2	21.17	3,422.0
6-Sep-98	209		276.10	132.90	1.0691	133.9	1.31	0.003	0.23	11.13	0.39	0.94	1.72	94.30	1.0951	86.1	2.52	565	0.77	0.49	0.50	90.60	1.0944	82.8	1.98	0.003		2.14	54,471.1	61.3	21.17	3,417.8
7-Sep-98	210		132.90	48.90	1.0691	78.6	1.31	0.003	0.23	11.13	0.33	0.76	1.82	103.10	1.0926	94.4	2.48	566	0.69	0.49	0.59	99.90	1.0924	91.5	1.86	0.004		2.66	54,535.5	61.4	21.17	3,413.8

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m³

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay Cu_{m}: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated Cu_{m}: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 $L/m^2/h$
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4	
		Feed									PLS			PLS								Raffinate							Leached	Consumption	
		H_2SO_4 added*	Start Weight	End Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cu	Fe	pH	Weight	s.g.	Volume	pH	ORP	Cu	Fe	Free H_2SO_4	Weight	s.g.	Volume	pH	Cu	Fe	Free H_2SO_4	Cum. Weight	Cum. Extraction	Cum. vs. feed	Cum. vs. Cu
		(kg)	(kg)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g/L)	(g/L)		(kg)	(g/mL)	(L)		(mV**)	(g/L)	(g/L)	(g/L)	(kg)	(g/mL)	(L)		(g/L)	(g/L)	(g/L)	(g)	(%)	(kg/t ore)	(kg/t Cu)
8-Sep-98	211	0.55	126.80	39.10	1.0900	80.5	1.48	0.004	0.24	9.58	0.31	0.68	1.74	105.40	1.0916	96.6	2.30	489	0.62	0.57	0.65	103.80	1.0891	95.3	1.98	.0.003		2.14	54,595.0	61.5	21.23	3,420.1
9-Sep-98	212	0.55	129.70	41.00	1.0937	81.1	1.51	0.004	0.27	8.71	0.28	0.63	1.79	100.00	1.0881	91.9	2.29	495	0.57	0.57	0.75	95.00	1.0880	87.3	1.91	0.004		2.52	54,647.1	61.5	21.29	3,426.9
10-Sep-98	213	3.38	469.10	376.60	1.0946	84.5	1.31	0.004	0.36	9.32	0.26	0.71	1.81	86.30	1.0889	79.3	2.41	535	0.60	0.61	0.61	82.00	1.0872	75.4	1.96	0.004		2.19	54,694.4	61.6	21.68	3,485.8
11-Sep-98	214		376.60	264.40	1.0946	102.5	1.31	0.004	0.36	9.32	0.30	0.87	1.62	92.10	1.0906	84.4	2.36	568	0.61	0.59	0.56	89.80	1.0901	82.4	1.88	0.005		2.55	54,745.1	61.6	21.68	3,482.6
12-Sep-98	215		264.40	174.20	1.0946	82.4	1.31	0.004	0.36	9.32	0.28	0.90	1.61	97.90	1.0936	89.5	2.29	589	0.58	0.68	0.79	97.70	1.0935	89.3	1.91	0.004		2.42	54,796.7	61.7	21.68	3,479.3
13-Sep-98	216		174.20	50.00	1.0946	113.5	1.31	0.004	0.36	9.32	0.30	0.96	1.59	97.90	1.0933	89.5	2.23	599	0.55	0.78	0.97	93.90	1.0943	85.8	1.86	0.004		2.68	54,845.5	61.7	21.68	3,476.2
14-Sep-98	217	0.65	139.80	15.50	1.0980	113.2	1.35	0.005	0.36	10.65	0.28	0.86	1.66	94.20	1.0952	86.0	2.23	602	0.56	0.75	1.19	91.80	1.0940	83.9	1.92	0.004		2.70	54,892.6	61.8	21.75	3,485.0
15-Sep-98	218		398.00	287.00	1.0925	101.6	1.86	0.005	0.54	2.73	0.24	0.77	1.65	103.90	1.0935	95.0	2.22	569	0.53	0.79	1.16	99.10	1.0924	90.7	1.85	0.004		2.82	54,942.5	61.9	21.75	3,481.9
16-Sep-98	219		287.00	249.80	1.0925	34.1	1.86	0.005	0.54	2.73	0.21	0.71	1.75	105.00	1.0927	96.1	2.18	574	0.53	0.80	1.30	102.10	1.0920	93.5	1.82	0.003		3.07	54,992.8	61.9	21.75	3,478.7
17-Sep-98	220		249.80	133.70	1.0925	106.3	1.86	0.005	0.54	2.73	0.27	0.63	1.99	106.60	1.0956	97.3	2.18	585	0.52	0.79	1.27	100.50	1.0948	91.8	1.83	0.003		2.85	55,042.9	62.0	21.75	3,475.5
18-Sep-98	221	0.91	403.20	264.50	1.0961	126.5	1.51	0.004	0.49	5.28	0.21	0.66	2.00	67.30	1.0954	61.4	2.58	564	0.79	0.48	0.56	66.90	1.0927	61.2	1.86	0.003		2.80	55,090.7	62.0	21.85	3,489.1
19-Sep-98	222		264.50	167.50	1.0961	88.5	1.51	0.004	0.49	5.28	0.24	0.74	1.80	95.20	1.0962	86.8	2.58	573	0.74	0.44	0.59	92.20	1.0954	84.2	1.91	0.003		2.61	55,154.6	62.1	21.85	3,485.0
20-Sep-98	223	.	167.50	49.00	1.0961	108.1	1.51	0.004	0.49	5.28	0.22	0.69	1.77	101.30	1.0963	92.4	2.56	590	0.69	0.44	0.73	97.80	1.0958	89.2	2.01	0.002		2.17	55,217.5	62.2	21.85	3,481.0
21-Sep-98	224	0.27	141.20	48.80	1.0965	84.3	1.55	0.004	0.37	5.44	0.20	0.66	1.81	93.60	1.0964	85.4	2.51	548	0.62	0.48	0.67	92.60	1.0960	84.5	1.92	0.002		2.61	55,269.7	62.2	21.89	3,482.7
22-Sep-98	225	0.72	349.20	242.90	1.0974	96.9	1.59	0.004	0.33	4.92	0.20	0.62	1.75	104.50	1.0965	95.3	2.46	570	0.57	0.50	0.84	103.00	1.0961	94.0	1.98	0.003		2.32	55,323.6	62.3	21.97	3,492.4
23-Sep-98	226		242.90	137.90	1.0974	95.7	1.59	0.004	0.33	4.92	0.20	0.57	1.83	92.30	1.0974	84.1	2.50	563	0.56	0.51	0.89	88.40	1.0974	80.6	1.92	0.002		2.46	55,369.9	62.3	21.97	3,489.5
24-Sep-98	227		137.90	35.60	1.0974	93.2	1.59	0.004	0.33	4.92	0.19	0.54	1.83	88.70	1.0981	80.8	2.52	564	0.58	0.50	0.87	86.90	1.0980	79.1	1.93	0.003		2.53	55,416.0	62.4	21.97	3,486.6
25-Sep-98	228	0.90	322.00	211.00	1.1016	100.8	1.56	0.173	0.35	5.20	0.20	0.54	1.85	102.20	1.0995	93.0	2.54	562	0.54	0.49	0.79			#DIV/0!					55,448.3	62.4	22.07	3,500.7
26-Sep-98	229		211.00	100.00	1.1016	100.8	1.56	0.173	0.35	5.20	0.29	0.62	1.78	102.60	1.1017	93.1	2.51	516	0.51	0.53	0.91			#DIV/0!					55,478.4	62.5	22.07	3,498.8
27-Sep-98	230		100.00	0.00	1.1016	90.8	1.56	0.173	0.35	5.20	0.31	0.58	1.82	97.00	1.1035	87.9	2.45	524	0.50	0.54	1.12			#DIV/0!					55,506.2	62.5	22.07	3,497.1
28-Sep-98	231	1.40	298.70	177.80	1.1082	109.1	1.55	0.535	0.51	5.50	0.34	0.60	1.81	98.10	1.1079	88.5	2.45	531	0.53	0.57	0.96			#DIV/0!					55,494.3	62.5	22.23	3,523.1
29-Sep-98	232		177.80	38.80	1.1082	125.4	1.55	0.535	0.51	5.50	0.44	0.61	1.76	96.60	1.1037	87.5	2.54	524	0.52	0.55	0.93			#DIV/0!					55,472.3	62.4	22.23	3,524.5
30-Sep-98	233	0.80	237.60	128.60	1.1069	98.5	1.61	0.530	0.51	5.50	0.51	0.66	1.79	102.20	1.1047	92.5	2.51	542	0.56	0.57	0.98			#DIV/0!					55,471.4	62.4	22.32	3,538.9
1-Oct-98	234		128.60	0.00	1.1069	116.2	1.61	0.530	0.51	5.18	0.53	0.65	1.80	113.60	1.1041	102.9	2.46	514	0.59	0.60	0.95			#DIV/0!					55,470.0	62.4	22.32	3,539.0
2-Oct-98	235	1.52	338.00	227.00	1.0745	103.3	1.41	0.410	0.41	5.10	0.57	0.65	1.56	124.40	1.1056	112.5	2.19	549	0.61	0.62	0.89			#DIV/0!					55,496.3	62.5	22.49	3,564.7
3-Oct-98	236		227.00	116.00	1.0745	103.3	1.41	0.410	0.41	5.10	0.58	0.67	1.48	120.10	1.1076	108.4	2.13	567	0.68	0.64	1.12			#DIV/0!					55,527.2	62.5	22.49	3,562.8
4-Oct-98	237		116.00	12.00	1.0745	96.8	1.41	0.410	0.41	5.10	0.55	0.62	1.50	106.10	1.1087	95.7	2.13	579	0.70	0.66	1.10			#DIV/0!					55,554.5	62.5	22.49	3,561.0
5-Oct-98	238	0.84	246.20	125.20	1.1075	109.3	1.45	0.669	0.56	4.95	0.54	0.61	1.70	104.20	1.1036	94.4	2.28	557	0.71	0.64	0.97			#DIV/0!					55,548.4	62.5	22.59	3,576.6
6-Oct-98	239		125.20	0.00	1.1075	113.0	1.45	0.669	0.56	4.95	0.61	0.63	1.65	107.10	1.0987	97.5	2.26	537	0.69	0.61	0.63			#DIV/0!					55,539.6	62.5	22.59	3,577.2
7-Oct-98	240	1.26	319.00	215.00	1.1026	94.3	1.52	0.720	0.54	4.68	0.65	0.67	1.95	106.70	1.1028	96.8	2.43	498	0.78	0.54	0.49			#DIV/0!					55,547.1	62.5	22.73	3,599.4

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B									SX							Cu	H_2SO_4
		Feed									PLS			PLS									Raffinate							Leached	Consumption
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
8-Oct-98	241		215.00	104.00	1.1026	100.7	1.52	0.720	0.54	4.68	0.68	0.76	1.87	111.20	1.1001	101.1	2.18	548	0.75	0.60	0.75			#DIV/0!					55,549.9	62.5	22.73	3,599.2
9-Oct-98	242		104.00	0.00	1.1026	94.3	1.52	0.720	0.54	4.68	0.72	0.77	1.81	104.30	1.1024	94.6	2.23	541	0.75	0.62	0.91			#DIV/0!					55,552.5	62.5	22.73	3,599.1
10-Oct-98	243	0.41	104.80	0.00	1.1097	94.4	1.45	0.815	0.69	5.00	0.80	0.82	1.80	104.80	1.1091	94.5	2.22	554	0.83	0.69	0.99			#DIV/0!					55,554.0	62.5	22.78	3,606.4
11-Oct-98	244	0.84	215.50	210.30	1.1035	4.7	1.41	0.750	0.62	4.98	0.84	0.81	1.74	102.70	1.1064	92.8	2.18	581	0.83	0.68	0.93			#DIV/0!					55,627.5	62.6	22.87	3,616.6
12-Oct-98	245		210.30	106.30	1.1035	94.2	1.41	0.750	0.62	4.98	0.84	0.76	1.86	86.20	1.1089	77.7	2.23	589	0.88	0.69	1.06			#DIV/0!					55,624.8	62.6	22.87	3,616.8
13-Oct-98	246		106.30	0.00	1.1035	96.3	1.41	0.750	0.62	4.98	0.82	0.80	1.82	51.20	1.1079	46.2	2.32	585	0.93	0.64	0.81			#DIV/0!					55,595.3	62.59	22.87	3,618.7
14-Oct-98	247	0.94	240.10	129.10	1.1133	99.7	1.31	0.895	0.69	5.00	0.88	0.81	1.78	88.20	1.1071	79.7	2.25	563	0.91	0.68	0.93			#DIV/0!					55,578.2	62.57	22.98	3,636.7
15-Oct-98	248		129.10	15.90	1.1133	101.7	1.31	0.895	0.69	5.00	0.89	0.82	1.76	83.60	1.1071	75.5	2.20	543	0.95	0.69	0.96			#DIV/0!					55,558.9	62.55	22.98	3,637.9
16-Oct-98	249	1.61	339.80	241.20	1.0860	90.8	1.48	0.730	0.47	5.02	0.92	0.72	1.81	86.70	1.1075	78.3	2.25	542	0.95	0.58	0.92			#DIV/0!					55,567.0	62.55	23.16	3,666.3
17-Oct-98	250		241.20	130.20	1.0860	102.2	1.48	0.730	0.47	5.02	0.98	0.77	1.69	99.80	1.1107	89.9	2.25	559	1.01	0.56	0.97			#DIV/0!					55,583.1	62.57	23.16	3,665.3
18-Oct-98	251		130.20	28.30	1.0860	93.8	1.48	0.730	0.47	5.02	0.91	0.70	1.63	99.90	1.1091	90.1	2.18	574	1.01	0.58	0.99			#DIV/0!					55,605.6	62.60	23.16	3,663.8
19-Oct-98	252	0.74	235.00	118.70	1.1077	105.0	1.47	0.965	0.56	4.83	0.86	0.67	1.64	105.80	1.1066	95.6	2.13	559	1.00	0.60	0.98			#DIV/0!					55,599.9	62.59	23.25	3,677.5
20-Oct-98	253		118.70	6.00	1.1077	101.7	1.47	0.965	0.56	4.83	0.90	0.70	1.63	108.20	1.1043	98.0	2.12	539	0.98	0.60	0.91			#DIV/0!					55,597.7	62.59	23.25	3,677.7
21-Oct-98	254	0.77	220.00	114.00	1.1079	95.7	1.47	0.980	0.60	4.75	0.96	0.70	1.73	115.40	1.1024	104.7	2.10	519	0.97	0.60	1.01			#DIV/0!					55,605.0	62.6	23.34	3,691.0
22-Oct-98	255		114.00	0.00	1.1079	102.9	1.47	0.980	0.60	4.75	0.98	0.71	1.81	111.40	1.1040	100.9	2.17	513	1.00	0.63	1.09			#DIV/0!					55,604.6	62.6	23.34	3,691.1
23-Oct-98	256	1.28	332.00	214.20	1.1062	106.5	1.52	0.990	0.62	4.99	1.01	0.72	1.91	103.90	1.1057	94.0	2.31	566	1.04	0.63	0.99			#DIV/0!					55,596.9	62.6	23.48	3,714.6
24-Oct-98	257		214.20	110.20	1.1062	94.0	1.52	0.990	0.62	4.99	1.15	0.91	1.84	111.60	1.1083	100.7	2.42	608	1.10	0.71	1.06			#DIV/0!					55,614.5	62.6	23.48	3,713.4
25-Oct-98	258		110.20	0.00	1.1062	99.6	1.52	0.990	0.62	4.99	1.16	0.81	1.89	101.50	1.1093	91.5	2.43	611	1.15	0.76	1.16			#DIV/0!					55,621.1	62.6	23.48	3,713.0
26-Oct-98	259	0.94	234.00	118.00	1.1044	105.0	1.53	1.070	0.70	5.03	1.10	0.80	1.84	90.50	1.1085	81.6	2.32	530	1.16	0.78	1.16			#DIV/0!					55,603.5	62.6	23.59	3,731.1
27-Oct-98	260		118.00	0.00	1.1044	106.8	1.53	1.070	0.70	5.03	1.10	0.80	1.79	102.50	1.1094	92.4	2.33	526	1.20	0.79	1.20			#DIV/0!					55,600.0	62.6	23.59	3,731.3
28-Oct-98	261	0.77	208.70	101.00	1.1057	97.4	1.49	1.110	0.75	4.83	1.12	0.82	1.78	103.20	1.1093	93.0	2.31	548	1.21	0.79	1.21			#DIV/0!					55,604.5	62.6	23.68	3,744.8
29-Oct-98	262		101.00	0.00	1.1057	91.3	1.49	1.110	0.75	4.83	1.16	0.84	1.82	104.70	1.1091	94.4	2.37	539	1.23	0.78	1.13			#DIV/0!					55,619.2	62.6	23.68	3,743.8
30-Oct-98	263	1.22	320.10	213.10	1.1079	96.6	1.59	1.160	0.77	4.89	1.16	0.88	1.83	101.00	1.1102	91.0	2.36	519	1.27	0.78	1.23			#DIV/0!					55,622.7	62.6	23.81	3,765.4
31-Oct-98	264		213.10	99.80	1.1079	102.3	1.59	1.160	0.77	4.89	1.27	0.94	1.91	105.50	1.1103	95.0	2.30	559	1.26	0.83	1.17			#DIV/0!					55,623.8	62.6	23.81	3,765.3
1-Nov-98	265		99.80	0.00	1.1079	90.1	1.59	1.160	0.77	4.89	1.35	0.87	2.07	105.60	1.1106	95.1	2.33	562	1.30	0.84	1.19			#DIV/0!					55,642.9	62.6	23.81	3,764.0
2-Nov-98	266	0.85	221.90	110.90	1.1069	100.3	1.62	1.210	0.79	5.12	1.22	0.87	1.79	108.60	1.1105	97.8	2.36	559	1.31	0.82	1.23			#DIV/0!					55,649.7	62.6	23.91	3,778.9
3-Nov-98	267		110.90	0.00	1.1069	100.2	1.62	1.210	0.79	5.12	1.27	0.86	1.76	103.80	1.1107	93.5	2.18	574	1.31	0.85	1.57			#DIV/0!					55,650.9	62.6	23.91	3,778.8
4-Nov-98	268	0.88	222.40	111.40	1.1068	100.3	1.59	1.240	0.74	5.06	1.28	0.81	1.80	113.50	1.1108	102.2	2.23	567	1.35	0.78	1.56			#DIV/0!					55,664.4	62.7	24.01	3,793.7
5-Nov-98	269		111.40	0.00	1.1068	100.7	1.59	1.240	0.74	5.06	1.29	0.83	1.79	111.70	1.1107	100.6	2.31	562	1.38	0.79	1.76			#DIV/0!					55,678.4	62.7	24.01	3,792.7
6-Nov-98	270	1.30	345.70	228.90	1.1065	105.6	1.54	1.240	0.75	4.95	1.28	0.86	1.73	109.20	1.1110	98.3	2.26	554	1.35	0.81	1.56			#DIV/0!					55,680.2	62.7	24.16	3,815.9

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 L/m^2/h
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX								Cu	H_2SO_4
		Feed									PLS			PLS								Raffinate								Leached	Consumption
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
7-Nov-98	271		228.90	106.50	1.1065	110.6	1.54	1.240	0.75	4.95	1.38	0.89	1.68	110.60	1.1115	99.5	2.15	572	1.36	0.85	1.99			#DIV/0!					55,678.4	62.7	24.16	3,816.0
8-Nov-98	272		106.50	0.00	1.1065	96.2	1.54	1.240	0.75	4.95	1.36	0.86	1.63	105.70	1.1115	95.1	2.15	592	1.37	0.82	1.65			#DIV/0!					55,689.3	62.7	24.16	3,815.3
9-Nov-98	273	1.06	341.00	230.00	1.1117	99.8	1.55	1.360	0.83	4.89	1.30	0.83	1.67	119.70	1.1117	107.7	2.08	578	1.38	0.85	1.70			#DIV/0!					55,702.1	62.7	24.28	3,833.4
10-Nov-98	274		230.00	100.60	1.1117	116.4	1.55	1.360	0.83	4.89	1.36	0.86	1.78	113.70	1.1115	102.3	2.18	540	1.43	0.87	1.65	106.80	1.1096	96.3	1.64	0.013		4.08	55,690.1	62.7	24.28	3,834.3
11-Nov-98	275		100.60	0.00	1.1117	90.5	1.55	1.360	0.83	4.89	1.46	0.92	1.77	114.90	1.1123	103.3	2.26	564	1.47	0.87	1.71	114.50	1.1102	103.1	1.73	0.008		4.23	55,718.9	62.7	24.28	3,832.3
12-Nov-98	276	0.12	111.90	0.00	1.1045	101.3	1.57	0.014	0.81	4.95	1.44	0.90	1.74	112.90	1.1134	101.4	2.28	571	1.48	0.93	2.14	110.30	1.1103	99.3	1.68	0.018		4.19	55,867.5	62.9	24.29	3,824.2
13-Nov-98	277	0.31	358.90	323.00	1.1041	32.5	1.61	0.015	0.78	4.76	0.85	0.87	1.81	115.60	1.1135	103.8	2.24	557	1.51	0.90	1.81	114.10	1.1103	102.8	1.71	0.010		4.59	56,023.8	63.1	24.33	3,819.0
14-Nov-98	278		323.00	212.00	1.1041	100.5	1.61	0.015	0.78	4.76	0.89	0.95	1.80	107.90	1.1132	96.9	2.23	574	1.35	0.86	2.10			#DIV/0!					56,153.1	63.2	24.33	3,810.2
15-Nov-98	279		212.00	101.00	1.1041	100.5	1.61	0.015	0.78	4.76	0.51	0.89	1.72	55.40	1.1136	49.7	2.28	591	1.35	0.85	1.60			#DIV/0!					56,218.8	63.3	24.33	3,805.8
16-Nov-98	280		101.00	0.00	1.1041	91.5	1.61	0.015	0.78	4.76	0.40	0.85	1.72	100.30	1.1127	90.1	2.17	577	1.12	0.88	2.00			#DIV/0!					56,318.4	63.4	24.33	3,799.0
17-Nov-98	281	1.32	377.50	250.30	1.1112	114.5	1.63	1.150	0.98	5.17	0.40	0.98	1.88	102.60	1.1111	92.3	2.23	564	1.00	1.01	1.20			#DIV/0!					56,279.1	63.4	24.48	3,825.1
18-Nov-98	282		250.30	122.00	1.1112	115.5	1.63	1.150	0.98	5.17	0.80	1.01	1.84	103.10	1.1111	92.8	2.24	557	0.95	1.01	1.16			#DIV/0!					56,234.5	63.3	24.48	3,828.1
19-Nov-98	283		122.00	0.00	1.1112	109.8	1.63	1.150	0.98	5.17	1.15	1.04	1.84	115.80	1.1120	104.1	2.19	551	1.05	1.04	1.49			#DIV/0!					56,217.5	63.3	24.48	3,829.3
20-Nov-98	284	1.02	343.50	220.30	1.1096	111.0	1.64	1.010	0.99	5.29	1.21	1.03	1.74	113.60	1.1127	102.1	2.10	548	1.18	1.02	1.31			#DIV/0!					56,225.9	63.3	24.59	3,846.9
21-Nov-98	285		220.30	122.50	1.1096	88.1	1.64	1.010	0.99	5.29	1.21	1.08	1.77	132.70	1.1145	119.1	2.13	551	1.25	1.04	1.57			#DIV/0!					56,285.7	63.4	24.59	3,842.8
22-Nov-98	286		122.50	0.00	1.1096	110.4	1.64	1.010	0.99	5.29	1.21	1.08	1.81	104.30	1.1147	93.6	2.16	607	1.24	1.05	1.38			#DIV/0!					56,290.2	63.4	24.59	3,842.5
23-Nov-98	287	0.80	242.80	121.40	1.1136	109.0	1.68	1.210	1.03	5.23	1.13	1.04	1.74	119.10	1.1139	106.9	2.12	568	1.24	1.05	1.71			#DIV/0!					56,290.9	63.4	24.68	3,856.6
24-Nov-98	288		121.40	0.00	1.1136	109.0	1.68	1.210	1.03	5.23	1.22	1.10	1.78	108.70	1.1136	97.6	2.10	547	1.26	1.05	1.74			#DIV/0!					56,282.0	63.4	24.68	3,857.2
25-Nov-98	289	0.72	233.60	116.80	1.1128	105.0	1.67	1.210	1.03	5.10	1.24	1.10	1.79	122.10	1.1149	109.5	2.12	564	1.29	1.07	1.88			#DIV/0!					56,296.2	63.4	24.77	3,869.1
26-Nov-98	290		116.80	0.00	1.1128	105.0	1.67	1.210	1.03	5.10	1.27	1.10	1.72	119.40	1.1158	107.0	2.08	548	1.32	1.09	2.06			#DIV/0!					56,310.5	63.4	24.77	3,868.1
27-Nov-98	291	1.19	370.10	232.10	1.1135	123.9	1.61	1.270	1.07	5.19	1.27	1.10	1.88	117.40	1.1156	105.2	2.10	553	1.32	1.10	2.20			#DIV/0!					56,292.0	63.4	24.90	3,890.5
28-Nov-98	292		232.10	104.10	1.1135	115.0	1.61	1.270	1.07	5.19	1.39	1.24	1.72	103.00	1.1176	92.2	2.02	566	1.37	1.10	2.21			#DIV/0!					56,272.3	63.3	24.90	3,891.9
29-Nov-98	293		104.10	0.00	1.1135	93.5	1.61	1.270	1.07	5.19	1.39	1.26	1.76	112.20	1.1169	100.5	2.07	584	1.37	1.11	2.19			#DIV/0!					56,291.2	63.4	24.90	3,890.6
30-Nov-98	294	1.07	353.80	241.00	1.1152	101.1	1.59	1.320	1.08	4.97	1.35	1.18	1.77	117.60	1.1173	105.3	2.03	560	1.39	1.15	2.29			#DIV/0!					56,303.9	63.4	25.02	3,908.7
1-Dec-98	295		241.00	117.90	1.1152	110.4	1.59	1.320	1.08	4.97	1.35	1.18	1.85	108.60	1.1170	97.2	2.13	549	1.39	1.14	2.01			#DIV/0!					56,293.4	63.4	25.02	3,909.4
2-Dec-98	296		117.90	0.00	1.1152	105.7	1.59	1.320	1.08	4.97	1.36	1.15	1.83	108.30	1.1177	96.9	2.17	555	1.40	1.10	1.80	107.90	1.1154	96.7	1.68	0.016		4.42	56,289.5	63.4	25.02	3,909.7
3-Dec-98	297	0.34	113.90	0.00	1.1128	102.4	1.64	1.310	1.03	4.95	1.36	1.11	1.84	124.80	1.1179	111.6	2.22	544	1.44	1.10	1.80	123.60	1.1155	110.8	1.69	0.028		4.12	56,316.2	63.4	25.06	3,913.8
4-Dec-98	298	0.57	361.60	241.10	1.1098	108.6	1.61	0.031	1.00	4.93	1.35	1.11	1.72	109.60	1.1179	98.0	2.09	552	1.45	1.09	1.77	111.30	1.1157	99.8	1.66	0.041		4.20	56,455.0	63.6	25.13	3,914.3
5-Dec-98	299		241.10	121.00	1.1098	108.2	1.61	0.031	1.00	4.93	1.01	1.19	1.79	105.00	1.1193	93.8	2.16	572	1.46	1.10	2.01	102.80	1.1169	92.0	1.71	0.015		4.71	56,588.6	63.7	25.13	3,905.0
6-Dec-98	300		121.00	0.00	1.1098	109.0	1.61	0.031	1.00	4.93	0.88	1.21	1.88	105.30	1.1183	94.2	2.17	598	1.34	1.09	2.06	103.70	1.1164	92.9	1.73	0.019		3.90	56,711.4	63.8	25.13	3,896.6

CARMACKS COLUMN AB LEACH TEST DATA

Carmacks Project

Project: 97-084
Column: A B
Column Size: 36"x154"
Initial Charge Height: 137 136 inch
Final Charge Height: inch
Sample Weight: 4405.5 4389.5 kg
Bulk Density: 1.916 1.923 tonne/m^3

Starting Date: February 9, 1998

Ore Sample: Carmacks ROM
Head Assay $Cu_{(T)}$: 1.01 %
Head Assay $Cu_{(acid\ soluble)}$: 0.93 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre

Report Date: February 23, 2001

Curing Acid Concentration: 235 g/L H_2SO_4
Curing Acid Volume: 472.1 L
Curing Period: 7 days
Curing Acid Consumption: 12.58 kg/tonne
Leach H_2SO_4 Solution Concentration: 8.0 g/L
Leach H_2SO_4 Solution Feed Rate: 7.0 $L/m^2/h$
Initial Sample Moisture: 1.77 % by weight
Final Residue Moisture: % by weight

Date	Day	COLUMN A												COLUMN B								SX							Cu	H_2SO_4
		Feed									PLS			PLS								Raffinate							Leached	Consumption
		H_2SO_4 added* (kg)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cu (g/L)	Fe (g/L)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	ORP (mV**)	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Cum. Weight (g)	Cum. Extraction (%)	Cum. vs. feed (kg/t ore)	Cum. vs. Cu (kg/t Cu)
7-Dec-98	301	0.34	226.50	121.50	1.1069	94.9	1.55	0.019	0.94	5.03	0.61	1.14	1.80	123.80	1.1173	110.8	2.16	565	1.23	1.08	1.91			#DIV/0!					56,845.8	64.0	25.16	3,893.3
8-Dec-98	302		121.50	0.00	1.1069	109.8	1.55	0.019	0.94	5.03	0.57	1.23	1.85	111.00	1.1168	99.4	2.20	543	1.15	1.22				#DIV/0!					56,958.1	64.1	25.16	3,885.7
9-Dec-98	303	0.86	245.70	122.70	1.1145	110.4	1.57	1.140	1.14	5.11	0.47	1.22	1.85	113.00	1.1162	101.2	2.20	556	1.06	1.18				#DIV/0!					56,939.6	64.1	25.26	3,902.1
10-Dec-98	304		122.70	0.00	1.1145	110.1	1.57	1.140	1.14	5.11	0.58	1.24	1.81	113.90	1.1154	102.1	2.12	553	0.91	1.21				#DIV/0!					56,907.0	64.1	25.26	3,904.3
11-Dec-98	305		360.40	247.60	1.1091	101.7	2.13	0.890	1.13	5.11	0.90	1.24	1.81	113.50	1.1151	101.8	2.12	553	0.90	1.20				#DIV/0!					56,908.1	64.1	25.26	3,904.2
12-Dec-98	306		247.60	106.80	1.1091	126.9	2.13	0.890	1.13		1.03	1.28	1.87	112.00	1.1160	100.4	2.13	562	0.98	1.23				#DIV/0!					56,893.4	64.0	25.26	3,905.2
13-Dec-98	307		106.80	0.00	1.1091	96.3	2.13	0.890	1.13		0.98	1.10	2.00	26.40	1.1175	23.6	2.48	489	1.11	1.08				#DIV/0!					56,833.9	64.0	25.26	3,909.3
14-Dec-98	308		255.40	134.90	1.1166	107.9	2.20	1.020	1.19		0.97	1.07	2.04	117.00	1.1183	104.6	2.19	596	1.07	1.19				#DIV/0!					56,835.8	64.0	25.26	3,909.2
15-Dec-98	309		134.90								1.00	1.07	2.09	110.90	1.1156	99.4	2.22	527	1.09	1.13				#DIV/0!					56,944.2	64.1	25.26	3,901.8
16-Dec-98	310	RECIRC.																						#DIV/0!					56,944.2	64.1	25.26	3,901.8
22-Dec-98	316										1.20	0.95	2.43				2.54	549	1.22	0.96				#DIV/0!					56,944.2	64.1	25.26	3,901.8
24-Dec-98	318													163.00	1.1174	145.9	2.55	555	1.27			158.00	1.1157	141.6	1.96	0.015			57,129.4	64.3	25.26	3,889.1
29-Dec-98	323										1.15		2.30	278.90	1.1181	249.4	2.38	544	1.22			274.70	1.1161	246.1	1.78	0.009			57,433.8	64.7	25.26	3,868.5
31-Dec-98	325										0.82		2.07	170.60	1.1173	152.7	2.02	544	0.69			163.10	1.1169	146.0	1.82	0.006			57,539.1	64.8	25.26	3,861.4
5-Jan-99	330										0.97		2.44				2.50	548	1.00										57,539.1	64.8	25.26	3,861.4
11-Jan-99	336										0.12		2.43	88.40	1.1217	78.8	2.49	558	0.12			87.00	1.1203	77.7	1.80	0.004			57,548.4	64.8	25.26	3,860.8
12-Jan-99	337										0.97		2.29	103.10	1.1224	91.9	2.30	526	0.98			99.80	1.1204	89.1	1.78	0.004			57,638.4	64.9	25.26	3,854.8
15-Jan-99	340										1.01		2.29				2.38	533	1.02										57,638.4	64.9	25.26	3,854.8
18-Jan-99	343										1.14		2.41	125.40	1.1268	111.3	2.55	496	1.19			124.80	1.1224	111.2	1.83	0.006			57,770.9	65.0	25.26	3,845.9
19-Jan-99	344										0.88		2.26	127.00	1.1229	113.1	2.30	532	0.77			124.60	1.1221	111.0	1.80	0.005			57,857.9	65.1	25.26	3,840.1
22-Jan-99	347										0.95		2.32				2.43	538	0.96										57,857.9	65.1	25.26	3,840.1
1-Feb-99	357										1.23		2.51				2.54	498	1.25										57,857.9	65.1	25.26	3,840.1
4-Feb-99	360	STOP COLUMN											2.50	127.90	1.1312	113.1	2.55	475											57,857.9	65.1	25.26	3,840.1

INTERNATIONAL PLASMA LABORATORY LTD.

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Process Research Associates Ltd

Project: 97-084

Out: Mar 05, 1998
In : Mar 03, 1998

[021714:39:31:89030598]

2 Samples 2=Solution

Symbol	Unit	Solution Col C PLS Day 12	Solution Col C RAF Day 12	Limit Low	Limit High
SO4	G/L	16.46	19.42	0.01	1000.00
Al	mg/L	814.0	822.2	0.2	9999.0
Sb	mg/L	<0.1	<0.1	0.1	9999.0
As	mg/L	1.0	0.9	0.2	9999.0
Ba	mg/L	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.16	0.18	0.01	999.00
Ca	mg/L	466.4	466.8	0.1	9999.0
Cr	mg/L	<0.01	<0.01	0.01	9999.00
Co	mg/L	4.51	4.47	0.01	9999.00
Cu	mg/L	5083.31	6.55	0.01	9999.00
Fe	mg/L	667.70	678.84	0.03	9999.00
La	mg/L	1.50	1.49	0.05	999.00
Pb	mg/L	0.14	<0.05	0.05	9999.00
Mg	mg/L	765.1	756.9	0.1	9999.0
Mn	mg/L	153.19	152.11	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.17	0.08	0.02	9999.00
Ni	mg/L	1.04	1.06	0.02	9999.00
P	mg/L	59.4	0.3	0.1	9999.0
K	mg/L	11.	12.	2.	9999.
Sc	mg/L	0.27	0.22	0.01	100.00
Ag	mg/L	<0.02	<0.02	0.02	999.00
Na	mg/L	<1.	<1.	1.	9999.
Sr	mg/L	1.51	1.52	0.01	999.00
Th	mg/L	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.2	<0.1	0.1	999.0
W	mg/L	0.7	<0.1	0.1	9999.0
V	mg/L	0.03	<0.01	0.01	999.00
Zn	mg/L	19.68	13.38	0.01	9999.00
Zr	mg/L	0.02	<0.01	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Mar 11, 1998
In : Mar 09, 1998

[023117:19:10:89031198]

4 Samples 4=Solution

Symbol	Unit	Solution Col. C PLS Day 19	Solution Col. C RAF Day 19	Limit Low	Limit High
SO4	G/L	16.22	17.60	0.01	1000.00
Al	mg/L	1175.7	1151.1	0.2	9999.0
Sb	mg/L	0.1	<0.1	0.1	9999.0
As	mg/L	1.5	1.1	0.2	9999.0
Ba	mg/L	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	0.1	9999.0
Cd	mg/L	0.20	0.19	0.01	999.00
Ca	mg/L	463.9	463.8	0.1	9999.0
Cr	mg/L	0.01	<0.01	0.01	9999.00
Co	mg/L	5.02	5.02	0.01	9999.00
Cu	mg/L	2720.73	12.70	0.01	9999.00
Fe	mg/L	740.58	740.20	0.03	9999.00
La	mg/L	1.30	1.32	0.05	999.00
Pb	mg/L	<0.05	<0.05	0.05	9999.00
Mg	mg/L	911.2	890.5	0.1	9999.0
Mn	mg/L	173.98	170.16	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.16	0.09	0.02	9999.00
Ni	mg/L	1.22	1.17	0.02	9999.00
P	mg/L	31.0	1.1	0.1	9999.0
K	mg/L	18.	20.	2.	9999.
Sc	mg/L	0.28	0.25	0.01	100.00
Ag	mg/L	<0.02	0.04	0.02	999.00
Na	mg/L	22.	21.	1.	9999.
Sr	mg/L	1.15	1.16	0.01	999.00
Th	mg/L	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.1	<0.1	0.1	999.0
W	mg/L	0.4	<0.1	0.1	9999.0
V	mg/L	0.02	<0.01	0.01	999.00
Zn	mg/L	18.91	15.34	0.01	9999.00
Zr	mg/L	<0.01	0.02	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Mar 20, 1998
In : Mar 17, 1998

[025117:35:56:89032098]

4 Samples 4=Solution

Symbol	Unit	Solution Col C RAF Day 26	Limit Low	Limit High
SO4	G/L	20.77	0.01	1000.00
Al	mg/L	1532.4	0.2	9999.0
Sb	mg/L	<0.1	0.1	9999.0
As	mg/L	1.6	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.22	0.01	999.00
Ca	mg/L	472.5	0.1	9999.0
Cr	mg/L	0.24	0.01	9999.00
Co	mg/L	5.39	0.01	9999.00
Cu	mg/L	9.11	0.01	9999.00
Fe	mg/L	1213.93	0.03	9999.00
La	mg/L	1.20	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	1127.4	0.1	9999.0
Mn	mg/L	179.91	0.01	999.00
Hg	mg/L	0.17	0.05	9999.00
Mo	mg/L	0.07	0.02	9999.00
Ni	mg/L	1.55	0.02	9999.00
P	mg/L	1.4	0.1	9999.0
K	mg/L	15.	2.	9999.
Sc	mg/L	0.83	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	21.	1.	9999.
Sr	mg/L	0.83	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	<0.1	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	<0.01	0.01	999.00
Zn	mg/L	17.66	0.01	9999.00
Zr	mg/L	<0.01	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Apr 01, 1998
In : Mar 23, 1998

[027812:58:58:89040198]

4 Samples 4=Solution

Symbol	Unit	Solution Col C RAF Day 33	Limit Low	Limit High
SO4	G/L	24.62	0.01	1000.00
Al	mg/L	1937.1	0.2	9999.0
Sb	mg/L	<0.1	0.1	9999.0
As	mg/L	1.7	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.23	0.01	999.00
Ca	mg/L	463.2	0.1	9999.0
Cr	mg/L	0.52	0.01	9999.00
Co	mg/L	5.93	0.01	9999.00
Cu	mg/L	9.58	0.01	9999.00
Fe	mg/L	1426.50	0.03	9999.00
La	mg/L	1.31	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	1399.7	0.1	9999.0
Mn	mg/L	197.54	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	0.04	0.02	9999.00
Ni	mg/L	1.73	0.02	9999.00
P	mg/L	2.8	0.1	9999.0
K	mg/L	18.	2.	9999.
Sc	mg/L	1.28	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	16.	1.	9999.
Si	mg/L	108.75	0.05	9999.00
Sr	mg/L	0.58	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	<0.1	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	0.03	0.01	999.00
Zn	mg/L	19.83	0.01	9999.00
Zr	mg/L	0.03	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Apr 01, 1998
In : Mar 31, 1998

[030217:42:16:89040198]

4 Samples 4=Solution

Symbol	Unit	Solution COL C RAF Day 40	Limit Low	Limit High
SO4	G/L	27.68	0.01	1000.00
Al	mg/L	2402.0	0.2	9999.0
Sb	mg/L	0.2	0.1	9999.0
As	mg/L	2.3	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.27	0.01	999.00
Ca	mg/L	495.1	0.1	9999.0
Cr	mg/L	0.91	0.01	9999.00
Co	mg/L	6.67	0.01	9999.00
Cu	mg/L	7.42	0.01	9999.00
Fe	mg/L	1831.20	0.03	9999.00
La	mg/L	1.38	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	1563.7	0.1	9999.0
Mn	mg/L	205.64	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	0.15	0.02	9999.00
Ni	mg/L	2.08	0.02	9999.00
P	mg/L	8.0	0.1	9999.0
K	mg/L	5.	2.	9999.
Sc	mg/L	1.66	0.01	100.00
Ag	mg/L	0.05	0.02	999.00
Na	mg/L	16.	1.	9999.
Sr	mg/L	0.61	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	<0.1	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	1.01	0.01	999.00
Zn	mg/L	23.95	0.01	9999.00
Zr	mg/L	0.03	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Apr 09, 1998
In : Apr 08, 1998

[032414:54:31:89040998]

4 Samples 4=Solution

Symbol	Unit	Solution Col C RAF Day 47	Limit Low	Limit High
SO4	G/L	32.07	0.01	1000.00
Al	mg/L	2765.7	0.2	9999.0
Sb	mg/L	<0.1	0.1	9999.0
As	mg/L	2.0	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.25	0.01	999.00
Ca	mg/L	503.4	0.1	9999.0
Cr	mg/L	1.32	0.01	9999.00
Co	mg/L	7.05	0.01	9999.00
Cu	mg/L	3.81	0.01	9999.00
Fe	mg/L	3061.59	0.03	9999.00
La	mg/L	1.46	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	1881.6	0.1	9999.0
Mn	mg/L	219.39	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	0.25	0.02	9999.00
Ni	mg/L	2.27	0.02	9999.00
P	mg/L	117.4	0.1	9999.0
K	mg/L	80.	2.	9999.
Sc	mg/L	1.83	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	9.	1.	9999.
Si	mg/L	259.23	0.05	9999.00
Sr	mg/L	0.97	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	0.2	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	7.05	0.01	999.00
Zn	mg/L	25.97	0.01	9999.00
Zr	mg/L	0.01	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

INTERNATIONAL PLASMA LABORATORY LTD.

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Process Research Associates Ltd

Project: 97-084

Out: Apr 17, 1998
In : Apr 14, 1998

[034212:10:03:89041798]

4 Samples 4=Solution

Symbol	Unit	Solution Col C RAF Comp 54	Limit Low	Limit High
SO4	G/L	40.53	0.01	1000.00
Al	mg/L	3426.5	0.2	9999.0
Sb	mg/L	<0.1	0.1	9999.0
As	mg/L	2.4	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.33	0.01	999.00
Ca	mg/L	479.4	0.1	9999.0
Cr	mg/L	1.96	0.01	9999.00
Co	mg/L	7.80	0.01	9999.00
Cu	mg/L	4.98	0.01	9999.00
Fe	mg/L	4203.01	0.03	9999.00
La	mg/L	1.60	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	2252.7	0.1	9999.0
Mn	mg/L	254.99	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	0.70	0.02	9999.00
Ni	mg/L	2.92	0.02	9999.00
P	mg/L	207.8	0.1	9999.0
K	mg/L	87.	2.	9999.
Sc	mg/L	2.14	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	10.	1.	9999.
Si	mg/L	243.53	0.05	9999.00
Sr	mg/L	1.06	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	0.5	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	11.34	0.01	999.00
Zn	mg/L	28.53	0.01	9999.00
Zr	mg/L	0.07	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Project: 97-084

Out: Apr 22, 1998
In : Apr 22, 1998

[037116:04:41:89042298]

4 Samples 4=Solution

Symbol	Unit	Solution Col C RAF Comp Day 61	Limit Low	Limit High
SO4	G/L	41.11	0.01	1000.00
Al	mg/L	3304.5	0.2	9999.0
Sb	mg/L	<0.1	0.1	9999.0
As	mg/L	1.6	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.28	0.01	999.00
Ca	mg/L	494.1	0.1	9999.0
Cr	mg/L	2.10	0.01	9999.00
Co	mg/L	7.07	0.01	9999.00
Cu	mg/L	6.09	0.01	9999.00
Fe	mg/L	4344.62	0.03	9999.00
La	mg/L	1.36	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	2197.9	0.1	9999.0
Mn	mg/L	209.25	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	1.50	0.02	9999.00
Ni	mg/L	2.37	0.02	9999.00
P	mg/L	232.1	0.1	9999.0
K	mg/L	147.	2.	9999.
Sc	mg/L	2.07	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	4.	1.	9999.
Si	mg/L	267.58	0.05	9999.00
Sr	mg/L	1.06	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	1.1	0.1	999.0
W	mg/L	0.5	0.1	9999.0
V	mg/L	13.17	0.01	999.00
Zn	mg/L	27.16	0.01	9999.00
Zr	mg/L	0.05	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Apr 30, 1998
In : Apr 29, 1998

[038911:43:47:89043098]

4 Samples 4=Solution

Symbol	Unit	Solution Col C RAF Comp Day 68	Limit Low	Limit High
SO4	G/L	46.36	0.01	1000.00
Al	mg/L	3868.0	0.2	9999.0
Sb	mg/L	<0.1	0.1	9999.0
As	mg/L	1.7	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.28	0.01	999.00
Ca	mg/L	488.8	0.1	9999.0
Cr	mg/L	2.52	0.01	9999.00
Co	mg/L	7.18	0.01	9999.00
Cu	mg/L	2.67	0.01	9999.00
Fe	mg/L	4974.65	0.03	9999.00
La	mg/L	1.38	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	2615.2	0.1	9999.0
Mn	mg/L	224.90	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	0.64	0.02	9999.00
Ni	mg/L	2.91	0.02	9999.00
P	mg/L	241.7	0.1	9999.0
K	mg/L	241.	2.	9999.
Sc	mg/L	2.15	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	2.	1.	9999.
Si	mg/L	305.63	0.05	9999.00
Sr	mg/L	1.12	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	3.2	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	15.74	0.01	999.00
Zn	mg/L	29.75	0.01	9999.00
Zr	mg/L	0.09	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98F0521

Process Research Associates Ltd

Project: 97-084 PO#043

Out: Jun 03, 1998
In : Jun 02, 1998

[052114:56:34:89060398]

3 Samples 3=Solution

Symbol	Unit	Solution Col. C PLS Day 103	Limit Low	Limit High
Al	mg/L	3424.8	0.2	9999.0
Sb	mg/L	0.2	0.1	9999.0
As	mg/L	6.6	0.2	9999.0
Ba	mg/L	<0.01	0.01	999.00
Bi	mg/L	<0.1	0.1	9999.0
Cd	mg/L	0.25	0.01	999.00
Ca	mg/L	497.5	0.1	9999.0
Cr	mg/L	2.19	0.01	9999.00
Co	mg/L	6.74	0.01	9999.00
Cu	mg/L	427.44	0.01	9999.00
Fe	mg/L	1608.21	0.03	9999.00
La	mg/L	0.60	0.05	999.00
Pb	mg/L	<0.05	0.05	9999.00
Mg	mg/L	2457.7	0.1	9999.0
Mn	mg/L	189.72	0.01	999.00
Hg	mg/L	<0.05	0.05	9999.00
Mo	mg/L	0.54	0.02	9999.00
Ni	mg/L	2.75	0.02	9999.00
P	mg/L	88.5	0.1	9999.0
K	mg/L	41.	2.	9999.
Sc	mg/L	1.76	0.01	100.00
Ag	mg/L	<0.02	0.02	999.00
Na	mg/L	16.	1.	9999.
Si	mg/L	211.91	0.05	9999.00
Sr	mg/L	0.29	0.01	999.00
Th	mg/L	<0.1	0.1	9999.0
Ti	mg/L	0.6	0.1	999.0
W	mg/L	<0.1	0.1	9999.0
V	mg/L	1.52	0.01	999.00
Zn	mg/L	31.43	0.01	9999.00
Zr	mg/L	<0.01	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Feb 26, 1998
In : Feb 24, 1998

6 Samples 6=Solution

[019217:03:54:89022698]

Symbol	Unit	Solution Col B Day 7 PLS	Solution Col B Day 7 Raf	Solution Col B Day 14 PLS	Limit Low	Limit High
SO4	G/L	65.76	67.50	39.86	0.01	1000.00
Al	mg/L	3912.9	3879.9	2037.3	0.2	9999.0
Sb	mg/L	<0.1	<0.1	0.2	0.1	9999.0
As	mg/L	4.0	2.9	2.6	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	0.6	0.1	9999.0
Cd	mg/L	<0.01	0.50	0.32	0.01	999.00
Ca	mg/L	482.2	493.4	470.2	0.1	9999.0
Cr	mg/L	0.92	0.94	0.20	0.01	9999.00
Co	mg/L	13.34	13.54	9.86	0.01	9999.00
Cu	mg/L	15.69g	1561.49	10.04g	0.01	9999.00
Fe	mg/L	3075.71	3056.49	1493.27	0.03	9999.00
La	mg/L	2.01	2.05	1.32	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	3496.8	3531.4	2301.7	0.1	9999.0
Mn	mg/L	505.18	499.30	368.08	0.01	999.00
Hg	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mo	mg/L	1.69	1.44	0.35	0.02	9999.00
Ni	mg/L	3.28	3.18	2.26	0.02	9999.00
P	mg/L	217.8	41.4	96.2	0.1	9999.0
K	mg/L	213.	227.	125.	2.	9999.
Sc	mg/L	1.49	1.38	0.77	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	29.	27.	26.	1.	9999.
Sr	mg/L	1.36	1.36	0.96	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	1.7	1.2	0.5	0.1	999.0
W	mg/L	3.4	<0.1	2.2	0.1	9999.0
V	mg/L	3.85	3.85	0.69	0.01	999.00
Zn	mg/L	57.44	40.11	39.66	0.01	9999.00
Zr	mg/L	0.10	0.09	0.02	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Mar 09, 1998
In : Mar 05, 1998

[022315:01:04:89030998]

2 Samples 2=Solution

Symbol	Unit	Solution Day 21 Col B PLS	Solution Day 21 Col B RAF	Limit Low	Limit High
SO4	G/L	28.38	28.37	0.01	1000.00
Al	mg/L	1389.6	1420.7	0.2	9999.0
Sb	mg/L	<0.1	0.3	0.1	9999.0
As	mg/L	2.1	1.5	0.2	9999.0
Ba	mg/L	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.27	0.29	0.01	999.00
Ca	mg/L	459.3	463.0	0.1	9999.0
Cr	mg/L	0.04	0.07	0.01	9999.00
Co	mg/L	7.37	7.35	0.01	9999.00
Cu	mg/L	6734.65	49.27	0.01	9999.00
Fe	mg/L	1013.21	1067.34	0.03	9999.00
La	mg/L	1.08	1.00	0.05	999.00
Pb	mg/L	<0.05	<0.05	0.05	9999.00
Mg	mg/L	1748.2	1751.3	0.1	9999.0
Mn	mg/L	266.33	268.84	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.12	0.20	0.02	9999.00
Ni	mg/L	1.79	1.71	0.02	9999.00
P	mg/L	87.5	1.5	0.1	9999.0
K	mg/L	70.	59.	2.	9999.
Sc	mg/L	0.46	0.40	0.01	100.00
Ag	mg/L	<0.02	<0.02	0.02	999.00
Na	mg/L	14.	15.	1.	9999.
Sr	mg/L	0.77	0.78	0.01	999.00
Th	mg/L	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.3	<0.1	0.1	999.0
W	mg/L	1.0	<0.1	0.1	9999.0
V	mg/L	0.09	0.31	0.01	999.00
Zn	mg/L	29.39	20.71	0.01	9999.00
Zr	mg/L	0.03	0.01	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98C0231

Process Research Associates Ltd

Project: 97-084

Out: Mar 11, 1998
In : Mar 09, 1998

[023117:19:10:89031198]

4 Samples 4=Solution

Symbol	Unit	Solution Col. B PLS Day 28	Solution Col. B RAF Day 28	Limit Low	Limit High
SO4	G/L	23.38	23.73	0.01	1000.00
Al	mg/L	1299.3	1291.7	0.2	9999.0
Sb	mg/L	<0.1	0.1	0.1	9999.0
As	mg/L	1.6	1.5	0.2	9999.0
Ba	mg/L	<0.01	<0.01	0.01	999.00
Bi	mg/L	0.6	<0.1	0.1	9999.0
Cd	mg/L	0.24	0.26	0.01	999.00
Ca	mg/L	455.9	462.6	0.1	9999.0
Cr	mg/L	0.03	0.03	0.01	9999.00
Co	mg/L	6.33	6.47	0.01	9999.00
Cu	mg/L	5005.51	184.54	0.01	9999.00
Fe	mg/L	1025.27	998.51	0.03	9999.00
La	mg/L	0.89	0.87	0.05	999.00
Pb	mg/L	0.24	<0.05	0.05	9999.00
Mg	mg/L	1616.6	1566.5	0.1	9999.0
Mn	mg/L	233.77	233.30	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.15	0.21	0.02	9999.00
Ni	mg/L	1.53	1.71	0.02	9999.00
P	mg/L	55.6	3.0	0.1	9999.0
K	mg/L	66.	59.	2.	9999.
Sc	mg/L	0.42	0.38	0.01	100.00
Ag	mg/L	<0.02	<0.02	0.02	999.00
Na	mg/L	23.	24.	1.	9999.
Sr	mg/L	0.69	0.70	0.01	999.00
Th	mg/L	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.2	<0.1	0.1	999.0
W	mg/L	0.7	<0.1	0.1	9999.0
V	mg/L	0.13	0.16	0.01	999.00
Zn	mg/L	25.19	19.12	0.01	9999.00
Zr	mg/L	0.03	0.03	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Mar 20, 1998
In : Mar 17, 1998

[025117:35:56:89032098]

4 Samples 4=Solution

Symbol	Unit	Solution Col B PLS Day 35	Solution Col B RAF Day 35	Solution Col C PLS Day 26	Limit Low	Limit High
SO4	G/L	25.55	25.48	19.88	0.01	1000.00
Al	mg/L	1413.9	1391.1	1485.2	0.2	9999.0
Sb	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
As	mg/L	2.1	1.6	1.7	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	2.6	<0.1	0.9	0.1	9999.0
Cd	mg/L	0.26	0.29	0.21	0.01	999.00
Ca	mg/L	467.7	469.7	467.0	0.1	9999.0
Cr	mg/L	0.05	0.07	0.23	0.01	9999.00
Co	mg/L	7.33	7.32	5.42	0.01	9999.00
Cu	mg/L	4703.37	71.37	2194.03	0.01	9999.00
Fe	mg/L	1093.43	1078.72	1176.52	0.03	9999.00
La	mg/L	0.87	0.94	1.26	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	1775.9	1750.9	1171.8	0.1	9999.0
Mn	mg/L	260.13	256.84	175.80	0.01	999.00
Hg	mg/L	0.11	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.21	0.15	0.13	0.02	9999.00
Ni	mg/L	2.04	1.75	1.58	0.02	9999.00
P	mg/L	49.8	2.2	26.5	0.1	9999.0
K	mg/L	54.	132.	22.	2.	9999.
Sc	mg/L	0.48	0.44	0.84	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	30.	31.	21.	1.	9999.
Sr	mg/L	0.64	0.64	0.82	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.2	<0.1	<0.1	0.1	999.0
W	mg/L	1.6	<0.1	0.7	0.1	9999.0
V	mg/L	0.39	0.39	0.02	0.01	999.00
Zn	mg/L	27.10	21.24	20.34	0.01	9999.00
Zr	mg/L	<0.01	<0.01	<0.01	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98C0278

Process Research Associates Ltd

Project: 97-084

Out: Apr 01, 1998
In : Mar 23, 1998

[027812:58:58:89040198]

4 Samples 4=Solution

Symbol	Unit	Solution Col B PLS Day 42	Solution Col B RAF Day 42	Solution Col C PLS Day 33	Limit Low	Limit High
SO4	G/L	26.38	26.99	22.12	0.01	1000.00
Al	mg/L	1750.0	1775.8	1950.2	0.2	9999.0
Sb	mg/L	0.1	<0.1	<0.1	0.1	9999.0
As	mg/L	1.7	1.6	1.6	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	1.7	<0.1	0.2	0.1	9999.0
Cd	mg/L	0.31	0.31	0.24	0.01	999.00
Ca	mg/L	463.9	465.6	470.0	0.1	9999.0
Cr	mg/L	0.11	0.09	0.50	0.01	9999.00
Co	mg/L	7.96	8.02	5.98	0.01	9999.00
Cu	mg/L	3924.04	52.15	1722.71	0.01	9999.00
Fe	mg/L	1290.37	1284.69	1443.16	0.03	9999.00
La	mg/L	0.91	0.93	1.31	0.05	999.00
Pb	mg/L	0.10	<0.05	<0.05	0.05	9999.00
Mg	mg/L	2149.5	2052.7	1453.1	0.1	9999.0
Mn	mg/L	290.49	289.32	199.37	0.01	999.00
Hg	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.25	0.13	0.24	0.02	9999.00
Ni	mg/L	2.15	2.06	1.72	0.02	9999.00
P	mg/L	49.3	3.2	24.6	0.1	9999.0
K	mg/L	61.	61.	13.	2.	9999.
Sc	mg/L	0.65	0.63	1.31	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	26.	28.	17.	1.	9999.
Si	mg/L	85.66	87.16	107.61	0.05	9999.00
Sr	mg/L	0.57	0.58	0.59	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.2	<0.1	<0.1	0.1	999.0
W	mg/L	1.6	<0.1	0.5	0.1	9999.0
V	mg/L	0.47	0.44	0.03	0.01	999.00
Zn	mg/L	28.80	24.21	22.21	0.01	9999.00
Zr	mg/L	<0.01	<0.01	<0.01	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

CERTIFICATE OF ANALYSIS
iPL 98C0302

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Process Research Associates Ltd

Project: 97-084

Out: Apr 01, 1998
In : Mar 31, 1998

[030217:42:16:89040198]

4 Samples 4=Solution

Symbol	Unit	Solution COL B PLS Day 49	Solution COL B RAF Day 49	Solution COL C PLS Day 40	Limit Low	Limit High
SO4	G/L	27.68	27.89	26.98	0.01	1000.00
Al	mg/L	1842.8	1850.7	2417.4	0.2	9999.0
Sb	mg/L	<0.1	<0.1	0.1	0.1	9999.0
As	mg/L	2.6	2.2	2.4	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	1.0	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.34	0.36	0.27	0.01	999.00
Ca	mg/L	500.9	497.0	496.1	0.1	9999.0
Cr	mg/L	0.15	0.16	0.83	0.01	9999.00
Co	mg/L	8.59	8.51	6.68	0.01	9999.00
Cu	mg/L	3207.61	36.02	1270.35	0.01	9999.00
Fe	mg/L	1391.77	1388.87	1787.69	0.03	9999.00
La	mg/L	0.88	0.92	1.38	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	2025.7	2049.9	1588.1	0.1	9999.0
Mn	mg/L	281.31	281.62	206.85	0.01	999.00
Hg	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.26	0.13	0.17	0.02	9999.00
Ni	mg/L	2.46	2.41	2.15	0.02	9999.00
P	mg/L	44.3	2.9	21.4	0.1	9999.0
K	mg/L	69.	67.	5.	2.	9999.
Sc	mg/L	0.68	0.75	1.60	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	26.	27.	15.	1.	9999.
Sr	mg/L	0.52	0.52	0.61	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.2	<0.1	<0.1	0.1	999.0
W	mg/L	0.9	<0.1	0.3	0.1	9999.0
V	mg/L	0.68	0.94	0.53	0.01	999.00
Zn	mg/L	31.56	26.86	25.70	0.01	9999.00
Zr	mg/L	<0.01	<0.01	0.06	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98D0324

Process Research Associates Ltd

Project: 97-084

Out: Apr 09, 1998
In : Apr 08, 1998

[032414:54:31:89040998]

4 Samples 4=Solution

Symbol	Unit	Solution Col B PLS Day 56	Solution Col B RAF Day 56	Solution Col C PLS Day 47	Limit Low	Limit High
SO4	G/L	30.94	30.92	33.06	0.01	1000.00
Al	mg/L	2274.4	2282.0	2935.3	0.2	9999.0
Sb	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
As	mg/L	2.3	2.3	1.7	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	0.2	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.34	0.34	0.26	0.01	999.00
Ca	mg/L	517.2	517.4	508.9	0.1	9999.0
Cr	mg/L	0.46	0.49	1.48	0.01	9999.00
Co	mg/L	9.02	9.05	7.26	0.01	9999.00
Cu	mg/L	1915.31	14.07	797.00	0.01	9999.00
Fe	mg/L	2044.03	2019.78	3537.02	0.03	9999.00
La	mg/L	1.13	1.11	1.54	0.05	999.00
Pb	mg/L	<0.05	0.21	<0.05	0.05	9999.00
Mg	mg/L	2354.4	2375.6	1966.0	0.1	9999.0
Mn	mg/L	299.20	301.58	224.68	0.01	999.00
Hg	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.91	0.21	0.94	0.02	9999.00
Ni	mg/L	2.45	2.54	2.36	0.02	9999.00
P	mg/L	80.0	54.9	160.7	0.1	9999.0
K	mg/L	152.	222.	106.	2.	9999.
Sc	mg/L	1.04	1.03	1.90	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	26.	27.	6.	1.	9999.
Si	mg/L	204.68	203.66	279.42	0.05	9999.00
Sr	mg/L	0.83	0.83	0.99	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	2.4	2.4	0.3	0.1	999.0
W	mg/L	1.1	<0.1	0.4	0.1	9999.0
V	mg/L	3.67	3.68	8.16	0.01	999.00
Zn	mg/L	31.22	29.10	27.97	0.01	9999.00
Zr	mg/L	<0.01	0.03	0.05	0.01	999.00

——=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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Process Research Associates Ltd

Project: 97-084

Out: Apr 17, 1998
In : Apr 14, 1998

[034212:10:03:89041798]

4 Samples 4=Solution

Symbol	Unit	Solution Col B PLS Day 63	Solution Col B RAF Day 63	Solution Col C PLS Day 54	Limit Low	Limit High
SO4	G/L	36.04	36.46	42.53	0.01	1000.00
Al	mg/L	2737.9	2797.4	3705.5	0.2	9999.0
Sb	mg/L	0.3	0.2	<0.1	0.1	9999.0
As	mg/L	2.4	3.0	2.2	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.38	0.39	0.34	0.01	999.00
Ca	mg/L	482.0	489.1	474.9	0.1	9999.0
Cr	mg/L	0.72	0.71	2.14	0.01	9999.00
Co	mg/L	9.01	9.15	8.09	0.01	9999.00
Cu	mg/L	1661.69	12.03	932.20	0.01	9999.00
Fe	mg/L	2576.85	2549.83	4616.31	0.03	9999.00
La	mg/L	1.12	1.08	1.69	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	2589.1	2605.4	2449.8	0.1	9999.0
Mn	mg/L	318.25	322.29	265.10	0.01	999.00
Hg	mg/L	<0.05	0.16	<0.05	0.05	9999.00
Mo	mg/L	1.57	0.45	1.55	0.02	9999.00
Ni	mg/L	2.77	2.83	2.84	0.02	9999.00
P	mg/L	92.8	73.3	209.2	0.1	9999.0
K	mg/L	117.	107.	92.	2.	9999.
Sc	mg/L	1.35	1.39	2.17	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	25.	27.	8.	1.	9999.
Si	mg/L	177.90	183.59	261.05	0.05	9999.00
Sr	mg/L	0.80	0.84	1.04	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	4.4	4.3	0.5	0.1	999.0
W	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
V	mg/L	4.67	4.70	12.81	0.01	999.00
Zn	mg/L	31.09	29.72	31.46	0.01	9999.00
Zr	mg/L	0.04	0.02	0.09	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

CERTIFICATE OF ANALYSIS
iPL 98D0371

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Process Research Associates Ltd

Project: 97-084

Out: Apr 22, 1998
In : Apr 22, 1998

[037116:04:41:89042298]

4 Samples 4=Solution

Symbol	Unit	Solution Col B PLS Day 70	Solution Col B RAF Day 70	Solution Col C PLS Day 61	Limit Low	Limit High
SO4	G/L	38.58	38.72	36.47	0.01	1000.00
Al	mg/L	3120.1	3051.9	2935.4	0.2	9999.0
Sb	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
As	mg/L	3.0	2.8	1.0	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	1.2	0.1	<0.1	0.1	9999.0
Cd	mg/L	0.41	0.41	0.22	0.01	999.00
Ca	mg/L	491.1	487.8	481.9	0.1	9999.0
Cr	mg/L	0.79	0.78	1.84	0.01	9999.00
Co	mg/L	9.78	9.71	5.80	0.01	9999.00
Cu	mg/L	1442.53	11.89	484.80	0.01	9999.00
Fe	mg/L	2677.90	2580.55	4291.79	0.03	9999.00
La	mg/L	1.13	1.11	1.07	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	2772.0	2790.5	1952.5	0.1	9999.0
Mn	mg/L	321.35	317.63	167.52	0.01	999.00
Hg	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mo	mg/L	1.86	1.32	3.43	0.02	9999.00
Ni	mg/L	2.82	2.82	1.83	0.02	9999.00
P	mg/L	71.4	51.2	219.9	0.1	9999.0
K	mg/L	104.	102.	154.	2.	9999.
Sc	mg/L	1.55	1.51	1.68	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	26.	26.	<1.	1.	9999.
Si	mg/L	171.99	169.90	264.96	0.05	9999.00
Sr	mg/L	0.73	0.71	1.05	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	2.7	2.4	1.1	0.1	999.0
W	mg/L	0.4	0.2	0.6	0.1	9999.0
V	mg/L	4.71	4.48	12.37	0.01	999.00
Zn	mg/L	33.32	31.46	23.27	0.01	9999.00
Zr	mg/L	0.02	0.03	0.06	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

CERTIFICATE OF ANALYSIS
iPL 98D0389

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Process Research Associates Ltd

Project: 97-084

Out: Apr 30, 1998
In : Apr 29, 1998

[038911:43:47:89043098]

4 Samples 4=Solution

Symbol	Unit	Solution Col B PLS Day 77	Solution Col B RAF Day 77	Solution Col C PLS Day 68	Limit Low	Limit High
SO4	G/L	39.75	39.33	44.42	0.01	1000.00
Al	mg/L	3319.9	3317.1	3778.7	0.2	9999.0
Sb	mg/L	0.3	<0.1	0.1	0.1	9999.0
As	mg/L	2.9	3.2	1.7	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.43	0.43	0.28	0.01	999.00
Ca	mg/L	479.8	485.5	491.2	0.1	9999.0
Cr	mg/L	0.82	0.84	2.50	0.01	9999.00
Co	mg/L	10.00	10.12	7.01	0.01	9999.00
Cu	mg/L	1222.32	6.00	323.90	0.01	9999.00
Fe	mg/L	2273.35	2131.68	5015.75	0.03	9999.00
La	mg/L	1.13	1.08	1.32	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	2917.8	2957.9	2574.1	0.1	9999.0
Mn	mg/L	350.77	351.93	217.77	0.01	999.00
Hg	mg/L	<0.05	0.11	<0.05	0.05	9999.00
Mo	mg/L	1.05	0.69	2.99	0.02	9999.00
Ni	mg/L	3.15	3.14	2.90	0.02	9999.00
P	mg/L	70.7	57.6	210.6	0.1	9999.0
K	mg/L	71.	63.	236.	2.	9999.
Sc	mg/L	1.66	1.67	2.12	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	28.	29.	<1.	1.	9999.
Si	mg/L	147.63	148.07	284.13	0.05	9999.00
Sr	mg/L	0.54	0.54	1.12	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	2.5	2.3	3.0	0.1	999.0
W	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
V	mg/L	3.46	3.35	16.05	0.01	999.00
Zn	mg/L	35.25	34.26	29.62	0.01	9999.00
Zr	mg/L	0.07	0.05	0.08	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98E0408

Process Research Associates Ltd

Project: 97-084

Out: May 06, 1998
In : May 05, 1998

[040811:44:14:89050698]

3 Samples 3=Solution

Symbol	Unit	Solution COL B PLS DAY 84	Solution COL B RAF DAY 84	Solution COL C PLS DAY 75	Limit Low	Limit High
SO4	G/L	40.38	40.86	39.24	0.01	1000.00
Al	mg/L	3667.6	3652.7	3353.2	0.2	9999.0
Sb	mg/L	0.3	0.2	0.5	0.1	9999.0
As	mg/L	4.3	4.4	2.3	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	0.7	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.54	0.54	0.29	0.01	999.00
Ca	mg/L	537.5	532.1	531.5	0.1	9999.0
Cr	mg/L	0.91	0.88	2.38	0.01	9999.00
Co	mg/L	11.56	11.50	6.41	0.01	9999.00
Cu	mg/L	1440.63	12.02	249.57	0.01	9999.00
Fe	mg/L	1430.71	1302.10	4247.16	0.03	9999.00
La	mg/L	0.93	1.01	1.06	0.05	999.00
Pb	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mg	mg/L	3116.0	3140.5	2334.6	0.1	9999.0
Mn	mg/L	378.88	378.83	183.88	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.11	0.05	9999.00
Mo	mg/L	0.76	0.86	1.67	0.02	9999.00
Ni	mg/L	3.66	3.64	2.92	0.02	9999.00
P	mg/L	69.7	51.9	136.4	0.1	9999.0
K	mg/L	17.	24.	171.	2.	9999.
Sc	mg/L	2.04	2.01	1.77	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	40.	41.	5.	1.	9999.
Si	mg/L	156.97	157.85	263.13	0.05	9999.00
Sr	mg/L	0.30	0.30	1.03	0.01	999.00
Th	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Ti	mg/L	1.5	1.3	1.8	0.1	999.0
W	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
V	mg/L	1.70	1.71	14.21	0.01	999.00
Zn	mg/L	42.26	40.17	28.60	0.01	9999.00
Zr	mg/L	0.04	0.02	0.08	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98F0521

Process Research Associates Ltd

Project: 97-084 PO#043

Out: Jun 03, 1998
In : Jun 02, 1998

[052114:56:34:89060398]

3 Samples 3=Solution

Symbol	Unit	Solution Col. B PLS Day 112	Solution Col. B RAF Day 112	Limit Low	Limit High
Al	mg/L	3782.9	3804.8	0.2	9999.0
Sb	mg/L	0.2	0.1	0.1	9999.0
As	mg/L	9.0	8.1	0.2	9999.0
Ba	mg/L	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.54	0.56	0.01	999.00
Ca	mg/L	515.2	509.5	0.1	9999.0
Cr	mg/L	0.52	0.56	0.01	9999.00
Co	mg/L	12.32	12.21	0.01	9999.00
Cu	mg/L	1080.05	3.39	0.01	9999.00
Fe	mg/L	267.30	170.22	0.03	9999.00
La	mg/L	0.52	0.59	0.05	999.00
Pb	mg/L	0.80	0.78	0.05	9999.00
Mg	mg/L	3320.4	3347.1	0.1	9999.0
Mn	mg/L	394.63	396.37	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.25	0.21	0.02	9999.00
Ni	mg/L	4.15	3.97	0.02	9999.00
P	mg/L	26.1	14.5	0.1	9999.0
K	mg/L	6.	15.	2.	9999.
Sc	mg/L	1.60	1.60	0.01	100.00
Ag	mg/L	<0.02	<0.02	0.02	999.00
Na	mg/L	37.	38.	1.	9999.
Si	mg/L	99.36	99.12	0.05	9999.00
Sr	mg/L	0.13	0.14	0.01	999.00
Th	mg/L	<0.1	<0.1	0.1	9999.0
Ti	mg/L	0.4	0.3	0.1	999.0
W	mg/L	0.2	<0.1	0.1	9999.0
V	mg/L	<0.01	<0.01	0.01	999.00
Zn	mg/L	45.48	43.69	0.01	9999.00
Zr	mg/L	<0.01	0.01	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

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CERTIFICATE OF ANALYSIS
iPL 98B0192

Process Research Associates Ltd

Project: 97-084

Out: Feb 26, 1998
In : Feb 24, 1998

[019217:03:54:89022698]

6 Samples 6=Solution

Symbol	Unit	Solution Col B Day 14 Raf	Solution Col C Day 5 PLS	Solution Col C Day 5 Raf	Limit Low	Limit High
SO4	G/L	39.93	39.97	46.02	0.01	1000.00
Al	mg/L	2054.3	1502.2	1655.0	0.2	9999.0
Sb	mg/L	<0.1	0.1	0.3	0.1	9999.0
As	mg/L	2.3	2.7	2.3	0.2	9999.0
Ba	mg/L	<0.01	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.36	<0.01	0.42	0.01	999.00
Ca	mg/L	472.9	497.9	505.1	0.1	9999.0
Cr	mg/L	0.22	0.21	0.28	0.01	9999.00
Co	mg/L	9.93	9.80	10.71	0.01	9999.00
Cu	mg/L	2299.47	15.78g	235.70	0.01	9999.00
Fe	mg/L	1487.32	503.13	586.58	0.03	9999.00
La	mg/L	1.40	2.17	2.32	0.05	999.00
Pb	mg/L	<0.05	0.48	0.11	0.05	9999.00
Mg	mg/L	2321.5	1325.5	1413.6	0.1	9999.0
Mn	mg/L	368.77	359.61	385.20	0.01	999.00
Hg	mg/L	<0.05	<0.05	<0.05	0.05	9999.00
Mo	mg/L	1.22	0.33	0.09	0.02	9999.00
Ni	mg/L	2.38	2.03	2.33	0.02	9999.00
P	mg/L	29.1	187.9	15.4	0.1	9999.0
K	mg/L	99.	17.	19.	2.	9999.
Sc	mg/L	0.69	0.73	0.69	0.01	100.00
Ag	mg/L	<0.02	<0.02	<0.02	0.02	999.00
Na	mg/L	26.	39.	41.	1.	9999.
Sr	mg/L	0.96	2.28	2.36	0.01	999.00
Th	mg/L	<0.1	0.2	<0.1	0.1	9999.0
Ti	mg/L	0.2	0.6	0.1	0.1	999.0
W	mg/L	0.2	3.7	<0.1	0.1	9999.0
V	mg/L	0.53	0.10	0.10	0.01	999.00
Zn	mg/L	29.65	45.23	27.70	0.01	9999.00
Zr	mg/L	0.03	0.02	0.03	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

Appendix 3

Waste Neutralization Batch Test Report

Carmacks Copper Project

Waste Neutralization Testwork

WESTERN COPPER HOLDINGS

MAY 1998

BEATTTIE CONSULTING LTD
VANCOUVER, B. C. CANADA

1.0 INTRODUCTION

Previous column testwork conducted on the neutralization of leached Carmacks composites achieved an effluent pH of about 4 with the addition of lime or sodium hydroxide solutions to the top of the column. The present testwork was an extension of that work and was intended to evaluate more completely the effectiveness of various neutralizing agents for achieving effluents having a neutral pH and low dissolved solids. The sample used for the testwork was residual waste from a crib test that had been conducted at the site several years ago. When that test was ended, the solids were emptied from the crib into trenches at the site and were left exposed to the environment until they were collected late in 1997 for the tests. The present report summarizes the results of testwork which was completed on the waste sample. All the testwork was conducted by Process Research Associates Ltd and the ICP analyses were carried out by International Plasma Laboratories in Vancouver.

2.0 SAMPLE DESCRIPTION

The sample used for the testwork was collected by representatives of Kilborn Engineering, late in 1997 and was shipped to the laboratory of Process Research Associates Ltd in Vancouver. The sample, weighing about 360 kg, was shipped to Vancouver in a single fibre bag. The sub samples which were used for the testwork were taken from the total waste sample by multiple point sampling since the moist condition of the sample precluded the use of other sample splitting techniques.

The sample was assayed to establish to what extent it had been leached and the results are summarized in Table 1. It is apparent from the analysis that the copper has been only partially leached from this sample.

Table 1
Assays of Waste Sample

Element	Assay, %
Cu total	0.58
Cu soluble	0.42
Fe total	3.84
Fe soluble	1.20

The size analysis showing the sample to be minus ¾ inch and an ICP analysis are included in Appendix A. The results of a whole rock analysis for the sample are summarized in Table 2. The rock is composed of aluminosilicates and the composition is consistent with a high biotite content.

Table 2
Whole Rock Analysis of Waste Sample

Compound	Analysis, %
Al_2O_3	16.98
BaO	0.22
CaO	3.43
Fe_2O_3	6.21
K_2O	2.43
MgO	2.24
MnO	0.07
Na_2O	4.59
P_2O_5	0.30
SiO_2	57.27
TiO_2	0.68
LOI	5.64
Total	100.06

3.0 TEST PROCEDURES

The detailed test procedures and results for all the testwork conducted on the waste sample (identified as sample L1) are included as Appendix B.

A portion of the L1 sample was leached with deionized water for 24 hours. The pH of the solution was monitored over this period and the final solution was analyzed by ICP analysis. This test was designated as test WL1.

In order to remove some of the soluble copper from the waste sample and re-acidify it prior to the neutralization testwork, a sub sample of the waste was placed in a column and was flooded with a 15 gpl H_2SO_4 solution. After 48 hours the solution was drained from the column and the column was re-flooded with a 2 gpl acid solution. After an additional 24 hours this rinse solution was also drained from the column although there was a high solution hold up in the solids. The solids at this point were removed from the column and were split into several portions for individual leaching tests. The column leaching of the L1 sample is identified as test AL1.

Four tests were conducted on the leached waste sample. In each case the test was conducted by mixing the waste sample with deionized water and titrating to target pH values with the selected base while agitating the sample. The pH was adjusted in several stages to observe the stability once a particular value was attained. In the first test (AL1-T1) the pH was adjusted to 4, 5.8 and then 7. The solution was sampled and analyzed by ICP after a pH of 5.8 and 7.1 was achieved. In subsequent tests, after a stable condition was achieved at pH 4, the target value was changed directly to pH 7. Only the final filtrates were analyzed by ICP for these tests. The test conditions are summarized in Table 3.

Table 3
Neutralization Tests on Carmacks Waste Samples

Test No.	Neutralizing Agent
AL1 – T1	NaOH
AL1 – T2	Lime
AL1 – T3	Na_2CO_3
AL1 – T4	Water

4.0 RESULTS

The water leach test of the waste sample as received indicated that the pH of water in contact with this material would have a pH near pH 4, starting with deionized water having a pH of 4.66. The ICP analysis for the solution from this test, along with those from all the other tests, is included in Appendix B. In addition to the soluble copper, leaching of Al, Ca, Fe, Mg, Mn, K and Na is apparent. The solution also contained 2,750 mg/L sulphate, which together with the dissolved copper indicates that the solids had not been well washed when leaching was ended.

While the acid leach test removed some of the copper from the waste, significant copper remained in the solids used for the neutralization tests. The solids also did not become as acidic as those previously

produced by column leaching, (pH 2.2). The consumption of base in the subsequent neutralization tests on this material therefore likely is understated.

A graphical presentation of the pH as a function of time for each of the titration tests is included in Appendix B. While the solution with no base added again remained at about pH 4, with sodium hydroxide, sodium carbonate or lime the solution could readily be adjusted to pH 7 and was stable at this value in each case. It appears from these tests that when a basic solution is in free contact with the solids, they are readily neutralized. This result suggests that lime is likely not a good choice for neutralizing a spent heap due to its limited solubility in water.

The resulting filtrates from these tests show that effective neutralization results in a large drop in dissolved aluminum, iron and copper and a lesser decrease in the magnesium and potassium. Sodium carbonate appears to have been the most effective at neutralization.

APPENDIX A

Waste Sample Characterization

Multielement ICP Analysis Results

Project: 97-084 **Date:** February 24, 1998

Element	Unit	Sample
		L1 (waste) Head
Al	ppm	15,089
Sb	ppm	< 5
As	ppm	< 5
Ba	ppm	104
Bi	ppm	< 2
Cd	ppm	0.7
Ca	ppm	5,388
Cr	ppm	35
Co	ppm	14
Cu	ppm	5,586
Fe	ppm	37,668
La	ppm	11
Pb	ppm	3
Mg	ppm	12,140
Mn	ppm	404
Hg	ppm	< 3
Mo	ppm	67
Ni	ppm	9
P	ppm	1,353
K	ppm	7,768
Sc	ppm	5
Ag	ppm	6.1
Na	ppm	< 100
Sr	ppm	25
Tl	ppm	< 10
Ti	ppm	1,406
W	ppm	< 5
V	ppm	91
Zn	ppm	82
Zr	ppm	3

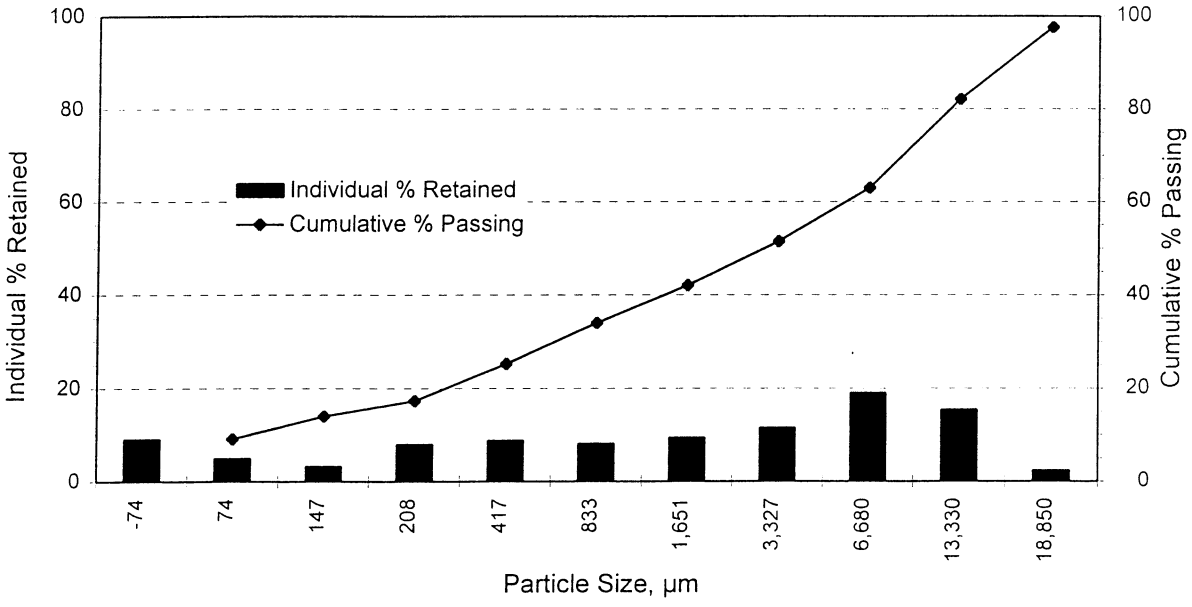
SIZE ANALYSIS REPORT

Test: S2 **Date:** February 19, 1998
Sample: L1 (waste) sample head **Project:** 97-084

Sieve Size		Individual	Cumulative
Size range	Micrometers	% Retained	% Passing
3/4"	18,850	2.4	97.6
1/2"	13,330	15.5	82.1
3	6,680	19.1	63.0
6	3,327	11.6	51.4
10	1,651	9.4	42.0
20	833	8.1	34.0
35	417	8.8	25.2
65	208	7.9	17.3
100	147	3.3	14.0
200	74	5.0	9.0
-200	-74	9.0	-
TOTAL:		100.0	

80 % Passing Size (µm) = 12,471

Size Distribution



Head Sample Moisture = 8.40% (by weight)

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APPENDIX B

Test Details

WATER LEACH TEST ON WASTE SAMPLE L1

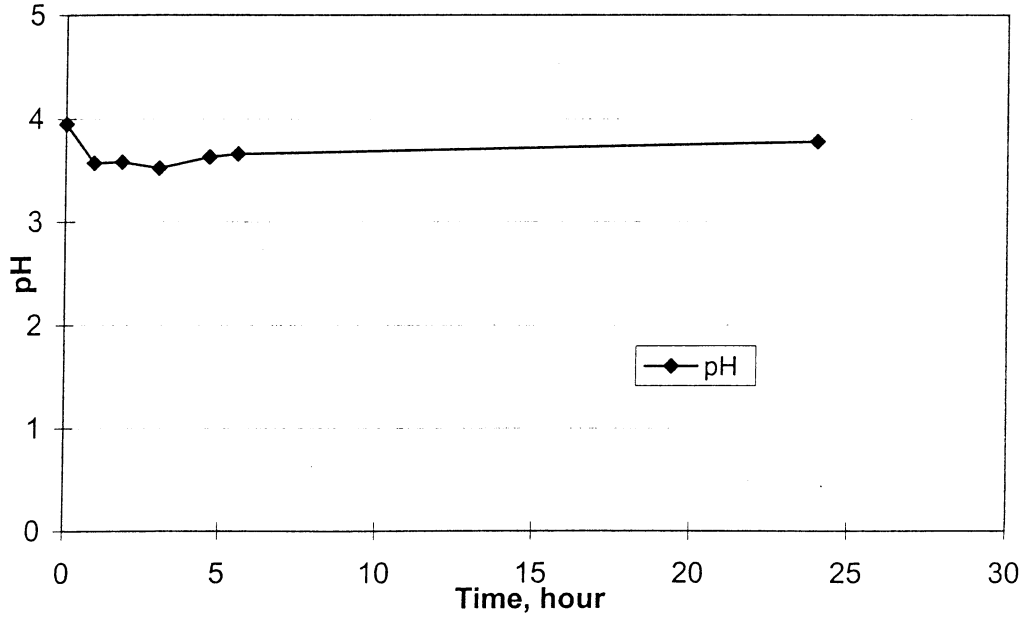
Test: WL1 **Date:** February 26, 1998
Sample: Waste L1 **Project:** 97-084

Procedure: - added 500 mL of deionized water to a 1-liter conical flask;
- recorded pH of the water;
- added 100 g waste sample L1 to the flask and recorded pH; and sulphate determinations.
- shook the slurry for 24 hours, recorded pH change;
- sampled the slurry for ICP analysis as well as total acidity and sulphate determination.

Time (hour)	pH	$SO_4^=$ (mg/L)	Total Acidity (mg $CaCO_3$/L)	ICP Sample ID
0.0	3.95			
0.9	3.57			
1.8	3.58			
3.0	3.52			
4.6	3.63			
5.5	3.66			
24.0	3.78	2,750.0	777.4	WL1 Filtrate

pH of deionized water was 4.66.

pH Change of the Residue Slurry



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ACID LEACH TEST ON WASTE SAMPLE L1

Test: AL1 **Date:** February 26, 1998
Sample: Waste L1 **Project:** 97-084

Procedure: - placed 8 kg L1 sample in a 4"x4' column;
- added 15 g/L H_2SO_4 solution to submerge the solids;
- drained the column after 48 hours;
- added 2 g/L H_2SO_4 solution to submerge the solids;
- drained the column after 24 hours;
- drained solutions analysed by ICP;
- wet residue was saved for titration tests.

Time (hour)	15 g/L H_2SO_4 added (mL)	2 g/L H_2SO_4 added (mL)	Total H_2SO_4 added (kg/t)	Solution Drained			
				Volume (mL)	pH	Cu (g/L)	ICP Sample ID
0	945		1.77				
48				332.00	3.49	19.40	AL1 Solution 1
72		349.00	0.09				
96				347.00	3.56	12.8	AL1 Solution 2

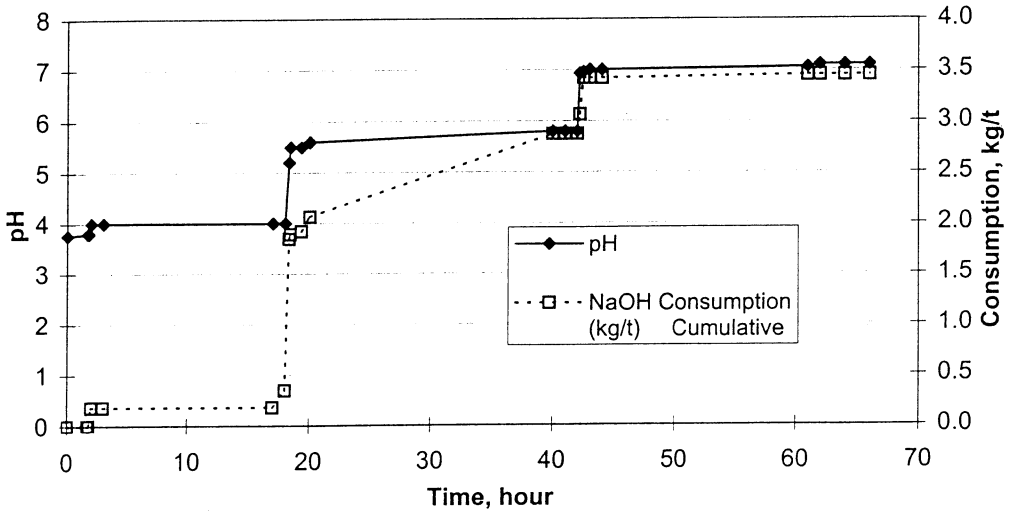
NEUTRALIZATION TEST ON WASTE SAMPLE L1

Test: AL1-T1 **Date:** February 26, 1998
Sample: AL1 residue/NaOH **Project:** 97-084

Procedure: - mixed 1 kg wet residue with 5 kg deionized water;
- titrated with 0.893 N NaOH;
- sequentially increase the end points to pH 3.5, 4, 5.5 and 7.0;
- sampled the slurry for ICP analysis.

Time (hour)	pH	NaOH added (mL)	NaOH Consumption (kg/t)		ICP Sample ID
			Individual	Cumulative	
0.0	3.8			0.00	
1.7	3.8			0.00	
1.8	3.8			0.00	
2.0	4.0	5.1	0.18	0.18	
3.0	4.0			0.18	
17.0	4.0			0.18	
18.0	4.0	4.6	0.16	0.35	
18.3	5.2	42.0	1.50	1.85	
18.4	5.5	1.3	0.05	1.89	
19.3	5.5	0.8	0.03	1.92	
20.0	5.6	4.0	0.14	2.06	
40.0	5.8	22.7	0.81	2.88	
41.0	5.8			2.88	
42.0	5.8			2.88	AL1-T1 Filtrate1
42.2	6.9	5.3	0.19	3.06	
42.5	7.0	10.0	0.36	3.42	
43.0	7.0			3.42	
44.0	7.0			3.42	
61.0	7.1	0.8	0.03	3.45	
62.0	7.1			3.45	
64.0	7.1			3.45	
66.0	7.1			3.45	AL1-T1 Filtrate 2
Total		**96.6**	**3.45**		

Titration of AL1 Residue with NaOH



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NEUTRALIZATION TEST ON WASTE SAMPLE L1

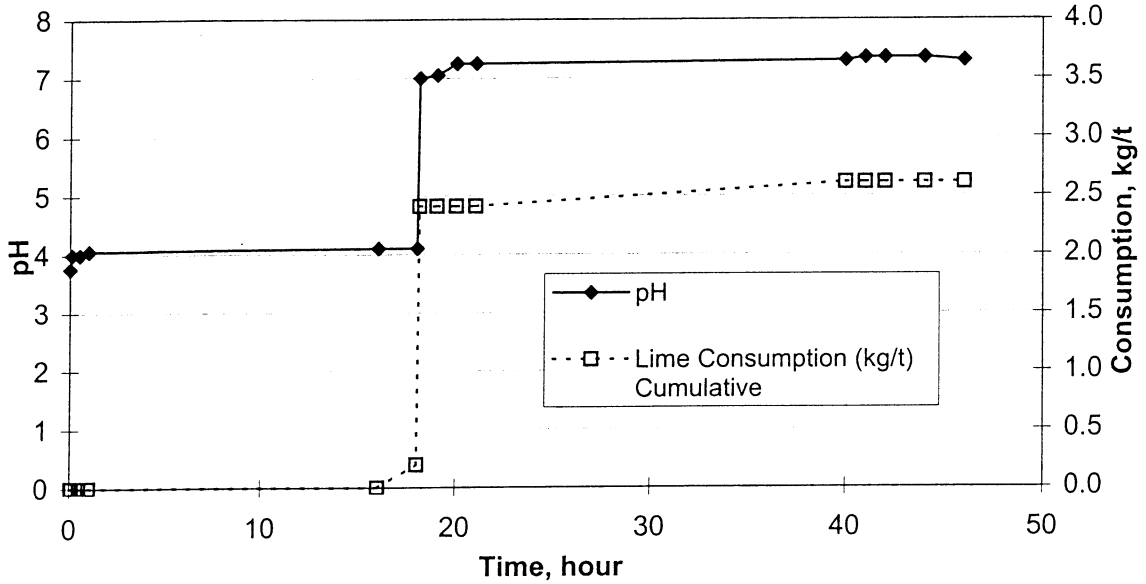
Test: AL1-T2
Sample: AL1 residue/Lime

Date: February 26, 1998
Project: 97-084

Procedure: - mixed 1 kg wet residue with 5 kg deionized water;
- titrated with 0.099 g/mL lime slurry;
- sequentially increased the end points to pH 3.5, 4.0 and 7.0;
- sampled the slurry for ICP analysis.

Time (hour)	pH	Lime added (mL)	Lime Consumption (kg/t)		ICP Sample ID
			Individual	Cumulative	
0.0	3.8		0.00	0.00	
0.1	4.0		0.00	0.00	
0.5	4.0		0.00	0.00	
1.0	4.1		0.00	0.00	
16.0	4.1		0.00	0.00	
18.0	4.1	2.0	0.20	0.20	
18.1	7.0	22.4	2.21	2.41	
19.0	7.1		0.00	2.41	
20.0	7.3		0.00	2.41	
21.0	7.3		0.00	2.41	
40.0	7.3	2.0	0.20	2.61	
41.0	7.4		0.00	2.61	
42.0	7.4		0.00	2.61	
44.0	7.4		0.00	2.61	
46.0	7.3		0.00	2.61	AL1-T2 Filtrate
Total		**26.4**	**2.61**		

Titration of AL1 Residue with Lime



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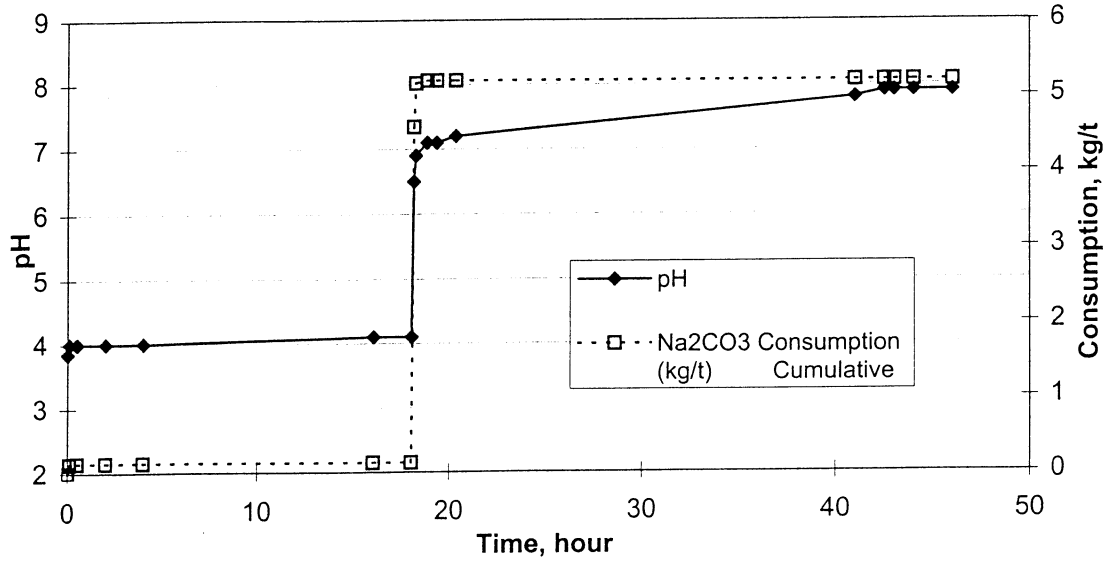
NEUTRALIZATION TEST ON WASTE SAMPLE L1

Test: AL1-T3 **Date:** February 26, 1998
Sample: AL1 residue/Na_2CO_3 **Project:** 97-084

Procedure: - mixed 1 kg wet residue with 5 kg deionized water;
- titrated with 1.73 N (9.169%) Na_2CO_3;
- sequentially increased the end points to pH 3.5, 4.0 and 7.0;
- sampled the slurry for ICP analysis.

Time (hour)	pH	Na_2CO_3 added (mL)	Na_2CO_3 Consumption (kg/t)		ICP Sample ID
			Individual	Cumulative	
0.0	3.9			0.00	
0.1	4.0	1.3	0.12	0.12	
0.5	4.0	0.1	0.01	0.13	
2.0	4.0			0.13	
4.0	4.0			0.13	
16.0	4.1			0.13	
18.0	4.1			0.13	
18.1	6.5	48.6	4.46	4.58	
18.2	6.9	6.3	0.58	5.16	
18.8	7.1	0.4	0.04	5.20	
19.3	7.1			5.20	
20.3	7.2			5.20	
41.0	7.8			5.20	
42.5	7.9			5.20	
43.0	7.9			5.20	
44.0	7.9			5.20	
46.0	7.9			5.20	AL1-T3 Filtrate
Total		**56.7**	**5.20**		

Titration of AL1 Residue with Sodium Carbonate



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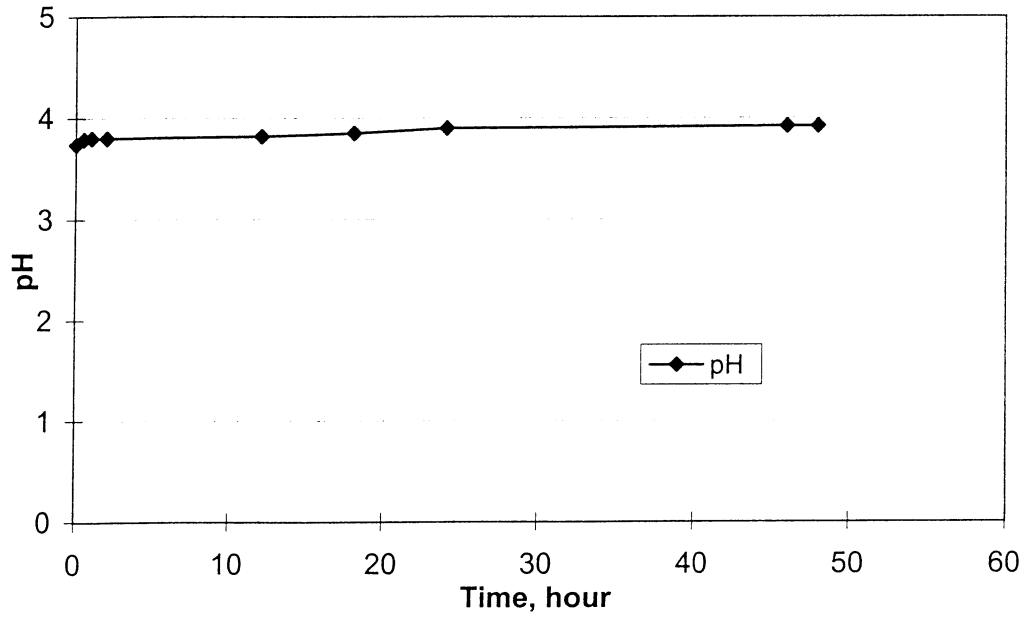
WATER LEACH TEST ON WASTE SAMPLE L1

Test: AL1-T4 **Date:** February 26, 1998
Sample: AL1 residue **Project:** 97-084

Procedure: - mixed 1 kg wet residue with 5 kg deionized water;
- monitored pH but did not adjust;
- sampled the slurry for ICP analysis as well as acidity and sulphate determinations.

Time (hour)	pH	$SO_4^=$ (mg/L)	Total Acidity (mg $CaCO_3$/L)	ICP Sample ID
0.0	3.74			
0.5	3.79			
1.0	3.80			
2.0	3.80			
12.0	3.82			
18.0	3.85			
24.0	3.90			
46.0	3.92			
48.0	3.92	2,200.0	556.7	AL1-T4 Filtrate

pH Change of the Residue Slurry



Process Research Associates Ltd.

Multi-element ICP Analysis Results

Project: 97-084 **Report Date:** March 20, 1998

Element	Unit	Sample							
		WL1 Filtrate	AL1 Solution 1	AL Solution 2	AL 1-T1 Filtrate 1	AL 1-T1 Filtrate 2	AL-T2 Filtrate	AL1-T3 filtrate	AL1-T4 Filtrate
Al	mg/L	25.96	1984.59	1454.51	0.71	0.66	0.88	0.52	24.03
Sb	mg/L	< 0.05	0.34	0.20	<0.05	<0.05	<0.05	<0.05	<0.05
As	mg/L	0.08	4.62	3.30	<0.03	<0.03	<0.03	<0.03	0.08
Ba	mg/L	0.031	<0.005	<0.005	0.008	0.009	<0.005	0.007	0.021
Be	mg/L	0.004	0.117	0.095	<0.001	<0.001	<0.001	<0.001	0.005
Bi	mg/L	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
B	mg/L	0.65	3.93	3.77	0.31	0.38	0.12	0.13	0.10
Cd	mg/L	0.016	0.720	0.377	0.006	<0.005	<0.005	<0.005	0.010
Ca	mg/L	437.16	479.84	454.97	305.40	307.88	624.63	255.11	395.37
Cr	mg/L	< 0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Co	mg/L	0.28	10.41	7.00	0.08	0.02	0.02	<0.01	0.15
Cu	mg/L	483.76	19.37g	12.77g	6.09	0.11	0.12	0.02	297.76
Fe	mg/L	13.09	35.97	38.45	<0.01	<0.01	<0.01	<0.01	13.64
Pb	mg/L	< 0.05	0.61	0.50	<0.05	<0.05	<0.05	<0.05	<0.05
Li	mg/L	0.04	1.15	0.89	<0.02	<0.02	<0.02	<0.02	0.02
Mg	mg/L	99.5	3706.1	2504.6	38.3	37.5	47.6	35.8	55.4
Mn	mg/L	13.580	559.789	371.125	3.949	3.085	3.956	0.778	7.107
Hg	mg/L	< 0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mo	mg/L	0.02	0.11	0.11	0.02	0.09	0.07	0.28	<0.01
Ni	mg/L	0.14	5.45	3.87	0.04	<0.01	<0.01	<0.01	0.12
P	mg/L	5.2	269.3	194.5	<0.1	0.1	<0.1	0.1	4.8
K	mg/L	66	34.	31.	11.	13.	4.	12.	16.
Se	mg/L	< 0.05	0.55	0.59	<0.05	<0.05	<0.05	<0.05	<0.05
Si	mg/L	10.97	43.05	56.08	7.28	6.55	5.18	4.29	10.18
Ag	mg/L	< 0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Na	mg/L	5.4	45.2	31.9	247.1	335.1	1.1	379.1	2.7
Sr	mg/L	0.436	0.341	0.358	0.210	0.179	0.648	0.140	0.360
Tl	mg/L	< 0.2	0.9	0.8	<0.2	<0.2	<0.2	<0.2	<0.2
Sn	mg/L	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ti	mg/L	0.03	0.76	0.52	0.01	0.01	0.02	0.02	0.03
W	mg/L	< 0.1	4.2	2.8	<0.1	<0.1	<0.1	<0.1	0.1
V	mg/L	< 0.01	0.08	0.10	<0.01	<0.01	<0.01	<0.01	<0.01
Zn	mg/L	0.718	65.051	44.115	0.192	<0.005	<0.005	<0.005	0.989

Appendix 4

Waste Column Neutralization Test Details

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N1
Column Size: 6"x216"
Initial Charge Height: 216 inch
Final Charge Height: inch
Sample Weight: 165.0 kg
Bulk Density: 1.649 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 5.00 %

Starting Date: May 15, 1998

Day	Feed							Effluent							Na_2CO_3 Consumption	Note
	Na_2CO_3 added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	SO^4 (g/L)	CO_3 (mg/L)	HCO_3 (mg/L)	(kg/t)	
0	1000.00	20.00	14.50	1.0499	5.24	3.64	11.89								1.67	
1		14.50	8.00	1.0499	6.19	4.30	11.89								3.65	
2		8.00	1.10	1.0499	6.57	4.56	11.89								5.74	
3	1000.00	21.10	13.80	1.0491	6.96	4.83	11.78								7.96	
4		13.80	5.80	1.0491	7.63	5.30	11.78	0.80	1.1007	0.73	3.92	70.8	<1	<1	10.39	
5		5.80	0.60	1.0491	4.96	3.44	11.78	4.40	1.0763	4.09	4.55				11.98	Foaming PLS, precipitate formed
6	2000.00	40.60	33.60	1.0479	6.68	4.64	11.48	4.40	1.0566	4.16	6.01				14.11	Foaming PLS, precipitate formed
7		33.60	25.10	1.0479	8.11	5.63	11.48	7.30	1.0668	6.84	3.88				16.69	No foams
8		25.10	20.80	1.0479	4.10	2.85	11.48	9.30	1.0443	8.91	4.01				18.00	No foams
9		20.80	13.30	1.0479	7.16	4.97	11.48	3.00	1.0397	2.89	4.18				20.29	No foams
10		13.30	8.70	1.0479	4.39	3.05	11.48	19.20	1.0429	18.41	7.30				21.69	Large volume of PLS with foams
11		8.70	1.80	1.0479	6.58	4.57	11.48	5.60	1.0452	5.36	9.37				23.79	No foams but PLS turned brown
12	1000.00	21.80	15.30	1.0481	6.20	4.31	11.60	6.70	1.0467	6.40	10.03				25.76	Brown PLS
13		15.30	8.30	1.0481	6.68	4.64	11.60	6.50	1.0480	6.20	10.18				27.89	Brown PLS
14	1000.00	28.30	22.50	1.0473	5.54	3.85	11.38	7.30	1.0472	6.97	10.18				29.66	Brown PLS
15		22.50	14.50	1.0473	7.64	5.30	11.38	6.30	1.0474	6.01	10.48				32.10	Brown PLS
16		14.50	7.90	1.0473	6.30	4.38	11.38	8.50	1.0479	8.11	10.59				34.11	Brown PLS
17		7.90	1.40	1.0473	6.21	4.31	11.38	6.50	1.0483	6.20	10.36				36.09	Brown PLS
18	1000.00	21.40	14.90	1.0474	6.21	4.31	11.57	6.80	1.0480	6.49	10.60				38.07	Brown PLS
19		14.90	8.20	1.0474	6.40	4.44	11.57	7.10	1.0477	6.78	10.59				40.11	Brown PLS
20		8.20	1.10	1.0474	6.78	4.71	11.57	7.00	1.0475	6.68	10.63	0.6	9000	37000	42.27	Brown PLS
21															42.27	
22															42.27	
23															42.27	
24															42.27	
25															42.27	
26															42.27	
27															42.27	
28	0.03	20.00	14.20	0.9987	5.81	4.03	7.00	4.90	1.0491	4.67	10.59				42.27	Brown PLS
29		14.20	7.60	0.9987	6.61	4.59	7.00	0.10	1.0400	0.10	10.38				42.27	Brown PLS
30		7.60	0.60	0.9987	7.01	4.87	7.00	1.80	1.0514	1.71	10.61				42.27	Brown PLS
31	0.03	20.60	14.20	0.9983	6.41	4.45	6.56	3.10	1.0488	2.96	10.68				42.27	Brown PLS
32		14.20	5.20	0.9983	9.02	6.26	6.56	3.20	1.0478	3.05	10.59				42.27	Brown PLS
33	0.06	45.20	37.80	0.9987	7.41	5.15	6.38	7.10	1.0254	6.92	10.60				42.27	Brown PLS
34		37.80	31.40	0.9987	6.41	4.45	6.38	7.50	1.0195	7.36	10.61				42.27	Brown PLS
35		31.40	23.00	0.9987	8.41	5.84	6.38	6.50	1.0161	6.40	10.66				42.27	Brown PLS
36		23.00	16.40	0.9987	6.61	4.59	6.38	8.70	1.0095	8.62	10.48				42.27	
37		16.40	10.70	0.9987	5.71	3.96	6.38	6.80	1.0049	6.77	10.41				42.27	

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
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Initial Charge Height: 216 inch
Final Charge Height: inch
Sample Weight: 165.0 kg
Bulk Density: 1.649 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 5.00 %

Starting Date: May 15, 1998

Day	Feed							Effluent							Na_2CO_3 Consumption	Note
	Na_2CO_3 added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	SO^4 (g/L)	CO_3 (mg/L)	HCO_3 (mg/L)	(kg/t)	
38		10.70	3.30	0.9987	7.41	5.15	6.38	4.70	1.0024	4.69	10.38				42.27	
39	0.03	23.30	17.30	0.9989	6.01	4.17	6.38	5.90	1.0017	5.89	10.30				42.27	
40		17.30	10.50	0.9989	6.81	4.73	6.38	5.60	1.0016	5.59	10.40				42.27	
41		10.50	4.20	0.9989	6.31	4.38	6.38	6.70	1.0010	6.69	10.13				42.27	
42	0.03	24.00	18.50	0.9987	5.51	3.82	6.32	6.00	1.0003	6.00	10.18				42.27	
43		18.50	7.50	0.9987	11.01	7.65	6.32	5.20	0.9999	5.20	10.56				42.27	
44		7.50	4.30	0.9987	3.20	2.23	6.32	10.80	0.9994	10.81	10.65				42.27	
45	0.03	24.30	16.80	0.9985	7.51	5.22	6.48	2.80	0.9992	2.80	10.59				42.27	
46		16.80	9.80	0.9985	7.01	4.87	6.48	7.70	0.9990	7.71	10.59				42.27	
47		9.80	5.30	0.9985	4.51	3.13	6.48	7.30	0.9987	7.31	10.57				42.27	
48	0.06	45.30	38.40	0.9981	6.91	4.80	6.38	4.60	0.9992	4.60	10.55				42.27	
49		38.40	31.40	0.9981	7.01	4.87	6.38	7.00	0.9989	7.01	10.45				42.27	
50		31.40	24.40	0.9981	7.01	4.87	6.38	7.00	0.9989	7.01	10.39				42.27	
51		24.40	16.50	0.9981	7.92	5.50	6.38	6.30	0.9989	6.31	10.48				42.27	
52		16.50	9.80	0.9981	6.71	4.66	6.38	7.30	0.9990	7.31	10.43				42.27	
53		9.80	3.60	0.9981	6.21	4.31	6.38	6.70	0.9984	6.71	10.42				42.27	
54	0.03	23.60	16.40	0.9984	7.21	5.01	6.18	6.00	0.9987	6.01	10.49				42.27	
55		16.40	9.30	0.9984	7.11	4.94	6.18	6.80	0.9986	6.81	10.52				42.27	
56	0.03	29.30	22.60	0.9982	6.71	4.66	5.80	6.80	0.9983	6.81	10.38				42.27	
57		22.60	16.00	0.9982	6.61	4.59	5.80	6.60	0.9988	6.61	10.38				42.27	
58		16.00	7.60	0.9982	8.42	5.84	5.80	6.50	0.9988	6.51	10.43				42.27	
59		7.60	1.50	0.9982	6.11	4.24	5.80	7.40	0.9989	7.41	10.43				42.27	
60								5.90	0.9987	5.91	10.39				42.27	
61								1.40	1.0009	1.40	10.45				42.27	
62								1.40	1.0011	1.40	10.36				42.27	

INTERNATIONAL PLASMA LABORATORY LTD.

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CERTIFICATE OF ANALYSIS

iPL 98E0469

Process Research Associates Ltd

Project : 97-084 PO#015
Shipper : Liu Qi
Shipment: PO#: 015

Analysis:
ICP(H2O)30 Water Package in mg/L

Comment:

2 Samples Out: May 22, 1998 In: May 19, 1998 [046911:20:26:89052298]

CODE	AMOUNT	TYPE	PREPARATION DESCRIPTION	PULP	REJECT
B412	2	Solution	Solution received as it is, no sample prep.	03M/Dis	00M/Dis

NS=No Sample Rep=Replicate M=Month Dis=Discard

Analytical Summary

##	Code	Method	Units	Description	Element	Limit Low	Limit High
01	0901	ICPH20	mg/L	Al ICP Water Analyses	Aluminum	0.2	9999.0
02	0902	ICPH20	mg/L	Sb ICP Water Analyses	Antimony	0.1	9999.0
03	0903	ICPH20	mg/L	As ICP Water Analyses	Arsenic	0.2	9999.0
04	0904	ICPH20	mg/L	Ba ICP Water Analyses	Barium	0.01	999.00
05	0905	ICPH20	mg/L	Bi ICP Water Analyses	Bismuth	0.1	9999.0
06	0907	ICPH20	mg/L	Cd ICP Water Analyses	Cadmium	0.01	999.00
07	0908	ICPH20	mg/L	Ca ICP Water Analyses	Calcium	0.1	9999.0
08	0909	ICPH20	mg/L	Cr ICP Water Analyses	Chromium	0.01	9999.00
09	0910	ICPH20	mg/L	Co ICP Water Analyses	Cobalt	0.01	9999.00
10	0911	ICPH20	mg/L	Cu ICP Water Analyses	Copper	0.01	9999.00
11	0912	ICPH20	mg/L	Fe ICP Water Analyses	Iron	0.03	9999.00
12	0913	ICPH20	mg/L	La ICP Water Analyses	Lanthanum	0.05	999.00
13	0914	ICPH20	mg/L	Pb ICP Water Analyses	Lead	0.05	9999.00
14	0915	ICPH20	mg/L	Mg ICP Water Analyses	Magnesium	0.1	9999.0
15	0916	ICPH20	mg/L	Mn ICP Water Analyses	Manganese	0.01	999.00
16	0932	ICPH20	mg/L	Hg ICP Water Analyses	Mercury	0.05	9999.00
17	0917	ICPH20	mg/L	Mo ICP Water Analyses	Molydenum	0.02	9999.00
18	0918	ICPH20	mg/L	Ni ICP Water Analyses	Nickel	0.02	9999.00
19	0919	ICPH20	mg/L	P ICP Water Analyses	Phosphorus	0.1	9999.0
20	0920	ICPH20	mg/L	K ICP Water Analyses	Potassium	2.	9999.
21	0936	ICPH20	mg/L	Sc ICP Water Analyses	Scandium	0.01	100.00
22	0921	ICPH20	mg/L	Ag ICP Water Analyses	Silver	0.02	999.00
23	0922	ICPH20	mg/L	Na ICP Water Analyses	Sodium	1.	9999.
24	0923	ICPH20	mg/L	Sr ICP Water Analyses	Strontium	0.01	999.00
25	0924	ICPH20	mg/L	Th ICP Water Analyses	Thorium	0.1	9999.0
26	0926	ICPH20	mg/L	Ti ICP Water Analyses	Titanium	0.1	999.0
27	0927	ICPH20	mg/L	W ICP Water Analyses	Tungsten	0.1	9999.0
28	0929	ICPH20	mg/L	V ICP Water Analyses	Vanadium	0.01	999.00
29	0930	ICPH20	mg/L	Zn ICP Water Analyses	Zinc	0.01	9999.00
30	0931	ICPH20	mg/L	Zr ICP Water Analyses	Zirconium	0.01	999.00

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BC Certified Assayer: David Chiu

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CERTIFICATE OF ANALYSIS
iPL 98E0469

Process Research Associates Ltd

Project: 97-084 PO#015

Out: May 22, 1998
In : May 19, 1998

[046911:20:26:89052298]

2 Samples 2=Solution

Symbol	Unit	Solution COL. N1 PLS Day 4	Solution COL. N2 PLS Day 4	Limit Low	Limit High
Al	mg/L	2213.8	2001.4	0.2	9999.0
Sb	mg/L	0.5	0.2	0.1	9999.0
As	mg/L	6.9	6.1	0.2	9999.0
Ba	mg/L	<0.01	<0.01	0.01	999.00
Bi	mg/L	<0.1	<0.1	0.1	9999.0
Cd	mg/L	0.08	0.85	0.01	999.00
Ca	mg/L	481.2	513.1	0.1	9999.0
Cr	mg/L	<0.01	0.03	0.01	9999.00
Co	mg/L	13.59	12.46	0.01	9999.00
Cu	mg/L	25.18g	23.37g	0.01	9999.00
Fe	mg/L	28.48	29.36	0.03	9999.00
La	mg/L	0.09	<0.05	0.05	999.00
Pb	mg/L	0.76	0.60	0.05	9999.00
Mg	mg/L	5155.2	4662.8	0.1	9999.0
Mn	mg/L	755.04	688.38	0.01	999.00
Hg	mg/L	<0.05	<0.05	0.05	9999.00
Mo	mg/L	0.05	0.15	0.02	9999.00
Ni	mg/L	7.18	6.67	0.02	9999.00
P	mg/L	334.0	288.1	0.1	9999.0
K	mg/L	33.	19.	2.	9999.
Sc	mg/L	0.47	0.44	0.01	100.00
Ag	mg/L	<0.02	<0.02	0.02	999.00
Na	mg/L	1077.	47.	1.	9999.
Sr	mg/L	0.18	0.20	0.01	999.00
Th	mg/L	0.5	0.5	0.1	9999.0
Ti	mg/L	0.9	0.9	0.1	999.0
W	mg/L	6.1	5.4	0.1	9999.0
V	mg/L	0.08	0.08	0.01	999.00
Zn	mg/L	82.99	77.45	0.01	9999.00
Zr	mg/L	0.01	0.01	0.01	999.00

—=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=ReCheck m=x1000 %=Estimate % NS=No Sample

BC Certified Assayer: David Chiu

Multi-element ICP Analysis of Column N1 PLS

Project: 97-084

Date Reported: January 17, 2001

Element	Unit	Column N1 PLS					
		Day 4	Day 20				
Al	mg/L	2213.8	< 0.2				
Sb	mg/L	0.5	0.1				
As	mg/L	6.9	0.3				
Ba	mg/L	< 0.01	< 0.01				
Bi	mg/L	< 0.1	< 0.1				
Cd	mg/L	0.08	< 0.01				
Ca	mg/L	481.2	2.1				
Cr	mg/L	< 0.01	< 0.01				
Co	mg/L	13.59	< 0.01				
Cu	mg/L	25180	5.86				
Fe	mg/L	28.48	0.23				
La	mg/L	0.09	< 0.05				
Pb	mg/L	0.76	< 0.05				
Mg	mg/L	5155.2	< 0.1				
Mn	mg/L	755.04	0.02				
Hg	mg/L	< 0.05	0.10				
Mo	mg/L	0.05	4.29				
Ni	mg/L	7.18	0.94				
P	mg/L	334.0	88.3				
K	mg/L	33	49				
Sc	mg/L	0.47	< 0.01				
Ag	mg/L	< 0.02	< 0.02				
Na	mg/L	1077	18000				
Sr	mg/L	0.18	< 0.01				
Th	mg/L	0.5	< 0.1				
Ti	mg/L	0.9	< 0.1				
W	mg/L	6.1	0.2				
V	mg/L	0.08	1.11				
Zn	mg/L	82.99	< 0.01				
Zr	mg/L	0.01	0.04				

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N2
Column Size: 6"x216"
Initial Charge Height: 216 inch
Final Charge Height: inch
Sample Weight: 165.0 kg
Bulk Density: 1.649 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
NaOH Solution pH: 9.0

Starting Date: May 15, 1998

Day	Feed							Effluent				NaOH Consumption	Note
	NaOH added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	(kg/t)	
0	0.11	20.00	14.50	0.9986	5.51	3.82	9.00					0.0002	
1		14.50	8.00	0.9986	6.51	4.52	9.00					0.0004	
2		8.00	1.10	0.9986	6.91	4.80	9.00					0.0006	
3	0.11	21.10	12.60	0.9983	8.51	5.91	9.00					0.0009	
4		12.60	5.10	0.9983	7.51	5.22	9.00	0.90	1.0906	0.83	3.49	0.0012	Clear blue PLS
5		5.10	0.20	0.9983	4.91	3.41	9.00	4.70	1.0701	4.39	3.42	0.0013	Clear blue PLS
6	0.23	40.20	33.20	0.9988	7.01	4.87	9.00	3.80	1.0437	3.64	3.78	0.0016	Clear blue PLS
7		33.20	24.70	0.9988	8.51	5.91	9.00	5.80	1.0261	5.65	3.67	0.0018	Clear blue PLS
8		24.70	20.20	0.9988	4.51	3.13	9.00	8.40	1.0172	8.26	3.81	0.0020	Clear blue PLS
9		20.20	13.50	0.9988	6.71	4.66	9.00	4.30	1.0086	4.26	3.90	0.0022	Clear blue PLS
10		13.50	7.60	0.9988	5.91	4.10	9.00	7.40	1.0064	7.35	4.11	0.0024	Clear blue PLS
11		7.60	0.70	0.9988	6.91	4.80	9.00	5.60	1.0048	5.57	3.98	0.0026	Clear blue PLS
12	0.11	20.70	14.20	0.9989	6.51	4.52	9.08	6.90	1.0043	6.87	4.13	0.0029	Clear blue PLS
13		14.20	7.20	0.9989	7.01	4.87	9.08	6.70	1.0036	6.68	4.28	0.0031	Clear blue PLS
14	0.11	27.20	21.40	0.9985	5.81	4.03	9.33	7.30	1.0032	7.28	4.20	0.0033	Clear blue PLS
15		21.40	13.40	0.9985	8.01	5.56	9.33	6.00	1.0025	5.99	4.73	0.0036	Clear blue PLS
16		13.40	7.30	0.9985	6.11	4.24	9.33	8.20	1.0025	8.18	4.60	0.0038	Clear blue PLS
17		7.30	0.60	0.9985	6.71	4.66	9.33	6.00	1.0021	5.99	4.93	0.0040	Clear blue PLS
18	0.11	20.60	14.10	0.9987	6.51	4.52	9.43	6.30	1.0016	6.29	4.83	0.0042	Clear blue PLS
19		14.10	7.40	0.9987	6.71	4.66	9.43	6.30	1.0016	6.29	4.28	0.0044	Clear blue PLS
20		7.40	0.40	0.9987	7.01	4.87	9.43	7.60	1.0013	7.59	4.60	0.0047	Clear blue PLS
21	0.11	20.40	13.90	0.9990	6.51	4.52	9.37	6.80	1.0019	6.79	4.23	0.0049	Clear blue PLS
22		13.90	7.40	0.9990	6.51	4.52	9.37	5.70	1.0015	5.69	3.91	0.0051	Clear blue PLS
23		7.40	0.10	0.9990	7.31	5.07	9.37	6.60	1.0010	6.59	3.98	0.0053	Clear blue PLS
24	0.11	20.10	13.90	0.9987	6.21	4.31	8.88	7.30	1.0011	7.29	3.99	0.0055	Clear blue PLS
25		13.90	7.40	0.9987	6.51	4.52	8.88	5.50	1.0015	5.49	3.96	0.0058	Clear blue PLS
26		7.40	0.00	0.9987	7.41	5.15	8.88	6.30	1.0014	6.29	3.90	0.0060	Clear blue PLS
27	0.23	40.00	33.40	0.9988	6.61	4.59	8.87	8.00	1.0013	7.99	3.96	0.0062	Clear blue PLS
28		33.40	27.60	0.9988	5.81	4.03	8.87	6.20	1.0010	6.19	4.56	0.0064	Clear blue PLS

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N2
Column Size: 6"x216"
Initial Charge Height: 216 inch
Final Charge Height: inch
Sample Weight: 165.0 kg
Bulk Density: 1.649 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
NaOH Solution pH: 9.0

Starting Date: May 15, 1998

Day	Feed							Effluent				NaOH Consumption	Note
	NaOH added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	(kg/t)	
29		27.60	20.00	0.9988	7.61	5.28	8.87	5.80	1.0012	5.79	4.38	0.0067	Clear blue PLS
30		20.00	12.30	0.9988	7.71	5.35	8.87	7.50	1.0012	7.49	4.52	0.0069	Clear blue PLS
31		12.30	4.80	0.9988	7.51	5.21	8.87	8.10	1.0015	8.09	4.00	0.0072	Clear blue PLS
32	0.11	24.80	15.40	0.9985	9.41	6.54	9.05	7.20	1.0007	7.19	4.55	0.0075	Clear blue PLS
33		15.40	8.10	0.9985	7.31	5.08	9.05	8.20	1.0011	8.19	4.50	0.0077	Clear blue PLS
34		8.10	1.70	0.9985	6.41	4.45	9.05	8.30	1.0010	8.29	4.50	0.0080	Clear blue PLS
35	0.11	21.70	13.30	0.9988	8.41	5.84	9.02	7.20	1.0010	7.19	4.50	0.0082	Clear blue PLS
36		13.30	7.70	0.9988	5.61	3.89	9.02	9.40	1.0000	9.40	4.08	0.0084	Clear blue PLS
37		7.70	3.70	0.9988	4.00	2.78	9.02	7.20	0.9999	7.20	4.18	0.0086	Clear blue PLS
38	0.11	23.70	17.10	0.9980	6.61	4.59	8.54	4.90	0.9999	4.90	3.43	0.0088	Clear blue PLS
39		17.10	11.10	0.9980	6.01	4.18	8.54	6.00	1.0005	6.00	4.21	0.0090	Clear blue PLS
40		11.10	5.70	0.9980	5.41	3.76	8.54	5.50	1.0010	5.49	4.22	0.0092	Clear blue PLS
41		5.70	0.00	0.9980	5.71	3.97	8.54	6.20	1.0009	6.19	4.08	0.0093	Clear blue PLS
42	0.11	20.00	15.20	0.9986	4.81	3.34	8.55	5.80	1.0009	5.79	4.10	0.0095	Clear blue PLS
43		15.20	6.10	0.9986	9.11	6.33	8.55	2.80	0.9998	2.80	4.21	0.0098	Clear blue PLS
44		6.10	3.50	0.9986	2.60	1.81	8.55	14.70	1.0000	14.70	4.16	0.0099	Clear blue PLS
45	0.11	23.50	16.00	0.9983	7.51	5.22	8.59	3.10	1.0003	3.10	4.23	0.0101	Clear blue PLS
46		16.00	9.00	0.9983	7.01	4.87	8.59	8.20	1.0000	8.20	4.15	0.0104	Clear blue PLS
47		9.00	6.90	0.9983	2.10	1.46	8.59	7.40	1.0000	7.40	4.14	0.0105	Clear blue PLS
48	0.23	46.90	42.10	0.9983	4.81	3.34	8.38	4.60	0.9999	4.60	4.12	0.0106	Clear blue PLS
49		42.10	35.10	0.9983	7.01	4.87	8.38	5.00	0.9998	5.00	4.15	0.0108	Clear blue PLS
50		35.10	28.00	0.9983	7.11	4.94	8.38	4.00	0.9998	4.00	4.20	0.0111	Clear blue PLS
51		28.00	21.00	0.9983	7.01	4.87	8.38	3.50	0.9997	3.50	4.22	0.0113	Clear blue PLS
52		21.00	15.00	0.9983	6.01	4.17	8.38	4.40	1.0000	4.40	4.24	0.0115	Clear blue PLS
53		15.00	9.00	0.9983	6.01	4.17	8.38	4.40	0.9995	4.40	4.25	0.0117	Clear blue PLS
54		9.00	2.20	0.9983	6.81	4.73	8.38	4.30	0.9996	4.30	4.22	0.0119	Clear blue PLS
55	0.23	42.20	36.70	0.9982	5.51	3.83	8.97	5.40	0.9997	5.40	4.32	0.0121	Clear blue PLS
56		36.70	30.00	0.9982	6.71	4.66	8.97	5.60	0.9994	5.60	4.25	0.0124	Clear blue PLS
57		30.00	23.40	0.9982	6.61	4.59	8.97	5.80	0.9997	5.80	4.30	0.0126	Clear blue PLS

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N2
Column Size: 6"x216"
Initial Charge Height: 216 inch
Final Charge Height: inch
Sample Weight: 165.0 kg
Bulk Density: 1.649 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
NaOH Solution pH: 9.0

Starting Date: May 15, 1998

Day	Feed							Effluent				NaOH Consumption	Note
	NaOH added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	pH	(kg/t)	
58		23.40	15.80	0.9982	7.61	5.29	8.97	6.20	0.9997	6.20	4.31	0.0128	Clear blue PLS
59		15.80	9.90	0.9982	5.91	4.10	8.97	7.30	0.9998	7.30	4.38	0.0130	Clear blue PLS
60								5.90	0.9996	5.90	4.41	0.0130	
61								5.30	1.0001	5.30	4.43	0.0130	

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N3
Column Size: 4" x 60"
Initial Charge Height: 54.5 inch
Final Charge Height: inch
Sample Weight: 16.5 kg
Bulk Density: 0.653 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10.00 %

Starting Date: August 12, 1998

		Feed							Effluent					Na_2CO_3	Note
Date	Day	Na_2CO_3 added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	ORP mV	pH	Addition (kg/t)	
12-Aug-98	0	0.10	20.00		0.9981	20.04		7.02			0.00			0.0000	
13-Aug-98	1		20.00	17.20	0.9981	2.81	1.95	7.02	1.40	1.0747	1.30	360.8	**3.43**	0.0009	
14-Aug-98	2		17.20	14.70	0.9981	2.50	1.74	7.02	2.40	1.0203	2.35	304.80	**3.60**	0.0016	
15-Aug-98	3		14.70	12.00	0.9981	2.71	1.88	7.02	2.90	1.0059	2.88	302.80	**3.71**	0.0024	
16-Aug-98	4		12.00	9.50	0.9981	2.50	1.74	7.02	2.20	1.0033	2.19	292.20	**3.82**	0.0032	
17-Aug-98	5		9.50	7.30	0.9981	2.20	1.53	7.02	1.90	1.0029	1.89	280.80	**3.86**	0.0039	
18-Aug-98	6		7.30	4.60	0.9981	2.71	1.88	7.02	2.50	1.0024	2.49	245.40	**3.95**	0.0047	
19-Aug-98	7		4.60	2.10	0.9981	2.50	1.74	7.02	2.40	1.0021	2.39	261.80	**3.98**	0.0054	
20-Aug-98	8	0.15	20.00	17.60	0.9981	2.40	1.67	8.06	2.50	1.0015	2.50	218.20	**3.95**	0.0065	
21-Aug-98	9		17.60	14.50	0.9981	3.11	2.16	8.06	2.90	1.0011	2.90	260.80	**3.94**	0.0080	
22-Aug-98	10		14.50	11.90	0.9981	2.60	1.81	8.06	2.60	1.0007	2.60	284.40	**3.98**	0.0091	
23-Aug-98	11		11.90	9.40	0.9981	2.50	1.74	8.06	2.10	1.0004	2.10	273.10	**4.00**	0.0103	
24-Aug-98	12		9.40	7.30	0.9981	2.10	1.46	8.06	2.07	1.0009	2.07	262.80	**4.01**	0.0112	
25-Aug-98	13		7.30	4.20	0.9981	3.11	2.16	8.06	2.90	1.0005	2.90	208.20	**4.01**	0.0127	
26-Aug-98	14		4.20	2.30	0.9981	1.90	1.32	8.06	1.80	1.0009	1.80	196.80	**4.00**	0.0135	
27-Aug-98	15	0.18	20.00	17.30	0.9987	2.70	1.88	8.08	2.70	1.0009	2.70	236.30	**4.05**	0.0150	
28-Aug-98	16		17.30	14.80	0.9987	2.50	1.74	8.08	2.30	1.0004	2.30	254.90	**3.96**	0.0163	
29-Aug-98	17	0.41	20.00	18.10	0.9979	1.90	1.32	9.03	1.80	0.9998	1.80	275.70	**4.04**	0.0187	
30-Aug-98	18		18.10	15.30	0.9979	2.81	1.95	9.03	2.50	0.9998	2.50	267.30	**4.06**	0.0222	
31-Aug-98	19		15.30	13.00	0.9979	2.30	1.60	9.03	2.10	0.9994	2.10	258.40	**4.08**	0.0251	
1-Sep-98	20		9.90	7.00	0.9979	2.91	2.02	9.03	2.70	0.9993	2.70	252.00	**4.12**	0.0287	
2-Sep-98	21		7.00	4.20	0.9979	2.81	1.95	9.03	2.70	0.9988	2.70	232.00	**4.19**	0.0322	
3-Sep-98	22		4.20	2.10	0.9979	2.10	1.46	9.03	2.50	0.9982	2.50	240.50	**4.20**	0.0348	
4-Sep-98	23	0.32	20.00	18.30	0.9984	1.70	1.18	9.02	1.90	0.9988	1.90	257.90	**4.08**	0.0365	
5-Sep-98	24		18.30	15.40	0.9984	2.90	2.02	9.02	1.90	0.9986	1.90	276.60	**4.31**	0.0393	
6-Sep-98	25		15.40	12.40	0.9984	3.00	2.09	9.02	2.30	0.9985	2.30	270.80	**4.32**	0.0423	
7-Sep-98	26		12.40	10.50	0.9984	1.90	1.32	9.02	2.80	0.9985	2.80	251.70	**4.32**	0.0442	
8-Sep-98	27		10.50	7.96	0.9984	2.54	1.77	9.02	1.70	0.9986	1.70	243.80	**4.44**	0.0466	
9-Sep-98	28		7.90	5.20	0.9987	2.70	1.88	9.02	2.40	0.9987	2.40	255.40	**4.18**	0.0493	
10-Sep-98	29		5.20	2.90	0.9987	2.30	1.60	9.02	2.40	0.9987	2.40	228.90	**4.27**	0.0516	
11-Sep-98	30	0.32	20.00	17.50	0.9987	2.50	1.74	9.01	2.30	0.9987	2.30	312.80	**4.29**	0.0540	
12-Sep-98	31		17.50	15.50	0.9987	2.00	1.39	9.01	2.50	0.9984	2.50	303.90	**4.23**	0.0560	
13-Sep-98	32	1.95	20.00	17.30	0.9984	2.70	1.88	10.00	1.90	0.9985	1.90	291.30	**4.14**	0.0586	

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N3
Column Size: 4" x 60"
Initial Charge Height: 54.5 inch
Final Charge Height: inch
Sample Weight: 16.5 kg
Bulk Density: 0.653 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10.00 %

Starting Date: August 12, 1998

		Feed							Effluent					Na_2CO_3	Note
Date	Day	Na_2CO_3 added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	ORP mV	pH	Addition (kg/t)	
14-Sep-98	33		17.30	14.60	0.9984	2.70	1.88	10.00	2.50	0.9988	2.50	284.20	**4.34**	0.0612	
15-Sep-98	34		14.60	12.20	0.9984	2.40	1.67	10.00	2.60	0.9986	2.60	230.80	**4.98**	0.0635	
16-Sep-98	35		12.20	9.70	0.9984	2.50	1.74	10.00	2.20	0.9987	2.20	349.70	**4.60**	0.0659	
17-Sep-98	36		9.70	7.30	0.9984	2.40	1.67	10.00	2.40	0.9985	2.40	221.60	**4.63**	0.0682	
18-Sep-98	37	2.91	20.00	17.00	0.9984	3.00	2.09	9.99	2.20	0.9986	2.20	291.30	**5.16**	0.0947	
19-Sep-98	38		17.00	14.30	0.9984	2.70	1.88	9.99	2.70	0.9984	2.70	344.80	**6.28**	0.1186	
20-Sep-98	39		14.30	12.80	0.9984	1.50	1.04	9.99	2.40	0.9984	2.40	314.80	**5.52**	0.1318	
21-Sep-98	40		12.80	10.30	0.9984	2.50	1.74	9.99	1.40	0.9986	1.40	324.80	**5.50**	0.1539	
22-Sep-98	41		10.30	7.80	0.9984	2.50	1.74	9.99	2.30	0.9989	2.30	222.10	**5.74**	0.1760	
23-Sep-98	42		7.80	5.20	0.9984	2.60	1.81	9.99	2.40	0.9988	2.40	329.80	**5.49**	0.1990	
24-Sep-98	43		5.20	2.70	0.9984	2.50	1.74	9.99	2.40	0.9986	2.40	380.80	**5.24**	0.2211	
25-Sep-98	44	2.69	20.00	18.10	0.9988	1.90	1.32	10.00	2.40	0.9985	2.40	357.00	**5.22**	0.2366	
26-Sep-98	45		18.10	15.30	0.9988	2.80	1.95	10.00	2.30	0.9988	2.30	192.80	**5.75**	0.2595	
27-Sep-98	46		15.30	12.10	0.9988	3.20	2.22	10.00	2.10	0.9987	2.10	217.30	**6.10**	0.2857	
28-Sep-98	47		12.10	10.40	0.9988	1.70	1.18	10.00	2.90	0.9986	2.90	208.00	**5.94**	0.2996	
29-Sep-98	48		10.40	7.70	0.9988	2.70	1.88	10.00	1.70	0.9981	1.70	211.10	**5.55**	0.3217	
30-Sep-98	49		7.70	5.40	0.9988	2.30	1.60	10.00	2.50	0.9987	2.50	208.10	**5.61**	0.3405	
1-Oct-98	50		5.40	2.90	0.9988	2.50	1.74	10.00	2.10	0.9986	2.10	263.80	**5.91**	0.3609	
2-Oct-98	51	4.69	20.00	17.30	0.9991	2.70	1.88	10.01	2.30	0.9990	2.30	309.50	**6.01**	0.3994	
3-Oct-98	52		17.30	15.10	0.9991	2.20	1.53	10.01	2.50	0.9990	2.50	292.80	**5.24**	0.4307	
4-Oct-98	53		15.10	12.70	0.9991	2.40	1.67	10.01	2.20	0.9993	2.20	323.80	**5.68**	0.4648	
5-Oct-98	54		12.70	10.30	0.9991	2.40	1.67	10.01	2.30	0.9994	2.30	315.40	**5.54**	0.4990	
6-Oct-98	55		10.30	7.20	0.9991	3.10	2.15	10.01	2.30	0.9990	2.30	345.40	**5.32**	0.5431	
7-Oct-98	56		7.20	5.30	0.9991	1.90	1.32	10.01	2.90	0.9990	2.90	211.30	**5.16**	0.5702	
8-Oct-98	57		5.30	2.80	0.9991	2.50	1.74	10.01	1.80	0.9990	1.80	322.80	**5.14**	0.6058	
9-Oct-98	58	3.76	20.00	17.60	0.9991	2.40	1.67	10.48	2.30	0.9990	2.30	160.80	**6.21**	0.6332	
10-Oct-98	59		17.60	15.10	0.9991	2.50	1.74	10.48	2.30	0.9990	2.30	184.30	**5.94**	0.6617	
11-Oct-98	60		15.10	12.10	0.9991	3.00	2.09	10.48	2.90	0.9990	2.90	183.30	**6.01**	0.6959	
12-Oct-98	61		12.10	10.30	0.9991	1.80	1.25	10.48	2.20	0.9990	2.20	192.80	**5.99**	0.7164	
13-Oct-98	62		10.30	8.00	0.9991	2.30	1.60	10.48	2.30	0.9990	2.30	190.50	**5.79**	0.7426	
14-Oct-98	63		8.00	7.70	0.9991	0.30	0.21	10.48	2.30	0.9990	2.30	191.00	**5.76**	0.7460	
15-Oct-98	64	9.25	20.00	17.30	0.9991	2.70	1.88	10.50	0.80	0.9990	0.80	190.90	**5.71**	0.8218	
16-Oct-98	65		17.30	15.00	0.9991	2.30	1.60	10.50	2.30	0.9990	2.30	272.80	**5.75**	0.8864	

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N3
Column Size: 4" x 60"
Initial Charge Height: 54.5 inch
Final Charge Height: inch
Sample Weight: 16.5 kg
Bulk Density: 0.653 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10.00 %

Starting Date: August 12, 1998

Date	Day	Feed							Effluent					Na_2CO_3 Addition	Note
		Na_2CO_3 added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	ORP mV	pH	(kg/t)	
17-Oct-98	66		15.00	12.70	0.9991	2.30	1.60	10.50	2.20	0.9990	2.20	351.00	**5.74**	0.9509	
18-Oct-98	67		12.70	10.10	0.9991	2.60	1.81	10.50	2.20	0.9990	2.20	323.50	**6.06**	1.0239	
19-Oct-98	68		10.10	7.90	0.9991	2.20	1.53	10.50	2.40	0.9990	2.40	304.50	**5.94**	1.0856	
20-Oct-98	69		7.90	5.30	0.9991	2.60	1.81	10.50	2.30	0.9990	2.30	108.70	**6.04**	1.1586	
21-Oct-98	70		5.30	2.50	0.9991	2.80	1.95	10.50	2.40	0.9990	2.40	105.10	**5.56**	1.2372	
22-Oct-98	71		2.50	0.00	0.9991	2.50	1.74	10.50	2.60	0.9990	2.60	128.90	**5.79**	1.3073	
23-Oct-98	72	7.30	20.00	17.60	0.9990	2.40	1.67	10.54	2.30	0.9990	2.30	296.80	**6.54**	1.3605	
24-Oct-98	73		17.60	15.30	0.9990	2.30	1.60	10.54	2.10	0.9990	2.10	210.90	**7.50**	1.4115	
25-Oct-98	74		15.30	12.40	0.9990	2.90	2.02	10.54	2.20	0.9990	2.20	192.80	7.81	1.4757	
26-Oct-98	75		12.40	10.50	0.9990	1.90	1.32	10.54	2.80	0.9990	2.80	197.00	7.43	1.5178	
27-Oct-98	76		10.50	8.00	0.9990	2.50	1.74	10.54	1.80	0.9990	1.80	193.90	7.02	1.5732	
28-Oct-98	77		8.00	5.10	0.9990	2.90	2.02	10.54	2.40	0.9990	2.40	324.80	6.94	1.6375	
29-Oct-98	78		5.10	3.30	0.9990	1.80	1.25	10.54	2.60	0.9990	2.60	248.20	6.88	1.6774	
30-Oct-98	79	8.00	20.00	17.40	0.9990	2.60	1.81	10.50	1.70	0.9990	1.70	103.80	6.78	1.7406	
31-Oct-98	80		17.40	15.00	0.9990	2.40	1.67	10.50	2.40	0.9990	2.40	118.30	7.68	1.7989	
1-Nov-98	81		15.00	13.10	0.9990	1.90	1.32	10.50	2.20	0.9990	2.20	124.80	7.84	1.8451	
2-Nov-98	82		13.10	10.80	0.9990	2.30	1.60	10.50	1.90	0.9990	1.90	154.50	7.38	1.9009	
3-Nov-98	83		10.80	8.40	0.9990	2.40	1.67	10.50	2.10	0.9990	2.10	223.90	6.98	1.9593	
4-Nov-98	84		8.40	6.20	0.9990	2.20	1.53	10.50	2.40	0.9990	2.40	260.50	6.74	2.0127	
5-Nov-98	85		6.20	3.20	0.9990	3.00	2.09	10.50	2.10	0.9990	2.10	228.10	7.03	2.0856	
6-Nov-98	86	8.28	20.00	18.10	0.9990	1.90	1.32	10.50	2.70	0.9990	2.70	168.00	7.28	2.1334	
7-Nov-98	87		18.10	15.50	0.9990	2.60	1.81	10.50	1.80	0.9990	1.80	201.80	8.33	2.1987	
8-Nov-98	88		15.50	13.30	0.9990	2.20	1.53	10.50	2.40	0.9990	2.40	204.80	7.94	2.2540	
9-Nov-98	89		13.30	11.10	0.9990	2.20	1.53	10.50	2.10	0.9990	2.10	208.20	7.54	2.3093	
10-Nov-98	90		11.10	8.40	0.9990	2.70	1.88	10.50	2.10	0.9990	2.10	171.80	7.38	2.3772	
11-Nov-98	91		8.40	6.10	0.9990	2.30	1.60	10.50	2.60	0.9990	2.60	137.50	7.98	2.4350	
12-Nov-98	92		6.10	3.80	0.9990	2.30	1.60	10.50	1.90	0.9990	1.90	148.40	7.61	2.44	
13-Nov-98	93	1.69	20.00	17.70	0.9990	2.30	1.60	7.00	2.10	0.9990	2.10	182.20	7.68	2.45	Tap water f.
14-Nov-98	94		17.70	15.10	0.9990	2.60	1.81	7.00	1.50	0.9990	1.50	183.30	8.40	2.46	
15-Nov-98	95		15.10	13.00	0.9990	2.10	1.46	7.00	2.10	0.9990	2.10	174.00	8.30	2.47	
16-Nov-98	96		13.00	10.40	0.9990	2.60	1.81	7.00	2.30	0.9990	2.30	176.50	7.78	2.48	
17-Nov-98	97	0.91	15.00	13.00	0.9990	2.00	1.39	5.30	2.10	0.9990	2.10	113.20	7.51	2.49	Deion. water f.
18-Nov-98	98		13.00	9.60	0.9990	3.40	2.36	5.30	2.70	0.9990	2.70	212.30	7.33	2.50	

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: N3
Column Size: 4" x 60"
Initial Charge Height: 54.5 inch
Final Charge Height: inch
Sample Weight: 16.5 kg
Bulk Density: 0.653 tonne/m^3
Sample Moisture: 8.40 %

Ore Sample: Carmacks Waste L1
Head Assay $Cu_{(T)}$: 0.58 %
Head Assay $Cu_{(acid\ soluble)}$: 0.42 %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10.00 %

Starting Date: August 12, 1998

Date	Day	Feed							Effluent					Na_2CO_3 Addition	Note
		Na_2CO_3 added (g)	Start Weight (kg)	End Weight (kg)	s.g. (g/mL)	Volume (L)	Pumping Rate (mL/min)	pH	Weight (kg)	s.g. (g/mL)	Volume (L)	ORP mV	pH	(kg/t)	
19-Nov-98	99		9.60	6.60	0.9990	3.00	2.09	5.30	2.30	0.9990	2.30	182.80	7.10	2.51	
20-Nov-98	100		6.60	4.20	0.9990	2.40	1.67	5.30	2.60	0.9990	2.60	192.70	6.99	2.51	
21-Nov-98	101		STOP F.						2.20	0.9990	2.20	192.80		2.51	Rest 2 weeks
22-Nov-98									0.20	0.9990	0.20	171.60	6.80	2.51	
23-Nov-98	126							7.00					7.41		
24-Nov-98	127							7.00					7.11		
25-Nov-98	128							7.00					6.78		

COLUMN NEUTRALIZATION TEST DATA

PROJECT: 97-084
TEST: COLUMN N3

Date	Time	Day	FEED		
			Soda ash g	Total Volume mL	pH
11-May	11:30	0	0.1	6400	7.0
12-May	12:20	1	-	2375	7.0
13-May	8:00	2	-	4335	7.0
14-May	12:30	3	0.02	4915	7.0
15-May	11:25	4	0.05	7985	7.0
16-May	16:00	5	-	6200	7.0
17-May	17:00	6	0.02	5730	7.0
18-May	17:15	7			
19-May	16:45	8	Drain down		
20-May		9			

DISCHARGE SOLUTION						
Volume mL	pH	Eh mV	H+ g/L	SO4 mg/L	Alk mg/L	Acidity mg/L
3300	5.9	224		160	11.5	19.3
3415	6.3	205				
4125	6.2	192				
4905	6.5	186				
7035	6.8	212				
6185	6.3	216				
5075	6.4	186		8	12.1	14.9
1285	6.3	205				
56	6.3	210				

Note: Feed rate 4.3 ml/min. Eh - Ag/AgCl reference.
Soda ash consumption is the amount used to adjust the pH for the initial volume.

Appendix 5

Column C Neutralization Details

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6" inch
Initial Charge Height: 17'10" inch
Final Charge Height: kg
Sample Weight: 164.2 tonne/m^3
Bulk Density: 1.566 %
Sample Moisture:

Ore Sample: Column C Residue
Head Assay $Cu_{(T)}$: %
Head Assay $Cu_{(acid\ soluble)}$: %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10 %

Starting Date: October 22,1998

Day	Feed							DISCHARGE SOLUTION							Na_2CO_3 Consumption
	Na_2CO_3 in soln. (g)	Volume (L)	Pumping Rate (mL/min)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	Volume (L)	Sulphate g/l	Acidity g/l $CaCO_3$	Alkalinity g/l $CaCO_3$	Eh mV	pH	(kg/t)
0	0.005	3.00		7.01											0.00
6	0.005	3.00	2.09	7.00				2.49	2.37	43.75	22.4	pH<4	515	**3.43**	0.00
7	0.005	3.00	2.09	7.05											0.00
10								2.90	2.79	41.25	22.1	pH<4	434	**3.12**	0.00
11	5.40	6.61	4.59	10.50											0.00
12		6.01	4.17	10.50				3.10	3.00	37.50	17.9	pH<4	448	**3.09**	0.01
13		5.71	3.96	10.50				6.50	6.37	22.50	10.70	pH<4	449	**3.18**	0.02
14	5.56	7.41	5.14	10.50				5.80	5.74	13.70	5.80	pH<4	428	**3.15**	0.03
15	9.20	4.90	3.41	10.50				6.90	6.86	8.75	3.20	pH<4	448	**3.17**	0.05
16		6.01	4.17	10.50				4.90	4.87	6.75	2.40	pH<4	450	**3.21**	0.06
17		4.70	3.27	10.50				6.10	6.08	6.00	1.80	pH<4	460	**3.26**	0.08
18	7.22	0.00	0.00	10.50				4.80	4.78	5.50	1.54	pH<4	454	**3.21**	0.08
19	*	6.81	4.73	10.50				2.80	2.79	4.38	1.50	pH<4	265	**3.34**	0.09
20		4.20	2.92	10.50				3.20	3.19	4.75	1.49	pH<4	478	**3.35**	0.10
21		4.80	3.34	10.50				4.70	4.69	4.38	1.30	pH<4	455	**3.32**	0.11
22	6.62	5.21	3.61	10.52				5.10	5.09	4.38	1.12	pH<4	452	**3.31**	0.12
23		5.31	3.68	10.52				5.10	5.09				482	**3.36**	0.13
24		5.41	3.75	10.52				5.10	5.09				479	**3.31**	0.14
25	6.96	4.80	3.34	10.50				5.30	5.29				468	**3.28**	0.15
26		5.21	3.61	10.50				4.70	4.70				448	**3.27**	0.16
27		5.61	3.89	10.50				5.10	5.09				415	**3.26**	0.18
28	10.03	6.61	4.59	10.50				5.50	5.49				446	**3.32**	0.20
29	10.22	5.61	3.89	10.50				6.60	6.59				436	**3.15**	0.21
30		4.60	3.20	10.50				5.50	5.49				459	**3.29**	0.23
31		6.61	4.59	10.50				4.10	4.09				429	**3.38**	0.25
32	7.64	5.21	3.61	10.50				6.10	6.09				441	**3.32**	0.26
33		6.11	4.24	10.50				5.10	5.10				400	**3.33**	0.27
34		6.21	4.31	10.50				6.00	6.00				410	**3.38**	0.29
35	6.65	6.51	4.52	10.51				6.10	6.10				417	**3.40**	0.30
36	7.49	6.81	4.73	10.53				6.40	6.40				442	**3.39**	0.32

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6" inch
Initial Charge Height: 17'10" inch
Final Charge Height: kg
Sample Weight: 164.2 tonne/m^3
Bulk Density: 1.566 %
Sample Moisture:

Ore Sample: Column C Residue
Head Assay $Cu_{(T)}$: %
Head Assay $Cu_{(acid\ soluble)}$: %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10 %

Starting Date: October 22,1998

Day	Feed							DISCHARGE SOLUTION							Na_2CO_3 Consumption
	Na_2CO_3 in soln. (g)	Volume (L)	Pumping Rate (mL/min)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	Volume (L)	Sulphate g/l	Acidity g/l $CaCO_3$	Alkalinity g/l $CaCO_3$	Eh mV	pH	(kg/t)
37		6.51	4.52	10.53				6.70	6.69				448	3.40	0.33
38		5.61	3.89	10.53				6.40	6.39				456	3.41	0.35
39	6.91	5.41	3.75	10.50				5.50	5.49				461	3.39	0.36
40		6.41	4.45	10.50				5.30	5.30				452	3.42	0.37
41		6.21	4.31	10.50				6.20	6.19				447	3.43	0.38
42	6.29	7.01	4.87	10.50				6.20	6.19				418	3.47	0.40
43	9.09	6.21	4.31	10.49				6.70	6.69				440	3.44	0.41
44		5.81	4.03	10.49				6.10	6.10				451	3.47	0.43
45		4.80	3.34	10.49				5.70	5.70				439	3.47	0.44
46	6.85	6.11	4.24	10.50				4.70	4.70				439	3.43	0.46
47		6.11	4.24	10.50				6.10	6.10				472	3.48	0.47
48		6.11	4.24	10.50				6.10	6.10				428	3.43	0.48
49	5.88	6.21	4.31	10.50				6.00	6.00				471	3.47	0.49
50	5.86	6.71	4.66	10.49				6.20	6.20				466	3.49	0.50
51		6.71	4.66	10.49				5.60	5.60				468	3.51	0.52
52		5.21	3.61	10.49				7.20	7.19				479	3.49	0.53
53	3.51	6.41	4.45	10.50				5.60	5.60				468	3.53	0.53
54		6.11	4.24	10.50				6.00	6.00				472	3.50	0.54
55		5.91	4.10	10.50				6.10	6.10				461	3.54	0.55
56	2.28	6.21	4.31	10.49				6.00	6.00				459	3.54	0.55
57	3.37	6.71	4.66	10.50				6.10	6.10				444	3.60	0.56
58		6.01	4.17	10.50				6.90	6.90				477	3.63	0.56
59		5.31	3.68	10.50				6.00	6.00				471	3.63	0.57
60	2.34	6.21	4.31	10.50				5.90	5.90				468	3.64	0.57
61		6.11	4.24	10.50				6.00	6.00				473	3.64	0.58
62		6.11	4.24	10.50				6.00	6.00				475	3.64	0.58
63	4.19	5.91	4.10	10.50				6.10	6.10				478	3.59	0.59
64		13.01	9.04	10.50				5.90	5.90				497	3.58	0.61
66		13.81	9.59	10.50				12.70	12.70				504	3.52	0.62
68		4.60	3.20	10.50				10.90	10.89				484	3.49	0.63

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6" inch
Initial Charge Height: 17'10" inch
Final Charge Height: kg
Sample Weight: 164.2 tonne/m^3
Bulk Density: 1.566 %
Sample Moisture:

Ore Sample: Column C Residue
Head Assay $Cu_{(T)}$: %
Head Assay $Cu_{(acid\ soluble)}$: %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10 %

Starting Date: October 22,1998

Day	Feed							DISCHARGE SOLUTION							Na_2CO_3 Consumption
	Na_2CO_3 in soln. (g)	Volume (L)	Pumping Rate (mL/min)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	Volume (L)	Sulphate g/l	Acidity g/l $CaCO_3$	Alkalinity g/l $CaCO_3$	Eh mV	pH	(kg/t)
69	2.88	6.81	4.73	10.50				5.40	5.40				483	3.47	0.63
70	5.60	5.81	4.03	10.50				6.10	6.10				495	3.50	0.64
71		6.31	4.38	10.50				6.40	6.40				459	3.59	0.66
72		5.71	3.96	10.50				6.10	6.10				448	3.60	0.67
73		6.11	4.24	10.50				5.70	5.70				445	3.60	0.68
74		5.81	4.03	10.50				6.10	6.10				446	3.61	0.69
75		6.01	4.17	10.50				5.70	5.70				504	3.68	0.70
76	3.30	6.31	4.38	10.50				6.10	6.10				445	3.68	0.70
77		5.91	4.10	10.50				6.10	6.10				481	3.54	0.71
78	3.29	6.01	4.17	10.49				6.00	6.00				443	3.51	0.71
79		6.11	4.24	10.49				5.90	5.90				493	3.54	0.72
80		6.11	4.24	10.49				6.20	6.20				491	3.55	0.73
81	2.70	6.21	4.31	10.50				4.80	4.80				486	3.54	0.73
82		5.71	3.96	10.50				6.20	6.20				480	3.53	0.74
83		6.31	4.38	10.50				5.70	5.70				483	3.50	0.74
84	2.34	6.31	4.38	10.50				6.20	6.20				473	3.54	0.75
85	3.40	6.21	4.31	10.49				6.20	6.20				496	3.57	0.75
86		6.31	4.38	10.49				6.30	6.30				483	3.62	0.76
87		4.80	3.34	10.49				4.70	4.70				482	3.61	0.76
88	2.56	5.91	4.10	10.49				5.40	5.40				480	3.61	0.77
89		6.31	4.38	10.49				6.00	6.00				478	3.63	0.77
90		6.21	4.31	10.49				6.40	6.40				435	3.63	0.78
91	2.50	6.11	4.24	10.50				6.10	6.10				444	3.62	0.78
92	2.84	6.31	4.38	10.50				6.10	6.10				481	3.70	0.79
93		12.41	8.62	10.50				6.30	6.30				430	3.70	0.80
95	3.18	6.31	4.38	10.51				12.40	12.40				443	3.71	0.81
96		6.41	4.45	10.51				6.30	6.30				443	3.73	0.81
97		5.51	3.82	10.51				6.40	6.40				414	3.70	0.82
98	3.69	6.01	4.17	10.50				6.40	6.40				239	3.73	0.82
99	3.78	6.31	4.38	10.50				6.30	6.30				243	3.75	0.83

WASTE COLUMN NEUTRALIZATION TEST DATA

Carmacks Project

Project: 97-084
Column: C
Column Size: 6" inch
Initial Charge Height: 17'10" inch
Final Charge Height: kg
Sample Weight: 164.2 tonne/m^3
Bulk Density: 1.566 %
Sample Moisture:

Ore Sample: Column C Residue
Head Assay $Cu_{(T)}$: %
Head Assay $Cu_{(acid\ soluble)}$: %
Calculated $Cu_{(T)}$: %
Calculated $Cu_{(acid\ soluble)}$: %
Hold up Volume: Litre
Drain Volume: Litre
Na_2CO_3 Concentration: 10 %

Starting Date: October 22,1998

Day	Feed							DISCHARGE SOLUTION							Na_2CO_3 Consumption
	Na_2CO_3 in soln. (g)	Volume (L)	Pumping Rate (mL/min)	pH	Cu (g/L)	Fe (g/L)	Free H_2SO_4 (g/L)	Weight (kg)	Volume (L)	Sulphate g/l	Acidity g/l $CaCO_3$	Alkalinity g/l $CaCO_3$	Eh mV	pH	(kg/t)
100		12.41	8.62	10.50				6.50	6.50				283	3.79	0.84
102	3.05	6.41	4.45	10.50				12.90	12.91				233	3.80	0.85
103		6.41	4.45	10.50				6.40	6.41				183	3.76	0.86
104		6.41	4.45	10.50				6.40	6.41				188	3.75	0.86
105	4.42	6.51	4.52	10.50				6.30	6.30				222	3.78	0.87
106	4.88	6.61	4.59	10.50				6.50	6.51				209	3.82	0.88
107		11.71	8.13	10.50				6.60	6.60				222	3.81	0.88
109	3.52	6.41	4.45	10.50				12.70	12.71				217	3.84	0.89
110		6.41	4.45	10.50				6.30	6.31				211	3.88	0.90
111		6.61	4.59	10.50				6.40	6.41	1.00	0.06	-	166	3.87	0.90
112	3.41	6.01	4.17	10.50				6.60	6.61				208	3.57	0.91
113	4.18	6.11	4.24	10.50				6.10	6.11				207	3.57	0.92
114		13.11	9.11	10.50				6.40	6.41				215	3.63	0.93
116	3.97	6.11	4.24	10.50				13.10	13.12				217	3.68	0.94
117		6.41	4.45	10.50				6.10	6.11				142	3.61	0.95
118		6.31	4.38	10.50				6.40	6.41				189	3.69	0.96
119	3.94	6.41	4.45	10.50				6.30	6.31				190	3.66	0.96
120	5.08	5.61	3.89	10.50				6.40	6.41				196	3.71	0.97
121		12.71	8.83	10.50				6.30	6.31				208	3.70	0.99
123	4.03	6.31	4.38	10.50				12.70	12.72				209	3.73	1.00
124		6.41	4.45	10.50				6.30	6.31				200	3.73	1.01
125		6.41	4.45	10.50				6.40	6.41				204	3.82	1.02
126	5.78	6.41	4.45	10.50				6.40	6.41				197	3.83	1.03
127		20.02	13.90	10.50				6.40	6.48				167	3.84	1.06
131	5.50	16.62	11.54	10.50				22.00	22.03				215	3.87	1.09
134	6.50	22.02	15.29	10.50				16.60	16.62				215	3.90	1.13
137	5.50	16.02	11.12	10.50				22.00	22.03				157	3.92	1.16
140	3.00	5.81	4.03	10.50				16.00	16.02				159	3.95	1.17
141	6.07	18.02	12.51	10.50				5.80	5.81				155	4.02	1.20

COLUMN NEUTRALIZATION TEST DATA AFTER REST PERIOD

PROJECT: 97-084
TEST: COLUMN C

Date	Time	Day	FEED			DISCHARGE SOLUTION						
			Soda ash g	Total Volume mL	pH	Volume mL	pH	Eh mV	H+ g/L	SO4 mg/L	Alk g/L	Acidity mg/L
11-May	11:45	0	0.07	6400	7.0							
12-May	14:00	1	0.02	2800	7.0							
13-May	8:10	2	-	5600	7.0							
14-May	11:00	3	0.01	5000	7.0	4675	4.0	398		1025		69.3
15-May	13:00	4	0.03	5700	7.0	4700	3.9	412				
16-May	13:10	5	0.02	6800	7.0	5000	4.0	414				
17-May	15:15	6	-	5800	7.0	5600	3.9	390				
18-May	15:30	7				5400	4.0	413		600		46.5
19-May		8	Drain down			2500	4.0	372				
20-May		9				256	4.0	391				
				38100		**28131**						

Note: Feed rate 4.3 ml/min. Eh - Ag/AgCl reference
Soda ash consumption is the amount used to adjust pH for the initial volume
Day 1 = day 525 in overall rinse test

COLUMN NEUTRALIZATION TEST DATA

PROJECT: 97-084
TEST: COLUMN AB

Date	Time	Day	FEED		
			Soda ash g	Total Volume L	pH
11-May	11:45	0	0.7	120	7.0
12-May	13:30	1	0.65	80	7.0
13-May	8:10	2	0.8	125	7.0
14-May	11:00	3	0.8	119	7.0
15-May	11:45	4	0.55	119	7.0
16-May	11:45	5	0.9	130	7.0
17-May	14:45	6	0.8	116	7.0
18-May	15:00	7			
19-May	14:15	8			

DISCHARGE SOLUTION						
Volume L	pH	Eh mV	H+ g/L	SO4 g/L	Alk g/L	Acidity g/L
73	3.0	386				
131	3.1	381				
113.5	3.2	386				
109.1	3.2	375				

Note: Feed rate 77 ml/min. Eh - Ag/AgCl reference
Soda ash consumption is the amount used to adjust pH for the initial volume

CERTIFICATE OF ANALYSIS
iPL 00E0489

INTERNATIONAL PLASMA LABORATORY LTD.
2036 Columbia Street
Vancouver, B.C.
Canada V5Y 3E1
Phone (604) 879-7878
Fax (604) 879-7898

Client : Process Research Associates Ltd
Project: 97-084

6 Samples
6=Solution

[046914:40:26:00053000]

Out: May 30, 2000
In : May 30, 2000

Sample Name	Type	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Bi mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	La mg/L	Pb mg/L	Mg mg/L	Mn mg/L
Col. N3-Day 1	Solution	27.2	<0.1	0.2	0.29	<0.1	<0.01	4.7	<0.01	<0.01	2.85	27.69	<0.05	0.21	6.6	0.17
Col. N3-Day 7	Solution	4.4	<0.1	<0.2	0.09	<0.1	<0.01	0.4	<0.01	<0.01	0.69	5.39	<0.05	<0.05	1.5	0.06
Col. C -Day 3	Solution	4.2	<0.1	<0.2	<0.01	<0.1	<0.01	282.9	<0.01	0.03	13.71	<0.03	<0.05	0.25	22.5	1.48
Col. C -Day 7	Solution	1.2	0.1	<0.2	<0.01	<0.1	<0.01	107.9	<0.01	<0.01	5.81	<0.03	<0.05	0.36	9.7	0.62
Col.AB -Day 5	Solution	5179.2	<0.1	16.4	<0.01	1.7	<0.01	470.5	0.32	15.57	2444.77	131.45	0.23	0.19	6903.7	545.98
Col.AB -Day 7	Solution	3210.7	<0.1	10.9	<0.01	0.9	<0.01	477.0	0.21	10.40	1503.75	65.96	0.15	0.43	4382.2	349.74
Minimum Detection		0.2	0.1	0.2	0.01	0.1	0.01	0.1	0.01	0.01	0.01	0.03	0.05	0.05	0.1	0.01
Maximum Detection		9999.0	9999.0	9999.0	999.00	9999.0	999.00	9999.0	9999.00	9999.00	9999.00	9999.00	999.00	9999.00	9999.0	999.00
Method		ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O

---=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Re=ReCheck n=x1000 %=Estimate % NS=No Sample

05/30/00 15:40 IPL 2036 COLUMBIA ST VANCOUVER > 604 ...

CERTIFICATE OF ANALYSIS
iPL 00E0489

INTERNATIONAL PLASMA LABORATORY LTD.
Vancouver, B.C.
Canada V5Y 3E1
Phone (604) 879-7878
Fax (604) 879-7898

Client : Process Research Associates Ltd
Project: 97-084

6 Samples
6=Solution

[048914:40:26:00053000]

Out: May 30, 2000
In : May 30, 2000

Sample Name	Hg mg/L	Mo mg/L	Ni mg/L	P mg/L	K mg/L	Sc mg/L	Ag mg/L	Na mg/L	Sr mg/L	Tl mg/L	Ti mg/L	W mg/L	V mg/L	Zn mg/L	Zr mg/L
Col. N3-Day 1	<0.05	0.08	<0.02	1.0	4	0.03	<0.02	88	0.04	<0.2	0.7	<0.1	0.13	0.04	0.02
Col. N3-Day 7	<0.05	<0.02	<0.02	<0.1	<2	<0.01	<0.02	15	0.03	<0.2	0.1	<0.1	0.02	<0.01	<0.01
Col. C -Day 3	<0.05	<0.02	<0.02	<0.1	19	0.01	<0.02	67	<0.01	<0.2	<0.1	<0.1	<0.01	0.40	<0.01
Col. C -Day 7	<0.05	<0.02	<0.02	0.3	16	<0.01	<0.02	110	0.02	0.5	<0.1	<0.1	0.02	0.17	<0.01
Col.AB -Day 5	<0.05	0.26	6.37	27.0	10	0.61	<0.02	30	0.18	<0.2	0.3	<0.1	<0.01	73.34	<0.01
Col.AB -Day 7	<0.05	0.28	4.33	21.2	8	0.42	<0.02	22	0.19	<0.2	0.1	<0.1	<0.01	48.71	<0.01
Minimum Detection	0.05	0.02	0.02	0.1	2	0.01	0.02	1	0.01	0.2	0.1	0.1	0.01	0.01	0.01
Maximum Detection	9999.00	9999.00	9999.00	9999.0	9999	100.00	999.00	9999	999.00	999.0	999.0	9999.0	999.00	9999.00	999.00
Method	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O	ICPH2O

---=No Test Ins=Insufficient Sample Del=Delay Max=No Estimate Rec=Re-Check m=x1000 %=Estimate % NS=No Sample

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Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix F

Conceptual Closure and Reclamation Plan



WESTERN SILVER CORPORATION

CARMACKS COPPER PROJECT
YUKON TERRITORY

CONCEPTUAL CLOSURE AND RECLAMATION PLAN

May 2005

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ACG-WS-01.001, CONCEPTUAL HEAP LEACH FACILITY CLOSURE

1. INTRODUCTION

1.1 Project Summary

This report was originally prepared in June 1997 by Western Copper Holdings Ltd. The report has since been modified to reflect the current status of the project and planned conceptual closure measures.

The Carmacks Copper Project is a proposed open pit copper mine and processing facility being developed by Western Silver Corporation. It is located in the Yukon Territory, 38 km north west of the town of Carmacks.

The project will comprise an open pit, crushing plant, acid heap leach and copper extraction facility and events pond, associated waste rock dumps, soil stockpiles, drainage ditches and sediment control ponds, and support facilities. The projected mine life is 10 years, followed by the mine closure

The general arrangement of the project is shown in Drawing No. 1785.000.

1.2 Closure Objectives

There are three overall objectives in mine closure:

- protection of public health and safety;
- minimize or prevent adverse environmental impacts; and,
- ensure land use commensurate with the surrounding land.

For a new mine, these objectives become part of the design process; to develop the mine in a manner that will ensure both physical stability and chemical stability in the long term. A new mine is designed and built such that at the end of the mine life there is a minimum of work required to achieve the above three objectives.

The ideal scenario at closure is to be able to achieve the above three objectives in a “walk-away” scenario, that is, one in which there will be no further requirements for monitoring and maintenance. Clearly, for some mines, some level of human activity may be required for a period after closure resulting in either an “active care” or “passive care” closure scenario.

This document describes the concepts that have been developed for closure of the Carmacks Copper Mine. The scenarios addressed include both temporary shutdown

and final closure. While the long-term objective is to achieve a "walk-away" closure condition, it is realised at this time that further testing and investigation would be required to demonstrate that "walk-away" closure can be achieved. At this time, therefore, an initial active care system is proposed, followed by a passive care system. The conceptual closure and reclamation plan for the project is shown in Drawing 100-13-60.

Also described in this document are the testing programs and engineering designs that have been incorporated into the proposed project development for closure planning. Recognizing that this is a conceptual closure plan, there remain some questions about physical and chemical stability that require either more investigation or actual field data before detailed closure measures can be developed. These further investigations are also identified in the text, which the reader is referred for additional details.

1.3 Closure Issues

Closure issues can be considered in terms of three major areas:

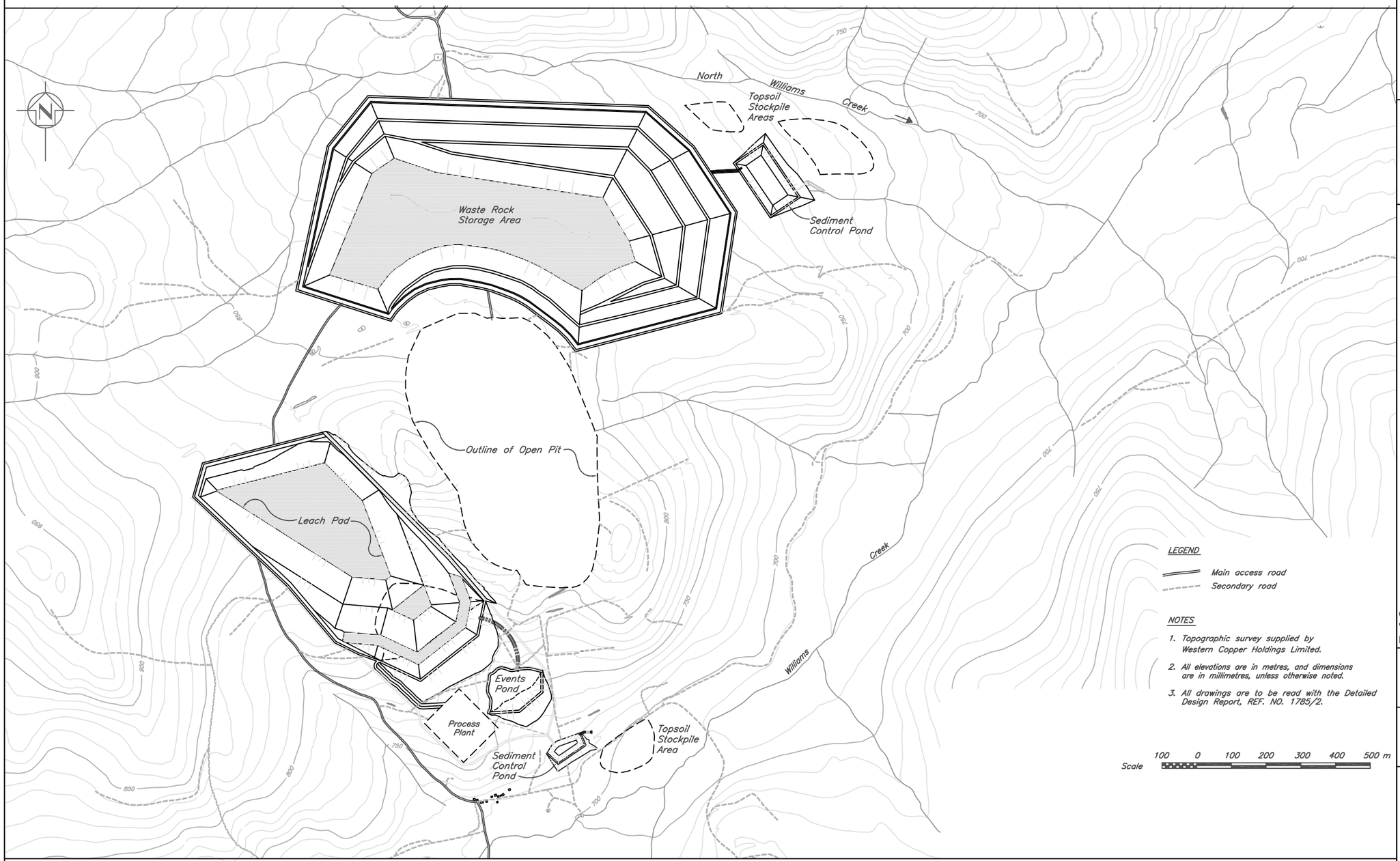
- issues associated with (geo)chemical stability;
- issues associated with physical stability; and,
- issues associated with land use, aesthetics and public health and safety.

For a copper heap leach project, issues of chemical stability and water quality are typically the major issues to be addressed at closure. These issues, which are associated with the heap, are therefore the focus of this conceptual closure plan.

At the closure of this copper mine there are no major water retaining structures, diversions or tailings impoundments for which physical stability must be ensured in the long term. The remaining structures for which physical stability must be addressed are the spent ore heap and associated water management facilities, and the rock waste dumps.

For most of the site, reclamation of the disturbed areas of the mine site and rock waste dumps would raise no issues that are particular to a heap leach project. The primary issue is the control of erosion.

However, reclamation of the spent heap does require special consideration in that the spent ore has been chemically changed from the in-situ condition. Reclamation of the spent heap is discussed herein primarily in terms of the issues associated with water chemistry. The requirements for control of water quality (i.e. rinsing, chemical addition, insitu treatment, covering) will dictate the conditions under which further reclamation would be done.



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

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General Arrangement

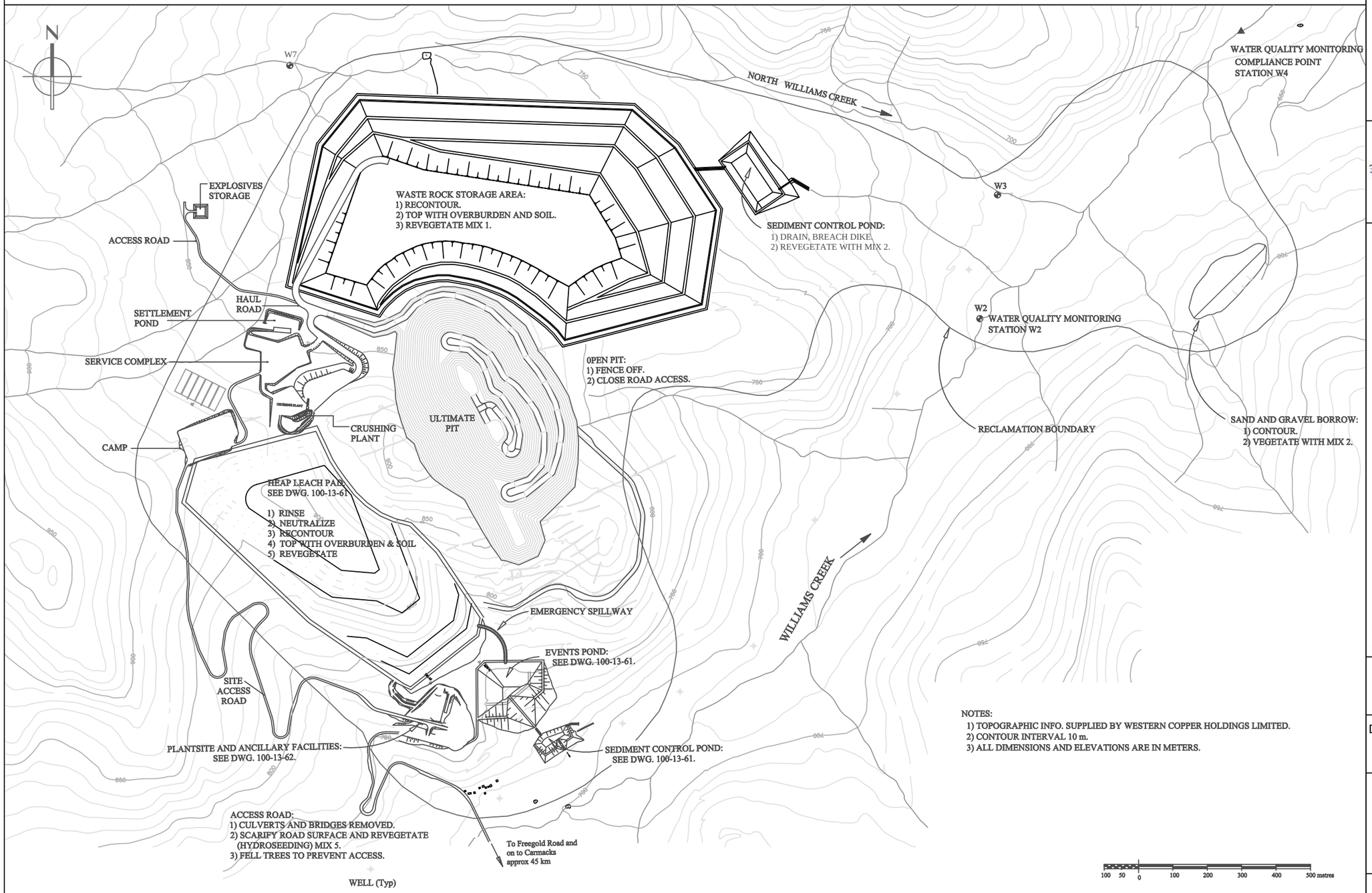
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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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NOTES:
1) TOPOGRAPHIC INFO. SUPPLIED BY WESTERN COPPER HOLDINGS LIMITED.
2) CONTOUR INTERVAL 10 m.
3) ALL DIMENSIONS AND ELEVATIONS ARE IN METERS.

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

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"Overall Site Conceptual Reclamation/Closure Plan", Drawing #100-13-60 Rev B

Overall Site Conceptual Reclamation/Closure Plan

Drawing Number:
100-13-60

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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2. MINE WORKINGS

2.1 Description

There is one open pit from which will be extracted approximately 14 million tonnes of ore and 70 million tonnes of waste rock.

The location and configuration of the pit are shown in drawing 1785.000

2.2 Closure Issues

Issues to be addressed for closure of the open pit are:

- control of access to pit as pit walls are steep (54^0);
- rate of flooding of pit; and
- pit water chemistry.

Investigations to date have shown that there is essentially no groundwater recharge to the open pit. Refer to IEE Addendum No. 3, Knight Piesold Report Ref. No. 1783/3 which provides a hydrogeological summary for the open pit. Based on recharge from precipitation alone, therefore, it is estimated that it will require over 300 years for the pit to fill. Seepage from the pit into the groundwater regime would be negligible due to the low permeability of the wall rock.

Based on investigations to date, it is not anticipated that there are water quality concerns associated with the pit water in the long term (IEE Addendum, June 1995, Section 4.2). Waste rock and therefore the pit wall rock is strongly acid consuming as shown in the above named report. Therefore neutral to alkaline water would be anticipated in the open pit. It is possible that there may be dissolved metals associated with the water draining the pit walls, however, the concentrations would be expected to be at low levels due to the alkalinity of the pit water.

2.3 Conceptual Closure Measures

At closure the pit will be allowed to flood, requiring at least 300 years based on current estimates.

To control inadvertent access by subsistence and recreational land users, the pit will be completely blocked off with large boulders placed around the pit perimeter or fenced off with a locked gate.

Areas along the top perimeter of the pit which were disturbed during initial stripping will be revegetated as required to reduce erosion.

2.4 Remaining Issues and Investigations

Monitoring of pit water chemistry will be done regularly during operation. Since the data to date indicate that any water chemistry issues would be associated with metal leaching rather than long-term acid generation, monitoring during operation should indicate whether there are long-term concerns.

3. HEAP AND PROCESSING FACILITIES

3.1 Description

The heap leach pad has been designed (EBA Engineering Ltd., March 2005) to:

- ensure protection of both the surface water and regional groundwater during operations and in the long term; and,
- to ensure that the facility is stable during extreme precipitation events and design seismic events during operation and after closure.

Details of the design and construction of the heap are provided in EBA Engineering Ltd, March 2005. The conceptual reclamation plan for the heap leach facility is shown in drawing 100-13-61.

The heap leach facility is designed for the valley heap leach method which involves preparation and placement of the ore on a pad behind a confining embankment. Leaching of the ore is performed with subsequent lifts progressing up slope. The heap is designed to hold approximately 14 million tonnes of oxide copper ore.

The heap leach pad covers an area of approximately 330,000 m^2 with an engineered double composite liner system with a leak detection and recovery system. The pad is surrounded by a 2 m high berm on two sides and perimeter bench on the east side. There is a lined events pond, also with leak detection and recovery, downstream of the heap leach pad.

Runoff around the facility is diverted in ditches and routed to the sediment control pond. The design also includes a foundation drainage system installed beneath the heap leach pad to intercept and remove potential shallow groundwater flow, although no natural groundwater springs have been encountered to date.

3.2 Closure Issues

In the closure of a heap leach facility, the primary issues to be addressed are:

- chemistry of the runoff and drainage from the heap;
- erosion and dust control from the heap;
- establishment of vegetation;
- decommissioning of the events pond; and,
- water management for both the heap and events ponds.

The issue of physical stability of the heap is addressed within the Heap Leach Pad Design Report (EBA Engineering, 2005) while closure is addressed in the updated Liner Design Report, (Knight Piesold Report 1785/1, and Section 2.16).

The specific issues to be addressed in the consideration of water chemistry for this copper heap leach are:

- rinsing of residual process solutions to remove acid and dissolved metals;
- neutralization of residual acidity in the rock mass;
- potential for acid rock drainage from sulphide oxidation;
- long-term weathering and leaching potential;
- sludge disposal from treatment plant.

The test work to address each of the above geochemical issues is discussed in detail in Lawrence and Beattie, 1996 and Beattie, 2001. The testing and conclusions are briefly summarized below to provide explanation of proposed closure measures.

3.2.1 Heap Rinsing and Neutralization

At the completion of the leach testing program, the two metallurgical test columns were each rinsed over a 6 or 12 month period (for columns PC2 and PC1 respectively) with fresh water and then alkaline solutions, to evaluate requirements for rinsing at closure. Testing was also done to evaluate water treatment (neutralization) to reduce acidity and precipitate dissolved metals from both process (raffinate) and rinse solutions. The details of this testing are provided in the appendices to Lawrence and Beattie, 1996.

The testing shows that a combination of rinsing and water treatment (neutralization) is required to remove residual process solutions, reduce the release of dissolved metals from the heap rinse solutions and achieve discharge water quality. Water treatment using lime neutralization is successful at removing dissolved metals and acidity from the process and rinse solutions.

However, complete rinsing and neutralization of the spent ore was not accomplished in the 1996 testwork. There appear to be geochemical controls on pH and metals that have not been completely defined in the testwork. Briefly, the heap decommissioning investigations indicate that:

- rinsing with water can remove the majority of the acidity and dissolved metals from the heap;

- however, longer term flushing with neutralized rinse solutions does not achieve “acceptable” discharge quality in the rinse solutions as metal concentrations remain elevated (e.g. Cu at > 20 mg/L) and pH values acidic (pH < 4.5);
- conventional alkali addition for water treatment is effective in removing dissolved metals and acidity from both raffinate and rinse solutions;
- re-circulation of neutralized rinse solutions appears to significantly and adversely affect the geochemistry of the spent ore when these solutions are re-circulated through the spent ore, resulting in weathering of the gangue, buffering of drainage water at pH 4, and rendering ineffective further removal of copper from the spent ore.

More recent evaluation of the metallurgical data, water chemistry and further detoxification test work conducted by Beattie, 2001 on spent ore strongly suggests that:

- process solutions can be rinsed from the columns using water rinses (without pH adjustment);
- in the latter stages of rinsing, the pH is controlled by weathering reactions in the alumino-silicate minerals, clays and feldspars with the dominant control primarily aluminium and silicate ions in solution;
- these alumino-silicates could also contribute to the apparent residual neutralization capacity of the spent ore;
- neutralization of the drainage water further accelerates the natural weathering of these minerals and changes the solution chemistry controls by adding sodium hydroxide to the rinse solution. This is supported by observation of rapid particle degradation of the spent ore when neutralized solutions are added to the columns;
- these buffering reactions are also probably limiting the removal of residual soluble copper from the column.
- previous column testwork indicated that the leached solids could be readily neutralized to result in an effluent of pH 4 which was buffered at this pH. Additional tests have indicated that when leached solids are freely mixed with solution containing an excess of base, the solution readily achieves a neutral pH and this pH is stable. Subsequent column tests have shown that sodium carbonate is effective at altering the leached solids so that effluents have a neutral pH. This condition appears to be stable over extended time periods.
- the most effective rinsing procedure for the spent heaps appears to be to recirculate the solutions until the free acid is consumed and the copper concentration in solution becomes uneconomic to recover. At this point the leach solution should be neutralized with lime out of the heap to precipitate

sulphate and other deleterious constituents before being discharged. The heap should then be rinsed with groundwater in a series of pulses with rest periods in between to allow dissolved sulphate, copper etc to diffuses from the rock particles. An effluent pH near pH 4 can be expected with this procedure. To achieve higher pH values, the addition of a base is required and sodium carbonate appears to be the most effective addition.

Further investigations will be done as soon as additional column testing residues are available to define the specific rinsing and neutralization regime that will be used to decommission the spent heap. These investigations are described in more detail in Section 3.5 Remaining Issues and Investigations.

3.2.2 Formation of Precipitates

The weathering and resultant physical degradation of the ore during rinsing with neutralized solutions and, to a lesser degree, in the early stages of leaching resulted in an increase in fines in the column. In addition, precipitates were reported to have formed as a result of acid leaching in the early leach stages (Lawrence and Beattie, 1996, Section 5.1). Precipitates also formed as a result of the neutralization reactions, some of which were recycled to the column in the early stages of the treated water rinsing. The particle degradation and formation of precipitates within the column would limit permeability in local areas which would reduce both the leach recovery and local rinsing and neutralization.

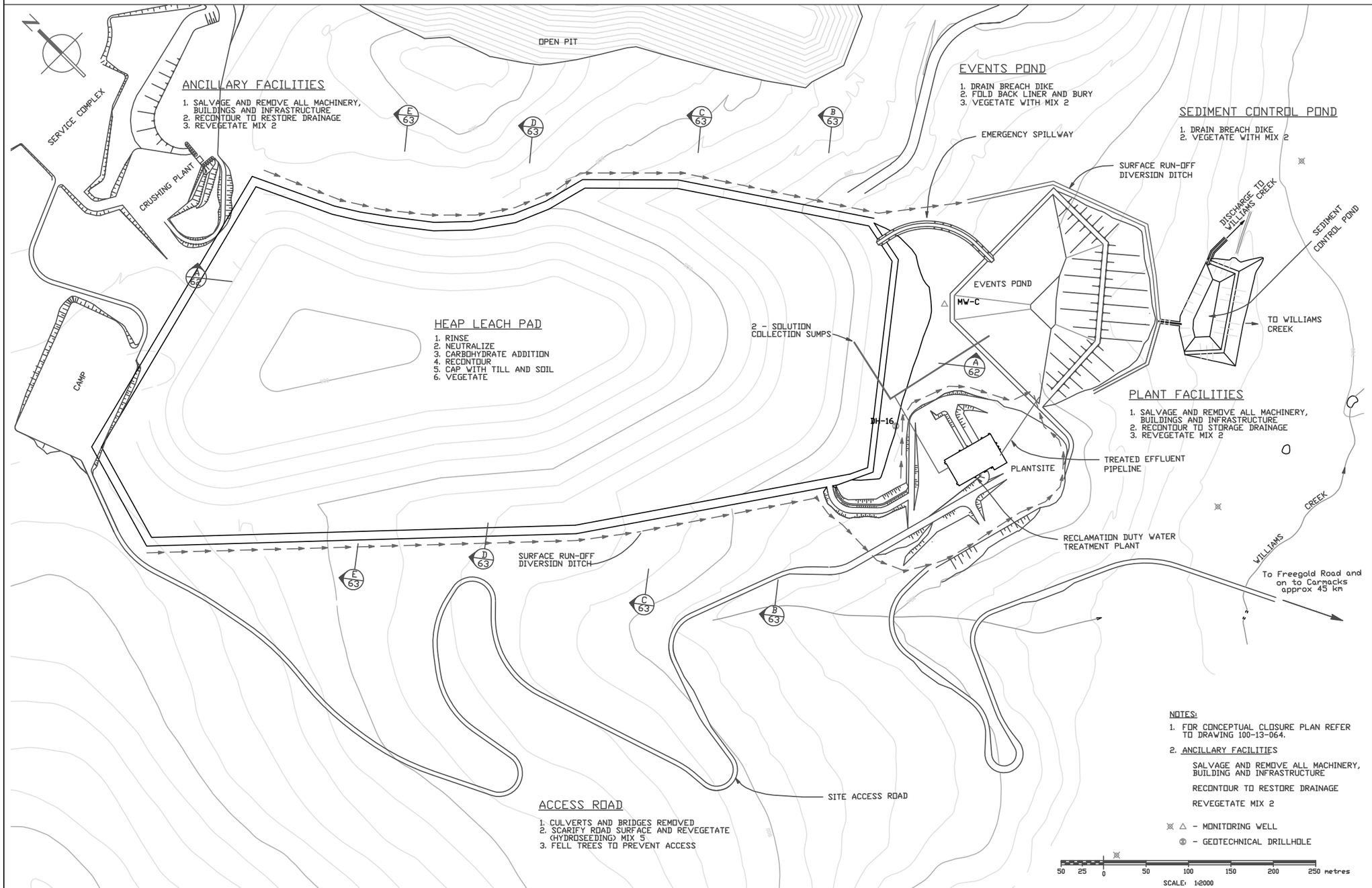
During operation, however, reagent addition will be controlled to limit these degradation and precipitation reactions. As noted in the detailed testing report (Lawrence and Beattie, Section 5.2.2, and Beattie 2001), the degradation of the ore does not occur during the leaching stage but rather in the decommissioning (heap neutralization) stage. Reagent addition and the rinse and/or neutralization components of the decommissioning circuit will be determined in further testing prior to operation of the leach or decommissioning circuits; however, as noted in Beattie 2001, an effective rinsing procedure involves pulses of ground water rinses followed by rest periods. Once effluent pH values reach pH 4 sodium carbonate addition should be used to neutralize the heap.

Some weathering and precipitation reactions are inevitable and can result in lower permeability zones in the heap. In these localized zones, the lower permeability will result in lower metal recovery and less complete rinsing both for decommissioning and in the long term, to infiltrating solutions. Thus, formation of precipitates and particle degradation must be avoided both during operation and decommissioning. Additional collection piping within the heap lifts should be considered.

3.2.3 Metal Leaching and Acid Generation Potential

Samples of the composite ore for the metallurgical testing program were tested to determine acid generation and metal leaching potential. Details of the testing are presented in IEE Addendum, Section 4.2.4 (Hallam Knight Piesold, June 1995). The results show that the ore samples are net acid consuming with very low sulphur content. Tests reported by Lawrence (Lawrence and Beattie, 1996) show NP values ranging from 7.3 to 54 kg $CaCO_3$/t at the conclusion of leaching. Mineralogical analysis of leach residues indicates essentially no residual iron sulphide. Thus, net acid generation from sulphide oxidation is not anticipated from the spent heap. However, as shown in the acid base account testing on spent ore, there can be residual sulphur from the acid addition. Further metallurgical and heap decommissioning testing will include analysis of the spent ore for acid base account and sulphur species. Neutralization of the heap would be part of the testing program.

Provision for water treatment of heap drainage is included as a closure measure to release and draindown residual heap solutions. Water treatment using a known treatment technology (caustic precipitation plant) is proposed. Testwork presented in Section 4.3 of the IEE Addendum (Hallam Knight Piesold, June 1995) demonstrate the effectiveness of this treatment process. Once the heap has been rinsed and neutralized, a cover will be constructed to reduce infiltration and promote runoff. A carbohydrate nutrient mixture will be added to recalculating solution to stabilize metals in the heap.



Project Description & Environmental Assessment Report

Carmacks Copper Project Yukon Territory

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"Heap Leach Facility Conceptual Reclamation Plan", Drawing #100-13-61 Rev B

Heap Leach Facility Conceptual Reclamation Plan

Drawing Number:
100-13-61

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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3.3 Conceptual Closure Measures

It is recognized that the testing to date does not conclusively demonstrate that a "walk-away" closure scenario can be achieved for the heap decommissioning. While experience at copper leaching operations indicates that walk-away closure can be a realistic closure option, the proposed closure at this time is based on demonstrated active care technology followed by a passive care system. Drainage from the heap will be collected and treated as described in Section 3.3.2 Water Treatment. A passive care system is planned that will stabilize metals within the heap with final polishing occurring through an infiltration gallery for long term release.

At this time, the proposed conceptual closure measures for the heap leach facility comprise:

- rinsing of the heap with re-circulated water from which copper is recovered at each cycle using the SX/EW plant;
- neutralization and precipitation for treatment of rinse water in the latter cycles of rinsing;
- carbohydrate nutrient addition to stabilize metals within the heap;
- after heap rinsing is completed, contouring and capping of the heap to promote runoff and reduce infiltration;
- collection and water treatment of any surface water drainage from the heap prior to discharge into the environment; and
- long-term release of heap effluent through an infiltration gallery.

The design concept for breaching the confining embankment at closure has been revised. The v-notch excavation through the embankment has been replaced with a permanent gravity flow solution pipeline to be constructed in the initial phase of construction to convey process solution to the SX plant or events pond. At closure these pipes will be used to convey solution to the process plant for neutralization and treatment. The general arrangement is presented in the Updated Liner Design Report, Ref. No. 1785/1 (Knight Piesold, 1997).

3.3.1 Heap Rinsing

The objective of rinsing the heap is to reduce the residual acidity and dissolved metals that could migrate from the heap through meteoric waters after the heap has been decommissioned. Typically, a combination of water rinsing followed by rinsing cycles with treated water is used, although some sites have found that water rinsing alone is more effective (Li, Jacob and Corneau, 1995). As discussed above, in laboratory testing fresh water rinsing significantly reduced contained metals and acidity in drainage from

the metallurgical columns, however subsequent recycle of neutralized solutions did not complete the heap rinsing and neutralization process.

An alternative detoxification process has been initially proposed for the Carmacks Copper project. In-situ biological detoxification has been successfully applied at the Brewery Creek operation. Given the similar climate conditions and size of the heap, the actual commercial application of biological heap detoxification at this northern heap leach operation provides considerable performance data for use at the Carmacks Copper project.

Once the economic copper values have been removed from the heap effluent through the SXEW process and the majority of free acid has been consumed through solution recirculation, fresh water rinsing will continue to be employed. The already constructed water treatment plant will treat the effluent rinse solution to acceptable discharge standards to ensure a proper water balance during fresh water rinsing is maintained. It is anticipated that fresh water rinsing alone will achieve an effluent pH of near pH 4. To achieve a higher pH, the addition of a base is required. Testwork has demonstrated the effectiveness of sodium carbonate for increasing solution pH to near 7.

Once the heap effluent pH has been maintained at a pH of 6-7, nutrients in the form of a carbon source such as molasses or alcohols will be introduced to the recirculating solutions. The intention of the introduction of nutrients into the heap pore waters is not to actually immobilize the metals in the heap (as is the case in a cyanidation heap breaking down cyanide complexes), rather it is to amend the heap pore waters so that, if and when any of these waters migrate, they will cause the mineralization of the contaminants within these pore waters onto the solids through which they pass. The long-term release of treated heap effluent is into a passive infiltration gallery. The addition of nutrients into the heap porewaters after rinsing as well as directly into the infiltration gallery will precipitate any remaining metals into the soils horizon within the infiltration zone.

3.3.2 Water Treatment

3.3.2.1 Treatment Circuit

The water treatment circuit used for operations will be modified and used for decommissioning and closure. The circuit for water treatment during closure and reclamation is described in Appendix A of this report. The following is a summary of the process description for the decommissioning and closure.

The treatment plant flowsheet is shown in Figure 400-03-11, “Reclamation Duty Water Treatment Plant” (Appendix A). The plant includes the following major facilities:

- seepage collection system
- one collection pond
- two stirred treatment reactors
- clarifier
- sand filter
- sludge filter press
- sludge dryer
- treated water retention pond
- utilities and ancillaries including reagent supply, air compressors, emergency and line power, drinking water, etc.
- support facilities, including office, control room and maintenance area.

Most of the process equipment will be enclosed in buildings.

The plant will have a treatment capacity sufficient to handle seepage and any contaminated run-off from the area of the closed leach pad. The flow rates will vary with the season and the weather.

Given sufficient capacity in the collection pond, the plant may be operated on a campaign basis, treating larger volumes of accumulated seepage as required.

This water treatment system is relatively simple, but allows flexibility for a number of process parameters, including:

- aeration and sludge re-circulation
- reagent dosages of pH adjustment and flocculation
- alternate & supplementary reagents including:
    - caustic soda
    - soda ash
    - sodium phosphate
    - lime and limestone
    - commercial precipitant
- alternate sludge collection and disposal methods.

Seepage will be collected from the leach pond gravity drain pipes, taking advantage of the double liner and collection systems installed for the heap leach operation. The area

of the leach pad behind the confining embankment serves as the low point collection point for the entire pad area.

The seepage will drain from the leach pad via gravity pipeline, through a metering system, into the two water treatment reactors operating in series. The seepage passes through neutralization reactors 1 and 2 in series, and emerges at a controlled pH of 9.0. Caustic pellets are metered to the reactors from a bin feeder, or solution from an adjacent storage tank will be added to both reactors via a circulation loop.

The resultant slurry will be treated by a mechanical drive clarifier. This clarifier may be fitted with Lamella-type inclined plates to improve settling performance. Clarifier under-flow will be re-circulated to maintain a suspended sludge bed. The clarifier sludge product will be bled from the re-circulating under-flow to the sludge receiver.

The sludge will be pumped from the sludge receiver, at about 8 to 10 percent solids, to the sludge press filter area. This filter area will include a sludge sump, an covered storage pad for dried sludge, the filter press, and the sludge dryer.

Clarifier overflow will be polished in a continuous backwash sand filter. Backwash will be returned to the clarifier, and filtrate will monitored and sampled before it passes through a lined concrete raffinate tank which will decant into the event and sediment ponds below the heap, for final discharge to the environment.

At the filter area, sludge will be pumped from the sump by air operated diaphragm pumps to the filter press, where a competent filter cake will emerge at about 20 to 25 percent solids. The filter cake drops into a dryer feed bin which will be equipped with paddles that extrude the material onto dryer feed belt. The dried sludge, to about 40 to 60 percent solids, discharges from the dryer directly into large transport bags for shipment and kept in a covered storage area until a suitable load is accumulated.

A flocculant mixing and dosing system will be enclosed in an existing building adjacent the clarifier. This building will also include a small control room, the MCC room and a laboratory. Other facilities in the building will include plant and instrument air compressors, diesel electric generators, and acid wash area for filter cloths.

Except for large ponds and related equipment, and outside storage pads, all process tankage and equipment will be protected from the elements and will operate automatically with minimal operator assistance. The plant operations would be monitored remotely by the operating personnel residing in Carmacks. The operating schedule for the plant will be seasonal during the months of April to October of each year.

3.3.2.2 Water Chemistry

Laboratory testing has shown that the treatment process will result in the precipitation of contained metals as hydroxides and sulphates, and will produce a supernatant which will be within levels specified by the Metal Mining Effluent Regulations (MMER) and will be non-toxic at 100 percent concentrations. Analysis of the treated raffinate is shown in Table 4.12 from the IEE Addendum, (Hallam Knight Piesold, June 1995). In addition, results of raffinate treatment for the column tests and pilot test are provided in the appendices to Lawrence and Beattie, 1996.

The testing details and water chemistry data for the neutralized rinsing solutions are provided in Appendix F of Lawrence and Beattie (1996) for the column testing neutralization program and Appendix 5, Beattie 2001. The most effective rinsing procedure for the spent heap appears to be to recirculate the solutions until the free acid is consumed and the copper concentration in solution becomes uneconomic to recover. At this point the leach solution should be neutralized with lime out of the heap to precipitate sulphate and other deleterious constituents before being discharged. The heap should then be rinsed with groundwater in a series of pulses with rest periods in between to allow dissolved sulphate, copper and other metals to diffuses from the rock particles. An effluent pH near pH 4 can be expected with this procedure. To achieve higher pH values, the addition of a base is required and sodium carbonate appears to be the most effective addition based on column test work (Beattie, 2001). Additional carbohydrate nutrient addition is proposed to stabilize metals in the heap. While it appears from the testwork to date that leach and rinse solutions can be successfully rinsed and treated using the above process, supplemented with conventional (lime) neutralization technology, additional testing is required during operations to produce specific water chemistry data for this project.

3.3.2.3 Sludge Disposal

As noted above, the current design for the water treatment circuit includes unit operations such that sludge from the treatment process can be filtered and bagged for transport off-site if required.

While the current concept is to haul sludge off-site, disposal of water treatment precipitates will be dictated by results of the research, chemical stability and legislative requirements at that time. A test program is planned once treatment plant precipitates have been generated. The results of these tests will dictate precipitate handling.

Western Silver is committed to conducting additional research into the chemical stability of closure precipitates and treatment plant sludges as part of their Reclamation Research Program and committed to defining an acceptable method, consistent with the nature of the sludge and then current legislation, for the safe disposal of the material for mine closure. Shipping accumulated sludges off-site to a waste reduction firm (i.e. Laidlaw) or a smelter, will be included in this evaluation.

The testing of chemical stability of treatment sludges is discussed in Lawrence and Beattie (1996), and Hallam Knight Piesold (1995).

Additional water treatment testing is proposed for the raffinate and the decommissioning solutions to evaluate both the treatment chemistry (reagent requirements) and the sludge production and chemical stability of sludges. These solutions and precipitates will be generated from actual process solutions.

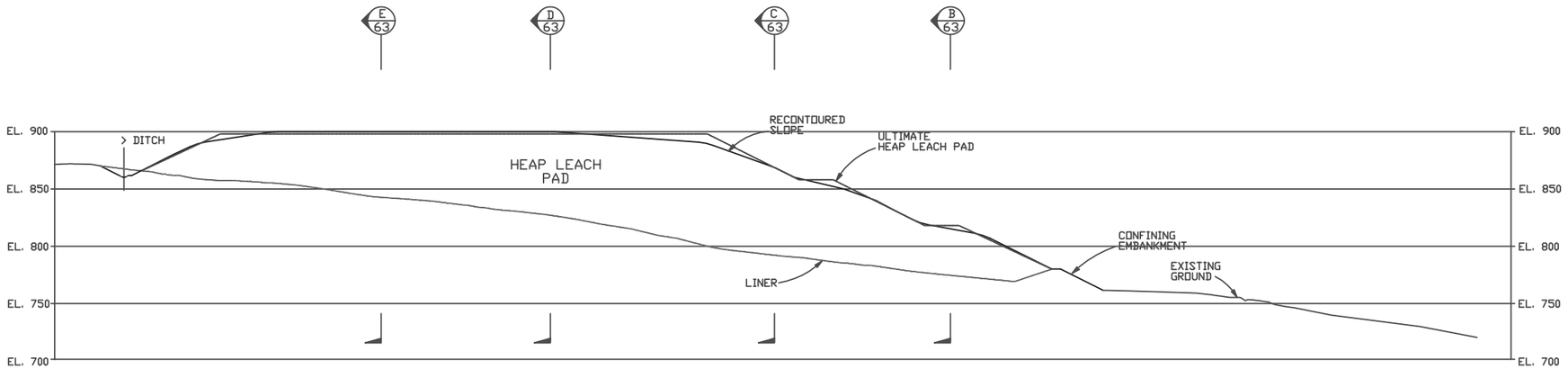
3.3.3 Contouring and Soil Cover

Following rinsing and nutrient addition operations, the top surface of the heap leach pad will be re-graded to promote the runoff of precipitation, eliminate areas where ponding of water may occur and to minimize seepage. The finished grade surface is shown on the attached drawings 100-13-62 and 100-13-63. 75 % of the surface area will have an average slope of 40% or steeper and 25% of the surface area is at 7% or steeper. These types of slopes are consistent with the topography of the area adjacent to the heap.

The top surface of the heap will then be covered with a cover system. One alternative cover approach is to cover the heap with a layer of locally borrowed low permeability soil. The soil cap will be planted with a hardy coarse grass seed mixture designed for maximum moisture uptake and evapotranspiration. The cover layer materials will be placed with bulldozers and are estimated to have a permeability of between 10^{-4} and 10^{-5} cm/sec. The infiltration and runoff characteristics of the covered heap are discussed in Section 3.3.4.

As an alternative cover design, a store and release cover system is preferred over a traditional compacted cap design due to concerns with freeze/thaw in climate conditions at site. Research has shown that freezing and thawing can significantly increase the hydraulic conductivity of compacted materials, especially those with a high fines content (Chamberlain et al, 1997). The advantage of a store and release cover is that a low permeability compacted layer is not required to reduce infiltration levels to acceptable and manageable long term rates. The store and release cover will reduce infiltration into the heap by storing precipitation (similar to a sponge) and then releasing the water back

to the atmosphere through evapotranspiration. The cover material is placed in a loose state and revegetated with species that have deeper root penetration and higher moisture uptake characteristics. Specific design parameters have not been completed for a store and release cover on the Carmacks Copper heap. A recent store and release cover system was constructed at a Yukon heap leach operation for closure and will be a valuable tool for providing the necessary design parameters and actual field performance.



SECTION A 61

50 25 0 50 100 150 200 250 metres

SCALE: 1:2000

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

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"Heap Leach Facility Conceptual Reclamation Section A-A", Drawing #100-13-62 Rev A

Heap Leach Facility Conceptual Reclamation Section A-A

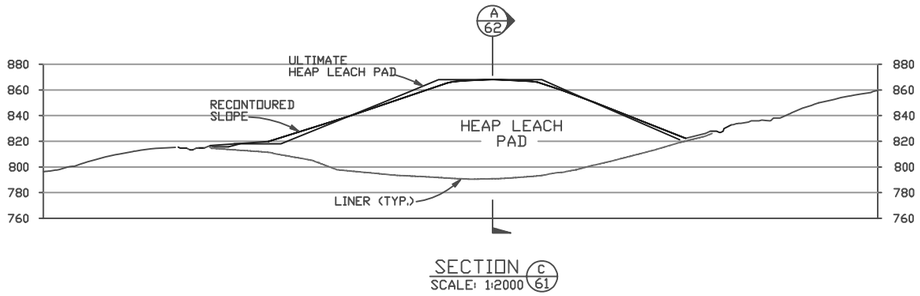
Drawing Number:
100-13-62

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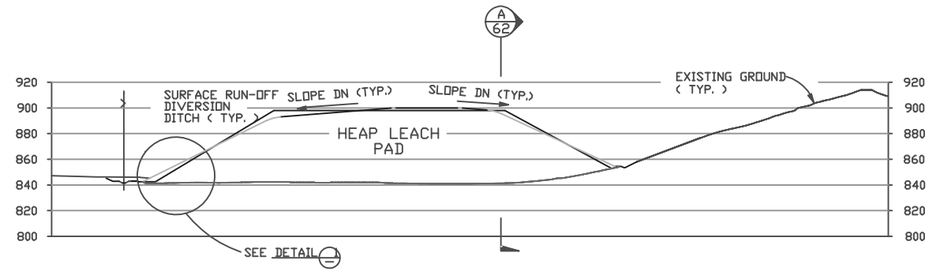
Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

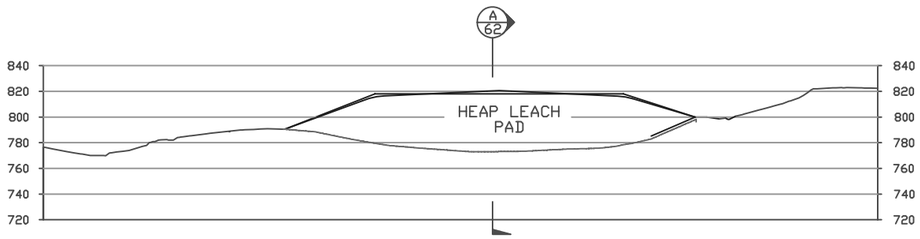
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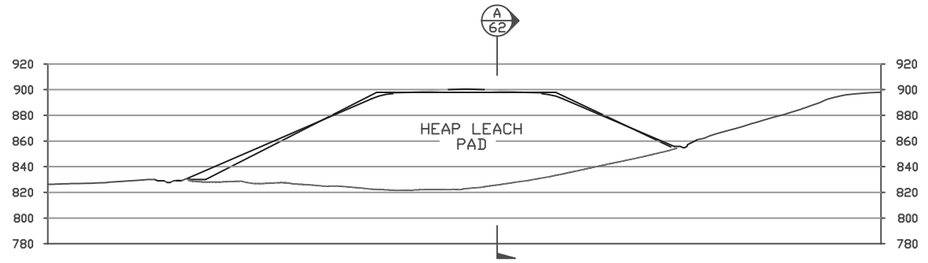
SECTION C
SCALE: 1:2000 61



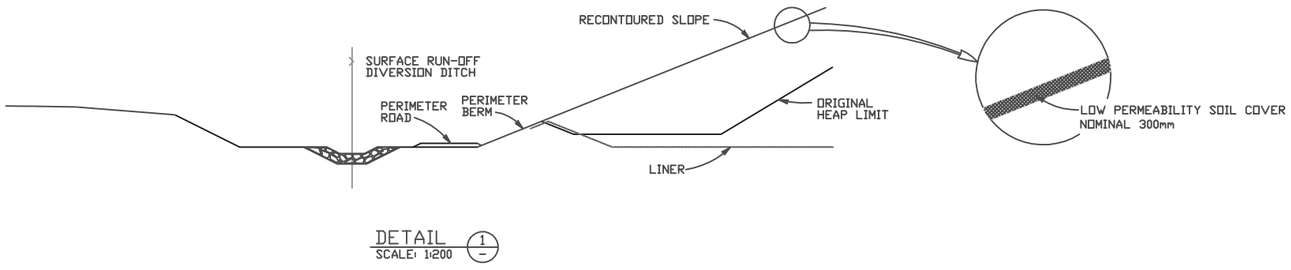
SECTION E
SCALE: 1:2000 61



SECTION B
SCALE: 1:2000 61



SECTION D
SCALE: 1:2000 61



DETAIL 1
SCALE: 1:200 –

5 2.5 0 5 10 15 20 25 metres
SCALE: 1:200

50 25 0 50 100 150 200 250 metres
SCALE: 1:2000

Project Description & Environmental Assessment Report

Carmacks Copper Project
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"Heap Leach Facility Conceptual Reclamation Sections", Drawing #100-13-63 Rev A

Heap Leach Facility Conceptual Reclamation Sections

Drawing Number:
100-13-63

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Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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3.3.4 Water Management

Water management and water collection for the proposed heap design are discussed in Knight Piesold Report 1785/1, Sections 2.6 (Water Management), 2.7 (Solution Management) and Section 2.16 (Closure). The design includes the installation of a permanent gravity flow solution pipeline that would be constructed in the initial phase of heap pad construction and would be modified to remain after closure. During the decommissioning phase however, the pipes would be used to convey rinse solution from the pad to the plant for copper removal and, in the latter stages, for neutralization and metal removal in the Reclamation Water Treatment Plant as described in Appendix A.

Once heap seepage is treated for release it will then mix with surface runoff from the surrounding area before entering Williams Creek. Treated effluent from the water treatment plant will meet MMER standards.

In addition to infiltration through the heap which reports to surface waters as described above, there are two further pathways by which drainage from the heap facility which is not collected could report to the receiving environment:

- runoff from the heap to surface waters; and,
- leakage through the heap and liner system into the groundwater.

One objective of the placement of a covering layer on the heap at closure is to minimize the amount of water which infiltrates into the heap. With the surface modifications proposed it is estimated that the runoff coefficients will be as follows:

Slope	Runoff Coefficient Uncapped Heap	Runoff Coefficient Capped Heap
slope > 40%	0.46	0.91
slope > 7%	0.80	0.46
flat areas with local depressions	0.14	not applicable
Average	---	0.8

The average coefficient used for the capped heap is estimated to be 0.8. With the average runoff coefficient determined above, surface permeability of 10^{-4} and the precipitation estimates for the project site shown on the attached Table 3.1, the annual seepage estimated entering into the heap was calculated to be in the range of 15,000 to 20,000 m^3/yr. In comparison, the estimated seepage entering a re-contoured and uncapped heap would be in the order of 35,000 to 45,000 m^3/yr. The seepage would occur during the

months of April to August as the remainder of the year the top of the heap would be frozen. Peak seepage flows would be partially retained within the heap, below the crest of the confining embankment until it flows via gravity pipeline into the water treatment plant. The water treatment plant would be sized accordingly to suit the expected average seepage values.

3.3.5 Infiltration Field.

Once the heap has been rinsed, amended with nutrients and the larger draindown volume has been released through chemical treatment and direct discharge, the long-term management and release of the heap effluent will transition to passive release and treatment in an infiltration field. The long-term infiltration rate through the covered heap is expected to be less than 30,000 m^3 per year. This equates to an annual average of 1.0 liters per second. In practice, higher flows will occur during the spring freshet and low to minimal flows in the late summer and winter months. In an infiltration gallery, the heap effluent will be collected and distributed or injected into the groundwater system through a series of ditches and higher permeability zones. The collection and distribution system will be covered with sufficient material for freeze protection. The infiltration field can be designed to sustain the higher peak spring flows or alternatively a buffering pond can be used ahead of the field to provide more uniform long-term flows into the infiltration field.

Although the heap effluent is planned to be rinsed and pH adjusted to near neutral conditions, a limestone rock drain and ditch may be required to maintain a neutral pH in the effluent prior to entering the infiltration gallery and groundwater system. A passive system for introduction of a carbon source (sugar/alcohol mixture) will be constructed and used to provide additional biological reduction of remaining contaminants in the heap effluent.

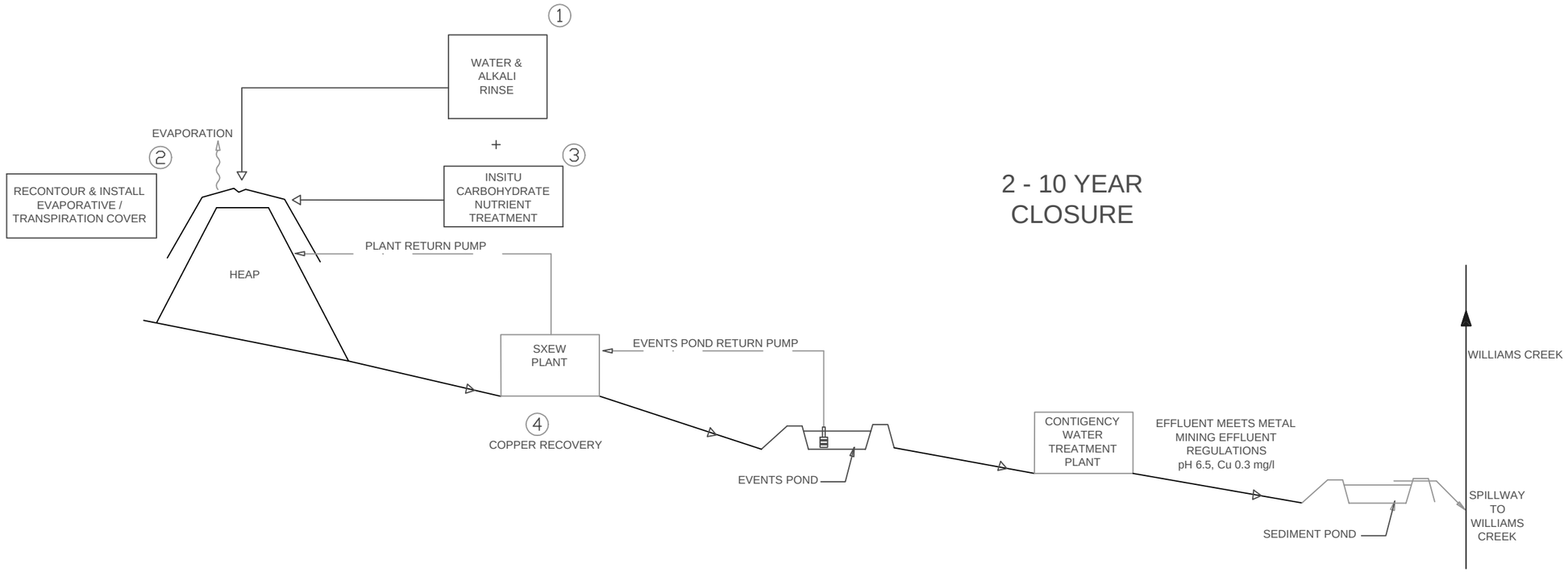
With the introduction of additional carbon sources, any remaining contaminants are biologically reduced in the anaerobic zone prior to entering the deeper groundwater system. A conceptual drawing for the long term heap leach facility is shown in drawing ACG-WS-01.001

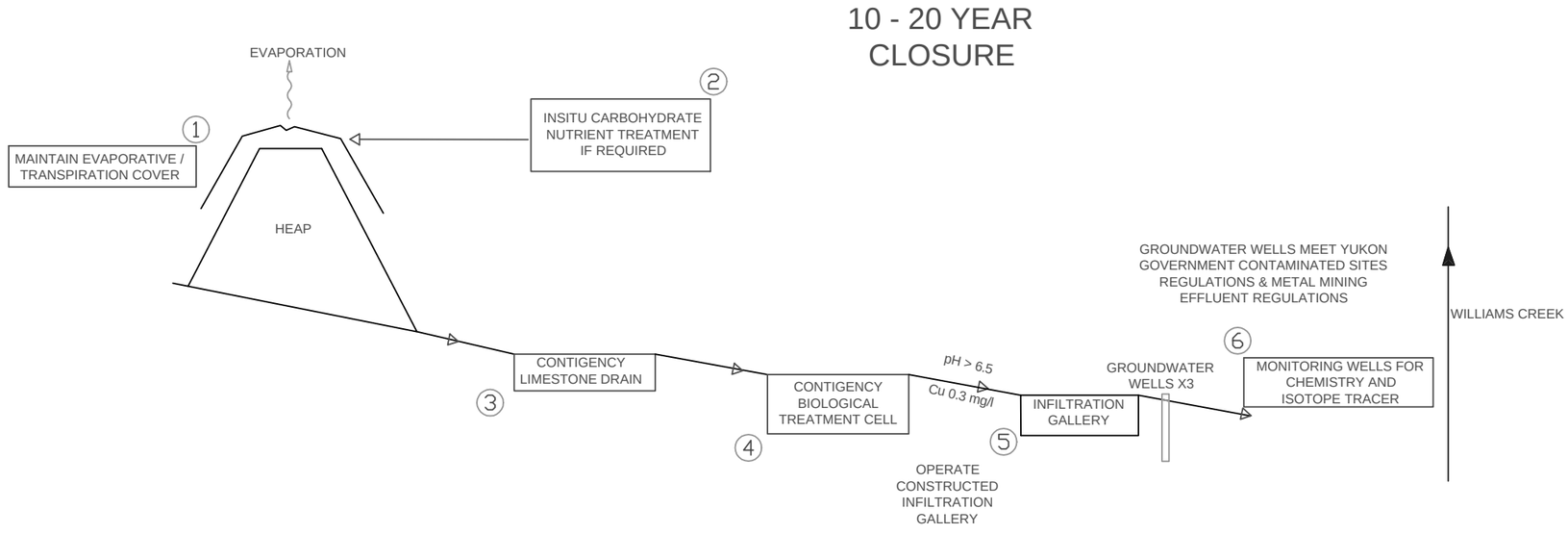
TABLE 3.1
WESTERN COPPER HOLDINGS LIMITED
CARMACKS COPPER PROJECT
PRECIPITATION DETAILS USED IN ANALYSIS

C:\ACG\Projects\WCH-01\Old reports\KP\11178\4\Data\WATBAL\[WTBALNR_revised March 10_05.XLS]Precip

DESCRIPTION		VALUE			
Precipitation Distribution					
Mean annual precipitation (mm)		375			
Mean annual rainfall (mm)		233			
Mean annual snowfall (mm)		143			
Proportions of Total Precipitation:					
Rainfall		0.62			
Snowfall		0.38			
Monthly Combined Rainfall & Snowmelt		Mean (mm)	Coefficient of Variation		Standard Deviation (mm)
Jul		75	0.60		45
Aug		53	0.50		27
Sep		36	0.60		22
Oct		4	0.40		2
Nov		0	0.60		0
Dec		0	0.90		0
Jan		0	0.90		0
Feb		0	0.70		0
Mar		0	0.80		0
Apr		100	0.80		80
May		61	0.70		43
Jun		47	0.40		19
Total (mm)		376	0.2		75
1 in 100 Year Monthly Rainfall & Snowmelt (mm)		Monthly Distribution			
		April	May	June	Total
April		286			286
May			161		161
June				91	91
April / May		286	100		386
April / May / June	Case A	286	100	64	450
April / May / June	Case B	198	161	91	450
1 in 100 Year Annual Rainfall & Snowmelt (mm)		RP = 100 Years			550
1 in 100 Year April + Average May to March (mm)		RP = 150 Years			562
1 in 100 Year Apr/May + Average June to March (mm)		RP = 750 Years			601
1 in 100 Year Apr/May/Jun + Average July to March (mm)		RP = 1600 Years			618

Notes:
(1) Monthly coefficients of variation (cv's) determined from regional streamflow records.
(2) 1 in 100 year monthly values calculated on the assumption that extreme monthly rainfall and snowmelt values are normally distributed. Multiple month cv's calculated from regional streamflow records (ie. Apr/May cv = 0.6, Apr/May/Jun cv =0.5).
(3) RP = Return Period





Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Conceptual Heap Leach Facility Closure

Drawing Number:
ACG-WS-01.001

ACCESS CONSULTING GROUP

Drawn by: HD | Checked by: DDC

Date: Feb. 1, 2005

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3.3.6 Plant and Ancillary Facilities

The plant and ancillary facilities that are not required for future use will be dismantled and sold for salvage value. Above ground foundations will be broken down to ground level, covered with local glacial tills and seeded. Recontouring will restore pre-mine drainage patterns and revegetation will follow the seed mixture for mixed deciduous/coniferous forests.

Water treatment facilities will remain intact until the heap leach pad has been neutralized and water quality is appropriate for release to the long term infiltration gallery.

The sand and gravel borrow areas south of the water storage dam will be recontoured and seeded with a mixture using indigenous plant species.

3.4 Water Chemistry/Seepage

3.4.1 Surface Water

Runoff from the reclaimed heap leach pad is estimated as follows:

Average annual precipitation	= 375 mm
Area of heap	= 310,000 m^2
Total annual precipitation	= 116,250 m^3
Runoff coefficient	= 0.8
Total annual runoff	= 93000 m^3
Total annual infiltration	
flux through covered heap	= 23250 m^3

Thus, for the covered heap, approximately 80% of the average annual precipitation would run off and report to surface water discharges. The remaining 20% would infiltrate to the heap through the covering layer. Ignoring any flow attenuation within the heap, a total of 23,250 m^3 per year of water could flow through the heap and exit to the long term infiltration gallery.

3.4.2 Groundwater

In the longer term, if there are disruptions in the heap liner integrity, there is a potential for leakage from the heap through the double liner system to surrounding ground. Estimates have been made of potential leakage and are reported in detail in Knight Piesold, No. 1785/1, Sections 2.9.4 and 2.15. However it should also be noted that the lower most silt liner is constructed to a thickness of 300 mm ($k = 1x10^{-6}$ cm/s).

Although it is clear from the contaminant transport modelling and the leakage and seepage estimates above that the impact of a small leak or seep from the heap is minimal because of the relatively small volume and flux through such a leak. To address potential concerns for long term closure, additional attenuation testwork will be conducted as part of the Closure and Reclamation Plan.

3.5 Remaining Issues and Investigations

Heap rinsing, neutralization, nutrient addition, and passive treatment requirements in the long term are the main issues to be addressed for heap closure. Laboratory testing will be done to:

- develop representative spent ore samples;
- evaluate heap rinsing with water and requirements for copper removal from water (untreated) rinse solutions;
- evaluate heap and/or rinse water neutralization requirements and options;
- identify mechanisms controlling pH and copper removal from heap to determine if there are geochemical controls on treatment for rinse solutions;
- evaluate and optimise carbohydrate nutrient addition;
- design of the long term infiltration gallery; and
- test sludge stability if on-site disposal is being considered.

There are a number of options to be considered for water treatment; which are dependent on the types of reagents utilized:

- air and oxygen for oxidation prior to precipitation;
- caustic soda;
- soda ash may be useful as a latter stage treatment for removal of some metals such as cadmium;
- sodium phosphate for iron removal;
- limestone and lime;
- TMT (trimercapto-s-triazine, trisodium salt) as an additive for metal removal and sludge stabilizer;
- Portland cement and fly ash as alternative alkali sources and to form a more “cemented” sludge than with alkali addition alone.

Options for reagent usage are discussed in Appendix A.

4. WASTE DUMPS

4.1 Description

The waste rock storage area (WRSA) is located immediately to the north of the open pit on a gentle north-east facing slope. The site was chosen to minimize haul distance from the pit, ensure stable foundation conditions, and also to minimize potential impact on existing surface drainage courses.

The WRSA covers an area of approximately 70 ha and is designed to provide permanent storage for approximately 70 million tonnes of waste rock. Waste rock will be deposited year round, at a rate of approximately 7.5 million tonnes per year. The dumps will be constructed in lifts with a maximum thickness of 25 m, with benches between successive lifts to flatten the overall slope to 2.25H:1V.

Surface drainage ditches are used to drain the footprint of the dump. Surface runoff and shallow seepage from the waste dumps will be collected in perimeter ditches and conveyed to the sediment control pond during operation.

Details of the design of the waste rock storage area are provided in Western Copper Holdings Limited, June 1996, Appendix A (Knight Piesold Report 1785/2).

Geochemical characterization testing of the waste rock is provided in the IEE Addendum, Section 4.2 (Hallam Knight Piesold, June 1995). The test results show that the waste rock samples are consistently net acid consuming and, in many cases, are strongly acid consuming. However, ICP analysis of the samples suggests that some of the samples (two of 23 samples, Table 4.5) have higher concentrations of copper than would be expected from the geology of the property. These samples appear to be located in or near the ore zone (Figures 4.3, hole 125, sample 1 and Figure 4.6, hole 157, sample 23) and are more representative of low grade mineralization than waste rock.

4.2 Closure Issues

The issues of physical stability associated with the waste rock storage area are primarily associated with the design and construction of the dumps on potentially thaw unstable ground. These issues are addressed as part of construction of the dumps and are not closure issues. At closure, the remaining physical issues are:

- control of erosion; and,

- water management.

Issues of chemical stability that are relevant to closure include:

- drainage water chemistry; and,
- potential for acid rock drainage (ARD) to develop over time.

Static geochemical testing has shown that ARD would not be anticipated from the waste rock. The testing to evaluate drainage water chemistry from the waste rock has been limited to short-term extraction testing. These tests, while more aggressive than site conditions in terms of leach extraction, show that there are potentially leachable metals although still at concentrations less than "Special Waste" material. Review of waste rock sampling and analysis shows that this extractable copper is derived from two low grade mineralized samples noted above rather than samples characterizing the bulk of the waste. (see Table 4.9, comp. 1 from hole 125, including sample 1 and comp. 6 from hole 157, including sample 23, Hallam Knight Piesold, June 1995). This low grade material would be segregated in a low grade stock pile in the area between the pit, leach pad and waste rock storage area for possible future leaching, thus there is no reason for the samples to bias the bulk of the rock test results. Drainage from such a pile can readily be directed to the leach pad treatment system or the pit. Once the prominence of this material is reduced in the rock waste data set there is no reason to expect significant leachable copper from the dump. However, monitoring would be required during operation to evaluate site drainage water chemistry. For long-term evaluations, kinetic (column leach) testing may be required.

4.3 Conceptual Closure Measures

Reclamation of the WRSA may be initiated during the early stages of production as this will lower final reclamation costs, improve short term stability, and reduce surface erosion and sedimentation. The following are preliminary recommendations for progressive reclamation and final closure of the WRSA:

- maintain sloped grading of bench surfaces to minimize surface water infiltration and erosion of downstream slopes;
- maintain surface water collection ditches and the sediment control pond to control surface drainage during operations and reclamation;
- the operational slopes, consisting of benches and raises, will be maintained at 2.25H:1V and will not be re-graded at closure. This approach removes the problems associated with the re-grading of long slopes and the corresponding erosion of drainage channels by runoff down long slopes;
- surface runoff collection ditches and the sediment controls pond will remain operational until vegetation on the storage area has reached a self sustaining growth.

When monitoring results have indicated that the waste rock storage area runoff and seepage are of suitable quality for direct release to the environment the surface runoff collection ditches will be backfilled with waste rock and the sediment control pond embankment will be breached.

4.4 Remaining Issues and Investigations

Remaining investigations for reclamation of the waste rock piles are:

- confirmation of drainage water chemistry for the waste rock;
- revegetation trials to identify appropriate species for seeding.

Monitoring during operation will be required to evaluate long-term drainage water chemistry. Kinetic testing may also be required.

5. INFRASTRUCTURE

5.1 Access Roads

Western Silver will consult with the Little Salmon Carmacks First Nation and the community to determine their desire for treatment of the road after closure. Should elimination of the access road be desired, the following concepts are applicable:

- removal of all culverts,
- bridges and approaches;
- scarifying ad decompact the road;
- restoring drainage patterns and seeding.

To discourage travel, the road can be bermed and ditched.

As suggested for linear developments, access roads at the project will be tested for revegetation with a seed mixture including a native selection of Yukon wheatgrass, violet wheatgrass, northern fescue, sheep fescue, yellow locoweed, showy locoweed, arctic lupine and glaucous bluegrass. Seed proportions will follow those suggested by Kennedy (1993).

Measures will be taken during design and construction to prevent permafrost degradation along access roads. However, if this occurs, reclamation of affected areas will be completed as necessary. This can usually be accomplished in relatively dry areas with a thin organic layer, such as exist at this location, by stripping the organic layer, replacing it with a sufficient depth of gravel to restore the natural thermal gradient and re-vegetating the area.

5.2 Ancillary Facilities

All ancillary site facilities including the camp, service complex, crushing plant will be salvaged and equipment and buildings or infrastructure removed. Sites will be recontoured to restore drainage and revegetated. Infrastructure not required for water treatment purposes will also be salvaged and removed, recontoured and revegetated from the plant site. Closure plans for ancillary facilities appears in Drawing 100-13-61.

6. REVEGETATION

6.1 Description

The mine site and facilities are located in an area dominated by white spruce on well drained slopes, black spruce on poorly drained slopes and lodgepole pine in several areas of previously burned vegetation. Stands are interspersed with paper birch, trembling aspen, and poplar.

Feathermoss dominates the understorey in dense black spruce stands, with willows and ericaceous shrubs in more open stands. Sedge and sphagnum tussocks are common in poorly drained areas. Ground cover on south facing slopes consists of sagewort; grasses and forbs occur in gullies and draws containing trembling aspen.

The total area affected by mine operations, including temporary haul roads and material storage is estimated to be 170.5 ha as presented in Table 6.1.

6.2 Closure Issues

- re-vegetate areas susceptible to erosion forces
- revegetate heap leach pad
- encourage natural revegetation in all other areas, including rock dump areas

6.3 Conceptual Closure Measures

Revegetation will follow “Guidelines for Reclamation/Revegetation in the Yukon” (Kennedy, 1993) and “Mine Reclamation in Northwest Territories and Yukon” (Steffen, Robertson and Kirsten (B.C.) Inc., 1992).

Experience at other mine sites in the Yukon indicates that fall seeding should be done to optimize initial vegetation growth. The areas presented in Table 6.1, with the exception of the open pit, will be revegetated.

The seed mixtures under consideration for reclamation of erosion susceptible areas are:

- lodgepole pine on the south and east facing slopes; and,
- white spruce on the north and west facing slopes.

Both of these mixtures comprise native seed mixtures of Yukon wheatgrass, violet wheatgrass, northern fescue, arctic lupine, yellow locoweed, and glaucous bluegress. Both seed mixtures have been identified as appropriate for the Yukon in areas of the Pelly River vegetation zone. Nutrient amendments will be added as necessary.

The pad will be revegetated with seed mixtures compatible with the mixed deciduous/coniferous vegetation areas. Native plant species in this association will include Yukon wheatgrass, northern fescue, violet wheatgrass, sheep fescue, glaucous bluegrass, sweetgrass, and arctic lupine. This will be optimized based on test plots.

6.4 Remaining Issues and Investigations

Additional work to be completed to define the revegetation program includes:

- soil characterization - some reclamation research work was initiated during the baseline program with cataloguing of the indigenous plant species, however, work is still required to characterize the available soils in the various biogeoclimatic and vegetation zones;
- testing of overburden from the open pit as this is the largest source of material for reclamation on site;
- establishment of test plots on various disturbed materials to evaluate seed mixtures and fertilizer requirements;
- documentation of natural recolonization.

Since test plot information is normally based on small scale optimum conditions, the information acquired from test plots must be applied successfully on a successively larger scale before they can be deemed applicable. These scale-ups are termed reclamation trials and are normally applied to areas of 1 to 2 ha in size. A series of reclamation trials will be implemented before mine closure on areas that have been completed, for example, inactive portions of the waste rock dump, unused exploration roads, and margins of diversion channels. Information obtained from reclamation trials can then be scaled up to reclaim areas as they become available for progressive reclamation during operation. In this manner, the company will be able to optimize species composition and ensure self-sustaining vegetation communities for closure.

Table 6.1
Carmacks Copper Project
Projected Area of Disturbance at End - of - Mine Life (Year - 9)

Reclamation Unit	Area (ha)
Open Pit (Ultimate)	29.5
Waste Rock Storage Area	69.6
Heap Leach Pad	37.2
Plant and Ancillary Facilities	13.3
Surface Water Distribution (8 wells)	0.004
Sand and Gravel Borrow	2.5
Access and Haul Roads	12.3
Exploration Trail	6.1
Total Estimated Disturbed Area	**170.5**

7. CLOSURE SCHEDULE

7.1 Schedule

Reclamation will begin during operations to promote slope stabilization and reduce erosion during the life of the mine. Following closure, equipment and buildings will be removed and resloping of the heap leach pad will occur during open ground periods for the first two years. The monitoring of the heap leach pad will continue until it is deemed safe at which time the treatment facility and settling pond will be removed, recontoured and revegetated. It is difficult at this point in the project to determine how long the neutralization process will take, but testwork to date indicates a period of at least 3 to 10 years.

Once final heap closure is attained, the main access road could be scarified and reclaimed. Biomonitoring and geotechnical assessment will occur annually for a minimum of 15 years to ensure that revegetation is successful, that slopes are stable, and heap chemistry is assured.

7.2 Suspended Operations or Premature Closure

Reclamation and revegetation will be ongoing so that in the event of suspended operations or a premature closure, revegetation will be well advanced in disturbed areas.

In the event of suspended operations, the heap leach will be drained down. However, no further reclamation will be carried out until operations recommend or a decision is made to proceed with full closure. Water collection from the heap will continue. Water treatment will be implemented if the water balance requires discharge of water from the pad and ponds.

In the event of a premature closure, a temporary closure plan based on material stability will be instigated. All materials, including stockpiles, reagents, and stored fuel will be secured and on-site monitoring will take place until mining recommences or full closure is initiated.

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CARMACKS COPPER PROJECT

APPENDIX A

“DESCRIPTION OF WATER TREATMENT PROCESS FOR RECLAMATION DUTY”

1.0 INTRODUCTION

Following mine closure, the Carmacks leach pad will be covered over to seal it from direct exposure to precipitation. However, some seepage may occur, and this water treatment plant is presented as a means for handling such seepage, until such time as the heap has been rinsed and neutralized.

The proposed water treatment system will be a caustic precipitation plant for bulk removal of metals and for pH adjustment. The process is illustrated on the attached drawing, "Reclamation Duty Water Treatment Flow Diagram," 400-03-11. The water treatment plant has been divided into 4 parts:

- Reagent/Water Treatment Reactors;
- flocculant System;
- Filter Press System;
- Clarifier/Sand Filter System.

The existing emergency raffinate treatment plant/neutralization tanks will be modified to act as water treatment reactors. The hydrated lime storage silo and screw feeder will be modified to make the reagent bin and feeder.

The filter press and pump, the sludge receiver and sludge bin/dryer will be provided by modifying the existing crud treatment and filter press system which form part of the flotation and organic treatment system.

The plant will include the following major facilities:

- Seepage collection system
- One collection pond
- Two stirred treatment reactors

- One Clarifier
- One sand filter
- One sludge filter press
- One sludge dryer
- Treated water retention pond
- Utilities and ancillaries including reagent supply, air compressors, emergency and line power, drinking water, etc.
- Support facilities, including office, control room and maintenance area.

Most of the process equipment will be enclosed in buildings.

The plant will have a treatment capacity sufficient to handle seepage and any contaminated run-off from the area of the closed leach pad. The flow rates will vary with the season and the weather.

Given sufficient capacity in the collection pond, the plant may be operated on a campaign basis, treating larger volumes of accumulated seepage as required.

This water treatment system is relatively simple, but allows flexibility for a number of process parameters, including:

- Aeration and sludge re-circulation
- Reagent dosages of pH adjustment and flocculation
- Alternate & supplementary reagents including:
  - Caustic soda
  - Soda ash

- Sodium phosphate
- Lime and limestone
- Commercial precipitant

• Alternate sludge collection and disposal methods.

2.0 PROCESS DESCRIPTION

Seepage will be collected from within the leach pad via the gravity solution pipelines installed during initial heap construction, which takes advantage of the double liner and leakage collection systems installed for the heap leach operation. The confining embankment, used for the heap leach operation serves as the low collection point for the pipeline to the treatment plant.

The seepage will be pumped through a metering system to the two water treatment reactors which will operate in series. The seepage passes through neutralization reactors 1 and 2 in series, and emerges at a controlled pH of 9.0. Caustic pellets are metered to the reactors from a bin feeder, or solution from an adjacent storage tank will be added to both reactors via a circulation loop.

The resultant slurry will be treated by a mechanical drive clarifier. This clarifier may be fitted with Lamella-type inclined plates to improve settling performance. Clarifier underflow will be re-circulated to maintain a suspended sludge bed. The clarifier sludge product will be bled from the re-circulating underflow to the sludge receiver.

The sludge will be pumped from the sludge receiver, at about 8 to 10 percent solids, to the sludge press filter area. This filter area will include a sludge sump, an covered storage pad for dried sludge, the filter press, and the sludge dryer.

Clarifier overflow will be polished in a continuous backwash sand filter. Backwash will be returned to the clarifier, and filtrate will then pass through a lined concrete raffinate tank and decant into the event and sediment ponds below the heap, before final discharge to Williams Creek. This discharge will meet MMER standards.

At the filter area, sludge will be pumped from the sump by air operated diaphragm pumps to the filter press, where a competent filter cake will emerge at about 20 to 25 percent solids. The filter cake drops into a dryer feed bin which will be equipped with paddles that extrude the material onto dryer feed belt. The dried sludge, to about 40 to 60 percent solids, discharges from the dryer directly into large transport bags for shipment and kept in a covered storage area until a suitable load is accumulated.

A flocculant mixing and dosing system will be enclosed in an existing building adjacent the clarifier. This building will also include a small control room, the MCC room and a laboratory. Other facilities in the building will include plant and instrument air compressors, diesel electric generators, and acid wash area for filter cloths.

Except for large ponds and related equipment, and outside storage pads, all process tankage and equipment will be protected from the elements.

3.0 REAGENTS

The chemical processes available for the treatment of Carmacks seepage vary according to the reagents utilized. The ultimate effectiveness of each process must be demonstrated in laboratory testwork, using a representative seepage composition. However, test work undertaken as part of the IEE Addendum, (Hallam Knight Piesold, June 1995, Section 4.3) indicates that raffinate solution can be effectively treated using this technology. The most generally accepted practice for removing and stabilizing heavy metal laden effluent is by neutralization and precipitation of metals as metal hydroxides. Certain other reagents may be utilized as oxidants, coagulants, antiscalants, modifiers, and flocculants. Kilborn has examined several alkaline chemical options as discussed below.

3.1 Air and Oxygen

Metal precipitates are more stable when the metals have been oxidised to the highest possible oxidation state prior the formation of the insoluble hydroxides, carbonates, or sulphates. For example, ferric hydroxide is less soluble than ferrous hydroxide. These oxidized precipitates will be more suitable for mine backfill or landfill disposal alternatives because the metals are less subject to re-dissolution and mobilization.

Aeration has additional benefits. Oxygen is useful in conditioning metal hydroxides, gypsum, and jarosite sludge by promoting additional oxidation and hydrolysis.

However, it must be recognized that an oxidized metallic salt will require more reagent for precipitation. For example, precipitation of ferric iron will require 50 percent more reagent than precipitation of ferrous iron:

Ferrous: $Fe^{++} + SO_4^{--} + 2NaOH \rightarrow Fe(OH)_2 + Na_2SO_4$

Ferric: $Fe^{3+} + 1.5SO_{4--} + 3NaOH \rightarrow Fe(OH)_3 + 1.5\ Na_2SO_4$

This additional consumption will raise the cost of treatment.

Oxidation reactions in solution are limited by the solubility of oxygen in water. Vigorous mixing and air sparging are generally necessary to drive the reaction. The process may be carried out in stirred tanks with aerators in ponds and lagoons.

3.2 Caustic Soda

Sodium hydroxide provides the alkaline conditions necessary for the precipitation of most heavy metals. Sulphates and phosphates are not removed from solution, so there is generally less sludge volume. However, these sludge are often difficult to thicken and filter, and the metals are more easily re-dissolved if the solutions become acidic once again. A final stabilization with fly-ash or portland cement may be considered to minimize subsequent leaching of metals from the sludge.

Even at high pH levels, caustic soda precipitation leaves in solution low concentrations of cadmium, nickel, and zinc, as well as sulfosalts such as arsenates. Sodium hydroxide is generally the most expensive neutralization reagent.

3.3 Soda Ash

Although sodium carbonate does not generate high pH levels, it can more effectively reduce certain metals (especially cadmium) as carbonate. As a neutralizing agent, soda ash generates carbon dioxide, which may interfere with thickening if not properly vented or allowed to dissipate. However, when combined with stronger alkaline reagents, soda ash is very effective in conditioning solutions and producing stable, more easily managed sludge. Also, it is a less expensive reagent than caustic soda.

Soda ash does not remove sulphates, phosphates or sulfosalts from solution.

3.4 Sodium Phosphate

If iron levels persist in solution after alkaline treatment, a small addition of sodium phosphate or phosphoric acid may reduce the iron to the 0.3 mg/ml effluent requirement. This will increase the levels of phosphate in the effluent, but phosphate concentrations are not always regulated.

3.5 Limestone and Lime

Limestone provides a comparatively low cost means of adjusting the pH of acidic solutions. It is also useful in buffering strongly alkaline solutions because of the carbonate generated. Limestone will reduce the concentrations of sulphate, phosphate, and arsenate as calcium salts. By itself, limestone is not an effective precipitant for heavy metals, but it is useful as a passive treatment medium either before or after other more active treatment steps.

For example, it may be considered as a pre-treatment for the process by filling one or a series of launders or trenches with limestone. Such launders would effect a partial pH adjustment and metal sulphate precipitation, but the resultant sulphates would have to be removed or displaced by periodic washing, ripping or bulk removal. Aeration would be conducted upstream of these launders, and antiscalants would be employed to keep pipelines and equipment clean.

Lime, either as quicklime for as slaked lime, is a low cost and effective neutralization and precipitation reagent. Precipitation reactions produce hydroxides, sulphates, phosphates

and more complex salts often referred to as jarosite. These complex precipitated solids are also effective in removing difficult to precipitate metals such as cadmium and zinc.

Although reactions with lime produce larger volumes of precipitates, the resulting sludge generally can be conditioned to produce a solid material that is relatively non-reactive. The sludge can be further stabilized by mixing with cement or fly-ash.

3.6 Portland Cement and Fly Ash

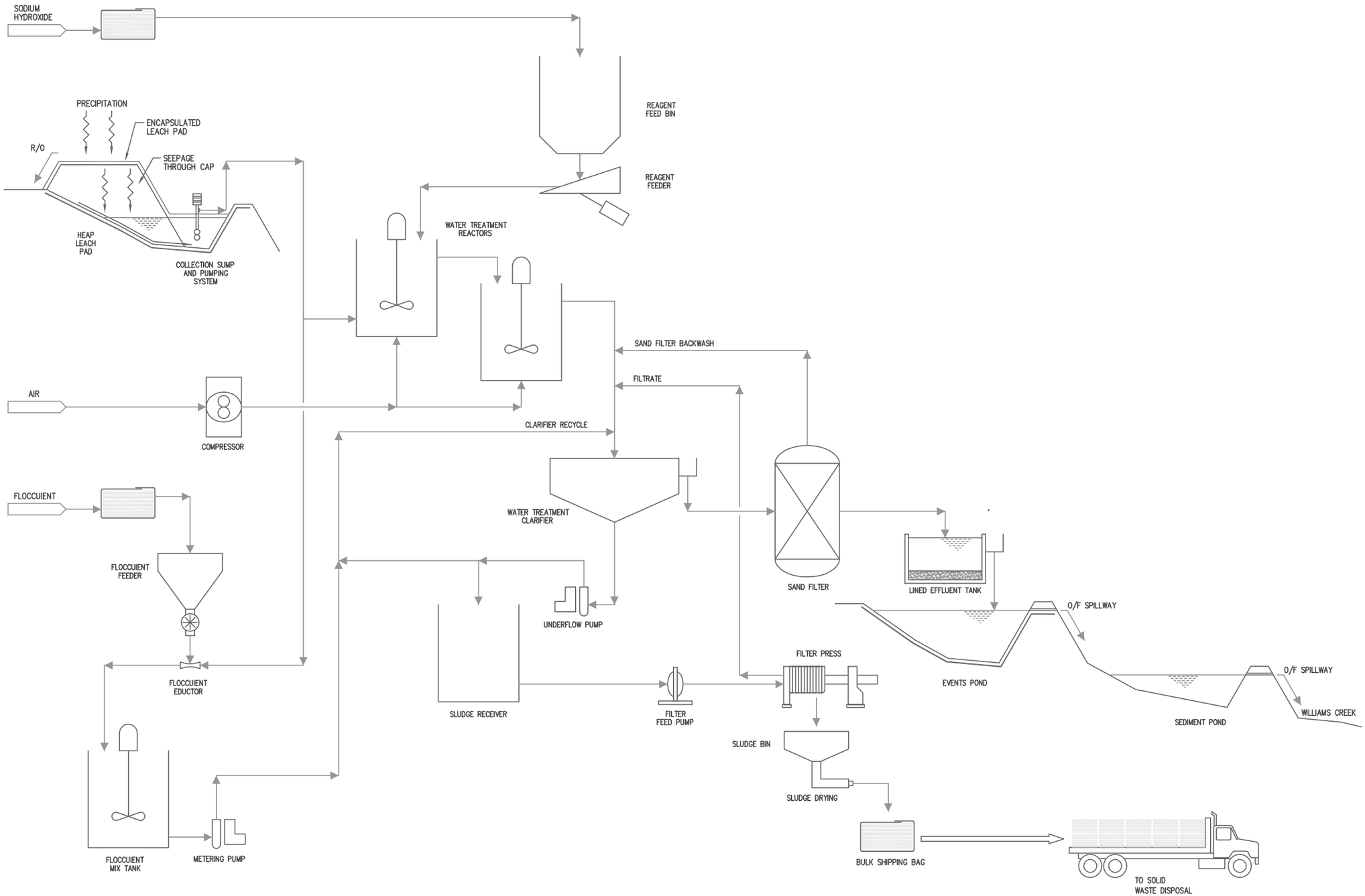
Pozzolanic materials such as portland cement and fly-ash can by used to neutralize, precipitate and stabilize heavy metals. Although highly alkaline, the materials are most effective in enmeshing the precipitates in the hydrated "cement" as highly insoluble hydroxides and silicates. Stabilization has proven to be and effective treatment method in most instances.

3.7 TMT

TMT (trimercapto-s-triazine, trisodium salt $C_3N_3Na_3S_3$) is a speciality chemical designed for efficient precipitation of metals from waste streams. Accompanied by pH correction, it produces a stable, easily settled sludge which will not be leached by dilute acids. As a trivalent molecule, each mole precipitates three moles of monovalent metals such as silver or mercury, or one and a half moles of divalent metals such as copper or ferrous iron. This chemical is marketed by the Degussa Corporation.

4.0 PROCESS CONTROLS AND OPERATION

All process equipment will be capable of operating with minimal operator assistance. Effluent sampling and monitoring will be monitored remotely by plant operations personnel residing in Carmacks. Flow measurement and water quality of influent/effluent will be recorded continually to ensure that the plant is operating correctly and to make adjustments to the process as needed.



Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

WESTERN SILVER CORPORATION

Note: Drawing is for illustrative purposes only, NOT FOR CONSTRUCTION

Original drawing from Kilborn,
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Reclamation Duty Water Treatment Flow Diagram", Drawing #400-03-11 Rev A

Reclamation Duty Water Treatment Flow Diagram

Drawing Number:
400-03-11

ACCESS CONSULTING GROUP

Revised by: HD	Checked by: DDC

Date: Feb. 1, 2005

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Project Description and Environmental Assessment Report

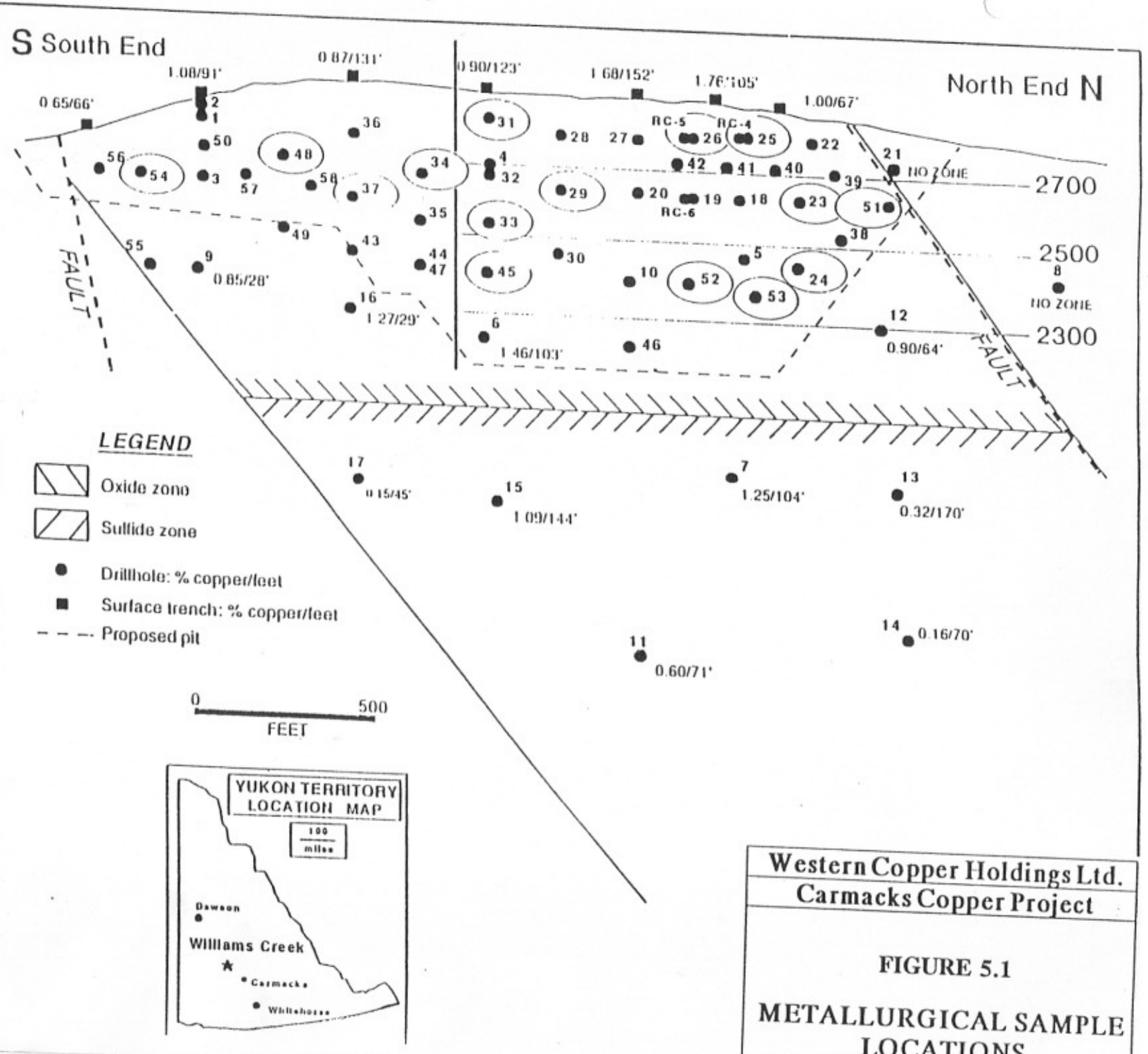
Carmacks Copper Project
Yukon Territory

Appendix G

Summary of Results from the Waste Rock Characterization Program

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HOLE	INTERVAL TRUE WIDTH	% Cu
1	80'	1.26
2	40'	0.45
3	40'	1.50
4	66'	0.69
5	190'	1.34
10	105'	1.30
18	160'	1.61
19	139'	0.96
20	124'	1.55
22	127'	1.19
23	203'	1.82
24	160'	1.14
25	130'	1.36
26	129'	0.83
27	136'	1.53
28	123'	0.98
29	121'	1.06
30	99'	1.51
31	112'	0.94
32	90'	1.07
33	56'	1.10
34	76'	1.45
35	57'	1.08
36	69'	0.76
37	61'	0.84
38	166'	0.55
39	83'	0.54
40	110'	1.36
41	155'	1.22
42	137'	1.11
43	131'	1.09
45	84'	0.99
46	174'	1.31
47	116'	1.39
48	55'	1.32
49	70'	0.78
50	127'	0.84
51	82'	0.31
52	165'	1.3
53	183'	1.17
54	35'	1.08
55	1.2'	1.39
56	30'	1.42
57	75'	1.16
58	121'	1.15
RC-4	118'	1.39
RC-5	130'	1.06
RC 6	126'	1.13



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FIGURE 5.1

METALLURGICAL SAMPLE LOCATIONS

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Table 5.1
Waste Rock Mineralogy

Sample #	Description	Mineralogy		
		Primary	Secondary	Supergene
TS 21 - 178'	Light grey to pink rock with medium grained matrix	Plagioclase - 40% (an 8 or 33) K-feldspar - 15% Hornblende - 6% Biotite - 0.5% Sphene - 1% Quartz - 13% Epidote - 1% Chlorite - 5% Opaques - 0.5%		Clay - 16% (montmorillonite type) Epidote - 1% Pore space - 0.5%
TS 38 - 187'	Light grey, fine to medium grained, rock with granitoid texture	Plagioclase - 70% (An 12 or 29) Quartz - 17% Biotite - 2% Sphene - 0.5% Apatite - 0.5% Magnetite - 1.5%	Montmorillonite - 5.5% Hydrobiotite - 2% Epidote - 0.3% Sericite - 0.1% Carbonate - 0.1%	
TS 40-33'	Light grey, medium grained rock with granitoid texture and approximately 25% mafic minerals	Plagioclase - 67% (An 11 or 30) Hornblende - 20% Biotite - 5% Sphene - 2% Apatite - 0.8% Magnetite - 0.7%	Hydrobiotite - 2% Epidote - 0.2% Magnetite - 0.2% Carbonate - 0.3%	Montmorillonite - 2% Limonite - 0.1% Pore space - $\leq$0.1%

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Table 5.2
Waste Rock Quality Test Results (ICP)

Parameter	DDH1-25 10-12	DDH1-25 180-182	DDH1-33 50-52	DDH1-33 150-152	DDH1-33 250-252	DDH1-33 350-352	DDH1-37 50-52	DDH1-37 150-152	DDH1-37 25-252	DDH1-37 349-351	DDH1-53 50-52	DDH1-53 150-152
Aluminum (%)	1.20	1.51	0.87	0.57	0.48	0.71	0.64	0.80	0.45	1.62	0.86	0.70
Arsenic (ppm)	22.00	25.00	17.00	19.00	10.00	11.00	14.00	10.00	6.00	25.00	14.00	15.00
Barium (ppm)	479.00	157.00	114.00	110.00	126.00	84.00	113.00	66.00	100.00	414.00	125.00	169.00
Beryllium (ppm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bismuth (ppm)	1.00	2.00	1.00	1.00	1.00	9.00	7.00	6.00	6.00	1.00	2.00	5.00
Boron (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium (ppm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Calcium (%)	1.28	2.08	1.14	0.62	0.32	0.51	0.82	0.88	0.39	1.27	0.88	0.84
Chromium (ppm)	22.00	16.00	16.00	23.00	23.00	28.00	26.00	23.00	30.00	22.00	25.00	26.00
Cobalt (ppm)	7.00	5.00	4.00	3.00	2.00	3.00	3.00	3.00	2.00	8.00	4.00	3.00
Copper (ppm)	1382.00	62.00	12.00	7.00	8.00	193.00	12.00	7.00	164.00	17.00	11.00	19.00
Gold (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (%)	2.81	2.06	1.71	1.24	1.00	1.68	1.60	1.36	1.22	3.09	1.90	1.34
Lanthanum (ppm)	3.00	3.00	3.00	1.00	1.00	5.00	2.00	2.00	2.00	10.00	2.00	1.00
Lead (ppm)	13.00	13.00	11.00	10.00	1.00	3.00	9.00	6.00	4.00	9.00	7.00	9.00
Magnesium (%)	0.85	0.56	0.63	0.32	0.33	0.43	0.34	0.43	0.28	1.29	0.47	0.40
Manganese (ppm)	500.00	393.00	322.00	197.00	179.00	268.00	179.00	179.00	197.00	715.00	286.00	179.00
Mercury (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum (ppm)	3.00	7.00	2.00	1.00	2.00	2.00	1.00	2.00	3.00	3.00	1.00	1.00
Nickel (ppm)	2.00	1.00	1.00	1.00	2.00	4.00	3.00	2.00	5.00	7.00	5.00	4.00
Phophorous (%)	0.12	0.15	0.16	0.11	0.06	0.10	0.14	0.15	0.08	0.16	0.16	0.17
Silicon (%)	0.02	0.33	0.04	0.11	0.02	0.04	0.09	0.11	0.02	0.15	0.19	0.10
Silver (ppm)	1.10	0.40	0.20	0.10	0.10	0.20	0.10	0.10	0.10	0.50	0.10	0.10
Sodium (%)	0.04	0.07	0.06	0.07	0.04	0.05	0.07	0.10	0.04	0.08	0.12	0.12
Strontium (ppm)	20.00	59.00	45.00	32.00	14.00	24.00	40.00	39.00	20.00	71.00	60.00	68.00
Sulphur (ppm)	1.00	4.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Titanium (%)	0.07	0.09	0.06	0.07	0.08	0.10	0.06	0.11	0.06	0.18	0.10	0.10
Tungsten (ppm)	1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uranium (ppm)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vanadium (ppm)	56.00	43.00	31.00	28.00	21.00	35.00	39.00	33.00	27.00	71.00	42.00	31.00
Zinc (ppm)	60.00	45.00	36.00	20.00	22.00	37.00	30.00	25.00	24.00	73.00	39.00	30.00

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Table 5.2
Waste Rock Quality Test Results (ICP)

Parameter	DDH1-53 250-252	DDH1-53 350-352	DDH1-53 450-452	DDH1-53 680-682	DDH1-56 50-52	DDH1-56 150-152	DDH1-56 220-222	DDH1-57 50-52	DDH1-57 150-152	DDH1-57 300-302	DDH1-57 350-352	AVERAGE
Aluminum (%)	0.27	0.88	1.64	1.86	1.08	0.72	0.87	1.24	0.70	1.33	1.75	0.91
Arsenic (ppm)	9.00	14.00	32.00	28.00	23.00	13.00	13.00	32.00	12.00	31.00	15.00	16.40
Barium (ppm)	99.00	220.00	391.00	359.00	118.00	100.00	94.00	203.00	198.00	450.00	635.00	196.96
Beryllium (ppm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.92
Bismuth (ppm)	1.00	1.00	3.00	10.00	10.00	4.00	4.00	8.00	10.00	9.00	1.00	4.12
Boron (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium (ppm)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.92
Calcium (%)	0.19	0.98	2.72	2.43	1.41	0.64	0.65	3.97	0.52	2.69	0.64	1.11
Chromium (ppm)	34.00	32.00	10.00	13.00	25.00	39.00	35.00	19.00	32.00	29.00	34.00	23.28
Cobalt (ppm)	1.00	4.00	5.00	7.00	5.00	3.00	4.00	7.00	4.00	3.00	7.00	3.88
Copper (ppm)	18.00	9.00	27.00	9.00	9.00	10.00	8.00	18.00	71.00	10.00	2344.00	177.08
Gold (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (%)	0.60	1.90	2.72	2.72	2.58	1.61	1.63	2.57	1.28	1.73	3.41	1.75
Lanthanum (ppm)	1.00	2.00	6.00	2.00	9.00	3.00	4.00	7.00	2.00	8.00	2.00	3.24
Lead (ppm)	3.00	5.00	21.00	21.00	15.00	6.00	4.00	20.00	4.00	21.00	1.00	8.64
Magnesium (%)	0.17	0.51	1.03	0.87	0.75	0.48	0.47	0.74	0.45	0.34	1.23	0.53
Manganese (ppm)	71.00	250.00	518.00	500.00	483.00	322.00	268.00	608.00	286.00	340.00	661.00	316.04
Mercury (ppm)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Molybdenum (ppm)	2.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	7.00	2.00	1.96
Nickel (ppm)	1.00	4.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	2.12
Phophorous (%)	0.02	0.14	0.14	0.18	0.17	0.10	0.10	0.13	0.07	0.09	0.11	0.11
Silicon (%)	0.02	0.18	0.29	0.33	0.09	0.04	0.13	0.04	0.03	0.32	0.08	0.11
Silver (ppm)	0.10	0.20	0.60	0.60	0.60	0.20	0.20	0.60	0.20	0.90	1.50	0.35
Sodium (%)	0.04	0.14	0.06	0.06	0.09	0.07	0.07	0.04	0.06	0.06	0.09	0.07
Strontium (ppm)	19.00	60.00	47.00	87.00	34.00	36.00	39.00	9.00	23.00	55.00	23.00	36.96
Sulphur (ppm)	1.00	4.00	1.00	3.00	10.00	1.00	3.00	9.00	1.00	7.00	1.00	2.28
Titanium (%)	0.05	0.10	0.11	0.16	0.14	0.08	0.06	0.05	0.09	0.01	0.29	0.09
Tungsten (ppm)	1.00	1.00	6.00	5.00	4.00	11.00	1.00	7.00	1.00	3.00	1.00	2.20
Uranium (ppm)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.60
Vanadium (ppm)	14.00	43.00	59.00	55.00	56.00	32.00	30.00	51.00	27.00	27.00	95.00	37.84
Zinc (ppm)	12.00	39.00	59.00	71.00	52.00	36.00	34.00	51.00	31.00	48.00	93.00	38.68

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WESTERN COPPER HOLDINGS LTD.
CARMACKS COPPER PROJECT

Table 5.3a
Acid-Base Accounting

Sample #	Sample Type	Total Sulphur (%)	Paste pH	Neutralizing Potential (NP)	Max Potential Acidity (AP)	Net Neutralizing Potential	NP/AP
	Pilot Plant Trench Samples						
	Comp 1	0.10	8.1	8.20	3.13	5.1	2.62
	Comp 2	0.12	8.0	13.3	3.75	9.6	3.55
	Comp 3	0.03	8.1	13.2	0.94	12.3	14.04
	Drill Core*						
	Comp 1 +27L*	0.14	8.4	27.2	4.38	22.8	6.21
	Comp 2 +27H	0.08	8.6	15.5	2.50	13.0	6.2
	Comp 3 25-27L	0.01	8.9	31.4	0.31	31.1	101.3
	Comp 4 25-27H	0.08	8.4	12.7	2.50	10.2	5.08
	Comp 5 23-25L	0.04	8.9	21.0	1.25	19.8	16.8
	Comp 6 23-25H	0.03	8.2	12.0	0.94	11.1	12.8
	Comp 7 SE	0.06	8.4	13.4	1.88	11.5	7.1
	Waste Rock Samples						
1	DDH 1-25/10-12	0.01	8.2	37.1	0.31	36.8	119.7
2	DDH 1-25/180-182	0.01	8.2	34.5	0.31	34.2	111.3
3	DDH 1-33/50-52	0.01	8.5	24.5	0.31	24.2	79.0
4	DDH 1-33/150-152	0.01	8.6	11.9	0.31	11.6	38
5	DDH 1-33/250-252	0.01	8.6	12.6	0.31	12.3	40.6
6	DDH 1-33/350-352	0.01	8.4	14.5	0.31	14.2	46.8
7	DDH 1-37/50-52	0.01	8.7	12.6	0.31	12.3	40.6
8	DDH 1-37/150-152	0.01	8.8	14.0	0.31	13.7	45.2
9	DDH 1-37/250-252	0.01	8.5	11.3	0.31	11.0	36.5
10	DDH 1-37/349-351	0.01	8.5	37.8	0.31	37.5	121.9
11	DDH 1-53/150-152	0.01	8.7	15.3	0.31	15.0	49.4
12	DDH 1-53/250-252	0.01	8.0	10.1	0.31	9.8	32.6
13	DDH 1-53/350-352	0.01	8.7	15.0	0.31	14.7	48.4
14	DDH 1-53/450-452	0.02	8.3	62.9	0.63	62.3	99.8
15	DDH 1-53/680-682	0.01	8.2	48.3	0.31	48.0	155.8
16	DDH 1-53/50-052	0.01	8.5	16.6	0.31	16.3	53.5
17	DDH 1-56/50-52	0.01	8.6	31.4	0.31	31.1	101.3
18	DDH 1-56/150-152	0.01	8.8	14.0	0.31	13.7	45.2
19	DDH 1-56/220-222	0.01	8.5	33.7	0.31	33.3	108.7
20	DDH 1-57/50-52	0.01	8.1	89.8	0.31	89.5	289.7
21	DDH 1-57/150-152	0.01	8.2	12.9	0.31	12.6	41.6
22	DDH 1-57/300-302	0.01	8.0	55.6	0.31	55.3	179.4
23	DDH 1-57/350-352	0.01	8.3	17.9	0.31	17.6	57.7

* L = low grade ore, H = high grade ore; See Table 3.2b for composite intervals.

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WESTERN COPPER HOLDINGS LTD.
CARMACKS COPPER PROJECT

Table 5.3b
Metallurgical Drill Core Composites

Sample #	DDH #	From	To	Length (feet)	Weight (lbs)
-27L	25	18	101	83	235
	26	10	86	76	215
	31	102	167	65	185
				224	635
-27H	25	101	176	75	213
	26	86	146	60	170
	31	32	102	70	199
				205	582
25-27L	23	122	241	119	338
	29	252	291	39	110
	33	323.5	334	10.5	30
	51	88.3	174.9	86.6	246
				255.1	724
25-27H	23	241	336	95	270
	29	164	252	88	250
	33	275	323.5	48.5	138
				231.5	658
23-25L	24	384.5	428	43.5	124
	45	436.2	480	43.8	124
	52	406	440	34	97
	52	555	580	25	71
	53	470.8	539.1	68.3	194
				214.6	610
23-25H	24	428	553	125	355
	45	480	524.3	44.3	126
	52	440	555	115	326
				284.3	807
SE	34	73.5	153.5	80	227
	37	181	245.5	64.5	183
	48	10	68	58	165
	54	160	197.2	37.2	106
				239.7	681

Grand total 4697 lbs

Table 5.4
SWEP Leachate Quality Standards

Contaminant	Concentration in Waste Extract (mg/L)
Aldicarb	0.9
Aldrin + Dieldrin	0.07
Arsenic	5.0
Barium	100.0
Benzene	0.5
Boron	500.0
Cadmium	0.5
Carbaryl/1-Naphthyl-N-methyl carbamate	9.0
Carbon tetrachloride	0.5
Chlordane	0.7
Chromium	5.0
Copper	100.0
Cyanide (free)	20.0
Diazinon	2.0
DDT	3.0
2,4-D	10.0
Ethylbenzene	0.24
Fluorides	150.0
Heptachlor + Heptachlor epoxide	0.3
Lead	5.0
Lindane	0.4
Mercury	0.1
Methoxychlor	90.0
Nitrate + Nitrite	1000.0
Nitrilotriacetic acid (NTA)	5.0
Pathion	5.0
Pentachlorophenol	3.0
Selenium	1.0
Silver	5.0
Tetrachlorophenol, 2,3,4,6-	0.1
Toluene	2.4
Trichlorophenoxyacetic acid, 2,4,5-(2,4,5-T)	28.0
Trihalomethanes	35.0
Uranium	10.0
Xylenes	30.0
Zinc	500.0

(B.C. Reg. 132/92, s.36(e))

WESTERN COPPER HOLDINGS LTD.

Carmacks Copper Project

Table 5.5

Analyses of Ore and Pregnant Leach Solutions (PLS)

Parameter	Ore Composite No. 1 (SWEP)	Ore Composite No. 2 (SWEP)	Ore Composite No. 3 (SWEP)	Head PLS (ICP)	Neutralized PLS Filtrate (ICP)	Neutralized PLS Precipitate (SWEP)
Ag	<0.01	<0.01	<0.01	<0.5	<0.1	<0.1
Al	1.39	0.5	<0.01	7487	<0.1	7.6
As	<0.02	<0.02	<0.02	1	<0.1	<0.1
Au	<0.01	<0.01	<0.01	<1	<0.1	<0.1
B	0.02	0.09	<0.01	370	<0.1	5.9
Ba	1.12	0.62	2.06	6	0.8	0.55
Be	<0.005	<0.005	<0.005	0.5	0.03	0.04
Bi	<0.02	<0.02	<0.02	<2	<0.1	<0.1
Ca	47.8	48.8	102.2	570	496.4	1411
Cd	0.005	<0.005	<0.005	0.7	<0.01	0.14
Co	0.01	0.02	0.07	22	0.3	1.2
Cr	<0.01	<0.01	<0.01	2	<0.1	<0.1
Cu	97.17	78.98	74.68	8935	0.8	261.5
Fe	2.68	2.43	2.3	7220	0.2	10.9
Hg	<1	<1	<1	<3	<1	<1
La	<0.01	<0.01	<0.01	1	<0.1	<0.1
Mg	8.2	9.3	13	6527	5445	572
Mn	2	2.86	4.1	816	138.4	134.6
Mo	<0.01	<0.01	<0.01	<1	<0.1	<0.1
Na	6	6	3	150	112	15
Ni	0.03	<0.01	<0.01	12	<0.1	0.3
P	<0.1	<0.1	<0.1	147	<0.1	0.4
Pb	<0.02	0.02	0.05	1	<0.1	<0.1
Sb	<0.02	<0.02	<0.02	<2	<0.1	<0.1
Si	7.62	8.09	11.13	120	9.2	9
Sr	0.31	0.27	0.35	1.1	5	5.3
Ti	<0.01	<0.01	<0.01	4	<0.1	<0.1
V	<0.01	<0.01	<0.01	9	<0.1	<0.1
W	<0.02	<0.02	<0.02	<2	<0.1	<0.1
Zn	0.87	0.72	0.72	31	0.1	7

* All parameter levels expressed in mg/L

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Western Copper Holdings Ltd.
Carmacks Copper Project

Table 5.6
SWEP Testing of Waste Rock

Element (ppm)	Comp 1	Comp 2	Comp 3	Comp 4	Comp 5	Comp 6	**Average**
Ag	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.01**
Cu	5.387	0.04	0.037	0.039	<0.010	6.784	**2.0495**
Pb	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	**0.04**
Zn	0.255	0.097	0.087	0.099	0.092	0.127	**0.1262**
As	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	**0.03**
Sb	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	**0.04**
Hg	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	**0.02**
Mo	0.009	<0.005	<0.005	0.006	<0.005	0.008	**0.0063**
Tl	<0.080	<0.080	<0.080	<0.080	<0.080	<0.080	**0.08**
Bi	<0.070	<0.070	<0.070	<0.070	<0.070	<0.070	**0.07**
Cd	0.004	0.002	<0.002	0.003	<0.002	0.005	**0.003**
Co	0.029	0.016	0.016	0.02	0.016	0.032	**0.0215**
Ni	0.012	<0.010	<0.010	0.016	0.015	<0.010	**0.0122**
Ba	4.878	0.865	1.854	3.887	1.3	4.704	**2.9147**
W	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	**0.008**
Cr	<0.008	<0.008	<0.008	0.014	<0.008	<0.008	**0.009**
V	0.006	0.006	<0.006	<0.006	<0.006	<0.006	**0.006**
Mn	6.878	1.968	2.329	3.028	3.231	8.187	**4.2702**
Be	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.001**
Sr	0.977	0.508	0.69	1.026	0.518	0.922	**0.7735**
B	0.069	0.076	0.064	0.077	0.057	<0.010	**0.0588**
Se	<0.040	<0.040	<0.040	<0.040	<0.040	0.043	**0.0405**
Ti	0.072	0.004	0.006	0.017	0.004	0.025	**0.0213**
Al	3.113	0.823	5.837	3.348	1.264	3.2	**2.9308**
Ca	546.073	104.578	144.194	417.824	175.848	744.569	**355.51**
Fe	3.926	4.552	3.89	5.99	9.143	9.759	**6.21**
Mg	9.031	8.513	11.82	10.683	11.291	12.242	**10.597**
K	17.483	7.834	6.939	6.108	8.088	20.956	**11.235**
Li	0.011	0.011	0.013	<0.010	<0.010	0.018	**0.0122**
P	<0.060	<0.060	<0.060	0.093	<0.060	<0.060	**0.0655**
Si	14.53	11.316	12.684	12.236	12.561	13.916	**12.874**
Sn	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	**0.02**
Na	12.606	13.47	12.353	12.644	14.368	10.183	**12.604**

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Western Copper Holdings Ltd.
Carmacks Copper Project

Table 5.7
Sequential Extraction of Waste Rock Composite

	Al (mg/kg)	Sb (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Bi (mg/kg)	B (mg/kg)	Cd (mg/kg)	Ca (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Pb (mg/kg)
Leach 1	9.55	<0.040	<0.030	83.35	<0.002	1.86	<0.01	<0.002	1307.50	<0.008	<0.002	1.48	<0.010	<0.040
Leach 2	118.76	<0.0005	0.36	82.22	<0.001	<0.001	0.80	2.36	3031.70	<0.008	0.18	43.62	142.76	5.80
Leach 3	4286.00	<0.04	<0.030	31.29	0.06	<0.07	<0.010	<0.002	3590.30	27.87	2.22	114.93	6035.10	2.37
Leach 4	599.00	<0.04	<0.030	18.02	<0.001	<0.07	<0.010	<0.002	448.21	<0.006	0.59	5.28	1050.90	<0.040
Leach 5	55284.00	<5	8.59	947.98	0.79	<5	395.90	0.14	18626.00	18.616	7.16	10.74	12586.00	8.59

	Mg (mg/kg)	Mn (mg/kg)	Hg (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	K (mg/kg)	Se (mg/kg)	Si (mg/kg)	Ag (mg/kg)	Na (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)
Leach 1	<0.050	14.93	<0.20	<0.005	2.28	<1.0	<0.040	21.34	0.08	171.05	8.29	<0.002	<0.006	59.68
Leach 2	265.12	73.54	0.004	<0.005	0.48	<1.0	<0.040	185.66	<0.001	<0.07	5.88	<0.002	<0.003	2.78
Leach 3	2131.80	103.89	<0.20	0.03	1.65	314.16	1.08	4203.00	0.18	433.95	21.27	69.00	9.45	29.43
Leach 4	424.25	20.66	<0.20	<0.005	<0.01	247.30	<0.040	1086.40	<0.01	129.76	2.31	183.28	2.64	13.33
Leach 5	4163.50	267.07	<3	<1	2.15	7638.30	3.58	4318.90	<1	31860.00	748.29	1981.20	53.70	194.75

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Western Copper Holdings Ltd.
Carmacks Copper Project

Table 5.8

Projected Fate of Nitrogen Losses from Blasting Residues

Location (Powder Factor 0.2 kg/t)	Type of Explosive	Explosives Losses (t/a)	Nitrogen Losses (tN/a)	Reporting to Mill	Reporting to Waste Dump	Reporting to Mine Water
Ore Production 1.76×10^6t/a Total Explosives 0.35×10^6kg/a	AN/FO (83%) 292 t/a Slurry (17%) 60 t/a	AN/FO (1%) 2.92 Slurry (6%) 3.6	AN/FO (33%) 0.96 Slurry (25%) 0.90	(85%) 0.82 (85%) 0.77	--	(15%) 0.14 (15%) 0.13
Waste Production 7.50×10^6t/a Total Explosives 1.50×10^6kg/a	AN/FO (83%) 1245 t/a Slurry (17%) 255 t/a	AN/FO (1%) 12.45 Slurry (6%) 15.30	AN/FO (33%) 4.11 Slurry (25%) 3.83	--	(85%) 3.49 (85%) 3.26	(15%) 0.62 (15%) 0.57
Total Production 9.26×10^6t/a Total Explosives 1.85×10^6t/a	AN/FO (83%) 1537 t/a Slurry (17%) 315 t/a	AN/FO (1%) 15.37 Slurry (6%) 18.9	AN/FO (33%) 5.07 Slurry (25%) 4.73	1.59	6.75	1.46

Western Copper Holdings Ltd.
Williams Creek Project

Table 5.9
ICP Analysis of Raffinate and Neutralized Raffinate

Parameter ppm	Raffinate	Neutralized+ Raffinate	% Reduction in Metals*
Aluminum	574.00	0.22	99.96%
Antimony	0.49	0.05	89.80%
Arsenic	0.12	0.02	83.33%
Barium	0.17	0.09	45.03%
Beryllium	0.13	0.00	99.25%
Boron	<0.05	0.05	0.00%
Cadmium	0.12	0.02	87.70%
Calcium	458.20	529.50	-15.56%
Chromium	0.26	0.01	96.59%
Cobalt	0.96	0.01	99.17%
Copper	1.79	0.04	97.93%
Iron	1274.00	2.92	99.77%
Lead	0.07	<0.02	71.43%
Magnesium	350.50	374.20	-6.76%
Manganese	4.32	2.02	53.24%
Mercury	<0.02	<0.02	0.00%
Molybdenum	0.07	0.02	70.27%
Nickel	0.74	0.02	97.31%
Phosphorous	52.51	8.46	83.89%
Silicon	340.00	0.79	99.77%
Silver	0.02	0.01	61.90%
Sodium	32.00	34.00	-6.25%
Strontium	2.11	0.94	55.47%
Titanium	0.11	0.03	73.45%
Tungsten	0.03	<0.02	33.33%
Vanadium	3.11	0.01	99.74%
Zinc	8.95	0.13	98.51%

*values of < are = for % reduction calculations

+raffinate at pH 1.8 was neutralized with slurried lime under aerated conditions to pH 7.0

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Western Copper Holdings Ltd.
Carmacks Copper Project

Table 5.10
SWEP Testing of Neutralized Raffinate Precipitate

Element (ppm)	Full Head Neutralized Raffinate
Ag	0.013
Cu	<0.010
Pb	<0.04
Zn	0.094
As	<0.030
Sb	<0.04
Hg	<0.020
Mo	0.02
Tl	<0.080
Bi	<0.070
Cd	0.049
Co	0.025
Ni	0.079
Ba	0.018
W	<0.080
Cr	<0.008
V	<0.006
Mn	26.257
Be	<0.001
Sr	3.527
B	<0.010
Se	0.08
Ti	0.019
Al	10.466
Ca	761.589
Fe	0.029
Mg	536.902
K	6.939
Li	0.035
P	0.066
Si	5.85
Sn	<0.020
Na	13.004

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Western Copper Holdings Ltd.
Carmacks Copper Project

Table 5.11
Sequential Extraction of Neutralized Raffinate Precipitate

	Al (mg/kg)	Sb (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Bi (mg/kg)	B (mg/kg)	Cd (mg/kg)	Ca (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Pb (mg/kg)
Leach 1	63.81	<0.040	<0.030	0.26	<0.001	<0.07	<0.01	<0.002	20877.00	<0.008	<0.002	<0.01	<0.010	<0.040
Leach 2	12182.00	<0.0005	0.20	<0.002	<0.001	<0.0005	<0.005	2.42	11763.00	<0.008	10.66	<0.01	2750.60	<0.04
Leach 3	35583.00	<0.04	6.84	<0.002	0.66	<0.07	<0.010	2.31	714.15	13.98	25.68	22.95	32896.00	3.09
Leach 4	14.60	<0.04	<0.030	0.16	<0.001	<0.07	<0.010	<0.002	43.16	<0.006	<0.002	1.28	6.36	<0.04
Leach 5	38.15	<5	<3	<1	<0.1	<5	0.55	0.01	17.02	0.15	0.02	0.64	15.61	0.96

	Mg (mg/kg)	Mn (mg/kg)	Hg (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	K (mg/kg)	Se (mg/kg)	Si (mg/kg)	Ag (mg/kg)	Na (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)
Leach 1	<0.050	203.65	5.820	<0.005	<0.01	<1.000	<0.040	<0.03	0.02	245.04	87.30	0.55	<0.006	0.002
Leach 2	3109.50	319.12	0.004	<0.005	8.80	<1	<0.0005	416.70	<0.001	<0.07	27.86	<0.002	<0.003	87.32
Leach 3	1077.70	331.80	<0.02	1.47	14.70	<1	6.75	1119.70	<0.01	104.25	6.09	107.46	129.48	283.35
Leach 4	1.00	0.28	<0.02	<0.005	<0.01	<1	<0.04	27.80	<0.010	22.24	0.24	1.92	<0.006	1.64
Leach 5	2.92	0.15	<3	<1	0.26	4.92	0.08	<10	<1	5.02	0.34	1.61	0.05	72.80

(\H1811\addend\rafseq.wk3)

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Carmacks Copper Project

Table 5.12

Acid Base Accounting of Foundation Area in the Vicinity of the Heap Leach Pad and Events Pond

Sample Identification	% Sulphur	NP/AP Ratio
DH-C 60-65'	0.02	25.3
DH-C 65-85'	0.02	28.3
DH-E 29'	0.02	61.3
DH-E 40-50'	0.02	38.1
DH-F till 36'	0.02	133.9
TR till 5-2'	0.03	40.6
TR 5-30' bedrock	0.02	27.9
RC 92-01, 0-10	0.02	18.9
RC 92-01, 50-60	0.02	25.1
RC 92-01, 100-110	0.03	18.7
RC 92-01, 150-160	0.02	28.3
RC 92-01, 205-210	0.02	18.1
RC 92-01, 255-265	0.02	27.2
RC 92-09, 55-65	0.02	20.2
RC 92-09, 105-115	0.02	20.8
RC 92-09, 155-165	0.02	29.1
RC 92-09, 205-215	0.02	19.5
RC 92-09, 255-265	0.02	19.2
RC 92-09, 305-315	0.02	27.6
RC 92-09, 305-315 (dup)	0.02	28.7

(\H1811\addend\LPABA.WK3)

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Carmacks Copper Project

Table 5.13
Till Layer ICP Analysis After Acid Leaching

TOTAL METALS	DH-F-TILL.36'	TR-5-2-TILL
AL	<0.20	<0.20
Sb	<0.20	<0.20
As	<0.20	<0.20
Ba	0.254	0.162
Be	<0.005	<0.005
Bi	<0.10	<0.10
B	<0.10	<0.10
Cd	<0.010	<0.010
Ca	325	342
Cr	<0.015	<0.015
Co	<0.015	<0.015
Cu	0.058	0.163
Fe	<0.030	<0.030
Pb	<0.050	<0.050
Li	<0.015	<0.038
Mg	13.4	8.72
Mn	0.204	0.422
Mo	<0.030	<0.030
Ni	<0.020	<1.12
P	<0.30	<0.30
K	8.9	6.2
Se	<0.20	<0.20 -
Si	6.53	6.58
Ag	<0.015	<0.015
Na	18.2	16.8
Sr	0.979	0.788
Tl	<0.10	<0.10
Sn	<0.30	<0.30
Ti	<0.010	<0.010
W	<0.10	<0.49
V	0.030	0.030
Zn	0.084	11.6

(\H1811\Addend\Tbl-Till.doc)

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix H

Baseline Water Quality Data 1989 – 1999

Water Quality Data for Station W-1 (Tributary to Williams Creek) from 1989 to 1992

Parameter	Units	Sample Date						Range	Average	CCME Guidelines Freshwater Aquatic Life*
		Oct-89	Aug-91	Dec-91	May-92	Jul-92	Oct-92			
Physical Parameters										
pH		7.7	7.9	8.1	7.9	7.9	7.5	7.7 - 8.1	7.8333	**6.5 - 9.0**
Conductivity	umho/cm	462	410	450	389	350	475	350 - 475	422.6667	
Total Suspended Solids	mg/L	20	17	100	<5	12	33	BD - 100	30.7500	
Turbidity	NTU	----	3	12	2	1	3	1 - 12	4.2000	
Hardness as $CaCO_3$	mg/L	184.2	208	215	196	180	207	180 - 215	198.3833	
Anions										
Alkalinity as $CaCO_3$	mg/L	53	119	125	115	142	140	53 - 142	115.6667	
Chloride	mg/L	4.7	----	----	----	----	----	4.7	4.7000	
Fluoride	mg/L	3.3	----	----	----	----	----	3.3	3.3000	
Sulphate	mg/L	129	112	102	95	93.9	83.9	83.9 - 129	102.6333	
Nutrients										
Ammonia-Nitrogen	mg/L	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	BD - 0.1	0.0375	**1.04 - 2.33**[1]
Nitrate-Nitrogen	mg/L	<0.1	<0.5	0.6	1.1	<0.2	0.6	BD - 1.1	0.4500	
Nitrite-Nitrogen	mg/L	<0.003	<0.003	<5.0	<0.03	<2.0	<2.0	BD	0.7530	**0.06**
Total Phosphorous	mg/L	----	----	0.05	0.005	0.011	0.049	0.005 - 0.05	0.0288	
Total Metals										
Aluminum	mg/L	0.03	<0.005	----	<0.005	<0.005	0.091	BD - 0.091	0.0257	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	BD	0.0138	
Arsenic	mg/L	<0.02	<0.05	**0.16**	<0.04	<0.04	<0.05	BD - 0.16	0.0433	**0.005**
Barium	mg/L	0.146	0.087	0.186	0.054	0.068	0.385	0.054 - 0.385	0.1543	
Beryllium	mg/L	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	BD	0.0001	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	BD	0.0080	
Boron	mg/L	0.004	----	----	----	----	----	0.004	0.0040	
Cadmium	mg/L	<0.0002	<0.0003	<0.0003	<0.0003	<0.0003	0.0004	BD - 0.0004	0.0002	**0.000017**
Calcium	mg/L	55.3	64.4	63.9	59	59	62	55.3 - 64.4	60.6000	
Chromium	mg/L	**0.0066**	0.002	**0.009**	<0.001	<0.001	0.002	BD	0.0034	**0.001**[2]
Cobalt	mg/L	<0.0005	<0.001	0.002	<0.001	<0.001	0.003	BD - 0.003	0.0011	
Copper	mg/L	<0.0005	<0.001	<0.001	<0.001	<0.001	**0.008**	BD - 0.008	0.0017	**0.002 - 0.004**
Iron	mg/L	0.181	0.038	0.244	0.1	0.099	0.152	0.038 - 0.244	0.1357	**0.3**
Lead	mg/L	<0.002	<0.004	<0.004	<0.004	<0.004	<0.005	BD	0.0019	**0.001 - 0.007**
Lithium	mg/L	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	BD - 0.26	0.0642	
Magnesium	mg/L	11.2	13.7	13.2	14	13.4	14.2	11.2 - 14.2	13.2833	
Manganese	mg/L	<0.001	0.003	0.01	<0.001	<0.001	0.005	BD - 0.01	0.0033	
Mercury	mg/L	<0.005	----	----	----	----	----	BD	0.0025	**0.0001**
Molybdenum	mg/L	0.015	0.021	0.025	0.022	0.015	0.023	0.015 - 0.025	0.0202	**0.073**
Nickel	mg/L	0.0009	<0.001	0.005	<0.001	0.003	0.002	BD - 0.005	0.0020	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	0.02	0.06	0.03	<0.02	0.08	BD - 0.08	0.0375	
Potassium	mg/L	1.1	1.27	1.18	1.22	1.1	1.51	1.1 - 1.51	1.2300	
Selenium	mg/L	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	BD	0.0071	**0.001**
Silicon	mg/L	4.42	7.5	2.7	6.43	8.72	9.52	2.7 - 9.52	6.5483	
Silver	mg/L	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0006	**0.0001**
Sodium	mg/L	4.42	10.9	8.8	9.34	8.91	11.4	4.42 - 11.4	8.9617	
Strontium	mg/L	0.644	0.74	0.62	0.82	0.75	0.75	0.62 - 0.82	0.7207	
Thorium	mg/L	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	BD	0.0058	
Titanium	mg/L	<0.001	<0.001	0.01	0.001	<0.001	<0.001	BD - 0.01	0.0022	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0100	
Vanadium	mg/L	<0.0002	0.0059	<0.0005	<0.001	<0.001	0.015	BD - 0. 015	0.0037	
Zinc	mg/L	**0.0476**	0.008	<0.001	0.005	0.002	0.01	BD - 0.0476	0.0122	**0.03**
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Dissolved Metals										
Aluminum	mg/L	----	<0.005	<0.005	<0.005	<0.005	<0.005	BD	0.0025	
Antimony	mg/L	----	<0.05	<0.05	<0.02	<0.02	<0.02	BD	0.0160	
Arsenic	mg/L	----	<0.05	0.120	<0.04	<0.04	<0.05	BD - 0.120	0.0420	
Barium	mg/L	----	0.057	0.065	0.041	0.066	0.067	0.041 - 0.067	0.0592	
Beryllium	mg/L	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	BD	0.0002	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	BD	0.0080	
Cadmium	mg/L	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	BD	0.0002	
Calcium	mg/L	----	61.80	64.70	57.90	52.80	59.90	52.80 - 64.70	59.4200	
Chromium	mg/L	----	<0.001	0.001	<0.001	<0.001	<0.001	BD	0.0006	
Cobalt	mg/L	----	<0.001	0.001	<0.001	<0.001	0.002	BD - 0.002	0.0009	
Copper	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Iron	mg/L	----	<0.005	0.080	0.080	0.090	<0.004	BD - 0.090	0.0509	
Lead	mg/L	----	<0.004	<0.004	<0.004	<0.004	<0.005	BD	0.0021	
Lithium	mg/L	----	<0.05	<0.05	<0.05	<0.05	<0.05	BD	0.0250	
Magnesium	mg/L	----	13.10	13.00	12.40	11.60	13.90	11.60 - 13.90	12.8000	
Manganese	mg/L	----	0.003	0.003	<0.001	<0.001	0.002	BD - 0.003	0.0018	
Molybdenum	mg/L	----	0.024	0.023	0.019	0.014	0.021	0.014 - 0.024	0.0202	
Nickel	mg/L	----	<0.001	0.002	<0.001	<0.001	<0.001	BD - 0.002	0.0008	
Phosphorous	mg/L	----	<0.02	0.030	0.020	0.020	0.050	BD - 0.050	0.0260	
Potassium	mg/L	----	1.190	1.040	0.990	1.100	1.450	0.990 - 1.450	1.1540	
Selenium	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	BD	0.0080	
Silicon	mg/L	----	6.800	2.600	6.360	8.640	9.470	2.600 - 9.470	6.7740	
Silver	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Sodium	mg/L	----	10.000	9.640	8.260	8.600	10.900	8.260 - 10.900	9.4800	
Strontium	mg/L	----	0.690	0.610	0.730	0.680	0.700	0.610 - 0.730	0.6820	
Thorium	mg/L	----	<0.02	<0.02	<0.005	<0.005	<0.01	BD	0.0060	
Titanium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Uranium	mg/L	----	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0100	
Vanadium	mg/L	----	0.004	<0.0005	<0.001	<0.001	0.015	BD - 0.015	0.0041	
Zinc	mg/L	----	0.006	<0.001	0.002	0.002	0.010	BD - 0.006	0.0041	
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	

Note: < Denotes that sample is below the laboratory detection limit parameter exceeds CCME guidelines for Freshwater Aquatic Life

Average values were calculated using 1/2 the detection limit

[1] Range is based on a average pH of 8.0 and a temperature range of 0 to 1C°C

[2] Based on guideline for Hexavalent chromium (Cr(VI)

BD = Below detection

Water Quality Data for Station W-2 (Williams Creek D/S of W-1 Tributary), W-6 (Williams Creek D/S of South East Tributary) and W-11 (Nancy Lee Creek) from 1989 to 1992

Parameter	Units	Sample Date / Station					Range	Average (W-11)	CCME Guidelines Freshwater Aquatic Life
		W-2	W-6	W-11					
		Oct-89	Oct-89	Dec-91	May-92	Oct-92			
Physical Parameters									
pH		7.7	7.9	8.1	7.4	7.8	7.4 - 8.1	7.7667	**6.5 - 9.0**
Conductivity	umho/cm	431	415	350	84	320	84 - 431	251.3333	
Total Suspended Solids	mg/L	8	<5	<5	8	<5	BD - 8	4.3333	
Turbidity	NTU	----	----	1	5	<1	BD - 5	2.1667	
Hardness as $CaCO_3$	mg/L	133.1	168.6	169	47	151	47 - 169	122.3333	
Anions									
Alkalinity as $CaCO_3$	mg/L	100	140	135	50	143	50 - 143	109.3333	
Chloride	mg/L	3.6	1.3	----	----	----	1.3 - 3.6		
Fluoride	mg/L	1.1	<1	----	----	----	BD - 1.1		
Sulphate	mg/L	76	51	49.2	2.6	29.2	2.6 - 76	27.0000	
Nutrients									
Ammonia-Nitrogen	mg/L	0.06	0.05	<0.05	<0.05	<0.05	BD - 0.06	0.0250	**1.04 - 2.33**[1]
Nitrate-Nitrogen	mg/L	<0.1	<0.1	<0.2	<0.05	<0.2	BD	0.0750	
Nitrite-Nitrogen	mg/L	<0.003	0.003	<2	<0.03	<2.0	BD - 0.003	0.6717	**0.06**
Total Phosphorous	mg/L	----	----	0.01	0.012	0.006	0.006 - 0.012	0.0093	
Total Metals									
Aluminum	mg/L	<0.02	<0.02	<0.005	**0.13**	0.055	BD - 0.13	0.0625	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.005	<0.05	<0.02	<0.02	BD	0.0150	
Arsenic	mg/L	<0.02	<0.02	**0.12**	<0.04	<0.05	BD - 0.12	0.0550	**0.005**
Barium	mg/L	0.035	0.034	0.04	0.016	0.046	0.016 -0.046	0.0340	
Beryllium	mg/L	<0.0001	<0.0001	<0.0005	<0.0002	<0.0002	BD	0.0002	
Bismuth	mg/L	----	----	<0.01	<0.02	<0.02	BD	0.0083	
Boron	mg/L	<0.001	0.002	----	----	----	BD - 0.002		
Cadmium	mg/L	<0.0002	<0.0002	<0.0003	<0.0003	<0.0004	BD	0.0002	**0.000017**
Calcium	mg/L	44.2	43.8	53.9	13.8	42.6	13.8 - 53.9	36.7667	
Chromium	mg/L	<0.0002	0.0012	**0.004**	<0.001	<0.001	BD - 0.004	0.0017	**0.001**[2]
Cobalt	mg/L	<0.0005	<0.0005	<0.001	<0.001	0.002	BD - 0.002	0.0010	
Copper	mg/L	<0.0005	0.001	<0.001	**0.003**	**0.005**	BD - 0.005	0.0028	**0.002 - 0.004**
Iron	mg/L	**0.371**	**0.637**	<0.005	0.161	0.268	BD - 0.637	0.1438	**0.3**
Lead	mg/L	<0.002	<0.002	<0.004	<0.004	<0.005	BD	0.0022	**0.001 - 0.007**
Lithium	mg/L	0.3	0.3	<0.05	<0.05	<0.05	BD - 0.3	0.0250	
Magnesium	mg/L	12.8	13.9	11.3	3.4	11.5	3.4 - 13.9	8.7333	
Manganese	mg/L	0.068	0.101	0.003	0.007	0.083	0.003 - 0.101	0.0310	
Mercury	mg/L	<0.005	<0.005	----	----	----	BD		**0.0001**
Molybdenum	mg/L	0.003	<0.001	<0.05	<0.003	<0.004	BD - 0.003	0.0095	**0.073**
Nickel	mg/L	0.0015	0.0018	0.002	<0.001	<0.02	BD - 0.002	0.0042	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	<0.05	<0.02	<0.02	<0.02	BD	0.0100	
Potassium	mg/L	0.9	0.9	1.13	1.3	1	0.9 - 1.3	1.1433	
Selenium	mg/L	<0.005	<0.005	<0.01	<0.02	<0.02	BD	0.0083	**0.001**
Silicon	mg/L	3.99	5.08	3.6	4.92	10	3.6 -10	6.1733	
Silver	mg/L	<0.002	<0.002	<0.001	<0.001	<0.001	BD	0.0005	**0.0001**
Sodium	mg/L	12.8	14.3	9.29	2.78	9.69	2.78 - 14.3	7.2533	
Strontium	mg/L	0.444	0.426	0.39	0.088	0.33	0.088 - 0.444	0.2693	
Thorium	mg/L	<0.01	<0.01	<0.02	<0.005	<0.01	BD	0.0058	
Titanium	mg/L	<0.001	<0.001	0.002	0.003	<0.001	BD - 0.003	0.0018	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0100	
Vanadium	mg/L	<0.0002	<0.0002	<0.0005	<0.001	0.008	BD - 0.008	0.0029	
Zinc	mg/L	**0.033**	**0.108**	0.004	0.007	0.007	0.004 - 0.108	0.0060	**0.03**
Zirconium	mg/L	----	----	<0.001	<0.001	<0.001	BD	0.0005	
Dissolved Metals									
Aluminum	mg/L			<0.005	0.084	0.05	BD - 0.084	0.0455	
Antimony	mg/L			<0.05	<0.02	<0.02	BD	0.0150	
Arsenic	mg/L			0.1	<0.04	<0.05	BD - 0.1	0.0483	
Barium	mg/L			0.035	0.014	0.045	0.014 - 0.045	0.0313	
Beryllium	mg/L			<0.0005	<0.0002	<0.0002	BD	0.0002	
Bismuth	mg/L			<0.01	<0.02	<0.02	BD	0.0083	
Boron	mg/L			----	----	----			
Cadmium	mg/L			<0.0003	<0.0003	<0.0004	BD	0.0002	
Calcium	mg/L			50.1	13.2	41.4	13.2 - 50.1	34.9000	
Chromium	mg/L			0.003	<0.001	<0.001	BD - 0.003	0.0013	
Cobalt	mg/L			<0.001	<0.001	0.001	BD - 0.001	0.0007	
Copper	mg/L			<0.001	<0.001	0.004	BD - 0.004	0.0017	
Iron	mg/L			----	0.115	0.2	0.115 - 0.2	0.1575	
Lead	mg/L			<0.004	<0.004	<0.005	BD	0.0022	
Lithium	mg/L			<0.05	<0.05	<0.05	BD	0.0250	
Magnesium	mg/L			10.7	3.24	11.4	3.24 - 11.4	8.4467	
Manganese	mg/L			<0.001	<0.001	0.08	BD - 0.08	0.0270	
Mercury	mg/L			----	----	----			
Molybdenum	mg/L			<0.005	<0.003	<0.004	BD	0.0020	
Nickel	mg/L			0.002	<0.001	0.003	BD - 0.003	0.0018	
Phosphorous	mg/L			<0.02	<0.02	<0.02	BD	0.0100	
Potassium	mg/L			0.92	1.19	0.99	0.92 - 1.19	1.0333	
Selenium	mg/L			<0.01	<0.02	<0.02	BD	0.0083	
Silicon	mg/L			3.3	4.47	9.6	3.3 - 9.6	5.7900	
Silver	mg/L			<0.001	<0.001	<0.001	BD	0.0005	
Sodium	mg/L			8.24	2.74	9.6	2.74 - 9.6	6.8600	
Strontium	mg/L			0.37	0.084	0.33	0.084 - 0.37	0.2613	
Thorium	mg/L			<0.02	<0.005	<0.01	BD	0.0058	
Titanium	mg/L			<0.001	0.001	<0.001	BD - 0.001	0.0007	
Uranium	mg/L			<0.02	<0.02	<0.02	BD	0.0100	
Vanadium	mg/L			<0.0005	<0.001	0.006	BD - 0.006	0.0023	
Zinc	mg/L			<0.001	0.003	0.006	BD - 0.006	0.0032	
Zirconium	mg/L			<0.001	<0.001	<0.001	BD	0.0005	

Note: < Denotes that sample is below the laboratory detection limit ☐ parameter exceeds CCME guidelines for Freshwater Aquatic Life

Average values were calculated using 1/2 the detection limit

[1] Range is based on a average pH of 8.0 and a temperature range of 0 to 1^{o}C

[2] Based on guideline for Hexavalent chromium (Cr(VI))

BD = Below Detection

Water Quality Data for Station W-3 (Tributary to Williams Creek, from WRSA) from 1989 to 1997

Parameter	Units	Sample Date							Range	Average	CCME Guidelines Freshwater Aquatic Life
		Oct-89	Aug-91	May-92	Jul-92	Oct-92	May-94	Sep-97			
In-Situ Parameters											
pH		----	----	----	----	----	----	7.4	7.4	7.4000	**6.5 - 9.0**
Conductivity	umho/cm	----	----	----	----	----	----	200	200	200.0000	
Physical Parameters											
pH		7.5	8.2	7.9	7.5	7.4	7.7	7.35	7.35 - 8.2	7.6500	
Conductivity	umho/cm	380	263	114	210	340	240	216	114 - 380	251.8571	
Total Suspended Solids	mg/L	<5	<5	<5	<5	<5	<5	2	BD - 2	2.4286	
Total Dissolved Solids	mg/L	----	----	----	----	----	188	----	188.0	188.0000	
Turbidity	NTU	----	<1	1	1	<1	1	----	BD - 1	0.8000	
Hardness as $CaCO_3$	mg/L	167.4	150	50.3	109	162	107.5	129	50.3 - 167.4	125.0286	
Anions											
Alkalinity as $CaCO_3$	mg/L	130	153	57	152	160	112	159	57 - 160	131.8571	
Hydroxide as $CaCO_3$	mg/L	----	----	----	----	----	<5	<1	BD	1.5000	
Carbonate as $CaCO_3$	mg/L	----	----	----	----	----	<5	<1	BD	1.5000	
Bicarbonate as $CaCO_3$	mg/L	----	----	----	----	----	112	159	112 - 159	135.5000	
Chloride	mg/L	2.8	----	----	----	----	0.83	1.4	0.83 - 2.8	1.6767	
Fluoride	mg/L	<1	----	----	----	----	<1	0.18	BD - 0.18	0.3933	
Sulphate	mg/L	21	8.1	3.6	9.5	16.8	14	20	3.6 - 21	13.2857	
Nutrients											
Ammonia-Nitrogen	mg/L	0.08	<0.05	<0.05	<0.05	0.07	<0.05	----	BD - 0.08	0.0417	**1.04 - 2.33**[1]
Nitrate-Nitrogen	mg/L	<0.1	<0.1	<0.05	<0.2	<0.2	<0.05	0.017	BD - 0.017	0.0524	
Nitrite-Nitrogen	mg/L	<0.003	<0.003	<0.03	<2.0	<2	<0.5	0.001	BD - 0.001	0.3241	**0.06**
Total Phosphorous	mg/L	----	----	0.02	0.013	0.01	0.008	----	0.008 - 0.02	0.0128	
Total Metals											
Aluminum	mg/L	<0.02	<0.005	0.091	0.067	0.03	0.04	**0.197**	BD - 0.197	0.0625	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.05	<0.02	<0.02	<0.02	<0.02	0.00006	BD - 0.00006	0.0097	
Arsenic	mg/L	<0.02	<0.05	<0.04	<0.04	<0.05	<0.02	0.0007	BD - 0.0007	0.0158	**0.005**
Barium	mg/L	0.037	0.051	0.019	0.038	0.092	0.04	0.0429	0.019 - 0.092	0.0457	
Beryllium	mg/L	<0.0001	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	BD	0.0001	
Bismuth	mg/L	----	<0.01	<0.02	<0.02	<0.02	<0.02	<0.0005	BD	0.0075	
Boron	mg/L	<0.001	----	----	----	----	----	0.003	BD - 0.003	0.0018	
Cadmium	mg/L	<0.0002	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.00005	BD	0.0001	**0.000017**
Calcium	mg/L	52.4	48.3	15	39.8	53.3	33.9	51.6	15 - 53.3	42.0429	
Chromium	mg/L	**0.0024**	**0.009**	<0.001	<0.001	<0.001	<0.001	<0.0005	BD - 0.0024	0.0020	**0.001**[2]
Cobalt	mg/L	<0.0005	<0.001	<0.001	<0.001	0.002	<0.001	0.0002	BD - 0.0002	0.0006	
Copper	mg/L	<0.0005	<0.001	<0.001	**0.009**	**0.013**	**0.028**	0.0017	BD - 0.028	0.0076	**0.002 - 0.004**
Iron	mg/L	0.084	0.088	0.171	0.172	0.261	**0.38**	**0.6**	0.084 - 0.6	0.2509	**0.3**
Lead	mg/L	<0.002	<0.004	<0.004	<0.004	<0.005	<0.01	0.00015	BD - 0.00015	0.0021	**0.001 - 0.007**
Lithium	mg/L	0.34	<0.05	<0.05	<0.05	<0.05	<0.002	<0.001	BD - 0.34	0.0631	
Magnesium	mg/L	8.89	8.74	3.56	7.3	11.1	6	9.27	3.56 - 11.1	7.8371	
Manganese	mg/L	0.57	0.004	0.004	0.159	0.361	0.124	0.293	0.004 - 0.57	0.2164	
Mercury	mg/L	<0.005	----	----	----	----	----	<0.00005	BD	0.0013	**0.0001**
Molybdenum	mg/L	<0.001	<0.005	<0.003	<0.003	<0.004	<0.005	0.00087	BD - 0.00087	0.0016	**0.073**
Nickel	mg/L	0.0009	<0.001	<0.001	0.005	0.006	0.005	0.0014	BD - 0.006	0.0028	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	<0.02	0.03	0.03	0.03	<0.05	<0.3	BD - 0.03	0.0429	
Potassium	mg/L	0.8	0.38	1.26	0.69	0.96	1.4	<2	BD - 1.4	0.9271	
Selenium	mg/L	<0.005	<0.01	<0.02	<0.02	<0.02	<0.02	<0.001	BD	0.0069	**0.001**
Silicon	mg/L	4.33	13	5.19	10.2	12.6	6.23	8.16	4.33 - 13	8.5300	
Silver	mg/L	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00001	BD	0.0005	**0.0001**
Sodium	mg/L	7.32	8.06	2.36	6.44	8.51	5.41	8	2.36 - 8.51	6.5857	
Strontium	mg/L	0.481	0.27	0.11	0.36	0.46	0.235	0.383	0.11 - 0.481	0.3284	
Sulfur	mg/L	----	----	----	----	----	3.92	----	3.92	3.9200	
Tin	mg/L	----	----	----	----	----	<0.01	<0.0001	BD	0.0025	
Thallium	mg/L	----	----	----	----	----	----	<0.00005	BD	0.0000	**0.0008**
Thorium	mg/L	<0.01	<0.02	<0.005	<0.005	<0.01	<0.01	----	BD	0.0050	
Titanium	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	0.005	<0.01	BD - 0.005	0.0020	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	0.00028	BD - 0.00028	0.0115	
Vanadium	mg/L	<0.0002	0.0032	<0.001	<0.001	0.006	<0.002	0.001	BD - 0.006	0.0018	
Zinc	mg/L	**0.0523**	0.002	0.005	0.004	0.009	<0.005	0.002	BD - 0.0523	0.0110	**0.03**
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	----	BD	0.0005	
Dissolved Metals											
Aluminum	mg/L	----	<0.005	0.046	0.066	<0.005	<0.01	0.011	BD - 0.066	0.0222	
Antimony	mg/L	----	<0.05	<0.02	<0.02	<0.02	<0.02	0.0001	BD - 0.0001	0.0109	
Arsenic	mg/L	----	<0.05	<0.04	<0.04	<0.05	<0.02	0.0005	BD - 0.0005	0.0168	
Barium	mg/L	----	0.05	0.017	0.036	0.046	0.039	0.0377	0.017 - 0.05	0.0376	
Beryllium	mg/L	----	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	BD	0.0002	
Bismuth	mg/L	----	<0.01	<0.02	<0.02	<0.02	<0.02	<0.0005	BD	0.0075	
Boron	mg/L	----	----	----	----	----	----	0.002	0.002	0.0020	
Cadmium	mg/L	----	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.00005	BD	0.0002	
Calcium	mg/L	----	45.8	14.4	33.6	46	33.9	49.2	14.4 - 49.2	37.1500	
Chromium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005	BD	0.0005	
Cobalt	mg/L	----	<0.001	<0.001	<0.001	0.002	<0.001	0.0001	BD - 0.002	0.0007	
Copper	mg/L	----	<0.001	<0.001	<0.001	0.002	0.023	0.0015	BD - 0.023	0.0047	
Iron	mg/L	----	0.064	0.11	0.11	0.26	0.16	0.07	0.064 - 0.26	0.1290	
Lead	mg/L	----	<0.004	<0.004	<0.004	<0.005	<0.01	<0.00005	BD	0.0023	
Lithium	mg/L	----	<0.05	<0.05	<0.05	<0.05	<0.002	<0.001	BD	0.0169	
Magnesium	mg/L	----	8.6	3.4	5.9	11.2	5.96	8.67	3.4 - 11.2	7.2883	
Manganese	mg/L	----	0.004	0.002	0.154	0.36	0.097	0.305	0.002 - 0.305	0.1537	
Molybdenum	mg/L	----	<0.005	<0.003	<0.003	<0.004	<0.005	0.00107	BD - 0.00107	0.0018	
Nickel	mg/L	----	<0.001	<0.001	0.003	0.003	0.005	0.0012	BD - 0.005	0.0022	
Phosphorous	mg/L	----	<0.02	0.02	<0.02	0.02	<0.05	<0.3	BD - 0.02	0.0392	
Potassium	mg/L	----	0.34	1.1	0.7	0.91	1.4	<2	BD - 1.4	0.9083	
Selenium	mg/L	----	<0.01	<0.02	<0.02	<0.02	<0.02	<0.001	BD	0.0076	
Silicon	mg/L	----	9	5.08	7.9	9	6.17	8.12	5.08 - 9	7.5450	
Silver	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00001	BD	0.0004	
Sodium	mg/L	----	7.42	2.33	6.16	8.01	5.37	7	2.33 - 8.01	6.0483	
Strontium	mg/L	----	0.26	0.1	0.31	0.4	0.248	0.322	0.1 - 0.4	0.2733	
Sulfur	mg/L	----	----	----	----	----	3.93	----	3.93	3.9300	
Tin	mg/L	----	----	----	----	----	<0.01	<0.0001	BD	0.0025	
Thallium	mg/L	----	----	----	----	----		<0.00005	BD	0.0000	
Thorium	mg/L	----	<0.02	<0.005	<0.005	<0.01	<0.01	----	BD	0.0050	
Titanium	mg/L	----	<0.001	<0.001	<0.001	<0.001	0.002	<0.01	BD - 0.002	0.0015	
Uranium	mg/L	----	<0.02	<0.02	<0.02	<0.02	<0.06	0.00031	BD - 0.00031	0.0117	
Vanadium	mg/L	----	0.0016	<0.001	<0.001	0.006	<0.002	<0.001	BD - 0.006	0.0017	
Zinc	mg/L	----	0.002	0.003	0.002	0.008	<0.005	0.001	BD - 0.008	0.0031	
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	----	BD	0.0005	

Note: < Denotes that sample is below the laboratory detection limit

parameter exceeds CCME guidelines for Freshwater Aquatic Life

Average values were calculated using 1/2 the detection limit

[1] Range is based on a average pH of 8.0 and a temperature range of 0 to 10 °C

[2] Based on guideline for Hexavalent chromium (Cr(VI))

BD = Below Detection

Water Quality Data for Station W-4 (Williams Creek D.S of Confluence with W-3 Tributary) from 1989 to 1997

Parameter	Units	Sample Date								Range	Average	CCME Guidelines Freshwater Aquatic Life
		Oct-89	Aug-91	Dec-91	May-92	Jul-92	Oct-92	May-94	Sep-97			
In-Situ Parameters												
pH		----	----	----	----	----	----	----	7.8	7.8	7.8000	**6.5 - 9.0**
Conductivity	umho/cm	----	----	----	----	----	----	----	160	160	160.0000	
Physical Parameters												
pH		7.7	8	8.1	7.4	7.8	7.5	7.8	7.71	7.4 - 8.1	7.7513	
Conductivity	umho/cm	395	210	465	98	210	370	207	178	98 - 465	266.6250	
Total Suspended Solids	mg/L	<5	37	<5	253	258	<5	<5	3	BD - 258	70.1250	
Total Dissolved Solids	mg/L	----	----	----	----	----	----	179	----	179.0	179.0000	
Turbidity	NTU	----	4	1	14	25	1	2	----	1 - 25	7.8333	
Hardness as $CaCO_3$	mg/L	145.1	111	216	28.3	103	159	85.6	129	85.6 - 216	122.1250	
Anions												
Alkalinity as $CaCO_3$	mg/L	120	103	169	28	94	125	79	111	28 - 169	103.6250	
Hydroxide as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	<1	BD	1.5000	
Carbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	<1	BD	1.5000	
Bicarbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	79	111	79 - 111	95.0000	
Chloride	mg/L	3.6	----	----	----	----	----	0.78	1.3	0.78 - 3.6	1.8933	
Fluoride	mg/L	<1	----	----	----	----	----	<1	0.2	BD - 0.2	0.4000	
Sulphate	mg/L	47	20.7	80.6	3.5	8.9	59.8	18.6	24	3.5 - 80.6	32.8875	
Nutrients												
Ammonia-Nitrogen	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.07	----	BD - 0.07	0.0364	**1.04 - 2.33**[1]
Nitrate-Nitrogen	mg/L	<0.1	<0.1	<0.5	0.05	<0.1	<0.02	<0.05	<0.005	BD - 0.05	0.0609	
Nitrite-Nitrogen	mg/L	<0.0003	<0.003	<5	<0.03	<1	<2.0	<0.5	0.001	BD - 0.001	0.5335	**0.06**
Total Phosphorous	mg/L	----	----	0.032	0.018	0.173	0.017	0.04	----	0.017 - 0.173	0.0560	
Total Metals												
Aluminum	mg/L	<0.02	**0.154**	<0.005	**2.75**	**3.89**	0.036	0.03	0.033	BD - 3.89	0.8632	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	0.00006	BD - 0.00006	0.0116	
Arsenic	mg/L	<0.02	<0.05	**0.12**	<0.04	<0.04	<0.05	<0.02	0.0006	BD - 0.12	0.0288	**0.005**
Barium	mg/L	0.031	0.049	0.057	0.078	0.11	0.175	0.03	0.0354	0.03 - 0.175	0.0707	
Beryllium	mg/L	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	BD	0.0002	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.0005	BD	0.0072	
Boron	mg/L	<0.001	----	----	----	----	----	----	0.004	BD - 0.004	0.0023	
Cadmium	mg/L	<0.0002	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.00005	BD	0.0001	**0.000017**
Calcium	mg/L	40.5	32.7	63.4	15.6	27.7	46.4	25	35.9	15.6 - 63.4	35.9000	
Chromium	mg/L	<0.0002	**0.012**	**0.006**	0.002	**0.006**	0.002	<0.001	<0.0005	BD - 0.012	0.0036	**0.001**[2]
Cobalt	mg/L	<0.0005	<0.001	0.002	0.003	0.002	0.003	<0.001	0.0002	BD - 0.003	0.0014	
Copper	mg/L	<0.0005	<0.001	<0.001	**0.01**	**0.014**	**0.008**	**0.016**	0.0011	BD - 0.016	0.0063	**0.002 - 0.004**
Iron	mg/L	**0.519**	**1.11**	**0.349**	**3.68**	**6.6**	**0.709**	**0.39**	**0.48**	0.349 - 6.6	1.7296	**0.3**
Lead	mg/L	<0.002	<0.004	<0.004	<0.004	**0.005**	<0.005	<0.01	<0.00005	BD - 0.005	0.0024	**0.001 - 0.007**
Lithium	mg/L	0.35	<0.05	<0.05	<0.05	<0.05	<0.05	<0.002	<0.001	BD - 0.35	0.0596	
Magnesium	mg/L	10.7	8.47	16.1	5.2	7.7	13	6.5	9.5	5.2 - 16.1	9.6463	
Manganese	mg/L	0.077	0.058	0.1	0.136	0.191	0.166	0.069	0.0477	0.0477 - 0.191	0.1056	
Mercury	mg/L	<0.005	----	----	----	----	----	----	<0.00005	BD	0.0013	**0.0001**
Molybdenum	mg/L	<0.001	<0.005	0.01	<0.003	<0.003	<0.004	<0.005	0.00242	BD - 0.01	0.0029	**0.073**
Nickel	mg/L	0.0014	0.002	0.005	<0.001	0.014	0.005	0.003	0.001	BD - 0.005	0.0040	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	0.05	0.04	0.03	0.2	0.03	<0.05	<0.3	BD - 0.2	0.0688	
Potassium	mg/L	0.8	0.48	1.14	1.41	1	0.95	1	<2	BD - 1.41	0.9725	
Selenium	mg/L	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.001	BD	0.0066	**0.001**
Silicon	mg/L	4.86	13.4	5.5	9.71	16.3	11	5.1	8.54	4.86 - 16.3	9.3013	
Silver	mg/L	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00001	BD	0.0005	**0.0001**
Sodium	mg/L	11.2	9.93	14.9	2.77	6.58	12.6	6.58	9	2.77 - 14.9	9.1950	
Strontium	mg/L	0.372	0.26	0.42	0.142	0.24	0.4	0.229	0.273	0.142 - 0.42	0.2920	
Sulfur	mg/L	----	----	----	----	----	----	5.39	----	5.39	5.3900	
Tin	mg/L	----	----	----	----	----	----	<0.01	<0.0001	BD	0.0025	
Thallium	mg/L	----	----	----	----	----	----	----	<0.00005	BD	0.0000	**0.0008**
Thorium	mg/L	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01		BD	0.0057	
Titanium	mg/L	<0.001	0.016	0.002	0.146	0.192	<0.001	0.002	<0.01	BD - 0.192	0.0455	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	0.00031	BD - 0.00031	0.0113	
Vanadium	mg/L	<0.0002	0.0049	<0.0005	<0.001	0.016	0.01	<0.002	<0.001	BD - 0.016	0.0042	
Zinc	mg/L	**0.0578**	0.004	<0.001	0.019	0.018	0.008	<0.005	0.003	BD - 0.0578	0.0141	**0.03**
Zirconium	mg/L	----	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	----	BD - 0.002	0.0008	
Dissolved Metals												
Aluminum	mg/L	----	0.007	<0.005	0.03	0.043	0.018	<0.01	0.021	BD - 0.043	0.0181	
Antimony	mg/L	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	0.00006	BD - 0.00006	0.0129	
Arsenic	mg/L	----	<0.05	0.11	<0.04	<0.04	<0.05	<0.02	0.0006	BD - 0.11	0.0301	
Barium	mg/L	----	0.04	0.053	0.01	0.041	0.054	0.03	0.0343	0.01 - 0.054	0.0375	
Beryllium	mg/L	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	BD	0.0002	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.0005	BD	0.0072	
Boron	mg/L	----	----	----	----	----	----	----	0.004	0.004	0.0040	
Cadmium	mg/L	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.00005	BD	0.0002	
Calcium	mg/L	----	30.7	61.3	7.49	27.3	43.4	24.5	35.9	7.49 - 61.3	32.9414	
Chromium	mg/L	----	0.002	0.004	<0.001	<0.001	<0.001	<0.001	<0.0005	BD - 0.004	0.0012	
Cobalt	mg/L	----	<0.001	0.002	<0.001	<0.001	0.003	<0.001	0.0003	BD - 0.003	0.0010	
Copper	mg/L	----	<0.001	<0.001	<0.001	<0.001	0.002	0.021	0.0011	BD - 0.021	0.0037	
Iron	mg/L	----	0.472	0.252	0.12	0.396	0.628	0.245	0.34	0.12 - 0.628	0.3504	
Lead	mg/L	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.01	<0.00005	BD	0.0022	
Lithium	mg/L	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.002	<0.001	BD	0.0181	
Magnesium	mg/L	----	8.11	15.3	2.24	7.66	12	6.43	9.63	2.24 - 15.3	8.7671	
Manganese	mg/L	----	0.037	0.098	0.014	0.033	0.165	0.068	0.0351	0.014 - 0.165	0.0643	
Molybdenum	mg/L	----	<0.005	0.009	<0.003	<0.003	<0.004	<0.005	0.00239	BD - 0.009	0.0031	
Nickel	mg/L	----	<0.001	0.004	<0.001	0.002	0.004	0.004	0.0011	BD - 0.004	0.0023	
Phosphorous	mg/L	----	0.03	0.02	0.02	0.03	0.02	<0.05	<0.3	BD - 0.03	0.0421	
Potassium	mg/L	----	0.48	0.97	0.61	0.54	0.99	1.2	<2	BD - 1.2	0.8271	
Selenium	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.001	BD	0.0072	
Silicon	mg/L	----	10.5	4.8	2.73	14	10	5.09	8.64	2.73 - 14	7.9657	
Silver	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00001	BD	0.0004	
Sodium	mg/L	----	9.2	13.8	1.74	6.37	12.5	6.55	9	1.74 - 13.8	8.4514	
Strontium	mg/L	----	0.26	0.41	0.063	0.24	0.36	0.229	0.279	0.063 - 0.41	0.2630	
Sulfur	mg/L	----	----	----	----	----	----	5.39	----	5.39	5.3900	
Tin	mg/L	----	----	----	----	----	----	<0.01	<0.0001	BD	0.0025	
Thallium	mg/L	----	----	----	----	----	----	----	<0.00005	BD	0.0000	
Thorium	mg/L	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	----	BD	0.0058	
Titanium	mg/L	----	0.002	<0.001	<0.001	0.002	<0.001	0.002	<0.01	BD - 0.002	0.0018	
Uranium	mg/L	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	0.00031	BD - 0.00031	0.0115	
Vanadium	mg/L	----	0.003	<0.0005	<0.001	<0.001	0.014	<0.002	<0.001	BD - 0.014	0.0028	
Zinc	mg/L	----	0.003	<0.001	0.004	0.007	0.008	<0.005	0.002	BD - 0.008	0.0039	
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	BD	0.0005	

Note: < Denotes that sample is below the laboratory detection limit

Average values were calculated using 1/2 the detection limit

[1] Range is based on a average pH of 8.0 and a temperature range of 0 to 10 °C

[2] Based on guideline for Hexavalent chromium (Cr(VI))

BD = Below Detection

Bold = parameter exceeds CCME guidelines for Freshwater Aquatic Life

Water Quality Data for Station W-5 (South East Tributary to Williams Creek) from 1989 to 1994

Parameter	Units	Sample Date							Range	Average	CCME Guidelines Freshwater Aquatic Life
		Oct-89	Aug-91	Dec-91	May-92	Jul-92	Oct-92	May-94			
			dupl.								
Physical Parameters											
pH		7.5	7.2	8.1	7.2	7.2	7.5	7.8	7.2 - 8.1	7.5000	**6.5 - 9.0**
Conductivity	umho/cm	157	91	280	91	89	228	135	89 - 280	153.0000	
Total Suspended Solids	mg/L	<5	1825	34	103	800	<5	6	BD - 1825	396.1429	
TotalDissolved Solids	mg/L	----	----	----	----	----	----	129	129.0	129.0000	
Turbidity	NTU	----	120	17	11	27	3	2	2 - 120	30.0000	
Hardness as $CaCO_3$	mg/L	84	51.8	139	38	135	93.7	52.8	38 - 139	84.9000	
Anions											
Alkalinity as $CaCO_3$	mg/L	88	58	145	44	66	100	112	44 - 145	87.5714	
Hydroxide as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	BD	2.5000	
Carbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	BD	2.5000	
Bicarbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	112	112.0	112.0000	
Chloride	mg/L	1.01	----	----	----	----	----	0.59	0.59 - 1.01	0.8000	
Fluoride	mg/L	<1	----	----	----	----	----	<1	BD	0.5000	
Sulphate	mg/L	3.29	3.2	3.8	2	2.7	9.4	11.6	2 - 11.6	5.1414	
Nutrients											
Ammonia-Nitrogen	mg/L	<0.05	0.08	<0.05	<0.05	0.11	0.2	<0.05	BD - 0.2	0.0700	**1.04 - 2.33**[1]
Nitrate-Nitrogen	mg/L	<0.1	<0.05	<0.2	<0.05	<0.03	<0.2	<0.05	BD	0.0486	
Nitrite-Nitrogen	mg/L	<0.003	0.003	<2.0	<0.03	<0.05	<2.0	<0.5	BD - 0.003	0.3278	**0.06**
Total Phosphorous	mg/L	----	----	0.132	0.022	0.24	0.027	0.009	0.009 - 0.24	0.0860	
Total Metals											
Aluminum	mg/L	<0.02	**9.58**	<0.005	**1.71**	**8.02**	0.037	**0.25**	BD - 9.58	2.8014	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	BD	0.0132	
Arsenic	mg/L	<0.02	**0.11**	**0.11**	0.04	<0.04	<0.05	<0.02	BD - 0.11	0.0464	**0.005**
Barium	mg/L	0.013	0.455	0.035	0.051	0.239	0.037	0.024	0.013 - 0.455	0.1220	
Beryllium	mg/L	<0.0001	0.00065	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	BD - 0.00065	0.0002	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	BD	0.0083	
Boron	mg/L	<0.001	----	----	----	----	----	----	BD	0.0005	
Cadmium	mg/L	<0.0002	**0.0006**	<0.0003	<0.0003	<0.0003	0.0004	<0.0005	BD - 0.0006	0.0003	**0.000017**
Calcium	mg/L	18.8	29.5	39.6	13.1	25.3	30.3	15.2	13.1 - 39.6	24.5429	
Chromium	mg/L	0.0016	**0.05**	**0.007**	<0.001	**0.014**	0.002	0.001	BD - 0.05	0.0109	**0.001**[2]
Cobalt	mg/L	<0.0005	0.016	0.001	<0.001	0.007	0.003	<0.001	BD - 0.016	0.0040	
Copper	mg/L	<0.0005	**0.059**	<0.001	**0.007**	**0.034**	**0.004**	**0.023**	BD - 0.059	0.0183	**0.002 - 0.004**
Iron	mg/L	**0.458**	**31.4**	**1.48**	**2.2**	**14.4**	**0.664**	**0.447**	0.447 - 31.4	7.2927	**0.3**
Lead	mg/L	<0.002	**0.015**	<0.004	<0.004	**0.009**	<0.005	<0.01	BD - 0.015	0.0052	**0.001 - 0.007**
Lithium	mg/L	0.36	<0.05	<0.05	<0.05	<0.05	<0.05	<0.002	BD - 0.36	0.0694	
Magnesium	mg/L	4.16	8.95	10.1	4.09	6.9	7.62	3.55	3.55 - 10.1	6.4814	
Manganese	mg/L	0.046	0.62	0.191	0.098	0.419	0.304	0.014	0.014 - 0.62	0.2417	
Mercury	mg/L	<0.005	----	----	----	----	----	----	BD	0.0025	**0.0001**
Molybdenum	mg/L	<0.001	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005	BD	0.0019	**0.073**
Nickel	mg/L	0.0029	**0.04**	0.007	<0.001	0.025	0.004	0.002	BD - 0.04	0.0116	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	1.64	0.16	0.08	0.82	0.03	<0.05	BD - 1.64	0.3971	
Potassium	mg/L	<0.2	3.28	1.65	1.61	1.21	0.52	1.2	BD - 3.28	1.3671	
Selenium	mg/L	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	BD	0.0075	**0.001**
Silicon	mg/L	5.53	19.8	5.9	7.84	22.2	13	5.26	5.26 - 22.2	11.3614	
Silver	mg/L	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0006	**0.0001**
Sodium	mg/L	5.57	6.56	9.7	2.85	6.28	8.65	5.25	2.85 - 9.7	6.4086	
Strontium	mg/L	0.089	0.22	0.159	0.083	0.15	0.157	0.086	0.083 - 0.22	0.1349	
Sulfur	mg/L	----	----	----	----	----	----	2.99	2.99	2.9900	
Tin	mg/L	----	----	----	----	----	----	<0.01	BD	0.0050	
Thorium	mg/L	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	BD	0.0057	
Titanium	mg/L	<0.001	1.07	0.005	0.084	0.364	<0.001	0.016	BD - 1.07	0.2200	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	BD	0.0129	
Vanadium	mg/L	<0.0002	0.126	<0.0005	0.008	0.043	0.007	<0.002	BD - 0.126	0.0265	
Zinc	mg/L	**0.0661**	**0.072**	0.004	0.015	**0.043**	0.01	<0.005	BD - 0.072	0.0304	**0.03**
Zirconium	mg/L	----	0.005	<0.001	<0.001	0.003	<0.001	<0.001	BD - 0.005	0.0017	
Dissolved Metals											
Aluminum	mg/L	----	0.037	<0.005	0.058	0.06	0.034	0.01	BD - 0.06	0.0336	
Antimony	mg/L	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	BD	0.0150	
Arsenic	mg/L	----	<0.05	0.09	<0.04	<0.04	<0.05	<0.02	BD - 0.09	0.0317	
Barium	mg/L	----	0.037	0.032	0.017	0.041	0.031	0.023	0.017 - 0.041	0.0302	
Beryllium	mg/L	----	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	BD	0.0002	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	BD	0.0083	
Cadmium	mg/L	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	BD	0.0002	
Calcium	mg/L	----	23.7	39.4	10	19	26.1	15.1	10 - 39.4	22.2167	
Chromium	mg/L	----	0.007	0.006	<0.001	<0.001	<0.001	<0.001	BD - 0.007	0.0025	
Cobalt	mg/L	----	0.001	0.001	<0.001	<0.001	0.003	<0.001	BD - 0.003	0.0011	
Copper	mg/L	----	0.001	<0.001	0.006	<0.001	0.001	0.009	BD - 0.009	0.0030	
Iron	mg/L	----	0.987	0.748	0.392	0.63	0.322	0.076	0.322 - 0.987	0.5258	
Lead	mg/L	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.01	BD	0.0026	
Lithium	mg/L	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.002	BD	0.0210	
Magnesium	mg/L	----	5.82	9.83	2.88	4.37	6.6	3.51	2.88 - 9.83	5.5017	
Manganese	mg/L	----	0.142	0.224	0.053	0.194	0.271	0.007	0.007 - 0.271	0.1485	
Molybdenum	mg/L	----	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005	BD	0.0021	
Nickel	mg/L	----	0.0045	0.005	<0.001	0.002	0.003	0.004	BD - 0.005	0.0032	
Phosphorous	mg/L	----	<0.02	0.11	0.03	0.03	0.03	<0.05	BD - 0.11	0.0392	
Potassium	mg/L	----	0.23	1.25	1.12	0.28	0.5	1.1	0.23 - 1.25	0.7467	
Selenium	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	BD	0.0083	
Silicon	mg/L	----	10.6	5.5	4.3	14.3	11.4	4.97	4.3 - 14.3	8.5117	
Silver	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Sodium	mg/L	----	5.38	7.95	2.47	5.44	6.96	5.22	2.47 - 7.95	5.5700	
Strontium	mg/L	----	0.074	0.156	0.06	0.11	0.136	0.085	0.06 - 156	0.1035	
Sulfur	mg/L	----	----	----	----	----	----	3.08	3.08	3.0800	
Tin	mg/L	----	----	----	----	----	----	<0.01	BD	0.0050	
Thorium	mg/L	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	BD	0.0058	
Titanium	mg/L	----	0.003	0.003	<0.001	0.002	<0.001	0.002	BD - 0.003	0.0018	
Uranium	mg/L	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	BD	0.0133	
Vanadium	mg/L	----	0.004	<0.0005	0.001	<0.001	0.006	<0.002	BD - 0.006	0.0021	
Zinc	mg/L	----	0.004	<0.001	0.008	0.005	0.008	0.008	BD - 0.008	0.0056	
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	

Note: < Denotes that sample is below the laboratory detection limit
Average values were calculated using 1/2 the detection limit

[1] Range is based on a average pH of 8.0 and a temperature range of 0 to 10°C
[2] Based on guideline for Hexavalent chromium (Cr(VI))
BD = Below Detection

parameter exceeds CCME guidelines for Freshwater Aquatic Life

Water Quality Data for Station W-7 (WRSA Tributary Near Road, U/S of W-3) from 1989 to 1994

Parameter	Units	Sample Date								Range	Average	CCME Guidelines Freshwater Aquatic Life
		Oct-89	Aug-91	Dec-91	May-92	Jul-92	Oct-92	May-94	May-94 (DUP)			
Physical Parameters												
pH		7.7	7.6	7.3	7.4	7.6	7.5	7.7	7.7	7.3 - 7.7	7.5625	**6.5 - 9.0**
Conductivity	umho/cm	325	192	435	81	166	345	145	143	81 - 435	229.0000	
Total Suspended Solids	mg/L	<5	<5	23	<5	<5	<5	<5	<5	BD - 23	5.0625	
Total Dissolved Solids	mg/L	----	----	----	----	----	----	145	147	145	146.0000	
Turbidity	NTU	----	1	6	2	4	<1	1	1	BD - 6	2.2143	
Hardness as $CaCO_3$	mg/L	123.6	114	188	39.4	122	158	62.2	62.6	39.4 - 188	108.7250	
Anions												
Alkalinity as $CaCO_3$	mg/L	120	111	230	41	110	141	73	74	41 - 230	112.5000	
Hydroxide as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	<5	BD	2.5000	
Carbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	<5	BD	2.5000	
Bicarbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	73	74	73 - 74	73.5000	
Chloride	mg/L	2.6	----	----	----	----	----	<0.3	<0.3	BD - 2.6	0.9667	
Fluoride	mg/L	<1	----	----	----	----	----	<1	<1	BD	0.5000	
Sulphate	mg/L	15.1	10.9	0.83	1.1	11	29.6	4.6	4.6	0.83 - 29.6	9.7163	
Nutrients												
Ammonia-Nitrogen	mg/L	0.05	<0.05	0.05	<0.05	<0.05	0.06	<0.05	<0.05	BD - 0.06	0.0356	**1.04 - 2.33**[1]
Nitrate-Nitrogen	mg/L	<0.1	<0.1	<0.05	<0.05	<0.1	<0.2	<0.05	<0.05	BD	0.0438	
Nitrite-Nitrogen	mg/L	<0.003	<0.003	<0.5	<0.03	<1	<2.0	<0.5	<0.5	BD	0.2835	**0.06**
Total Phosphorous	mg/L	----	----	0.3	0.016	0.015	<0.005	<0.005	<0.005	BD - 0.3	0.0564	
Total Metals												
Aluminum	mg/L	<0.02	<0.005	<0.005	0.084	**0.192**	0.035	<0.01	<0.01	BD - 0.192	0.0420	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0128	
Arsenic	mg/L	<0.02	<0.05	**0.16**	<0.04	<0.04	<0.05	<0.02	<0.02	BD - 0.16	0.0350	**0.005**
Barium	mg/L	0.037	0.036	0.091	0.012	0.039	0.062	0.024	0.024	0.012 - 0.091	0.0406	
Beryllium	mg/L	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	BD	0.0001	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0086	
Boron	mg/L	0.007	----	----	----	----	----	----	----	0.007	0.0070	
Cadmium	mg/L	<0.0002	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.0005	BD	0.0002	**0.000017**
Calcium	mg/L	38.2	36.2	68.3	11.5	37	54.4	19.2	19.4	11.5 - 68.3	35.5250	
Chromium	mg/L	**0.0081**	**0.007**	**0.007**	<0.001	<0.001	<0.001	<0.001	<0.001	BD - 0.0081	0.0031	**0.001**[2]
Cobalt	mg/L	<0.0005	<0.001	0.007	<0.001	<0.001	0.002	<0.001	<0.001	BD - 0.007	0.0015	
Copper	mg/L	**0.009**	<0.001	<0.001	**0.01**	**0.004**	**0.005**	0.014	0.014	BD - 0.014	0.0071	**0.002 - 0.004**
Iron	mg/L	0.195	0.267	**11.6**	0.072	0.266	0.219	0.172	0.175	0.072 - 11.6	1.6208	**0.3**
Lead	mg/L	0.003	<0.004	<0.004	<0.004	<0.004	<0.005	<0.01	<0.01	BD - 0.003	0.0029	**0.001 - 0.007**
Lithium	mg/L	0.36	<0.06	<0.05	<0.05	<0.05	<0.05	<0.002	<0.002	BD - 0.36	0.0615	
Magnesium	mg/L	8.84	6.83	12.6	2.83	7.2	11.3	3.54	3.57	2.83 - 12.6	7.0888	
Manganese	mg/L	0.026	0.03	3.62	0.004	0.007	0.073	0.069	0.069	0.004 - 3.62	0.4873	
Mercury	mg/L	<0.005	----	----	----	----	----	----	----	BD	0.0025	**0.0001**
Molybdenum	mg/L	<0.001	<0.005	0.008	<0.003	<0.003	<0.004	<0.005	<0.005	BD - 0.008	0.0026	**0.073**
Nickel	mg/L	0.002	0.002	0.009	<0.001	0.007	0.002	0.003	0.001	BD - 0.009	0.0033	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	<0.02	0.34	0.03	0.03	0.03	<0.05	<0.05	BD - 0.34	0.0644	
Potassium	mg/L	0.3	0.25	0.5	1.54	0.35	0.44	1	1.2	0.25 - 1.54	0.6975	
Selenium	mg/L	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0078	**0.001**
Silicon	mg/L	4.69	13.9	5.8	4.14	13.9	14.8	5.42	5.46	4.14 - 14.8	8.5138	
Silver	mg/L	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0006	**0.0001**
Sodium	mg/L	7.21	5.56	6.45	1.74	6.09	9.93	3.48	3.6	1..74 - 9.93	5.5075	
Strontium	mg/L	0.161	0.14	0.23	0.053	0.18	0.26	0.086	0.088	0.053 - 0.26	0.1498	
Sulfur	mg/L	----	----	----	----	----	----	1.31	1.38	1.31 - 1.38	1.3450	
Tin	mg/L	----	----	----	----	----	----	<0.01	<0.01	BD	0.0050	
Thorium	mg/L	<0.01	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	<0.01	BD	0.0056	
Titanium	mg/L	<0.001	<0.001	0.005	0.002	0.008	<0.001	0.002	0.002	BD - 0.008	0.0026	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	<0.06	BD	0.0150	
Vanadium	mg/L	<0.0002	0.0008	<0.0005	<0.001	<0.001	0.006	<0.002	0.002	BD - 0.006	0.0014	
Zinc	mg/L	0.0185	0.01	0.003	0.005	0.007	0.014	<0.005	<0.005	BD - 0.0185	0.0078	**0.03**
Zirconium	mg/L	----	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	BD - 0.002	0.0008	
Dissolved Metals												
Aluminum	mg/L	----	<0.005	<0.005	0.059	0.017	0.035	<0.01	<0.01	BD - 0.059	0.0180	
Antimony	mg/L	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0143	
Arsenic	mg/L	----	<0.05	0.12	<0.04	<0.04	<0.05	<0.02	<0.02	BD - 0.12	0.0329	
Barium	mg/L	----	0.036	0.09	0.01	0.039	0.061	0.027	0.025	0.01 - 0.09	0.0411	
Beryllium	mg/L	----	<0.0005	0.003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	BD - 0.003	0.0005	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0086	
Cadmium	mg/L	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.0005	BD	0.0002	
Calcium	mg/L	----	34.5	60.3	11.1	37	44.6	18.8	18.9	11.1 - 60.3	32.1714	
Chromium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Cobalt	mg/L	----	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	BD - 0.007	0.0014	
Copper	mg/L	----	<0.001	<0.001	0.009	<0.001	0.002	0.01	0.021	BD - 0.021	0.0062	
Iron	mg/L	----	0.199	9.4	0.07	0.054	0.161	0.166	0.175	0.054 - 9.4	1.4607	
Lead	mg/L	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.01	<0.01	BD	0.0029	
Lithium	mg/L	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.002	<0.002	BD	0.0181	
Magnesium	mg/L	----	6.63	9	2.73	7.24	11.1	3.41	3.44	2.73 - 11.1	6.2214	
Manganese	mg/L	----	0.024	2.59	0.002	0.004	0.066	0.012	0.011	0.002 - 2.59	0.3870	
Molybdenum	mg/L	----	<0.005	<0.005	<0.003	<0.003	<0.004	<0.005	<0.005	BD	0.0021	
Nickel	mg/L	----	0.004	0.005	<0.001	0.002	0.001	0.004	0.005	BD - 0.005	0.0031	
Phosphorous	mg/L	----	<0.02	0.2	0.02	<0.02	<0.02	<0.05	<0.05	BD - 0.2	0.0429	
Potassium	mg/L	----	0.19	0.45	1.46	0.23	0.4	1	1	0.19 - 1.46	0.6757	
Selenium	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02	BD	0.0086	
Silicon	mg/L	----	11	5.3	3.9	13.5	9.9	5.25	5.27	3.9 - 13.5	7.7314	
Silver	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	
Sodium	mg/L	----	6.86	6.35	1.69	6.06	9.92	3.48	3.54	1.69 - 9.92	5.4143	
Strontium	mg/L	----	0.138	0.16	0.051	0.176	0.2	0.082	0.084	0.051 - 0.2	0.1273	
Sulfur	mg/L	----	----	----	----	----	----	1.32	1.35	1.32	1.3350	
Tin	mg/L	----	----	----	----	----	----	<0.01	<0.01	BD	0.0050	
Thorium	mg/L	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	<0.01	BD	0.0057	
Titanium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	BD - 0.002	0.0009	
Uranium	mg/L	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	<0.06	BD	0.0157	
Vanadium	mg/L	----	0.0007	<0.0005	<0.001	<0.001	0.003	<0.002	<0.002	BD - 0.003	0.0010	
Zinc	mg/L	----	0.003	0.002	0.004	0.006	0.009	<0.005	<0.005	BD - 0.009	0.0041	
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BD	0.0005	

Note: < Denotes that sample is below the laboratory detection limit

parameter exceeds CCME guidelines for Freshwater Aquatic Life

Average values were calculated using 1/2 the detection limit

[1] Range is based on a average pH of 8.0 and a temperature range of 0 to 10°C

[2] Based on guideline for Hexavalent chromium (Cr(VI))

BD = Below Detection

Water Quality Data for Station W-9 (Willimas Creek U/S of Access Road) from 1989 to 1999

Parameter	Units	Sample Date									Range	Average	CCME Guidelines Freshwater Aquatic Life
		Oct-89	Aug-91	Dec-91	May-92	Jul-92	w9Oct-92	May-94	Sep-97	Oct-99 [1]			
In Situ Parameters													
pH		----	----	----	----	----	----	----	7.6		7.6	7.6000	**6.5 - 9.0**
Conductivity	umho/cm	----	----	----	----	----	----	----	160		160	160.0000	
Physical Parameters													
pH		7.8	8.2	7.9	7.5	7.9	7.6	7.8	7.63		7.5 - 8.2	7.7913	
Conductivity	umho/cm	505	275	635	85	130	475	200	195		85 - 635	312.5000	
Total Suspended Solids	mg/L	<5	<5	15	<5	<5	<5	<5	72		BD - 72	12.7500	
Total Dissolved Solids	mg/L	----	----	----	----	----	----	160	----		160	160.0000	
Turbidity	NTU	----	<1	7	2	<1	<1	1	----		BD - 7	1.9167	
Hardness as $CaCO_3$	mg/L	185.3	142	297	31.2	95.6	194	78.1	135		31.2 - 297	144.7750	
Anions													
Alkalinity as $CaCO_3$	mg/L	170	157	255	38	84	188	102	127		38 - 255	140.1250	
Hydroxide as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	<1		BD	1.5000	
Carbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	<5	<1		BD	1.5000	
Bicarbonate as $CaCO_3$	mg/L	----	----	----	----	----	----	102	127		102 - 127	114.5000	
Chloride	mg/L	2	----	----	----	----	----	0.5	1.4		0.5 - 2	1.3000	
Fluoride	mg/L	<1	----	----	----	----	----	<1	0.23		BD - 0.23	0.4100	
Sulphate	mg/L	54	17	50.8	1.8	6.2	47.8	14.4	21		1.8 - 54	26.6250	
Nutrients													
Ammonia-Nitrogen	mg/L	0.08	<0.05	0.44	<0.05	<0.05	0.06	<0.05	----		BD - 0.44	0.0971	**1.04 - 2.33** [2]
Nitrate-Nitrogen	mg/L	<0.1	<0.1	<0.05	<0.05	<0.1	<0.2	<0.05	0.007		BD - 0.007	0.0415	
Nitrite-Nitrogen	mg/L	<0.003	<0.003	<5.0	<0.03	<1	<2.0	<0.5	0.002		BD - 0.002	0.5338	**0.06**
Total Phosphorous	mg/L	----	----	0.29	0.012	0.009	0.009	<0.005	----		BD - 0.29	0.0645	
Total Metals													
Aluminum	mg/L	<0.02	<0.005	<0.005	0.088	0.057	0.026	0.01	**0.569**	<0.06	BD - 0.569	0.0883	**0.005 - 0.1**
Antimony	mg/L	<0.005	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	0.00007	<0.02	BD - 0.00007	0.0114	
Arsenic	mg/L	<0.02	<0.05	**0.16**	<0.04	<0.04	<0.05	<0.02	0.0011	<0.04	BD - 0.16	0.0323	**0.005**
Barium	mg/L	0.043	0.049	0.082	0.013	0.034	0.067	0.028	0.0556	0.04	0.013 - 0.082	0.0457	
Beryllium	mg/L	<0.0001	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	<0.0005	<0.0002	BD	0.0001	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.0005	<0.02	BD	0.0075	
Boron	mg/L	0.004	----	----	----	----	----	----	0.006	<0.04	BD - 0.006	0.0100	
Cadmium	mg/L	<0.0002	<0.0003	<0.0003	**0.0004**	<0.0003	<0.0004	<0.0005	<0.00005	<0.002	BD - 0.0004	0.0003	**0.000017**
Calcium	mg/L	44.2	35.6	83	9.8	25.7	48.5	20.9	34.3	46.8	9.8 - 83	38.7556	
Chromium	mg/L	0.0005	**0.008**	**0.007**	<0.001	<0.001	<0.001	<0.001	0.0009	<0.002	BD - 0.008	0.0022	**0.001** [3]
Cobalt	mg/L	<0.0005	<0.001	0.004	<0.001	0.001	0.003	<0.001	0.0005	<0.004	BD - 0.004	0.0014	
Copper	mg/L	<0.0005	<0.001	<0.001	0.002	**0.004**	0.003	**0.027**	0.0025	<0.003	BD - 0.004	0.0046	**0.002 - 0.004**
Iron	mg/L	0.199	0.138	3.17	0.117	0.137	0.197	0.137	**0.91**	0.08	0.08 - 3.17	0.5650	**0.3**
Lead	mg/L	<0.002	<0.004	<0.004	<0.004	<0.004	<0.005	<0.01	0.00049	<0.03	BD - 0.00049	0.0036	**0.001 - 0.007**
Lithium	mg/L	0.29	<0.06	<0.05	<0.05	<0.05	<0.05	<0.002	0.001		BD - 0.29	0.0528	
Magnesium	mg/L	18.2	13.8	22.7	3.1	7.5	19.2	6.6	11.1	11.2	3.1 - 22.7	12.6000	
Manganese	mg/L	0.015	0.016	1.3	0.003	<0.001	0.044	0.023	0.0713	0.007	BD - 1.3	0.1644	
Mercury	mg/L	<0.005	----	----	----	----	----	----	<0.00005	<0.00005	BD	0.0009	**0.0001**
Molybdenum	mg/L	<0.001	<0.005	0.007	<0.003	<0.003	<0.004	<0.005	0.00049	<0.005	BD - 0.007	0.0023	**0.073**
Nickel	mg/L	0.0012	0.005	0.007	<0.001	0.006	0.003	0.002	0.0018	<0.01	BD - 0.007	0.0035	**0.025 - 0.15**
Phosphorous	mg/L	<0.05	<0.02	0.37	0.03	<0.02	0.02	<0.05	<0.3	<0.1	BD - 0.37	0.0767	
Potassium	mg/L	1.3	0.82	1.91	0.85	0.45	1.64	1.1	<2	<0.5	BD - 1.91	1.0356	
Selenium	mg/L	<0.005	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.001	<0.03	BD	0.0076	**0.001**
Silicon	mg/L	4.92	9.9	4.3	3.66	13	12	4.8	8.94		3.66 - 13	7.6900	
Silver	mg/L	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00001	<0.03	BD - 0.00001	0.0021	**0.0001**
Sodium	mg/L	19.1	14.2	7	2.13	5.98	22.9	6.72	11	10	2.13 - 22.9	11.0033	
Strontium	mg/L	0.583	0.4	0.56	0.078	0.28	0.54	0.238	0.294	0.47	0.078 - 0.583	0.3826	
Sulfur	mg/L	----	----	----	----	----	----	3.71	----	14.8	3.71 - 14.8	9.2550	
Tin	mg/L	----	----	----	----	----	----	<0.01	<0.0001	<0.02	BD	0.0050	
Thallium	mg/L	----	----	----	----	----	----	----	<0.00005	<0.03	BD	0.0075	**0.0008**
Thorium	mg/L	<0.01	<0.02	<0.02	<0.005	0.01	<0.01	<0.01	----		BD - 0.01	0.0068	
Titanium	mg/L	<0.001	<0.001	0.007	0.004	0.002	<0.001	0.003	<0.01	<0.003	BD - 0.007	0.0027	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	0.00061		BD - 0.00061	0.0113	
Vanadium	mg/L	<0.0002	0.0038	<0.0005	0.001	<0.001	0.016	0.002	0.003	<0.003	BD - 0.016	0.0031	
Zinc	mg/L	0.0064	0.008	<0.001	0.007	0.003	0.017	<0.005	0.005	<0.01	BD - 0.017	0.0060	**0.03**
Zirconium	mg/L	----	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	----	<0.003	BD - 0.002	0.0009	
Dissolved Metals													
Aluminum	mg/L	----	<0.005	<0.005	0.035	0.022	0.022	<0.01	0.018	<0.02	BD - 0.035	0.0146	
Antimony	mg/L	----	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	0.00006	<0.015	BD - 0.00006	0.0122	
Arsenic	mg/L	----	<0.05	0.16	<0.04	<0.04	<0.05	<0.02	0.0008	<0.04	BD - 0.16	0.0351	
Barium	mg/L	----	0.049	0.066	0.009	0.029	0.064	0.027	0.0406	0.042	0.009 - 0.066	0.0408	
Beryllium	mg/L	----	<0.0005	<0.0005	<0.0002	<0002	<0.0002	<0.0002	<0.0005	<0.001	BD	0.1252	
Bismuth	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.0005	<0.02	BD	0.0075	
Boron	mg/L	----	----	----	----	----	----	----	0.006	0.012	0.006 - 0.012	0.0090	
Cadmium	mg/L	----	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.0005	<0.00005	<0.002	BD	0.0003	
Calcium	mg/L	----	35.5	81.9	8.15	25.5	46.3	20.1	35.1	50.8	8.15 - 81.9	37.9188	
Chromium	mg/L	----	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.0005	0.002	BD - 0.005	0.0012	
Cobalt	mg/L	----	<0.001	0.004	<0.001	<0.001	0.003	<0.001	0.0001	<0.003	BD - 0.004	0.0013	
Copper	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	0.022	0.0009	<0.001	BD - 0.022	0.0032	
Iron	mg/L	----	0.094	1.24	0.043	0.379	0.161	0.098	0.23	0.075	0.043 - 1.24	0.2900	
Lead	mg/L	----	<0.004	<0.004	<0.004	<0.004	<0.005	<0.01	<0.00005	<0.02	BD	0.0032	
Lithium	mg/L	----	<0.05	<0.05	<0.05	<0.05	<0.05	<0.002	<0.001		BD	0.0181	
Magnesium	mg/L	----	13	22.5	2.58	7.54	18.9	6.3	11.5	12.2	2.58 - 22.5	11.8150	
Manganese	mg/L	----	0.016	1.26	0.001	<0.001	0.042	0.021	0.058	0.008	BD - 1.26	0.1758	
Molybdenum	mg/L	----	<0.005	0.006	<0.003	<0.003	<0.004	<0.005	0.0005	<0.00005	BD - 0.006	0.0021	
Nickel	mg/L	----	0.005	0.004	<0.001	0.004	0.003	0.002	0.0009	<0.004	BD - 0.005	0.0027	
Phosphorous	mg/L	----	<0.02	0.23	0.02	<0.02	<0.02	<0.05	<0.3	0.008	BD - 0.23	0.0579	
Potassium	mg/L	----	0.81	1.83	0.62	0.38	1.41	1.1	<2	<0.04	BD - 1.83	0.8963	
Selenium	mg/L	----	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.001	<0.4	BD	0.0313	
Silicon	mg/L	----	9.9	4	2.95	12.6	11.6	4.6	8.6	<0.03	BD - 12.6	6.7831	
Silver	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00001	<0.01	BD	0.0010	
Sodium	mg/L	----	13.9	6.7	1.84	5.91	22.7	6.72	12	10.8	6.7 - 22.7	10.0713	
Strontium	mg/L	----	0.4	0.55	0.065	0.232	0.53	0.222	0.304	0.501	0.065 - 0.55	0.3505	
Sulfur	mg/L	----	----	----	----	----	----	3.6	----	16.1	3.6 - 16.1	9.8500	
Tin	mg/L	----	----	----	----	----	----	<0.01	<0.0001	<0.02	BD	0.0050	
Thallium	mg/L	----	----	----	----	----	----	----	<0.00005	<0.02	BD	0.0050	
Thorium	mg/L	----	<0.02	<0.02	<0.005	<0.005	<0.01	<0.01	----		BD	0.0058	
Titanium	mg/L	----	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.01	<0.003	BD - 0.002	0.0016	
Uranium	mg/L	----	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	0.00054		BD - 0.00054	0.0115	
Vanadium	mg/L	----	0.0037	<0.0005	<0.001	<0.001	0.011	<0.002	<0.001	<0.003	BD - 0.011	0.0024	
Zinc	mg/L	----	0.004	<0.001	0.003	0.002	0.008	<0.005	0.001	<0.002	BD - 0.008	0.0028	
Zirconium	mg/L	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	----	<0.003	BD	0.0006	

Note: < Denotes that sample is below the laboratory detection limit
Average values were calculated using 1/2 the detection limit

parameter exceeds CCME guidelines for Freshwater Aquatic Life

[1] Sample collected at the culvert for the access road near the west end of the camp

[2] Range is based on a average pH of 8.0 and a temperature range of 0 to 10 °C

[3] Based on guideline for Hexavalent chromium (Cr(VI))

BD = Below Detection

Water Quality Data for Station W-10 (Williams Creek U/S of Yukon River) from 1989 to 1999

Parameter	Units	Sample Date						Range	Average	CCME Guidelines Freshwater Aquatic Life
		Aug-91	Dec-91	May-92	Jul-92	Oct-92	Oct-99 [1]			
Physical Parameters										
pH		8.1	8.1	7.6	8	7.7		7.6 - 8.1	7.9000	**6.5 - 9.0**
Conductivity	umho/cm	188	204	97	140	355		97 - 355	196.8000	
Total Suspended Solids	mg/L	<5	<5	25	20	<5		BD - 25	10.5000	
Turbidity	NTU	2	1	7	6	<1		BD - 7	3.3000	
Hardness as $CaCO_3$	mg/L	105	171	58.1	102	156		58.1 - 171	118.4200	
Anions										
Alkalinity as $CaCO_3$	mg/L	103	166	59	94	144		59 - 166	113.2000	
Sulphate	mg/L	15.5	12.2	4.9	9.5	34.8		4.9 - 34.8	15.3800	
Nutrients										
Ammonia-Nitrogen	mg/L	<0.05	0.05	<0.05	<0.05	<0.05		BD - 0.05	0.0300	**1.04 - 2.33** [2]
Nitrate-Nitrogen	mg/L	<0.1	0.08	<0.05	<0.1	<0.20		BD - 0.08	0.0610	
Nitrite-Nitrogen	mg/L	<0.003	<0.5	<0.03	<1	<2.0		BD	0.3533	**0.06**
Total Phosphorous	mg/L	----	0.015	0.014	0.04	0.025		0.014 - 0.04	0.0235	
Total Metals										
Aluminum	mg/L	<0.005	<0.005	**0.389**	**0.463**	0.043	<0.06	BD - 0.463	0.1550	**0.005 - 0.1**
Antimony	mg/L	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02	BD	0.0150	
Arsenic	mg/L	<0.05	**0.08**	<0.04	<0.04	<0.05	<0.04	BD - 0.08	0.0317	**0.005**
Barium	mg/L	0.026	0.146	0.026	0.034	0.055	0.041	0.026 - 0.146	0.0547	
Beryllium	mg/L	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	BD	0.0002	
Bismuth	mg/L	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	BD	0.0083	
Cadmium	mg/L	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	0.002	BD - 0.002	0.0005	**0.000017**
Calcium	mg/L	32.1	59	16.3	29.9	47.9	38.2	16.3 - 59	37.2333	
Chromium	mg/L	**0.009**	**0.004**	<0.001	<0.001	<0.001	<0.002	BD - 0.009	0.0026	**0.001** [3]
Cobalt	mg/L	<0.001	0.002	<0.001	<0.001	0.002	<0.004	BD - 0.002	0.0013	
Copper	mg/L	<0.001	<0.001	0.001	**0.005**	**0.005**	**<0.003**	BD - 0.005	0.0023	**0.002 - 0.004**
Iron	mg/L	0.163	0.07	**0.454**	**0.824**	0.257	0.1	0.07 - 0.824	0.3113	**0.3**
Lead	mg/L	<0.004	<0.004	<0.004	<0.004	<0.005	<0.03	BD	0.0043	**0.001 - 0.007**
Lithium	mg/L	<0.06	<0.05	<0.05	<0.05	<0.05		BD	0.0260	
Magnesium	mg/L	6.79	8.61	4.53	6.71	12	14.6	4.53 - 14.6	8.8733	**0.0001**
Manganese	mg/L	0.004	0.034	0.024	0.027	0.018	0.014	0.004 - 0.034	0.0202	**0.073**
Molybdenum	mg/L	<0.005	<0.003	<0.003	<0.003	<0.004	<0.005	BD	0.0019	**0.025 - 0.15**
Nickel	mg/L	0.006	0.004	<0.001	0.006	0.003	<0.01	BD - 0.006	0.0041	
Phosphorous	mg/L	<0.02	<0.02	0.02	0.04	0.03	<0.1	BD - 0.04	0.0267	
Potassium	mg/L	0.41	1.24	1.4	0.62	1.3	<0.5	BD - 1.4	0.8700	
Selenium	mg/L	<0.01	<0.01	<0.02	<0.02	<0.02	<0.03	BD	0.0092	**0.001**
Silicon	mg/L	13.2	1.4	6.18	12.2	10	<0.03	BD - 13.2	7.1658	
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	15.8	BD - 15.8	2.6338	
Sodium	mg/L	7.77	2.57	3.49	6.02	11.1	0.434	0.434 - 11.1	5.2307	**0.0001**
Strontium	mg/L	0.24	0.166	0.132	0.29	0.47	<0.03	BD - 0.47	0.2188	
Thorium	mg/L	<0.02	<0.02	<0.005	<0.005	<0.01		BD	0.0060	
Titanium	mg/L	0.002	0.001	0.017	0.02	<0.001	<0.003	BD - 0.02	0.0070	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.003	BD	0.0086	
Vanadium	mg/L	0.0021	<0.0005	<0.001	<0.001	0.01		BD - 0.01	0.0027	
Zinc	mg/L	0.003	**0.195**	0.007	0.01	0.008	<0.01	BD - 0.195	0.0380	**0.03**
Zirconium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.003	BD	0.0007	
Dissolved Metals										
Aluminum	mg/L	<0.005	<0.005	0.08	0.042	0.043	<0.02	BD - 0.08	0.0300	
Antimony	mg/L	<0.05	<0.05	<0.02	<0.02	<0.02	<0.015	BD	0.0146	
Arsenic	mg/L	<0.05	0.06	<0.04	<0.04	<0.05	<0.04	BD - 0.06	0.0283	
Barium	mg/L	0.026	0.038	0.017	0.03	0.054	0.043	0.017 - 0.054	0.0347	
Beryllium	mg/L	<0.0005	<0.0005	<0.0002	<0.0002	<0.0002	<0.001	BD	0.0002	
Bismuth	mg/L	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	BD	0.0083	
Cadmium	mg/L	<0.0003	<0.0003	<0.0003	<0.0003	<0.0004	<0.002	BD	0.0003	
Calcium	mg/L	31	57.1	15.8	29.5	43.5	42	15.8 - 57.1	36.4833	
Chromium	mg/L	<0.001	0.004	<0.001	<0.001	<0.001	<0.002	BD - 0.004	0.0012	
Cobalt	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	<0.003	BD - 0.001	0.0008	
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	BD - 0.005	0.0013	
Iron	mg/L	0.08	0.022	0.171	0.164	0.129	0.094	0.022 - 0.171	0.1100	
Lead	mg/L	<0.004	<0.004	<0.004	<0.004	<0.005	<0.02	BD	0.0034	
Lithium	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05		BD	0.0250	
Magnesium	mg/L	6.63	6.92	4.38	6.65	11	16.1	4.38 - 16.1	8.6133	
Manganese	mg/L	0.001	0.002	<0.001	<0.001	0.016	0.016	BD - 0.016	0.0060	
Molybdenum	mg/L	<0.005	<0.005	<0.003	<0.003	<0.004	<0.004	BD	0.0020	
Nickel	mg/L	0.004	<0.001	<0.001	0.004	0.003	<0.008	BD - 0.004	0.0027	
Phosphorous	mg/L	<0.02	<0.02	0.02	0.04	0.02	<0.04	BD - 0.04	0.0200	
Potassium	mg/L	0.59	0.64	1.25	0.5	1.32	<0.4	BD - 1.32	0.7500	
Selenium	mg/L	<0.01	<0.01	<0.02	<0.02	<0.02	<0.03	BD	0.0092	
Silicon	mg/L	10.4	1.2	5.21	11.5	8.9	<0.01	BD - 11.5	6.2025	
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	17.4	BD - 17.4	2.9004	
Sodium	mg/L	7.35	0.89	3.48	5.92	11.1	0.474	0.474 - 11.1	4.8690	
Strontium	mg/L	0.24	0.11	0.131	0.234	0.43	<0.02	BD - 0.43	0.1925	
Thorium	mg/L	<0.02	<0.02	<0.005	<0.005	<0.01		BD	0.0060	
Titanium	mg/L	0.001	0.001	0.001	<0.001	<0.001	<0.003	BD - 0.001	0.0009	
Uranium	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.003	BD	0.0086	
Vanadium	mg/L	0.0011	<0.0005	<0.001	<0.001	0.004		BD - 0.0011	0.0013	
Zinc	mg/L	0.002	<0.001	0.005	0.01	0.008	<0.002	BD - 0.01	0.0044	
Zirconium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.003	BD	0.0007	

Note: < Denotes that sample is below the laboratory detection limit

Average values were calculated using 1/2 the detection limit

parameter exceeds CCME guidelines 'for Freshwater Aquatic Life

[1] Sample collected at the mouth of Williams Creek

[2] Range is based on a average pH of 8.0 and a temperature range of 0 to 1C°C

[3] Based on guideline for Hexavalent chromium (Cr(VI)'

BD = Below Detection

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix I

Public Consultation 1991-1994

Carmacks Copper Project – Public Consultation 1991 – 1994:

Mr. Robert Quartermain, Western Copper Holdings Ltd.
Mr. Ken McNaughton, Western Copper Holdings Ltd.

- Spring 1991: Initial meeting with Chief Fairclough.
- May 22-24 1991: Meeting with Regional Environmental Review Committee.
- August 19-21, 1992: Project presentation to Village to Carmacks and the Carmacks Little Salmon First Nation.
- November 23, 1992: Meeting with Chief Eric Faircough to update the Little Salmon Carmacks First Nation on the Carmacks Copper Project.
- February 17-21, 1993: Meeting with Little Salmon Carmacks First Nation concerning the Carmacks Copper Project and traplines.

Little Salmon – 1993-1994

- September 10-12, 1993: Meeting with Little Salmon First Nation on EDA; Update Mayor.
- November 24, 1993: Meeting with Little Salmon First Nation on EDA.
- March 19, 20, 1994: Meeting with LSFN on EDA; Update Mayor and Government Leader.
- July 16, 1993: Regional Environmental Review Committee and local community member Project Site tour.
- October 14, 1993: Government, media public information meeting and tour of Pilot Plant.
- October 14, 1993: Community tour of Pilot Plant in conjunction with YG Open House for Freegold Road Re-Alignment.
- November – December, 1993: Sponsored mill operators course; financed and administered by Yukon College. Included 20 hours of practical experience in the Pilot Plant – 6 persons.
- December 7, 1993: Heap leaching in Carmacks. Short course and Pilot Plant tour.
- December 8, 1993: Seminar for High School students in Carmacks and Pilot Plant tour.
- March 23, 1994: Regional Environmental Review Committee Meeting – Project update and Baseline Data feedback.

Bob Muir, Antiquus Archaeological Consultants Ltd.

- August 11, 1992: Little Salmon Carmacks First Nation Band and Council in attendance to discuss upcoming archaeological field program.

- August 14, 1992: Meeting with Mr. Eric Fairclough, Chief of Little Salmon Carmacks First Nation, to discuss the results of the archaeological field program.

- Several interviews were conducted with individuals from the Little Salmon Carmacks First Nation pertaining to traditional First Nation Land use practices in the Williams Creek Valley (Mr. Wilfred Charlie, Ms. Viola Mullet, Mr. Johnny Sam, Mr. Eric Fairclough).

Mr. Paul Harder, P.A. Harder and Associates Ltd., Biological Consultants

- August 12, 1993: Meeting with Chief Eric Fairclough to discuss fisheries resource use and environmental concerns.

- August 12, 1993: Meeting with Mr. Johnny Sam of Carmacks to discuss fish resource use and trapping in the Williams Creek drainage.

- August 21, 1993: Letter to Chief Eric Fairclough requesting further information on the activities and concerns of First Nation members in relation to the proposed Williams Creek project.

- October, 1992: Meeting with Mrs. Kathy Sam of Carmacks to discuss fish harvesting practices on the Yukon River.

- October, 1992: Meeting with Mrs. Gladys Johnny of Carmacks to discuss fish harvest practices on the Yukon River.

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

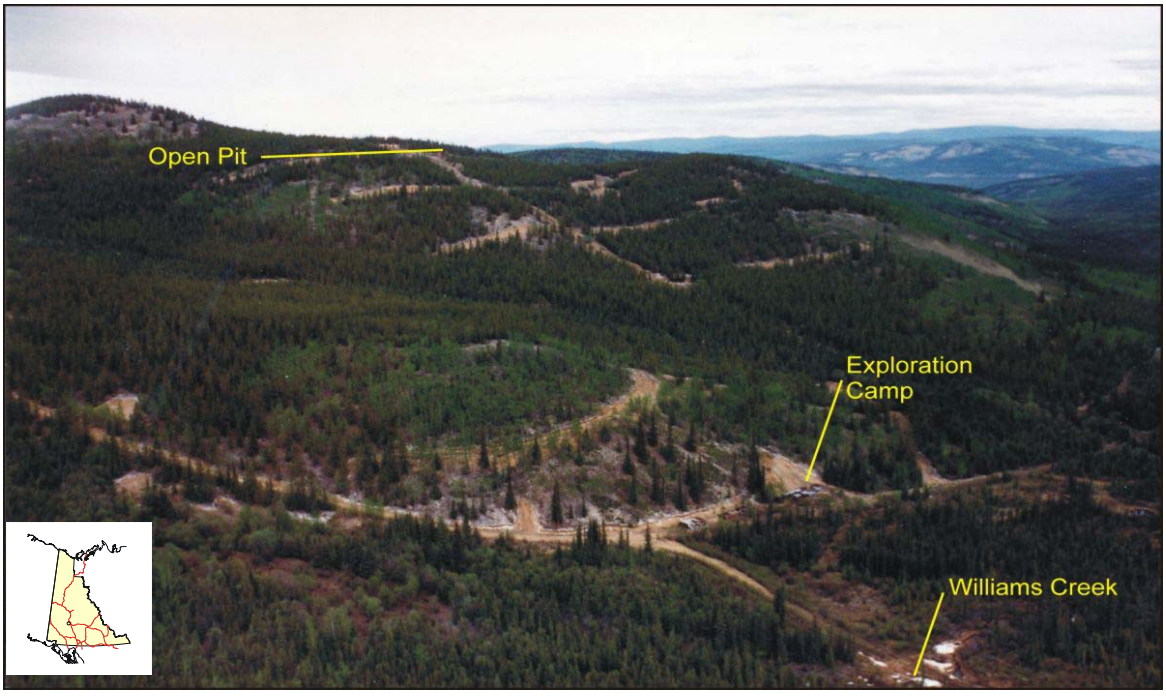
Carmacks Copper Project
Yukon Territory

Appendix J

Western Silver
Newsletter and Posters for Open House

WESTERN SILVER CORPORATION

PROPOSED CARMACKS COPPER PROJECT – OVERVIEW



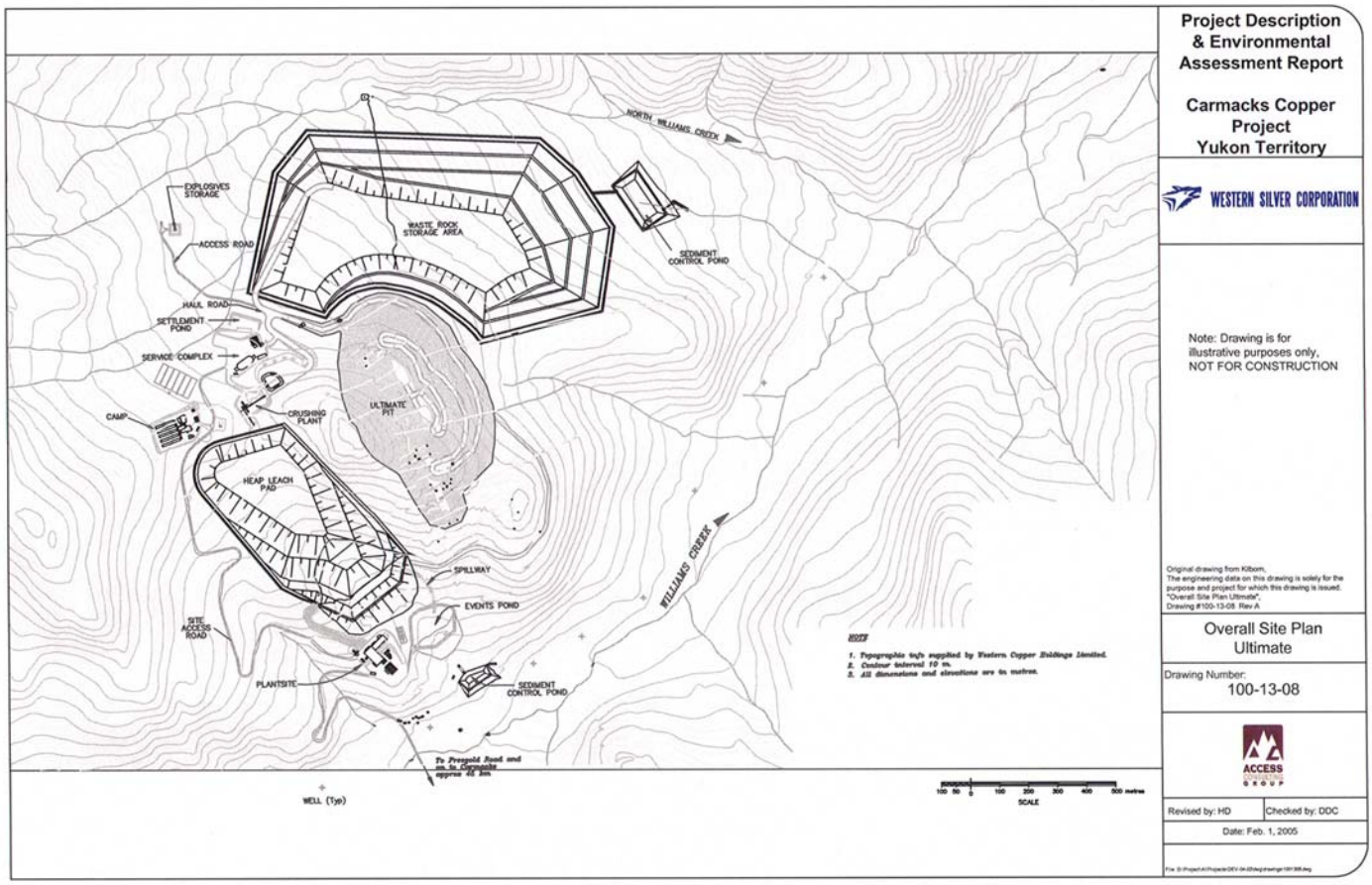
Carmacks Copper Project Area

- The Carmacks Copper Project is located 46 km by gravel road (Freegold Road and an exploration trail) northwest of Carmacks in Yukon
- The project site is located within a group of mineral claims covering 1,000 ha.
- Deposit has 13.3 million tonnes of mineable reserves at an average grade of 0.97% total copper. Active mining is estimated to be for eight years.
- The open pit mine will have a stripping ratio of 4.6 tonnes of waste to 1 tonne of ore (4.6:1).
- Copper in solution will be recovered from the oxide ore by acid heap leaching of crushed minus 19 mm, agglomerated ore.
- The project will treat oxide ore to produce 14,310 tonnes of copper cathodes per year, at a recovery rate of 80%.
- Pregnant leach solution (PLS) will be treated in a solvent extraction electrowinning (SX/EW) plant to produce high purity copper cathodes for shipment via truck to the ice-free port of Skagway, Alaska.
- Mine operations will be carried out using conventional mining equipment.
- Crushing and heap leach pad loading will take place during 200 days of the year (early summer to late fall). Ore leaching will continue year round.
- The process facilities, ultimate leach pad, open pit and waste rock storage will occupy an area of approximately 100 ha.
- Water supply for the project will come from wells in the Williams Creek Valley and make up water from local settlement ponds
- Other site facilities will include: offices, changehouse, operations camp, gatehouse/first-aid; work shops/warehouse and laboratory; water supply and distribution system, power supply, fuel storage, acid storage, sewage treatment, and communications system.

WESTERN SILVER CORPORATION

PROPOSED CARMACKS COPPER PROJECT – OVERVIEW

- Power will be generated on-site by 5 x 1.6 mW modulized diesel generators complete with heat recovery equipment. Alternatively, Yukon Energy Corporation (YEC) may supply power to the site via a transmission power line.
- Sulphuric acid required for the heap leach will be produced on site from commercial 120 tpd contact catalytic plant using sulfur trucked to the site.
- Off-site infrastructure includes: 13 km of property access road (which has already been cleared and grubbed), and project administration offices and warehousing in Carmacks.
- After mining ceases, the heap will be leached for two years, covered with an evaporative transpiration soil cover, and decommissioned. In-situ biological treatment will be undertaken in the heap to assist in stabilization of metals. Active water treatment may be required for a period of time to reach effluent performance standards; however, a long-term passive treatment (infiltration gallery) is proposed for final closure.
- The waste rock storage area and heap will be resloped, covered, and revegetated. Site infrastructure and hazardous materials will be removed from the site and reclaimed.



Western Silver Corporation
1550 – 1185 West Georgia St.
Vancouver, BC V6E 4E6
Telephone: (604) 684-9497
Fax: (604) 668-4670
Website: www.westernsilvercorp.com

IF YOU HAVE ANY QUESTIONS RELATED TO WESTERN SILVER'S PROPOSED CARMACKS COPPER PROJECT WE INVITE YOU TO CONTACT:

Dan Cornett
Agent for Western Silver
Access Consulting Group
Tel: (867) 668-6463
Email: dan@accessconsulting.ca

Jonathan Clegg
Project Manager
Western Silver Corporation
Tel: (604) 641-2774
Email: jclegg@westernsilvercorp.com

Carmacks Copper Project

Project Overview

Western Silver

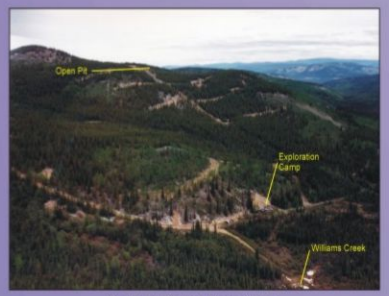
Corporate Information:

- Publicly traded mineral exploration company focused on discovering and developing silver properties in the Americas.
- Internationally recognized for technical ability.
- Listed on the American (AMEX:WTZ) and Toronto (TSX:WTC) stock exchanges.
- Member of the Mining Association of Canada.
- Western Silver is the 100% owner of 206 claims on the Carmacks Copper property.
- To take advantage of higher copper prices, Western Silver is moving the Environmental Assessment and permitting process to completion so that development can proceed in a timely basis.

Carmacks Copper Project Scope:

- Proposed open pit copper mine and solvent extraction and electrowinning (SX/EW) processing facility.
- Orebody is located in the Yukon Territory northwest of the Village of Carmacks.
- Deposit contains an open pit mineable reserve of 13.3 million tonnes.
- Project will include an open pit, acid heap leach and copper extraction facility, waste rock storage area, soil stockpiles, events pond, drainage ditches, sediment control ponds, roads, construction camp, and miscellaneous facilities to support mining operations.





Carmacks Copper Project Area

Western Silver

Commitments:

- Committed to sustainable development, including protection of human health, the natural environment and a prosperous economy.
- Protect the safety of its workers, conserve natural resources, and minimize the impact of its activities on the environment.
- Diligent application of appropriate technology and responsible conduct at all stages of exploration, mine development, mining, mineral processing, decommissioning, and reclamation.
- Evaluate, plan, construct, and operate all projects and facilities to reduce adverse environmental impacts and to meet or exceed applicable environmental laws, regulations, and standards.
- Where applicable regulations are absent, the Corporation will apply cost effective best management practices to protect the environment.

Carmacks Copper Project

Project Components

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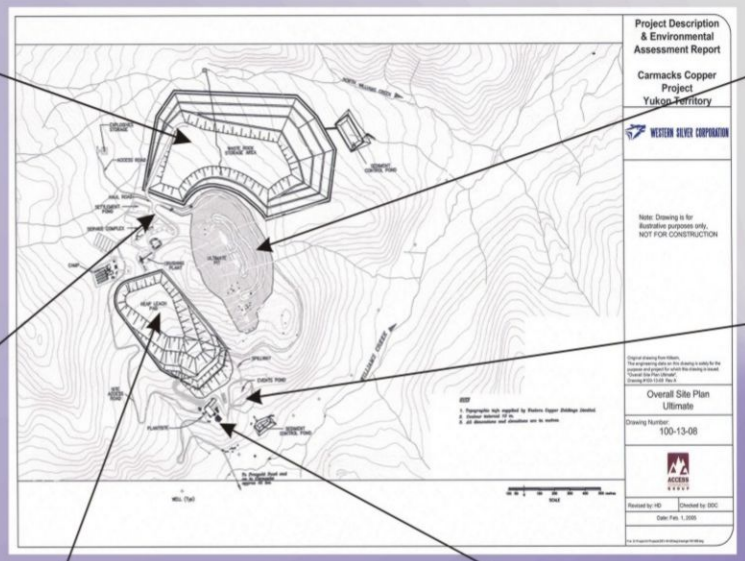
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Waste Rock Storage

- 7.5 million tonnes waste rock produced per year
- Storage capacity of 60 million tonnes over 70 ha

Haul Roads

- Provide access to the open pit, waste rock storage area, and heap leach facility



Copper Oxide Open Pit Mine

- 13.3 million tonnes of mineable reserve
- 8 year mine life



Carmacks Copper Open Pit Area

Events Pond

- designed to provide additional storage for major stormwater events or when the process plant can not accept solution
- Connected to the heap leach pad via gravity flow solution pipes
- storage capacity of 160,000 m3

Heap Leach Facility

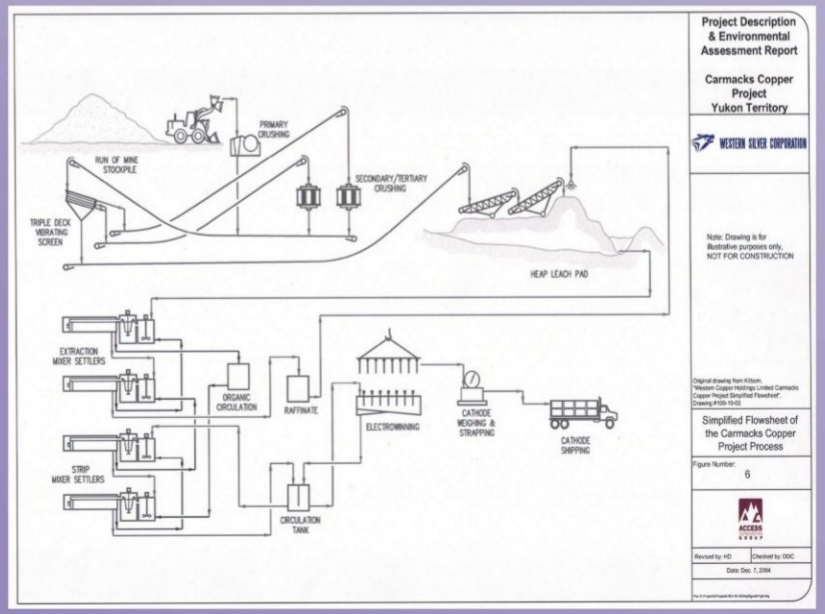
- leaching will occur 365 days/year for 9 years
- solutions from the leaching of the ore is collected and conveyed to the events pond and/or process plant via gravity flow solution pipes

Process Facility

- Copper extracted from the ore using heap leach technology followed by solvent extraction and electrowinning (SX/EW) for the recovery of copper



Collecting Copper Ore From Trench for Pilot Plant



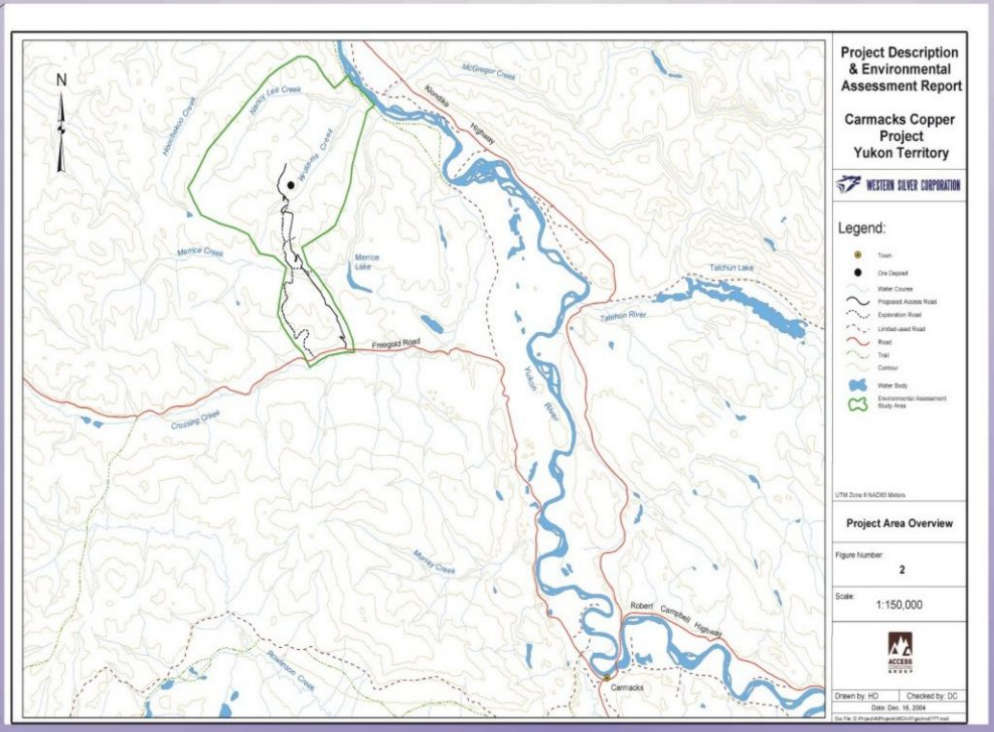
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Carmacks Copper Project
Environmental Assessment Study Area

WESTERN SILVER CORPORATION



- The project area is located 38 km northwest of the town of Carmacks.
- Site is accessible by an existing 13 km exploration road that leads north from km 33 of the secondary, roadway (Freegold Road) from Carmacks.
- Spatial boundaries proposed for the assessment of biological environment, physical environment, current land uses, and heritage resources are defined as the Environmental Assessment Study Area.
- Socioeconomic and economic effects is assessed in a regional context, including Carmacks and the Yukon Territory as a whole.
- Study area encompass all mine infrastructure including the access road and waterways in the downstream flowpath from the mine.





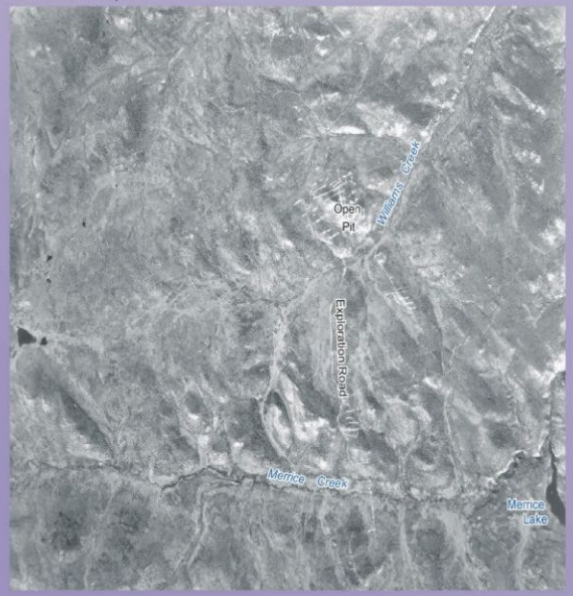
View South Towards Williams Creek



Heap Leach Pad Site

- Study area is within the Yukon Plateau-Central Ecoregion and characterized by subdued topography.
- Study area is located in the Williams Creek watershed.
- Williams Creek Valley and Nancy Lee Creek are the main features in the area.
- Traditional Territory of Little Salmon Carmacks First Nation and the Selkirk First Nation.
- First report of copper made in 1887, claims first staked in 1970.

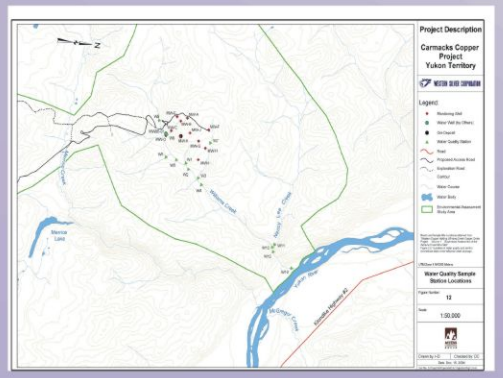
Aerial Overview of Study Area

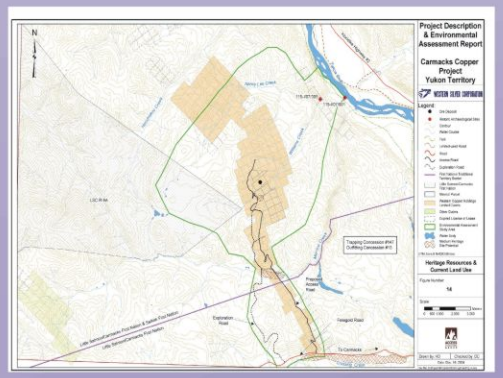


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Carmacks Copper Project
Project Studies

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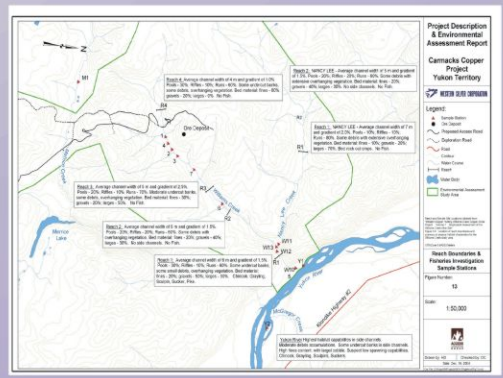


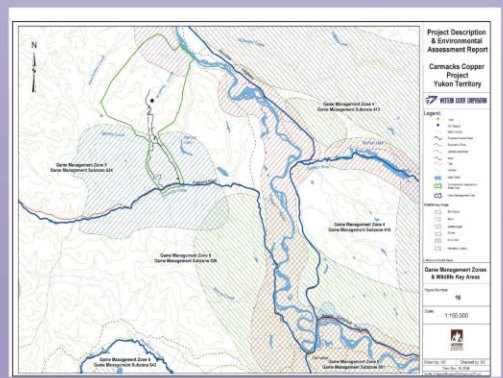
Study Activities:

Activities undertaken to complete the environmental assessment for the Carmacks Copper Project are based on previous studies undertaken by Western Silver (Western Copper Holdings Ltd.) These studies are directly related to the proposed project:

- climate
- terrain/soils/permafrost
- hydrology
- fisheries
- vegetation
- wildlife
- archaeology/traditional use
- current land use
- community consultation
- engineering designs
- metallurgical tests and pilot plant

Activities involved literature reviews, interviews, and field surveys as necessary. The results of the activities will be included in the environmental assessment and permitting documents to be submitted in support of the project. Anticipated environmental effects and proposed mitigation measures for the study area will be identified.





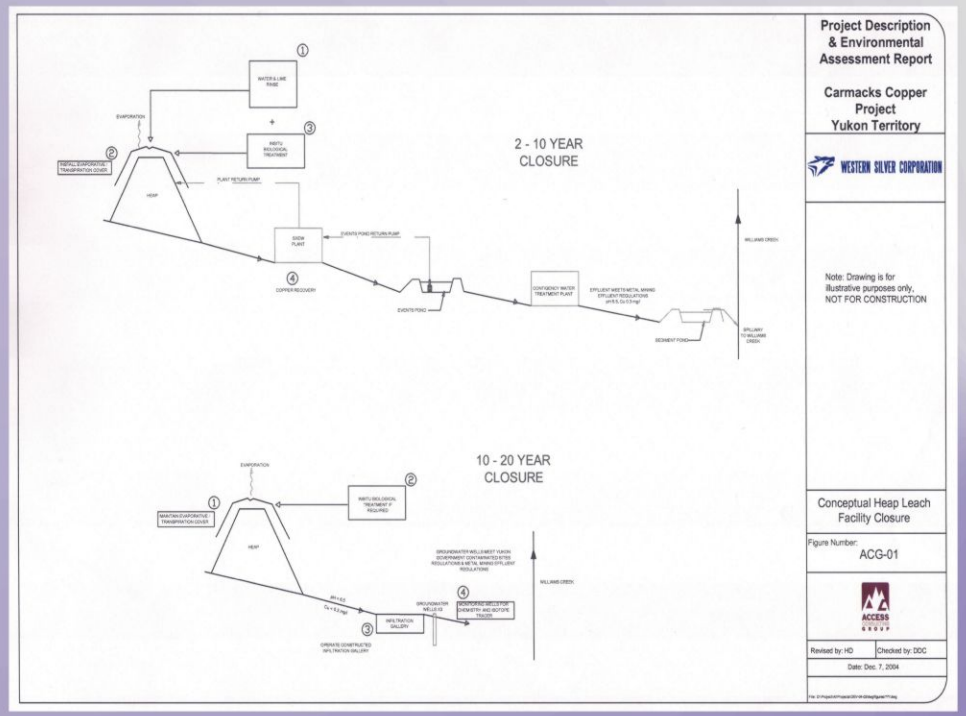
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Heap Leach Pad View Toward Exploration Trail


Upper Williams Creek Looking Southeast

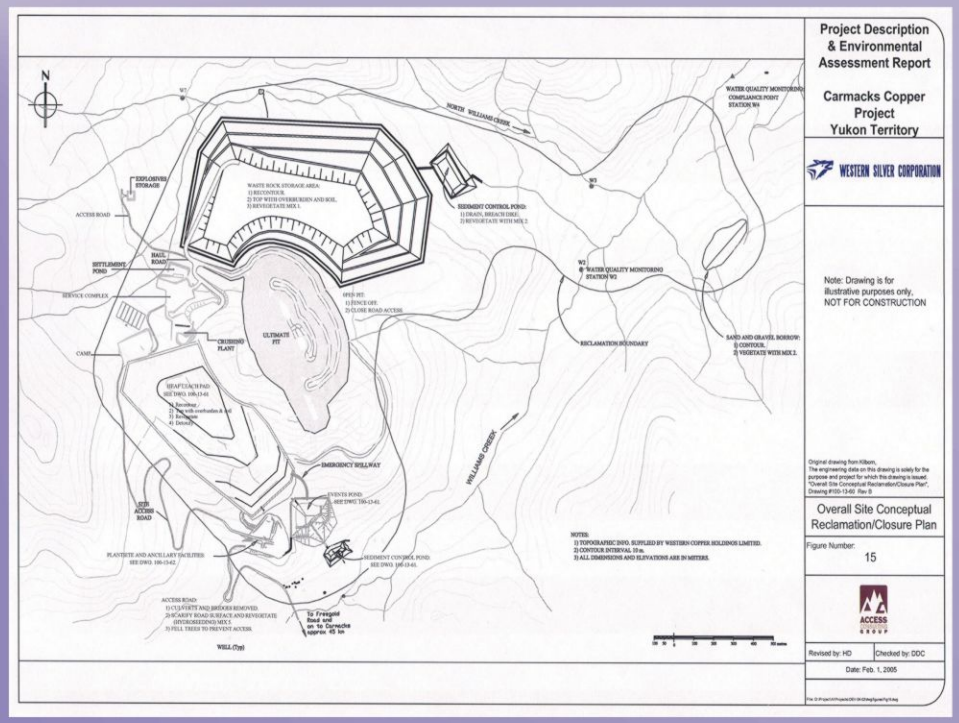

Heap Leach Pad Area Section
Through Geotechnical Trench

Carmacks Copper Project
Conceptual Reclamation / Closure Plan




Upper Open Pit Section Through Trench


Heap Leach Pad Area View to Open Pit



- Overburden stockpiled and used for reclamation
- Slopes will be graded and covered with overburden and re-vegetated
- Infrastructure and hazardous materials removed from the site and reclaimed
- Effluent from the heap will be treated for release
- Monitoring and maintenance will continue to demonstrate decommissioning and closure success

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Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix K

Summary of Potential Environmental Effects and Associated Mitigation Plan

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Appendix K Summary of Potential Environmental Effects and Associated Mitigation Plan

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
ATMOSPHERIC				
Release of SO_2, or volatile hydrocarbons could cause injury or mortality to living organisms by fire, explosion, toxicity, or asphyxiation.	AF	Process controlled production of sulphuric acid to minimize gaseous emissions. Any gaseous emission will meet national emission standards.	Moderate risk to humans and other animals can be minimized through monitoring and contingency measures.	L
			Duration is short, but over plant life (8 yr).	L
	AF	Process plant and laboratory area equipped with gaseous scrubbers and ventilation systems to remove particulate matter and gaseous emissions.	Geographic extent low.	L
			Emission control and monitoring minimizes the risk to the immediate environment. Upsets occur infrequently and personnel are trained to exercise appropriate preventative measures. Magnitude of release is low.	L
	AF	Gas monitoring meters, to measure L.E.L., SO_2, and O_2 level, and equipped with both audio and visual alarms, will be used at all times in process facilities. Safety procedures will be initiated in the event of L.E.L. > 10%, SO_2 > 450 mg/m^3, and O_2 < 19% or > 23% by volume in air.	Effects reversible at low concentration or short duration.	L
			Ecological significance moderate due to localized extent of impact.	M

* Open Pit – OP; Waste Rock Storage Area – WR; Heap Leach Pad and Events Pond – HLP; Access and Haul Roads – AR; Ancillary Facilities – AF; All Mine Activities – All.

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	AF	Gas meters will be calibrated regularly to ensure accuracy.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	AF	Personnel trained in the appropriate safety measures will be on site at all times during operations to manage emergency response plans.	Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and moderate consequence assessment.	L-M
	AF	Wind direction will be monitored to ensure appropriate zone of safety established in the event of an uncontrolled release of gas.	Effects to atmosphere are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local air quality.	L-M
Settling of SO_2 produced by acid plant can cause high ground level concentrations that could damage vegetation and soils and affect human and animal health.	AF	Gas meters will be calibrated regularly to ensure accuracy.	Duration is short, but over plant life (8 yr). Effect considered low.	L
	AF	Emergency Response Plan will be followed as required.	Geographic extent localized since concentration decreases with distance from source.	L
	AF	Personnel trained in the appropriate safety measures will be on site at all times during operations to manage Emergency Response Plans.	Sulfur dioxide not very hazardous. Risks minimized through monitoring and contingency measures. Magnitude of release is low.	L
	AF	Wind direction will be monitored to ensure appropriate zone of safety established in the event of an uncontrolled release of gas.	Reversibility of effects considered high through the use of emission monitoring and controls.	L
			Ecological significance moderate due to localized extent of impact.	M
	AF	Acid plant emissions will be strictly regulated to ensure emissions	Economy and social effects to community and	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		standards are adhered too.	society considered moderate. Trapping in the area, limited cultural use in project area.	
	AF	Sulfur dioxide monitors will be used. Ground level concentrations will not exceed 450 mg/m^3.	Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and moderate consequence assessment.	L-M
	AF	Air contaminants will be monitored.	Effects to atmosphere are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local air quality.	L-M
Burning of diesel, gasoline, and propane causes emissions of air polluting gases.	All	Equipment installed with approved manufactures devices for controlling air emissions.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Proper maintenance of vehicles, pumps, compressors, generators, and other internal combustion engines will minimize emissions of polluting gases.	Geographic extent localized but concentration decreases exponentially with distance from source.	L
	AF	Exhaust gases must be vented to outside of enclosed spaces and adequate ventilation supplied.	Due to the sparse population in the vicinity of operations, it is unlikely that there will be a significant health effect. Magnitude of effects to surrounding environment considered low with implementation of mitigation.	L
			Reversibility of effects considered high through the use of emission controls.	L
			Ecological significance moderate due to localized extent of impact.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low hazard assessment; very low exposure assessment and low consequence assessment.	L
			Effects to air quality are not considered significant with implementation of identified mitigation measures.	L
Noise generated during operations may have a negative effect on the quality of life for residents and wildlife in the vicinity of operations.	OP, AF	Worker Health and Safety program monitored so that sound levels will be maintained below worker safety requirements.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	No public vehicle access will be allowed to the site.	Geographic extent considered moderate. Impact of noise decreases with distance from source.	M
	All	Peak traffic operations occur during brief periods (project construction).	Reversibility of effects considered high through the use of low impact techniques.	L
	AR	Freegold Road bypass directs traffic away from Village of Carmacks residential areas.	Ecological sensitivity considered low due to sporadic nature of noise emissions during the day and throughout the project.	L
	All	No known sensitive habitats in the project area.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			hazard assessment; very low exposure assessment; and low consequence assessment. Due to the sparse population in the vicinity of operations, it is unlikely that there will be a significant noise impact.	 L
Particulate matter during operations (fugitive dust) may have a negative effect on worker health and safety and the local environment (vegetation, wildlife, aquatic)	All All AR All	Road watering and other dust suppression measures used to control dust release. No public vehicle access will be allowed to the site. Freegold Road bypass directs traffic away from Village of Carmacks residential areas. No known sensitive habitats in the project area.	Proposed duration of project is moderate (10-25 years). Effect considered moderate. Geographic extent considered low. Impact of noise decreases with distance from source. Reversibility of effects considered high through the use of low impact techniques. Ecological sensitivity considered low due to sporadic nature of noise emissions during the day and throughout the project. Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area. Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low consequence assessment. Due to the sparse population in the vicinity of operations, it is unlikely that there will be a	M L L L M L L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			significant noise impact.	
TOPOGRAPHY/ TERRAIN AND SOILS				
Loss or disturbance to topography or ground. Disturbance to the soil profile (i.e. soil loss, compaction, admixing, etc.).	All	Stockpiling of soils for future reclamation.	Proposed duration of project is moderate (10 - 25 years); however, the open pit is a permanent feature. Overall effect considered moderate.	M
	AR, AF, HLP	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	All	No unnecessary disturbance to ground. Environmental Management System (EMS) will be followed as required.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures, to very high for open pit.	L-M
	All	Surface disturbance will be re-sloped and covered with soil or revegetated as appropriate.	Ecological sensitivity considered low. No unique or rare habitats in project area.	L
	All	Vehicle movement will be restricted to access or haul roads to prevent permafrost and organic mat disturbance.	Reversibility of effects considered high through the use of reclamation techniques that minimize disturbances to terrain and soils. However, reversibility is low for the open pit.	L
	All	No recreational off-road use of wheeled vehicles will be allowed.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	OP, HLP, WR	Permanent alteration to local topography (OP, HLP, WR) -	Risk characterization very low with negligible	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		recontouring and revegetation to enhance changes to topographic relief.	to low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	
	HLP	An evaporative transpiration cover will be applied over the heap to minimize water infiltration and provide for vegetation growth on closure of the mine.	Effects to topography, terrain, and soils are not considered significant with the implementation of identified mitigation measures.	L
	WR, HLP, AR, AF	Revegetation of disturbed soils and vegetation where appropriate.		
Disturbance to erosion prone banks and slopes.	WR, HLP, AR, AF	Facilities located to minimize erosion prone banks and slopes.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	WR, HLP, AR, AF	Erosion protection measures (rip rap, cross ditches, breaks) along roads and facilities.	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	WR, HLP, AR, AF	Recontour and re-sloping of disturbed areas and progressive reclamation.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	L
	All	No recreational off-road use of wheeled vehicles will be allowed.	Reversibility of effects considered high through the use of techniques that minimize disturbances and reclamation to terrain and soils.	L
	All	EMS plans not to disturb the organic mat and soils. All activity will be conducted on constructed roadways. Facilities and waste rock area located to reduce the possibility of inadvertent surface disturbance.	Ecological sensitivity considered low. Terrain and soils community with good ecological fitness and a high degree of resilience.	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to terrain and soils are not considered significant, with the implementation of identified mitigation measures.	L
Disturbance of surface and subsurface drainage systems.	All	Facilities located in areas away from surface water drainage systems to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	AR	Hand cutting will be employed near access road stream crossings to reduce disturbance to riparian areas.	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	AR	Access road with clear span bridge structure across Merrice Creek to reduce disturbances.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	M
	AR, AF	Ensure drainage channels are maintained and free of debris.	Ecological sensitivity considered low. Terrain and soils community with good ecological fitness and a high degree of resilience.	L
	AR, AF	Reclaim surface drainage to original condition (recontour, revegetation).	Reversibility of effects considered high through the use of techniques that minimize disturbances and reclamation to terrain and soils.	L
	All	Routine monitoring and maintenance		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		in accordance with EMS to prevent disturbances.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to terrain and soils are not considered significant, with the implementation of identified mitigation measures.	L
Contamination of soil/potential for fuel and/or other substance spillage.	HLP	Heap leach pad and events ponds constructed with double liner and LDRS system to prevent solution migration to soils and groundwater. Facilities located greater than 50 m from any watercourse.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
			Geographic extent considered low (37.2 ha – heap)	L
	HLP	Heap leach pad and events pond LDRS will be monitored and sampled regularly.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	L
	AF	Liquid hydrocarbons, acids, and other chemicals will be stored in appropriate containers during transportation. No fuels or chemicals will be stored within 100 m of a watercourse.	Reversibility of effects considered high, with the implementation of identified mitigation measures.	L
			Ecological sensitivity considered moderate. Terrain and soils community with good ecological fitness and a high degree of	M
	AF	Main fuel, acid, and chemical storage		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		facilities located at the plant site. Storage tanks with secondary containment. Segregation and controlled storage of plant chemicals. All hazardous materials located within controlled facility and routinely inspected and monitored as part of EMS.	resilience. Headwater streams drain to important river downstream (Yukon River). Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area. Risk characterization moderate with moderate hazard assessment; moderate exposure assessment; and low consequence assessment.	 M M
	All All	A Spill Contingency Plan is in place, as part of the Environmental Management System. In the event of a spill, the Spill Contingency Plan will be implemented. Spills will be immediately reported to the Spill Report Line.	Effects to terrain and soils are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local watercourses.	M
	All AF	Upon closure, assessment of soils for local contamination and completion of remediation activities. All hydrocarbons, chemicals, and waste materials resulting from the project will be removed from the area and cleaned up.		
PERMAFROST				
There is a potential for localized melting of	HLP	HLP site has been previously cleared and stripped to enable local thaw.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
permafrost in isolated portions of the heap leach pad, waste rock storage area, and roads.		Additional geotechnical drilling to confirm permafrost existence under leach pad area to minimize environmental effects.	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	WR	Stripping of WRSA to allow permafrost thawing and construction of drainage ditches and sediment ponds to control water. Staged WRSA construction and monitoring with contingency berm.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	L
			Ecological sensitivity considered moderate. Disturbed permafrost ground has a low degree of resilience.	H
	AR	Road alignments chosen and constructed to maintain permafrost conditions. Gravel road base to be approximately 3 m thick directly on top of existing soils.	Reversibility of effects considered high, with the implementation of identified mitigation measures.	L
	All	Wheeled vehicles will be used only on access roads and mine areas. No recreational off-road use of wheeled vehicles will be allowed.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	All	Equipment operators will be instructed not to disturb ground unnecessarily.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to permafrost are not considered significant with implementation of identified mitigation measures. HLP area previously cleared and permafrost degradation low.	L
	HLP, WR	HLP and WR physical stability		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		routinely monitored. EMS inspection and monitoring plans.		
AQUATIC RESOURCES (hydrology, water quality, fisheries, and benthic macroinvertebrates)				
Erosion of stream banks.	All	Project components and operations will be located away from watercourses, except at Merrice and Williams Creek stream crossings.	Duration of project construction short (1-<5 years). Effect considered very low.	VL
			Geographic extent considered low. Project area located near headwaters of watercourses.	L
	All	Construction minimized around streams during critical spawning periods (May-June for grayling).	Magnitude of effects to surrounding environment considered low with implementation of mitigation.	L
	AR	Bridge crossing (Merrice Creek) and culvert (Williams Creek) designed to protect watercourse and prevent erosion.	Reversibility of effects considered high through the use of low impact techniques that minimize effects to aquatic resources.	L
	AR	Ditch construction along roadways will incorporate settling ponds and baffles to reduce erosion and settle out sediments.	Ecological sensitivity considered moderate. Headwater streams drain to important rivers downstream.	M
	HLP, AR, AF	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	All	No recreational off-road use of wheeled vehicles will be allowed.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
	AR	Any material that accidentally falls into watercourses will be removed.		
	AR, AF	Erosion protection measures (rip rap, cross ditches, breaks) along roads and facilities.	Effects to aquatic resources are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local watercourses.	L
	HLP, WR, AF	Project footprint with buffer zone around riparian areas. Sediment ponds to control water releases.		
	HLP, WR, AR, AF	If the surface is disturbed in an area such as drainage channels where erosion is a possibility, control measures may include using earth breaks or cross ditches.		
Physical damage to fish habitat and spawning sites.	HLP, WR, OP, AF	Upper Williams Creek does not support fish. Project mine components and operations will be located at least 50 m away from watercourses.	Duration of project is low for effluent release (5- 10 years). Effect considered low.	L
			Geographic extent considered low. Project area located near headwaters of watercourses.	L
	HLP, AR, AF	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Magnitude of effects to surrounding environment considered low with implementation of mitigation.	L
	All	No recreational off-road use of wheeled vehicles will be allowed.	Reversibility of effects considered high through	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	AR	Clear span bridge located at Merrice Creek to minimize disturbance to riparian zones.	the use of low impact techniques that minimize effects to aquatic resources. Ecological sensitivity considered moderate. Headwater streams drain to important rivers downstream.	M
	AF	Hazardous materials stored with secondary containment away from watercourse in controlled areas.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	All	Spill Contingency and Emergency Response Plan in place to prevent materials from accidentally entering watercourses.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
	HLP	Heap leach pad and events ponds constructed with composite liner and LDRS system to prevent solution migration to surface and groundwater. Sediment pond located downstream from events pond. Facilities located greater than 50 m from any watercourse.	Effects to aquatic resources are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local watercourses.	L
	All	Water for mining and processing will be collected from deep wells in the Williams Creek drainage basin and numerous sediment ponds (WR, HLP, AF). No direct surface water use. Recycling of water from AF and sediment ponds to minimize groundwater well use.		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	HLP	At closure, controlled release of HLP solutions to prevent direct hydrological effects to local drainage.		
	All	Environmental monitoring program with stations on Williams Creek to monitor stream hydrology and water quality. Perform required MMER EMM program.		
Contamination of watercourses or groundwater.	HLP, AF	No direct discharge of process solutions or wastewater to surface waters during operations. Recycling of process solutions and wastewater for other water uses.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
			Geographic extent considered low. Project area located near headwaters of watercourses.	L
	HLP	Heap leach pad and events ponds constructed with composite liner and LDRS system to prevent solution migration to surface and groundwater.	Magnitude of effects to surrounding environment considered moderate with implementation of mitigation.	M
	HLP, WR, AF	Sediment pond located below HLP, WR, AF to prevent sediment release and treat surface water if necessary. Construction of diversion ditches.	Reversibility of effects considered high through the use of low impact techniques that minimize effects to aquatic resources.	L
		Facilities located greater than 50 m from any watercourse.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	HLP	Heap leach pad and events ponds designed to withstand combinations of critical events (operating solution	Risk characterization low to moderate with low to moderate hazard assessment; low exposure	L-M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		volume, plus excess runoff inflows from the critical duration 100-yr return period event occurring at the most critical point in time, plus an allowance for heap draindown as follows: During the first year of operation, 100% of the total potential heap draindown volume, or During subsequent years of operation, 48 hours of draindown at the full rate of solution application. For a solution application rate of 540 m^3/hr this volume is 26 000 m^3; and Redundant systems (i.e. pumps, power, spare parts) to prevent direct release of process solutions.	assessment; and low to moderate consequence assessment. Ecological sensitivity considered moderate. Headwater streams drain to important rivers downstream. Effects to aquatic resources are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local watercourses.	 M L-M
	HLP	Heap leach pad and events pond LDRS will be monitored and sampled regularly.		
	HLP	Contingency water treatment plant constructed on site using known technology to treat process solutions, if required.		
	HLP, AF	Sediment ponds will be monitored and sampled regularly to ensure wastewater quality.		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	AR, AF	Liquid hydrocarbons, acids, and other chemicals will be stored in appropriate containers during transportation. No fuels or chemicals will be stored within 100 m of a watercourse.		
	AF	Main fuel, acid, and chemical storage facilities located at the plant site. Storage tanks with secondary containment. Segregation and controlled storage of plant chemicals. All hazardous materials located within controlled facility and routinely inspected and monitored as part of EMS.		
	All	A Spill Contingency Plan, as part of the EMS.		
	All	In the event of a spill, the Spill Contingency Plan will be implemented. Spills will be immediately reported to the Spill Report Line.		
	All	Any deleterious material that accidentally falls into a watercourse will be removed. A spill response plan will be implemented.		
	AF	Segregation of camp and AF		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		wastewaters and treatment using in ground disposal and tile/absorption fields.		
	HLP	At closure, covering, rinsing and detoxification of HLP and treating solutions in a controlled manner to prevent effects to Williams Creek. Long-term heap solutions directed to infiltration gallery to provide final solution polishing and prevent direct release to Williams Creek.		
	All	Environmental monitoring program with stations on Williams Creek to monitor stream hydrology and water quality. Perform required MMER EMM program.		
	All	Progressive cleanup and remediation will be completed where possible.		
	All	Construction during heavy rainfall or snowfall events will be minimized.		
	AF	All waste materials containing fuels, chemicals, and specials waste will be properly stored and removed from the area.		
	AR, AF, WR,	A revegetation program using		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	HLP	indigenous flora will be implemented for disturbed sites (AR, AF, WR, HLP) where native vegetation has been removed or destroyed to prevent degradation of stream water quality.		
Other aquatic issues – Hydrogeological effects	OP	Water will be collected in the pit and pumped to the process plant as make-up water. Resulting flow conditions in Williams Creek will not be significantly altered. Expected that the pit will take >300 years to fill.	Proposed duration of project is moderate (10-25 years). Effect considered moderate. Geographic extent considered low. Project area located near headwaters of watercourses.	M L
	WR	Runoff that enters the WRSA will be minimal and will flow in the near surface groundwater at the base of the pile for collection in the toe drains and ultimately into the sediment control pond for use as make-up water.	Magnitude of effects to surrounding environment considered low with implementation of mitigation. Reversibility of effects considered high through the use of low impact techniques that minimize effects to aquatic resources.	L L
	HLP	Near-surface groundwater flows could be partially diverted in the HLP area; however, the effect is not expected to be significant, as the leach pad area has been cleared to allow permafrost to thaw.	Ecological sensitivity considered moderate. Headwater streams drain to important rivers downstream. Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M M
	AF	Water will be pumped from deep groundwater wells. Water Recycle and use of events and sediment ponds for make-up water.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			assessment. Effects to aquatic resources are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to protect local watercourses.	 L
WILDLIFE				
Disturbance to wildlife from direct habitat loss.	HLP, AR, AF All All	Existing trails and disturbed areas will be used where suitable to minimize environmental effect. All project activities will be maintained to the project area. No hunting, trapping or fishing will be allowed on the project. A ”no firearms” policy will be enforced (banned except as authorized for protection of employee’s safety while in the field). Employees will be instructed regarding the project’s “no wildlife harassment” policy, which will encompass no wildlife feeding, employee wildlife education, and wildlife avoidance. Environmental personnel on site to monitor project activities and modify	Proposed duration of project is moderate (10-25 years). Effect considered moderate. Geographic extent considered moderate, all mine activities = 170.5 ha. Magnitude of effects to surrounding environment considered moderate, with the implementation of identified mitigation measures. Reversibility of effects considered high through the use of techniques that minimize habitat disturbances and programs that reduce wildlife conflicts. Ecological sensitivity considered low. No rare or endangered wildlife species. Economy and social effects to community and society considered moderate. Trapping in the	M M M L L M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		operations to address wildlife concerns.	area, limited cultural use in project area.	
	AR, AF	Wildlife surveys of the area indicate no sensitive habitats or unique wildlife habitat features. Avoidance of sensitive habitats, such as denning or nesting sites, if encountered during operations.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment. Effects to wildlife are not considered significant with implementation of identified mitigation measures. Mitigation measures are designed to minimize project effects to habitat loss and program activities to reduce wildlife conflicts within the project area.	L M
	All	Routine garbage patrols will be undertaken to remove materials, (e.g., metals, plastics, grease) which may be potentially harmful to wildlife.		
	All	No recreational off-road use of wheeled vehicles will be allowed.		
	All	All encounters with wildlife, and/or mortalities, will be reported to a YG Conservation Officer.		
Disturbance of wildlife migration or blockage of wildlife movement corridors.	HLP, AR, AF	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	AR, AF, WR	Avoidance and buffer zones between stream riparian areas and facilities to minimize wildlife disturbances and protect wildlife corridors.	Geographic extent considered moderate, all mine activities = 170.5 ha. Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	M L
	All	Environmental personnel on site to		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		monitor project activities and modify operations to address wildlife concerns.	Reversibility of effects considered high through the use of techniques that minimize habitat disturbances and programs that reduce wildlife conflicts.	L
	All	Employees will be instructed regarding the project's "no wildlife harassment" policy, which will encompass no wildlife feeding, employee wildlife education, and wildlife avoidance.	Ecological sensitivity considered low. No rare or endangered wildlife species.	L
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	All	Personnel movement will be restricted to the project area and access routes.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to wildlife are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to avoid wildlife corridors.	L
Project components may create fragmentation and alter wildlife movements.	All	Project footprint localized and buffer zone between riparian area and corridors. Wildlife movements will not be restricted.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
			Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	All	No unnecessary disturbance to local surroundings (EMS).	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation	L
	HLP, WR,	Surface disturbance will be re-sloped,		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	AR, AF	covered with soil or revegetated as appropriate.	measures.	
	HLP, WR, AR, AF	Natural revegetation will be encouraged as part of the revegetation plan.	Reversibility of effects considered high through the use of techniques that minimize habitat disturbances and programs that reduce wildlife conflicts.	L
	AR	Snow banks on access roads will be plowed back, with breaks in the bank to ensure adequate road wildlife sighting and escape.	Ecological sensitivity considered low. No rare or endangered wildlife species.	L
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to wildlife are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to avoid wildlife corridors.	L
Attraction of nuisance animals.	All	Garbage and debris will be collected routinely for disposal, or stored in wildlife proof containers for disposal at approved facilities.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
			Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	All	Employees will be instructed regarding the project's "no wildlife harassment" policy, which will	Magnitude of effects to surrounding environment considered low, with the	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		encompass no wildlife feeding, employee wildlife education, and wildlife avoidance.	implementation of identified mitigation measures.	
	All	Wildlife monitoring of site by environmental personnel.	Reversibility of effects considered high through monitoring and disposal techniques.	L
	AF	Use of approved gas fired incinerator with high efficiency burner for camp facilities.	Ecological sensitivity considered low. No rare or endangered wildlife species.	L
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to wildlife are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to minimize wildlife conflicts.	L
Encroachment on endangered species or important wildlife habitats.	AR, HLP, AF	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	AR, AF	Wildlife surveys of the area indicate no sensitive habitats or unique wildlife habitat features. Avoidance of sensitive habitats, such as denning or nesting sites, if encountered during	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
			Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		operations.	measures.	
	All	Project avoids key habitat areas (raptors, moose) along Yukon River.	Reversibility of effects considered high through monitoring and avoidance.	L
	All	Personnel movement will be restricted to the project area and access routes.	Ecological sensitivity considered low. No rare or endangered wildlife species.	L
	All	Local YG biologists and officers will be notified if a bear encounter occurs.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	All	Very few waterbodies exist within the project area. However, no disturbance within 50 m of a watercourse will occur.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
	All	Wildlife monitoring of site by environmental personnel to advise on environmental and wildlife concerns in the areas of operation.	Effects to wildlife are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to minimize encroachment on important wildlife habitats.	L
	All	No hunting, trapping, or fishing will be allowed on the project. A “no firearms” policy will be enforced (banned except as authorized for protection of employee’s safety while in the field). Employees’ will be instructed regarding the project’s “no wildlife harassment” policy, which will encompass, no wildlife feeding, employee wildlife education, and		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		wildlife avoidance.		
	All	No recreational off-road use of wheeled vehicles will be allowed.		
Roads could allow for increased access for wildlife harvesting or direct mortalities.	AR, AF	Restrict direct access to mine site and project area by using a gate during operations to prevent opportunities for increased hunter access.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
			Geographic extent considered moderate, all mine activities = 12.3 ha.	L
	AR	Provide and encourage project busing and transportation to mine site to minimize hunting opportunities and direct road mortalities.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	L
	AR	Post speed limits and signage at wildlife crossings to minimize direct road mortalities.	Reversibility of effects considered high through monitoring and access restrictions.	L
	All	No recreational off-road use of wheeled vehicles will be allowed.	Ecological sensitivity considered low. No rare or endangered wildlife species.	L
	HLP	Fencing of HLP areas to minimize direct mortalities.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to wildlife are not considered significant	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			with implementation of identified mitigation measures. Mitigation measures designed to minimize wildlife conflicts.	
VEGETATION				
Loss of vegetation communities.	AR, AF, HLP	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	No unnecessary disturbance to ground (EMS).	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	All	No recreational off-road use of wheeled vehicles will be allowed.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures and high for the OP.	L-M
	AR, AF	Access road width will be restricted to 8 m. Clearing for new access and facilities will be kept to the minimal amount required.	Reversibility of effects considered high, with the implementation of identified mitigation measures, but low for the OP.	L-M
	AR	Hand cutting will be employed near access road stream crossings to reduce disturbance to riparian areas.	Ecological sensitivity considered low. No rare or endangered plant species.	L
	AR	Windrows will not be created so that wildlife movements are not restricted, and fire hazards are minimized.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	HLP, WR,	Recontour and re-sloping of disturbed	Risk characterization low with low hazard assessment; negligible to very low exposure	L

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	AR, AF	areas and progressive reclamation.	assessment; and low consequence assessment.	
	HLP, WR, AR, AF	Surface disturbance will be re-sloped, covered with soil or revegetated as appropriate.	Effects to vegetation are not considered significant with implementation of identified mitigation measures.	L
	All	Routine monitoring and maintenance in accordance with EMS to prevent disturbances.		
Loss of timber.	AR, AF, HLP	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-15 years). Effect considered moderate.	M
	AR, AF, HLP	In areas with denser woodlands (AR, AF, HLP), clearing will be kept to the minimal amount required.	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	HLP, WR, AR, AF	Surface disturbance will be re-sloped, covered with soil or revegetated as appropriate to promote natural revegetation.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures and high for the OP.	L-M
			Reversibility of effects considered high through the use of techniques that minimize surface disturbances and revegetation of disturbed area.	L
			Ecological sensitivity considered low. No rare or endangered plant species.	L
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to timber are not considered significant with implementation of identified mitigation measures.	L
Fire hazards.	All	Fire safety measures and responses, as provided in the EMS will be adhered to.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Fire protection and distribution systems and equipment will be located at the project area.	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	All	Trained personnel for fire response as part of EMS.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures. Area previously burnt.	L
	HLP, AF	Redundant systems for key operations (HLP, AF) as part of fire contingency plans.	Reversibility of effects considered moderate through the use of contingency measures and training.	M
	All	If fire hazards exist in the area during operations, procedures will be implemented to avoid fire hazard areas and prevent inadvertent fires.	Ecological sensitivity considered low. No rare or endangered plant species.	L
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment.	L
			Effects to vegetation are not considered significant with implementation of identified mitigation measures.	L
Potential disturbance to rare, sensitive or unique plant species or vegetation communities.	AR, AF, HLP	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	No unnecessary disturbance to ground (EMS).	Geographic extent considered moderate, all mine activities = 170.5 ha.	M
	All	No recreational off-road use of wheeled vehicles will be allowed.	Magnitude of effects to surrounding environment considered low, with the implementation of identified mitigation measures.	L
	All	Vegetation survey indicates that no rare or sensitive plant species are located in the project area; however, surface disturbances will be kept to a minimum.	Reversibility of effects considered high through the use of techniques that minimize surface disturbances and revegetation of disturbed area.	L
	AR	Hand cutting will be employed near access road stream crossings to reduce disturbance to riparian areas.	Ecological sensitivity considered low. No rare or endangered plant species.	L
	HLP, WR, AR, AF	A revegetation program using indigenous flora will be implemented for disturbed sites (AR, AF, WR, HLP)	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		where native vegetation has been removed or destroyed. Natural revegetation of disturbed areas will be promoted as part of revegetation plans.	Risk characterization low with low hazard assessment; negligible to very low exposure assessment; and low consequence assessment. Effects to vegetation are not considered significant with implementation of identified mitigation measures.	L L
CULTURAL RESOURCES				
Loss, damage, or alteration of heritage sites or sites of archaeological / historical interest or cultural artifacts.	HLP, AR, AF All All All	Existing trails and disturbed areas will be used where suitable to minimize environmental effect. A heritage site survey was completed. Known sites located off the project area (Yukon River) will be avoided. Medium potential sites will be investigated prior to construction. Should any archaeological or palaeontological sites be discovered during construction or operations, work will be suspended at that location until permission is sought and granted to continue operations. In the event previously unknown heritage resources are discovered	Proposed duration of project is moderate (10-25 years). Effect considered moderate. Geographic extent considered low. Heritage survey has not identified cultural resources of concern. Magnitude of effects to surrounding environment considered low. Heritage resources known and will be avoided. Reversibility of effects considered high through the use of low impact and avoidance techniques. Ecological sensitivity considered moderate. Cultural resources considered important and need to be protected.	M L L L M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		during mining operations, staff of the YG Heritage Branch and LSCFN will be notified and consulted for advice on mitigation.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area. Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low consequence assessment. Effects to cultural resources are not considered significant with implementation of identified mitigation measures.	M L L
Loss or damage or alienation of traditional uses or pursuits by First Nations.	HLP, AR, AF All All	Existing trails and disturbed areas will be used where suitable to minimize environmental effect. Previous vegetation, wildlife, fisheries, and traditional use surveys and studies were conducted to identify local areas of interest. Area is generally used for traditional hunting and gathering, however no known unique areas identified. Local trapper uses area for trapping and traditional life style. Identification of trapping trails and relocation, re-establishment of trapper trails if required. Compensation for loss of income during active mining operations, if required.	Proposed duration of project is moderate (10-25 years). Effect considered moderate. Geographic extent considered low. Heritage survey has not identified cultural resources of concern. Magnitude of effects to surrounding environment considered low. Heritage resources known and will be avoided. Reversibility of effects considered high through the use of low impact and avoidance techniques. Ecological sensitivity considered moderate. Cultural resources considered important and need to be protected.	M L L L M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	L-M
			Effects to cultural resources are not considered significant with implementation of identified mitigation measures.	L
Loss or damage to existing cabins / structures along the roads.	AR	No specific cabin/structures have been identified. Appropriate site-specific mitigation measures will be discussed with any identified cabin / structure owners in the project area.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
			Geographic extent considered low. Heritage survey has not identified cultural resources or cabins of concern.	L
			Magnitude of effects to surrounding environment considered low. Heritage resources or cabins known and will be avoided.	L
			Reversibility of effects considered high through the use of low impact and avoidance techniques.	L
			Ecological sensitivity considered moderate. Cultural resources considered important and need to be protected.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	L-M
			Effects to cultural resources are not considered significant with implementation of identified mitigation measures.	L
SOCIOECONOMICS				
Conflicts with wildlife harvesting.	HLP, AR, AF	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Public consultation with all local communities has been undertaken to notify communities of operations and timing.	Geographic extent considered low. Project area within traditional territories of LSCFN and SFN.	L
	AR, AF	Posting of warning signs on roads and mine site areas.	Magnitude of effects to surrounding communities considered low with implementation of mitigation.	L
	AR, AF	Identification of trapping trails and relocation, re-establishment of trapper trails if required.	Reversibility of socio effects considered moderate through implementation of mitigation measures.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Ecological sensitivity considered moderate.	M
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	M
			Effects to socio-economic conditions are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to enhance local economic benefits and preserve socio conditions.	M
Conflicts with trap line operations.	HLP, AR, AF	Existing trails and disturbed areas will be used where suitable to minimize environmental effect.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Public consultation with all local communities has been undertaken to notify communities of operations and timing.	Geographic extent considered low. Project area within traditional territories of LSCFN and SFN.	L
	All	Notification will alert trappers and land users to operations and timing.	Magnitude of effects to surrounding communities considered low with implementation of mitigation.	L
	All	Work with local trappers to ensure effects to traplines are minimized.	Reversibility of socio effects considered moderate through implementation of mitigation measures.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	All	Identify work or hazardous areas with signage.	Ecological sensitivity considered moderate.	M
	All	Compensation for loss of income during active mining operations.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	M
			Effects to socio-economic conditions are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to enhance local economic benefits and preserve socio conditions.	M
Accidents/Malfunctions.	All	Training will be provided to all staff on general safety and safe vehicle operations.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Supervisors and emergency personnel on site at all times to address accident/malfunctions.	Geographic extent considered low. Project area within traditional territories of LSCFN and SFN.	L
	All	Safety meetings will be held for all staff at the beginning of each work assignment period.	Magnitude of effects to surrounding communities considered low with implementation of mitigation.	L
	All	Medical equipment and trained	Reversibility of socio effects considered moderate through implementation of mitigation	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		personnel will be on site 24 hours a day during operations.	measures. Ecological sensitivity considered moderate.	 M
	All	Occupational health and safety standards will be enforced for all personnel on the site.	Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
	All	Consumption of alcohol and 'recreational' drugs will not be allowed on site. Employees will be required to undergo drug testing.	Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	M
	All	Emergency Response Plan will be implemented as necessary.	Effects to socio-economic conditions are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to enhance local economic benefits and preserve socio conditions.	M
	All	Employees will be eligible for Workers Compensation.		
	AR, AF	Transportation crews will be instructed on traffic safety. Traffic will be controlled on mine access road. Communication and notification of hazardous materials transport to the site.		
	AR, AF	Vehicles will be equipped for winter travel and will carry emergency first aid kits.		
	AR, AF	Posting of warning signs on the highways and access road.		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	AR	Freegold Road bypass directs traffic away from Village of Carmacks residential areas to minimize traffic accidents.		
	All	Project engineering designs with appropriate factors of safety, containment systems, and redundant systems to minimize accidents and malfunctions.		
	All	Monitoring and maintenance programs to ensure facility and worker safety and equipment integrity.		
Economic impacts.	A, D	Public consultations will allow people to voice economic concerns about the program.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	A, D	Economic concerns have been discussed during public consultations.	Geographic extent considered low. Project area within traditional territories of LSCFN and SFN.	L
	A, D	Benefits Agreement will be negotiated with local First Nations.	Magnitude of effects to surrounding communities considered low with implementation of mitigation.	L
	A, D	When possible, local individuals and companies will be preferentially hired for the program.	Reversibility of socio effects considered moderate through implementation of mitigation measures.	M
			Ecological sensitivity considered moderate.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
			Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M
			Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	M
			Effects to socio-economic conditions are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to enhance local economic benefits and preserve socio conditions.	M
Social effects.	All	Public consultations will allow people to voice social concerns about the project.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Economic Benefits Agreement will be negotiated with LSCFN.	Geographic extent considered low. Project area within traditional territories of LSCFN and SFN.	L
	All	When possible, local individuals and companies will be preferentially hired for the project.	Magnitude of effects to surrounding communities considered low with implementation of mitigation.	L
	All	Consumption of alcohol and 'recreational' drugs will not be allowed on site. Employees will be required to undergo drug testing.	Reversibility of socio effects considered moderate through implementation of mitigation measures.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	All	Occupational health and safety standards will be enforced for all personnel on the site.	Ecological sensitivity considered moderate. Economy and social effects to community and society considered moderate. Trapping in the area, limited cultural use in project area.	M M
	All	Traditional land use activities (excluding hunting) will be permitted when they do not compromise site safety.	Risk characterization low to moderate with low hazard assessment; very low exposure assessment; and low –moderate consequence assessment.	M
	All	Employee transport from workplace to mine site.	Effects to socio-economic conditions are not considered significant with implementation of identified mitigation measures. Mitigation measures designed to enhance local economic benefits and preserve socio conditions.	M
	All	Western Silver will work with YG, Village of Carmacks, and LSCFN to ensure that measures are undertaken to ensure that local infrastructure and accommodations are planned, and social programs (health, education) are augmented.		
	All	Western Silver will work with YG highways to ensure that the Freegold road is maintained and community bypass constructed to coincide with project development.		
	All	Western Silver will participate in local meetings and information sessions, and take other appropriate steps to promote consultation and		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		communication with the community. The company will actively consult in an ongoing manner with communities, individuals, groups, and stakeholders, so that local people are kept informed regarding project activities.		
	All	Western Silver will ensure that subcontractors agree to the company's commitments and policies for employment of northern residents.		
Impairment of visual aesthetics by mining operations.	All	Project area will not be visible from public roads.	Proposed duration of project is moderate (10-25 years). Effect considered moderate.	M
	All	Equipment and infrastructure will be removed at end of program. Garbage will be regularly collected and removed from site.	Geographic extent considered moderate (170.5 ha).	M
	All	A reclamation and revegetation plan will be finalized for the project. Revegetation using indigenous flora for AR, AF, HLP, and WR where native vegetation has been removed or destroyed. Natural revegetation of the roads, leach pad, and waste rock area will be promoted.	Magnitude of effects to surrounding environment considered moderate, with the implementation of identified mitigation measures. Ecological sensitivity considered moderate. Terrain and soils community with good ecological fitness and a high degree of resilience.	M M
	All	All equipment and refuse will be removed or buried by the end of the project.	Effects to landscape are not considered significant, with the implementation of identified mitigation measures.	M

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
EFFECTS OF THE ENVIRONMENT ON THE PROJECT				
Extreme climatic conditions can cause process upsets	HLP, AF	HLP, events pond and facilities designed to retain and store excess precipitation events and 100 year snow melts. Redundant systems in place to ensure solution pumping and power systems operational during extreme events	Project planning and design incorporates cold climate and freezing conditions. Heap leaching a known technology during cold conditions. Redundant systems and equipment in place for cold climate conditions. Camp accommodation and key personnel available on site. Environmental effects on operations will be low – moderate with implementation of mitigation measures	L-M
	HLP, AF	Onsite fuel storage and back up power generators to ensure pumping and process systems operational.		
	HLP, AF	Spare parts and equipment to ensure equipment failures are replaced and repaired and ensure continued solution processing.		
	HLP, AF	Sediment ponds and other water management structures designed for extreme events (10 yr return period 24 hr duration storm)		
	HLP, AF	Trained personnel onsite to maintain redundant systems during emergency situations.		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
	HLP, AF	Monitoring of HLP solutions inventory and climatic conditions to forecast solution storage requirements.		
	HLP, AF	Contingency water treatment system in place if controlled release necessary.		
Unusually cold weather	AF, HLP	Heap leaching proven technology in winter conditions. Sulphuric acid heap leach an exothermic reaction and produces heat. Redundant systems in place as contingency measures. Facilities and equipment design has been previously proven and personnel are trained to work under Arctic conditions.	Project planning and design incorporates cold climate and freezing conditions. Heap leaching a known technology during cold conditions. Redundant systems and equipment in place for cold climate conditions. Camp accommodation and key personnel available on site. Environmental effects on operations will be low with implementation of mitigation measures	L
Reduced visibility due to winter storms and blowing snow can restrict access to or from the site.	AR	Government of Yukon is expected to maintain the Freegold Road year-round.	Environmental effects on operations will be low with implementation of mitigation measures.	L
	AR	Snow clearing equipment will be available on site to maintain mine access road.		
	All	Radio telephone or satellite phones will be on site to ensure communications links.		
	AF	Trained first aid staff will be on site at		

Potential Environmental Effects / Issues	Project Component*	Mitigation Measures	Significance Assessment with Mitigation (Summarized for each Potential Environmental Effects/Issues Grouping)	Significance Ranking VL=very low L=low M=moderate H=high VH=very high
		all times during operations.		
	AF	Scheduled changes and alternative delivery methods (aircraft) will be implemented in case environmental changes affect usability of the winter access.		

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix L

Spill Contingencies and Emergency Response Plan



WESTERN SILVER CORPORATION

CARMACKS COPPER PROJECT
YUKON TERRITORY

SPILL CONTINGENCY AND EMERGENCY RESPONSE PLAN

May 2005

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1.0 INTRODUCTION

The Carmacks Copper operations consist of an open pit copper mine, heap leach pad, copper recovery process plant and related ancillary facilities, and waste rock storage area. Due to the nature and layout of the operations, all storage areas have been designed for spill containment and control with runoff control facilities, liners, containment diking or concrete flooring of the plant itself.

The purpose of the Spill Contingency and Emergency Response Plan is to minimize spill potential through design features (such as secondary containment impoundments), the establishment of procedures for storage and handling of material, and to enable a quick and efficient response in the event of a spill. This plan, which has been patterned after that of the Brewery Creek Emergency Response Plan, has been developed using industry and regulatory approved handling, storage, containment, response and notification procedures.

The procedures outlined in this plan are designed to protect the health and safety of mine personnel and the public, to minimize adverse effects to wildlife, and to help ensure that waters of the Territory will not be degraded. The Carmacks Copper Spill Contingency and Emergency Response Plan is designed to cover the operations area and the access road into the site. However, the company will also respond, if requested, to any incidents between Whitehorse and the Freegold Road turnoff, but will assume no responsibility for the incident outside this defined response area.

This Spill Contingency and Emergency Response Plan accounts for facility design, construction, operation and maintenance. This document is designed to highlight the elements of the Carmacks Copper Spill Contingency and Emergency Response Plan and associated procedures.

The Spill Contingency and Emergency Response Plan will be maintained in the following locations:

- Mine Manager Office;
- Administration Offices (i.e. Safety offices);
- Departmental Superintendents Offices;
- Environmental Coordinators Offices;
- First Aid Room; and
- Ambulance.

In addition, copies will be issued to:

- Little Salmon Carmacks First Nation (LSCFN);
- Village of Carmacks;
- Carmacks RCMP;
- Whitehorse General Hospital;
- Environment Canada Spill Centre;
- YG Department of Environment, Water Resources Branch;
- YG Department of Environment, Environmental Affairs;
- YG Energy, Mines and Resources, Minerals Development Branch; and

- YG Energy, Mines and Resources, Client Services & Inspection Branch, Village of Carmacks Natural Resource Officer.

A variety of heavy equipment, suitable for contingency use during a hazardous spill, will be on site at different phases of the operation. An Equipment Inventory will be kept updated for efficient relocation of heavy equipment required for spill response. The On-Scene Coordinator (OSC) and Spill Contingency and Emergency Response Team (ERT) will have a current list of available heavy equipment.

Typically, bulldozers, backhoes, excavators, and other equipment will be located at various locales throughout the mine site and the access road and will be available for spill contingencies on a site-specific basis.

Maps of the Contingency Plan Area covered by the final Spill Contingency Plan will be prepared. Potentially affected watercourses will be highlighted on the topographic maps. Important strategic items for a spill response (heavy machinery, sorbents, safety items, etc.) will be localized at fuel or chemical storage areas during construction and will be relocated as construction progresses. During operations, permanent storage locations will be situated for minimum response times. Refer to Appendix A for a map that shows the general arrangement of the site with material storage locations.

The only solid materials requiring special containment are lime and cobalt powder; liquid materials include SX/EW reagents (including sulphuric acid), kerosene, gasoline, diesel fuel, propane, varsol, and ethylene glycol. Storage facilities will be designed with adequate containment and response facilities to rapidly clean up any spills. Loading and transport protocols will reduce the possibility of spills occurring during shipment. Full design details of quantities of hazardous materials to be handled and stored are presented in the Feasibility Study completed by Kilborn (1994).

Transportation to the site from Alaska or British Columbia (B.C.) will follow all transportation regulations for Alaska, B.C. and the Yukon Territory. Any spills on site or during transport will follow the general procedures presented in the spill plan. Transport of sulphuric acid from Skagway to the mine site will require the storage of neutralizing agents such as bicarbonate or a slaked lime/soda ash mixture and sorbents at various department of highways stations along the route (i.e. Carcross, Whitehorse, and Carmacks). In addition, liquid bicarbonate will be stored at the stations to treat acid spills in adjacent waterways. Contractors will be identified for emergency response and an emergency response team will be trained.

2.0 SECURITY

The Carmacks Copper Mine will have an active security/safety system. All in-coming traffic will enter the plant site area first and will be required to sign in. Visitors will be directed to the administration offices and equipment and supplies will be directed to the warehousing or cold storage receiving areas. All trucks and vehicles delivering chemicals, fuels, etc. will be inspected for leakage and integrity when entering the Carmacks Copper property. The inspection will be performed by warehouse personnel with the assistance of maintenance personnel when requested. The inspection will include:

- Cargo inspection, quantity and quality against way bills and bills of lading;
- Checks for any visible leakage; and

- General condition of the vehicle and equipment.

Routine patrols of the property, including the waste rock storage area and explosives magazines will be carried out on a daily basis either by foot or by vehicle. All pump stations and process control points will be equipped with adequate lighting or area and yard lighting to prevent vandalism and to allow detection of spills or leaks. Primary facilities will be secured or equipped with locks (i.e. valves or pump starters).

The Carmacks Copper Mine security system will prevent accidental or intentional entry to the plant that might result in vandalism, theft, sabotage or other improper or illegal use of facilities that could possibly result in an incident.

3.0 TRANSPORTERS

Transporter Qualifications

Transporters will be carefully selected, and are required to have Department of Transport certification, acceptable spill response programs, hazardous materials safety and handling procedures (including material safety data sheets [MSDS]), and driver training programs. Each approved transporter will be periodically reviewed to assure that they continue to carry valid Department of Transport certification.

Delivery Scheduling

The potential for spills will be minimized to the extent possible by scheduling deliveries to avoid any regular or temporary congestion that may occur along routes leading to Carmacks Copper project. Transporters will be required to advise the operations of any delays or schedule changes that occur. Deliveries will be timed during daylight hours to coincide with warehousing hours and to minimize offloading problems.

Regulatory Compliance

Transporters making deliveries to Carmacks Copper operations will be required to follow all federal and territorial Department of Transportation regulations for the transportation of dangerous goods, as defined in the Transportation of Dangerous Goods Act (TDGA). This will include all placarding, packaging, manifests, etc.

Response Outside Territory

The transporters or contact carriers will implement their response plan. The Carmacks Copper OSC will be notified as a courtesy and kept informed of the success of the cleanup.

Response Inside Territory

Carmacks Copper's Spill Contingency and Emergency Response Plan is designed to cover the operations area and the access road into the site. However, the company will also respond, if requested, to any incidents between Whitehorse and the Freegold Road turnoff. The transporter or other agency (i.e. RCMP) who is first made aware of the emergency will be required to notify the territory emergency response office. If the Carmacks Copper operations

are informed of the incident, the OSC may then direct the ERT to the scene if requested, although Carmacks Copper will assume no responsibility for the incident beyond their defined Response Area.

Response Access Road and Operations Area

The Carmacks Copper's Spill Contingency and Emergency Response Plan is designed to respond to spills or an emergencies which arise at the site or along the access road from the Mt. Freegold Road turnoff to the site. The transporter or mine personnel who is first made aware of the emergency will be required to notify the OSC. He/she will then immediately coordinate the clean-up operations and direct the ERT to the scene.

4.0 RELEASE/SPILL PREVENTION AND CONTAINMENT

Release prevention measures centre around proper design, inspection, and maintenance procedures. The leach pad and events pond at Carmacks Copper are designed as zero discharge facilities under all normal and extreme operating conditions; all process solutions are either contained within the events pond or process fluid management system for re-circulation.

A perimeter diversion system consisting of a lined ditch and raised access road has been included in the design to direct all clean runoff away from the heap leach pad and to direct all extraneous runoff from the heap into the heap events pond. The general arrangement includes a 5.0 m wide lined barren solution ditch between the heap perimeter toe, with the heap synthetic and soil liner ramped up onto a 1m high outer dike. Outside of the dike is a 5.0 m wide running course and a runoff collection ditch.

Runoff from the plant site area will be directed to a plant site sedimentation pond, located downslope of the plant site, heap leach pad and events pond.

Runoff from the waste rock storage area will be intercepted by a perimeter ditch and directed to a stilling pond located at the eastern end of the stockpile. This pond also serves as a source of plant make-up water.

Any release from the plant site sedimentation pond and waste rock storage area stilling pond will enter Williams Creek once it is determined that effluent criteria are met.

4.1 LEACH PAD AND EVENTS POND

The leach pad has been designed such that any catastrophic release of process fluids would be contained within the events pond.

4.1.1 Liner System

The entire heap leach area will be lined. The heap leach pad will be equipped with a double synthetic geomembrane liner system overlying by a low permeability soil liner, and incorporates a leak detection and recovery system (LDRS).

The primary and secondary liners will be separated by a HDPE geonet LDRS. A high level of QA/QC will be employed during liner placement ensuring liner integrity.

Any seepage collected by this system will be pumped back to the heap storage. In addition to the geonet leak detection system, the entire heap leach pad below the secondary soil liner will be equipped with foundation drains, which are located in natural draws within the heap leach pad area. This secondary drainage system, which is designed to provide drainage and pore pressure relief for groundwater generated by thawing permafrost, terminates in the events pond and acts as a secondary LDRS. Consequently, minimal contamination to the groundwater is expected since any seepage through the primary leak detection system and any seepage picked-up by the foundation drains will be directed to heap or events pond storage.

The events pond is also equipped with a double synthetic geomembrane liner separated by its own geonet LDRS, independently equipped with a pump-back recovery system. Any seepage that escapes the LDRS and the foundation drainage system, if any, is expected to be extremely minor. Any water below the heap will migrate down gradient toward the events pond, the mine site sediment control pond, and then to Williams Creek.

4.1.2 Leakage Rates

Seepage rates through the outer liner from the heap leach pad have been estimated to be in the order of 0.1 m^3/day when applying a contact coefficient of 0.21 for the liner moulding and 0.5 m^3/day when using an extremely conservative coefficient of 1.15. Even if these seepage rates could not be intercepted by the fountain drains, they would have little or no impact on regional groundwater quality and were found to be too small to project impacts on Williams Creek water quality. Seepage through the liner and seepage collection systems would be minor, given that the active layer is relatively restricted and shallow. If localized groundwater was adversely affected, measures could be implemented to intercept this water within the draw down-gradient of the heap leach pad for pump-back or treatment, as required.

4.1.3 Events Pond Capacity

Normally, solution will flow directly from the heap to the plant. When there is a high-rainfall or high-precipitation event, or when the plant cannot accept solution, the flow can be directed from the heap to the events pond. The events pond will have a capacity of approximately 160,000 m^3 to store the following combinations of events:

- The operating solution volume, plus
- Excess runoff inflows from the critical duration 100-yr return period event occurring at the most critical point in time, plus,
- An allowance for heap draindown as follows:
    - During the first year of operation, 100% of the total potential heap draindown volume, or
    - During subsequent years of operation, 48 hours of draindown at the full rate of solution application. For a solution application rate of 540 m^3/hr this volume is 26 000 m^3; and
- Redundant systems (i.e. pumps, power, spare parts).

The total available solution storage volume of 160 000 m^3 will provide storage for 100% of the total potential draindown volumes in the winter months. This volume is calculated to be 22,000 m^3 more than the maximum required solution storage volume (Clearwater Consultants Ltd., 1998). At the start of the winter season and until the start of the snowmelt every year, the

events pond will be empty thereby ensuring that the full solution storage capacity of the system is available during the winter and in advance of the annual snowmelt. Therefore, 100% of the total potential draindown volume may be stored in the winter at all times throughout the mine life for all precipitation conditions.

4.1.4 Emergency Response

If monitoring reveals that the volume of water in the LDRS has increased but the quality is uncontaminated, the sources of water would be from below the heap leach pad and no immediate action would be required. If the quantity increases and the quality deteriorates by more than 50% of normal (e.g. copper concentrations or sulphate concentrations double), the source of seepage would be from the heap leach pad and would be a confirmed leak and action would be required immediately to intercept this water at source. Action would be to immediately increase the amount of pumping and seepage withdrawal to the heap storage to ensure that there is minimal hydraulic head on the outer liner and to increase the amount of monitoring of the foundation drains. The location of the leak would be determined from specific LDRS monitoring locations and heap application in that area would be restricted.

The specific "action level trigger" would be changes in total copper concentrations since this analyses would be done routinely by AAS at the site laboratory where quick turn around times can be expected.

If monitoring reveals that the volume of water in the foundation drains has increased but the water is uncontaminated, the source of water would likely be from groundwater and no immediate action would be required. If the quantity of water in the foundation drains increases and the quality deteriorates by more than 25% of normal, the source of seepage would be from the heap leach pad. This would again be considered a confirmed leak and immediate action would be required to intercept this water at source. Since the foundation drainage network reports to the events pond, depending on the volume of seepage, action would be to pump this water to the mill raffinate treatment system for neutralization or depending on quality, back to the mill pregnant solution system.

In the event that there was a major rupture of both primary and secondary liners, the volume of leakage could outpace the ability of the seepage recovery systems. Under such circumstances, all operations would have to be immediately suspended and Spill Contingency and Emergency Response Plans implemented immediately. Action would require the excavation of cut-off trenches below the heap leach pad and the installation of pumping equipment to intercept groundwater flow below the events pond and the pumping of ground water to the events pond and raffinate treatment system.

4.2 PIPELINES/SOLUTION COLLECTION DITCHES

Pipelines between the leach pad, events pond and process plant are either buried or located in ditches lined with synthetic geomembrane. Solution collection ditches are graded, so that in the event of a pipeline leak, solution will flow to either the in-heap solution pond or the events ponds.

In the event of a major pipeline rupture, temporary berms or dikes will be constructed using earthmoving equipment to contain releases until emergency pumps can be mobilized to return

the process fluids to the processing circuits. Damaged portions of the fluid management system will be shut down until they can be satisfactorily repaired and tested.

4.3 FUEL STORAGE AND HANDLING

Fuel storage areas will be lined with an impermeable geomembrane and bermed or set on concrete foundations with berms. Design of these areas will follow both the Gasoline Handling Act under the Yukon Government and the Canadian Council of Ministers of the Environment (CCME) guidelines. The bermed area will be sized to accommodate 110% of the largest tank volume. All tanks are located above ground and are visually inspected on a regular basis for leaks, damage or unusual conditions. The berms and liners will also be inspected on a regular basis. Any leaks or other damage will be reported to the Plant Superintendent, who will ensure that necessary repairs are completed in a timely manner.

Diesel Tanks – Service Complex

The mine will use diesel-powered trucks and various diesel-powered items of surface equipment. The diesel fuel tank will be a steel, above ground vertical tank with a 190 m^3 capacity. There will be room within the lined, bermed storage area for an additional tank in addition to 110% capacity and 300 mm of freeboard. Diesel will be transported into the site from Whitehorse via a 42,000 L capacity B-train haul truck. The following controls will be incorporated.

- The tanks will be located in bermed areas with a concrete base and concrete curbs. The preferred strategy will be to operate each tank independently, and consequently the containment volume would be 110% of the volume of the largest tank. However, if the final design incorporates the more flexible operation of tanks in parallel, a worst-case scenario will be assumed and the containment volume will be designed to accommodate the total volume of all tanks.

- The containment foundations will be designed by geotechnical engineers.

- The bottom of the containment area will be sloped slightly so that spilled material will drain toward a corner sump where the material can be reclaimed.

- A drain valve will be installed through the berm wall adjacent to the sump to allow for periodic drainage of precipitation. A locking system incorporated in the valve will ensure that the valve is not left open inadvertently.

Gasoline Storage Tank

A gasoline tank will be provided in the service complex fuel storage area along with the diesel tanks and the waste oil tank. The gasoline fuel tank will have 38 m^3 capacity. The spill control measures outlined for the diesel storage area will also apply to the gasoline tank.

Flammable Materials Storage

A lockable, fireproof cabinet will be installed in the laboratory to isolate the small quantities of flammable materials that are normally used in analytical laboratories. This is a standard safety practice at other operating mines, which in addition to deducing fire hazard is designed also to

prevent spillage of these materials and to confine any cleanup operation within the laboratory building.

Small quantities of flammable materials for use in general operations will be stored in the warehouse. A fireproof cabinet will be installed in a designated area of the warehouse, to minimize spillage of these materials and to facilitate cleanup.

4.4 ACID PROCESSING REAGENT STORAGE

Sulphuric acid will be stored on site in two insulated, carbon steel, 10 000 mm x 8,500 mm tanks, providing 2,500 tonnes of storage. The tanks will be placed in a lined containment dike with a 110% capacity. Kerosene will be stored in a 4,100 mm x 5,000 mm tank outside of the warehouse in a lined containment with a 110% capacity. The organic solvent will be stored in 45 gallon (200 litre) kegs in the warehouse in the area designated for solvents and degreasers. Guartec and cobalt sulphate powder will be stored in 25 kg bags on pallets in the warehouse. Lime powder will be stored in a 75 tonne silo within a lined containment dike adjacent to the Solvent Extraction building. All chemicals will be kept separate to avoid reactivity in the event of a spill.

4.5 LUBRICANTS, OILS, SOLVENTS AND DEGREASERS

Lubricants, oils, solvents and flammable materials will be stored in the warehouse or maintenance shop. Storage and dispensing of bulk delivered lubricants and solvents in the shops will be done through a well engineered, integrated system that has been developed and used at other major mine sites. This system, which is designed to minimize and control spillage, will consist of the following components:

- Bulk storage tanks for lubricants and solvents will be located outside the pit shop in a concrete bermed storage area. Smaller day tanks will be located inside the pit shop and will incorporate standard spill control measures.
- All liquids will be piped directly to the area in the shop where they will be used. As a result of the direct piping of liquids to the point of use, the manual transfer of liquids in small containers will be minimized. This will reduce the spillage and fire hazards associated with the use of open vessels of petroleum products.
- Sight glasses will be located on each tank to indicate the liquid level in the tank. Appropriate filling techniques and schedules can then be used, which will eliminate spillages from overfilling the tanks.
- The simplicity of this overall system will encourage a clean and safe working environment, which in turn will reduce the risk of spills within the mine site area.

All solvents and degreasers delivered in small containers will be stored inside the cold storage area. Incoming container trucks will report to the warehouse personnel, where new containers will be offloaded and empty containers loaded on returning trucks.

The following will be incorporated in the design to minimize the impact of minor spills and to allow an orderly cleanup.

- The storage of these materials inside a building will prevent accidental spillage or puncture of the containers from vehicle traffic or other mine activities.

- The cold storage and warehouse will have a concrete floor to confine any spilled liquids. In the area of the stored liquids, the floor will be slightly sloped toward a small sump designed to contain spills and allow them to be cleaned up.
- A separate area will be defined for the storage of solvents and degreaser materials, away from the general materials in the warehouse. Areas designated for storage of solvent and degreaser materials will be surrounded by a concrete curb. Concrete roll curbs will be installed to allow access by forklifts. The compatibility of materials for storage in a common area will be determined and, where necessary, additional intermediate berms will be installed to isolate and separate incompatible materials.
- Clear labels for each area will declare the type of material stored. WHMIS labels will be posted as appropriate, to ensure that materials are handled safely and that correct methods are used to clean up any spilled materials.

This overall berming strategy will ensure that any spillage is confined inside the building, and will eliminate the potential problems of minor spills seeping into adjacent ground with attendant cleanup difficulties.

5.0 INSPECTION AND MAINTENANCE

A regular inspection and maintenance program for all elements of the barren and pregnant solution management system will be followed to ensure systems are operating properly and are maintained in good condition. In the event of a release of process solution from any portion of the fluid management system, the plant operators will, as soon as possible, shut down the portion of the process circuit where the release is occurring to stop the release of process solutions. The fluid management system will be thoroughly inspected, and measures to abate the release and prevent spread of solution will be initiated as soon as possible.

Process plant and mill facilities such as pipelines, tanks, and pumps will be inspected regularly for leaks, deterioration or other damage.

Inspection of storage facilities will be completed on a regular basis. Materials in the warehouse or cold storage area will be routinely checked by personnel. The inspection included checking for visible signs of leakage, checking containers for any sign of weakness, tearing or rupturing and checking for cracks or breaks in containment berms. Any observed problem will immediately be reported and repaired.

Good housekeeping practices will be employed at all times during the handling of chemicals and reagents. Dry chemicals are stored in sealed containers or pallets or above ground in bins or silots to prevent water infiltration. Incompatible materials, such as acids and bases, are stored in separate areas. All empty chemical containers are disposed of appropriately.

Solution fluid levels in tanks and the events pond throughout the leach system will be monitored daily.

Routine monitoring of leak detection and recovery systems for the leach pads, solution collection ditches, solution ponds, and solution tanks and the regular schedule of inspection and maintenance of other process components provide early detection of releases occurring from these units.

6.0 OPERATING PROCEDURES

Operating procedures relate to on-site movement and use of chemicals, and monitoring of fluid containment areas. Employees involved in chemical handling will receive WHMIS and TDGA training and instruction on safe work practices. This will include:

- Driving vehicles (trucks and forklifts) carefully to avoid collisions or ruptures to storage containers and pipelines.
- Making sure there is adequate clearance when positioning a truck or equipment adjacent to storage or distribution points.
- Checking to ensure all pallets or containers are securely placed when transporting and storing, to prevent tipping and spilling.
- Proper dispensing of fuels and other motor vehicle fluids (including dipping tanks before filling).
- Locations of storage and use areas for chemicals and solutions.
- Employees assigned to areas in which chemicals are utilized, receive personal instruction and task training to promote and ensure safe chemical work practices.

7.0 ORGANIZATION AND RESPONSIBILITIES

A structured organization will be created for contingency planning and spill response. Preparations will include clear definitions of responsibilities in the event of a spill. The OSC and back-ups will be designated in the final Spill Contingency and Emergency Response Plan.

During construction and operational phases of the Carmacks Copper Project, a designated OSC who is a member of the Spill Response Team will be on site at all times. The OSC will have the prime responsibility of coordination and directing control efforts at the scene of a spill incident. The duties of the OSC are outlined below and will be assumed by the Project Manager or other senior management personnel.

The OSC will contact the Construction Supervisor, the Environmental Supervisor, and the First Aid Supervisor to relay details of the spill incident. The OSC will notify the appropriate authorities and submit the required reports, including all relevant details of the spill.

The Construction Supervisor will indicate the deployment of available equipment to facilitate containment and clean-up functions. He or she will be responsible for procuring off-site contractors or additional equipment as required.

The Environmental Supervisor will assess the impact of the spill on the environment and direct the actions needed to reduce further impact. The Environmental Supervisor will determine and supervise the institution of appropriate disposal techniques and restoration measures in cooperation with government representatives.

The First Aid Supervisor will ensure that personnel involved with spill containment and clean up are outfitted with proper safety equipment. In addition, clean-up personnel will be advised of the possible hazards and proper clean-up procedures for the spill.

All on-site personnel will receive training in spill response procedures, materials hazards, and local biophysical constraints. Special training will be provided to truck driving personnel, road

maintenance personnel, freight handlers and load-out operators, and others most likely to be present at a possible spill.

The detailed contingency plan will be kept in a loose-leaf binder with tabbed sections so that information is easily accessible and can be updated as operations progress. This manual will contain the response organization, action procedures, environmental mapping, resource inventory, training, hazardous materials information and supporting documentation. In addition, training and exercises in the form of mock spills will be undertaken to ensure that individuals know their responsibilities, spill response, action plan, where and what type of clean up equipment can be obtained.

Responsibilities of the On-Scene Coordinator

Specific responsibilities of the OSC include:

- Becoming familiar with all aspect of the contingency plan for which he/she is responsible;
- Becoming familiar with potential spill situations within the project area and applicable techniques for confinement, recovery, and restoration;
- Establishing liaison with various government authorities and industry in the area;
- Ensuring the training of personnel in spill clean-up procedures;
- During a spill, directing the acquisition and employment of resources for containment, clean-up, disposal, and restoration;
- Collecting any required samples for analysis;
- Preparing a report on all aspects of the spill; and
- Providing a focal point for incorporating the concerns of the public and government agencies into the counter-measures taken to deal with a spill.

At the Carmacks Copper Mine, any person witnessing a serious injury, fire, chemical spill or serious incident will be charged with the responsibility for immediately advising the OSC. This requirement and responsibility will be conveyed to all new employees through the orientation and environmental awareness training. All communications for mine-site emergencies will be coordinated through the OSC. Depending on the emergency (serious injury, fire, chemical spills, serious incidents) the following people will be notified:

- On-Scene Coordinator;
- Mine Manager;
- Safety Officer;
- Mine Superintendent;
- Plant Superintendent; and
- Environmental Supervisor.

An Emergency Phone Numbers list will be compiled and include the numbers of:

- the On-Scene Coordinator and alternates;
- the Construction Supervisor;
- the Environmental Supervisor;
- the First Aid Supervisor;
- the construction camp and/or Mine Operations;
- Yukon Spill Line;
- helicopter company;

- regional and central Territorial Emergency Program;
- regional RCMP;
- regional General Hospital/Nursing Station;
- regional Fire Department;
- poison Control Centre;
- CANUTEC (Canada Transport Emergency Centre);
- Village of Carmacks;
- LSCFN office;
- YG Department of Environment, Monitoring and Inspections Section;
- YG Environmental Protection Branch;
- YG Department of Environment, Water Resources Branch;
- YG Energy, Mines and Resources, Minerals Development Branch; and
- YG Energy, Mines and Resources, Client Services & Inspection Branch, Village of Carmacks Natural Resource Officer.

Once these positions have been filled, the emergency response plan will be amended to include the person's name and home phone number. Some of the contact phone numbers are provided in Table 1.

Table 1 Spill Related Resources and Contact Numbers

Resource	Contact Number
Yukon Spill Line	**(867) 667-7244**
Village of Carmacks	**(867) 863-6271**
Fire Department – Carmacks	**(867) 863-6709**
Police – Carmacks	**(867) 863-5555**
Hospital – Whitehorse	**(867) 667-8700**
Fire Department – Whitehorse	**(867) 668-8699 or (867) 668-2462**
Police – Whitehorse	**(867) 667-5555**
Access Consulting Group (Environmental Consultant)	**(867) 668-6463**
YG Department of Environment, Water Resources Branch	**(867) 667-3227**
YG Environmental Protection Branch	**(867) 667-3436**
Little Salmon Carmacks First Nation	**(867) 863-5576**
YG EMR, Village of Carmacks Natural Resource Officer	**(867) 863-5271**

The ERT will include members that have received St. John Advanced First Aid training, WHMIS and TDGA training, specialized hazardous materials response training, fire fighting training, and production or facility operators that have specialized knowledge. Members of the ERT, Safety Officer, Plant Superintendent, and Mine Superintendent, will stand by to assist the emergency response agency(s) and offer the benefit of their special knowledge of the facility and its

contents. A well-stocked first aid treatment room and ambulance will be also be available on-site.

Any employee affected by exposure to a hazardous materials release or spill, that may require medical attention, will be transported to Whitehorse. This is the nearest medical facility that can provide appropriate treatment and/or evaluation of chemical related injuries. A copy of the appropriate WHMIS and MSDS, which includes emergency medical and/or first-aid treatment, will accompany the affected person(s) to the hospital. The first aid room and ambulance will be provided with a complete copy of the Carmacks Copper Spill Contingency and Emergency Response Plan prior to production beginning at the mine.

8.0 PETROLEUM PRODUCT SPILLS

Spills and leaks are addressed herein.

A, **"spill"** is defined as:

> "Petroleum product or lubricant which is poured, spilled, or pumped onto the ground or into water, by faulty conveyance or transfer, overturned vehicles or equipment, or through human error or negligence."

Severity rating:	Non-Reportable – Less than 100 litres*
	Minor – More than 100 litres and Less than 400 litres
	Major – More than 400 and Less than 1,000 litres
	Emergency - More than 1,000 litres

*If a spill is less than 100 litres and has not entered a watercourse, the Owner and/or operator do not have to report the spill.

A **"leak"** is defined as:

> "Passing of a petroleum product through a breach, tear or puncture in a container, or receptacle at a rate of less than 10 litres per minute."

Please find a table of reportable spills for various substances in Appendix B.

9.0 REPORTING PROCEDURES

The following two levels of reporting is required by any individual who locates a spill or leak:

Report to a Supervisor: Refers to the direct supervisor in charge of the individual who located the spill or leak.

and,

Report to the Owner: The Owner shall immediately be given details of any leak or spill. It is the Owner's responsibility to ensure protection of human health and safety, provide directions to stop or contain spills, and report the spill (if necessary, see severity rating and notes above) to affected agencies prior to investigating the spill themselves.

Affected Agencies: Affected Agencies shall all be contacted through the 24-hour emergency spill response line at ***(867) 667-7244***. Affected parties may include organizations associated with fuel supply and transport companies. All of the major suppliers in the Yukon are members of TEAP, or the Transportation Emergency Assistance Plan. One of the responsibilities of this organization is the sharing of resources, consumables, equipment, and personnel in the event of a spill.

The following information shall be conveyed to the affected agencies through the 24-hour Emergency Spill Response Line. This information should be documented on the "Spill Reporting Form" provided in Appendix C.

- Location of the Spill or Leak
  - Nearest community, town, highway, major water body, kilometre location on highway if known etc.
- Time of Spill
- Severity of Spill or Leak
  - Minor – more than 100 litres and less than 400 litres
  - Major – more than 400 litres and less than 1,000 litres
  - Emergency - more than 1,000 litres
- Type of Spill
  - Total loss/leakage
  - Overturned vehicle or tanker (plus name of transport company)
  - Ruptured tank
  - Lost drum
- Product Spilled
  - Diesel Fuel (Identify Grade)
  - Gasoline
  - Lubricant (Identify Grade)
  - Other (Identify)
- Nearest Watercourse
  - Identify by name and description the nearest watercourse, pond or lake, with an approximate distance to the spill.
  - Describe the soils conditions and direction of probable flow for the spilled product.
- Potential to enter surface water
- Fire Hazard
- Hazard to life and limb, injuries
- Environmental effect expected, if any
- Equipment and clean-up consumables on hand

Response by Affected Agencies depends upon the location of the possible spill and will vary. However, they will be coordinated by phoning the Emergency Response Spill Line ***(867) 667-7244***. For the purpose of this Plan, it is recommended that only one call be made to government or other agencies using the 24 hr spill line.

Other affected parties may include organizations associated with fuel supply and transport companies or local First Nations. Most major suppliers in the Yukon are members of the Transportation Emergency Assistance Plan (TEAP). One of the responsibilities of this organization is the sharing of resources, consumables, equipment and personnel in the event of a spill. The transporter is responsible for contacting TEAP in the event of a spill.

The Canadian Transport Emergency Centre (CANUTEC), a branch of Transport Canada, can also be contacted for 24 hr technical advise on Dangerous Goods, as needed. The CANUTEC – help line for dangerous goods is **0 (613) 996-6666 (collect)**.

10.0 EMERGENCY SPILL RESPONSE PROCEDURE

As outlined in the previous section, any person witnessing a spill will be charged with the responsibility for notifying the OSC. The ERT members and the appropriate people within the mine operation will be alerted and mobilized, as appropriate. These people will ensure the following activities are conducted in a timely manner in the event of a discharge:

Ensure personal and worker safety, if you cannot identify the spilled substance consider it dangerous.

<u>If Personnel Are Injured</u>

- Call for medical help, attend to injured person, and administer first aid if safe to do so.
- Warn / remove bystanders

<u>If Safe (do not enter confined spaces or expose self to fire hazard)</u>

- Stop all sources of ignition and stop or reduce the source flow of the spill
- Shut off all valves
- Shut off all electrical power
- Initiate containment: put down sorbent pads and berm spill area, if possible
- Recover product and contaminated soil / other materials
- Remain at the site and assist with response as needed when help arrives.

<u>If Unsafe</u>

- Initiate evacuation (upgrade or upwind), move to safe area
- Notify Owner
- Report the following: location, initial spill site, possible cause, description of present condition, affecting or about to enter water.
- Isolate area and deny entry until qualified response personnel arrive
- Deny access to all unauthorized personnel
- Update Owner on spill status

At Carmacks Copper, the following procedures are part of the release response policy:

- If it is determined that there is a release outside secondary containment, then the ERT will be called into action and will immediately commence containment and clean up of the spill or release.
- Personal protection equipment is required to be used when responding to a release or spill. The personal protection equipment will be determined by the product specific

Material Safety Data Sheet (MSDS). All precautions that are stated in the MSDS will be followed. Special personal protection equipment will be available for the ERT.

- If the spill is all liquid and outside secondary containment, a pump will be used to place the liquid back into contained area.
- If a spill occurs within a stream or creek, previously approved (by emergency response agencies) booms, absorbents, etc. will be put to use immediately.
- Soil contaminated with regulated material will be removed and disposed of according to the product specific MSDS. Disposal will follow applicable local, territorial and federal regulations and guidelines.

10.1 RESPONSE FOR GASOLINE SPILLS

If in water and if safe to do so:

1. Stop or reduce discharge, if safe to do so, by plugging, uprighting, adjusting valves, or other suitable method.
2. If possible, contain discharge by booming using commercial boom material, logs, or other material at hand.
3. If in rapidly flowing water, direct to quieter backwater using booms to deflect material.
4. Ensure that you have reported the spill.
5. Remove from water by skimming, using absorbents, and collect in suitable container (tanks, drums, plastic lined depression in ground or snow). **See Appendix D for a listing typical spill response tools/equipment**.

NOTE: IN THE EVENT MATERIAL IS SPILLED DURING VERY WARM WEATHER AND THERE IS DANGER OF FIRE DUE TO FUMES, DO NOT ATTEMPT TO CONTAIN PRODUCT ON WATER. ALLOW PRODUCT TO DISPERSE AND EVAPORATE.

6. Dispose absorbents by recycling or incineration if conditions are suitable and after consultation with environmental authorities and/or forestry officials contacted through the Emergency Spill Response Line.

Response for Gasoline Spills (Cont'd)

If on land and it is safe to do so:

1. Stop, or reduce discharge if safe to do so by plugging, uprighting, adjusting valves or other suitable method.
2. Contain spill by diking with earth, snow and ice or other barrier, possible trenching or creating a lined sump down gradient from the spill source.
3. Ensure that you have reported the spill.
4. Remove fuel from containment area with pumps, vacuum equipment and place in appropriate containers. Ensure equipment intrinsically safe (does not have a source of ignition/spark).
5. Absorb residual liquid on natural or synthetic absorbents (e.g. 3M products).
6. Remove contaminated soils in the spill site to an appropriate disposal site if spill located near water supply or stream/river course or for aesthetic reasons.

7. Dispose of contaminated fuel by recycling or incineration. In situ, incineration may be possible if permission granted from environmental and forestry officials contacted through the Emergency Spill Response Line.

10.2 RESPONSE FOR DIESEL SPILLS

If in water and if safe to do so:

1. Stop, or reduce discharge if safe to do so by plugging, uprighting, adjusting valves, or other suitable method.
2. If possible, contain discharge by booming using commercial boom material, logs or other material at hand.
3. If in rapidly flowing water, direct to quieter backwater using booms to deflect material.
4. Ensure that you have reported the spill.
5. Remove from water by skimming, using absorbents, and collect in suitable container (tanks, drums, plastic lined depression in ground or snow).
6. Dispose by recycling or incineration, if conditions are suitable and regulatory authorities grant permission.

Response for Diesel Spills (Cont'd)

If on land and it is safe to do so:

1. Stop or reduce discharge if safe to do so by plugging, uprighting, adjusting valves or other suitable method.
2. Contain spill by diking with earth, snow or ice or other barrier, possible trenching or creating a lined sump down gradient from the spill source.
3. Ensure that you have reported the spill.
4. Remove fuel from containment area with pumps, vacuum equipment and place in appropriate containers.
5. Absorb residual liquid on natural or synthetic absorbents (e.g. 3M products).
6. Remove contaminated soils in the spill to an appropriate disposal site if spill site is located near water supply or stream/river course or for aesthetic reasons.
7. Dispose of contaminated fuel by recycling or incineration. In site, incineration may be possible if permission granted from environmental and forestry officials.

Specific Information for Gasoline and Diesel

Gasoline

Characteristics
- Flammable
- Solubility in water 1 to 100 ppm
- Floats
- Flash point - 38 to -43 C

Human Health
- Moderately toxic by inhalation. Avoid prolonged exposure to fumes

Environment
- Harmful to aquatic life. Fish toxicity: 5 - 40 ppm rainbow trout

Protective Clothing
- No specific recommendations. Protective clothing is required.

Diesel

Characteristics
- Combustible/Flammable liquid
- Insoluble in water (30 ppm)
- Floats
- Flash point 52 to 96 C

Human Health
- Low toxicity by all routes

Environment
- Fish toxicity: 10 ppm rainbow trout; 2 ppm for grass shrimp

Protective Clothing
- Gloves and boots made from neoprene or butyl rubber

11.0 DANGEROUS SUBSTANCES

The substances used or generated at the mine site or to be transported via the Freegold Road and highways are listed below. Each of these products is to be classified according to Federal 1993 *Transportation of Dangerous Goods Regulations* Classification codes:

copper cathode	Exempt
gasoline	Flammable Liquid 3.1
diesel	Flammable Liquid 3.2
ethylene glycol (antifreeze)	N/A – very toxic material
ammonium nitrate (for ANFO)	Oxidizer 5.1
varsol	N/A – Combustible Liquid
propane	Ignitable Gases 2.1
mill reagents:	
- petroleum derived organic	flammable liquid
- Hydrated lime	not regulated
- sulphuric acid	corrosive 8
- cobalt SO_4	unclassified
- guar gum	unclassified
- kerosene	unclassified

Action plans for each of these dangerous goods will be based on published Materials Safety Data Sheets (MSDS) issued by the manufacturer. The action plan for each substance lists potential dangers, the recommended initial spill response, the recommended fire response, recovery protocol, and disposal protocol. Employees who have any potential to come in direct contact with these materials (in particular, sulphuric acid and lime) will be educated in the properties of each chemical, proper handling techniques and personal protection measures.

Sulphuric acid spills may potentially occur: from tankers along the access road to the mine; during transfer from the trucks to the on-site storage facility; from pipelines to the heap leach pad; and from pregnant solution pipelines from the leach pad to the process plant.

Sulphuric acid is a colourless liquid that must be handled carefully with proper protective equipment and adequate ventilation. Ventilation systems must be non-corrosive. When in contact with some metals, sulphuric acid liberates hydrogen gas, which is explosive. Therefore, flames and sparks should not be used in these areas. In the event of a spill, all sources of ignition should be eliminated and the product should be collected for recovery or disposal. Personal safety must come first before attempting clean up. For release to land, or storm water runoff, discharge should be contained by constructing dykes or applying inert absorbent; for release to water, damming and/or water diversion should be utilized to minimize the spread of contamination. Applicable government authorities should be notified if the environment may be adversely affected.

Hydrated lime will be used for neutralizing raffinate (effluent) from the process plant prior to disposal. Lime is a basic (high pH, corrosive) powder that should be only handled with proper protective equipment. In the event of a spill, lime powder should be swept up, not allowed to enter sewers or watercourses, airborne dust should be minimized, and enclosed areas vented.

Cobalt sulphate is a toxic, odourless pink crystalline powder that may cause irritation to skin, eyes or respiratory tract if contact is made. Ingestion can cause nausea, gastrointestinal upset and abdominal pain. Proper protective handling measures should be taken and spills cleared up. Cobalt sulphate should not be allowed to enter the streams and should not be disposed of with normal garbage; special disposal is required.

Organic reagents will be used as industrial solvents in the process plant. Potential spills may occur during transportation to site, transfer to storage facilities and during use. If a spill occurs, the product should be collected for recovery or disposal, the area should be ventilated, and release to watercourses should be avoided.

Kerosene is an organic solvent that will be used to aid the organic reagents. As with the organic reagents, spills will be recovered and/or disposed of and the handling areas will be kept well ventilated. Initial spill response to a kerosene spill is to stop the flow if possible, eliminate open flame ignition processes, contain flow of oil by dyking, barricading or blocking flow by any means available (use earth moving equipment as available), and preventing the spill from reaching open water. If fire is involved, CO_2 should be used in dry chemical, foam, or water spray (fog) to fight the fire. Fog streams are a means used to protect rescue team and trapped people and to cool surface tanks. Alternatively, fuel is diverted to an open area where it is left to burn off under controled conditions. If the fire is extinguished before it is fully consumed, there is a chance of re-ignition. Contact with strong oxidizing agents (e.g. ammonium nitrate) may ignite the product, or cause it to explode. Unburned kerosene can be recovered by soaking up with sand, straw, peat moss, or by commercial sorbents (e.g. Graboil). Contaminated soil should be excavated and seepage entering the ground should be recovered by digging sumps or trenches and pumping from below the water table. Spills to surface waters should be collected and recovered by booms, sorbents such as Graboil, or collected by a liquid/solid vacuum cleaner. Recovery materials should be incinerated under controlled conditions with the approval of the Territory Emergency Response Officer or burned at an approved site

Copper cathode is not regarded as being a hazardous material and will be secured down by strapping and covered for truck transportation.

12.0 PLAN IMPLEMENTATION AND AMENDMENT

Warning signs are part of the chemical spill prevention program and will be posted at all material storage and use areas. These signs are posted to remind people of the nature of the material, potential hazards and to promote safe work practices. Copies of the Spill Contingency and Emergency Response Plan will be maintained by the Safety Officer. Response tables will be posted in appropriate areas of the processing facilities in highly visible locations. Material Safety Data Sheets (MSDS) and WHMIS sheets will be kept accessible to personnel at appropriate locations, including the Mine Managers office, line Superintendent offices, Safety and Environmental Supervisors offices, first aid room and ambulance. Material safety data sheets for some of the substances likely to be found at the Carmacks Copper project mine site are located in Appendix E.

All workers will be trained in the following area to ensure that implementation of the Spill Contingency and Emergency Response Plan is possible:

- Handling and clean-up of hazardous materials and combinations of hazardous materials on site;
- Fire fighting and fire suppression;
- First Aid (St John Advanced First Aid); and
- Supply and maintenance of equipment needed to control and clean-up any incidents.

Copies of the plan will also be sent to the following people:

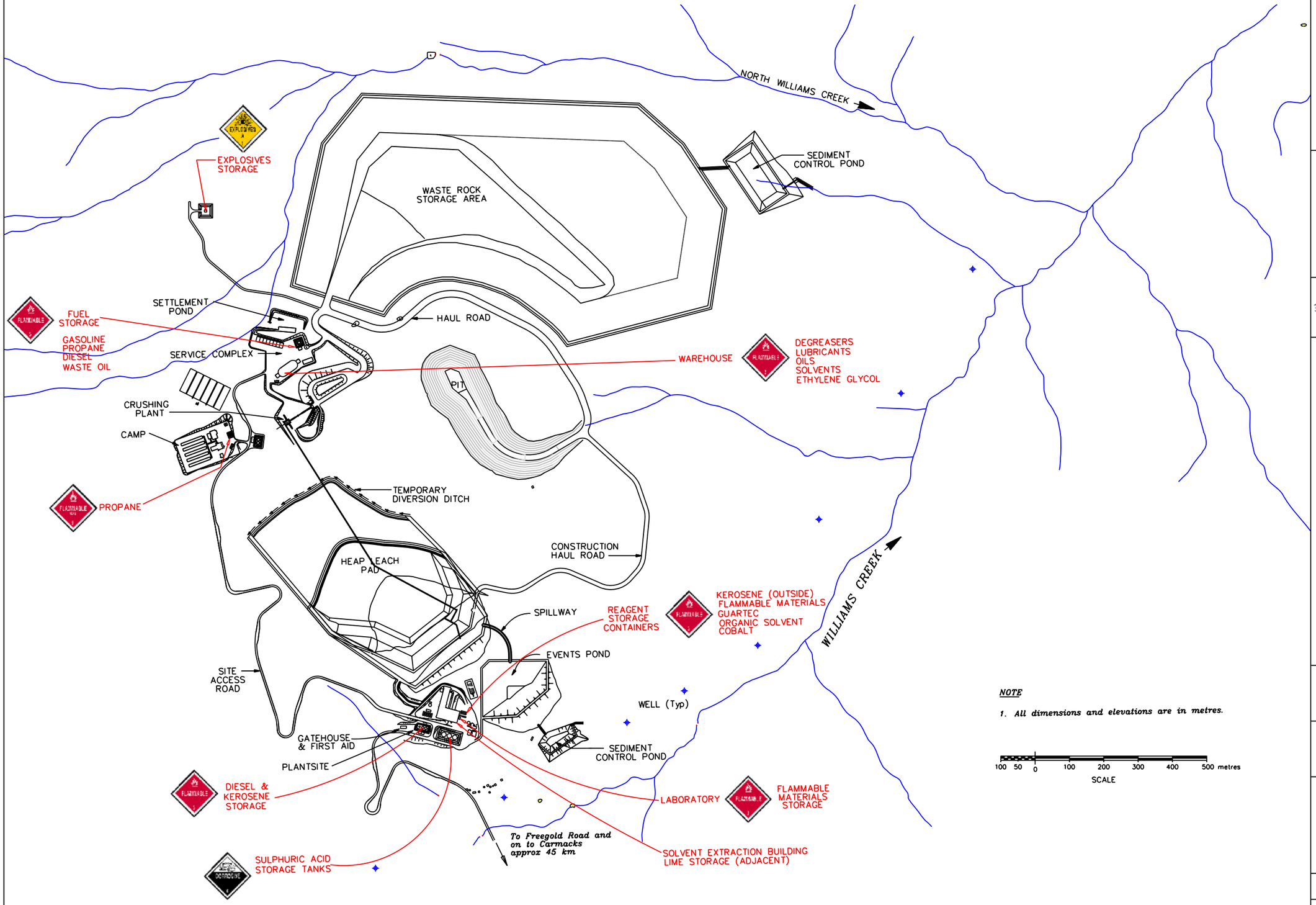
- Village of Carmacks;
- RCMP in Carmacks;
- Whitehorse General Hospital;
- Environment Canada Spill Centre;
- YG Water Resources, Inspection Section;
- YG Energy, Mines and Resources, Minerals Development Branch;
- LSCFN Office; and
- YG Energy, Mines and Resources, Client Services & Inspection Branch, Village of Carmacks Natural Resource Officer.

The Spill Contingency and Emergency Response Plan will be updated internally on a quarterly basis or as necessary. An updated Spill Contingency and Emergency Response Plan will be provided to the appropriate regulatory authorities on an annual basis.

SPILL CONTINGENCY AND EMERGENCY RESPONSE PLAN

APPENDIX A

GENERAL ARRANGEMENT – MATERIALS STORAGE LOCATIONS



NOTE

1. All dimensions and elevations are in metres.

100 50 0 100 200 300 400 500 metres

SCALE

Project Description & Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix L - Spill Contingency & Emergency Response Plan

WESTERN SILVER CORPORATION

Legend

TDGA Product Classification & Storage Locations

Original drawing from Kilborn.
The engineering data on this drawing is solely for the purpose and project for which this drawing is issued.
"Overall Site Plan Year 2",
Drawing #100-13-45 Rev B

General Arrangement - Material Storage Locations

Spill Plan - Appendix A

ACCESS CONSULTING GROUP

Revised by: HD | Checked by: DDC

Date: April, 2005

File: D:\Project\AllProjects\WCH-01\cad\spill_plan\Fig1_Mat_Stor_Loc.dwg

SPILL CONTINGENCY AND EMERGENCY RESPONSE PLAN

APPENDIX B

REPORTABLE SPILLS

A spill in excess of the following thresholds is considered a spill under the Yukon *Spill Regulations* (O.I.C. 1996/193), pursuant to the Environment Act. In this table, the listed regulations "Federal Regulations" means the *Transportation of Dangerous Goods Regulations* (Canada) Sor/85/77 of January 18, 1985.

Substance Spilled	TDG Code	Reportable Quantity
Explosives of Class 1 as defined in section 3.9 of the Federal Regulations.	1	Any amount
Flammable gases, of Division 1 of Class 2 as defined in section 3.11 (a) of the Federal Regulations.	2.1	Any amount of gas from a container larger than 100L, or where the spill results from equipment failure, error or deliberate action or inaction.
Non-flammable gases of Division 2 of Class 2 as defined in section 3.11 (d) of the Federal Regulations.	2.2	Any amount of gas from a container larger than 100L, or where the spill results from equipment failure, error or deliberate action or inaction.
Poisonous gases of Division 3 of Class 2 as defined in section 3.11(b) of the Federal Regulations.	2.3	Any amount
Corrosive gases of Division 4 of Class 2 as defined in section 3.11 (c) of the Federal Regulations.	2.4	Any amount
Flammable liquids of Class 3 as defined in section 3.12 of the Federal Regulations.	3	200L (Any amount if spilled into a watercourse)
Flammable solids of Class 4 as defined in section 3.15 of the Federal Regulations.	4	25 kg
Products or substances that are oxidizing substances of Division 1 of Class 5 as defined in sections 3.17(a) and 3.18(a) of the Federal Regulations.	5.1	50 kg or 50 L
Products or substances that are organic compounds that contain the bivalent "-0-0-" structure of Division 2 of Class 5 as defined in sections 3.17 (b) and 3.18 (b) of the Federal Regulations.	5.2	1 kg or 1L
Products or substances that are poisons of Division 1 of Class 6 as defined in sections 3.19 (a) to (e) and 3.20 (a) of the Federal Regulations.	6.1	5 kg or 5 L
Organisms that are infectious or that are reasonable believed to be infectious and the toxins of these organisms as defined in sections 3.19(f) and 3.20(b) of the Federal Regulations.	6.2	Any amount
Radioactive materials of Class 7 as defined by section 3.24 of the Federal Regulations.	7	Any discharge or a radiation level exceeding 10 mSv/h at the package surface and 200 mSv/h at 1 m from the package surface.
Products or substances of Class 8 as defined by section 3.24 of the Federal Regulations.	8	5 kg or 5 L
Miscellaneous products or substances of Division 1 of Class 9 as defined by sections 3.27 (1) and 2 (a) of the Federal Regulations.	9	50 kg or 50 L

SPILL RESPONSE FOR PETROLEUM PRODUCTS (FUELS)

APPENDIX C

SPILL REPORTING FORM

Spill Reporting Form

1) Type: (check) Oil ____Gasoline ____Diesel ____Sewage ____

   Other (name) _____

2) Source (Company): _____

3) Severity: (check) Minor 100 – 400 litres _____ Major 400 - 1,000 litres _____
   Emergency more than 1,000 litres _____

4) Date of Incident: _____ Time: _____

5) General Roadway Kilometre Mine Site Location: _____

6) Specifics of Location (nearest community, watercourse etc.): _____

   _____

7) Cause of Incident (e.g.: building failure): _____

8) Reason: (e.g.: earthquake): _____

9) Weather Conditions: Temperature _____ Wind Direction/Speed _____ Precipitation _____

10) Hazards to human life or health: _____

11) Expected Environmental Effects: _____

12) Nearest Surface Water with Approximate Distance to Spill: _____

    _____

13) Potential to Enter Surface Water: _____

14) Fish Kill: Yes ___ No ___ Bird Kill: Yes ___ No ___

15) Fire Hazard: _____

16) Threat to drinking water: _____

17) Who to contact at the scene: _____

    Company: _____ Phone: _____

18) General Comments: _____

19) How to prevent recurrence: _____

20) Action taken to date: Containment: _____

    Clean up: _____

Reported by:
Name: _____ Dept.: _____ Phone: _____

Reported to:
Name: _____ Dept.: _____ Phone: _____

SPILL RESPONSE FOR PETROLEUM PRODUCTS (FUELS)

APPENDIX D

LIST OF TYPICAL SPILL RESPONSE EQUIPMENT

List of Typical Spill Response Equipment

- **Absorbents** (For Petroleum Hydrocarbon {Fuels, Lubricants, and Solvents} and Wastewater)
  - Booms
  - Sheets
  - Towels
  - Absorbent granules

- **Contaminated Soils Recovery Tools**
  - Shovels
  - Picks
  - Excavators
  - Loaders
  - Trucks

- **Liquid Recovery Tools**
  - Pumps
  - Containers
  - Vacuum / Eductor Truck

- **Fire Suppression Equipment**
  - Various, for different material types

- **Personal Safety Equipment**
  - Protective Clothing
  - Eye Protection
  - Breathing Apparatus

Note:

This is by no means an exhaustive list of materials and tools that can be assembled and used for spill response.

More information on spill response equipment and equipment suppliers can be found on the Internet. Yukon Explosives in Whitehorse is an example of a local supplier.

SPILL RESPONSE FOR PETROLEUM PRODUCTS (FUELS)

APPENDIX E

MATERIAL SAFETY DATA SHEETS

CITGO Gasolines, All Grades Unleaded

Material Safety Data Sheet

CITGO Petroleum Corporation
P.O. Box 4689
Houston, TX 77210

MSDS No. UNLEAD
Revision Date 05/23/2005

IMPORTANT: Read this MSDS before handling or disposing of this product and pass this information on to employees, customers and users of this product.

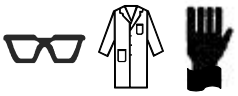
Hazard Rankings

	HMIS	NFPA
Health Hazard	* 2	1
Fire Hazard	3	3
Reactivity	0	0

*** = Chronic Health Hazard**

Protective Equipment

Minimum Recommended
See Section 8 for Details



Emergency Overview

Physical State Liquid.

Color Transparent, clear to amber or red. **Odor** Pungent, characteristic gasoline.

DANGER:
Extremely flammable liquid; vapor may cause flash fire or explosion.
Vapor may travel considerable distance to source of ignition and flash back.
Use Only as a Motor Fuel. Do Not Siphon by Mouth.
Harmful or fatal if swallowed - Can enter lungs and cause damage.
High concentrations of vapor reduce oxygen available for breathing and may cause suffocation.
May be harmful if inhaled or absorbed through the skin.
Mist or vapor may irritate the eyes, mucous membranes, and respiratory tract.
Liquid contact may cause eye and skin irritation.
Overexposures may cause central nervous system (CNS) depression and target organ effects (See Section 3).
Harmful or fatal if swallowed - Can enter lung and cause damage.
Inhalation overexposure can increase the heart's susceptibility to arrhythmias (irregular beats).
Contains Benzene - Cancer Hazard.
Long term exposure to gasoline vapor has caused cancer in laboratory animals.
Avoid Spills. Spills may present both a physical and an environmental hazard.

SECTION 1. PRODUCT IDENTIFICATION

Trade Name	CITGO Gasolines, All Grades Unleaded	**Technical Contact**	(800) 248-4684
Product Number	Various	**Medical Emergency**	(832) 486-4700
CAS Number	Mixture.	**CHEMTREC Emergency (United States Only)**	(800) 424-9300

Product Family Motor fuels.

Synonyms Unleaded Gasolines; Motor Gasolines; Petrol; Automobile Motor Fuels; Finished Gasolines; Gasoline, Regular Unleaded; Gasoline, Mid-grade Unleaded; Gasoline, Premium Unleaded; Reformulated Gasolines (RFG); Reformulated Motor Fuels; Oxygenated Motor Spirits; Gasoline, Regular Reformulated; Gasoline, Mid-grade Reformulated; Gasoline, Premium Reformulated.

SECTION 2. COMPOSITION

Gasoline is a complex and variable mixture that originates from finished refinery streams. These streams can contain the hydrocarbons and oxygenated chemicals (oxygenates) listed below that are regulated or are associated with certain potential health effects. The typical concentration of oxygenates in gasoline does not exceed 18% (v/v).

Component Name(s)	CAS Registry No.	Concentration (%)
Methyl tertiary-Butyl Ether (MTBE)	1634-04-4	0 - 15
Tertiary-Amyl Methyl Ether (TAME)	994-05-8	0 - 15
Ethyl tertiary Butyl Ether (ETBE)	637-92-3	0 - 15
Tertiary-Amyl Ethyl Ether (TAEE)	919-94-8	0 - 15
Diisopropyl Ether (DIPE)	108-20-3	0 - 15
Ethanol	64-17-5	0 - 10
Toluene	108-88-3	<20
Xylene, all isomers	1330-20-7	<18
n-Hexane	110-54-3	<8
Trimethylbenzenes, all isomers	25551-13-7	<5
Benzene	71-43-2	<5
Cumene	98-82-8	<4
Ethylbenzene	100-41-4	<4
Cyclohexane	110-82-7	<3
Naphthalene	91-20-3	<2
Styrene	100-42-5	<1

SECTION 3. HAZARDS IDENTIFICATION

Also see Emergency Overview and Hazard Ratings on the top of Page 1 of this MSDS.

Major Route(s) of Entry Skin contact. Eye contact. Inhalation. Ingestion.

Signs and Symptoms of Acute Exposure

Inhalation Breathing high concentrations may be harmful. Mist or vapor can irritate the throat and lungs. Breathing this material may cause central nervous system depression with symptoms including nausea, headache, dizziness, fatigue, drowsiness, or unconsciousness. Breathing high concentrations of this material, for example, in an enclosed space or by intentional abuse, can cause irregular heartbeats which can cause death.

Eye Contact This product can cause eye irritation with short-term contact with liquid, mists or vapor. Symptoms include stinging, watering, redness, and swelling. In severe cases, permanent eye damage can result.

Skin Contact This material can cause skin irritation. The severity of irritation will depend on the amount of material that is applied to the skin and the speed and thoroughness that it is removed. It is likely that some components of this material are able to pass into the body through the skin and may cause similar effects as from breathing or swallowing it. If the skin is damaged, absorption increases.

Ingestion

If swallowed, this material may irritate the mucous membranes of the mouth, throat, and esophagus. It can be readily absorbed by the stomach and intestinal tract. Symptoms include a burning sensation of the mouth and esophagus, nausea, vomiting, dizziness, staggered gait, drowsiness, loss of consciousness and delirium, as well as additional central nervous system (CNS) effects.

Due to its light viscosity, there is a danger of aspiration into the lungs during swallowing and subsequent vomiting. Aspiration can result in severe lung damage or death. Cardiovascular effects include shallow rapid pulse with pallor (loss of color in the face) followed by flushing (redness of the face). Also, progressive CNS depression, respiratory insufficiency and ventricular fibrillation leads to death.

Chronic Health Effects Summary

Intentional misuse by deliberately concentrating and inhaling gasoline can be harmful or fatal. Altered mental state, drowsiness, peripheral motor neuropathy, irreversible brain damage ("Petrol Sniffers Encephalopathy"), delirium, seizures and sudden death are associated with repeated abuse of gasoline or naphtha.

Chronic effects of ingestion and subsequent aspiration into the lungs may include pneumatocele (lung cavity) formation and chronic lung dysfunction.

Benzene, a component of this product, causes blood disorders and damages the bone marrow (certain types of anemia, leukemia, and lymphoma). It is also capable of causing changes in living cells' genetic material (chromosomes). Benzene is considered to be a mutagen and a cancer-causing agent (leukemogen).

Repeated and prolonged overexposure to n-hexane has been associated with peripheral nerve tissue damage. Adverse effects include numbness, tingling, pain, and loss of muscle control in the extremities, disorientation, impaired vision and reflexes, decline in motor function and paralysis.

Prolonged or repeated overexposure to toluene, a component of this product, has been associated with reproductive effects in experimental animals and in long-term chemical abuse situations. Long-term overexposure to toluene has been associated with impaired color vision. Also, long-term overexposure to toluene in occupational environments have been associated with hearing damage.

Prolonged or repeated overexposure to xylene, a component of this product, has been associated with hearing damage in laboratory animals. Repeated overexposure may cause injury to bone marrow, blood cells, kidney, and liver.

Refer to Section 11 of this MSDS for additional health-related information.

Conditions Aggravated by Exposure

Disorders of the following organs or organ systems that may be aggravated by significant exposure to this material or its components include: Skin, Respiratory System, Liver, Kidneys, Central Nervous System (CNS), Cardiovascular System, Blood-forming system

Target Organs

May cause damage to the following organs: blood, kidneys, lungs, the reproductive system, liver, mucous membranes, heart, peripheral nervous system, cardiovascular system, upper respiratory tract, skin, auditory system, bone marrow, central nervous system (CNS), eye, lens or cornea.

Carcinogenic Potential

This material may contain benzene, ethylbenzene, naphthalene or styrene at concentrations above 0.1%. Benzene is considered to be a known human carcinogen by OSHA, IARC and NTP. IARC has identified ethylbenzene, styrene, naphthalene, gasoline and gasoline engine exhaust as possibly carcinogenic to humans (Group 2B) based on laboratory animal studies.

OSHA Hazard Classification is indicated by an "X" in the box adjacent to the hazard title. If no "X" is present, the product does not exhibit the hazard as defined in the OSHA Hazard Communication Standard (29 CFR 1910.1200).

OSHA Health Hazard Classification				OSHA Physical Hazard Classification					
Irritant	X	Sensitizer		Combustible		Explosive		Pyrophoric	
Toxic		Highly Toxic		Flammable	X	Oxidizer		Water-reactive	
Corrosive		Carcinogenic	X	Compressed Gas		Organic Peroxide		Unstable	

SECTION 4. FIRST AID MEASURES

Take proper precautions to ensure your own health and safety before attempting rescue or providing first aid. For more specific information, refer to Exposure Controls and Personal Protection in Section 8 of this MSDS.

Inhalation

Immediately move victim to fresh air. If victim is not breathing, immediately begin rescue breathing. If heart has stopped, immediately begin cardiopulmonary resuscitation (CPR). If breathing is difficult, 100 percent humidified oxygen should be administered by a qualified individual. Seek medical attention immediately. If exposed to benzene in an emergency situation, a medical evaluation should be completed at the end of the work-shift in accordance with OSHA requirements.

Eye Contact

Flush eyes with cool, clean, low-pressure water for at least 15 minutes. Hold eyelids apart to ensure complete irrigation of the eye and eyelid tissue. If easily accomplished, check for and remove contact lenses. If contact lenses cannot be removed, seek immediate medical attention. Do not use eye ointment. Seek medical attention.

Skin Contact

Remove contaminated shoes and clothing. Flush affected area with large amounts of water. If skin surface is damaged, apply a clean dressing and seek medical attention. Do not use ointments. If skin surface is not damaged, clean affected area thoroughly with mild soap and water. Seek medical attention if tissue appears damaged or if pain or irritation persists.

Ingestion

Do not induce vomiting. If spontaneous vomiting is about to occur, place victim's head below knees. If victim is drowsy or unconscious, place on the left side with head down. Never give anything by mouth to a person who is not fully conscious. Do not leave victim unattended. Seek medical attention immediately.

Notes to Physician

INHALATION: Inhalation overexposure can produce toxic effects. Monitor for respiratory distress. If cough or difficulty in breathing develops, evaluate for upper respiratory tract inflammation, bronchitis, and pneumonitis. Administer supplemental oxygen with assisted ventilation, as required.

This material (or a component) sensitizes the heart to the effects of sympathomimetic amines. Epinephrine and other sympathomimetic drugs may initiate cardiac arrhythmias in individuals exposed to this material. Administion of sympathomimetic drugs should be avoided.

INGESTION: If ingested, this material presents a significant aspiration and chemical pneumonitis hazard. Induction of emesis is not recommended. Consider activated charcoal and/or gastric lavage. If patient is obtunded, protect the airway by cuffed endotracheal intubation or by placement of the body in a Trendelenburg and left lateral decubitus position.

SECTION 5. FIRE FIGHTING MEASURES

NFPA Flammability Classification	NFPA Class-IB flammable liquid.
Flash Point	Closed cup: -43°C (-45°F). (Tagliabue [ASTM D-56])
Lower Flammable Limit	AP 1.4 % **Upper Flammable Limit** AP 7.6 %
Autoignition Temperature	280°C (536°F)
Hazardous Combustion Products	Carbon dioxide, carbon monoxide, smoke, fumes, unburned hydrocarbons, aldehydes and other products of incomplete combustion.
Special Properties	Flammable Liquid! This material releases vapors at or below ambient temperatures. When mixed with air in certain proportions and exposed to an ignition source, its vapor can cause a flash fire. Use only with adequate ventilation. Vapors are heavier than air and may travel long distances along the ground to an ignition source and flash back. A vapor and air mixture can create an explosion hazard in confined spaces such as sewers. If container is not properly cooled, it can rupture in the heat of a fire.
Extinguishing Media	SMALL FIRE: Use dry chemicals, carbon dioxide, foam, or inert gas (nitrogen). Carbon dioxide and inert gas can displace oxygen. Use caution when applying carbon dioxide or inert gas in confined spaces. LARGE FIRE: Use foam, water fog, or water spray. Water May Be Ineffective. Water may not extinguish the fire. Water fog and spray are effective in cooling containers and adjacent structures. However, water can be used to cool the external walls of vessels to prevent excessive pressure, autoignition or explosion. DO NOT use a solid stream of water directly on the fire as the water may spread the fire to a larger area.
Protection of Fire Fighters	Firefighters must use full bunker gear including NIOSH-approved positive pressure self-contained breathing apparatus to protect against potential hazardous combustion or decomposition products and oxygen deficiencies. Evacuate area and fight the fire from a maximum distance or use unmanned hose holders or monitor nozzles. Cover pooling liquid with foam. Containers can build pressure if exposed to radiant heat; cool adjacent containers with flooding quantities of water until well after the fire is out. Withdraw immediately from the area if there is a rising sound from a venting safety device or discoloration of vessels, tanks, or pipelines. Be aware that burning liquid will float on water. Notify appropriate authorities of potential fire and explosion hazard if liquid enter sewers or waterways.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Take proper precautions to ensure your own health and safety before attempting spill control or clean-up. For more specific information, refer to the Emergency Overview on Page 1, Exposure Controls and Personal Protection in Section 8 and Disposal Considerations in Section 13 of this MSDS.

Flammable Liquid! Release causes an immediate fire or explosion hazard. Evacuate all non-essential personnel from immediate area and establish a "regulated zone" with site control and security. A vapor-suppressing foam may be used to reduce vapors. Eliminate all ignition sources. All equipment used when handling this material must be grounded. Stop the leak if it can done without risk. Do not touch or walk through spilled material. Remove spillage immediately from hard, smooth walking areas. Prevent spilled material from entering waterways, sewers, basements, or confined areas. Absorb or cover with dry earth, sand, or other non-combustible material and transfer to appropriate waste containers. Use clean, non-sparking tools to collect absorbed material.

For large spills, secure the area and control access. Prevent spilled material from entering sewers, storm drains, other drainage systems, and natural waterways. Dike far ahead of a

liquid spill to ensure complete collection. Water mist or spray may be used to reduce or disperse vapors; but, it may not prevent ignition in closed spaces. This material will float on water and its run-off may create an explosion or fire hazard. Verify that responders are properly HAZWOPER-trained and wearing appropriate respiratory equipment and fire-resistant protective clothing during cleanup operations. In an urban area, cleanup spill as soon as possible; in natural environments, cleanup on advice from specialists. Pick up free liquid for recycle and/or disposal if it can be accomplished safely with explosion-proof equipment. Collect any excess material with absorbant pads, sand, or other inert non-combustible absorbent materials. Place into appropriate waste containers for later disposal. Comply with all applicable local, state and federal laws and regulations.

SECTION 7. HANDLING AND STORAGE

Handling

FLAMMABLE LIQUID AND VAPOR. **USE ONLY as a motor fuel.** DO NOT siphon by mouth. DO NOT use as a lighter fluid, solvent or cleaning fluid. Prior to handling or refueling, stop all engines and auxillary equipment. Turn off all electronic equipment including cellular telephones. DO NOT leave nozzle unattended during filling or refueling a vehicle. DO NOT re-enter vehicle while refueling. Keep nozzle spout in contact with the container during the entire filling operations.

A static electrical charge can accumulate when this material is flowing through pipes, nozzles or filters and when it is agitated. A static spark discharge can ignite accumulated vapors particularly during dry weather conditions. Always bond receiving containers to the fill pipe before and during loading. Always keep nozzle in contact with the container throughout the loading process. Do not fill any portable container in or on a vehicle. Special precautions, such as reduced loading rates and increased monitoring, must be observed during "switch loading" operations (i.e., loading this material in tanks or shipping compartments that previously contained middle distillates or similar products).

A spill or leak can cause an immediate fire hazard. Keep containers closed and do not handle or store near heat, sparks, or any other potential ignition sources. Do not contact with oxidizable materials. Do not breathe vapor. Use only with adequate ventilation and personal protection. Never siphon by mouth. Avoid contact with eyes, skin, and clothing. Prevent contact with food and tobacco products. Do not take internally.

When performing repairs and maintenance on contaminated equipment, keep unnecessary persons away from the area. Eliminate all potential ignition sources. Drain and purge equipment, as necessary, to remove material residues. Follow proper entry procedures, including compliance with 29 CFR 1910.146 prior to entering confined spaces such as tanks or pits. Use gloves constructed of impervious materials and protective clothing if direct contact is anticipated. Provide ventilation to maintain exposure potential below applicable exposure limits. Use appropriate respiratory protection when concentrations exceed any established occupational exposure level (See Section 8). Promptly remove contaminated clothing. Wash exposed skin thoroughly with soap and water after handling.

Protect the environment from releases of this material. Prevent discharges to surface waters and groundwater. Maintain handling, transfer and storage equipment in proper working order.

Misuse of empty containers can be dangerous. Empty containers may contain material residues which can ignite with explosive force. **Cutting or welding of empty containers can cause fire, explosion, or release of toxic fumes from residues.** Do not pressurize or expose empty containers to open flame, sparks, or heat. Keep container closed and drum bungs in place. All label warnings and precautions must be observed. Return empty drums to a qualified reconditioner. Consult appropriate federal, state and local authorities before reusing, reconditioning, reclaiming, recycling, or disposing of empty containers and/or waste residues of this material.

Storage

Store and transport in accordance with all applicable laws. Keep containers tightly closed. Store in a cool, dry, well-ventilated place. Clearly label all containers. Do not allow containers to be kept in enclosed vehicles. Keep away from all ignition sources. Ground all equipment containing this material. Containers must be able to withstand pressures that are created from changes in product temperature. Product samples and other small containers of this flammable liquid should be stored in a separate safety cabinet or room. All electrical equipment in areas where this material is stored or handled should be installed and operated in accordance with applicable regulatory requirements and the National Electrical Code.

SECTION 8. EXPOSURE CONTROLS AND PERSONAL PROTECTION

Engineering Controls

Provide ventilation or other engineering controls to keep the airborne concentrations of vapor or mists below the applicable workplace exposure limits indicated below. All electrical equipment should comply with the National Electric Code. An emergency eye wash station and safety shower should be located near the work-station.

Personal Protective Equipment

Personal protective equipment should be selected based upon the conditions under which this material is used. A hazard assessment of the work area for PPE requirements should be conducted by a qualified professional pursuant to OSHA regulations. The following pictograms represent the minimum requirements for personal protective equipment. For certain operations, additional PPE may be required.



Eye Protection

Safety glasses equipped with side shields are recommended as minimum protection in industrial settings. Chemical goggles should be worn during transfer operations or when there is a likelihood of misting, splashing, or spraying of this material. A suitable emergency eye wash water and safety shower should be located near the work station.

Hand Protection

Avoid skin contact. Use gloves (e.g., disposable PVC, neoprene, nitrile, vinyl, or PVC/NBR). Wash hands with plenty of mild soap and water before eating, drinking, smoking, use of toilet facilities or leaving work. DO NOT use this material as a skin cleaner.

Body Protection

Avoid skin contact. Wear long-sleeved fire-retardant garments (e.g., Nomex®) while working with flammable and combustible liquids. Additional chemical-resistant protective gear may be required if splashing or spraying conditions exist. This may include an apron, boots and additional facial protection. If product comes in contact with clothing, immediately remove soaked clothing and shower. Promptly remove and discard contaminated leather goods.

Respiratory Protection

For known vapor concentrations above the occupational exposure guidelines (see below), use a NIOSH-approved organic vapor respirator if adequate protection is provided. Protection factors vary depending upon the type of respirator used. Respirators should be used in accordance with OSHA requirements (29 CFR 1910.134). For airborne vapor concentrations that exceed the recommended protection factors for organic vapor respirators, use a full-face, positive-pressure, supplied air respirator. Due to fire and explosion hazards, do not enter atmospheres containing concentrations greater than 10% of the lower flammable limit of this product.

General Comments

Warning! Use of this material in spaces without adequate ventilation may result in generation of hazardous levels of combustion products and/or inadequate oxygen levels for breathing. Odor is an inadequate warning for hazardous conditions.

Occupational Exposure Guidelines

Substance	Applicable Workplace Exposure Levels

Gasoline	**ACGIH (United States).** TWA: 300 ppm 8 hour(s). STEL: 500 ppm 15 minute(s).
Toluene	**ACGIH (United States). Skin** TWA: 50 ppm 8 hour(s). **OSHA (United States).** TWA: 200 ppm 8 hour(s). CEIL: 300 ppm PEAK: 500 ppm
Xylene, all isomers	**ACGIH (United States).** TWA: 100 ppm 8 hour(s). STEL: 150 ppm 15 minute(s). **OSHA (United States).** TWA: 100 ppm 8 hour(s).
Tertiary-Amyl Methyl Ether (TAME)	**ACGIH TLV (United States).** TWA: 20 ppm 8 hour(s).
Methyl tertiary-Butyl Ether (MTBE)	**ACGIH (United States).** TWA: 50 ppm 8 hour(s).
Ethyl tertiary Butyl Ether (ETBE)	**ACGIH TLV (United States).** TWA: 5 ppm 8 hour(s).
n-Hexane	**ACGIH (United States). Skin** TWA: 50 ppm 8 hour(s). **OSHA (United States).** TWA: 500 ppm 8 hour(s).
Cumene	**ACGIH (United States).** TWA: 50 ppm 8 hour(s). **OSHA (United States). Skin** TWA: 50 ppm 8 hour(s).
Trimethylbenzenes, all isomers	**ACGIH (United States).** TWA: 25 ppm 8 hour(s).
Benzene	**ACGIH (United States). Skin** TWA: 0.5 ppm 8 hour(s). STEL: 2.5 ppm 15 minute(s). **OSHA (United States). Skin Notes: See Table Z-2 for exclusions in 20 CFR 1910.1028 to the PEL.** TWA: 1 ppm 8 hour(s). STEL: 5 ppm 15 minute(s).
Ethylbenzene	**ACGIH (United States).** TWA: 100 ppm 8 hour(s). STEL: 125 ppm 15 minute(s). **OSHA (United States).** TWA: 100 ppm 8 hour(s).
Cyclohexane	**ACGIH (United States).** TWA: 100 ppm 8 hour(s). **OSHA (United States).** TWA: 300 ppm 8 hour(s).
Naphthalene	**ACGIH (United States). Skin** TWA: 10 ppm 8 hour(s). STEL: 15 ppm 15 minute(s). **OSHA (United States).** TWA: 10 ppm 8 hour(s).
Styrene	**ACGIH (United States).** TWA: 20 ppm 8 hour(s). STEL: 40 ppm 15 minute(s). **OSHA (United States).** TWA: 100 ppm 8 hour(s). STEL: 200 ppm 15 minute(s). PEAK: 600 ppm

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES (TYPICAL)

Physical State	Liquid.	**Color**	Transparent, clear to amber or red.	**Odor**	Pungent, characteristic gasoline.
Specific Gravity	0.72 - 0.77 (Water = 1)	**pH**	Not applicable	**Vapor Density**	3 to 4 (Air = 1)

Boiling Range	38 to 204°C (100 to 400°F)	**Melting/Freezing Point**	Not available.
Vapor Pressure	220 to 450 mm Hg at 20°C (68°F) or 6 to 15 Reid-psia at 37.8°C (100°F).	**Volatility**	720 to 770 g/l VOC (w/v)
Solubility in Water	Hydrocarbon components of gasoline are slightly soluble in water. Oxygenate components, such as MTBE, are more soluble than the hydrocarbon components. Ethanol has greater solubility in water than hydrocarbon components or other oxygenate components.	**Viscosity (cSt @ 40°C)**	<1

Flash Point	Closed cup: -43°C (-45°F). (Tagliabue [ASTM D-56])
Additional Properties	Average Density at 60°F = 6.0 to 6.4 lbs./gal. (ASTM D-2161)

SECTION 10. STABILITY AND REACTIVITY

Chemical Stability	Stable.	**Hazardous Polymerization**	Not expected to occur.
Conditions to Avoid	Keep away from heat, flame and other potential ignition sources. Keep away from strong oxidizing conditions and agents.		
Materials Incompatibility	Strong acids, alkalies and oxidizers such as liquid chlorine, other halogens, hydrogen peroxide and oxygen.		
Hazardous Decomposition Products	No additional hazardous decomposition products were identified other than the combustion products identified in Section 5 of this MSDS.		

SECTION 11. TOXICOLOGICAL INFORMATION

For other health-related information, refer to the Emergency Overview on Page 1 and the Hazards Identification in Section 3 of this MSDS.

Toxicity Data

Gasoline:
VAPOR (TELo) Acute: 140 ppm (Human) (8 hours) - Mild eye irritant.
VAPOR (TELo) Acute: 500 ppm (Human) (1 hour) - Moderate eye irritant.
INHALATION (TCLo) Acute: 900 ppm (Human) (1 hour) - CNS and pulmonary effects.
DERMAL (TDLo) Acute: 53 mg/kg (Human) - Skin allergy effects.
INHALATION (LC50) Acute: 101,200 ppm (Rat, Mouse, & Guinea Pig) (5 minutes).

Gasoline Containing 15% MTBE:
ORAL (LD50) Acute: >5,000 mg/kg (Rat screen level).
DERMAL (LD50) Acute: >2,000 mg/kg (Rabbit screen level).
INHALATION (LC50) Acute: >5,200 ppm (Rat screen level) (8 hours).
DRAIZE EYE Acute: Mild eye irritant. (Rabbit).

DRAIZE DERMAL Acute: Moderate skin irritant. (Rabbit).
BUEHLER DERMAL Acute: Non-sensitizing. (Guinea Pig).
28-Day DERMAL Sub-Chronic: Severe skin irritant. (Rabbit).

A major epidemiological study concluded that there was no increased risk of kidney cancer associated with gasoline exposures for petroleum refinery employees or neighboring residents. Another study identified a slight trend in kidney cancers among service station employees following a 30-year latency period. Two-year inhalation toxicity studies with fully vaporized unleaded gasoline (at concentrations of 67, 292 and 2,056 ppm in air) produced kidney damage and kidney tumors in male rats, but not in female rats or mice of either sex. Results from subsequent scientific studies suggest that the kidney damage, and probably the kidney tumor response, is limited to the male rat. The kidney tumors apparently were the result of the formation of alpha-2u-globulin, a protein unique to male rats. This finding is not considered relevant to human exposure. Under conditions of the study, there was no evidence that exposure to unleaded gasoline vapor is associated with developmental toxicity. Experimental studies with laboratory animals did suggest that overexposure to gasoline may adversely effect male reproductive performance. Also, in laboratory studies with rats, the maternal and developmental "no observable adverse effect level" (NOAEL) was determined to be 9,000 ppm (75% of the LEL value). Female mice developed a slightly higher incidence of liver tumors compared to controls at the highest concentration. In a four week inhalation study of Sprague Dawley® rats, gasoline vapor condensate was determined to induce sister chromatid exchanges in peripheral lymphocytes. IARC has listed gasoline as possibly carcinogenic to humans (Group 2B).

Pentanes, all isomers:
Studies of pentane isomers in laboratory animals indicate exposure to extremely high levels (roughly 10 vol.%) may induce cardiac arrhythmias (irregular heartbeats) which may be serious or fatal.

Toluene:
Effects from Acute Exposure:
Deliberate inhalation of toluene at high concentrations (e.g., glue sniffing and solvent abuse) has been associated with adverse effects on the liver, kidney and nervous system and can cause CNS depression, cardiac arrhythmias and death. Case studies of persons abusing toluene suggest isolated incidences of adverse effects on the fetus including birth defects.

Effects from Repeated or Prolonged Exposure:
Studies of workers indicate long-term exposure may be related to impaired color vision and hearing. Some studies of workers suggest long-term exposure may be related to neurobehavioral and cognitive changes. Some of these effects have been observed in laboratory animals following repeated exposure to high levels of toluene. Several studies of workers suggest long-term exposure may be related to small increases in spontaneous abortions and changes in some gonadotropic hormones. However, the weight of evidence does not indicate toluene is a reproductive hazard to humans. Studies in laboratory animals indicate some changes in reproductive organs following high levels of exposure, but no significant effects on mating performance or reproduction were observed. Case studies of persons abusing toluene suggest isolated incidences of adverse effects on the fetus including birth defects. Findings in laboratory animals were largely negative. Positive findings include small increases in minor skeletal and visceral malformations and developmental delays following very high levels of maternal exposure. Studies of workers indicate long-term exposure may be related to effects on the liver, kidney and blood, but these appear to be limited to changes in serum enzymes and decreased leukocyte counts. Studies in laboratory animals indicate some evidence of adverse effects on the liver, kidney, thyroid, and pituitary gland following very high levels of exposure. The relevance of these findings to humans is not clear at this time.

Heptane, all isomers:
n-Heptane was not mutagenic in the Salmonella/microsome (Ames) assay and is not considered to be carcinogenic.

Xylene, all isomers:
Effects from Acute Exposure:
ORAL (LD_{50}), Acute: 4,300 mg/kg [Rat].
INHALATION (LC_{50}), Acute: 4,550 ppm for four hours [Rat].
DERMAL (LD_{50}), Acute: 14,100 uL/kg [Rabbit].
Overexposure to xylene may cause upper respiratory tract irritation, headache, cyanosis, blood serum changes, CNS damage and narcosis. Effects may be increased by the use of alcoholic beverages. Evidence of liver and kidney impairment were reported in workers recovering from a gross over-exposure.

Effects from Prolonged or Repeated Exposure:
Impaired neurological function was reported in workers exposed to solvents including xylene. Studies in laboratory animals have shown evidence of impaired hearing following high levels of exposure. Studies in laboratory animals suggest some changes in reproductive organs following high levels of exposure but no significant effects on reproduction were observed. Studies in laboratory animals indicate skeletal and visceral malformations, developmental delays, and increased fetal resorptions following extremely high levels of maternal exposure. Adverse effects on the liver, kidney, bone marrow (changes in blood cell parameters) were observed in laboratory animals following high levels of exposure. The relevance of these observations to humans is not clear at this time.

Ethyl tertiary Butyl Ether (ETBE):
ETBE can cause eye, skin and mucous membrane irritation. In a four week inhalation study, moderate ataxia was observed in rats at the highest dose level (4,000 ppm). The test animals appeared normal within 15 minutes of termination of exposure. A no observed adverse effect level (NOAEL) of 500 ppm was indicated by the study authors based on neurotoxic effects. In two unpublished 90 day inhalation studies, rats and mice were exposed six hour/day, five days/week at concentrations of 0, 500, 1750 and 5000 ppm of ETBE vapor. The male rats exhibited time and concentration-dependent nephropathy consistent with alpha-2µ-globulin formation. An ETBE NOAEL for male rats of 500 ppm was suggested based on a finding of testicular lesions. In human studies with eight males, slight, but significant ($p<0.05$) decreases in objective pulmonary function measures after exposure to ETBE at concentrations of 25 and 50 ppm for two hours.

Tertiary-Amyl Methyl Ether (TAME):
TAME was found to be negative for the induction of structural chromosome aberrations (both metabolically-activated and non-activated) in Chinese hamster ovary (CHO) cells. Inhalation of TAME vapors at concentrations above 250 ppm produced reversible CNS depression in rats and mice. In a four week inhalation study, increases in liver weights with no tissue injury were observed in rats exposed to a TAME concentration of 500 ppm. Birth defects in mice and fetotoxicity in both rats and mice were observed after inhalation exposures to maternally toxic concentrations of TAME.

Methyl tertiary-Butyl Ether (MTBE):
Acute symptoms associated with human exposure to MTBE appear to be mild and transient. In laboratory studies, rats and mice exposed to high doses of MTBE exhibited blood chemistry changes and liver and kidney abnormalities. In laboratory studies, MTBE vapor exposure at the high dose concentration was associated with an increased incidence of liver tumors in female mice. Also, at high dose concentration exposures, MTBE was associated with an increased incidence of kidney and testicular (Leydig cell) tumors in male rats. Additional oncogenicity studies on rats resulted in testicular tumors following administration by ingestion. These data are not generally considered relevant to humans. NTP has not identified MTBE as either a known carcinogen or reasonably anticipated to be carcinogenic to humans. In animal studies, developmental and reproductive toxicity related to MTBE inhalation exposures was observed only at concentrations that were maternally toxic. MTBE was shown to be maternally toxic at 4,000 and 8,000 ppm levels when mice were exposed for six hours per day during their pregnancy. Also, a decrease in the number of successful pregnancies and a reduction in birth weights were observed at these exposure levels. Birth defects (cleft palate) were observed at the high dose level. These data suggest that the risk of developmental and reproductive toxicity in humans is negligible as a result of anticipated

exposures to MTBE.

Diisopropyl Ether (DIPE):
Increased kidney and liver weights were observed in rats and mice in subchronic and chronic inhalation studies of DIPE. Also, evidence of microscopic changes (hyaline droplets) were reported in liver tissue and kidney tubules of rabbits and male rats exposed to DIPE at concentrations of 7,100 ppm. These findings were similar those found in gasoline studies. Overexposure by inhalation of pregnant rats to DIPE at concentrations of 3,095 and 6,745 ppm increased the frequency of rudimentary 14th ribs in the offspring. This effect was not observed at exposure concentrations of 430 ppm. The significance of these findings to human exposure is unclear.

Ethanol:
Inhalation exposure to ethanol vapor at concentrations above applicable workplace exposure levels is expected to produce eye and mucus membrane irritation. Human exposure at concentrations from 1000 to 5000 ppm produced symptoms of narcosis, stupor and unconsciousness. Subjects exposed to ethanol vapor in concentrations between 500 and 10,000 ppm experienced coughing and smarting of the eyes and nose. At 15,000 ppm there was continuous lacrimation and coughing. While extensive acute and chronic effects can be expected with ethanol consumption, ingestion is not expected to be a significant route of exposure to this product.

Butane, all isomers:
Studies in laboratory animals indicate exposure to extremely high levels of butanes (1-10 or higher vol.% in air) may cause cardiac arrhythmias (irregular heartbeats) which may be serious or fatal.

n-Hexane:
This material contains n-hexane. Long-term or repeated exposure to n-hexane can cause permanent peripheral nerve damage. Initial symptoms are numbness of the fingers and toes. Also, motor weakness can occur in the digits, but may also involve muscles of the arms, thighs and forearms. The onset of these symptoms may be delayed for several months to a year after the beginning of exposure. Co-exposure to methylethyl ketone or methyl isobutyl ketone increases the neurotoxic properties of n-hexane. In laboratory studies, prolonged exposure to elevated concentrations of n-hexane was associated with decreased sperm count and degenerative changes in the testicles of rats.

Cumene:
Effects from Acute Exposure:
Overexposure to cumene may cause upper respiratory tract irritation and severe CNS depression.

Effects from Prolonged or Repeated Exposure:
Studies in laboratory animals indicate evidence of adverse effects on the kidney and adrenal glands following high level exposure. The relevance of these findings to humans is not clear at this time.

Trimethylbenzenes, all isomers:
Studies of Workers:
Levels of total hydrocarbon vapors present in the breathing atmosphere of these workers ranged from 10 to 60 ppm. The TCLo for humans is 10 ppm, with somnolence and respiratory tract irritation noted.

Studies in Laboratory Animals:
In inhalation studies with rats, four of ten animals died after exposures of 2400 ppm for 24 hours. An oral dose of 5 mL/kg resulted in death in one of ten rats. Minimum lethal intraperitoneal doses were 1.5 to 2.0 mL/kg in rats and 1.13 to 12 mL/kg in guinea pigs. Mesitylene (1, 3, 5 Trimethylbenzene) inhalation at concentrations of 1.5, 3.0, and 6.0 mg/L for six hours was associated with dose-related changes in white blood cell counts in rats. No significant effects on the complete blood count were noted with six hours per day exposure

for five weeks, but elevations of alkaline phosphatase and SGOT were observed. Central nervous system depression and ataxia were noted in rats exposed to 5,100 to 9,180 ppm for two hours.

Benzene:

ORAL (LD50):	Acute: 930 mg/kg [Rat]. 4700 mg/kg [Mouse].
INHALATION (LC50):	
(VAPOR):	Acute: 10000 ppm 7 hour(s) [Rat]. 9980 ppm 8 hour(s) [Mouse].

Studies of Workers Over-Exposed to Benzene:
Studies of workers exposed to benzene show clear evidence that over-exposure can cause cancer of the blood forming organs (acute myelogenous leukemia) and aplastic anemia, an often fatal disease. Studies also suggest over-exposure to benzene may be associated with other types of leukemia and other blood disorders. Some studies of workers exposed to benzene have shown an association with increased rates of chromosome aberrations in circulating lymphocytes. One study of women workers exposed to benzene suggested a weak association with irregular menstruation. However, other studies of workers exposed to benzene have not demonstrated clear evidence of an effect on fertility or reproductive outcome in humans. Benzene can cross the placenta and affect the developing fetus. Cases of aplastic anemia have been reported in the offspring of persons severely over-exposed to benzene.

Studies in Laboratory Animals:
Studies in laboratory animals indicate that prolonged, repeated exposure to high levels of benzene vapor can cause bone marrow suppression and cancer in multiple organ systems. Studies in laboratory animals show evidence of adverse effects on male reproductive organs following high levels of exposure but no significant effects on reproduction have been observed. Embryotoxicity has been reported in studies of laboratory animals but effects were limited to reduced fetal weight and skeletal variations.

Ethylbenzene:
Effects from Acute Exposure:
ORAL (LD50), Acute: 3,500 mg/kg [Rat].
DERMAL (LD50), Acute: 17,800 uL/kg [Rabbit].
INTRAPERITONEAL (LD50), Acute: 2,624 mg/kg [Rat].

Effects from Prolonged or Repeated Exposure:
Findings from a 2-year inhalation study in rodents conducted by NTP were as follows: Effects were observed only at the highest exposure level (750 ppm). At this level the incidence of renal tumors was elevated in male rats (tubular carcinomas) and female rats (tubular adenomas). Also, the incidence of tumors was elevated in male mice (alveolar and bronchiolar carcinomas) and female mice (hepatocellular carcinomas). IARC has classified ethyl benzene as “possibly carcinogenic to humans” (Group 2B). Studies in laboratory animals indicate some evidence of post-implantation deaths following high levels of maternal exposure. The relevance of these findings to humans is not clear at this time. Studies in laboratory animals indicate limited evidence of renal malformations, resorptions, and developmental delays following high levels of maternal exposure. The relevance of these findings to humans is not clear at this time. Studies in laboratory animals indicate some evidence of adverse effects on the liver, kidney, thyroid, and pituitary gland.

Cyclohexane:
Cyclohexane can cause eye, skin and mucous membrane irritation, CNS depressant and narcosis at elevated concentrations. In experimental animals exposed to lethal concentrations by inhalation or oral route, generalized vascular damage and degenerative changes in the heart, lungs, liver, kidneys and brain were identified.

Cyclohexane has been the focus of substantial testing in laboratory animals. Cyclohexane was not found to be genotoxic in several tests including unscheduled DNA synthesis, bacterial and mammalian cell mutation assays, and in vivo chromosomal aberration. An increase in chromosomal aberrations in bone marrow cells of rats exposed to cyclohexane

was reported in the 1980's. However, a careful re-evaluation of slides from this study by the laboratory which conducted the study indicates these findings were in error, and that no significant chromosomal effects were observed in animals exposed to cyclohexane. Findings indicate long-term exposure to cyclohexane does not promote dermal tumorigenesis.

Naphthalene:
Studies in Humans Overexposed to Naphthalene:
Severe jaundice, neurotoxicity (kernicterus) and fatalities have been reported in young children and infants as a result of hemolytic anemia from over-exposure to naphthalene. Persons with Glucose 6-phosphate dehydrogenase (G6PD) deficiency are more prone to the hemolytic effects of naphthalene. Adverse effects on the kidney have also been reported from over-exposure to naphthalene but these effects are believed to be a consequence of hemolytic anemia, and not a direct effect.

Studies in Laboratory Animals:
Hemolytic anemia has been observed in laboratory animals exposed to naphthalene. Laboratory rodents exposed to naphthalene vapor for 2 years (lifetime studies) developed non-neoplastic and neoplastic tumors and inflammatory lesions of the nasal and respiratory tract. Cataracts and other adverse effects on the eye have been observed in laboratory animals exposed to high levels of naphthalene. Findings from a large number of bacterial and mammalian cell mutation assays have been negative. A few studies have shown chromosomal effects (elevated levels of Sister Chromatid Exchange or chromosomal aberrations) *in vitro.*

Styrene:
Neurological injury associated with chronic styrene exposure include distal hypesthesia, decreased nerve conduction velocity, and altered psychomotor performance. These effects did not occur with exposures to airborne concentrations that were less than 100 ppm. Increased deaths from degenerative neurological disorders were found in a comprehensive epidemiological study of Danish reinforced plastics workers. These workers were reported to have a 2.5-fold increased risk for myeloid leukemia with clonal chromosome aberrations. Also, there are several studies that suggest potential reproductive effects in humans and experimental animals from overexposure to styrene. Styrene was not mutagenic in the standard (liquid phase) Ames Salmonella/microsome assay, but was weakly positive when tested in the vapor phase. IARC has listed styrene as possibly carcinogenic to humans (Group 2B).

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Unleaded gasoline is potentially toxic to freshwater and saltwater ecosystems. Various grades of gasoline exhibited range of lethal toxicity (LC_{100}) from 40 PPM to 100 PPM in ambient stream water with Rainbow Trout (*Salmo irideus*). A 24-hour TLm (Median Toxic Limit) was calculated to be 90 PPM with juvenile American Shad (*Squalius cephalus*). In Bluegill Sunfish (*Lepomis macrochirus*), Grey Mullet (*Chelon labrosus*) and Gulf Menhaden (*Brevoortia patronus*), gasoline exhibited a 96-hour LC_{50} of 8 PPM, 2 PPM, and 2 PPM, respectively.

The aquatic toxicity of Methyl tertiary-Butyl Ether (MTBE) is considered to be relatively low. In the crustacean Harpacticoid Copepods (*Nitrocra spinipes*), MTBE exhibited an LC_{50} (96-hour) of 1,000 PPM to 10,000 PPM depending upon various water temperatures. In Bleak Fish (*Alburnus alburnus*), MTBE exhibited an LC_{50} (24-hour) of 1,700 PPM and an LC_{50} (96-hour) of 1,000 PPM at 10° C. In Golden Orfe Fish (*Leuciscus idus melanotus*), MTBE exhibited an LC_{50} (48-hour) of 1,000 PPM and an LC_{100} of 2,000 PPM.

Environmental Fate

Avoid spilling gasoline. Spilled gasoline can result in environmental damage. Spilled gasoline can penetrate soil and contaminate ground water. Although gasoline is biodegradable, it may persist for prolonged time periods, particularly where oxygen levels are reduced. The hydrocarbon components of gasoline are slightly soluble in water. Gasoline hydrocarbon components do not readily dissolve in water but can be adsorbed to soils.

Gasoline contains components that are potentially toxic to freshwater and saltwater ecosystems. It will normally float on water. The components of gasoline will evaporate rapidly. Evaporated hydrocarbon components may contribute to atmospheric smog.

MTBE and other oxygenates are more soluble than other gasoline components. In addition, oxygenates such as MTBE do not adsorb to soils, sediments or suspended particulate matter as readily as other gasoline components. MTBE does not degrade as readily as other gasoline components once in ground water or subsoil. MTBE is not expected to bioconcentrate in the aquatic environment.

SECTION 13. DISPOSAL CONSIDERATIONS

Hazard characteristic and regulatory waste stream classification can change with product use. Accordingly, it is the responsibility of the user to determine the proper storage, transportation, treatment and/or disposal methodologies for spent materials and residues at the time of disposition.

Maximize material recovery for reuse or recycling. Recovered non-usable material may be regulated by US EPA as a hazardous waste due to its ignitibility (D001) and/or its toxic (D018) characteristics. Conditions of use may cause this material to become a "hazardous waste", as defined by federal or state regulations. It is the responsibility of the user to determine if the material is a RCRA "hazardous waste" at the time of disposal. Transportation, treatment, storage and disposal of waste material must be conducted in accordance with RCRA regulations (see 40 CFR 260 through 40 CFR 271). State and/or local regulations may be more restrictive. Contact your regional US EPA office for guidance concerning case specfic disposal issues.

SECTION 14. TRANSPORT INFORMATION

The shipping description below may not represent requirements for all modes of transportation, shipping methods or locations outside of the United States.

US DOT Status A U.S. Department of Transportation regulated material.

Proper Shipping Name Gasoline, 3, UN 1203, PG II
Gasohol, 3, NA 1203, PGII (Use only for gasoline blended with less than 20% ethanol)

Hazard Class 3 DOT Class: Flammable liquid.

Packing Group(s) II

UN/NA Number UN1203 or NA1203

Reportable Quantity A Reportable Quantity (RQ) has not been established for this material.

Placard(s)



Emergency Response Guide No. 128

MARPOL III Status Not a DOT "Marine Pollutant" per 49 CFR 171.8.

SECTION 15. REGULATORY INFORMATION

TSCA Inventory

This product and/or its components are listed on the Toxic Substances Control Act (TSCA) inventory.

SARA 302/304 Emergency Planning and Notification

The Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requires facilities subject to Subparts 302 and 304 to submit emergency planning and notification information based on Threshold Planning Quantities (TPQs) and Reportable Quantities (RQs) for "Extremely Hazardous Substances" listed in 40 CFR 302.4 and 40 CFR 355. No components were identified.

SARA 311/312 Hazard Identification

The Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requires facilities subject to this subpart to submit aggregate information on chemicals by "Hazard Category" as defined in 40 CFR 370.2. This material would be classified under the following hazard categories:

fire, Acute (Immediate) Health Hazard, Chronic (Delayed) Health Hazard

SARA 313 Toxic Chemical Notification and Release Reporting

This product contains the following components in concentrations above de minimis levels that are listed as toxic chemicals in 40 CFR Part 372 pursuant to the requirements of Section 313 of SARA:
Toluene [CAS No.: 108-88-3] Concentration: <20%
Xylene, all isomers [CAS No.: 1330-20-7] Concentration: <18%
Methyl tertiary-Butyl Ether (MTBE) [CAS No.: 1634-04-4] Concentration: <15%
n-Hexane [CAS No.: 110-54-3] Concentration: <8%
Cumene [CAS No.: 98-82-8] Concentration: <4%
Benzene [CAS No.: 71-43-2] Concentration: <5%
Ethylbenzene [CAS No.: 100-41-4] Concentration: <4%
1, 2, 4 Trimethylbenzene [CAS No.: 95-63-6] Concentration: <4%
Cyclohexane [CAS No.: 110-82-7] Concentration: <3%
Naphthalene [CAS No.: 91-20-3] Concentration: <2%
Styrene [CAS No.: 100-42-5] Concentration: <1%

CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requires notification of the National Response Center concerning release of quantities of "hazardous substances" equal to or greater than the reportable quantities (RQ's) listed in 40 CFR 302.4. As defined by CERCLA, the term "hazardous substance" does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically designated in 40 CFR 302.4. Chemical substances present in this product or refinery stream that may be subject to this statute are:
Toluene [CAS No.: 108-88-3] RQ = 1000 lbs. (453.6 kg) Concentration: <20%
Xylene, all isomers [CAS No.: 1330-20-7] RQ = 100 lbs. (45.36 kg) Concentration: <18%
Methyl tertiary-Butyl Ether (MTBE) [CAS No.: 1634-04-4] RQ = 1000 lbs. (453.6 kg) Concentration: <15%
n-Hexane [CAS No.: 110-54-3] RQ = 5000 lbs. (2268 kg) Concentration: <8%
2,2,4-Trimethylpentane [CAS No.: 540-84-1] RQ = 1000 lbs. (453.6 kg) Concentration: <5%
Benzene [CAS No.: 71-43-2] RQ = 10 lbs. (4.536 kg) Concentration: <5%
Cumene [CAS No.: 98-82-8] RQ = 5000 lbs. (2268 kg) Concentration: <4%
Ethylbenzene [CAS No.: 100-41-4] RQ = 1000 lbs. (453.6 kg) Concentration: <4%
Cyclohexane [CAS No.: 110-82-7] RQ = 1000 lbs. (453.6 kg) Concentration: <3%
Naphthalene [CAS No.: 91-20-3] RQ = 100 lbs. (45.36 kg) Concentration: <2%
Styrene [CAS No.: 100-42-5] RQ = 1000 lbs. (453.6 kg) Concentration: <1%

Clean Water Act (CWA)

This material is classified as an oil under Section 311 of the Clean Water Act (CWA) and the Oil Pollution Act of 1990 (OPA). Discharges or spills which produce a visible sheen on waters of the United States, their adjoining shorelines, or into conduits leading to surface waters must be reported to the EPA's National Response Center at (800) 424-8802.

California Proposition 65

This material may contain the following components which are known to the State of California to cause cancer, birth defects or other reproductive harm, and may be subject to the requirements of California Proposition 65 (CA Health & Safety Code Section 25249.5): Gasoline (Wholly Vaporized and Engine Exhaust), Benzene [CAS No. 71-43-3], Toluene [CAS No. 108-88-3], Ethylbenzene [CAS No.100-41-4] and Naphthalene [CAS No.91-20-3]

New Jersey Right-to-Know Label

Gasoline [NJDEP CAS No. 8006-61-9]

Additional Regulatory Remarks

As minimum requirements, CITGO recommends that the following advisory information be displayed on equipment used to dispense gasoline in motor vehicles. Additional warnings specified by various regulatory authorities may be required: "DANGER: Extremely Flammable. Use as a Motor Fuel Only. No Smoking. Stop Engine. Turn Off All Electronic Equipment including Cellular Telephones. Do Not Overfill Tank. Keep Away from Heat and Flames. Do Not leave nozzle unattended during refueling. **Static Sparks Can Cause a Fire, especially when filling portable containers.** Containers must be metal or other material approved for storing gasoline. PLACE CONTAINER ON GROUND. DO NOT FILL ANY PORTABLE CONTAINER IN OR ON A VEHICLE. Keep nozzle spout in contact with the container during the entire filling operation. **Harmful or Fatal if Swallowed. Long-Exposure Has Caused Cancer in Laboratory Animals.** Avoid prolonged breathing of vapors. Keep face away from nozzle and gas tank. Never siphon by mouth."

WHMIS Class B-2: Flammable liquid with a flash point lower than 37.8°C (100°F).
WHMIS Class D-2B: Material causing other toxic effects (TOXIC).

SECTION 16. OTHER INFORMATION

Refer to the top of Page 1 for the HMIS and NFPA Hazard Ratings for this product.

REVISION INFORMATION

Version Number	7.0
Revision Date	05/23/2005
Print Date	Printed on 05/23/2005.

ABBREVIATIONS

AP: Approximately EQ: Equal >: Greater Than <: Less Than NA: Not Applicable ND: No Data NE: Not Established

ACGIH: American Conference of Governmental Industrial Hygienists
AIHA: American Industrial Hygiene Association
IARC: International Agency for Research on Cancer
NTP: National Toxicology Program
NIOSH: National Institute of Occupational Safety and Health
OSHA: Occupational Safety and Health Administration
NPCA: National Paint and Coating Manufacturers Association
HMIS: Hazardous Materials Information System
NFPA: National Fire Protection Association
EPA: US Environmental Protection Agency

DISCLAIMER OF LIABILITY

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THE CONDITIONS OR METHODS OF HANDLING, STORAGE, USE, AND DISPOSAL OF THE PRODUCT ARE BEYOND OUR CONTROL AND MAY BE BEYOND OUR KNOWLEDGE. FOR THIS AND OTHER REASONS, WE DO NOT ASSUME RESPONSIBILITY AND EXPRESSLY DISCLAIM LIABILITY FOR LOSS, DAMAGE OR EXPENSE ARISING OUT OF OR IN ANY WAY CONNECTED WITH HANDLING, STORAGE, USE OR DISPOSAL OF THE PRODUCT.

1. Chemical Product

Product Name: Diesel

2. Composition, Information On Ingredients

Product Use: This product is intended for use as a fuel in engines and heaters designed for diesel fuels, and for use in engineered processes. Use in other applications may result in higher exposures and require additional controls, such as local exhaust ventilation and personal protective equipment.

Description: Diesel is a complex mixture of hydrocarbons from a variety of chemical processes blended to meet standardized product specifications.

3. Hazards Identification

Health Hazard Data:

1. The major effect of exposure to this product is giddiness, headache, central nervous system depression; possible irritation of eyes, nose, and lungs; and dermal irritation. Signs of kidney and liver damage may be delayed. Pulmonary irritation secondary to exhalation of solvent.

2. NIOSH recommends that whole diesel engine exhaust be regarded as a potential occupational carcinogen. Follow OSHA and NSHA rules where diesel engine exhaust fumes may be generated.

3. A lifetime skin painting study by the American Petroleum Institute has shown that similar naphtha products with a boiling range of 350-700 degrees F usually produce skin tumors and/ or skin cancers in laboratory mice. Only a weak to moderate response occurred. The effect to humans has not been determined.

4. Positive results at 2.0 ml/kg and 6.0 ml/kg noted in mutagenesis studies via in-vivo bone marrow cytogenetics assay in rats.

5. Kerosene is classified as a severe skin irritant. Mutation data has been reported for kerosene products. Hydrotreated kerosene is listed as being probably carcinogenic to humans with limited evidence in humans and sufficient evidence in experimental animals.

Hazards of Combustion Products: Carbon monoxide and carbon dioxide can be found in the combustion products of this product and other forms of hydrocarbon combustion. Carbon monoxide in moderate concentrations can cause symptoms of headache, nausea, vomiting, increased cardiac output, and confusion. Exposure to higher concentrations of carbon monoxide can cause loss of consciousness, heart damage, brain damage, and/or death. Exposure to high concentrations of carbon dioxide can cause simple asphyxiation by displacing available oxygen. Combustion of this and other similar materials should only be carried out in well-ventilated areas.

Medical Condition Generally Aggravated By Exposure: Medical conditions which have the same symptoms and effects as those outlined under the health hazard information section can be aggravated by exposure to this product.

Medical Limitation: N/A

Routes Of Exposure

Inhalation: Irritation of the upper respiratory tract and eyes, with possible euphoria, dizziness, headache, discoordination, ringing in the ears, convulsions, coma, and respiratory arrest.

Skin Contact: Defatting of the skin may occur with continued and prolonged contact. Irritation and burning sensation may occur on exposure to the liquid or mists.

Skin Absorption: Not significant.

Eye Contact: Severe burning sensation with temporary irritation and swelling of lids.

Ingestion: Irritation of the mucous membranes of throat, esophagus and stomach which may result in nausea and vomiting; central nervous system depression may occur, if absorbed (see inhalation symptoms above). If aspirated, chemical pneumonitis may occur with potentially fatal results. Possible kidney and liver damage may be delayed.

Carcinogenicity Statement: Diesel is not listed as carcinogenic by NTP, OSHA, and ACGIH. IARC has listed kerosene and light catalytic cracked distillates as a probable

human carcinogen. Light paraffinic hydrotreated petroleum distillates are listed as confirmed human carcinogens by IARC.

4. First Aid Measures

Eyes: Immediately flush eyes with large amount of water for at least 15 minutes holding lids apart to ensure flushing of the entire eye surface. SEEK IMMEDIATE MEDICAL ATTENTION.

Skin: Wash contaminated areas with plenty of soap and water. A soothing ointment may be applied to irritated skin after thoroughly cleansing. Remove contaminated clothing and footwear. SEEK IMMEDIATE MEDICAL ATTENTION.

Inhalation: Get person out of contaminated area to fresh air. If breathing has stopped resuscitate and administer oxygen if readily available. SEEK MEDICAL ATTENTION IMMEDIATELY.

INGESTION: Never give anything by mouth to an unconscious person. If swallowed, do not induce vomiting. If vomiting occurs spontaneously, keep airway clear. SEEK MEDICAL ATTENTION IMMEDIATELY.

Note to Physician: Do not induce vomiting, use gastric lavage only. Aspiration of liquid into the lungs could result in Chemical pneumonitis. Use of adrenaline is not advised. Treat symptomatically.

5. Fire and Explosion Data

Flash Point: 100 degrees F PM (minimum)
Autoignition Temperature: 494 degrees F
Flammable Limits In Air: UEL: 5% - LEL: 0.7%

Extinguishing Media: Use dry chemical, carbon dioxide, foam or water spray. Water may be ineffective in fighting fires of liquids with low flash points, but water should be used to keep fire exposed containers cool. If a leak or spill has not ignited, use water spray to disperse the vapors and to protect persons attempting to stop a leak.

Special Fire Fighting Procedures: Pressure-demand, self contained, breathing apparatus should be provided for fire fighters in buildings or confined areas where product is stored.

Unusual Fire And Explosion Hazard: Vapor accumulation is possible, and flashback can occur with explosive force if vapors are ignited.

6. Accidental Release Measures

If material is spilled, steps should be taken to contain liquid and prevent discharges to streams or sewer systems and control or stop the loss of volatile materials to the atmosphere. Spills or releases should be reported, if required to the appropriate local, state and federal regulatory agencies.

Small Spills: Remove ignition sources. Absorb spilled material with non-combustible materials such as cat litter, dirt, sand, or petroleum sorbent pads/pillows. Do not use combustible materials like rags, wood chips, or saw dust. Remove contaminated materials to an appropriate disposal container.

Large Spills: Remove ignition sources. Dike spill area with sand or dirt to contain material and cover sewers/drains. Remain upwind and keep unnecessary people away. Contact trained emergency response team for cleanup. Remove liquid using grounded suction pumps, isolate hazard area and deny entry.

7. Handling and Storage Information

Store only in approved containers. Protect containers against physical damage. Outside or detached storage is preferred. Separate from oxidizing materials. Store in cool, well ventilated area of non-combustible construction away from possible sources of ignition. Keep away from incompatible materials and follow OSHA 29 CFR 1910.106 and NFPA 30 for storage requirements.

Product Use: This product is intended for use as a fuel in engines and heaters designed for kerosene or diesel fuels, and for use in engineered processes. Use in other

applications may result in higher exposures and require additional controls, such as local exhaust ventilation and personal protective equipment.

8. Exposure Controls/Personal Protection

Ventilation Requirements: Work in well-ventilated areas using good engineering practices to process, transfer and store. Special ventilation in not required unless product is sprayed or heated. High volume use may require engineering controls.

Specific Personal Protective Equipment

Respiratory: Respiratory protection is not required unless product is sprayed or heated. Use NIOSH approved respiratory protection following manufacture's recommendations where spray, mists, or vapors may be generated. Supplied air respiratory protection is required for IDLH areas. See 29 CFR 1910.134 for OSHA Respirator Protection regulations.

Eye: Face shield and goggles or chemical goggles should be worn where mist or spray may be generated, and where splashing occurs. Shower and eyewash facilities should be accessible.

Gloves: Impermeable protective gloves such as nitrile gloves should be worn during routine handling of this product. Barrier creams may also be appropriate where tactile sensitivity is required.

Other Clothing and Equipment: Clothing contaminated with this product should be removed and laundered before reuse. Items which cannot be laundered should be discarded. Allow contaminated items to air-dry or hang in a well-ventilated area. Spontaneous combustion or fire may result from contaminated materials being placed together before drying.

Exposure Monitoring

Biological: No applicable procedure, breath analysis for hydrocarbons has been suggested.

Personal/Area: Based on similarity to kerosene, both active and passive monitors employing charcoal adsorption follow by gas chromatography. An average molecular weight of 170 has been suggested as the average value to convert the determined

weight of hydrocarbons to ppm. Direct reading colorimetric tubes are available to evaluate short-term exposure.

9. Physical and Chemical Properties

Appearance and Odor: Colorless to straw, or red oily liquid with characteristic kerosene-like odor.
Viscosity: Specification dependent, 1.7 - 3.4 cSt @ 140 degrees F
Boiling Range @ 760 mm Hg: 302-644 degrees F
Vapor Density (Air=1): 4.5 (kerosene)
Evaporation Rate (BuAc=1): N/A
Specific Gravity (H2O=1): 0.865
Bulk Density At 60 degrees F: 6.8-7.2 lbs./gal.
Solubility in H2O % by WT.: Insoluble
Freezing Point: -51 degrees F
Vapor Pressure: 0.5 mmHg @ 20 degrees C
% Volatiles By Vol.: N/A
API Gravity: Specification dependent
pH: NA

10. Stability and Reactivity Information

Conditions Contributing to Instability: Under normal conditions, the material is stable. Avoid sources of ignition such as flames, hot surfaces, sparks, and electrical equipment.
Incompatibility: Avoid contact with strong oxidizers such as chlorine, concentrated oxygen, and sodium hypochlorite or other hypochlorites.
Hazardous Decomposition Products: Thermal decomposition products may include carbon monoxide, carbon dioxide, oxides of sulfur and nitrogen, and other toxic gases
Hazardous Polymerization: Material is not known to polymerize.

11. Disposal Considerations

Shipment, storage, disposal, and cleanup actions of waste materials are regulated under local, provincial and federal rules. Contact the appropriate agencies if uncertain of

applicability. Waste product and contaminated material having a flash point below 140 degrees F is considered a hazardous waste. Consult appropriate agencies for disposal requirements.

12. Other

This material safety data sheet was originally prepared by T. W. Brown Oil Co., Inc. and modified by Access Consulting Group. All information, recommendations and suggestions appearing herein concerning this product are based upon tests and data believed to be reliable, however, it is the user's responsibility to determine the safety, toxicity and suitability for his own use of the product described herein. Since the actual use by others is beyond our control, no guarantee expressed or implied is made by T. W. Brown Oil Co., Inc. or Access Consulting Group as to the effects of such use, the results to be obtained or the safety and toxicity of the product nor does T. W. Brown Oil Co., Inc. or Access Consulting Group assume any liability arising out of use by others of the product referred to herein. Nor is the information herein to be construed as absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations.

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MG INDUSTRIES
3 GREAT VALLEY PARKWAY
MALVERN, PENNSYLVANIA 19355
PHONE: 610-695-7400
FAX: 610-695-7596

EMERGENCY CONTACT:
CHEMTREC:
1-800-424-9300

SUBSTANCE: PROPANE
TRADE NAMES/SYNONYMS:
N-PROPANE; DIMETHYLMETHANE; PROPYL HYDRIDE; R-290; PROPYLHYDRIDE; LIQUEFIED PETROLEUM GAS; LPG; STCC 4905781; UN 1978; C3H8; MGI19690; RTECS TX2275000
CHEMICAL FAMILY: hydrocarbons, aliphatic
CREATION DATE: May 07 1990
REVISION DATE: Mar 19 2003

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2. COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: PROPANE
CAS NUMBER: 74-98-6
EC NUMBER (EINECS): 200-827-9
EC INDEX NUMBER: 601-003-00-5
PERCENTAGE: 100

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3. HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=1 FIRE=4 REACTIVITY=0
EMERGENCY OVERVIEW:
PHYSICAL DESCRIPTION: Colorless gas with a characteristic natural gas odor.
MAJOR HEALTH HAZARDS: central nervous system depression, difficulty breathing
PHYSICAL HAZARDS: Flammable gas. May cause flash fire.
POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: nausea, vomiting, irregular heartbeat, headache, symptoms of drunkenness, disorientation, suffocation, convulsions, coma
LONG TERM EXPOSURE: same as effects reported in short term exposure
SKIN CONTACT:
SHORT TERM EXPOSURE: blisters, frostbite
LONG TERM EXPOSURE: no information on significant adverse effects
EYE CONTACT:
SHORT TERM EXPOSURE: frostbite, blurred vision
LONG TERM EXPOSURE: no information is available
INGESTION:
SHORT TERM EXPOSURE: frostbite

LONG TERM EXPOSURE: no information is available
CARCINOGEN STATUS:
OSHA: No
NTP: No
IARC: No

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4. FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.
SKIN CONTACT: If frostbite or freezing occur, immediately flush with plenty of

lukewarm water (105-115 F; 41-46 C). DO NOT USE HOT WATER. If warm water is not available, gently wrap affected parts in blankets. Get immediate medical attention.
EYE CONTACT: Flush eyes with plenty of water.
INGESTION: If a large amount is swallowed, get medical attention.
NOTE TO PHYSICIAN: For inhalation, consider oxygen.

5. FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. Severe explosion hazard. Vapor/air mixtures are explosive. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Electrostatic discharges may be generated by flow or agitation resulting in ignition or explosion.
EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical
Large fires: Flood with fine water spray.
FIRE FIGHTING: Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Stop leak if possible without personal risk. Let burn unless leak can be stopped immediately. For smaller tanks or cylinders, extinguish and isolate from other flammables. Evacuation radius: 800 meters (1/2 mile). Stop flow of gas.
FLASH POINT: -157 F (-105 C)
LOWER FLAMMABLE LIMIT: 2.1%

UPPER FLAMMABLE LIMIT: 9.5%
AUTOIGNITION: 842 F (450 C)

6. ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Do not touch spilled material. Stop leak if possible without personal risk. Reduce vapors with water spray. Keep unnecessary people away, isolate hazard area and deny entry. Remove sources of ignition. Ventilate closed spaces before entering.

7. HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.110. Grounding and bonding required. Keep separated from incompatible substances.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
PROPANE:
1000 ppm (1800 mg/m3) OSHA TWA
2500 ppm ACGIH TWA
1000 ppm (1800 mg/m3) NIOSH recommended TWA 10 hour(s)
1800 mg/m3 (1000 ml/m3) DFG MAK (peak limitation category - II, with excursion factor of 2)

UK OES (simple asphyxiant)
MEASUREMENT METHOD: Combustible gas meter; NIOSH II(2) # S87
LIQUIFIED PETROLEUM GAS (LPG):
1000 ppm (1800 mg/m3) OSHA TWA
1000 ppm ACGIH TWA
1000 ppm (1800 mg/m3) NIOSH recommended TWA 10 hour(s)
1000 ppm (1750 mg/m3) UK OES TWA
1250 ppm (2180 mg/m3) UK OES STEL
MEASUREMENT METHOD: Combustible gas meter; NIOSH II(2) # S93
VENTILATION: Provide local exhaust ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.
EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.
CLOTHING: For the gas: Protective clothing is not required. For the liquid: Wear appropriate protective, cold insulating clothing.

GLOVES: Wear insulated gloves.
RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
2100 ppm
Any supplied-air respirator.
Any self-contained breathing apparatus with a full facepiece.
Escape -
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION: Colorless gas with a characteristic natural gas odor.
MOLECULAR WEIGHT: 44.11
MOLECULAR FORMULA: C-H3-C-H2-C-H3
BOILING POINT: -44 F (-42 C)
FREEZING POINT: -310 F (-190 C)
VAPOR PRESSURE: 6536 mmHg @ 20 C
VAPOR DENSITY (air=1): 1.55
SPECIFIC GRAVITY (water=1): 0.5853 @ -45 C
WATER SOLUBILITY: very slightly soluble
PH: Not applicable
VOLATILITY: Not applicable
ODOR THRESHOLD: 5000-20000 ppm
EVAPORATION RATE: Not applicable
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable
SOLVENT SOLUBILITY:
Soluble: absolute alcohol, ether, chloroform, benzene, turpentine

10. STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.
CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Minimize contact with material. Containers may rupture or explode if exposed to heat.

INCOMPATIBILITIES: oxidizing materials, combustible materials
PROPANE:
  BARIUM PEROXIDE: Violent exothermic reaction.
  CHLORINE DIOXIDE: Spontaneous explosion.
  PLASTICS, RUBBER, COATINGS: Attacked by liquid propane.
  OXIDIZERS (STRONG): Fire and explosion hazard.

HAZARDOUS DECOMPOSITION:
  Thermal decomposition products: oxides of carbon
POLYMERIZATION: Will not polymerize.

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11. TOXICOLOGICAL INFORMATION

PROPANE:
TARGET ORGANS: central nervous system
ADDITIONAL DATA: Stimulants such as epinephrine may induce ventricular fibrillation.
HEALTH EFFECTS:
INHALATION:
  ACUTE EXPOSURE:
    PROPANE: Brief exposure to 10,000 ppm caused no symptoms in human subjects; 100,000 ppm produced slight dizziness in a few minutes but was not noticeably irritating to the nose or respiratory tract. High levels may produce disorientation, excitation, excessive salivation, headache and vomiting. In primates, 100,000 ppm produced some myocardial effects and at 200,000 ppm aggravation of these parameters and respiratory depression. Concentrations of 100,000 ppm in mice and 150,000 ppm in dogs appear to produce no arrhythmia but weak cardiac sensitization. Concentrations of 75% may produce nausea, vomiting, prostration, unconsciousness, convulsions, deep coma and death.
  CHRONIC EXPOSURE:
    PROPANE: Repeated contact may result in symptoms as described in acute exposure.
SKIN CONTACT:
  ACUTE EXPOSURE:
    PROPANE: No adverse effects have been reported from the gas. Due to rapid evaporation, the liquid may cause frostbite with redness, tingling and pain or numbness. In more severe cases, the skin may become hard and white and develop blisters.
  CHRONIC EXPOSURE:
    PROPANE: No adverse effects reported.
EYE CONTACT:
  ACUTE EXPOSURE:
    PROPANE: Vapor concentrations of 100,000 ppm were not noticeably irritating to the eyes. Due to rapid evaporation, the liquid may cause frostbite with redness, pain and blurred vision.
  CHRONIC EXPOSURE:
    PROPANE: No data available.
INGESTION:
  ACUTE EXPOSURE:
    PROPANE: Ingestion of a gas is unlikely. If the liquid is swallowed, frostbite damage of the lips, mouth and mucous membranes may occur.

  CHRONIC EXPOSURE:
    PROPANE: No data available.

New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **KEROSENE**

CAS Number: 8008-20-6
DOT Number: UN 1223

RTK Substance number: 1091
Date: September 1986 Revision: January 1997

HAZARD SUMMARY

* **Kerosene** can affect you when breathed in and by passing through your skin.
* Contact can irritate and burn the skin and eyes.
* Breathing **Kerosene** can irritate the nose, throat and lungs.
* High exposure can affect the nervous system causing headache, nausea, weakness, drowsiness and even coma.
* **Kerosene** may damage the kidneys.

IDENTIFICATION

* **Kerosene** is a clear to pale yellowish liquid with a fuel oil odor. It is used as a rocket fuel, a home heating fuel, and a solvent.

REASON FOR CITATION

* **Kerosene** is on the Hazardous Substance List because it is cited by DOT, NIOSH and NFPA.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

NIOSH: The recommended airborne exposure limit is **100 mg/m^3** averaged over a 10-hour workshift.

It should be recognized that **Kerosene** can be absorbed through your skin, thereby increasing your exposure.

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing.
* Wash thoroughly immediately after exposure to **Kerosene**.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Kerosene** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Kerosene**:

* Contact can irritate and burn the skin and eyes.
* Breathing **Kerosene** can irritate the nose and throat causing cough and wheezing.
* High exposure can affect the nervous system causing headache, nausea, weakness, disorientation, drowsiness and even coma.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Kerosene** and can last for months or years:

Cancer Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Kerosene** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Kerosene** has not been tested for its ability to affect reproduction.

Other Long-Term Effects

* Repeated skin contact can cause ithching and a skin rash.
* **Kerosene** can irritate the lungs. Repeated exposures may cause bronchitis to develop with cough, phlegm, and/or shortness of breath.
* **Kerosene** may damage the kidneys.

MEDICAL

Medical Testing

If symptoms develop or overexposure is suspected, the following may be useful:

* Lung function tests.
* Kidney function tests.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

Mixed Exposures

Because smoking can cause heart disease, as well as lung cancer, emphysema, and other respiratory problems, it may worsen respiratory conditions caused by chemical exposure. Even if you have smoked for a long time, stopping now will reduce your risk of developing health problems.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following control is recommended:

* Where possible, automatically pump liquid **Kerosene** from drums or other storage containers to process containers.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by **Kerosene** should change into clean clothing promptly.
* Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **Kerosene**.
* On skin contact with **Kerosene**, immediately wash or shower to remove the chemical.
* Do not eat, smoke, or drink where **Kerosene** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

* Avoid skin contact with **Kerosene**. The ACGIH recommends wearing *Neoprene, Nitrile Rubber or Polyvinyl Alcohol* gloves when handling **Kerosene**.

Eye Protection

* Wear splash-proof chemical goggles and faceshield when working with liquid, unless full facepiece respiratory protection is worn.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* Where the potential exists for exposures over **100 mg/m^3**, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in a pressure-demand or other positive-pressure mode. For increased protection use in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?
A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?
A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?
A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?
A: Conditions which increase risk of exposure include physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?
A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.

The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information
Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation
If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations
Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources
The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<

Common Name: **KEROSENE**
DOT Number: **UN 1223**
NAERG Code: **128**
CAS Number: **8008-20-6**

Hazard rating	NJDHSS	NFPA
FLAMMABILITY	-	2
REACTIVITY	-	0
COMBUSTIBLE LIQUID		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* **Kerosene** is a COMBUSTIBLE LIQUID.
* Use dry chemical, CO_2, water spray, or foam extinguishers.

* **Kerosene** presents a MODERATE EXPLOSION HAZARD when involved in a fire.
* If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If **Kerosene** is spilled or leaked, take the following steps:

* Restrict persons not wearing protective equipment from area of spill or leak until clean-up is complete.
* Remove all ignition sources.
* Ventilate area of spill or leak.
* Absorb liquids in vermiculite, dry sand, earth, or a similar material and deposit in sealed containers.
* Keep **Kerosene** out of a confined space, such as a sewer, because of the possibility of an explosion, unless the sewer is designed to prevent the build-up of explosive concentrations.
* It may be necessary to contain and dispose of **Kerosene** as a HAZARDOUS WASTE. Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

CHEMTREC: (800) 424-9300
NJDEP HOTLINE: (609) 292-7172

HANDLING AND STORAGE

* Prior to working with **Kerosene** you should be trained on its proper handling and storage.
* Store in tightly closed containers in a cool well-ventilated area.
* **Kerosene** is not compatible with OXIDIZING AGENTS (such as PERCHLORATES, PEROXIDES, PERMANGANATES, CHLORATES, NITRATES, CHLORINE, BROMINE and FLUORINE)
* Sources of ignition such as smoking and open flames are prohibited where **Kerosene** is handled, used, or stored.
* Metal containers involving the transfer of **Kerosene** should be grounded and bonded. Drums must be equipped with self-closing valves, pressure vacuum bungs, and flame arresters.

FIRST AID

In NJ, POISON INFORMATION 1-800-962-1253

Eye Contact
* Immediately flush with large amounts of water for at least 15 minutes, occasionally lifting upper and lower lids.

Skin Contact
* Quickly remove contaminated clothing. Immediately wash contaminated skin with large amounts of soap and water.

Breathing
* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.

PHYSICAL DATA

Vapor Pressure: 5 mm Hg at 100°F (38°C)
Flash Point: 100° - 160°F (38° - 71°C)
Water Solubility: Insoluble

OTHER COMMONLY USED NAMES

Chemical Name:
Kerosine
Other Names:
Fuel Oil #1; Coal Oil

Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
CN 368, Trenton, NJ 08625-0368
(609) 984-2202

ETHYLENE GLYCOL

1. Product Identification

Synonyms: 1,2-Ethanediol; glycol; 1,2-Dihydroxyethane; Ethylene Alcohol; Ethulene Dihydrate
CAS No.: 107-21-1
Molecular Weight: 62.07
Chemical Formula: CH2OHCH2OH
Product Codes:
J.T. Baker: 5387, 5845, 9140, 9298, 9300, 9346, 9356, L715
Mallinckrodt: 5001, 5037

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Ethylene Glycol	107-21-1	99 - 100%	Yes

3. Hazards Identification

Emergency Overview

WARNING! HARMFUL OR FATAL IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. MAY CAUSE ALLERGIC SKIN REACTION. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate (Life)
Flammability Rating: 1 - Slight
Reactivity Rating: 1 - Slight
Contact Rating: 3 - Severe (Life)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: Green (General Storage)

Potential Health Effects

Inhalation:
Vapor inhalation is generally not a problem unless heated or misted. Exposure to vapors over an extended time period has caused throat irritation and headache. May cause nausea, vomiting, dizziness and drowsiness. Pulmonary edema and central nervous system depression may also develop. When heated or misted, has produced rapid, involuntary eye movement and coma.
Ingestion:
Initial symptoms in massive dosage parallel alcohol intoxication, progressing to CNS depression, vomiting, headache, rapid respiratory and heart rate, lowered blood pressure, stupor, collapse, and unconsciousness with convulsions. Death from respiratory arrest or cardiovascular collapse may follow. Lethal dose in humans: 100 ml (3-4 ounces).
Skin Contact:
Minor skin irritation and penetration may occur.
Eye Contact:
Splashes may cause irritation, pain, eye damage.
Chronic Exposure:
Repeated small exposures by any route can cause severe kidney problems. Brain damage may also occur. Skin allergy can develop. May damage the developing fetus.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders, eye problems, or impaired liver, kidney, or respiratory function may be more susceptible to the effects of this substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.
Skin Contact:
Remove any contaminated clothing. Wash skin with soap and water for at least 15 minutes. Get medical attention if irritation develops or persists.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
Give sodium bicarbonate intravenously to treat acidosis. Urinalysis may show low

specific gravity, proteinuria, pyuria, cylindruria, hematuria, calcium oxide, and hippuric acid crystals. Ethanol can be used in antidotal treatment but monitor blood glucose when administering ethanol because it can cause hypoglycemia. Consider infusion of a diuretic such as mannitol to help prevent or control brain edema and hemodialysis to remove ethylene glycol from circulation.

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5. Fire Fighting Measures

Fire:
Flash point: 111C (232F) CC
Autoignition temperature: 398C (748F)
Flammable limits in air % by volume:
lel: 3.2; uel: 15.3
Slight to moderate fire hazard when exposed to heat or flame.
Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Containers may explode when involved in a fire.
Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Water or foam may cause frothing. Water spray may be used to extinguish surrounding fire and cool exposed containers. Water spray will also reduce fume and irritant gases.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Toxic gases and vapors may be released if involved in a fire.

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6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

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7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Separate from acids and oxidizing materials. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
50 ppm Ceiling

-ACGIH Threshold Limit Value (TLV):
50 ppm Ceiling (vapor)
Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face respirator with an organic vapor cartridge and particulate filter (NIOSH type P95 or R95 filter) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece respirator with an organic vapor cartridge and particulate filter (NIOSH P100 or R100 filter) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. Please note that N series filters are not recommended for this material. For emergencies or instances where the exposure levels are not known, use a full-face piece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear protective gloves and clean body-covering clothing.
Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Appearance:
Clear oily liquid.
Odor:
Odorless.
Solubility:
Miscible in water.
Specific Gravity:
1.1 @20C/4C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
197.6C (388F)
Melting Point:
-13C (9F)
Vapor Density (Air=1):
2.14
Vapor Pressure (mm Hg):
0.06 @ 20C (68F)
Evaporation Rate (BuAc=1):
No information found.

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
Carbon dioxide and carbon monoxide may form when heated to decomposition. May produce acrid smoke and irritating fumes when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizing agents. Reacts violently with chlorosulfonic acid, oleum, sulfuric acid, perchloric acid. Causes ignition at room temperature with chromium trioxide, potassium permanganate and sodium peroxide; causes ignition at 212F(100C) with ammonium dichromate, silver chlorate, sodium chloride and uranyl nitrate.
Conditions to Avoid:
Heat, flames, ignition sources, water (absorbs readily) and incompatibles.

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11. Toxicological Information

Toxicological Data:
Oral rat LD50: 4700 mg/kg; skin rabbit LD50: 9530 mg/kg.
Irritation - skin rabbit: 555mg(open), mild; eye rabbit: 500mg/24H, mild.
Investigated as a tumorigen, mutagen, reproductive effector.
Reproductive Toxicity:
Has shown teratogenic effects in laboratory animals.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Ethylene Glycol (107-21-1)	No	No	None

12. Ecological Information

Environmental Fate:
When released into the soil, this material is expected to readily biodegrade. When released into the soil, this material is expected to leach into groundwater. When released into the soil, this material is not expected to evaporate significantly. When released into water, this material is expected to readily biodegrade. When released into the water, this material is expected to have a half-life between 1 and 10 days. This material is not expected to significantly bioaccumulate. This material has a log octanol-water partition coefficient of less than 3.0. When released into water, this material is not expected to evaporate significantly. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life between 1 and 10 days.
Environmental Toxicity:
The LC50/96-hour values for fish are over 100 mg/l.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

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15. Regulatory Information

--------\Chemical Inventory Status - Part 1\---------------------------------

Ingredient	TSCA	EC	Japan	Australia
Ethylene Glycol (107-21-1)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\---------------------------------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Ethylene Glycol (107-21-1)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------------

Ingredient	-SARA 302- RQ	TPQ	------SARA 313------ List	Chemical Catg.
Ethylene Glycol (107-21-1)	No	No	Yes	No

--------\Federal, State & International Regulations - Part 2\----------------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Ethylene Glycol (107-21-1)	5000	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: Yes Fire: No Pressure: No
Reactivity: No (Pure / Liquid)

Australian Hazchem Code: None allocated.
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **1** Flammability: **1** Reactivity: **0**
Label Hazard Warning:

WARNING! HARMFUL OR FATAL IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. MAY CAUSE ALLERGIC SKIN REACTION. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM.

Label Precautions:

Do not breathe vapor or mist.
Use only with adequate ventilation.
Keep container closed.
Avoid contact with eyes, skin and clothing.
Wash thoroughly after handling.

Label First Aid:

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes. Call a physician if irritation develops or persists. If swallowed, give water or milk to drink and induce vomiting. Never give anything by mouth to an unconscious person. In all cases call a physician.

Product Use:

Laboratory Reagent.

Revision Information:

MSDS Section(s) changed since last revision of document include: 3.

RECEIVED MAR 7 - 1994

Date: Tuesday, 5 November 1991 3:17pm ET
To: MSDS-ENGLISH
From: Greg.Brown
Subject: COBALT SULPHATE HEPTAHYDRATE, 910CT31

STANCHEM Inc.
195 The West Mall,
Suite 500,
Etobicoke, Ontario
M9C 5K1
(416) 620-1711

COBALT SULPHATE HEPTAHYDRATE

MATERIAL SAFETY DATA SHEET

Date Revised: 1991 October 31
WHMIS Number: 00060162
Index: HCI0120/91D

EMERGENCY TELEPHONE NUMBERS

Toronto, Ont.	(416) 226-6117	Montreal, Que	(514) 861-1211
Winnipeg, Man.	(204) 943-8827	Edmonton, Alta.	(403) 424-1754
Vancouver, B.C.	(604) 685-5036		

PRODUCT IDENTIFICATION

Product Name: Cobalt (II) Sulphate Heptahydrate.
Chemical Name: Sulphuric Acid, Cobalt (II) salt.
Synonyms: Not applicable.
Chemical Family: Inorganic metallic salt.
Molecular Formula: $CoSO_4.7H_2O$.
Product Use: Ceramic glazes. Glass colouring.

REGULATORY SECTION

Controlled Products Regulations Classification: D-1B: Toxic (acute effects).

OSHA Hazard Communication (29CFR 1910.1200) Classification: Highly Toxic.

CANADIAN TDG ACT SHIPPING DESCRIPTION

Shipping Name: Not regulated.
Shipping Class/Division: Not regulated.
Product Identification No (PIN): Not regulated.
Packing Group: Not regulated.

U.S. DOT Classification: Not regulated.

Other Regulations: None known.

Read the entire MSDS for the complete hazard evaluation of this product.

HAZARDOUS INGREDIENTS OF MATERIAL

Hazardous Ingredients	%	ACGIH TLV	CAS No.
Cobalt Sulphate Heptahydrate	95 - 100 %	0.05 mg/M3 as Cobalt	0010124-43-3

PHYSICAL PROPERTIES

Physical State: Solid.
Appearance and Odour: Odourless pink crystalline powder.
Odour Threshold: Not available.
Boiling Range (Deg C): 420 Deg. Celsius (loses water).
Melting/Freezing Point (Deg C): Decomposes at 735 Deg. Celsius.
Vapour Pressure: Not applicable.
Specific Gravity: 1.1 - 3.7 gm/cc (water = 1.00).
Vapour Density: Not applicable.
Bulk Density: Not available.
Evaporation Rate: Not applicable.
Solubility: 320 gm/Liter H20 at 20 Deg. Celsius:
830 gm/Liter H20 at 100 Deg. Celsius.
% Volatile by Volume: 0 %.
pH: Not available.
Coefficient of Water/Oil Distribution: Not available.

Sensitivity to Mechanical Impact: Not available. Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not available. Not expected to be sensitive to static discharge.

REACTIVITY DATA

Stability:
Under Normal Conditions: Stable.
Under Fire Conditions: Not flammable.
Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition.

Materials to Avoid: Avoid moisture contamination. Strong oxidizers, ammonium nitrates.

Hazardous Decomposition or Combustion Products: Thermal decomposition products are toxic and may include oxides of sulphur and cobalt.

FIRE AND EXPLOSION DATA

Flash Point (Method): Does not form vapour.
Autoignition Temperature: Not applicable.
Flammability Limits in Air (%): LEL: Not applicable.
UEL: Not applicable.

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials.

Fire Fighting Procedures: Use water spray to cool fire-exposed containers or structures. Use water spray to disperse vapours. Use self-contained breathing apparatus and special protective clothing.

Other Fire or Explosion Hazards: None known.

TOXICOLOGICAL AND HEALTH DATA

Recommended Exposure Limit: None established for this product. See "HAZARDOUS INGREDIENTS OF PRODUCT" Section.

Toxicological Data:

Cobalt Sulphate LD50 (oral rat) = 424 mg/Kg (1).

Carcinogenicity Data: The ingredient(s) of this product is (are) not classified as carcinogenic by ACGIH (American Conference of Governmental Industrial Hygienists) or IARC (International Agency for Research on Cancer), not regulated as carcinogens by OSHA (Occupational Safety and Health Administration), and not listed as carcinogens by NTP (National Toxicology Program).

Reproductive Effects: No information is available and no adverse reproductive effects are anticipated.

Mutagenicity Data: No information is available and no adverse mutagenic effects are anticipated.

Teratogenicity Data: No information is available and no adverse teratogenic/embryotoxic effects are anticipated.

Synergistic Materials: None known.

EFFECTS OF EXPOSURE WHEN:

. Inhaled: Product is irritating to the nose, throat and respiratory tract.

. In contact with the skin: This product may cause irritation due to abrasive action.

. In contact with the eyes: This product may cause irritation, redness and possible damage due to abrasiveness.

. Ingested: Ingestion of large amounts may cause nausea, gastrointestinal upset and abdominal pain. May cause nausea and vomiting

Other Health Effects: None known.

FIRST AID PROCEDURES WHEN:

. Inhaled: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical advice IMMEDIATELY.

. In contact with the skin: Wash affected areas thoroughly with soap and water. If irritation, redness, or a burning sensation develops and persists, obtain medical advice.

. In contact with the eyes: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY.

. Ingested: If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local poison control centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.

Emergency Medical Care: None known.

PREVENTATIVE MEASURES

Recommendations listed in this section indicate the type of equipment which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

Engineering Controls: Local exhaust ventilation required.

Respiratory Protection: A NIOSH/MSHA-approved air-purifying respirator equipped with dust, mist, fume cartridges for concentrations up to 0.25 mg/M3. An air-supplied respirator if concentrations are higher or unknown.

Skin Protection: Gloves and protective clothing made from butyl rubber should be impervious under conditions of use. Prior to use, user should confirm impermeability.

Eye Protection: Safety glasses with side shields are recommended to prevent eye contact.

Other Personal Protective Equipment: Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

Handling Procedures and Equipment: Use normal "good" industrial hygiene and housekeeping practices.

Storage Temperature (Deg C): See below.

Storage Requirements: Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Do not expose sealed containers to temperatures above 40 Deg. Celsius. Keep containers closed. Avoid moisture contamination.

Other Precautions: Use only with adequate ventilation and avoid breathing vapours Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use. Do not store or transport with food or feed.

ENVIRONMENTAL PROTECTION DATA

Steps to be Taken in the Event of a Spill or Leak: Eliminate all sources of ignition. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent: for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

Environmental Effects: May be harmful to aquatic life. Can be dangerous if allowed to enter drinking water intakes.

Deactivating Chemicals: None known.

Waste Disposal Methods: Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, On-line search, Canadian Centre for Occupational Health and Safety RTECS database, Vol I-V, 1985-1986 edition, Doris V. Sweet, Ed., National Institute for Occupational Safety and Health, U.S. Dept. of Health and Human Services, Cincinnati, 1987.
2. Supplier's Material Safety Data Sheets, 1985 September 25.

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Stanchem Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

Date Issued: 1991 October 31
Date Revised: 1991 October 31
MSDS Index No: HCI0120/91D

Prepared By: Regulatory Affairs Officer, Stanchem Inc., (416) 259-8231.

Date: Tuesday, 20 April 1993 9:43am ET
To: MSDS-ENGLISH
From: Carol.Palichuk
Subject: SULPHURIC ACID 60 - 100 %, ENG, 93APR19

STANCHEM Inc.
43 Jutland Road,
Etobicoke, Ontario,
M8Z 2G6
(416) 259-8231

SULPHURIC ACID 60 - 100 %
(48 - 66 Baume; 1.48 - 1.84 Density)

MATERIAL SAFETY DATA SHEET

Issue Date: 1993 April 19
WHMIS Number: 00060799
Index: GCD0052/93B

EMERGENCY TELEPHONE NUMBERS

Toronto, Ont.	(416) 226-6117	Montreal, Que	(514) 861-1211
Winnipeg, Man.	(204) 943-8827	Edmonton, Alta.	(403) 424-1754
Vancouver, B.C.	(604) 685-5036		

PRODUCT IDENTIFICATION

Product Name: Sulphuric Acid, 60 - 100 %.
Chemical Name: Sulphuric Acid.
Synonyms: Oil of Vitriol, Nordhausen Acid.
Chemical Family: Inorganic Acid.
Molecular Formula: H_2SO_4.
Product Use: Fertilizer. Dyes and pigments. Industrial explosives. Electrical storage batteries.
CAS #: 7664-93-9.

REGULATORY SECTION

Controlled Products Regulations Classification: D-1A: Very Toxic (Acute Effects), E: Corrosive.

OSHA Hazard Communication (29CFR 1910.1200) Classification: Highly Toxic, Corrosive.

CANADIAN TDG ACT SHIPPING DESCRIPTION

Shipping Name: Sulphuric Acid.
Shipping Class/Division: 8 (9.2).
Product Identification No (PIN): UN1830.
Packing Group: II.
Regulated Limit: Not applicable.

U.S. DOT Classification:

Identification: Sulphuric Acid.
Hazard Class: 8.
UN Identification: UN1830.
Packing Group: II.
Label(s)/Placard: Corrosive.
Reportable Quantity: 1000 lb.

ENVIRONMENTAL PROTECTION ACTS: CANADA AND USA

The (All) constituent(s) of this product is (are) included on the DSL/NDSL of the CEPA and the TSCA Inventory of the US-EPA.

Read the entire MSDS for the complete hazard evaluation of this product.

HAZARDOUS INGREDIENTS OF MATERIAL

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Sulphuric Acid	007664-93-9	1 mg/M3	60 - 100

PHYSICAL PROPERTIES

Physical State: Liquid.
Appearance and Odour: Clear, colourless liquid with characteristic odour.
Odour Threshold (ppm): Not available.
Boiling Range (Deg Celsius): 330 (98% Sulphuric Acid).
Melting/Freezing Point (Deg Celsius): -1.1 (98% Sulphuric Acid).
Vapour Pressure (mm Hg at 20 Deg. Celsius): 0.002 (98% Sulphuric Acid).
Specific Gravity (gm/cc, Water = 1.0): 1.48 (60% Sulphuric Acid) - 1.84 (98% Sulphuric Acid).
Vapour Density (Air = 1.0): 3.4 (Sulphuric Acid Component).
Bulk Density: Not applicable.
Evaporation Rate (Butyl Acetate = 1.0): Not applicable.
Solubility: Soluble in water.
Volatile by Volume: Not available.
pH: 0.3 (1N Solution).
Coefficient of Water/Oil Distribution: Not available.

Sensitivity to Mechanical Impact: Not available. Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not available. Not expected to be sensitive to static discharge.

REACTIVITY DATA

Stability:
Under Normal Conditions: Stable.
Under Fire Conditions: Not flammable.
Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition.

Materials to Avoid: Organic materials. Alcohols. Chlorinated compounds. Hydrogen gas may be produced on prolonged contact with metals such as aluminium, tin, lead and zinc.

Hazardous Decomposition or Combustion Products: Thermal decomposition products are toxic and may include oxides of sulphur.

FIRE AND EXPLOSION DATA

Flash Point (TCC, Deg. Celsius): Not applicable.
Autoignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable.
UEL: Not applicable.

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials.

Fire Fighting Procedures: Use water spray to cool fire-exposed containers or structures. Use water spray to disperse vapours. Use self-contained breathing apparatus and special protective clothing.

Other Fire or Explosion Hazards: Avoid direct contact of this product with water as this can cause a violent exothermic reaction.

TOXICOLOGICAL AND HEALTH DATA

Recommended Exposure Limit: See "HAZARDOUS INGREDIENTS OF PRODUCT" Section.

Toxicological Data:

Sulphuric Acid	LD50 (Oral, Rat) = 472 mg/kg (3) LC50 (Inhal'n, Rat) = 90 ppm for 4 hours (1)

Carcinogenicity Data: The ingredient(s) of this product is (are) not classified as carcinogenic by ACGIH (American Conference of Governmental Industrial Hygienists) or IARC (International Agency for Research on Cancer), not regulated as carcinogens by OSHA (Occupational Safety and Health Administration), and not listed as carcinogens by NTP (National Toxicology Program). See "Other Health Effects" Section.

Reproductive Effects: No information is available and no adverse reproductive effects are anticipated.

Mutagenicity Data: No information is available and no adverse mutagenic effects are anticipated.

Teratogenicity Data: No information is available and no adverse teratogenic/embryotoxic effects are anticipated.

Respiratory / Skin Sensitization: None known.

Synergistic Materials: None known.

EFFECTS OF EXPOSURE WHEN:

. Inhaled: Product may cause severe irritation of the nose, throat and respiratory tract. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary edema (fluid build-up in lungs), and reduction of pulmonary function. Prolonged or repeated exposure may cause discolouration and erosion of teeth.

. In contact with the skin: Concentrated solutions may cause pain and deep and severe burns to the skin. Prolonged and repeated exposure to dilute solutions often causes irritation, redness, pain and drying and cracking of the skin.

. In contact with the eyes: Extremely corrosive! This product causes corneal scarring and clouding. Glaucoma, cataracts and permanent blindness may occur.

. Ingested: This product causes severe burning and pain in the mouth, throat and abdomen. Vomiting, diarrhea and perforation of the esophagus and stomach lining may occur.

Other Health Effects: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following ANY exposure is ESSENTIAL.

Although no direct link has been established between exposure to sulphuric acid, itself, and cancer in man, the World Health Organization (WHO) and International Agency for Research on Cancer (IARC) have concluded that occupational exposure to strong inorganic acid mists containing sulphuric acid is carcinogenic to man, causing cancer of the larnyx (the voice box) and, to a lesser extent, the lung. Exposure to any mist or aerosol during the use of this product should be avoided and, in any case, keep exposures below the occupational exposure limit for sulphuric acid. (3)

Acid mist is most likely to be generated at the vents of process or storage tanks, especially during filling operationa. The use of compressed air to force acids from delivery trucks is of special concern. Scrubbing the exhaust of these vents is highly recommended. Jurisdictional regulations should be consulted to determine required practices.

FIRST AID PROCEDURES WHEN:

Inhaled: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Oxygen administration may be beneficial in this situation but should only be administered by personnel trained in its use. Obtain medical attention IMMEDIATELY.

In contact with the skin: Flush skin with running water for a minimum of 20 minutes. Start flushing while removing contaminated clothing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. Do not transport victim unless the recommended flushing period is completed or flushing can be continued during transport.

. In contact with the eyes: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. Do not transport victim until the recommended flushing period is completed unless flushing can be continued during transport.

. Ingested: If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local poison control centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.

Emergency Medical Care: While the patient is being transported to a medical facility, apply compresses of iced water. If medical treatment must be delayed, immerse the affected area in iced water. If immersion is not practical, compresses of iced water can be applied. Avoid freezing tissues.

PREVENTATIVE MEASURES

Recommendations listed in this section indicate the type of equipment which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

Engineering Controls: Local exhaust ventilation required. Ventilation should be corrosion proof.

Respiratory Protection: A NIOSH/MSHA-approved air-purifying respirator equipped with acid gas cartridges for concentrations up to 10 mg/M3 Sulphuric Acid. An air-supplied respirator if concentrations are higher or unknown.

Skin Protection: Gloves and protective clothing made from neoprene or PVC should be impervious under conditions of use. Prior to use, user should confirm impermeability.

Eye Protection: Use full face-shield and chemical safety goggles when there is potential for contact.

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

Handling Procedures and Equipment: Use normal "good" industrial hygiene and housekeeping practices.

When diluting, add this product to water in small amounts to avoid spattering. Never add water to this product. The water should be lukewarm. Never start with hot or cold water.

Storage Temperature (Deg Celsius): See below.

Storage Requirements: Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Do not expose sealed containers to temperatures above 40 Deg. Celsius.

Other Precautions: Use only with adequate ventilation and avoid breathing mists and vapours. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

ENVIRONMENTAL PROTECTION DATA

Steps to be Taken in the Event of a Spill or Leak: Eliminate all sources of ignition. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent; for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

Environmental Effects: Harmful to aquatic life at low concentrations. Can be dangerous if allowed to enter drinking water intakes. Product has an unaesthetic appearance and can be a nuisance. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

Deactivating Chemicals: Neutralize carefully with soda ash or sodium bicarbonate to a pH of 6 to 9.

Waste Disposal Methods: Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, On-line search, Canadian Centre for Occupational Health and Safety RTECS database, Vol I-V, 1985-1986 edition, Doris V. Sweet, Ed., National Institute for Occupational Safety and Health, U.S. Dept. of Health and Human Services, Cincinnati, 1987.
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
3. Supplier's Material Safety Data Sheet(s).
4. "CHEMINFO", through "CCINFOdisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
5. Guide to Occupational Exposure Values, 1992, American Conference of Governmental Industrial Hygienists, Cincinnati, 1992.

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Stanchem Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Stanchem Regional office.

Stanchem Regional Offices

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Phone: (604) 685-1411 Facsimile: (604) 681-5218

Stanchem Inc., 9637 - 45 th. Avenue, Edmonton, Alberta, T5J 2L4
Phone: (403) 434-1818 Facsimile: (403) 434-9009

Stanchem Inc., 681 Plinquet Street, Winnipeg, Manitoba, R2J 2X2
Phone: (204) 233-5361 Facsimile: (204) 233-7005

Stanchem Inc., 43 Jutland Road, Etobicoke, Ontario, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Stanchem Inc., 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Stanchem Inc., A-105 Akerley Boulevard, Dartmouth, Nova Scotia, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Issue Date: 1993 April 19
Date Revised: 1993 April 19
Index: GCD0052/93B

Prepared By: Regulatory Affairs Group, Stanchem Inc., (416) 259-8231.

Date: Monday, 26 October 1992 1:21pm ET
To: MSDS-ENGLISH
From: Carol.Palichuk
Subject: HYDRATED LIME, ENG, 920CT20

STANCHEM Inc.
43 Jutland Road,
Etobicoke, Ontario,
M8Z 2G6
(416) 259-8231

HYDRATED LIME

MATERIAL SAFETY DATA SHEET

Issue Date: 1992 October 20
WHMIS Number: 00060399
Index: GCD1281/92D

EMERGENCY TELEPHONE NUMBERS

Toronto, Ont.	(416) 226-6117	Montreal, Que	(514) 861-1211
Winnipeg, Man.	(204) 943-8827	Edmonton, Alta.	(403) 424-1754
Vancouver, B.C.	(604) 685-5036		

PRODUCT IDENTIFICATION

Product Name: Hydrated lime.
Chemical Name: Calcium Hydroxide.
Synonyms: Calcium hydrate, caustic lime, slaked lime.
Chemical Family: Hydroxide.
Molecular Formula: $Ca(OH)_2$.
Product Use: Mortars, plasters, cements.
CAS #: 1305 - 62-0.

REGULATORY SECTION

Controlled Products Regulations Classification: E: Corrosive.

OSHA Hazard Communication (29CFR 1910.1200) Classification: Corrosive.

CANADIAN TDG ACT SHIPPING DESCRIPTION

Shipping Name: Not regulated.
Shipping Class/Division: Not regulated.
Product Identification No (PIN): Not regulated.
Packing Group: Not regulated.
Regulated Limit: Not regulated.

.S. DOT Classification:

Identification: Not regulated.
Hazard Class: Not regulated.
UN Identification: Not regulated.
Label(s)/Placard: Not regulated.

ther Regulations: None known.

ead the entire MSDS for the complete hazard evaluation of this product.

AZARDOUS INGREDIENTS OF MATERIAL

azardous Ingredients	CAS No.	ACGIH TLV	%
alcium Hydroxide	001305-62-0	5 mg/M3	90 - 100

HYSICAL PROPERTIES

hysical State: Solid.
ppearance and Odour: Odourless, greyish-white powder or lumps.
dour Threshold (ppm): Odourless.
oiling Range (Deg Celsius): 2850.
elting/Freezing Point (Deg Celsius): Not available.
apour Pressure (mm Hg at 20 Deg. Celsius): Not applicable.
pecific Gravity (gm/cc, Water = 1.0): 2.2 - 2.4.
apour Density (Air = 1.0): Not applicable.
ulk Density: Not available.
vaporation Rate (Butyl Acetate = 1.0): Not applicable.
olubility: Partially soluble in water.
Volatile by Volume: Not applicable.
H: 12 - 12.4.
oefficient of Water/Oil Distribution: Not available.

ensitivity to Mechanical Impact: Not available. Not expected to be sensitive to mechanical impact.
ate of Burning: Not available.
xplosive Power: Not available.
ensitivity to Static Discharge: Not available. Not expected to be sensitive to static discharge.

REACTIVITY DATA

Stability:
- Under Normal Conditions: Stable.
- Under Fire Conditions: Not flammable.
- Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition.

Materials to Avoid: Lewis or mineral acids. Maleic anhydride. Nitro-organic compounds. Phosphorous.

Hazardous Decomposition or Combustion Products: Calcium oxide.

FIRE AND EXPLOSION DATA

Flash Point (TCC, Deg. Celsius): Not applicable.
Auto Ignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable.
UEL: Not applicable.

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials.

Fire Fighting Procedures: Use water spray to cool fire-exposed containers or structures. Use water spray to disperse vapours. Use self-contained breathing apparatus and special protective clothing.

Other Fire or Explosion Hazards: None known.

TOXICOLOGICAL AND HEALTH DATA

Recommended Exposure Limit: See "HAZARDOUS INGREDIENTS OF PRODUCT" Section.

Toxicological Data:

Calcium Hydroxide LD50 (Oral, Rat) = 7340 mg/kg (1)

Carcinogenicity Data: The ingredient(s) of this product is (are) not classified as carcinogenic by ACGIH (American Conference of Governmental Industrial Hygienists) or IARC (International Agency for Research on Cancer), not regulated as carcinogens by OSHA (Occupational Safety and Health Administration), and not listed as carcinogens by NTP (National Toxicology Program).

Reproductive Effects: No information is available and no adverse reproductive effects are anticipated.

Mutagenicity Data: No information is available and no adverse mutagenic effects are anticipated.

Teratogenicity Data: No information is available and no adverse teratogenic/embryotoxic effects are anticipated.

Respiratory / Skin Sensitization: None known.

Synergistic Materials: None known.

EFFECTS OF EXPOSURE WHEN:

Inhaled: Product may cause severe irritation of the nose, throat and respiratory tract.

In contact with the skin: Concentrated solutions may cause pain and deep and severe burns to the skin. Prolonged and repeated exposure to dilute solutions often causes irritation, redness, pain and drying and cracking of the skin.

In contact with the eyes: This product causes immediate pain, severe burns and permanent corneal damage which may result in blindness.

Ingested: This product causes severe burning and pain in the mouth, throat and abdomen. Vomiting, diarrhea and perforation of the esophagus and stomach lining may occur.

Other Health Effects: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following ANY exposure is ESSENTIAL.

FIRST AID PROCEDURES WHEN:

. Inhaled: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical attention IMMEDIATELY.

. In contact with the skin: Flush skin with running water for a minimum of 30 minutes or up to 60 minutes for critical body areas. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. Do not transport victim unless the recommended flushing period is completed or flushing can be continued during transport.

. In contact with the eyes: Immediately flush eyes with running water for a minimum of 30 minutes, preferably up to 60 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Do not transport victim until the recommended flushing period is completed unless flushing can be continued during transport.

. Ingested: If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local poison control centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.

Emergency Medical Care: Treat symptomatically.

PREVENTATIVE MEASURES

Recommendations listed in this section indicate the type of equipment which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

Engineering Controls: Local exhaust ventilation required. Ventilation should be corrosion proof.

Respiratory Protection: A NIOSH/MSHA-approved air-purifying respirator equipped with dust, mist, fume cartridges for concentrations up to 50 mg/M3. An air-supplied respirator if concentrations are higher or unknown.

Skin Protection: Gloves and protective clothing made from neoprene or PVC should be impervious under conditions of use. Prior to use, user should confirm impermeability.

Eye Protection: Safety glasses with side shields are recommended to prevent eye contact. Use chemical safety goggles when there is potential for eye contact.

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

Handling Procedures and Equipment: Use normal "good" industrial hygiene and housekeeping practices.

Storage Temperature (Deg Celsius): See below.

Storage Requirements: Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Do not expose sealed containers to temperatures above 40 Deg. Celsius.

Other Precautions: Use only with adequate ventilation and avoid breathing dusts and mists. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

ENVIRONMENTAL PROTECTION DATA

Steps to be Taken in the Event of a Spill or Leak: Sweep up immediately to eliminate slipping hazard. Do not allow to enter sewers or watercourses. Minimize air borne spreading of dust. Eliminate all sources of ignition. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent; for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

Environmental Effects: Harmful to aquatic life at low concentrations. Can be dangerous if allowed to enter drinking water intakes. Product has an unaesthetic appearance and can be a nuisance. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

Deactivating Chemicals: Neutralize carefully with weak acid to a pH of 6 to 9.

Waste Disposal Methods: Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, On-Line search, Canadian Centre for Occupational Health and Safety RTECS database, Vol I-V, 1985-1986 edition, Doris V. Sweet, Ed., National Institute for Occupational Safety and Health, U.S. Dept. of Health and Human Services, Cincinnati, 1987.
2. Guide to Occupational Exposure Values, 1991, American Conference of Governmental Industrial Hygienists, Cincinnati, 1991.
3. Supplier's Material Safety Data Sheet(s).
4. "CHEMINFO", through "CCINFOdisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Stanchem Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Stanchem Regional office.

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Issue Date: 1992 October 20
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Index: GCD1281/92D

Prepared By: Regulatory Affairs Group, Stanchem Inc., (416) 259-8231.

Date: Thursday, 18 June 1992 1:46pm ET
To: MSDS-ENGLISH
From: Carol.Palichuk
Subject: SOLVENT 160, ENG, 92JUN19

STANCHEM Inc.
43 Jutland Road,
Etobicoke, Ontario,
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(416) 259-8231

SOLVENT 160

MATERIAL SAFETY DATA SHEET

Date Revised: 1992 June 19
WHMIS Number: 00060729
Index: GCD3186/92B

EMERGENCY TELEPHONE NUMBERS

Toronto, Ont.	(416) 226-6117	Montreal, Que	(514) 861-1211
Winnipeg, Man.	(204) 943-8827	Edmonton, Alta.	(403) 424-1754
Vancouver, B.C.	(604) 685-5036		

PRODUCT IDENTIFICATION

Product Name: Solvent 160.
Chemical Name: Not applicable.
Synonyms: Petroleum solvent.
Chemical Family: Hydrocarbons.
Molecular Formula: Not applicable.
Product Use: Industrial solvent, cleaner, degreaser.
CAS #: 64742-47-8.

REGULATORY SECTION

Controlled Products Regulations Classification: B-3: Combustible Liquid, D-2B: Toxic (Skin Irritant).

OSHA Hazard Communication (29CFR 1910.1200) Classification: Combustible Liquid, Skin Irritant.

CANADIAN TDG ACT SHIPPING DESCRIPTION

Shipping Name: Not regulated.
Shipping Class/Division: Not regulated.
Product Identification No (PIN): Not regulated.
Packing Group: Not regulated.
Regulated Limit: Not regulated.

U.S. DOT Classification:

Identification: Not regulated.
Hazard Class: Not regulated.
UN Identification: Not regulated.
Label(s)/Placard: Not regulated.

Other Regulations: None known.

Read the entire MSDS for the complete hazard evaluation of this product.

HAZARDOUS INGREDIENTS OF MATERIAL

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Solvent 160	064742-47-8	Not listed.	95 - 100
Benzene	000071-43-2	10 ppm *A1	Trace

*A1 = Confirmed Human Carcinogen (ACGIH).

PHYSICAL PROPERTIES

Physical State: Liquid.
Appearance and Odour: Clear, colourless liquid with characteristic odour.
Odour Threshold (ppm): Not available.
Boiling Range (Deg Celsius): 199 - 264.
Melting/Freezing Point (Deg Celsius): Not available.
Vapour Pressure (mm Hg at 20 Deg. Celsius): Not available.
Specific Gravity (gm/cc, Water = 1.0): 0.8.
Vapour Density (Air = 1.0): Not available.
Bulk Density: Not applicable.
Evaporation Rate (Butyl Acetate = 1.0): Not available.
Solubility: Not soluble in water.
% Volatile by Volume: 100.
pH: Not applicable.
Coefficient of Water/Oil Distribution: Not available.

Sensitivity to Mechanical Impact: Not available. Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not available. Expected to be sensitive to static discharge when vapours are present below the lower and upper explosive limits.

REACTIVITY DATA

Stability:
Under Normal Conditions: Stable.
Under Fire Conditions: Flammable.
Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition.

Materials to Avoid: Strong oxidizers.

Hazardous Decomposition or Combustion Products: Thermal decomposition products are toxic and may include carbon dioxide, carbon monoxide and, possibly, irritating gases.

FIRE AND EXPLOSION DATA

Flash Point (TCC, Deg. Celsius): Above 71.
Autoignition Temperature (Deg. Celsius): Not available.
Flammability Limits in Air (%): LEL: Not available.
UEL: Not available.

Fire Extinguishing Media: For large fires use an all purpose type AFFF foam according to foam manufacturer's recommended techniques. The foam supplier should be consulted for recommendations regarding foam types and delivery rates for specific applications. Use carbon dioxide or dry chemical media for small fires. If only water is available, use it in the form of a fog.

Do not use water. This material may produce a floating fire hazard in extreme fire conditions.

Fire Fighting Procedures: Use water spray to cool fire-exposed containers or structures. Use water spray to disperse vapours; re-ignition is possible. Use self-contained breathing apparatus and protective clothing.

Other Fire or Explosion Hazards: Vapours from this product are heavier than air, and may "travel" to a source of ignition (eg. pilot lights, heaters, electric motors) some distance away, and then "flash back" to the point of product discharge causing an explosion and fire.

TOXICOLOGICAL AND HEALTH DATA

Recommended Exposure Limit: None established for this product.

Manufacturer's Recommended Exposure Level = 1000 ppm mg/M3 (max) for 8 hours, or 500 mg/M3 (max) for 12 hours exposure.

Toxicological Data:

Solvent 160 LD50 (oral, rat) = Above 5600 mg/kg (3)
LC50 (inhal'n, rat) = 13700 ppm 4 hours (3)

Carcinogenicity Data: This product may contain a trace amount (less than 0.1%, w/w) of a carcinogen (Benzene). It is our belief that, under conditions of normal occupational exposure, this product should not pose such a hazard to the worker.

Reproductive Effects: No information is available and no adverse reproductive effects are anticipated.

Mutagenicity Data: No information is available and no adverse mutagenic effects are anticipated.

Teratogenicity Data: No information is available and no adverse teratogenic/embryotoxic effects are anticipated.

Respiratory / Skin Sensitization: None known.

Synergistic Materials: None known.

EFFECTS OF EXPOSURE WHEN:

. Inhaled: Product is irritating to the nose, throat and respiratory tract. May cause central nervous system (CNS) depression. See "Other Health Effects" Section.

. In contact with the skin: May cause defatting, drying and cracking of the skin. Prolonged and repeated contact may lead to dermatitis.

. In contact with the eyes: Vapours from this product are irritating to the eyes. This product causes irritation, redness and pain.

. Ingested: This product causes irritation, a burning sensation of the mouth and throat and abdominal pain.

Other Health Effects: CNS depression is characterized by headache, dizziness, drowsiness, nausea, vomiting and incoordination. Severe overexposures may lead to coma and possible death due to respiratory failure.

Intentional misuse of organic solvents (eg. "glue sniffing") over prolonged periods of time may be habit forming and lead to behavioural changes.

This product may sensitize heart muscle causing cardiac arrhythmia, in rare cases.

FIRST AID PROCEDURES WHEN:

. Inhaled: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical attention IMMEDIATELY.

. In contact with the skin: Flush skin with running water and wash affected areas thoroughly with soap and water. Start flushing while removing contaminated clothing. Obtain medical attention IMMEDIATELY.

. In contact with the eyes: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY.

. Ingested: If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local poison control centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.

Emergency Medical Care: This product contains materials that may cause severe pneumonitis if aspirated. If ingestion has occurred less than 2 hours earlier, carry out careful gastric lavage; use endotracheal cuff if available, to prevent aspiration. Observe patient for respiratory difficulty from aspiration pneumonitis. Give artificial resuscitation and appropriate chemotherapy if respiration is depressed.

Medical conditions that may be aggravated by exposure to this product include diseases of the skin, eyes or respiratory tract.

PREVENTATIVE MEASURES

Recommendations listed in this section indicate the type of equipment which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

Engineering Controls: Local exhaust ventilation required. Ventilation should be explosion proof. Ventilate low lying areas such as sumps or pits where dense vapours may collect.

Respiratory Protection: An air-supplied respirator if concentrations are high or unknown.

Skin Protection: Gloves and protective clothing made from nitrile rubber or Viton should be impervious under conditions of use. Prior to use, user should confirm impermeability.

Eye Protection: Safety glasses with side shields are recommended to prevent eye contact. Use chemical safety goggles when there is potential for eye contact.

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

Handling Procedures and Equipment: Ground and bond equipment and containers to prevent a static charge buildup. Use spark-resistant tools and avoid "splash-filling" of containers. Do not use in poorly ventilated or confined areas without proper respiratory protection.

Storage Temperature (Deg Celsius): See below.

Storage Requirements: Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Do not expose sealed containers to temperatures above 40 Deg. Celsius.

Other Precautions: Use only with adequate ventilation and avoid breathing vapours or mists. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

ENVIRONMENTAL PROTECTION DATA

Steps to be Taken in the Event of a Spill or Leak: Eliminate all sources of ignition. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent: for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

Environmental Effects: Harmful to aquatic life at low concentrations. Can be dangerous if allowed to enter drinking water intakes. Product has an unaesthetic appearance and can be a nuisance. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

Deactivating Chemicals: Not applicable.

Waste Disposal Methods: Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, On-line search, Canadian Centre for Occupational Health and Safety RTECS database, Vol I-V, 1985-1986 edition, Doris V. Sweet, Ed., National Institute for Occupational Safety and Health, U.S. Dept. of Health and Human Services, Cincinnati, 1987.
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
3. Supplier's Material Safety Data Sheet(s).
4. "CHEMINFO", through "CCINFOdisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
5. Guide to Occupational Exposure Values, 1991, American Conference of Governmental Industrial Hygienists, Cincinnati, 1991.

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Prepared By: Regulatory Affairs Group, Stanchem Inc., (416) 259-8231.

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix M

Qualitative Risk Assessment Worksheets

Failure Scenario A2

Area:	Mine – Waste Rock Storage Area (WRSA)
Phase:	Construction/Operation/Closure
System/activity:	Construction/Operation/Closure of waste rock storage facilities
Failure Mode:	Physical Embankment Failure; Sediment or metals release to local drainages

Hazard Assessment

- Hazard Description and Qualitative Assessment

    - Hazards are materials movement and sediment (possibly heavy metals from waste rock itself) from local soils or permafrost failure.
    - WRSA cleared to promote permafrost thaw and drainage ditches to capture runoff.
    - Sediment control pond located down gradient of WRSA.
    - Contingency berm located below WRSA if required.
    - Maintenance and monitoring during operations.
    - Erosion/control and revegetation of bare surface.
    - It is expected that at most up to 100,000 tonnes of material and 2,000 mg/L of sediment can be released. Metals (copper) from waste rock would be 0.05 to 1 mg/L (low). Based on Table 7-13 this results in medium hazard for material and/or sediment release.

Exposure Assessment

- Possible Failure Mechanisms

    - Physical material release due to: permafrost degradation causing slope instability and slope raveling, failure of contingency berm.
    - Sediment release, under normal design flood (design/ construction error) or under runoff event exceeding design flood, due to: materials movement down gradient to watercourse; inadequate sedimentation capacity design; unprotected areas – no sediment control facilities constructed (human error); failure of sediment structures.
    - Metals release, under normal design flood (design/ construction error) or under runoff event exceeding design flood, due to: materials (waste rock) movement down gradient to watercourse; inadequate sedimentation capacity design; unprotected areas – no sediment control facilities constructed (human error); failure of sediment structures.

- Possible Initiating Events

    - Natural events – climate change, permafrost degradation and thaw, high precipitation event, or snow melt.
    - Site specific events – stripped surface causing slope instability; contingency berm failure; bare surfaces with no erosion control or sediment collection.

- Design, construction or maintenance events – inadequate capacity; poor construction, sediment dam filling up.

- Potential For Release

  - WRSA stripped prior to use to reduce physical failure from permafrost degradation.
  - Control ditches and sediment control pond in place.
  - Contingency berm in place to provide stability to WRSA if needed.
  - Low metals levels in non-acid generating waste rock.
  - WRSA construction with periodic slope grading to ensure stability.
  - Monitoring during operations.
  - During the construction phase it is expected that the potential of release will be low, assuming that good construction control is practiced.

- Magnitude of Release

  - Low because of construction practices. Waste rock with low metals. Permafrost soils provide sediment load, however WRSA set back from any North Williams Creek watercourse. Monitoring during operations.

- Duration of Release

  - Very short to days depending on precipitation events, quality of construction supervision and facility inspection.

- Pathways

  - Overland flow to North Williams Creek.

- Ecosystems at Risk

  - Forested drainages in the WRSA area with overland flow to surrounding creeks, or if major event, to nearby river. North Williams Creek very small stream with limited ability to transport materials down gradient. WRSA set back with buffer from the creek.

- Exposure Description and Qualitative Assessment

  - WRSA set back from North Williams Creek. Stripping of WRSA and contingency berm in place to ensure that materials and metals movement would be limited and not released directly to the stream. Materials would have to flow overland to impact aquatic ecosystems. There is a very low probability of a materials, sediment or metals release due to a significant precipitation event occurring coupled with poor construction practices or operational practices. Therefore, due to low potential of release it is not expected that the concentration of sediment will exceed 1,000 mg/L or metals at 1.0 mg/L. According to Table 7-13 there will be a low exposure.

Consequence Assessment

- Consequence Description and Qualitative Assessment

    - Possible consequences include materials movement down gradient below WRSA.
    - Materials not expected to effect local watercourse.
    - Contingency berm available to control and stabilize WRSA failure.
    - Slight sedimentation of streambeds causing habitat degradation and slight (<5%) reduction in fish productivity, only in lower reaches of Williams Creek.
    - Metals release to North Williams Creek causing slight habitat degradation in upper reaches, with no fish. Slight effects to lower stream reaches.
    - Based on Table 7-14 the consequences are therefore very low.

Risk Characterization

- Risk Description and Qualitative Characterization

    - The medium hazard posed by the materials and sediments and a low metals hazard combined with a low exposure will lead to very low consequences to the aquatic ecosystem. The overall risk therefore is very low (Table 7-15).

Project Specific Considerations

- EMS in final design phasing of project construction to prevent unprotected soil surfaces, construction of sediment collection structures.

- Mitigation and contingency planning for contingency WRSA toe berm.

- Monitoring of WRSA dump slopes for slope stability. Grade slopes to ensure stability or construct contingency berm if required.

- Careful scheduling and supervision during construction operations to construct sediment collection structures first, strip WRSA materials, remove sediment if structures fill up quickly, stabilize erodible surfaces and slopes and revegetate.

- Recommendations: practice good construction scheduling and control to eliminate areas unprotected by sediment or runoff control.

- Geotechnical instruments on WRSA and monitoring to determine need to construct contingency berm.

- Monitoring quality and quality of effects, and climate. Routine inspections and maintenance of WRSA and sediment control pond.

Failure Scenario A5

Area:	Mine
Phase:	Construction/Operation
System/activity:	Construction/Operation of onsite facilities
Failure Mode:	Sediment release to local drainages

Hazard Assessment

- Hazard Description and Qualitative Assessment
    - Hazards are sediments and possibly heavy metals.
    - Only small surface areas will be exposed during construction, heap leach pad already cleared.
    - Maintenance and monitoring to take place during operations.
    - Erosion control and revegetation of bare surface.
    - Expected that at most 2,000 mg/L of sediment will be released; based on Table 7-13 this results in medium hazard for sediment release.

Exposure Assessment

- Possible Failure Mechanism
    - Sediment release, under normal design flood (design/construction error) or under runoff event exceeding design flood, due to:
        1. Inadequate sedimentation capacity design.
        2. Unprotected areas – no sediment control facilities constructed (human error).
        3. Failure of sediment structures.
- Possible Initiating Events
    - Natural events – high precipitation event or snow melt.
    - Site specific events – bare surfaces with no erosion control or sediment collection.
    - Design, construction or maintenance events – inadequate capacity; poor construction; sediment dam filling up.
- Potential For Release
    - During the construction phase it is expected that the potential for release will be low, assuming that good construction control is practiced.
    - Maintenance and monitoring to take place during operations.
    - Potential during operations considered low/moderate.
- Magnitude of Release
    - Low, because of appropriate construction practices and the ongoing maintenance and monitoring that will take place during operations.

- Duration of Release
    - Very short to days depending on: precipitation event, quality of construction supervision and facility inspection.
- Pathways
    - Overland flow to Williams Creek.
- Ecosystems at Risk
    - Forested drainages in the mine area to aquatic ecosystems overland flow to surrounding creeks, or if major event, to nearby river.
- Exposure Description and Qualitative Assessment
    - Construction will take place near watercourses with buffer zones and any release of sediment could be directly discharged to the streams and overland flow could have some impact on aquatic ecosystems.
    - There is a very low probability of a sediment release due to a significant precipitation event occurring coupled with poor construction or operational practices. Therefore, due to low potential of release it is not expected that the concentration of sediment will exceed 1,000 mg/L. According to Table 7-13 there will be a low exposure.

Consequence Assessment

- Consequence Description and Qualitative Assessment
    - Possible consequences include slight sedimentation of streambeds causing habitat degradation and slight (<5%) reduction in fish productivity (only in lower reaches of creek). Based on Table 7-14 the consequences are considered very low.

Risk Characterization

- Risk Description and Qualitative Characterization
    - The low hazard posed by the sediments combined with a low exposure will lead to very low consequences to the aquatic ecosystem. The overall risk therefore is very low (Table 7-15).

Project Specific Considerations

- EMS in final design phasing of project construction to prevent unprotected soil surfaces, and include construction of sediment collection structures.
- Mitigation and contingency planning. Careful scheduling and supervision during construction and operations: construct sediment collection structures

first, remove sediment if structures fill up quickly, stabilize erodible surfaces and slopes, and revegetate.

- Recommendations: practice good construction scheduling and control to eliminate areas unprotected by sediment or runoff control.

- Monitoring quality and quantity of effects, and climate. Routine inspections and maintenance.

- Progressive reclamation and revegetation of disturbed areas.

Failure Scenario B5

Area:	Heap Leach Pad/Events Ponds
Phase:	Operation
System/activity:	Operation of onsite facilities
Failure Mode:	Metals and low pH release to local drainage

Hazard Assessment

- Hazard Description and Qualitative Assessment
    - Hazards are heavy metals, particularly copper and low pH. Possibly sediments due to the concentration of metals and pH of raffinate solutions. According to Table 7-13, the hazard is high.

Exposure Assessment

- Possible Failure Mechanism
    - Release of metals and low pH contaminated waters from heap leach facility, events ponds, emergency spillways, water management structures, sediment ponds, or process plant or water treatment plant and finally to creek.
    - Sediment release due to component structural failure or failure of sediment structure.
    - Metals release, under normal design flood or snowmelt (design/construction error or equipment malfunction) or under runoff event exceeding design flood or snowmelt event, due to:
        1. Inadequate solution capacity design in heap leach pad, events pond, process plant or water treatment plant.
        2. Pumping and redundant system failure (mechanical or human error).
        3. Liner leakage or tear (mechanical or human error).
        4. LDRS failure and seepage to groundwater.
        5. Failure of heap or events ponds embankments, diversion ditches, sediment pond, or emergency overflow structures.
- Possible Initiating Events
    - Natural events – high precipitation event, snowmelt, or earthquake.
    - Site specific events – heap, events pond, or sediment pond over topping and flowing through emergency spillway; embankment failures; solution pumping system or power system failure; pipe breakage; water treatment plant failure; process plant failure.
    - Design, construction or maintenance events – inadequate design (heap/ponds/treatment plant, ditches); inadequate capacity (heap/ponds/treatment plant); process system failure (power, pumping); poor construction or maintenance; human error; or vandalism.

- Potential For Release
    - The relative risk of a release is very low to low due to the proposed design of heap and events ponds for high consequence category; double liners systems with LDRS; provision for extreme event capacity (rain and snow melt); provision for redundant systems (power, pumping, piping, equipment and parts); provision for contingency water treatment system; and on site personnel providing care and maintenance and routine monitoring.
    - The QA/QC program will ensure good construction control is practiced.

- Magnitude of Release
    - Small under normal operating conditions and rapid response with redundant and contingency systems.
    - Large if extreme precipitation or earthquake event, however, a large event means natural dilution. Excess system storage events pond capacity, as it is not expected that all systems will fail at once. Climate and solution monitoring to predict and plan for process upsets.

- Duration of Release
    - Very short to days depending on site or release and type of precipitation event and lack of facility inspection.

- Pathways
    - Overland flow to Williams Creek. Creek with low aquatic production and small size. No fisheries resources in upper drainage, however, lower Williams Creek and receiving Yukon River sensitive with important fish species (juvenile Chinook salmon). Small stream has limited ability to dilute or complex metals or buffer pH. Treatment plant produces high hardness, decreased metals, and reduced toxicity. Yukon River large river with dilution.

- Ecosystems at Risk
    - Upper Williams Creek small creek, supports limited aquatic resources, however, no fish. Lower creek drains to important Yukon River and important aquatic ecosystem and wildlife habitat area. Spawning and rearing in Yukon River. No rare or unique terrestrial ecosystems near mine site.

- Exposure Description and Qualitative Assessment
    - There is a very low probability of an extreme event occurring and all redundant and contingency systems failing at the same time.
    - Facility design incorporates provision for extreme events.
    - Extreme events typically provide dilution and attenuation capability in the stream.

- A very low release over a short duration of untreated solution could increase pH slightly (pH 2-4 units) and reduce metals levels (Cu 1-10 mg/L) in the stream. Treated effluents have very low hazard. Due to a low potential for release, based on Table 7-13, there will be a medium exposure of untreated solutions.

Consequence Assessment

- Consequence Description and Qualitative Assessment

  - Possible consequences include loss of aquatic productivity in the upper stream reach with potential for fish kills and longer-term aquatic ecosystem harm in the lower reaches. Based on Table 7-14 the consequences are therefore medium to high.

Risk Characterization

- Risk Description and Qualitative Characterization

  - The high hazard posed by the release of untreated solutions and the medium exposure will lead to medium to high consequences to the aquatic ecosystem, particularly if the Yukon River is affected. The overall risk therefore is considered high (Table 7-15) if preventative engineering, system designs, and redundancy and contingency measures are not considered. However, the likelihood of extreme events exceeding design storage capacity and occurring in combination with the loss of all operating and redundant systems and contingency water treatment plant is considered very low. The risk characterization considering the likelihood of events is then considered very low to low.

Project Specific Considerations

- Preventative engineering and design measures including:
  - stand-by emergency power generation;
  - redundant systems (pumping, piping, equipment and power);
  - double liner with leak detection and recovery system constructed with construction quality assurance and quality control program;
  - contingency water treatment plant;
  - events ponds, sized to handle a combination of extreme events conditions and capacity to contain 100% of draindown in the first year of operation and for all winter of operations throughout the mine life;
  - sediment control ponds; and
  - operation plans that ensure that the events pond is empty in the fall, climate monitoring and solution water balance and inventory control.

- Final designs with construction QA/QC to ensure liner integrity and embankment and ditch construction.

- Contingency water treatment plant available during operations to treat effluent to meet MMER water quality and toxicity standards.

- Recommendations: construction QA/QC and Operation plans and system, and qualified personnel on site at all times to implement redundant and treatment systems as necessary.

- Monitoring quality and quantity of effects, and climate. Monitor LDRS and routine inspections and maintenance.

Failure Scenario B7

Area:	Heap Leach Pad/Events Pond Water Treatment Plant
Phase:	Operation/Closure
System/activity:	Operation of water treatment plant facilities
Failure Mode:	Accident/Equipment failure - metals and low pH release to local drainage

Hazard Assessment

- Hazard Description and Qualitative Assessment
    - Hazards are heavy metals particularly copper, and low pH. Due to the concentration of metals and pH of raffinate solutions, the hazard is high according to Table 7-13.

Exposure Assessment

- Possible Failure Mechanism
    - Release of metals, and low pH contaminated waters from water treatment plant and finally to creek. Release under normal design flood or snowmelt (design/construction error, or equipment malfunction) or under runoff event exceeding design flood or snowmelt event due to:
        1. Inadequate solution capacity design in the water treatment plant.
        2. Pumping and redundant system failure (mechanical or human error).
        3. Power outage (mechanical or human error).
        4. Failure of sediment pond or emergency overflow structures.
- Possible Initiating Events
    - Natural events – high precipitation event, snowmelt, or earthquake.
    - Site specific events – heap, events pond or sediment pond over topping and plant exceeding capacity; solution pumping system or power system failure; pipe breakage in water treatment plant failure or process plant failure.
    - Design, construction or maintenance events – inadequate water treatment plant design; inadequate capacity (treatment plant); process system failure (power, pumping); poor construction or maintenance; human error; or vandalism.
- Potential for Release
    - The relative risk of a release is low due to proposed design of heap and events ponds for high consequence category, provision for extreme event capacity (rain and snow melt) in heap and events pond, provision for redundant systems (power, pumping, piping, equipment and parts), on site personnel providing care and maintenance and routine monitoring.
    - The QA/QC program will ensure good construction control is practiced.

- Magnitude of Release

    - Small under normal operating conditions and rapid response with routine monitoring, redundant and contingency system.
    - Large if extreme precipitation or earthquake event, however, a large event means natural dilution. Excess system storage capacity and pond capacity, as all systems are not expected to fail at once. Sediment pond located down gradient provides an opportunity to minimize non-compliance release. Climate and solution monitoring to predict and plan for process upsets. Routine monitoring and inspection of facility.

- Duration of Release

    - Very short to days depending on site conditions, or release and type of precipitation event and lack of facility inspection.

- Pathways

    - Discharge from water treatment plant to sediment control pond and then controlled flow to Upper Williams Creek. Creek with low aquatic production and small size. No fisheries resources in upper drainage however lower creek reach and receiving Yukon River sensitive with important fish species (juvenile Chinook salmon). Small stream has limited ability to dilute or complex metals or buffer pH. Treatment in sediment pond as contingency. Yukon River large river with dilution.

- Ecosystems at Risk

    - Upper Williams Creek is a small creek, supports limited aquatic resources, however no fish. Lower creek drains to Yukon River and important aquatic ecosystem and wildlife habitat area. Spawning and rearing in Yukon River. No rare or unique terrestrial ecosystems near mine site.

- Exposure Description and Qualitative Assessment

    - There is a very low probability of an extreme event occurring and all redundant and contingency systems failing at the same time.
    - Extreme events typically provide dilution and attenuation capability in the stream.
    - Moderate probability of pump or equipment failure, however short term event.
    - Sediment pond located down gradient provides an opportunity to minimize non-compliance release (in situ treatment).
    - A very low release over a short duration of untreated solution could decrease stream pH slightly (pH 2-4 units) and increase metals levels (Cu 1-10mg/L) in the stream. Treated effluents have very low hazard. Due to a low potential for release, based on Table 7-13, there will be a medium exposure of untreated solutions.

Consequence Assessment

- Consequence Description and Qualitative Assessment

    - Possible consequences include loss of aquatic productivity in the upper stream reach with potential for fish kills and longer-term aquatic ecosystem harm in the lower stream reaches. Based on Table 7-14 the consequences are therefore medium to high.

Risk Characterization

- Risk Description and Qualitative Characterization

    - The high hazard posed by the release of untreated solutions and the medium exposure will lead to medium to high consequences to the aquatic ecosystem, particularly if the Yukon River is affected. The overall risk is therefore considered high (Table 7-15) if preventative engineering, system designs and redundancy and contingency measures are not considered. However the likelihood of extreme events exceeding design storage capacity and occurring in combination with the loss of all operating and redundant systems is considered very low. Any release as a result of equipment failure or accident is expected to be short-term thereby minimizing downstream exposure and resultant effects. Sediment control pond provides opportunity for contingency water treatment. The risk characterization considering the likelihood of events is then considered to be low.

Project Specific Considerations

- Preventative engineering and design measures including:
    - stand-by emergency power generation;
    - redundant systems (pumping, piping, equipment and power);
    - events ponds sized to handle a combination of extreme events conditions and capacity to contain 100% of draindown in the first year of operation and for all winter operations throughout the mine life;
    - sediment control ponds that provides an opportunity for controlled treatment; and
    - operation plans that ensure that the events pond is empty in the fall, climate monitoring and solution water balance and inventory control.

- Final designs with construction QA/QC to ensure proper plant construction and operation.

- Contingency water treatment plant available during operations to treat effluent to meet MMER water quality and toxicity standards.

- Recommendations: construction QA/QC and Operation plans and system, and qualified personnel on site at all times to implement redundant and treatment systems as necessary.

- Monitoring plant operations and effluent quantity and quality of effects, and climate monitoring. Routine inspections and maintenance.

- Spill Contingency Plan for emergency sediment control pond water treatment.

Failure Scenario C1 and C2

Area:	Transportation, Storage and Handling Facilities
Phase:	Construction/Operation/Closure
System/activity:	Transport and handling of hazardous materials to or on site
Failure Mode:	Hazardous materials release to ground and/or local drainages

Hazard Assessment

- Hazard Description and Qualitative Assessment

    - Hazards are petroleum products, sulphur, sulphuric acid, and other processing reagents.
    - Hazardous materials may be released to ground in a localized area or directly or indirectly to watercourse depending on event location.
    - Trained personnel only transport large volumes of materials.
    - Spill response planning and equipment available.
    - Maintenance and monitoring of road and traffic conditions during operations.
    - Quantities typically limited to shipping quantities: 5,000 to 50,000 liters. Based on Table 7-13 this results in a medium hazard for petroleum product release.

Exposure Assessment

- Possible Failure Mechanism

    - Hazardous material release due to:

        1. Equipment or tank failure or breach.
        2. Accident(s) or human error.
        3. Single or multiple vehicle accident.

- Possible Initiating Events

    - Natural events – high precipitation event, weather conditions – poor road conditions.
    - Site specific events – wildlife crossing or collision;
    - Design, construction or maintenance events – inadequate road maintenance or poor construction; improper training.

- Potential for Release

    - During the construction and closure phase it is expected that the potential for release will be lower than operations with reduced traffic.
    - Likelihood of an accident is high.
    - Road maintained, personnel trained, emergency response and spill contingency plan in place.
    - Monitoring of hazardous materials traffic.

- Magnitude of Release
    - Low magnitude as a spill is confined to local ground area and sorption to soils.
    - Possible release to watercourse indirectly or directly, however, limited stream crossings and major crossings with bridges.
- Duration of Release
    - Very short to days depending on: response time and precipitation event, and material clean up. Trained personnel and spill response equipment readily available.
- Pathways
    - On local soils, through to groundwater; overland flow to watercourse.
- Ecosystems at Risk
    - Forested drainages along the transportation corridor and at the mine area to aquatic ecosystems, overland flow to surrounding creeks, or if a major event, to nearby river.
- Exposure Description and Qualitative Assessment
    - Transport and storage or handling of hazardous materials will take place along defined road corridors and on the mine property.
    - Release expected initially to ground and potentially to a nearby watercourse, and some impact to terrestrial or aquatic ecosystems.
    - There is a moderate probability of an accident and/or materials release due to human error or accident.
    - For a single incident, the magnitude of the largest loss into the receiving environment would be restricted to the capacity of the largest load, be it fuel, reagents or ammonium nitrate.
    - A spill of hazardous material could contaminate soil and/or surface and groundwater.
    - Contaminated soils can be removed and treated.
    - Receptors affected by a spill would generally be the aquatic biota.
    - Due to moderate potential of release it is not expected that all transport volumes of hazardous materials will be released and exceed 50,000 liters. According to Table 7-13 there will be a low to medium exposure.

Consequence Assessment

- Consequence Description and Qualitative Assessment
    - Possible consequences include localized contamination of soils with possible release to watercourse if sorption capacity of soil is exceeded and materials flow into a watercourse.

- Likelihood of materials in watercourse is low. Slight habitat degradation and slight (<5%) reduction in fish productivity due to smaller stream in area of the Freegold road, mine access and mine site.
- Based on Table 7-14 the consequences are very low to low, depending on the type of watercourse affected.

Risk Characterization

- Risk Description and Qualitative Characterization

  - The medium hazard posed by the petroleum and processing products combined with a low to medium exposure will lead to very low consequences if released to soils and a low consequence if released to the aquatic ecosystem. The overall risk therefore is low (Table 7-15).

Project Specific Considerations

- Materials storage and handling located in protected areas designed to minimize potential for product release. Secondary containment of product storage on mine site.

- EMS with requirements for personnel training and emergency response for trucking and handling hazardous materials.

- Emergency Response and Spill Contingency Plan and procedures in place with appropriate equipment.

- Monitoring of road conditions and maintenance, highway signage, and posting of any wildlife crossings to minimize accident potential.

- Traffic scheduling and monitoring to control materials transport and track materials movement and arrival.

- Recommendations: practice emergency and spill contingency procedures; ensure equipment in good condition and trucks with spill containment equipment.

- Monitoring climatic and road conditions and restrict traffic during poor road conditions. Routine inspections and road maintenance.

WESTERN SILVER CORPORATION

Project Description and Environmental Assessment Report

Carmacks Copper Project
Yukon Territory

Appendix N

Information Sheet for Quartz Mining Undertakings

Yukon Water Board
106-419 Range Rd. Whitehorse YT Y1A 3V1
Phone (867) 456-3980 Fax (867) 456-3890
email: ywb@yukonwaterboard.ca

Information Sheet for Quartz Mining Undertakings

Notes to Applicant:
This information sheet must be accompanied by a completed Schedule IV and the applicable fees.

This information sheet is intended to apply only to new or renewal applications. If you are applying to amend an existing licence, you are required to provide a letter indicating precisely the nature of the amendment, the licence sections for which amendment is requested, the proposed amendment wording and the rationale for the amendment.

In addition to the information requested in this form, please refer to Section 5 of the *Waters Regulation* and the Board's *Licensing Guidelines for Type A Quartz Mining Undertakings* to ensure that your application contains all of the required information.

The information provided in this form should reference relevant page numbers of any supporting reports submitted with your application. If insufficient space is provided in this form, or where no space is provided, please attach the required information using the same section titles and numbers as listed in this form.

If more than one licenceable activity or facility is proposed (e.g. multiple water sources, waste deposits, dams, water crossings, etc.), the required information should be presented for each activity or facility.

All design drawings submitted as part of the application must be sealed by a Professional Engineer licenced to practice in the Yukon. Drawings shall be to at least a preliminary design level as described in *the Licensing Guidelines for Type A Quartz Mining Undertakings* but may be labelled "Not for Construction".

An environmental assessment of this application, as required by *the Environmental Assessment Act ("EAA")* will be carried out by applicable Responsible Authorities as defined in *EAA*.

A. GENERAL INFORMATION

1. Name of Applicant: Western Silver Corporation

2. Are you applying for a Type A Licence or a Type B Licence? Type A (✓) Type B ( )

3. If you are applying for a Type B Licence, confirm that every aspect of your proposed undertaking does not exceed the licensing criteria specified in Column III of Schedule VII of the *Waters Regulation.*

4. Name of Waterbody(ies): Williams Creek

5. Tributary of: Yukon River

6. a) National Topographical System (NTS) 1:50,000 scale Map Sheet Number(s):
   115 I/7

   b) Indicate your project location on a 1:50,000 topographical map, or part thereof. Please ensure that the map sheet number is clearly indicated, selected UTM grid lines are labelled and the UTM zone is indicated.

   c) Attach a copy of the claim map for the project area and outline your claims.

7. Provide map co-ordinates for the project. If the project covers an area, provide the co-ordinates for a box that includes the entire project as well as the co-ordinates of the centre of the project area.

Minimum Latitude	62 deg 14' 51" N	Maximum Latitude	62 deg 24' 38" N
Minimum Longitude	136deg 35'34" W	Maximum Longitude	136 deg 49'45" W
Centre Latitude	62 deg 19' 44" N	Centre Longitude	136 deg 42' 40" W

8. Nearest Community: Village of Carmacks

9. Name of Highway and Kilometre Location: Freegold Road - Km 33

10. In which First Nation Traditional Territory (or Territories) is your project located?
Little Salmon Carmacks and Selkirk First Nations

11. Is your project located on or near First Nation Settlement Land? Yes (✓) No ( )

Will water flowing from your project flow on or adjacent to First Nation Settlement Land? Yes ( ) No (✓)

If so, provide details and attach a map showing the Settlement Lands in relation to your project.

12. Have you contacted the First Nation(s) regarding your project? Yes (✓) No ( )

If so, provide details.

13. Are there any existing licences or pre-existing applicants whose use of water may be affected by your project? Yes ( ) No (✓)

If so, provide information about who they are and any contacts that you have made with them.

14. Are there any other surface water or groundwater users that might be affected by your project?

Yes ( ) No (✓)

If YES, identify the other users and describe how they will or may be affected.

15. Does the undertaking require any other permits (e.g. land use permit, quarry permit, timber permit, etc.)?

Yes (✓) No ( ) If YES specify the type of permit and it's status.
Quartz Mining Production Licence; Type A Water Use Licence

B. PROJECT DESCRIPTION

16. Provide a general description of the project.

17. Is this a new undertaking or a reactivation of a previous operation?
New quartz mining undertaking.

18. Indicate the status of the mine and/or mill (or other relevant processing facility) on the date of the application:

	Mine	Mill
In Design	April, 2005	April, 2005
Under Construction	N/A	N/A
In Operation	N/A	N/A
Temporarily Closed	N/A	N/A
Permanently Closed	N/A	N/A

19. If a change in the status of the mine or the mill is expected, please indicate the proposed date of such change(s).

20. Indicate the proposed operating schedule:

	Mine	Mill
Hours per day	24	24
Days per week	7	7
Weeks per year	300 days/yr ~ 43 weeks	365 days/yr or 52 weeks
Number and length of shifts	2, 12 hour shifts/day	2, 12 hour shifts/day
Number of workers on site	109 average	43

21. Attach an overall project layout plan at a scale not less detailed than 1:5000 showing the locations of all of the main components of the project, including but not limited to the mining claims, mine, mill, rock dump(s), ore stockpile(s), dam(s), tailings area(s), access road(s), camp(s), water supply source(s), waste discharge(s) and any other facilities proposed to be licenced through this application. Indicate any Settlement Land and the location of other users identified in Part A if they are within the area of the map.

22. Describe the type(s) of mining operation(s) proposed (i.e. conventional underground, conventional open pit, combined conventional underground and open pit, strip mining, etc.). Include in the description the mining methods to be used, the magnitude of each operation in terms of tonnes of ore and waste to be removed per day on average. Indicate any seasonal operation.

23. Does your site include any existing underground workings?

    Yes ( ) No (✓)

    If so, describe them and provide drawings showing the location and extent. Do the workings free-drain? If so, describe the quantity and quality of the existing flow.

24. Specify the proposed milling rate in tonnes of ore per day: Ore production rate: max 9,872 tonnes ore per day; avg production capacity of 14,310 tonnes/yr copper cathode.

25. Describe the proposed milling and processing operation, including methods, equipment, reagents, etc. Provide a flow chart of the operation.

26. Generally characterize the project by providing at least the following information:

    a) Topographic maps: copies of the most recent and largest scale (up to 1:2000) topographic maps available, showing where the mine, mill, tailings and other related facilities will be located.

    b) Soil maps: copies of the most recent and largest scale (up to 1:2000) soil maps available of the project area complete with legends and explanations.

    c) Geologic maps: copies of the most recent and largest scale (up to 1:2000) geologic maps available of the project area complete with legends and explanations.

    d) Climate: climatological information, including precipitation and evaporation data for the project area.

e) Hydrology: hydrologic information for the project area, including peak flows, average flows, seasonal flows, flood flows and their return periods, flow patterns, seasonal water quality and quantity, and stream sediment data.

f) Information pertaining to groundwater in the project area, including location, flow direction(s) and quality.

g) Information pertaining to the distribution and nature of permafrost in the project area, including any areas where your assessments indicate the potential existence of ice-rich, thaw unstable permafrost.

C. GEOLOGY AND GEOCHEMISTRY

27. Describe the physical nature of the ore body(ies), including location, known dimensions and approximate shape. Include separate descriptions of any recognized ore types and waste rocks within the ore bodies.

28. Describe the country rock in the vicinity of the ore body, paying particular attention to any rocks that will be excavated during mining or will remain in pit walls or workings.

29. For each country rock unit, waste rock unit or ore type, describe the minerology of the unit, listing the constituent minerals and their average percentage weights. If available, provide summary chemical analysis of the rock types, including trace elements.

30. Are pyrite and/or pyrrohotite present in the ore body, waste rocks or country rocks? Yes (✓) No ( )

Is arsenopyrite present in the ore body, waste rocks or country rocks? Yes (✓) No ( )

If YES, be sure that the response to Question 29 indicates the amount of each mineral. Describe the grainsize and habit of the mineral (i.e. disseminated, veinlet, etc.). If any parameter is variable, then provide the range and average of the parameter. If the response to Question 30 is YES, then provide for each rock type and ore, any results for Acid Base Accounting, paste pH or other static/kinetic testing available.

31. Is there a potential for acid rock drainage to occur? Yes (✓) No ( )

If YES, describe the location, extent and degree of any anticipated acid rock drainage, including from waste rock, and the methods proposed to be used to minimize or mitigate any significant adverse environmental impacts. If NO, provide a technically based analysis, supported by site-specific data, that justifies the conclusion.

D. USES

32. Does the project include Direct Water Use? Yes (✓) No ( )

If YES, attach the following information for each source:

a) a description of the water use and source.

b) the acquisition rate in cubic metres per day and cubic metres per year.

c) a description of the location the water source(s). If the source is groundwater, attach well logs.

d) the water intake method.

e) details of any screening to exclude fish.

f) the location and design of any water storage facility, if applicable, and the water storage volume in cubic metres.

g) streamflow data in cubic metres per second for the water supply source, including:

i) Mean Annual Flow
ii) Mean Seasonal Flow
iii) Minimum Summer Flow
iv) Minimum Annual Flow
v) Mean Annual Flood
vi) Maximum Summer Flood
vii) Mean Summer Flood

33. Does the project include Construction of a Watercourse Crossing? Yes (✓) No ( )

If YES, attach the following information for each crossing:

a) a description of the type of crossing (i.e. bridge, culvert, rock drain, ford, etc.).

b) an explanation of why the crossing is required and the rationale for selection of the type of crossing.

c) the following information for the crossing location:

i) the width of the watercourse at the Ordinary High Water Mark (OHWM).
ii) the gradient of the watercourse.
iii) the Design Flood Flow in cubic metres per second and its Return Period.
iv) the Mean Seasonal Flow in cubic metres per second.
v) an explanation of the rationale for the selected Design Flood Flow and its Return Period.
vi) a description of the streambed material, streambank material and streambank vegetation.
vii) a description of proposed sediment control measures.
viii) design drawings in plan and profile.
ix) a description of the construction methods, schedule, quality assurance/quality control measures, and inspection and maintenance procedures and schedule proposed to be used.

34. Does the project include Watercourse Training? Yes ( ) No (✓)
(includes channel and/or bank alterations, watercourse infilling, spurs, docks, culverts, erosion control, rip-rap, etc.)

If YES, attach the following information for each proposed training work:

a) a description of the type of watercourse training proposed.

b) an explanation of why the training is required.

c) the following information for the watercourse training location:

i) the Design Flood Flow in cubic metres per second and its Return Period.
ii) the Mean Seasonal Flow in cubic metres per second.
iii) an explanation of the rationale for the selected Design Flood Flow and its Return Period.
iv) a description of the streambed material, streambank material, and streambank vegetation.
v) a description of the source, size, and composition of any material to be used for the training and the quantity of material to be either placed into or removed from the watercourse.
vi) a description of proposed sediment control measures
vii) design drawings in plan and profile.
viii) a description of the construction methods, schedule, quality assurance/quality control measures, and inspection and maintenance procedures and schedule proposed to be used.

35. Does the project include Diversions? Yes ( ) No (✓)
(includes dikes and other structures relating to the diversion)

If YES, attach the following information for each diversion and related structure:

a) the width of the pre-diversion watercourse at the Ordinary High Water Mark (OHWM).

b) a description of the proposed diversion or structure.

c) an explanation of the reason for the diversion or structure.

d) information on the length and gradient of the existing channel and of the proposed diversion.

e) the following information for the diversion:

i) the Design Flood Flow in cubic metres per second and its Return Period.
ii) the Mean Seasonal Flow in cubic metres per second.
iii) an explanation of the rationale for the selected Design Flood Flow and its Return Period.
iv) design drawings in plan and profile.

v) a description of the construction methods, schedule, quality assurance/quality control measures, and inspection and maintenance procedures and schedule proposed to be used.

36. Does the project include Waste Rock Dumps or Ore/Concentrate Storage?

Yes (✓) No ( )

If YES, attach the following information for each contiguous dump:

a) a description of the proposed dump site, including location and extent, topography, soil and rock conditions (provide test pit/drill hole logs and laboratory test results), permafrost conditions, geologic and hydrologic characteristics, rock types and amounts to be placed in the dump, physical and chemical quality of rock to be placed in the dump, and the quantity and quality of surface runoff and seepage through the dump to surface water and groundwater.

b) a description of the methods proposed to be used to ensure stability of the dump and avoid, minimize or mitigate significant adverse environmental impacts, including, but not limited to, site preparation, methods of rock placement, operating and final slopes, caps and crowns, seepage collection or interception ditches, sediment control measures, revegetation/reclamation measures, and monitoring of stability and seepage.

c) design drawings in plan and profile.

d) a description of the site preparation, construction methods, schedule, proposed quality assurance/quality control measures, inspection and maintenance procedures, and schedule.

37. Does the project include Dams, Spillways, Cofferdams or Dikes? Yes ( ) No (✓)

If YES, attach the following information for each structure:

a) a description of the structure and its purpose.

b) a description of the site conditions, including the location, topography, geologic and hydrologic characteristics, permafrost conditions, and soil and rock conditions (provide test pit/drill hole logs and laboratory test results).

c) a description of the type and composition of the material to be used in the construction of the structure.

d) design drawings in plan and profile.

e) a description of the construction methods, schedule, quality assurance/quality control measures, and inspection and maintenance procedures and schedule proposed to be used.

f) in the case of a dam, details of the seismic design parameters and confirmation that the structure is designed to withstand the Maximum Credible Earthquake.

g) in the case of a spillway, details of the hydraulic design parameters and confirmation that the structure is designed to pass the Probable Maximum Flood.

h) If the structure creates a reservoir in a natural watercourse, attach drawings of the reservoir in plan and profile and show representative cross sections. Identify the size of the drainage basin upstream of the reservoir and provide a topographic plan showing the drainage area boundary. Indicate the number of hectares to be flooded, the surface area of the reservoir at full supply level, the total storage capacity of the reservoir, and details of any shoreline protection proposed.

38. Does the project include the Deposit of Solid or Liquid Waste? Yes (✓) No ( )

(Note: This includes all wastes as defined in Section 1 of the *Waters Act* that have the potential to alter or degrade surface or groundwater. Wastes include but are not limited to tailings, milling residues, runoff from mine workings and tailings, discharges from workings, explosives residues, debris, domestic sewage, sediment, etc, whether treated or not.)

If YES, attach the following information for each liquid waste:

a) the type and quantity of waste proposed to be deposited and the reason for the deposit.

b) in the case of a liquid waste, the chemical characterization and concentration of the waste proposed to be deposited.

c) in the case of a solid waste, the geochemical characteristics of the waste.

d) the location, rate, timing, frequency and duration of the deposit.

e) the baseline surface and groundwater quality at the location of the proposed discharge.

f) the potential qualitative and quantitative effects that the deposit may have on any watercourse and/or surface water and/or groundwater.

g) the proposed methods for collecting, storing, treating and discharging the waste, and the volumes of any waste storage systems.

h) a description of the construction methods, schedule, quality assurance/quality control measures, and inspection and maintenance procedures and schedule proposed to be used for any waste treatment/storage/discharge facilities.

i) a description and justification of the standards proposed to be applied to any discharges of waste to the receiving environment.

E. HAZARDOUS MATERIALS AND SPILL CONTINGENCY

39. Does the project include the Handling or Storage of Petroleum Products or Hazardous Materials? Yes (✓) No ( )

If YES, provide the following information:

a) a plan for the safe handling, storage, and disposal of petroleum products or hazardous materials.

b) a description of equipment to be kept available for spill response or other emergency and it's location, and a description of proposed training programs for workers.

c) a contingency plan for the containment and clean-up in the event of a spill.

F. EMERGENCY RESPONSE

40. Provide an emergency response plan that includes mechanisms and processes for addressing potential or actual failures of structures, equipment and material stockpiles, and programs for appropriate training to workers.

G. WATER BALANCE MODEL

41. Provide the analysis and results of a detailed water balance model for the project, including all assumptions, calculations and findings, including wet and dry events modelled.

H. WATER QUALITY MODEL

42. Provide the analysis and results of a predictive water quality model for the project.

I. PROJECT EFFECTS

43. Provide a description of any potential impacts to fish and fish habitat.

44. Provide a description of plans to mitigate any effects on fish resources.

45. Provide a description of plans for compensation of any fish habitat lost due to the project.

46. Provide a description of wildlife uses in the project area including sport hunting, subsistence hunting, trapping, and non-consumptive uses.

47. Provide a description of plans to mitigate any effects on wildlife resources due to the project.

48. Provide a description of plans to mitigate any damage to plant cover and topsoil.

49. Provide a detailed description of any potential impacts to water quality, quantity and/or seasonal rate of flow, and any mitigative measures included in the project design.

50. Are there anticipated to be any potential impacts to traditional uses and water rights of a First Nation as described in Section 14.8.0, or of a Yukon Indian Person as described in Section 14.9.0 of the *Umbrella Final Agreement*? Yes ( ) No (✓)

    If YES, provide an explanation of how they have been considered and what mitigative measures have been included in the project design.

51. Provide an explanation of how any existing water use licensees or pre-existing applicants, whose use of water may be affected by your project, have been considered and what mitigative measures have been included in the project design.

52. Are there any trapline concession holders in the area of your project? Yes (✓) No ( )

    If YES, provide information about who they are, what contacts that you have made with them, how they have been considered in the project development, and what mitigative measures have been included in the project design.

53. Are there any outfitters in the area of your project? Yes (✓) No ( )

    If YES, provide information about who they are, what contacts that you have made with them, how they have been considered in the project development, and what mitigative measures have been included in the project design.

54. Are there any other owners or occupiers of land in the area of your project? Yes ( ) No (✓)

    If YES, provide information about who they are, what contacts that you have made with them, how they have been considered in the project development, and what mitigative measures have been included in the project design.

J. DECOMMISSIONING PLANS

55. What is the expected life of the project?
    15 years: 0-8 yrs construction & mine operation; 8-15 yrs decommissioning &
    reclamation, closure, & post closure.

56. Provide a detailed description of decommissioning measures to be taken when the project is either temporarily or permanently abandoned and describe how project facilities will be removed and the site reclaimed.

57. Provide a description of proposed monitoring and inspection procedures to be followed during either temporary or permanent decommissioning.

K. MONITORING PLANS

58. Provide a detailed description of the methods, procedures, standards, systems, networks and schedules proposed to be used to monitor the performance of the project facilities/systems and their impact on the environment.

OFFICERS OF THE COMPANY/CORPORATION

This page must only be completed if the applicant is a corporation, limited company, or other business entity. Non profit organizations should provide proof that they are a registered society or organisation in the Yukon.

Before issuing a water licence in the name of a corporation, limited company or other business entity, the Yukon Water Board will require that the following declaration be completed:

I, Jonathan Clegg certify that (name of business entity) Western Silver Corporation is incorporated or registered pursuant to the *Business Corporations Act* Of The Yukon Territory or is registered in the province of British Columbia.

The officers of the company are:

Name (Please Print):	Title
DALE CORMAN	CHAIRMAN & CEO
THOMAS PATTON	PRESIDENT & COO
JOSEPH LITNOSKY	V.P. FINANCE & CFO
JEFFERY GIESBRICHT	V.P. LEGAL & SECRETARY
GERALD PROSALENDIS	V.P. CORP. DEVELOPMENT.
	V.P. ENGINEERING.

Signature

Title

12 May 2005

Date

Please Note:If the above information is not completed, the Board will consider the application to be in the name of the individual who signed the Schedule IV.

Yukon
Justice

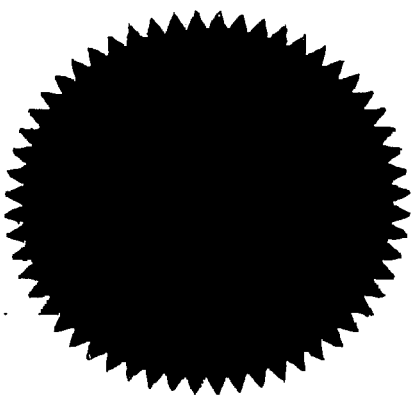
BUSINESS CORPORATIONS ACT
FORM 11

CERTIFICATE OF REGISTRATION
EXTRA-TERRITORIAL CORPORATION

WESTERN COPPER HOLDINGS LIMITED

Name of Corporation

I HEREBY CERTIFY THAT THE ABOVE-MENTIONED CORPORATION, THE STATEMENT OF REGISTRATION OF WHICH IS ATTACHED, WAS REGISTERED AS AN EXTRA-TERRITORIAL CORPORATION UNDER THE BUSINESS CORPORATIONS ACT OF YUKON.



Registrar of Corporations

Malcolm Florence

March 9, 1990

Date of Registration

YC(30650)F1

Certified a true copy
this 29th day of May, 2003
NUMBER: [illegible]
NOTARY FOR
BRITISH COLUMBIA

BRITISH COLUMBIA

CERTIFICATE OF CHANGE OF NAME

COMPANY ACT

I Hereby Certify that

WESTERN COPPER HOLDINGS LIMITED

has this day changed its name to

WESTERN SILVER CORPORATION

Issued under my hand at Victoria, British Columbia,
on March 20, 2003

JOHN S. POWELL
Registrar of Companies
PROVINCE OF BRITISH COLUMBIA
CANADA

Yukon
Community Services

BUSINESS CORPORATIONS ACT
FORM 17

Certificate

WESTERN SILVER CORPORATION

I hereby certify that the name of the above-mentioned corporation was changed in accordance with the attached notice.

Corporate Access Number:30150
Date:2003-06-03

M. Richard Roberts
Registrar of Corporations

115I/07

LSC R-17B

LSC S-30B1

SFN S-1B1/D

LSC S-303B1

LSC S-127B1

LSC S-304B1

LSC S-130B1

LSC R-9A

LSC R-53B

Y.T. HIGHWAY No. 2

YUKON RIVER

MERRICE LAKE

Hootalinqua Creek

Stoddart Creek

Merrice Creek

Williams Creek

Quartz Creek

FREEGOLD ROAD

ACCESS ROAD

GRANITE MOUNTAIN

73 REM Group 953

H170 H165 H160 H155 H152A H150 H149 H148

3 G 10

20 G953 41 G10 40 G10 18 G953 17 G953 19 G953 22 G 953 21 G 953 23 G10 38 G10 37 G10 34 G10 35 G10 36 G10

1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019

115I/07

115I/07

MINING CLAIMS

2003 MAGNETIC DECLINATION 0 Annual Change: 18.7' W

UTM Zone: UTM Zone 8
Datum: NAD 83
Mining District: Whitehorse
Map Creation Date: Apr 20, 2005

115I11	115I10	115I09
115I06	115I07	115I08
115I03	115I02	115I01

1500 750 0 1500 3000 4500 6000 7500 Feet

1000 500 0 1000 2000 3000 Metres

Mining
- Staking Direction
- Placer Baselines
- Mining District Boundaries

Claim Status
- Active Quartz Claim
- Active Placer Claim
- Expired Claim

Coal
- Coal Exploration Licence
- Coal Mining Lease
- Expired Licence or Lease

Areas Withdrawn from Staking
- First Nation Interim Protected Lands
- Parks and Special Management Areas

First Nation Settlement Land
Category
- A
- B
- FS

First Nations Surveyed Lands
Category
- A
- B
- FS

NRCan Legal Survey Cadastral
- First Nations Community Lots
- Special Access Rights through FN Lands
- Mineral Claims
- Community Land Transfers (Order in Council)
- Land Dispositions (Lots)
- Easements

EMR Lands
- Land Disposition
- Land Application
- Agricultural Disposition
- Agricultural Application
- Privy Council Orders

Mapsheet Index
Hydrographic
- 1:10000 Mineral Index
- 1:50000 Mineral Index

Base Map Features
Hydrographic
- Watercourse
- Waterbody
- Intermittent waterbody
- Underwater sand
- Dry river bed

Topography
- Contours

Transportation Routes
- Highway
- Main
- Secondary
- Street
- Limited-use road
- Trail
- Cut line
- Railway
- Bridge
- Foot Bridge
- Ferry route
- Ford

This map is a compilation of data obtained from many sources. As such, the Mining Lands Branch accepts no responsibility for errors, inaccuracies, or omissions. Where the map differs from the actual post locations on the ground, the ground location has precedence.

Category A Land - Contact First Nation for staking
Category B Land - Contact Mining Recorder's Office for staking

For mining claim information, please contact the Mining Recorder's Office for the appropriate mining district:

Whitehorse District Office:
Rm 102 - 300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 667-3190 Fax: (867) 667-5150
email: **whitehorse.mining@gov.yk.ca**

Dawson District Office:
Box 249
Dawson City, YT Y0B 1G0
Ph: (867) 993-5343 Fax: (867) 993-6747
email: **dawson.mining@gov.yk.ca**

Watson District Office:
Box 269
Watson Lake, YT Y0A 1C0
Ph: (867) 536-7366 Fax: (867) 536-7842
email: **watson.mining@gov.yk.ca**

Mayo District Office:
Box 10
Mayo, YT Y0B 1M0
Ph: (867) 996-2256 Fax: (867) 996-2617
email: **mayo.mining@gov.yk.ca**

Sources:
Mining claim locations obtained from staking sketches except for Global Positioning System (GPS) located claims.

1:50000 scale digital topography obtained from Natural Resources Canada National Topographic System data.

Survey data obtained from Natural Resources Canada Legal Surveys Division. For more information, please contact:
Natural Resources Canada Legal Surveys Division, Whitehorse
Rm 225 - 300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 667-3950 Fax: (867) 393-6707

Lands Information obtained from Energy, Mines and Resources Lands Branch. For more information, please contact:
Energy, Mines and Resources Lands Branch
Rm 320-300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 667-5215 Fax: (867) 393-6285
email: **land.disposition@gov.yk.ca**

Agricultural Information obtained from Energy, Mines and Resources Agriculture Branch. For more information, please contact:
Energy, Mines and Resources Agriculture Branch
Rm 320 - 300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 667-5838 Fax: (867) 393-6222

Interim Protected Land Claims Information obtained from Indian and Northern Affairs Canada, Claims and Indian Government Mapping
For more information, please contact:
Claims and Indian Government
Rm 420 - 300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 667-3814 Fax: (867) 667-3372

Other Resources:
For access to airphotos, Mining Assessment Reports, and geology publications:

Yukon Energy, Mines and Resources Library
Rm 335 - 300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 667-3111 Fax: (867) 456-3888
email: emrlibrary@gov.yk.ca

Yukon Geological Survey
Rm 102 - 300 Main St
Whitehorse, YT Y1A 2B5
Ph: (867) 456-3808 Fax: (867) 667-3198
or:
2099 2nd Ave
Whitehorse, YT Y1A 2C6
Ph: (867) 667-8508 Fax: (867) 393-6232

Yukon Geological Survey Maps and Publications are available by emailing:
map.sales@gov.yk.ca
or can be downloaded from:
www.geology.gov.yk.ca

Online Resources:

Mining claims maps are also available online at the Yukon Mining Recorder Website:
www.yukonminingrecorder.ca

Yukon Geological Survey Maps, Minfile, and Publications are also available at the Yukon Geological Survey Website:
www.geology.gov.yk.ca

Old Crow, Dawson, Mayo, Beaver Creek, Carmacks, Faro, Whitehorse, Haines Junction, Watson Lake

Yukon
Energy, Mines and Resources
Minerals Management Branch