The Rehabilitation of The Kam Kotia Mine Site:

An Exercise in Cover Construction and Water Management

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Background Information

- Kam Kotia is a former Cu/Zn mine near Timmins, Ontario
- There are about 6 million tonnes of unmanaged acid generating tailings originally covering more than 500 ha
- Environmental impacts are locally significant
  - acidic metal leachate
  - aesthetics
  - dusting
  - physical safety
- Principle exploration: 1926-1928 - exploration shaft
- Mining *: 1943-1944 - 169,000 tonnes open pit
- Mining: 1961-1972 - 5,840,000 tonnes, mainly underground
- Production 6.6 MT @ 1.1% Cu, 1.17% Zn, 0.10 oz/Ag

* Mining in 1943-1944 carried out on behalf of Wartime Metals Corporation, a Federal Government Agency. Cu sold to Metals Reserve Company, Washington, which paid operating costs and royalty.


HIGHWAY 576
NORTH
IMPOUNDED
TAILINGS
(NIT)
NORTH
UNIMPOUNDED
TAILINGS
(NUT)
SOUTH
UNIMPOUNDED
TAILINGS
(SUT)
KAM KOTIA
PLANT SITE
ACCESS ROAD
TO JAMELAND MINE
N


The mine
plant area.

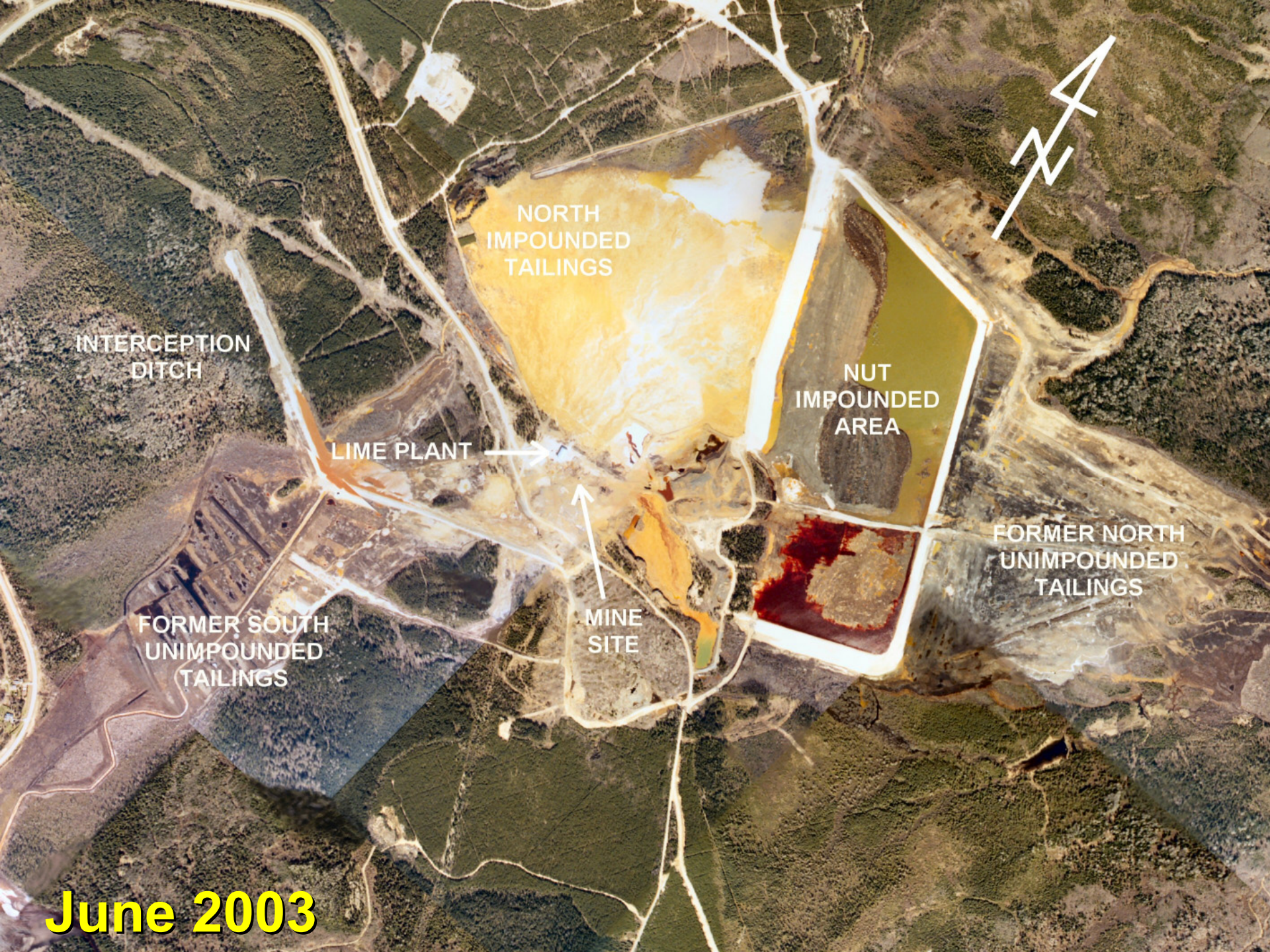
The Rehabilitation of Kam Kotia

- A five phased approach to conduct the rehabilitation of the Kam Kotia Mine site was developed in 2000
- The first phase of rehabilitation work began in 2001
- Currently, more than 80% of the required measures have been completed, at a cost of approximately $53 million
- It is expected that all rehabilitation will be completed by 2011
- The final cost of rehabilitation is expected to be ~ $62 million
- It is predicted that the Lime Treatment Plant will need to operate for an estimated 50 years after the completion of all rehabilitation on the site (i.e. three flushings of groundwater)


93 6 23


HITACHI


CAT
CATERPILLAR


NORTH
IMPOUNDED
TAILINGS
INTERCEPTION
DITCH
NUT
IMPOUNDED
AREA
LIME PLANT
FORMER NORTH
UNIMPOUNDED
TAILINGS
MINE
SITE
FORMER SOUTH
UNIMPOUNDED
TAILINGS
N
June 2003


93 6 23


Summer 2004

The Construction of the NIT Cover

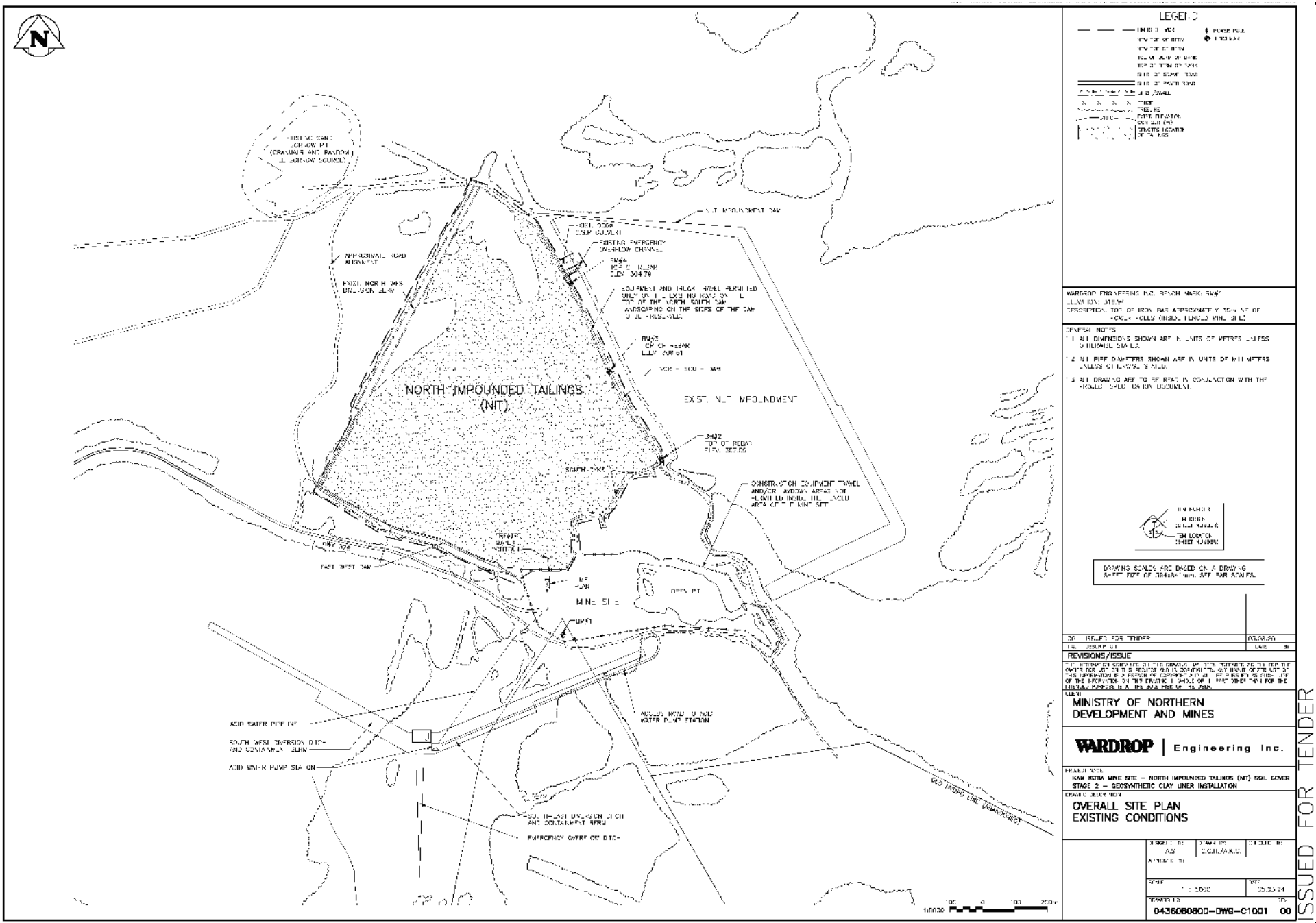

The NIT area
prior to
rehabilitation.

The NIT area
on a windy day,
Summer 2001

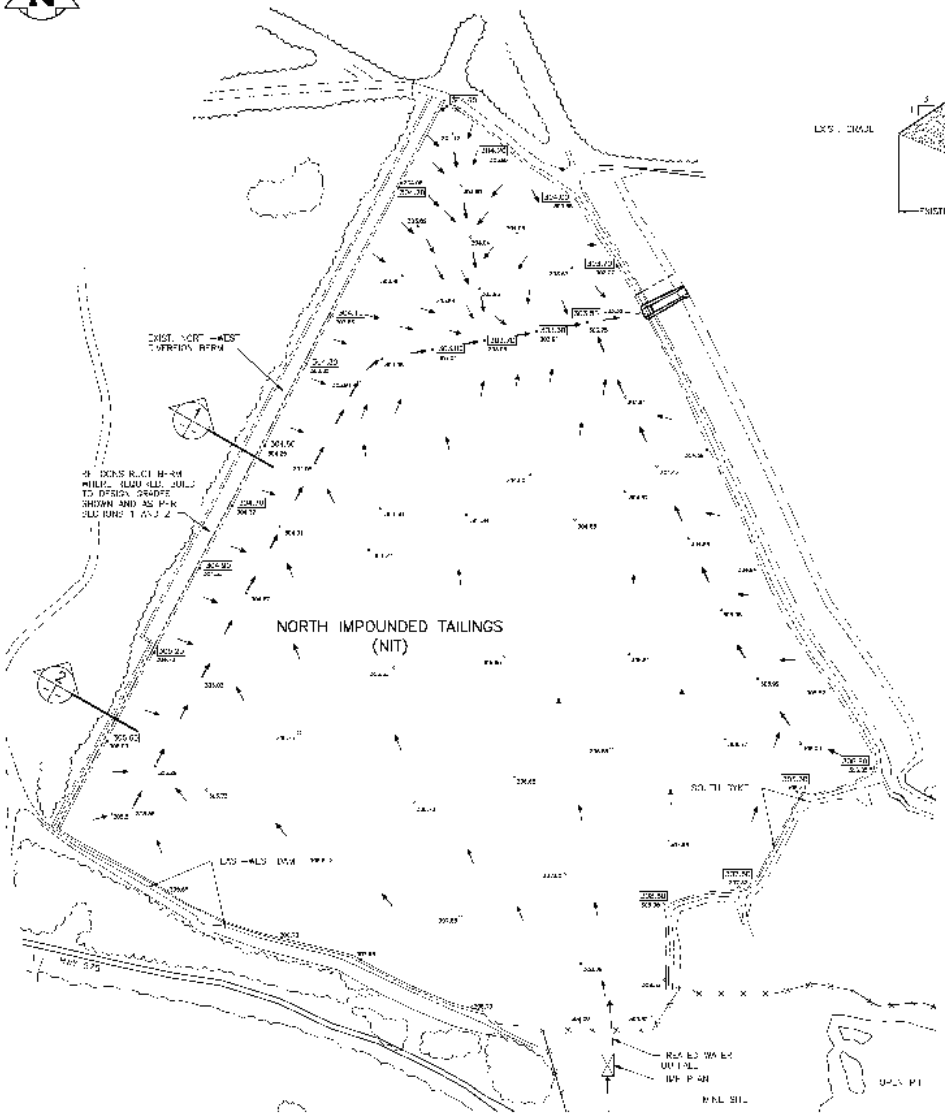
The NIT Cover

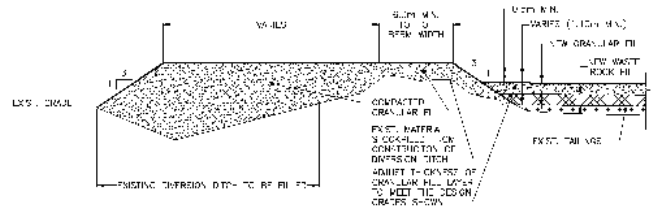
- Due to their higher elevation, it was determined that the most appropriate rehabilitation measure for the NIT area would be a multi-layered, “dry”, engineered cover.
- The engineering design was developed in 2004-06.
- The first two layers (i.e. the Capillary Break) was constructed in the winter of 2004/05.
- The remainder of the cover construction began in late 2006 and was completed by October 2008.
- The NIT is almost 80 ha in area and the rehabilitation cost was approximately $16.5 million
    - **i.e. at a cost of more than $200,000 per hectare**

Overall Site Plan – Existing Conditions

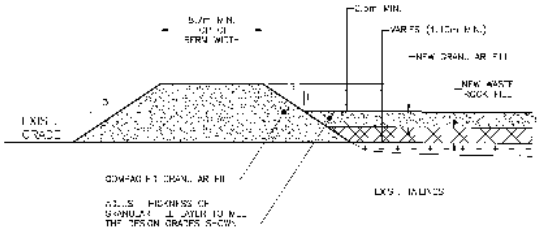


Grading Plan – Pre-Liner Placement





1 NORTH–WEST DIVERSION BERM SECTION ADJACENT EXIST. NIT DIVERSION DITCH
N.T.S



2 NORTH–WEST DIVERSION BERM SECTION
N.T.S

LEGEND

DRAWING SCALES ARE BASED ON A DRAWING SIZE OF ISO A1 (594 x 841 mm). SEE BAR SCALES.

REVISIONS/ISSUE

OWNER
MINISTRY OF NORTHERN DEVELOPMENT AND MINES

WARDROP | Engineering Inc.

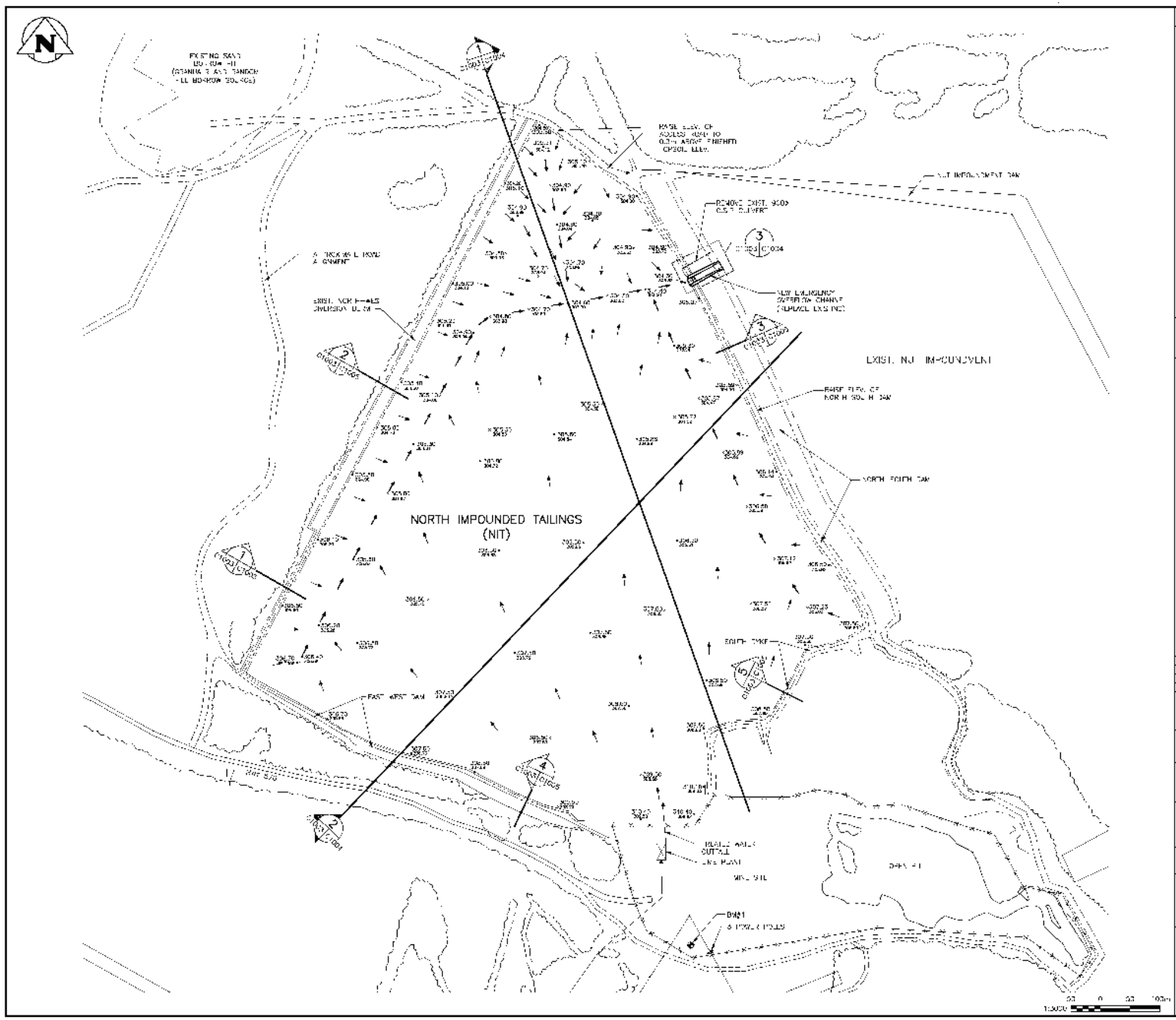
PROJECT NAME
KAM KOTIA MINE SITE – NORTH IMPOUNDED TAILINGS (NIT) SOIL COVER STAGE 2 – GEOSYNTHETIC CLAY LINER INSTALLATION

DRAWING DESCRIPTION
GRADING PLAN
PRE–LINER PLACEMENT

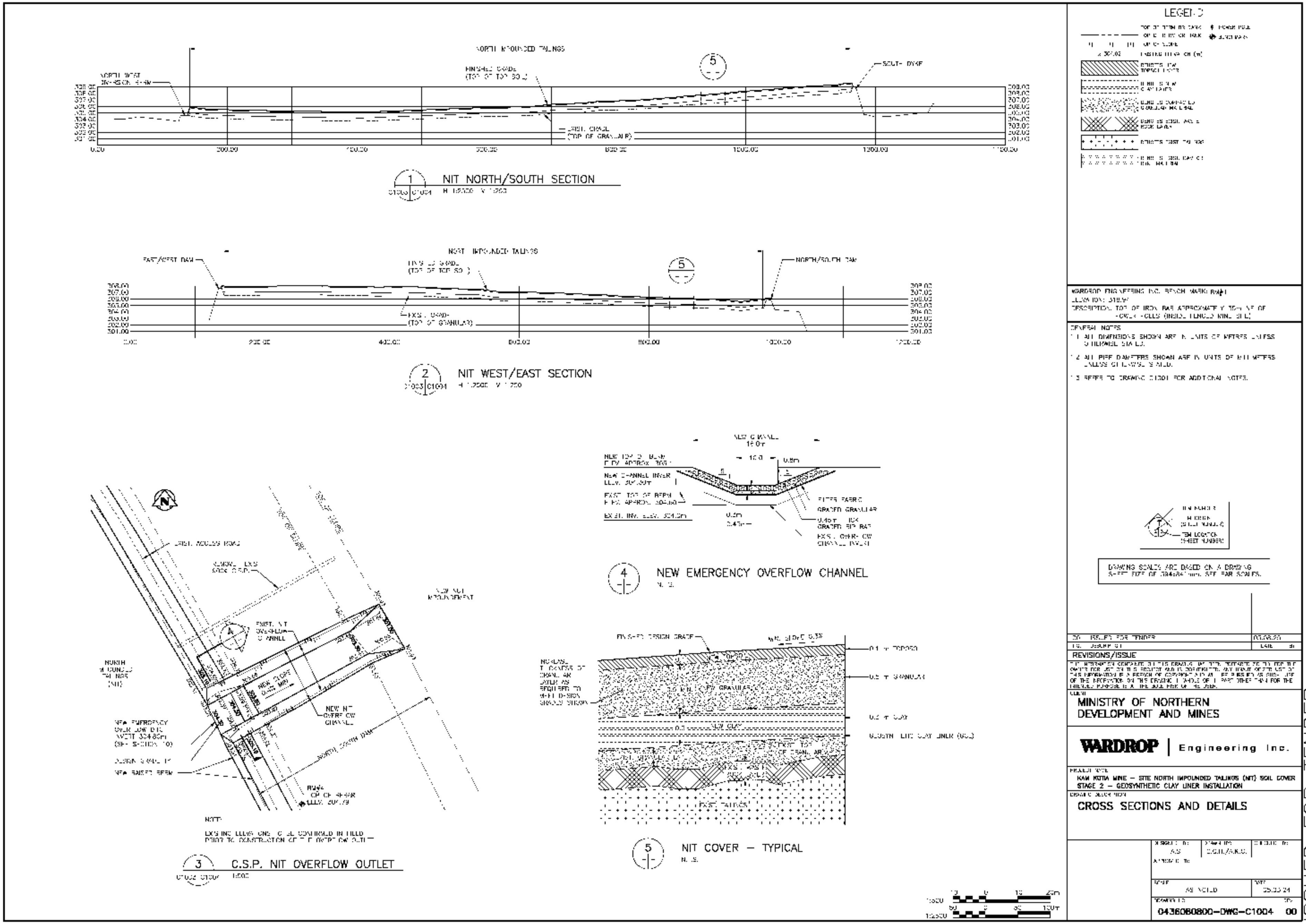
DESIGNED BY: A.S. | DRAWN BY: | CHECKED BY:
APPROVED BY:
DATE: 08.06.06
DRAWING NO. 0436060800–DWG–C1002 REV. 00

ISSUED FOR TENDER

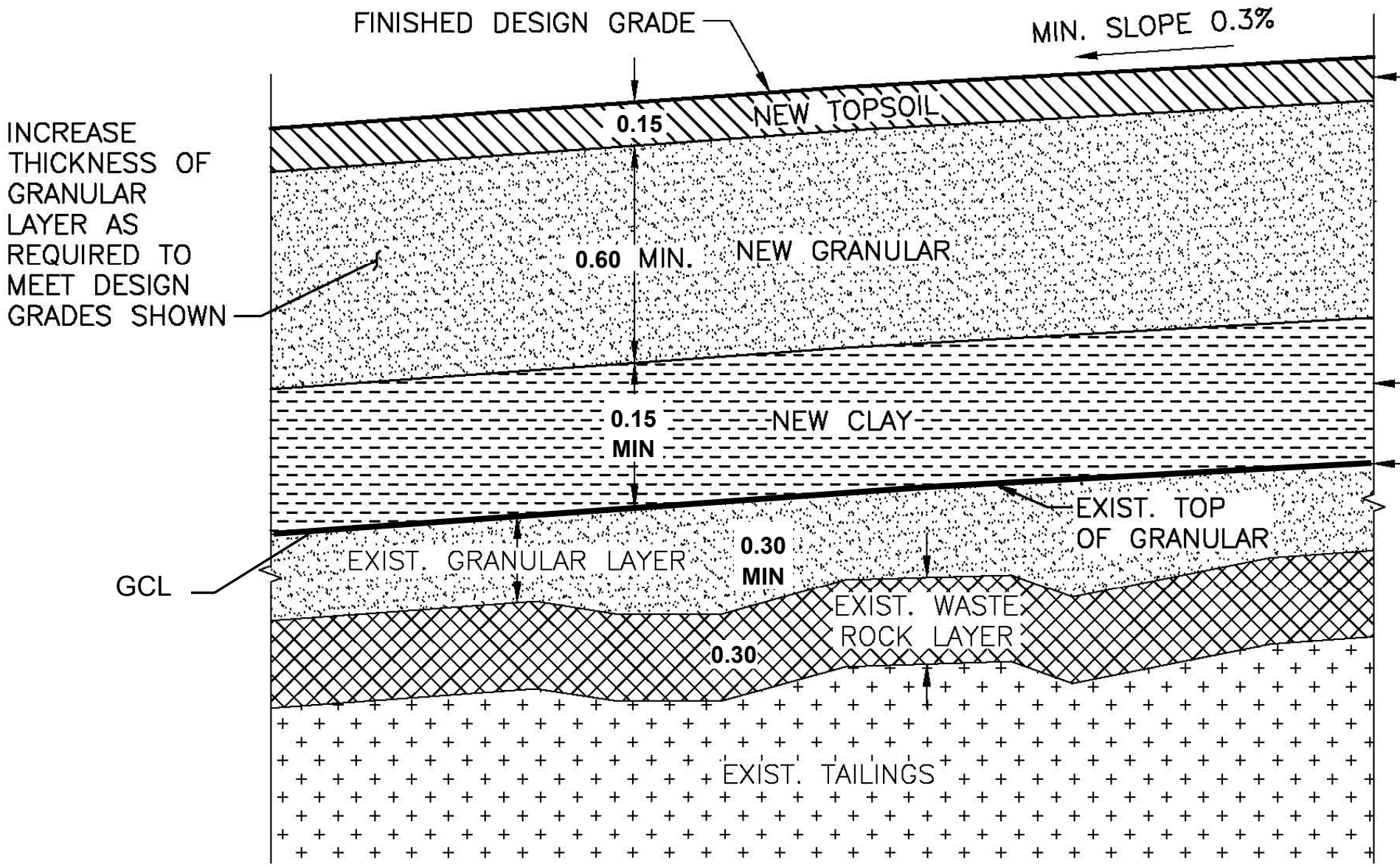
Final Grading Plan – Post-Liner Placement



Cross Sections and Details



Cover Design – Cross Section



Stage 1

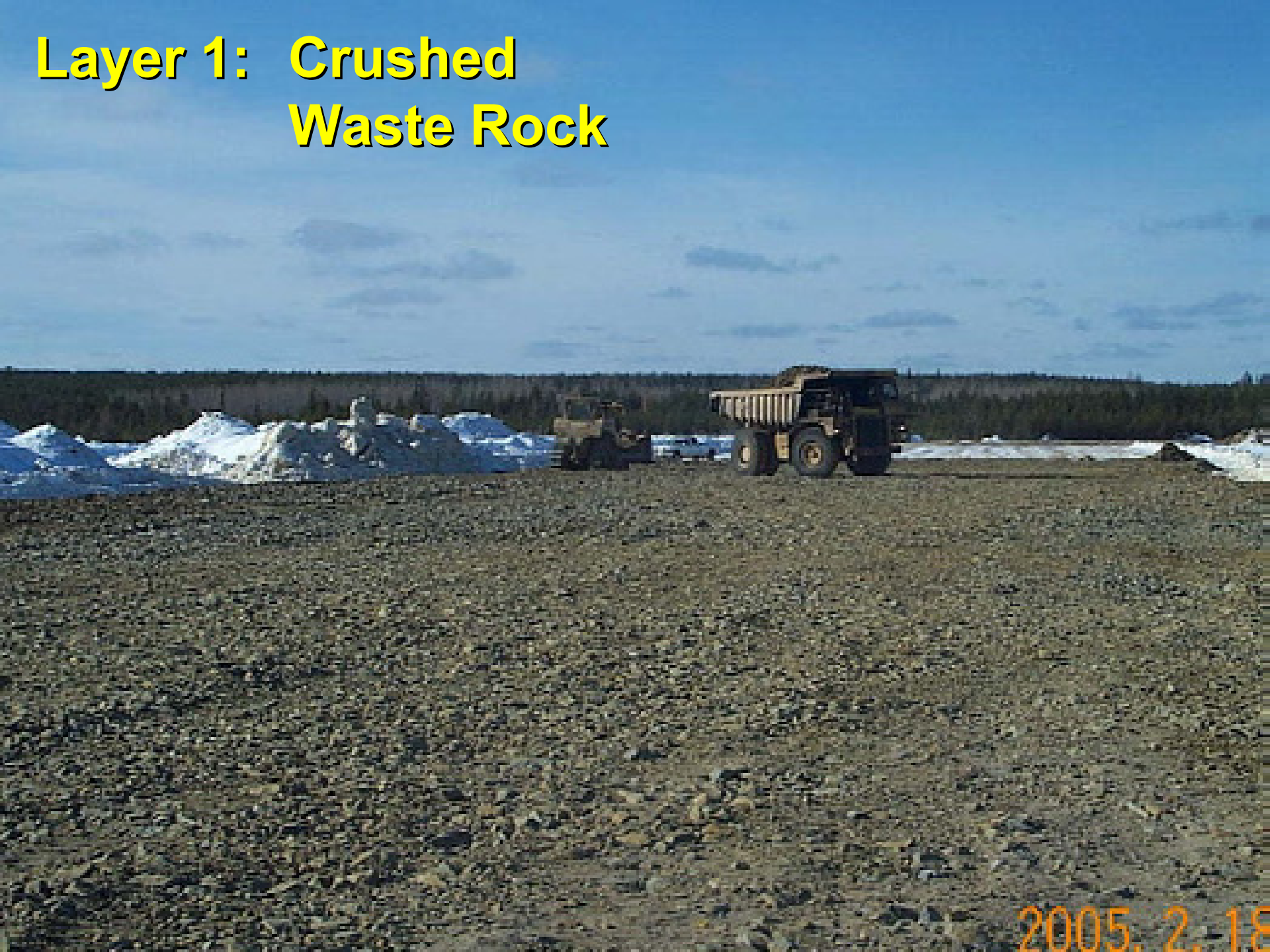
The Construction of the NIT Cover Capillary Break

Winter 2004/05

Layer 1: Crushed Waste Rock


Layer 1: Crushed
Waste Rock

Layer 1: Crushed Waste Rock



Layer 2: Granular B

Layer 2: Granular B

Stage 2

The Completion of the NIT Cover

2006 - 2008

GCL Specifications

Table 1 – GCL Physical Properties			
GEOTEXTILE PROPERTIES	**TEST METHOD**	**MINIMUM TEST FREQUENCY**	**VALUE**
Cap Non-woven Mass/Unit Area	ASTM D 5261	1/20,000 sq. m	200 g / m^2 MARV
Woven Scrim Mass/Unit Area *Polypropylene membrane applied to the woven fabric*	ASTM D 5261	1/20,000 sq. m	105 g / m^2 MARV
BENTONITE PROPERTIES			
Swell Index	ASTM D 5890	1/50,000 kg	24 ml / 2g min.
Moisture Content	ASTM D 4643	1/50,000 kg	12 % max.
Fluid Loss	ASTM D 5891	1/50,000 kg	18 ml max.
FINISHED GCL PROPERTIES			
Bentonite Mass Per Unit Area[1,2]	ASTM D 5993	1/4,000 m^2	3.66 kg / m^2 MARV
Grab Strength[3]	ASTM D 4632	1/4,000 m^2	422 N MARV
Grab Elongation[3]	ASTM D 4632	1/4,000 m^2	150 % Typical
Peel Strength[4]	ASTM D 4632	1/4,000 m^2	66 N
Permeability[5]	ASTM D 5084	1/10,000 m^2	5×10^{-10} cm/sec max 5×10^{-11} cm/sec E96
Index Flux[5]	ASTM D 5887	1/Week	5×10^{-11} m^3/m^2/sec
Internal Shear Strength[6]	ASTM D 6243	Periodic	24 kPa
DIMENSIONS			
Width x Length	nominal	Every Roll	4.7 x 45.72 m
Area per Roll	nominal	Every Roll	216 m^2
Packaged Weight	typical	Every Roll	980 kg

Layer 3: Surface Prep

Layer 3: GCL Arriving


Layer 3: GCL Stockpile

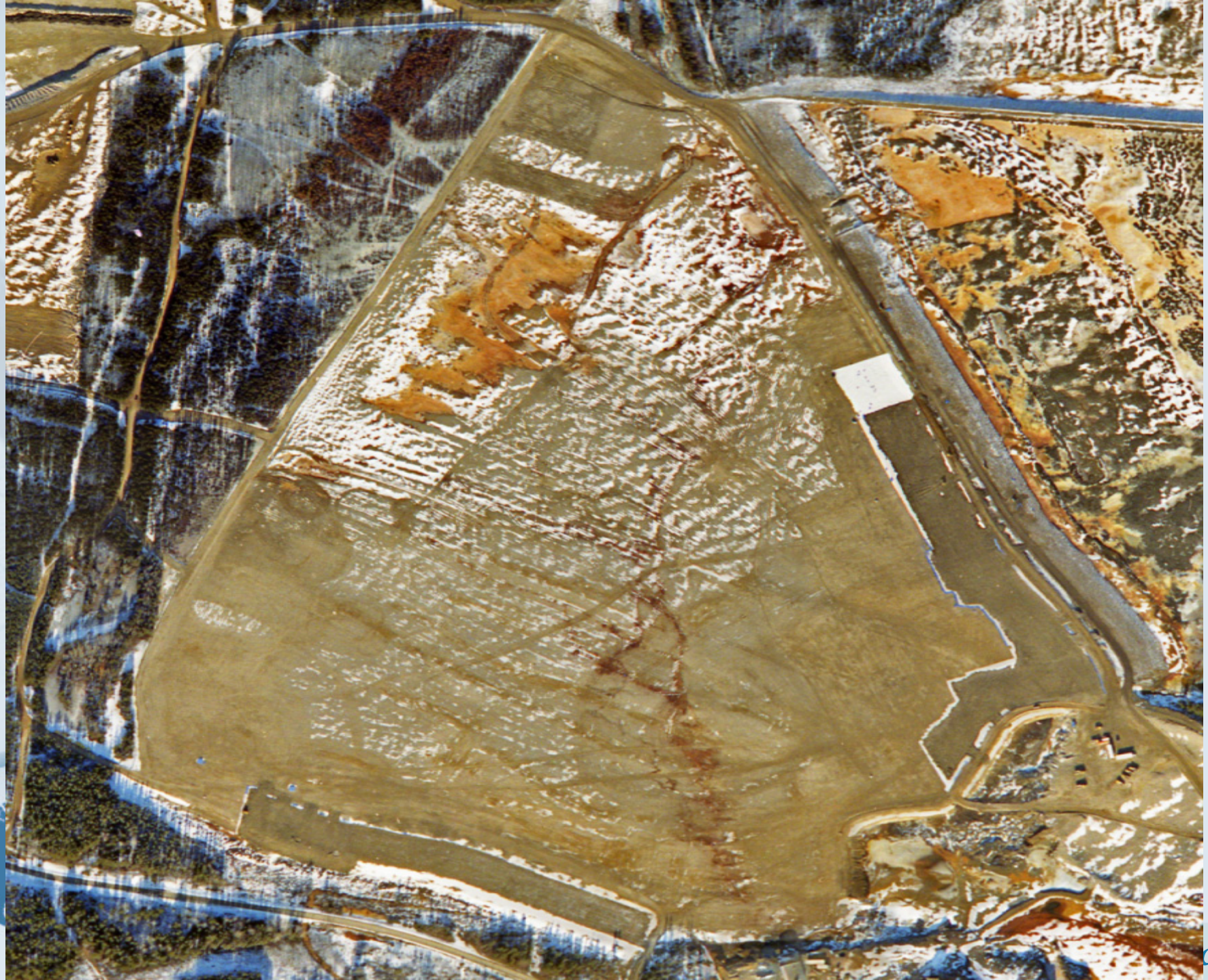
Layer 3: GCL Installation

Layer 3: GCL Installation

Layer 3: GCL Installation

Layer 4: Clay

Layer 4: Clay



Layer 5: Granular B

Layer 5: Granular B


Stockpiled Clay for
Slope Completion

Layer 6: Topsoil & Vegetation

Layer 6: Topsoil & Vegetation

Layer 6: Topsoil & Vegetation

The NIT area, 2001


June 2009

Conclusions

Construction Material Quantities

	Waste Rock (m^3)	Clay (m^3)	Granular (m^3)	GCL (m^2)
2005	268,000		300,000	
2006		92,864	129,149	775,888
2007		161,148	314,007	
2008			122,636	
TOTAL	**268,000**	**254,012**	**865,792**	**775,888**

The NIT Cover is comprised of:

- **almost 1.4 million m^3 of aggregate materials, and**
- **almost 78 hectares of GCL**

NIT Cover Issues and Resolutions

- Water management
  - Greater than predicted volumes of ground water,
    - Resulted in unexpected repair time and additional costs.

Water Issues

Water Issues

NIT Cover Issues and Resolutions

- Water management
  - Greater than predicted volumes of ground water,
    - Resulted in unexpected repair time and additional costs.
  - Relocation of Treatment Plant effluent discharge line,
    - Caused challenges for both the NIT Cover Project and the Treatment Plant operation.
    - Resulted in break-downs and additional costs.

Water Issues

NIT Cover Issues and Resolutions (cont'd)

- Complications in keying-in the slopes
  - Additional engineering needed,
    - Resulted in additional costs and time.

Keying-in the GCL edge

NIT Cover Issues and Resolutions (cont'd)

- Complications in keying-in the slopes
  - Additional engineering needed,
    - Resulted in additional costs and time.

- Access vs. seasonal conditions
  - Must carefully plan and sequence all components of project,
    - Otherwise delays and additional costs.

If you ever undertake a large, multi-phased project….

Ensure detailed communication between all of the Contractors and/or Consultants of the various work components and phases.

Thank You

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