Mining and Mineral Resources Division
Ministry of Energy and Mines

MOUNT POLLEY MINE

TAILINGS STORAGE FACILITY BREACH

August 4, 2014

AL HOFFMAN, P.Eng.
CHIEF INSPECTOR OF MINES

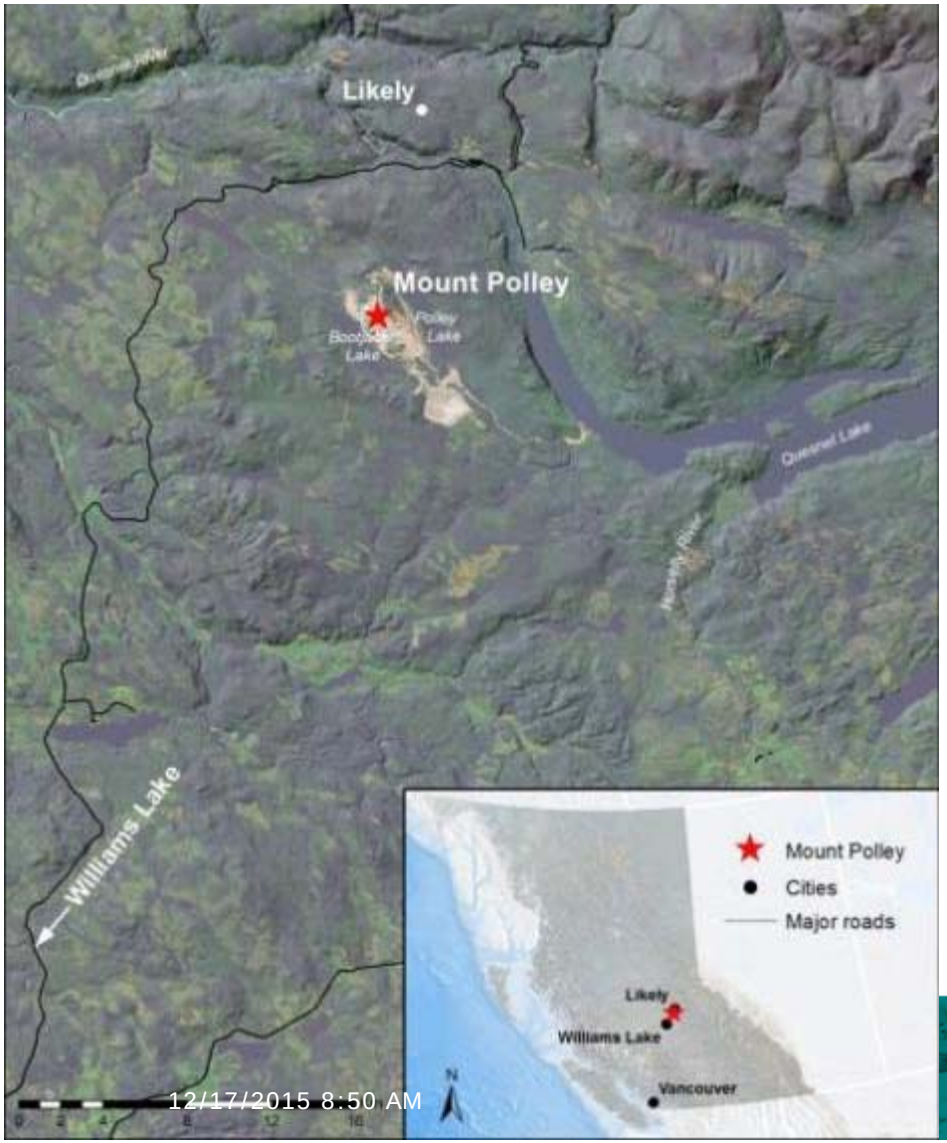
Investigation Report
of the Chief Inspector of Mines

Mount Polley Mine

Mount Polley Mining Corporation

subsidiary of

Imperial Metals Corporation




MOUNT POLLEY TAILINGS STORAGE FACILITY BREACH, AUGUST 4, 2014
BREACH AREA
PERIMETER EMBANKMENT
POLLEY LAKE
7KM TO QUESNEL LAKE
DEBRIS FIELD INTO
HAZELTINE CREEK

BRITISH COLUMBIA

Mining and Mineral Resources Division
Ministry of Energy and Mines

DEBRIS FIELD THOUGH HAZELTINE CREEK


QUESNEL LAKE

MOUNT POLLEY MINE
TAILINGS STORAGE FACILITY BREACH

CONCURRENT INVESTIGATIONS

BRITISH COLUMBIA
Mining and Mineral Resources Division
Ministry of Energy and Mines

Chief Inspector of Mines

- investigation as per Section 7 of the *Mines Act*

Conservation Officer Service (COS), BC Ministry of Environment and Federal Fisheries and Oceans Canada

- conducting joint investigation pursuant to:
  - *Environmental Management Act*
  - *Federal Fisheries Act*

The Independent Expert Engineering Panel

- issued report January 30, 2015

Chief Inspector of Mines Investigation Objectives:

Mining and Mineral Resources Division
Ministry of Energy and Mines

Determine:

- cause of the dam failure
- any contraventions of regulatory requirements
- orders pursuant to the *Mines Act and Code* as appropriate
- recommendations to prevent future occurrence
- if appropriate, a report to Crown Counsel for Crown's assessment of whether charges for contraventions pursuant to the *Mines Act*, should be laid.

CHIEF INSPECTOR OF MINES INVESTIGATION INCLUDED:

BRITISH COLUMBIA
Mining and Mineral Resources Division
Ministry of Energy and Mines

Largest, most complex in Mines Inspectorate history

- Adopted discipline of Major Case Management
- Review of documentation, for chronology of activities of mining company, engineering consultants and regulator
- ~100 interviews
- Geoforensic site investigations to determine *what* happened
  - "mechanism of failure"
- Root Cause Analysis to support *why* it happened, from NASA
  - "cause" of failure
- findings, lessons learned and recommendations

www.gov.bc.ca/mountpolleyinvestigation


BRITISH COLUMBIA
Mining and Mineral Resources Division
Ministry of Energy and Mines
MOUNT POLLEY MINE
TAILINGS STORAGE FACILITY BREACH
August 4, 2014
HARVEY MCLEOD, P.Eng. P.Geo.
KLOHN CRIPPEN BERGER LTD.
Investigation Report of the Chief Inspector of Mines

Chief Inspector of Mines Investigation
Geoforensic

Mining and Mineral Resources Division
Ministry of Energy and Mines

Comprehensive geotechnical investigation to support Expert Panel and Chief Inspector:

- Contracted Klohn Crippen Berger
- Comprehensive site investigation and drilling program to characterize the foundation
- Field mapping, geophysics, test pits and trenches
- In situ and laboratory strength testing
- Instrumentation

MOUNT POLLEY MINE
TAILINGS STORAGE FACILITY BREACH

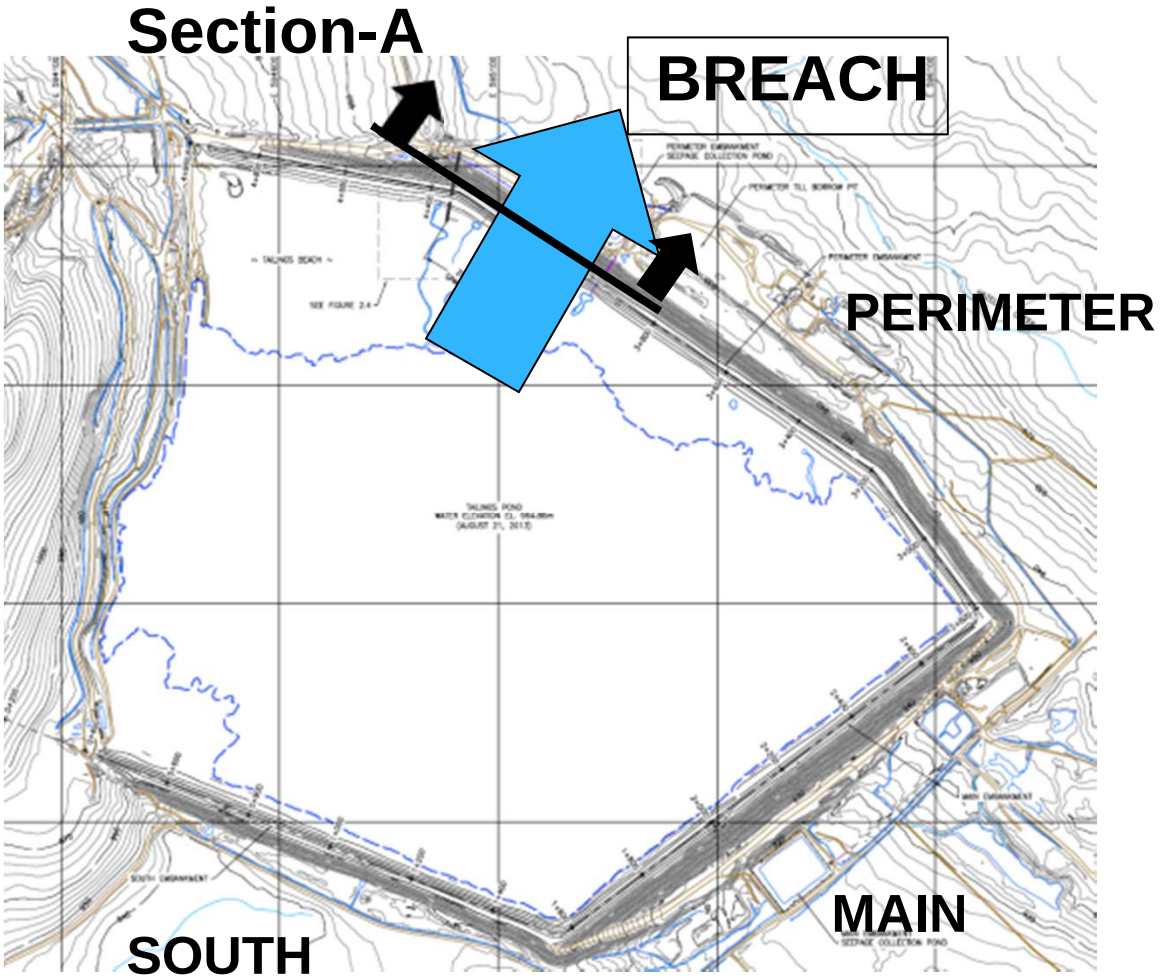
Chief Inspector of Mines Investigation

Mining and Mineral Resources Division
Ministry of Energy and Mines
British Columbia

Three embankments:

- 4 km length
- 40 m to 50 m high

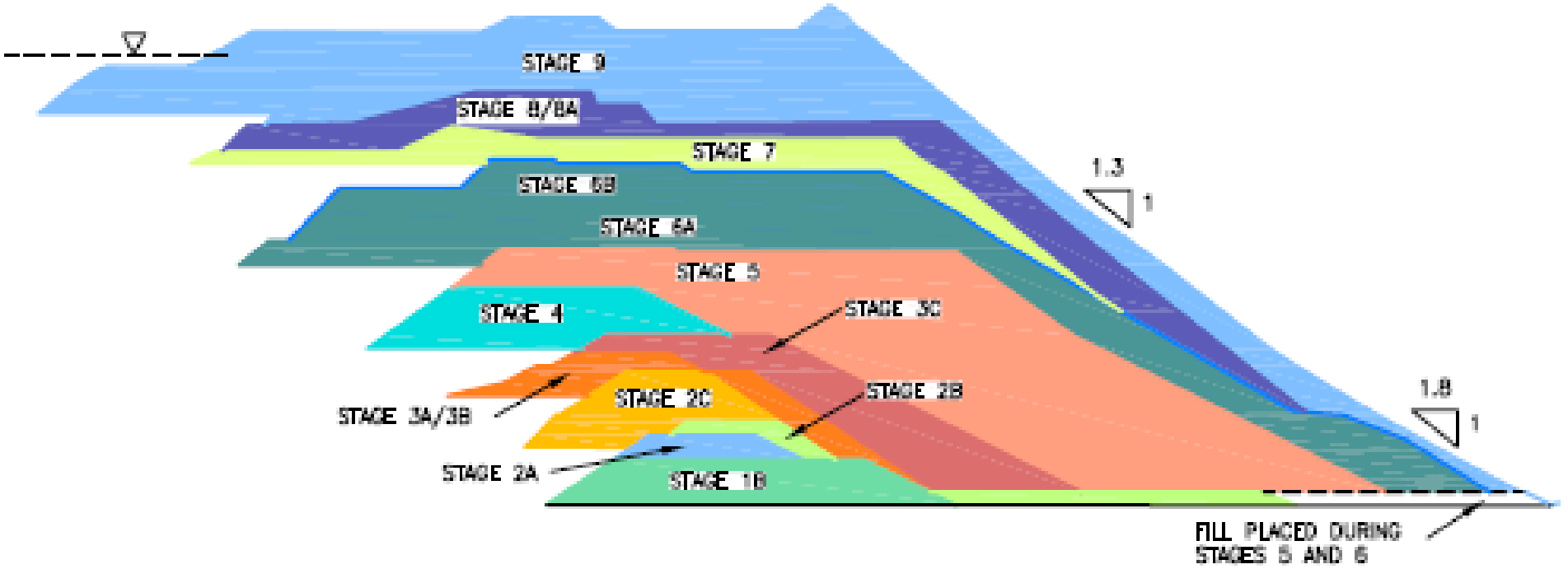
1. Assessed pre-breach knowledge;
2. Geoforensic investigation & analysis



PRE-BREACH GEOTECHNICAL UNDERSTANDING

Perimeter Embankment as-constructed condition

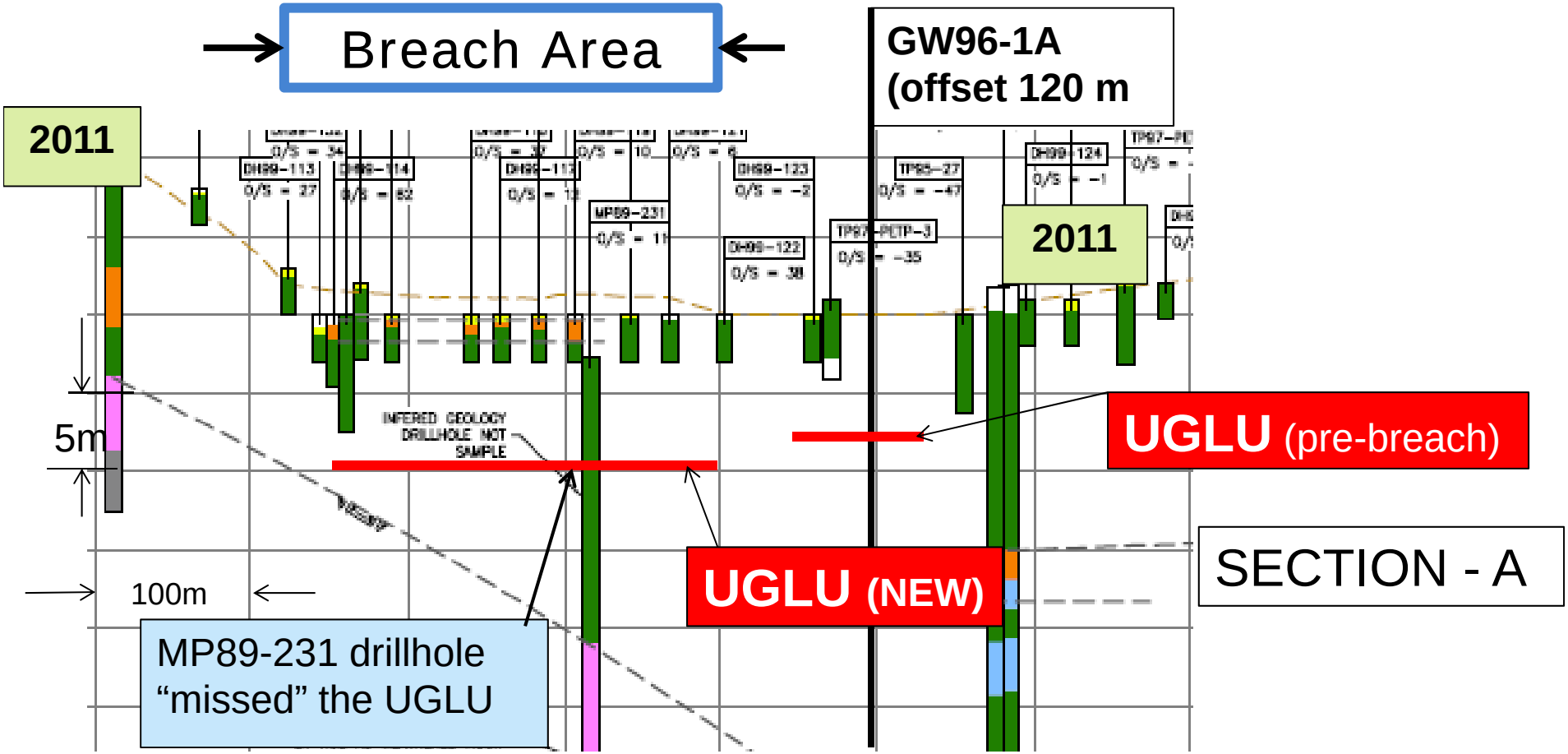
- Constructed in 9 stages (raises)
- Modified centerline dam with low permeability core zone, downstream rockfill with filters



PRE-BREACH STATE OF KNOWLEDGE

Mining and Mineral Resources Division
Ministry of Energy and Mines

Limited deep soil investigations did not identify the weak clay layer (UGLU) - complex geologic history

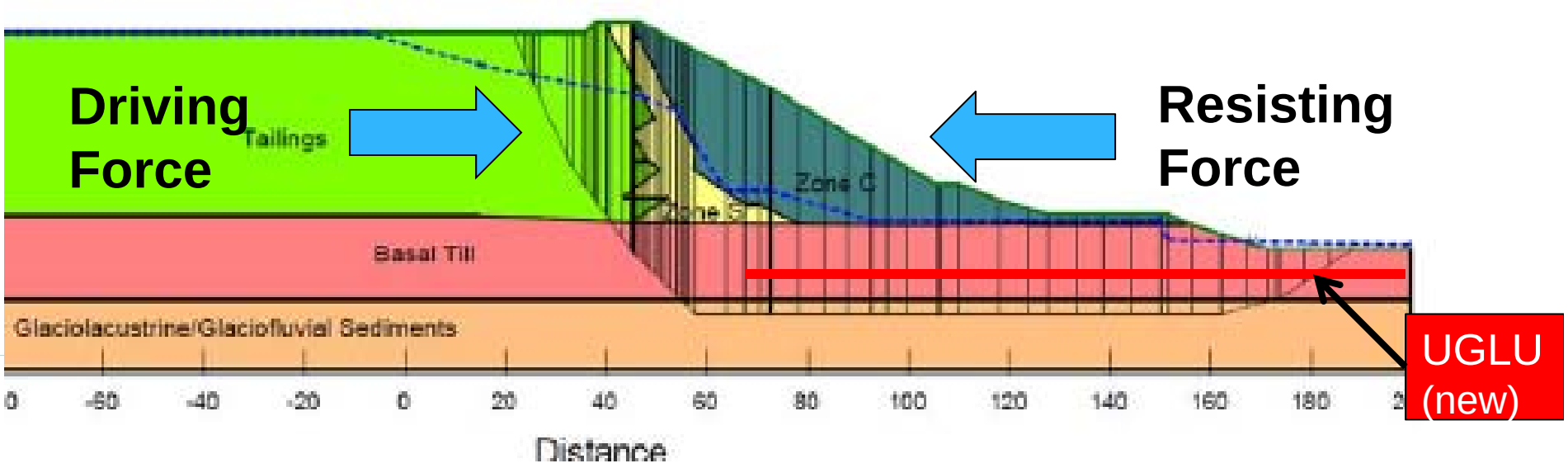


PRE-BREACH KNOWLEDGE

The soil foundation conditions did not include the UGLU.

- Purpose of stability analyses
- The expected Factor of Safety calculated for the stage 9 permit was 1.63

$$\textbf{Factor of Safety} = \frac{\text{Resisting Force}}{\text{Driving Force}}$$



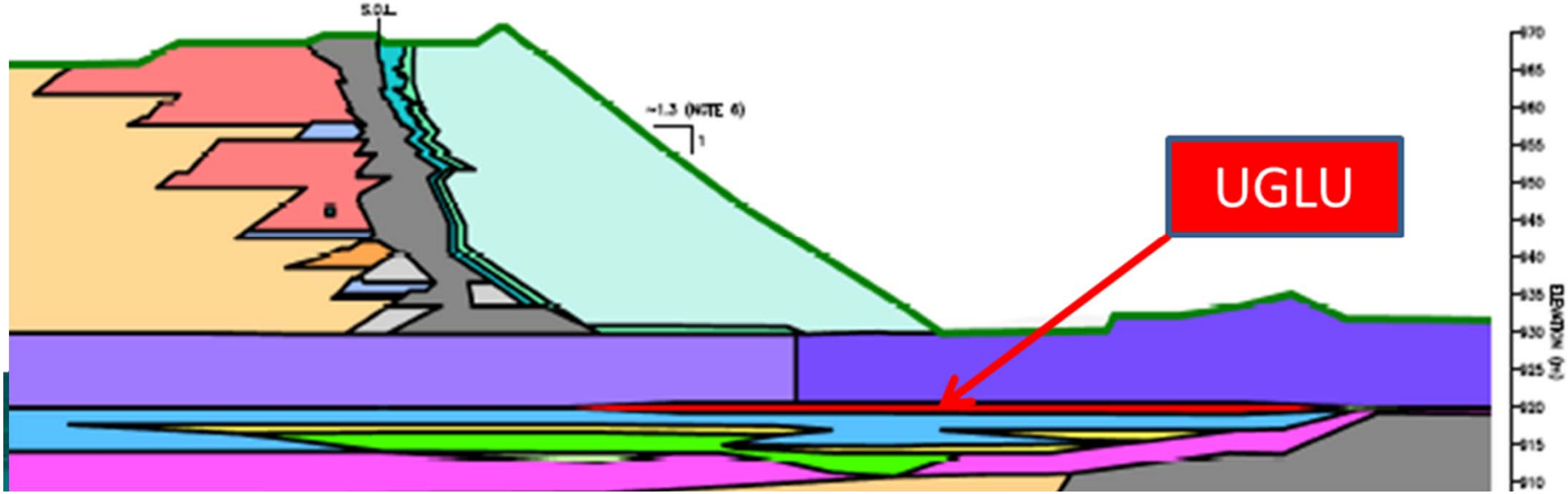
RESULTS: MECHANISM OF FAILURE

Mining and Mineral Resources Division
Ministry of Energy and Mines
BRITISH COLUMBIA

"WHAT HAPPENED"

Dam failed by sliding on foundation clay layer, glaciolacustrine in origin at 10 m depth (UGLU)

- Location was confirmed in area of breach
- 40 m high steep embankment subjected UGLU to stresses initiating progressive failure of dam
- Comprehensive analysis builds upon Expert Panel



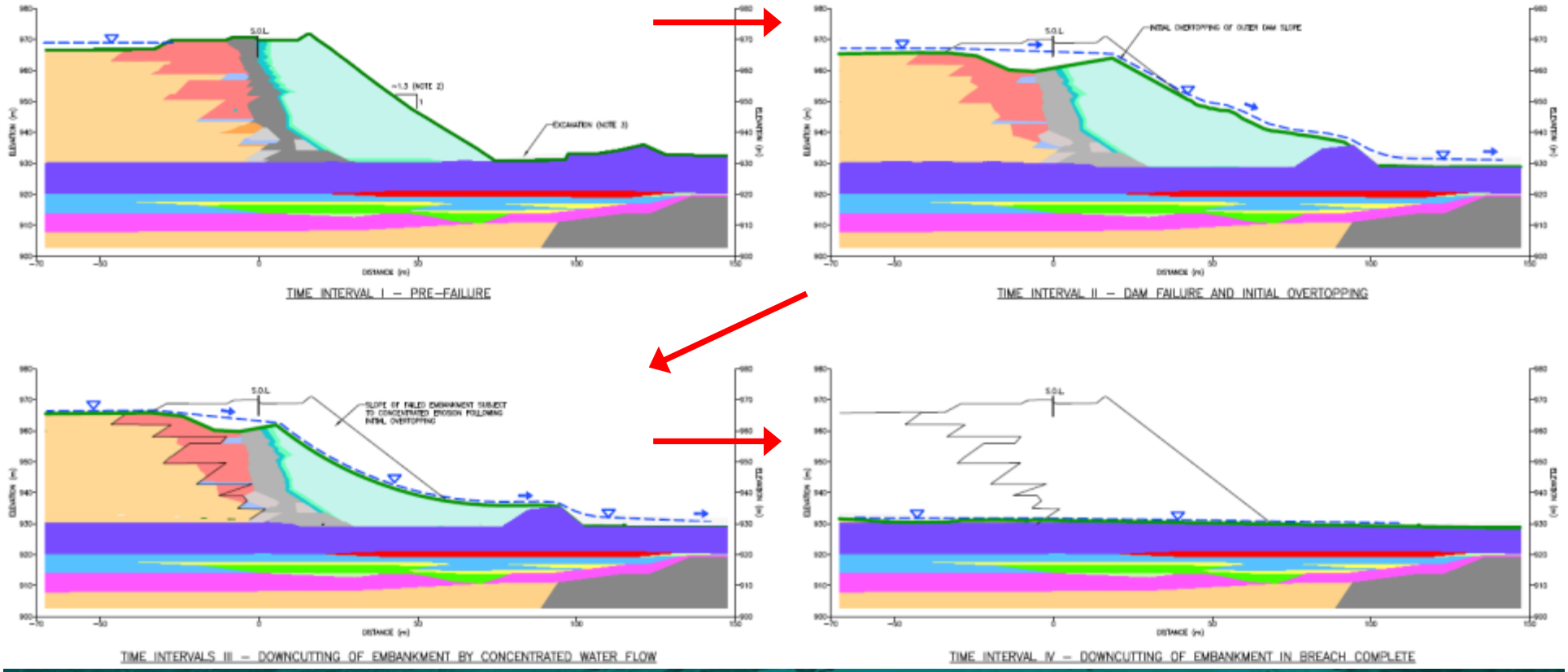
Undisturbed clay outside failed embankment area

Disturbed clay below failed embankment area

Failure Progression led to Breach

Mining and Mineral Resources Division
Ministry of Energy and Mines

Erosion followed the failure as the water overtopped the slumped crest of the embankment.



Conceptual Sequence of Dam Failure through Reconstructed Breach Section

CAUSE SUMMARY

Mining and Mineral Resources Division
Ministry of Energy and Mines
BRITISH COLUMBIA

THE DAM *FAILURE MECHANISM* WAS **GEOTECHNICAL**:

- sliding failure on a weak clay layer 10 m below the surface

Once the embankment failed,
THE DAM *BREACH MECHANISM* WAS **HYDROLOGIC**:

- Water flowed over the crest and eroded the dam
- insufficient beaches did not protect the embankment from the surplus of water once embankment failed

THE ROOT CAUSES OF THE EVENT WERE **ORGANIZATIONAL**:

- absent foundation investigation standards of practice
- mistaken belief in foundation conditions
- misplaced faith in Factor of Safety
- narrow planning perspective of mine management
- failure to adequately understand and act on risk

Report To Crown Counsel

There is not sufficient information to indicate a contravention of existing regulatory requirements

- A sub-excavation at the toe and the over-steepened slope were in general conformance with the design
- There were no regulatory requirements for foundation characterization and beach design parameters or surplus water

There will be no Report to Crown Counsel for Crown's assessment of whether charges for contraventions pursuant to the *Mines Act*, should be laid.

KEY RECOMMENDATIONS OF THE CHIEF INSPECTOR: – MINING OPERATOR AND INDUSTRY

Mine Dam Safety Manager

- qualified individual to anticipate, recognize and prevent conditions from developing that could impact safety of TSF.

Water Management

- qualified professional design and qualified individual to oversee water balance and water management plan to anticipate and oversee the mine's water balance and water management plan.

Independent Technical Review Board

- strengthen oversight and risk management

KEY RECOMMENDATIONS OF THE CHIEF INSPECTOR: -PROFESSIONAL ORGANIZATIONS

Professional Reliance Standards and Integration

The implementation of professional reliance is not adequately structured or formalized in policy

- APEGBC: foundation investigation, roles and responsibilities and transfer of EoR
- MAC: review of TSF management guidelines
- CDA: update to safety guidelines, roles, responsibilities

Then,

- MEM: Standards and guidelines to be considered and incorporated into the Code

Mining and Mineral Resources Division
Ministry of Energy and Mines

KEY RECOMMENDATIONS OF THE CHIEF INSPECTOR: -REGULATOR

Review of the Code

- Findings, lessons learned, recommendations and professional guidelines to be considered

Investigation, Compliance and Enforcement Review

- operational development and regulatory tools

Internal Records Management

- Records management system supports long-term, integrated decision making

Collaborative Education, Research & Development

- Both government and industry should support research and development efforts to improve current technologies

CONCLUSION

Findings and lessons learned confirm status quo no longer acceptable:

- complexities within mine operations need to be continuously anticipated, integrated and managed
- formalized policy, guidelines, and accountability is essential to design and management of tailing storage facilities

Continuous improvement by the mining industry, professional consultants and the Regulator will serve to meet the expectations of all British Columbians.

Mining and Mineral Resources Division
Ministry of Energy and Mines

Recommendations of the Chief Inspector:

19 recommendations, directed to:

- Mining Operator – MPMC
- Mining Industry
- Professional Organizations
- Regulator

.

For full report, visit:

www.gov.bc.ca/mountpolleyinvestigation