# Muskrat Falls Generation

## Independent Dam Safety Review and Audit

Audit #1 January 29 to February 2, 2017



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# Agenda

- Executive Summary
- General
- Review of Dam Safety Organization
- Assessment of Inspection and Reporting
- Assessment of Adequacy of Dam Safety Training
- Review of Emergency Preparedness Planning
- Operations Maintenance and Surveillance
- Review of Upstream Cofferdam Remedial Works Program
- Impoundment Planning – Cofferdams
- Audit of North Spur Dam Safety Response Program – Impoundment
- Inspection Frequency Audit
- Dam Safety Management Program Audit
- Site Visit Photos
- Conclusions and Next Steps



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# Executive Summary

- A dam safety audit of the Dam Safety Management Plan in place at the Muskrat Falls Construction Site was performed between January 29 and February 2, 2017
  - Based on observations made during the site visit and information obtained from Nalcor
- The audit included interviews with dam safety personnel and a review of dam safety related documents and plans
- The results of the audit indicate that;
  - the dam safety management program at the site meets and exceeds industry best practices;
  - the dam safety organization is appropriate and staff are experienced;
  - emergency preparedness planning and Operations and Maintenance procedures are in accordance with industry best practice;
  - the dam safety management program is in compliance with the CDA guiding principles;
  - the practices as witnessed are appropriate to reduce dam safety risks such that the probability of a significant dam safety incident are very low and that
  - there are areas of improvement suggested in this report that may further enhance the existing program.



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# Executive Summary

## ES-1 Results of Audit

| Item | Assessment | Remarks |
|---|---|---|
| Organization | Meets Industry best practices | Staff well experienced, all positions filled |
| Inspection and reporting | Exceeds Industry best practices | Extensive instrumentation, real time data collection and assessment |
| Training | Meets Industry best practices | All staff trained, annual updates, excellent training materials |
| Emergency preparedness | Meets Industry best practices | Well documented, dam break assessments performed, actual level 2 emergency response performed |
| Operations, Maintenance and Surveillance | Exceeds Industry best practices | Number, quality of instruments and surveillance frequency exceeds typical industry best practices |

# Executive Summary

## ES-1 Results of Audit (cont'd)

| Item | Assessment | Remarks |
|---|---|---|
| Upstream Cofferdam Remedial Program | Meets Industry best practices | Cofferdam instrumentation, monitoring and inspections sufficient to minimize risks while cofferdam is remediated |
| Impoundment preparedness and monitoring – Cofferdams | Exceeds Industry best practices | Number, quality of instruments and surveillance frequency exceeds typical industry best practices |
| Impoundment preparedness and monitoring – North Spur | Exceeds Industry best practices | Number, quality of instruments and surveillance frequency exceeds typical industry best practices |
| Inspection Frequency | Exceeds Industry best practices | Frequency of monitoring to el. 18 exceeds industry standards. Will be further enhanced with addition of continuous reading data loggers |
| Dam Safety Management Program | Meets Industry best practices | Compliant or generally compliant with all CDA dam safety guiding principles |

# Executive Summary

## ES-2 Areas for Improvement

| Item | Remarks |
|---|---|
| Organization | No Deficiencies<br>- Continue with plan to provide a dedicated dam safety engineer to the site |
| Inspection and reporting | No Deficiencies<br>- Implement plan to install additional data loggers |
| Training | No Material Deficiencies<br>- Documentation of training can be improved |
| Emergency preparedness | Minor Deficiencies<br>- Document contractors procedures meet program requirements<br>- Verify readiness of all third party stakeholders |
| Operations, Maintenance and Surveillance | Minor Deficiency<br>- Add dam safety personnel roles and responsibilities |
| Upstream Cofferdam Remedial Program | No Deficiencies |
| Impoundment preparedness and monitoring – Cofferdams | No Material Deficiencies<br>- Update alarm levels based on collected data and in line with EPP alert levels |



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# Executive Summary

## ES-2 Areas for Improvement

| Item | Remarks |
|---|---|
| Impoundment preparedness and monitoring – North Spur | No Material Deficiencies<br>- Update alarm levels based on collected data and in line with EPP alert levels<br>- Consider updating the 3D model when impounding commences |
| Inspection Frequency | No Deficiencies<br>- Continue with plan to increase monitoring frequency during impounding<br>- Install continuous reading data loggers as planned |
| Dam Safety Management Program | Generally Fully Compliant<br>- Documentation of training could be improved |

# Gaps

- No material gaps in the program that would constitute a dam safety problem were identified
- Issues that could be improved or clarified include:
  - Documentation of the rational for not undertaking data readings at the Kettle Lake Outlet Weir during the winter is missing
  - Written roles and responsibilities for dam safety personnel missing
  - Documentation of training in Emergency Preparedness and dam safety inspections not available

# General



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# General

- The objective of this presentation is to cover the results of a dam safety audit and overall review performed for the Muskrat Falls GS between January 29 – February 2, 2017
- Provides details of the audit
- Observations
- Potential areas for improvement



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# Scope of work

- This independent review involves an audit/assessment of all water retaining structures at the Muskrat Falls site
- Review includes
  - Audit of instrumentation
  - Monitoring
  - Surveillance
  - Operations and Maintenance
  - Emergency Preparedness
  - Public and worker safety
- Performed in accordance with Canadian Dam Association Guidelines (2013 revision)



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# Scope of Work - Permanent Structures

- South Dam
- Intake/Powerhouse
- Spillway
- North Dam
- North Spur
- Transition Dams
  - North
  - South
  - Centre
- Separation Wall



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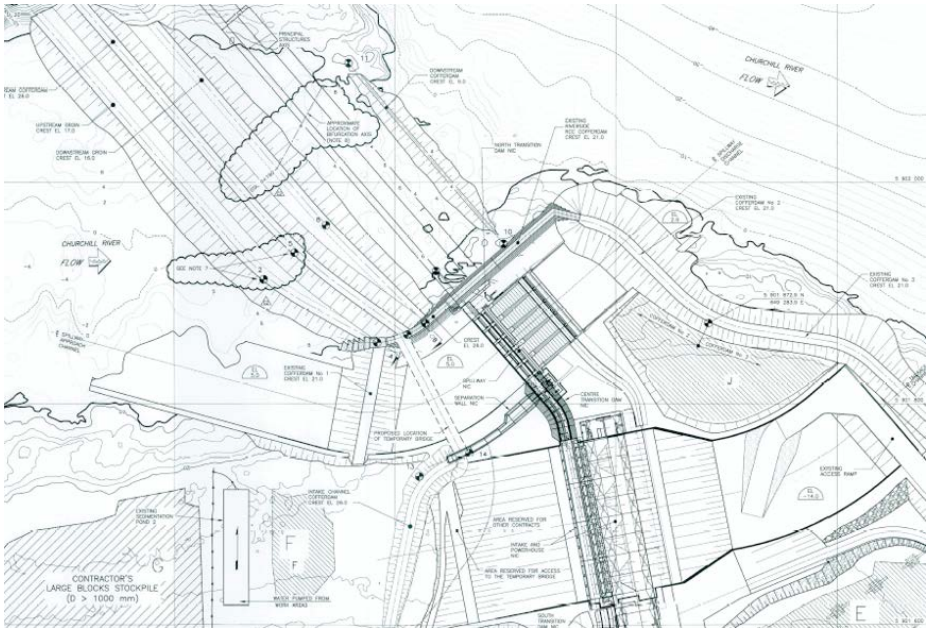
# Scope of Work - Temporary Structures

- Upstream Cofferdam
- Downstream Cofferdam
- Tailrace Cofferdam
- Intake Cofferdam
- RCC cofferdam



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# Audit Definitions

- Fully Compliant
- Materially Compliant
  - Minor issues such as documentation or demonstration of documentation needed for full compliance
- Materially Non-compliant
  - Minor issues not performed such as appropriate documentation or rational for decisions
- Non-compliant
  - Issue that might affect safety not demonstrated or in the plan



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# Auditor – C. Richard Donnelly

- Principal Consultant for Dams and Water Power
- Advanced Degree in Geotechnical Engineering
- Over 38 years experience in the design and construction of dams
  - Received two national engineering awards for dam design and construction
- Worked in 14 countries around the globe
- Recognized leader in the field of dam safety
  - Over 300 dam safety and condition assessments for individual dams and entire hydroelectric facilities
  - Assisted in update of the Canadian Dam Association 2007 Dam Safety Guidelines
  - Led the preparation of National Dam Safety Guidelines for Parks Canada
  - Serves on the Ontario Government's Lakes and River Improvement Act advisory panel
  - Assisted in the development of 2011 Ontario dam safety guidelines
  - Led development of dam safety standards and regulations for the National Utilities of El Salvador and Costa Rica
  - Currently developing national dam safety standards for Nepal as part of the nations reconstruction efforts
  - Received two national engineering awards for dam safety
  - Led development of a new Dam Safety Risk Screening tool which received the inaugural Innovation Award from the Ontario Waterpower Association
- Currently serving as the principal geotechnical consultant for the Keeyask GS
- Awarded the Professional Engineer's of Ontario's medal for excellence in engineering in 2013
- Published over 100 technical papers and received several awards for these articles



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# Design Review

- The review of the design of structures did not form part of this audit
  - Audit intended to review dam safety management processes at site
  - Designs performed by SNC-Lavalin (SLI) a well respected waterpower engineering company
  - Internal QA performed internally by SLI in accordance with industry best practice
  - Independent reviews of the designs performed by highly respected waterpower professionals from Hatch and the Independent Engineer



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# Organization



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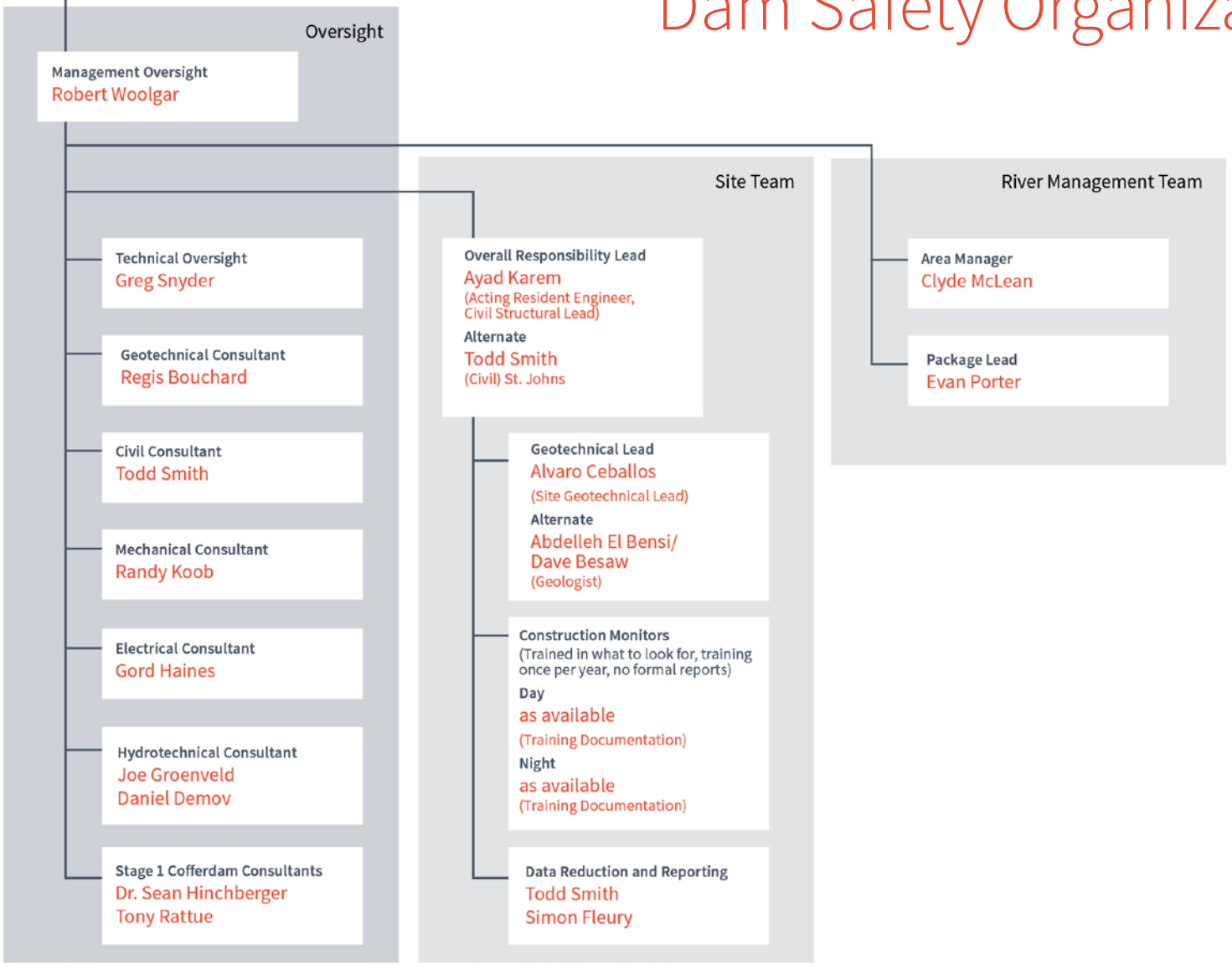
# Dam Safety Organization



# Comments on Organization

- Oversight team highly experienced. Data provided daily on cofferdam behavior
- Site team is well trained with appropriate experience
  - Experience in James Bay and other similar projects
- Data reduction and reporting appropriate and timely

# Reporting



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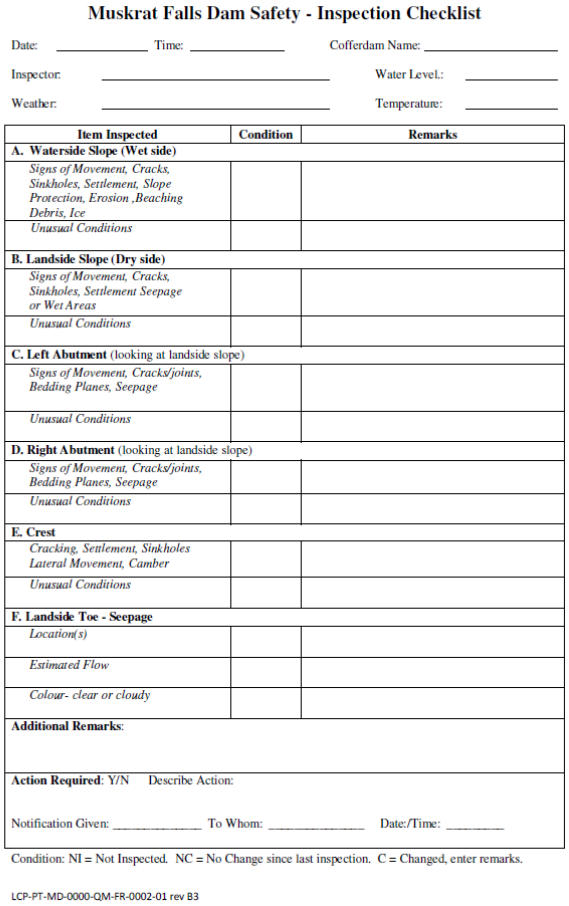
# Dam Safety Daily Inspection Form



**Muskrat Falls Dam Safety - Inspection Checklist**

Date: _____ Time: _____ Cofferdam Name: _____

Inspector: _____ Water Level.: _____

Weather: _____ Temperature: _____

| Item Inspected | Condition | Remarks |
|---|---|---|
| **A. Waterside Slope (Wet side)** | | |
| *Signs of Movement, Cracks, Sinkholes, Settlement, Slope Protection, Erosion ,Beaching Debris, Ice* | | |
| *Unusual Conditions* | | |
| **B. Landside Slope (Dry side)** | | |
| *Signs of Movement, Cracks, Sinkholes, Settlement Seepage or Wet Areas* | | |
| *Unusual Conditions* | | |
| **C. Left Abutment** (looking at landside slope) | | |
| *Signs of Movement, Cracks/joints, Bedding Planes, Seepage* | | |
| *Unusual Conditions* | | |
| **D. Right Abutment** (looking at landside slope) | | |
| *Signs of Movement, Cracks/joints, Bedding Planes, Seepage* | | |
| *Unusual Conditions* | | |
| **E. Crest** | | |
| *Cracking, Settlement, Sinkholes Lateral Movement, Camber* | | |
| *Unusual Conditions* | | |
| **F. Landside Toe - Seepage** | | |
| *Location(s)* | | |
| *Estimated Flow* | | |
| *Colour- clear or cloudy* | | |
| **Additional Remarks**: | | |
| **Action Required**: Y/N Describe Action: Notification Given: _____ To Whom: _____ Date:/Time: _____ | | |

Condition: NI = Not Inspected. NC = No Change since last inspection. C = Changed, enter remarks.

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- Simple, effective, collects the needed data in an efficient manner
- Information is collected at least once daily and processed in real time
- Meets and exceeds industry best practice for data collection, processing and interpretation



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# Review of current status of reporting

- Instrumentation, frequency of readings, compilation and assessment of data meet and exceed industry standards
- Meteorological station at the site provides accurate information needed for assessments exceeds industry best practices
- Potential enhancements to the reporting program include
  - Ensuring that photos are taken from the same point each time. Add plan showing the location of photo points to the inspection form
  - Indicate on form under remarks where other photos have been taken and why
  - In some cases specific comments on seepage missing. The comments might include seepage not observed, wet, flowing/estimate of flow, number of pumps and size working. It is recognized that this data is collected elsewhere but ongoing observations and reporting could be of value
  - Add in specific comments on fill to abutment contact condition, (wetness, seepage, not observed etc.)
  - Headpond/tailpond levels at the time of the visit should be noted
  - Overall the current data collection and reporting is considered to be in line with industry best practices and sufficient to ensure the safety of water retaining structures. The suggested enhancements would result in the program exceeding these standards.



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# Potential Enhancement - Other reports

- Monitoring and reporting practices are considered appropriate to identify any developing issues in a timely manner such that remedial action can be performed.
- Two additional reports are suggested
  - Weekly comprehensive inspection reports
    - should include summary of daily reports, seepage and piezometric data
  - Monthly evaluation reports
    - should include a review and assessment of all collected data, what the data means and recommended action



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# Dam Safety Training



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# Training

- Training overview provided and noted to be quite complete
  - As the project proceeds update the training presentation with Muskrat examples would be of value
- All dam safety staff are trained
  - New staff are trained as they come on board
  - Annual training refreshers performed
    - This should include lessons learned and workshop sessions to share experiences
- Documentation of training needed
  - This would involve a simple sign-up sheet to ensure training is being updated on an annual basis
  - Overall, it is considered that training in dam safety procedures and monitoring meets and exceeds industry best practices.



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# Emergency Preparedness Planning – Impounding Phase



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# Emergency Preparedness Plan (winter head pond construction phase)

- Updated December 2016
  - Should be updated by December 2017
- Inundation limits not entirely clear in EPP plan provided
  - The contrast between the flood and dam break inundation is not readily apparent. Suggest undertaking a review to determine if contrast can be improved
- Response coordinated by Emergency Operations Center
  - The set-up is appropriate and in accordance with industry best practice
- Well thought out but need to highlight the possibility for immediate action by resident engineer/contractor in the event of an emergency situation
- Dam break assessment performed winter head pond at el. 25 m and full supply at el. 39 m
  - Construction flood analysis exceeds industry standards and serves to further enhance public safety
  - Downstream public safety assessed by means of inundation mapping. At site, safe muster points defined, drills performed

# Operations Maintenance and Surveillance Program



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# Review of Operations, Maintenance and Surveillance Program and Practices

- Document complete
- Briefly reviewed during the visit
  - Appears to be in full compliance with CDA guidelines
  - Will be verified during the next audit
- Practices observed on site including inspection, reporting and flow control equipment operations to maintain and lower head pond levels met and exceed industry standards
- Overall the OMS plan as observed and as reported meet and exceed industry best practices.



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# Assessment of Winter Head pond Construction Phase Emergency Planning

- Advance preparations in place and are in accordance with industry best practices
- Instrumentation to monitor cofferdam and North Spur behavior exceeds industry best practices
- Monitoring frequency and reporting meet and exceed industry best practices

Overall the plans as observed and as reported meet and exceed industry best practices.

# Upstream Cofferdam Remedial Works Program



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# Upstream Cofferdam



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# Location of Cofferdam Instruments and Grout Holes

# Current Areas of Leakage

- Upstream/downstream cofferdams
  - Current levels of leakage in line with what would be expected for a cofferdam of this type
  - Remediation program underway to deal with increased leakage that occurred on first impoundment
  - Measures are appropriate and appear to be effective
- Intake cofferdam (very minor leakage)
- Separation wall (very minor leakage)
- RCC cofferdam (minor leakage)

# Review of Remedial Grouting Program

- Grouting is proceeding well and the results indicate it is effective
- Grouting results are collected daily and transmitted to the dam safety team for assessment
- Weekly (or as required) meetings held with the site and oversight teams to discuss results and plans for future grouting
- Grouting contractor, site team and oversight team highly experienced



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# Review of Remedial Grouting Program (cont'd)

- The remedial works program is well organized and well conceived
- The work appears to be rectifying the root cause of the issues that resulted in increased seepage and turbid discharges during the initial impounding
- Adequate instrumentation has been installed to monitor cofferdam response
- The instruments are read and evaluated on a timely basis
- The reservoir level can be held or reduced if instrumentation anomalies are observed
- The cofferdam design is robust such that catastrophic failure of the structure would not be expected
- The upstream cofferdam is safe for continued impoundment following the established protocols.

# Impounding Planning - Cofferdams



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# Impoundment Planning - Audit

| Item | Complete (y/n) | Comments |
|---|---|---|
| General | | |
| Cofferdam Grouting Review | Y | ongoing |
| Gate Body/Guide heaters complete | Y | |
| Gate De-Icing Crews ready | Y | |
| Stage 1 requirements (to el. 18) | | |
| Impound 0.5 m per day and hold | Y | Duration of hold based on instrumentation and ice surveys |
| Repeat to el. 18 m | Y | ongoing |
| Gate 1 locked fully open for ice passage | Y | |
| Stage 2 requirements (to el. 21.5) | | |
| Impound 0.5 m per day and hold | NA | Review of alert levels needed based on performance. Duration of hold based on instrumentation and ice surveys |
| Helicopter ice survey for border ice release | NA | |
| Gate 1 locked fully open for ice passage | NA | |
| Stage 3 requirements (hold at el 25) | | |
| Not yet defined | NA | This will be defined on the basis of observations made during impounding |
| Helicopter ice survey for border ice release | NA | |
| Gate 1 locked fully open for ice passage | NA | |

Impoundment Planning is adequate and program is in full compliance.



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# Cofferdam Inspection Protocols - Audit





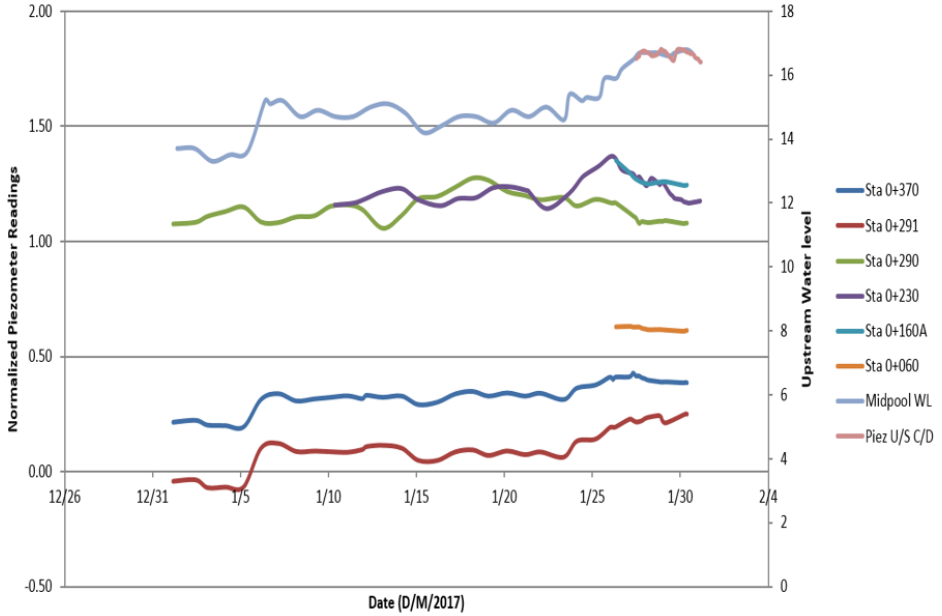
| Item | Remarks |
|---|---|
| Organization | No deficiencies<br>- continue with plan to provide a dedicated dam safety engineer to the site |
| Inspection and reporting | No deficiencies<br>- continue with plan to install additional data loggers (divers) |
| Training | No material deficiencies<br>- documentation of training can be improved |
| Emergency preparedness | Minor deficiencies.<br>- Document contractors procedures to meet program requirements<br>- Verify readiness of all third party stakeholders<br>- Improve contrast of inundation mapping |
| Operations, Maintenance and Surveillance | Minor deficiency<br>- add dam safety personnel roles and responsibilities |
| Upstream Cofferdam Remedial Program | No material deficiencies<br>- review frequency requirements and document |
| Impoundment preparedness and monitoring – Cofferdams | No Deficiencies<br>- alarm levels to be aligned with EPP alert levels |
| Impoundment preparedness and monitoring – North Spur | Minor deficiencies<br>- establish alarm levels in line with the EPP<br>- consider updating the 3D model when impounding has been completed to winter head pond level |
| Inspection Frequency | No deficiencies<br>- install continuous reading data loggers as is planned |
| Dam Safety Management Program | Minor deficiency<br>- Documentation of training could be improved |

# Comments on Cofferdam Inspection and Monitoring Protocols

- The program exceeds industry best practices and ongoing work at site is in full compliance with the exception of seepage monitoring
  - The plan calls for 12 measurements daily. Generally 10 to 12 measurements are taken. This needs review
  - This is considered to be acceptable in the period up to el. 18 m where the headpond can be reduced in an hour or less
  - Above el 18, frequency should be reviewed/divers installed
  - After full impoundment level is achieved and the cofferdam reaches steady state the frequency of readings can be re-assessed
- The currently defined alarm levels are adequate but, given the availability of increased data, should be reviewed

# Review of Alert Levels
# Actual Piezometric Response

- Actual piezometric response complex, affected by rising headwater



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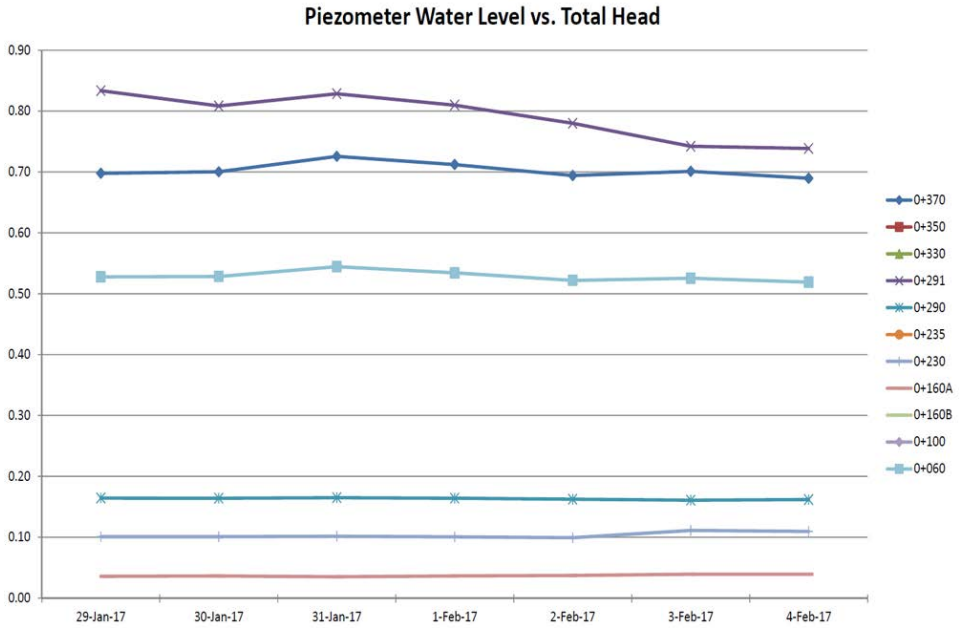
# Review of Alert Levels Normalized Upstream Cofferdam Piezometric Response

- Normalized piezometric response accounts for influence of reservoir rise on response
- Can be used to set alert levels
- P 291 is not responding to headpond
  - Consider replacement



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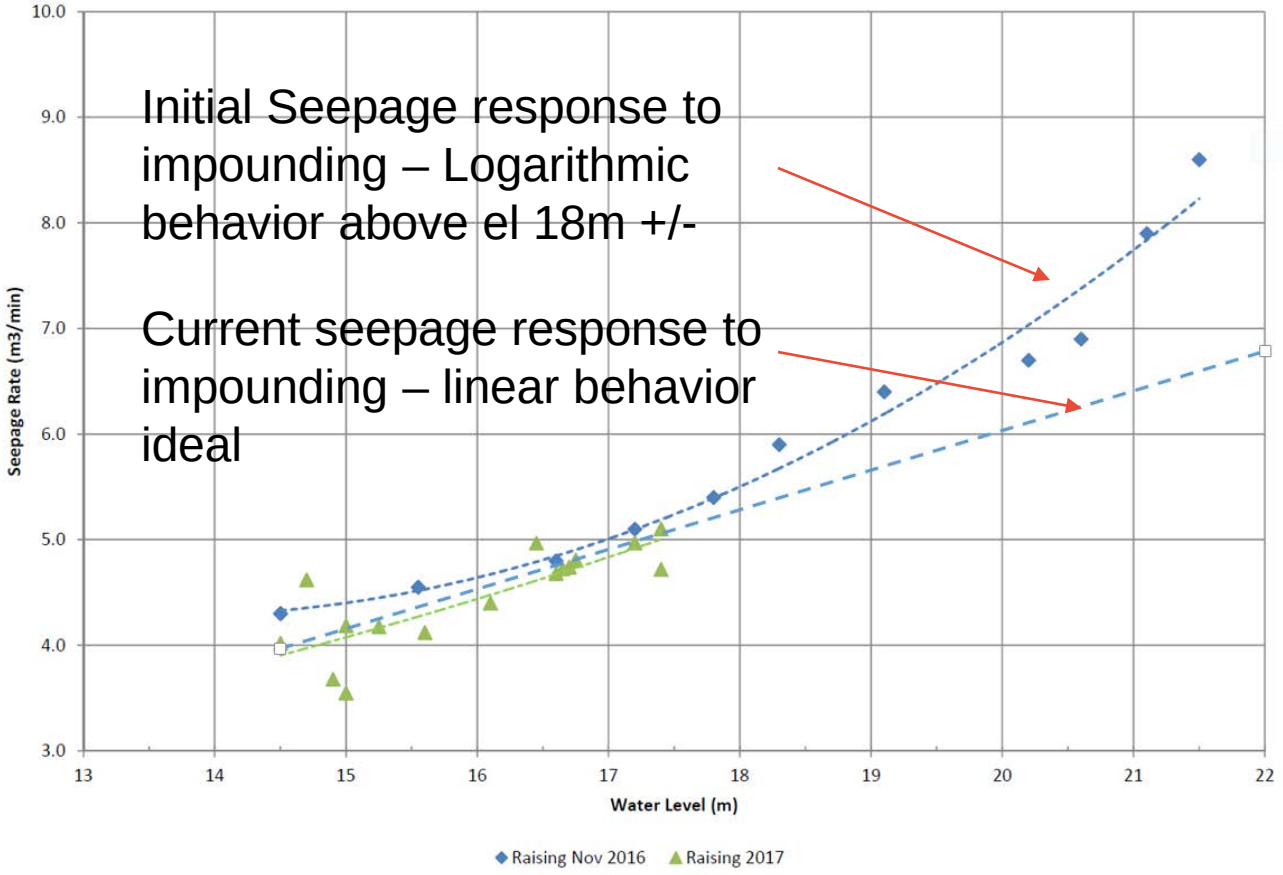
# Review of Alert Levels - Seepage

- Comparison of initial impending and post remedial work seepage rates can be used to define alarm levels



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# Comments on Alert Levels

- Current levels are appropriate up to about el 20
- Above that alert levels should be defined on the basis of deviations from observed trends in seepage and piezometric response to headpond
- Alert levels should be aligned with EPP alert levels (level 1, 2 and 3)
  - Appropriate criteria for each level should be defined and documented
  - Alert levels should be posted

# Ready for Impoundment - Checklist

| Item | Status |
|---|---|
| Midpool Preparation Sign-offs | Completed |
| Dam Safety Inspections | |
| Upstream cofferdam | Completed |
| North Spur | Completed |
| Intake Cofferdam | Completed |
| Spillway | Completed |
| Mid Pool Level Measurements | Completed |
| Seepage Measurements | Completed |
| Tailwater Level Measurements | Completed |
| Instruments | |
| All instruments read | Completed |
| Review by engineering | Completed |
| Inspection/pronto forms prepared and uploaded to Aconex daily | Completed |
| DSP on impoundment readiness to el. 18 m | Completed |



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# North Spur Instrumentation and Impounding Planning



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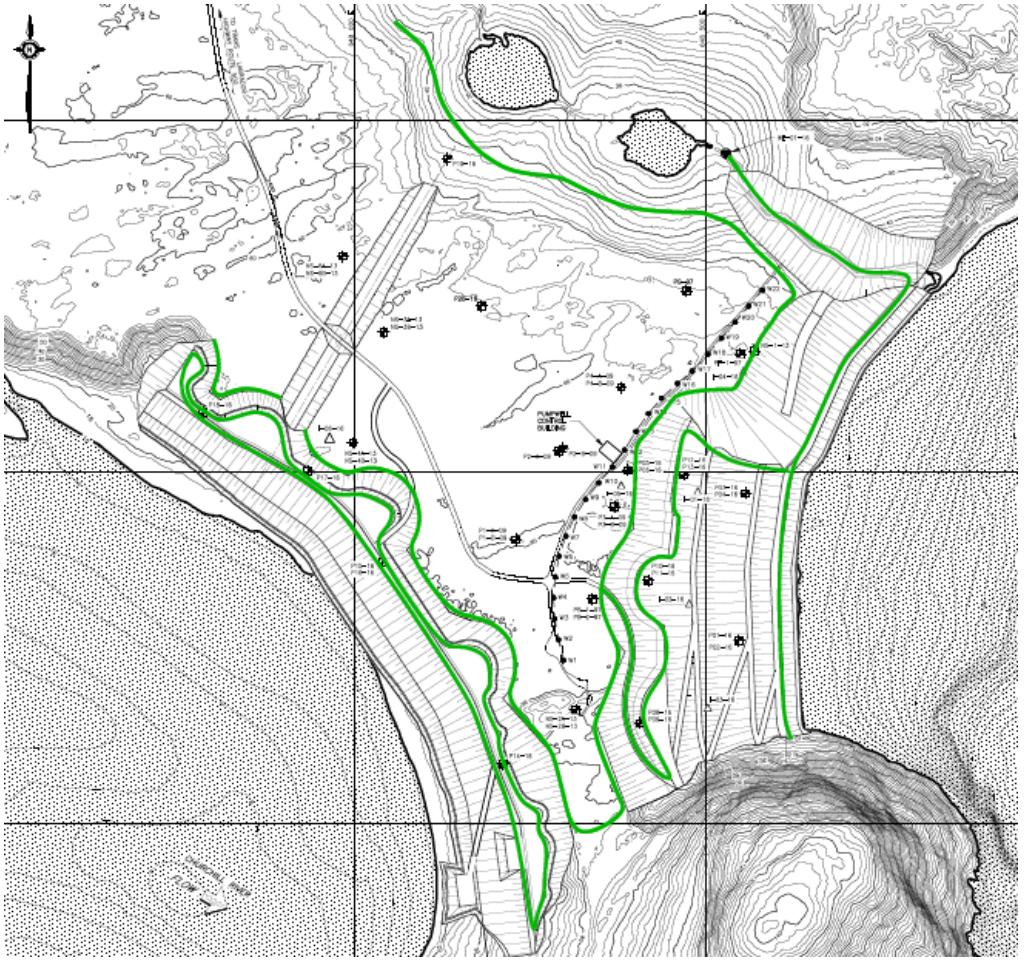
# North Spur

## General Arrangement and location of Instrumentation

- 40 piezometers
  - 3 in lower aquifer
  - 7 upstream
  - 6 NW cow
  - 24 downstream
- 6 inclinometers
  - 5 downstream
  - 1 upstream
- 1 flow meter
  - Kettle lake outlet





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# North Spur
## Review of Pre-impoundment (above el 18) Plan



| | |
|---|---|
| **Piezometers** | |
| In place and connected to ADAS (automatic Data Acquisition System) | complete |
| LCP access to data available | complete |
| Remote access to data (from south side) finalized | complete |
| **Inclinometer** | |
| Baseline inclinometer readings established | complete |
| **Kettle Lake Outlet Weir** | |
| automatic data collection complete | Note 1 |
| **Visual Observation** | |
| Inspection "Path“ developed for regular visual observation | complete |
| Photo points established. | complete |
| **Instrumentation** | |
| Spillway Operators read instruments as part of their routine | complete |
| Immediate transfer/copy for engineering to review/assess/action being performed | complete |
| Information issued in Aconex | complete |

Note 1: Access for readings not available during the winter due to lack of access for battery recharge battery.
Site staff noted that winter readings in this area not required. Documentation of rational for this or a solar panel to recharge batteries installed

# Inspection Frequency Audit



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# Inspection Frequency Audit

| Site | Information | Action | Frequency | |
|---|---|---|---|---|
| | | | Before impoundment | During impoundment |
| North Spur | Ground water pressure piezometer | Download ADAS | 1/week | 1/day Note 4 |
| | Inclinometer | Reading | Baseline | 1/week |
| | Weir, seepage | Reading or visual | 1/week note 2 | 1/day |
| | Visual inspection | Walk Obs. Path | Once for Baseline | 1/day |
| Reservoir | Visual inspection | Helicopter flight | Once for Baseline | 1/week |
| | Middle pool level | Borehole WL (USCD) | Manual: 1/ day | Manual 2/day |
| | Downstream level | Borehole WL (DSCD) | Manual: 1/ day | Manual 2/day |
| | Reading | Download Diver | 1/day | 1/day |
| U/S Cofferdam | Visual inspection | Walk Obs. Path | 1/day | 2/day |
| | Seepage | Reading | 1/day | 12/day note 1 |
| | Crest deformation | Not accessible | note 3 | note 3 |
| | Berm deformation | Survey | 1/day | 1/day |
| | Piezometer | Reading | 1/day | 12/day note 1 |
| | Reading | Download Diver | 1/day | 1/day |

Note 1: Actual is 10 to 12 per day. Should be increased to planned amount when impounding above 18 m

Note 2: Rational for not taking readings at the Kettle Lake Outlet Weir not provided

Note 3: Visual assessments of crest deformations is performed on a daily basis

Note 4: Impounding of the North Spur has not commenced



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# Inspection Frequency Audit (cont'd)

| Site | Information | Action | Frequency | |
|---|---|---|---|---|
| | | | Before impoundment | During impoundment |
| **D/S Cofferdam** | Visual inspection | Walk Obs. Path | 1/day | 2/day |
| | Seepage | Reading | 1/day | 12/day note 1 |
| **U/S Intake Cofferdam** | Visual inspection | Walk Obs. Path | 1/week | 1/day |
| | Seepage | Observation | 1/week | 1/day |
| **Tailrace Cofferdam** | Visual inspection | Walk Obs. Path | 1/week | 1/day |
| | Seepage | Observation | 1/week | 1/day |
| **RCC Cofferdam** | Visual inspection | Walk Obs. Path | 1/week | 1/day |
| | Seepage | Observation | 1/week | 1/day |
| **Separation Wall** | Visual inspection | Walk Obs. Path | 1/week | 1/day |
| | Seepage | Observation | 1/week | 1/day |
| **Spillway** | Ground water pressure piezometer | Download ADAS | 1/week | 1/day |
| | Survey monument | Survey | Once for Baseline | 1 at WL ele 18m |
| | Visual inspection | Observation points | 1/day | 1/day |
| **Power House** | Ground water pressure piezometer | Manual reading | Once for Baseline | 1/day |
| **Weather information** | Visual inspection | Walk Obs. Path | 1/week | 1/day |
| | Seepage | Reading (?) | 1/day | 1/day |
| | Temperature, Rain, Snow | From weather station | 1/day | 1/day |



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# Overall Dam Safety Management Audit



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# CDA Guiding Principles
# Principle 1 – Dam Safety Management

| Principle | Description | Compliance |
|---|---|---|
| 1 | Dam Safety Management | Generally Compliant – Document defining responsibilities |
| 1a | The public and the environment shall be protected from the effects of dam failure, as well as release of any or all of the retained fluids behind a dam, such that the risks are kept as low as reasonably practicable | Compliant<br><br>Inundation mapping, monitoring , trained personnel, adequate instrumentation |
| 1b | The standard of care to be exercised in the management of dam safety shall be commensurate with the consequences of dam failure. | Compliant<br><br>Cofferdam designed in accordance with requirements for a temporary structure, consequences known. EPP in place. Gates have sirens in the event of gate opening.<br><br>Emergency preparedness plan (Level 2) has been exercised |
| 1c | Due diligence shall be exercised at all stages of a dam's life cycle. | Compliant<br><br>Current plans meet and exceed industry best practice |
| 1d | A dam safety management system, incorporating policies, responsibilities, plans and procedures, documentation, training, and review and correction of deficiencies and non-conformances, shall be in place. | Generally Compliant<br><br>Correction of deficiencies performed, Plans and schedules in place, Training in monitoring and surveillance<br><br>Minor deficiency – roles and responsibilities for dam safety personnel need to be defined in the OMS Manual |

# Public Safety Around Dams

- Document exists, not thoroughly reviewed during this audit



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# CDA Guiding Principles
## Principle 2 – Operation, Maintenance, and Surveillance

| Principle | Description | Compliance |
|---|---|---|
| 2 | Operation, Maintenance, and Surveillance | Compliant |
| 2a | Requirements for the safe operation, maintenance, and surveillance of the dam shall be developed and documented with sufficient information in accordance with the impacts of operation and the consequences of dam failure. | Compliant<br><br>Plans, instrumentation, and monitoring exceed industry best practices |
| 2b | Documented operating procedures for the dam and flow control equipment under normal, unusual, and emergency conditions shall be followed | Compliant<br><br>Vista used as operating system, unusual conditions covered in OMS manual. Manual will be reviewed in next audit |
| 2c | Documented maintenance procedures shall be followed to ensure that the dam remains in a safe and operational condition. | Compliant<br><br>Plan in place and training that meets or exceeds industry best practices. Need to review OMS manual during next audit |
| 2d | Documented surveillance procedures shall be followed to provide early identification and to allow for timely mitigation of conditions that might affect dam safety. | Compliant<br><br>Surveillance procedures well documented and extensive monitoring in place |



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# CDA Guiding Principles
## Principle 3 – Emergency Preparedness

| Principle | Description | Compliance |
|---|---|---|
| 3 | Emergency Preparedness | Generally Compliant - training and engagement of stakeholders to be completed and documented |
| 3a | An effective emergency management process shall be in place for the dam. | **Compliant**<br>Documentation and procedures in line with industry best practice |
| 3b | The emergency management process shall include emergency response procedures to guide the dam operator and site staff through the process of responding to an emergency at a dam. | **Compliant**<br>Communications protocol in place, Emergency response plan in place |
| 3c | The emergency management process shall ensure that effective emergency preparedness procedures are in place for use by external response agencies with responsibilities for public safety within the floodplain. | **Compliant**<br>Suggestion for improvement include;<br>• Consultation with stakeholders and RCMP.<br>• Table top exercise had been planned<br>• Level 2 emergency response including all stakeholders was successfully completed |
| 3d | The emergency management process shall ensure that adequate staff training, plan testing, and plan updating are carried out. | **Generally Compliant**<br>Contractor program and training is not documented, Nalcor training needs documentation |



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# CDA Guiding Principles
## Principle 4 – Dam Safety Review

| Principle | Description | Compliance |
|---|---|---|
| 4 | Dam Safety Review | Compliant |
| 4a | A safety review of the dam ("Dam Safety Review") shall be carried out periodically. | Compliant<br><br>Daily inspection, assessment and review performed. Weekly comprehensive inspections to be enacted. Comprehensive Dam Safety inspection every two months<br><br>Dedicated dam safety engineer to be placed at site<br><br>Third party dam safety audit being performed monthly<br><br>Consequence classifications based on CDA. Will review the classification and selected dam safety parameters during the next audit |
| 4b | A qualified registered professional engineer shall be responsible for the technical content, findings, and recommendations of the Dam Safety Review and report. | Compliant<br><br>See above |



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# CDA Guiding Principles
## Principle 5 – Analysis and Assessment

| Principle | Description | Compliance |
|---|---|---|
| 5 | Analysis and Assessment | Generally Compliant – check if piping hazard has been assessed |
| 5a | The dam system and components under analysis shall be defined | Compliant<br><br>All components of the system defined with inspection and surveillance procedures identified |
| 5b | Hazards external and internal to the dam shall be defined. | Compliant<br><br>This has been done in the OMS manual and in the Risk Register. This will be reviewed during the next audit. |
| 5c | Failure modes, sequences, and combinations shall be identified for the dam. | Generally Compliant<br><br>All hazards have been assessed as part of the final design (flood, earthquake, seismic, ice loads. Landslide hazard assessment completed. Piping may not have been. This will be confirmed during the next audit. |
| 5d | The dam shall safely retain the reservoir and any stored solids, and it shall pass flows as required for all applicable loading conditions. | Compliant<br><br>Adequate discharge capacity, redundant capacity for almost all phases except for period in which two rollways are under construction where capacity exists but redundancy does not<br><br>Consider plan for enhanced gate exercising during this period to reduce risk |



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# Selected Visit Photos

# Actions & Items for Discussion

- Comments and discussions
- Additional information to review for next trip
  - Emergency response plan
  - OMS Manual
  - Documentation as to the need for winter data measurements at the Kettle Lake outlet weir
- Action Plan
  - Next trip in late February/March 2017
  - Deliverable for next trip update of audit report, general overview
  - Comments on format of report – to come
  - Areas for improvement
  - Continue monitoring and reporting



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# Thank you

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