

Dam Safety Maturity Matrix – October 6, 2022

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This report documents the initial evaluation of the GRCA's Dam Safety program using the Dam Safety Maturity Matrix in 2022.

The Dam Safety Maturity Matrix provides a template for a benchmarking exercise to evaluate dam management programs. The matrices were developed within the Centre for Energy Advancement through Technological Innovation (CEATI) Dam Safety Interest Group (DSIG). It is a tool to allow owners to assess the effectiveness of their dam safety program against industry practice, and to assist with identifying improvement initiatives. Because it is a relatively subjective exercise, it relies on evaluations from experienced dam managers and staff familiar with day-to-day operation of the infrastructure. Collectively this group looked at the entire dam program, and identified where the GRCA program stands in each of twelve areas:

1. Understanding the Dam System
2. Dam Surveillance
3. Flow Control Equipment
4. Reservoir Operations
5. Public Safety & Security
6. Emergency Preparedness & Response
7. Dam & WCS Maintenance
8. Dam Safety Issue & Risk Management
9. Audits & Reviews
10. Training, Education & Competence
11. Information Management
12. Governance

Program elements in each maturity matrix were evaluated and given a number between 1 and 5. From there, the scores within the program element were averaged to come up with a maturity level for each element of GRCA's dam safety program. The maturity levels are defined as follows:

1. Needing Development - Does not conform to applicable guidelines, standards and industry practice.
2. Intermediate - Partially conforms to applicable guidelines, standards and industry practice.
3. Good Industry Practice - Mostly conforms to applicable guidelines, standards and industry practice - could be improved on.
4. Best Industry Practice - High degree of understanding and conformance with applicable guidelines, standards and industry practice - hard to improve on.
5. Leading Edge - Achieving Level 4 Best Industry Practice, AND Developing, trialling and implementing new technology, methods or systems.

A preliminary assessment of the program was completed and each of the twelve matrices were filled out with an estimate of the maturity level for each program element. The majority of the GRCA program

elements were identified as Level 3 maturity, good industry practice. There were a few aspect of the programs were identified at level 2 or level 4.

Two workshops with staff were held to review the matrices and discuss the status of the dam management program. The workshops were facilitated by Joe Farwell, with Katelyn Lynch tracking comments. The workshops focused on Matrices 2, 3, 4, 5, 6, 7 and 10. The remaining matrices were evaluated by senior engineering staff.

On April 21, April 27, and June 14, dam operators and staff from the engineering division and management committee participated in workshops to review the Dam Safety Maturity Matrices and identify strengths in the dam management program, along with areas for improvement. Working through the exercise of filling out the matrices was an effective way to quickly gain an understanding of the dam management program. Staff were able to share knowledge about the dam management program, and identify a number of areas for improvements.

RESULTS of the Matrix Evaluation exercise

The following section provides an overview of the twelve matrices, along with discussion of the results of the workshops and recommendations for actions to advance the maturity levels. The recommendations were developed to respond to issues raised during the workshops.

1. ***Understanding the Dam System*** – Understanding the Dam System is about gaining portfolio-wide understanding of the dam systems' definition, design, construction, component design functions and interdependencies, external and internal hazards and disturbances, how system and components fail to function and the consequences of failure. The definition of failure should not be limited to complete loss of reservoir contents and should not focus only on extreme events. Unlikely combinations of likely events are also important. Failure to function at both component level and system level should also be considered. The purpose of understanding the dam system is to draw attention to vulnerabilities, assist identification of appropriate controls to operate the system safely, and identify consequences of system and component failure to function. Note that the dam system includes all civil components such as structures, foundations, drainage systems etc. - it is not only about mechanical, electrical and communications components.

Results: This matrix was not reviewed in the workshops. The matrix refers to an over-arching and comprehensive understanding of the dam management system. Although GRCA staff have expertise in their respective disciplines, there is limited understanding of the depth and breadth of the dam management program. This level of understanding exists among the senior engineers with decades of experience. With pending retirements, there will be a need to support ongoing training, and to expose staff to opportunity for senior engineering staff to gain hands-on experience with the dam management program.

Recommendations	timing
i. There are recommendations throughout the report to address training, engagement of senior staff and support for developing knowledge and experience in the dam management program.	ongoing
ii. Prioritize staff training in the dam management program.	ongoing
iii. Incorporate high-level systems operations and design of the dam system and operating policy into the Operational Plan required by the CA Act for Water Control Infrastructure.	2024
iv. Develop a comprehensive information strategy to highlight the role of the reservoirs in flood management, assimilative capacity, and auxiliary benefits like recreation and hydro production.	Year end 2023
v. Share the Operational Plan with the Provincial MNRF and MECP so the operational design of the reservoir system in the Grand River watershed is recognized by provincial staff and considered in their approval process for water related initiatives, like waste water treatment plans and permits to take water.	Year end 2024

2. **Dam Surveillance** - Dam Surveillance is defined as the close monitoring of dam (and other containment or conveyance structure) behaviour, including collection, analysis and evaluation of data from visual inspections and instrumentation, and the identification and escalation of issues.

Results: The GRCA operates an effective dam surveillance program. The role of the dam operators and their daily surveillance of the large dams is the foundation of the dam surveillance program, and it is important that this continues. It is noted that there are different surveillance requirements for small dams. The frequency of inspections could be increased.

Recommendations	timing
i. To assist with having a clear understanding of the best practices in the dam industry, review the GRCA's participation in external groups like the Canadian Dam Association (CDA), the American Society of Dam Safety Officials (ASDSO), the Centre for Energy Advancement through Technological Innovation (CEATI) and the Provincial Dam Safety Committee.	ongoing
ii. Confirm the practice of operating all flow components (gates and valves) and testing emergency backup generators prior to major events, to ensure they operate when required.	ongoing
iii. Develop a formalized incident recording, reporting and tracking system for both public safety incidents and technical dam safety incidents associated with GRCA dams	2023

iv.	Consider including Occupational Health and Safety on dam inspection forms	2023
v.	Form a project team of dam operators and head office personnel to review the status of the Operation and Maintenance manuals, with a goal to developing a consistent format, and completing manuals for all the dams by the end of 2023.	2022
vi.	Develop a plan and budget estimate for installing remote video surveillance of the of the discharge areas on the large dams	Early 2023
vii.	Review the practice of recording results of dam inspections and reporting back to senior staff and the GRCA board	2023
viii.	Prepare and inventory and status report of all piezometers at the dams; establish warning levels where appropriate.	2023

3. **Flow Control Equipment** - Flow Control Equipment is defined as the inspection, maintenance, testing and routine performance evaluation of gates, valves and associated power supplies, control systems and communications that contribute to safety of the dam and reservoir.

Results: The flow control equipment is well-managed and there is a high level of understanding throughout the operations and engineering staff of the importance of the equipment. The gaps generally relate to documentation and clarity of roles between various staff.

Recommendations	timing
i. Clearly identify roles and responsibilities of operations staff and dam maintenance staff with respect to the flow control equipment.	2022
ii. Continue to reinforce the importance of ability of the flow control equipment to operate as required.	ongoing
iii. Continue to install reservoir level monitoring separate from reservoir water wells to have independent means of checking reservoir levels.	ongoing
iv. Where appropriate create an inventory of spare parts and replenish inventory as parts are used.	2023
v. Develop a watchlist to track the status of maintenance and repair projects	2023
vi. Include testing requirement for the flow control equipment in the updated O&M manuals.	2023
vii. Continue to refine calibration of gate and valve curves at major dams based on manual flow measurements	during dam safety reviews
viii. Review the contact list for the outside contractors to ensure there are available resources in the event of an after-hours emergency with the flow control equipment.	2023
ix. Develop a project plan to update the original dam drawings to ensure they are up-to-date and can be read.	2025

4. **Reservoir Operations** - Reservoir Operations is defined as the safe operation of dams and their reservoirs, including run-of-river systems, in the context of water management, operational and duty of care requirements.

Results: The reservoir operations program is well developed and supported by a high-quality flow monitoring and forecast system. There are concerns with the aging software for the flood forecasting model, and the limited number of staff able to operate and debug the GRIFFS/GAWSER models. There is an opportunity to continue to improve communication between operations staff and the engineering staff. It is important to understand the limitations of the large dams for controlling flooding, while serving their role as water supply for the river.

Recommendations	timing
i. Develop a program of regular training /communication for the senior operators from the engineering group and dam operators to foster clear and frequent communication.	2022.
ii. Document and provide general reservoir operating procedures for reservoirs for a range of flood events. High level document and training summer 2022	2022
iii. Prepare a plan to update the GAWSER/GRIFFS program. Prepare a status report on the model update, to advise senior staff on developing a plan for longer term model update.	2023
iv. Include a description of the role of reservoirs in ice management in the ice management plan required as part of the new Conservation Authorities Act. Include ice management plans in O&M Manuals	2023
v. Develop a communications plan to assist with managing public expectations around GRCA's ability to prevent flooding. It will be critical to communicate that flood levels are estimates, and the limitations of the flow modelling and forecasting.	2023
vi. Document reservoir operating procedures and considerations for extreme low flow and drought events, document learnings from the late 1990's flood events and drought contingency plans.	2024
vii. Complete reach-based flood zone mapping along the regulated reaches downstream of large dams to identify impacted areas and compliment flood warning and response and reservoir discharge decisions	2024/25
viii. Continue to extend stream gauge station rating curves to accommodate extreme events up to and including the Regulatory flood. Identify operating limits of a stream gauge.	2025
ix. Explore technology to provide accurate low flow estimates from Glen Allan gauge downstream of Conestogo Dam when the gauge is under backwater effects from aquatic vegetation.	2025

5. **Public Safety & Security** - Public Safety is defined as the development and implementation of a Public Safety Management System with plans, control measures, monitoring and evaluation to ensure high levels of public safety around dams and reservoirs. Security is defined as the development and implementation of physical and cyber security plans and control measures to ensure that dam safety and public safety are not threatened by potential security breach.

Results: Public safety at the dams has received significant attention and appropriate levels of funding support. Gaps in this program area relate to communication and internal information dissemination. Risk assessments for public safety plans require updates. In addition, increased recreational use of the reservoirs, including winter use, is introducing new risk that should be addressed in public safety plans. There is a need to review Transport Canada approvals in boom/buoy placement at some of the dams.

Recommendations	timing
i. Send out copies of the Public Safety Plans to the dam operators. Ensure that plans are available at the dam sites (where feasible) and included in the O&M manuals. Summer 2022.	2022
ii. Develop annual training/refresher on public safety for operations staff	2023
iii. Ensure that operational public safety controls (like sounding the alarm prior to operating the gates) are included in the O&M manuals.	2023
iv. Consider joining a provincial reporting system being advocated to the Dam Owners Advisory Committee by OPG and OWA	2022
v. Initiate a project to update the public safety plans for all dams.	2023
vi. Review Transport Canada approvals for public safety measures and seek approvals for variances as required.	2023
vii. Review the process for tracking, reporting on, and addressing public safety incidents at the dams.	2023
viii. conduct a cyber-security assessment for the water control infrastructure	2024

6. **Emergency Preparedness & Response** - Emergency Preparedness and Response is defined as the plans, procedures, activities, resources and equipment that prepare for and guide response during events where dam safety may be or has been compromised. Includes emergency preparedness and response plans, external relationship building, and tests and exercises. Emergency Preparedness and Response is the term used in ICOLD Bulletin 154, Dam Safety Management (ICOLD, 2010).

Results: GRCA's Emergency Preparedness and Response Plans (EPRPs) benefit from a long history of effective flood forecasting and warning. There are a few gaps related to internal communications and clarity of roles in an emergency. Other recommendations relate to the continuing need to ensure ongoing communication with emergency response personnel for the watershed municipalities.

Recommendations	timing
i. Continue to reinforce the commitment to communicating with municipal flood coordinators, and to recognize that flooding may not	ongoing

	be top-of-mind as their municipalities recover from COVID-19 challenges	
ii.	Carry out a review of the flood warning system role descriptions and clarify senior operator and other staff roles during an emergency.	2022
iii.	Work with Deputy CAO and Finance Manager to review HR policy regarding emergency spending. - 2022.	2022
iv.	Prepare a formalized training plan for the entire engineering group.	2022.
v.	Review the list of suppliers/contractors who can assist with response to an emergency.	Summer 2022.
vi.	Prepare schedule for review and update of ERPR plans and desktop exercises on a recurring cycle (ie every five years).	2023
vii.	Explain roles and responsibilities for Dam ERPR plans to municipalities. During semi-annual municipal flood coordinators meetings.	2023 and ongoing
viii.	Work with communications staff to develop a plan for re-engaging the public following Covid (assume 2023/24)	2023/24
ix.	Explore implementing automated dialer calls to residents and agencies contacted directly by GRCA in a dam failure emergency	2024
x.	Re-engage Waterloo Region CEMC's and work to integrate flood zone mapping and ERPR plans into municipal emergency response plans for floods.	2024
xi.	Consider including additional flood warning zones for the probable maximum flood, sunny day dam-break and probable maximum flood with dam-break floods.	2025

7. ***Dam & Water Conveyance Structure Maintenance*** - Dam and Water Conveyance Structure Maintenance is defined as the maintenance of civil structures and constructions associated with the dam and reservoir. Includes structural maintenance or repairs, erosion protection, vegetation control and drain maintenance (surface and internal relief drainage). Includes water conveyance structures such as canals, headraces, tunnels, and penstocks that perform a dam safety containment or conveyance function. Note: Flow Control Equipment maintenance is evaluated in Matrix 3.

Results: GRCA has a good quality maintenance program, with most of the program elements falling under good industry practice. The major structures are maintained to a reliable operating condition, however the entire portfolio can be classified as aging infrastructure and is increasingly challenging to maintain identified deficiencies and failing elements. The GRCA maintains a 5 year capital forecast of major maintenance items and in general, it can be a challenge to keep up with the repairs. Participation of senior engineering staff in the dam maintenance program allow for issues to escalate quickly in accordance with best industry practice. Gaps were identified in the areas of clarity of roles between maintenance staff and dam operators. In addition, there is an opportunity to improve the Operation and Maintenance manuals (see the Dam Surveillance matrix for more detail). It is noted that there is a problem with the access to the stream gauge below Shand Dam in the winter.

Recommendation	timing
i. Prepare asset management plan to include all water control structures – Initiate project in late 2022. Coordinate the asset management plan	2024

	with an overall corporate asset management plan. - resolve status of smaller locally significant structures with respect to funding and priority of major maintenance	
ii.	Review project management resourcing needs to carry out identified maintenance projects. Consider additional project management staff particularly within current staff transition period.	2023
iii.	Develop process for tracking maintenance activities Leverage the maintenance ticketing system developed by the central services group to track and help prioritize maintenance actions	2024

8. ***Dam Safety Issue & Risk Management*** - Dam Safety Issue and Risk Management is defined as the identification, assessment, treatment and communication of dam safety risk in a developed risk management program, including the identification, categorization and prioritization of Dam Safety Issues, some of which may be identified as dam safety risks. Dam Safety Issues can be categorized as Physical Infrastructure Issues, Potential or Confirmed Dam Safety Deficiencies, and Non-Conformances. For the purpose of these Maturity Matrices, Dam Safety Risk Management does not include implementation of remedial works, except for ensuring that dam safety objectives are considered and met during implementation.

Results: This matrix was not reviewed in the workshops. Formal risk-based decision tools have not been widely applied at GRCA. Placing numerical values on risks has had limited application at GRCA. Rather, budgeting for addressing risks at the dams has relied on engineering judgement from GRCA staff, Ministry of Natural Resources and the consulting industry. There is an opportunity to examine how risk-based decision making could be applied to the GRCA program, but it is not identified as a priority.

Recommendations	timing
i. Hold a workshop for the engineering staff on classifying hazard potential for dams and applying technical guidelines based on hazard potential.	late 2022
ii. Investigate ways to ensure risk associated with the dam and flood management program are well understood by senior management and the board, and balanced appropriately with overall corporate risk management	Ongoing
iii. Ensure Statement of Objectives for the dam management program has a link to risk management.	2023

9. ***Audits & Reviews*** - Audits and Reviews are grouped and defined in this matrix as follows:

- Dam Safety Program Audits and Reviews (sub-elements 9-A and 9-B respectively):
- Dam Safety Program Audits are usually to check that the owner's dam safety program's systems, processes and procedures are being followed.

Dam Safety Program Reviews review the effectiveness of a dam safety program and the appropriateness of its systems and processes. Dam Safety Reviews review a dam system's safety status, including a review of the dam safety management practices relevant to that dam system.

Results: This matrix was not reviewed at the workshops. GRCA does not apply an audit process to the dam safety program. The matrix was developed by dam owners of utilities where primary objectives of the facilities are to produce hydro; the audit process is an important component to the dam owners that run utilities. Dam safety reviews have been conducted on the dams with high consequence of failure. Guidelines suggest dam safety reviews on a regular cycle, GRCA has a practice of completing comprehensive dam safety reviews and implementing the recommendations over a period of several years. Safety review and studies on individual elements of the dam are carried out as issues are identified.

The Ministry of Natural Resources through the provincial dam owners' advisory group is reviewing the frequency of dam safety reviews. The current Canadian Dam Association (CDA) guidelines are now advocating for dam safety reviews on a five-year basis, concerns have been raised from dam owners around the table that the frequency recommended by CDA is too frequent. There is also a need to better define the term dam safety review to capture the range of reviews from ground up reviews, to periodic reviews to issue specific reviews. Currently the MNRF position after discussion with the dam owner's advisory group is to continue with the current provincial guidelines with minor revisions.

Recommendations	timing
i. Review the status of recommendations from the dam safety reviews at Shand, Conestoga, Guelph and Woolwich dams and confirm all recommendations have been addressed.	2022
ii. Prepare a report for the GRCA board on the status of the dam program and identify the need for continuing budget support.	2023
iii. Initiate an audit program to ensure the dam safety processes and procedures are being followed.	2023
iv. Evaluate the frequency of dam safety reviews with respect to provincial and CDA guidelines. There will be a need to update some of the dam safety reviews	2024

10. **Training, Education & Competence** - Training, Education and Competence of persons responsible for and involved with the dam safety program, public safety and security as appropriate to the nature of the activities, and level of risk involved with each. The 5 sub-elements cover five different role groupings. This matrix centralizes evaluation of training, education and competence, rather than having it spread throughout multiple matrices. Training is defined as teaching a skill or behaviour (may be practical or theoretical). Education is defined as giving or receiving specific instruction or knowledge (more likely to be theoretical). Competence is defined as having the skill, knowledge and experience to do something proficiently or effectively.

Results: Recent and pending retirements of senior staff members have left a gap in training. Engineering staff have tended toward training in river flow management rather than dam management. There has been a high level of change in the dam operator roster and many staff are still learning their roles on new dams. The dual role of dam operator and park superintendent can be a challenge at certain times of the year. There is a very high level of on-the-job training for the dam operators. With ongoing upgrades, training on new equipment is required.

Recommendations	timing
i. Provide ongoing training for engineering staff in dam management.	ongoing
ii. Place a priority on succession planning and align it with the training plans.	2022
iii. Continue to involve the CAO, Deputy CAO and Corporate Services Manager in the dam management program. Establish a formalized process for communication between senior engineering staff and senior management staff.	ongoing
iv. Review training process for engineering staff and identify opportunities/requirements for training from outside sources (ASDSO, CDA, OWA and CEATI)	2022
v. Review the list of back-up operators for the large dams, and consider expanding the list of trained operators.	2022
vi. Develop a process for tracking training activities	2023

11. **Information Management** - Information Management is defined as the collation, cataloguing, completeness, safe storage, retrieval and change control of all documented information relevant to the delivery of a dam safety program, public safety and security. The sub-elements reflect different groupings/types of information relevant to the delivery of those programs and activities.

Result: This matrix was not reviewed in the workshops. Digital information around river flows and reservoir levels is well catalogued and easy to retrieve. There are some gaps in storage and change control for the paper copies of the historical dam records. This gap extends to challenges retrieving information from dam safety reviews, and from original dam drawings.

Recommendation	timing
i. Initiate a project to update the dam drawings to ensure they are complete, with all the changes/ repairs identified	2023/24
ii. Include conversion of paper copy files and overall information storage as part of a corporate strategy file management strategy	2025

12. **Governance** - Governance is defined as the organizational commitment to, and resourcing and oversight of, the effective delivery of a dam safety program, management of dam safety risk, and public safety. Includes the governance of emergency management (as part of dam safety program).

Results: this matrix was not reviewed in the workshops. GRCA staff have a strong working relationship with the provincial staff and continue to have a role in ensuring advancing dam safety regulation in the province. There is a need to continue to keep the GRCA board engaged in dam safety matters through regular update reports. A new board of directors will be appointed following the 2022 municipal elections. Day to day workloads have often taken priority over longer range initiatives like succession planning.

Recommendations	timing
i. Continue to assign senior engineering staff to the provincial dam safety working group.	ongoing
ii. Prepare a Statement of Objectives for the dam program for board approval.	2023
iii. In addition to monthly watershed conditions reports, provide opportunities for GRCA board engagement through annual reports on the dam program.	2023
iv. Provide the new board with detailed information about the dam management program as part of the orientation program.	2023
v. Re-initiate tours of the GRCA water control infrastructure for the board and senior staff- after COVID-19 subsides	2023/4