Saskatchewan Watershed Authority

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Main points

Saskatchewan Watershed Authority operates, maintains, and inspects Saskatchewan's dams and related water work channels worth an estimated $1.37 billion. A significant number of Saskatchewan residents rely on these dams to provide stable water supply for municipal and industrial use, irrigation, hydroelectric power generation, and recreation opportunities, and to protect downstream communities from flooding.

Over half of Authority's dams are more than 35 years old. Like all infrastructure, dams require continuous investment to ensure their ongoing safety and their ability to meet expected service needs. Inadequate investment of time and resources could significantly increase risks to public safety.

Saskatchewan's four largest dams are Gardiner, Qu'Appelle River, Rafferty, and Alameda. These dams would have major consequences downstream if they failed. This makes it critical for the Authority to have strong processes to keep these dams safe.

This chapter reports that while the Authority had adequate processes in many areas to keep these dams safe, it needs to make improvements in four areas. First, it should obtain independent comprehensive dam safety reviews on it four largest dams at least every five years. Second, it must have up-to-date tested emergency preparedness plans for each dam. Third, it needs a process to ensure it keeps all of its key manuals current and complete. And fourth, it should set long-term targets to better monitor the effectiveness of its dam safety activities.

Background

On October 1, 2002, the Saskatchewan Watershed Authority (Authority) was established from amalgamating the Saskatchewan Wetlands Conservation Corporation with part of Saskatchewan Water Corporation and the Department of Environment. A major focus of the Authority's activities is to manage and protect the quality and quantity of Saskatchewan's surface and ground water resources.

The Authority is also responsible for the operation, maintenance, and surveillance of 45 dams and 130 kilometres of conveyance channels[1] in Saskatchewan. The estimated replacement cost of the Authority's dams and related waterworks is $1.37 billion.[2] Each year, the Authority devotes between 20 and 25% of its total budget of $21 million to the operation, maintenance, and rehabilitation of its dams and related waterworks. Thirty-one of its 191 employees carry out these responsibilities throughout the year.

The dams are an essential part of the Province's water management infrastructure. They provide water for municipal and industrial use, irrigation, and hydroelectric power generation. Also, they reduce the risk of flood damage, enhance recreational opportunities, and maintain aquatic habitat.

Of its 45 dams, the Authority's four largest dams are Gardiner, Qu'Appelle River, Rafferty, and Alameda.[3]

The 64 metre-high Gardiner dam and the 27 metre-high Qu'Appelle River dam create a 225 kilometre long reservoir (Lake Diefenbaker) in the South Saskatchewan River basin. The reservoir holds over 9.4 billion cubic metres of water. The reservoir provides water for about 45% of the province's population. The Federal Government completed these dams in 1967, after eight years of construction. The Gardiner dam is one of the world's largest earth-fill dams. The total volume of earth fill is over 65 million cubic metres. The Provincial Government assumed full responsibility for these dams in 1997.

[1] 2005-2006 Provincial Budget: Performance Plan: Saskatchewan Watershed Authority, p 3.
[2] Annual Report 2003-2004 Saskatchewan Watershed Authority, p 8.
[3] Saskatchewan Watershed Authority web site, available at http://www.swa.ca/WaterManagement/DamsAndReservoirs.asp?type=LakeDiefenbaker.

The 20 metre-high Rafferty dam is located on the Souris River six kilometres northwest of Estevan. The Provincial Government constructed Rafferty Dam over a four-year period between 1988 and 1992. Its reservoir provides water for the Shand Thermal Electric Generating Station, flood protection for downstream communities, irrigation, and recreation.

The 43 metre-high earth-fill Alameda dam is located on the Moose Mountain Creek (a part of the Souris River basin) north of the town of Oxbow. The Provincial Government constructed the dam over a four-year period between 1991 and 1995. Its reservoir provides a stable water supply, flood protection for downstream communities, irrigation, and recreation, and contributes to meeting Saskatchewan's water obligations to the United States.

Like all infrastructure, dams deteriorate over time. They require a continuous investment in maintenance to ensure their safety and ability to meet expected service needs. Inadequate maintenance of these aging dams could significantly increase risks to public safety.

"More than 50% of the Authority's dams are 35 years old or older. Not only has their physical condition declined over time, but in many instances, the criteria used for their design falls well short of today's standards."[4] One of the Authority's objectives is that "water management infrastructure is safe and meets operational requirements."[5]

The Authority classifies its four largest dams as very high consequence based on the potential impact of dam failure, as these four dams "would have major consequences from down stream flooding, including property damage and risk of loss of life, if they failed."[6] According to its analysis, if the Gardiner dam broke under the worst-case scenario, the entire South Saskatchewan River Valley throughout its length and large portions of the southern and western parts of Saskatoon would be flooded. It estimates that the water level would peak at 15 metres above the Broadway Bridge in Saskatoon.

[4] Annual Report 2003-2004 Saskatchewan Watershed Authority, p 9.
[5] 2005-2006 Provincial Budget: Performance Plan: Saskatchewan Watershed Authority, p 4.
[6] Ibid., p 9.

The safety of the four largest dams affects the livelihood of most Saskatchewan residents.

Our audit objective and criteria

The objective of our audit was to determine whether the Saskatchewan Watershed Authority had adequate processes to ensure its four largest dams are safe at December 31, 2004.

In carrying out our audit, we defined a safe dam as one that "performs its intended functions without imposing unacceptable risks to the public by its presence."[7]

Throughout our audit, we followed *The Standards for Assurance Engagements* established by The Canadian Institute of Chartered Accountants.

Our criteria, set out in Exhibit 1, describe the key processes that we expected the Authority to use to ensures its four largest dams are safe. We used the Canadian Dam Association's dam safety principles and guidelines (CDA) to develop the criteria. The Authority accepts these criteria as reasonable standards for assessing its processes.

Exhibit 1 — Audit criteria

Adequate processes to ensure dams are safe should include:

- Assessing the status of dams
- Documenting procedures based on the status of dams
- Monitoring the effectiveness of dam safety

Our conclusion

At December 31, 2004, the Saskatchewan Watershed Authority had adequate processes to ensure its four largest dams are safe except as reflected in the following recommendations.

[7] BC Inspection & Maintenance of Dams Dam Safety Guidelines p 9.

1. **We recommend that the Saskatchewan Watershed Authority obtain an independent comprehensive dam safety review on each of its very high consequence dams (i.e., Rafferty, Alameda, Qu'Appelle River, and Gardiner) at least every five years.**

2. **We recommend that the Saskatchewan Watershed Authority have up-to-date tested emergency preparedness plans for each of its major dams (i.e., Rafferty, Alameda, Qu'Appelle River, and Gardiner).**

3. **We recommend that the Saskatchewan Watershed Authority set processes that ensure its manuals always include complete procedures to operate, maintain, and monitor dam safety.**

4. **We recommend that the Saskatchewan Watershed Authority set long-term targets (e.g. five to ten years) for measures related to dam safety to help it better monitor the effectiveness of its dam safety activities.**

Key findings by criteria

We describe below our detailed audit findings for each criterion. For each criterion, we identify what we expected (in italics) and what we found.

Assessing the status of dams

To assess the status of the dams, we expected the Authority's processes to define:

- *components of dams and their functions*
- *condition of dams*
- *risks that may affect the safety of dams*
- *potential consequences of dam failure*

The principle of dam safety management is that a dam whose failure would cause excessive damage or the loss of many lives must be designed to a higher standard than a dam whose failure would result in less damage or fewer lives lost.

The Authority maintains extensive documentation on its dams. For each dam, it keeps the original dam designs, modifications and revisions, history of the structures, log books, and reports.

The Authority has set up processes for performing routine surveillance, monitoring, and maintenance activities. It uses the results of these activities to determine the condition of dams, related safety risks, consequences of dam failure, and to prepare five-year operational and maintenance plans.

In 2004, the Authority selected some performance measures related to dam safety. For example, it uses a risk ratio to "gauge the Authority's progress in upgrading its infrastructure to acceptable standards and quantifies the overall risk of the water management infrastructure."[8] It tracks the number of dams requiring significant upgrades to meet dam safety standards.

The Authority uses job descriptions to assign clear responsibility for dam safety. It employs professional engineers with expertise in water resources engineering to evaluate inspections reports and determine risk of dam failure. When the Authority identifies problems beyond its expertise, it engages engineering consultants.

Regularly scheduled activities, along with technical data from equipment installed at each dam site, provides the Authority with detailed information. For example, information includes readings of subsurface movements (e.g., in dam foundations), surveys detecting surface movements, and cathodic tests assessing corrosion risks to equipment or structures. Some of these activities are ongoing, others are annual, and still others are periodic. It uses information from these activities to help determine the condition of the dams and identify potential safety risks.

[8] 2004-2005 Saskatchewan Provincial Budget: Performance Plan: Saskatchewan Watershed Authority, p 10. The risk measure is a ratio of the aggregated assessed risk of all the Authority's water management infrastructure at a given time, compared to the maximum possible risk generated by this infrastructure. The measure assesses risk, defined as the likelihood of a failure multiplied by the consequences of a failure. This measure gauges the Authority's progress in upgrading its infrastructure to acceptable standards and quantifies the overall risk of the water management infrastructure. A lower ratio indicates safer infrastructure, with a ratio of 0 indicating no current assessed risk.

The CDA requires the first dam safety review (safety review) for a new dam to be completed within three years of initial reservoir filling.[9] In addition, the CDA recommends a safety review within a maximum of every five years for very high consequence dams. A safety review is a comprehensive formal review carried out by an independent registered professional engineer at regular time intervals. The review is to determine whether an existing dam is safe, and if it is not safe, to determine required safety improvements.[10]

The Rafferty and Alameda dams filled first in 1997 and 1999, respectively. Between 1995 and 2000, the Authority engaged engineering consultants to further assess risks the Authority had previously identified through its own activities. At March 2005, the Authority had not done a comprehensive safety review of the Rafferty and Alameda dams.

In 2001, the Authority hired an independent engineering consultant to do safety reviews for Gardiner and Qu'Appelle River dams. It did not require these safety reviews to include all aspects recommended by CDA. Rather, the Authority addressed certain risks not covered by the above reviews later. It engaged engineering consultants to provide assessments of the hydrology/hydraulic aspects[11] of Gardiner dam and of the geotechnical performance of both Gardiner and Qu'Appelle River dams.

The 2001 safety review concluded that the dams and associated works were in fair to satisfactory condition and that the Authority maintained an excellent program of inspection and maintenance. The review made several recommendations for improvement.

In its most recent five-year operational and maintenance plan, the Authority expects to have independent safety reviews performed on the Gardiner and Qu'Appelle River dams during the 2006-07 fiscal year. In line with CDA expectations, the Authority plans to do these reviews within five years from the original safety reviews completed in 2001. In addition, it has a plan to start safety reviews for the Alameda dam in 2006-07 and Rafferty dam in 2007-08.

[9] Canadian Dam Association Guidelines (Jan 1999) p 2-1.
[10] Canadian Dam Association Draft Principles (Feb 2005) p G-2.
[11] Hydrology/hydraulic includes assessing the capacity of the dam structures and their capability to perform under extreme water flooding conditions.

Documenting procedures on the status of dams

We expected the Authority's processes to document procedures for dam:

- *operation, maintenance, and surveillance*
- *emergency management*

Documenting procedures in manuals make them more readily accessible to employees. Complete and current operation, maintenance, and surveillance procedures provide direction to employees to ensure that they maintain the structural integrity and safety of the dams. Complete manuals also help transfer key knowledge when personnel change.

Procedures for the Authority's activities change with time and new equipment. At times, the Authority documents these changes in various documents. The Authority has not set out when and how it expects staff to revise its manuals to ensure they are kept current.

The Authority has detailed operation and maintenance manuals for each dam site. Although it has established surveillance practices, the Authority does not have surveillance manuals for its four largest dams.

The Authority is updating its operation and maintenance manuals. Also, it is preparing a surveillance manual for Gardiner dam. It plans to complete the manual during the 2005-06 fiscal year. The Authority expects the surveillance manual to contain all aspects of monitoring, analysis, and reporting. When the manual is complete, the Authority expects to use it to prepare manuals for the remaining large dams.

An Emergency Preparedness Plan (EPP) "is a formal written plan that identifies the procedures and processes that the dam operators should follow in the event of an emergency at a dam."[12] The EPP is prepared to safeguard lives and to reduce property damage in the event of natural flooding or dam failure.

Floods can cause significant property damage and loss of production. The Authority has processes to minimize flood damage by using water management infrastructure, predicting areas at risk of flooding, and advising those potentially affected.

[12] Canadian Dam Association Guidelines (Jan 1999) p 4-1.

The Authority has not set out how often it must prepare and update an EPP and the content of an EPP for each of its largest dams. The Authority has prepared an EPP for one of its four largest dams. In April 2002, the Authority issued an EPP for Gardiner dam. However, the Authority had not completely tested it to ensure the planned emergency procedures would work appropriately.

As indicated in its 2005-06 Performance Plan, the Authority plans to update the Gardiner dam EPP and start preparing an EPP for the Alameda dam in 2005-06[13]. In addition, it has plans to do an EPP for the Qu'Appelle River dam in 2006-07 and the Rafferty dam in subsequent years.

Monitoring effectiveness of dam safety

We expected the Authority's processes to monitor the effectiveness of dam safety. Senior management should:

- *review periodic reports*
- *obtain a periodic independent dam safety review*
- *take corrective action when dams are found to be in inadequate condition*

Staff has a clear understanding of the reporting expected by senior management. Senior management expects, receives, and reviews regular reports on the results of activities carried out at each dam site. These reports include:

- monthly reporting on the operations, physical maintenance, and surveillance at the four largest dams
- annual reports on the operations, physical maintenance, and surveillance (including inspections) activities conducted at the Gardiner and Qu'Appelle River dams
- annual inspection and periodic surveillance reports for the Rafferty and Alameda dams

Senior management reviews and approves five-year plans for its four largest dams. These plans outline the detailed operations, maintenance, and surveillance activities and special undertakings planned for the next

[13] 2005-2006 Provincial Budget: Performance Plan: Saskatchewan Watershed Authority.

five years. The plans include the corresponding annual budget required to complete the planned activities. In addition, the plans explain significant changes and set out the status of activities from the prior plan.

In addition to the results of its various activities, the Authority uses two key measures to monitor dam safety (i.e., aggregated risk ratio of dam failure, and number of dams requiring significant upgrades). The Board has approved these measures for inclusion in its public performance plan.

Senior management updates the Authority's board of directors semi-annually on its key activities and the status of its performance measures. The 2004-05 Performance Plan reports the following: at March 2004, 27 of its 45 dams require significant upgrades to meet the CDA Safety Guidelines and its dams had an aggregated risk ratio of 14.7%. Two of the four largest dams are included in the 27 dams that require significant upgrades and the risk ratio of one of the four largest dams is greater than the aggregated ratio to due this dam's very high consequence rating.

It is important the Authority carry out the right activities at the right time. The Authority must continually balance the timing of these activities with the current condition of the dams and available funding. Delays of these activities can reduce the safety of the dam.

As previously noted, the Authority does not meet the CDA guidelines in a number of key areas (e.g., independent dam safety reviews within recommended periods). In addition, the 2001 Gardiner and Qu'Appelle River independent dam safety reviews noted several deficiencies, some of which are not yet addressed. These deficiencies include the need for a surveillance manual, emergency operating procedures, and a number of areas for improvement in the Gardiner dam EPP (e.g., additional stability analysis of spillway crest structure). The Authority's own activities have also noted a number of matters that require action (e.g. installing a rock berm at Rafferty dam).

Targets are quantifiable estimates of results expected over a specific period. Comparing actual results against targets help to determine performance. For infrastructure, such as dams, the specified period for targets is generally longer term (e.g., five to ten years).

Based on planned activities, the Authority has projected aggregated risk ratio targets for each of the next two years. It has not yet set longer term targets. Without longer term targets for each of its measures at the overall level and each dam level, it is difficult to determine effectiveness of dam safety and the severity of problems. Also, it makes it difficult to determine if the Authority is carrying out the right activities at the right time to keep the risk of dam failure to an acceptable level.

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