Rosedale Dam – Issues associated with a high-hazard dam in an urban area

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The Rosedale Dam retains the No 1 oxidation pond at the Rosedale Wastewater Treatment Plant facility. The pond has a surface area of 36 hectares and an impounded volume of over 1 million cubic metres. The dam owner, the North Shore City Council, is presently applying to the Auckland Regional Council and the North Shore City Council for renewal of resource consents for the Rosedale Wastewater Treatment Plant facilities. The treatment plant handles all the sewage from the North Shore area, which has undergone rapid growth since the plant was commissioned in the early 1960s. Stormwater flows from surrounding catchments are diverted around the reservoir by a ring drain.

Growth of the North Shore has enveloped the dam, transforming rural landscape into residential and industrial suburbia. Consequently, the hazard rating of the dam has escalated from Medium to High, requiring increased dam safety standards. Public awareness of the dam and its function has also increased with aesthetic awareness.

Various upgrade works to the dam were completed in the period 1992 to 1994 to alleviate concerns with various aspects of the dam's performance, principally with respect to seepage and internal erosion. In 1996 a further safety evaluation highlighted uncertainties with respect to the capability of the emergency spillway to safely discharge extreme storm events. Remedial measures have been implemented in 1999/2000 to raise the crest level, and improve the emergency spillway.

The consent process has highlighted discharges from the emergency spillway and potential downstream impacts as a significant issue of concern. This paper describes the issues associated with a high-hazard dam in an urban area which has been subject to rapid downstream development, and some of the complicating factors when the retained reservoir is a key component of the city's sewerage infrastructure.

Keywords: *high-hazard dam, remedial works, urban development, safety evaluation*

Introduction

Almost all high-hazard dams in New Zealand are located on major river systems, and are not located in the midst of densely populated areas. The Rosedale Dam is unusual in several aspects compared with other high hazard dams. In particular:

- The hazard rating has escalated from Medium to High because of the urban development that has occurred in the downstream valley in the past 10–15 years. The eastern arm of the lake is crossed by the northern motorway giving a high public awareness.
- The retained liquid is treated sewage effluent, which is stored in the pond in its final stage of treatment prior to being piped to the outfall point off the coast.
- The pond system is hydrologically complex. Both stormwater and sewage effluent can combine to raise the pond level; the pond outfall pipe at present has limited capacity.
- Inflows to the pond have increased with the increase in the development of the North Shore; in wet weather the sewage inflows increase markedly.
- Two major upgrades have been undertaken in the past 6 years to improve the safety of the dam.
- The dam is 1 km long, retaining the sides of the reservoir.

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Background

The earth dam is owned by North Shore City Council (NSCC) who took over responsibility for the treatment plant complex from the North Shore Drainage Board during local body restructuring. The dam is the only permanent water-retaining dam owned by NSCC (all other dams are flood detention structures).

The earth dam was completed in the early 1960s. The lake has a surface area of 36 ha, and an impounded volume of over 1 million m^3.

The dam was initially constructed as a homogeneous embankment, typically 4 m high over the majority of its length, but across two old stream beds near the right abutment the embankment height increases to 14 m. The total dam length is about 1000 m. Some key elements of the original dam were:

- Crest width of 3 m, 2:1 H:V downstream shoulder slope, 2.5:1 upstream shoulder slope. (Upstream refers to the lake side of the embankment).

Figure 1. Rosedale Dam and North Shore City, with Rangitoto in the background.

- Upstream slope protection of concrete slabs from the crest to 1.5 m water depth.
- 1.8 m deep cutoff trench filled with clay along the dam centreline, with toe drains using field tiles encased in scoria.
- Two concrete cutoff walls constructed across the old stream beds. The walls have a crest width of 600 mm with 0.1:1 side slopes, and were keyed into the foundation materials.
- A 1.5 m square diversion culvert which incorporates a valve tower located upstream of the dam centreline. After construction the culvert was sealed with a 0.9 m concrete plug which incorporates a 600 m diameter gate valve. The gate valve has subsequently been encased in concrete to alleviate concerns with corrosion of the support bolts.
- A grass channel spillway on the right abutment with a crest level about 0.6 m below the dam crest.

Stormwater from surrounding local catchments is normally prevented from entering the lake by a series of open channels around the eastern and southern shores. The open channels discharge into a 1200 mm diameter pipe with an inlet located adjacent to the motorway and which discharges downstream of the dam. Upstream detention ponds reduce the peak stormwater flow into the open channels. The oxidation ponds on either side of the motorway are hydraulically interconnected by a weir and culvert. A locality plan of the catchment and oxidation ponds is given in Figure 2. Figure 3 shows the extent of the earth dam and main features, and a typical cross-section is shown in Figure 4.

When the dam was built, there was very little development in the downstream valley, particularly within the immediate vicinity. In parallel with the trends on the North Shore, development has escalated in the past 10–15 years. An industrial/commercial area is now located immediately downstream, and residential subdivisions now cover part of the remaining valley.

The NSCC has applied to the Auckland Regional Council for the renewal of resource consents for the entire treatment plant complex. The process has taken several years, and has been named "Project Rosedale". The

renewal of consents for the dam comes under the umbrella of Project Rosedale. During the resource consent process, potential discharges from the emergency spillway to the downstream waterways have been a significant issue with some of the stakeholders.

Dam hazard

In terms of statistics alone the dam would be rated a Medium hazard dam by the present NZSOLD guidelines. The rating increases to High when the consequences of a failure on the downstream environment are considered. The dam and treatment plant complex are now surrounded by residential and industrial suburbia.

Immediately downstream of the highest part of the dam there has been significant commercial and industrial development. Residential subdivisions are still being constructed adjacent to the downstream watercourse. In terms of impact, a failure on the highest dam section would be most severe. A breach on a lower dam section could also be significant. A breach on the northwest

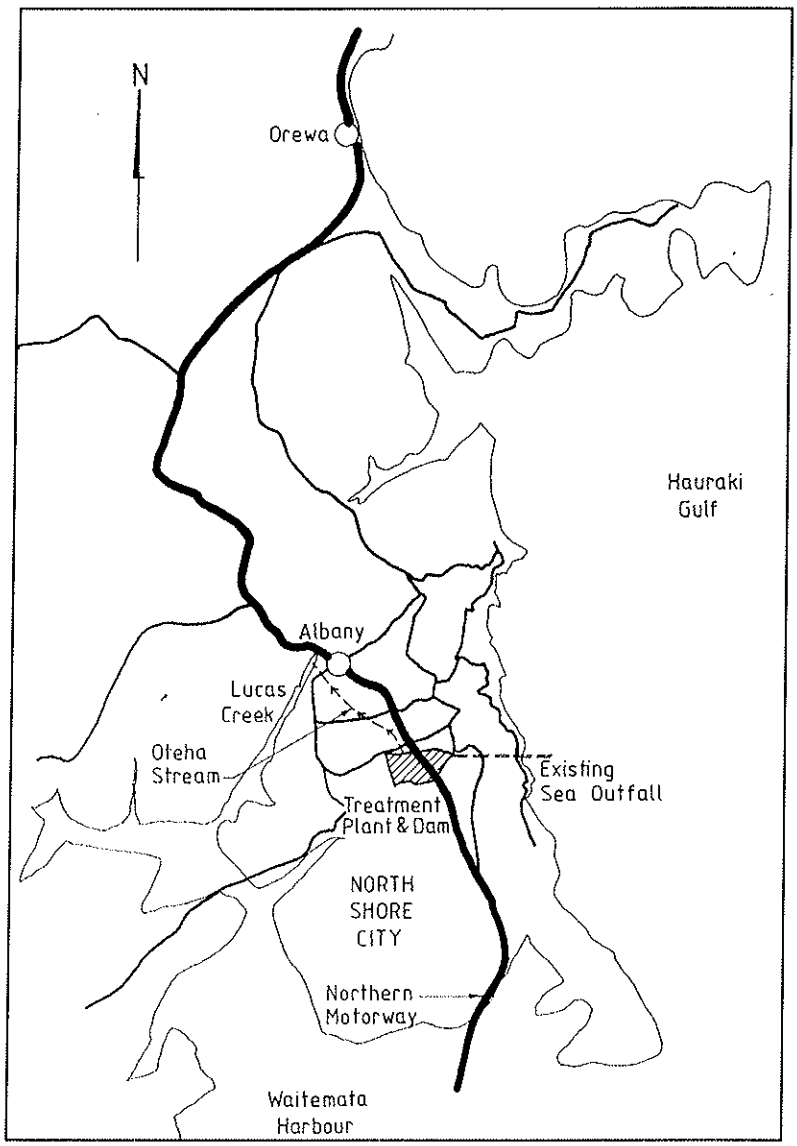
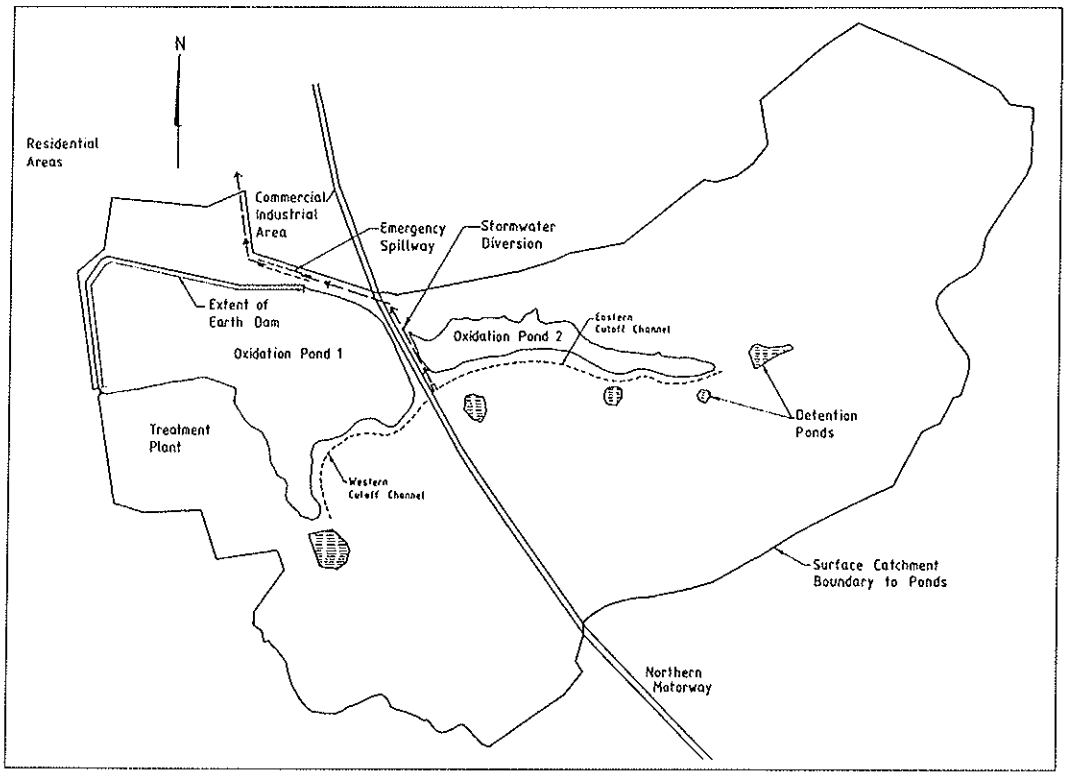


Figure 2. Locality plan for the Rosedale Dam.

Figure 3. Extent of the dam, and its main features.



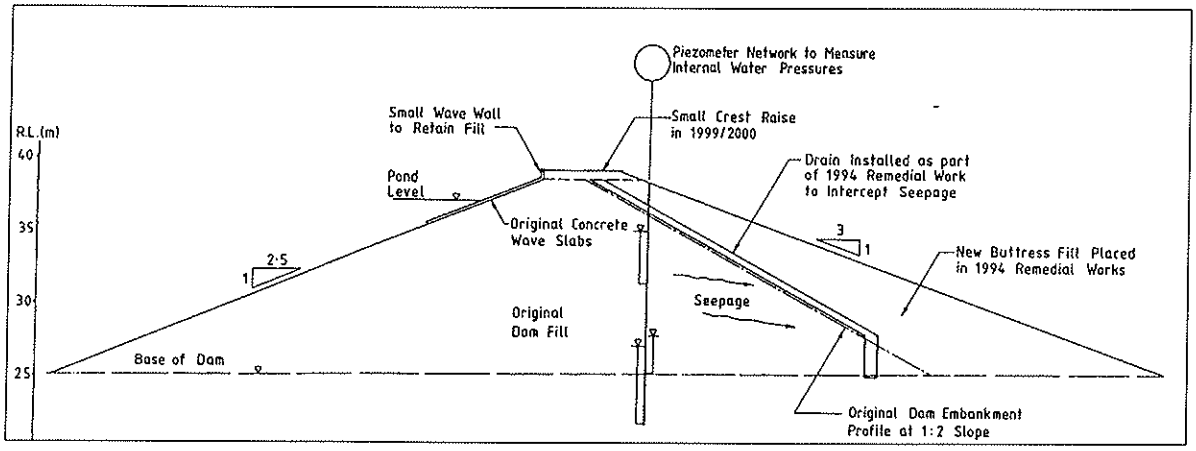


Figure 4. Typical cross-section of the Rosedale Dam.

corner of the dam would flow towards a tributary of the main stream. The flow path at this breach location would cross the treatment plant access road, a council reserve adjacent to the dam, and may also affect the adjoining residential properties.

The importance of reassessment of hazard ratings is emphasised in the NZSOLD Dam Safety Guidelines. It would be interesting to re-assess many of the hazard ratings of flood detention dams located in urban areas in New Zealand. Many of these seemingly innocuous structures could be considered significant or even high-hazard structures due to the consequences of a failure, when they were full, in an urban area.

Dam stability

General

At the time NSCC took over responsibility for the dam, there had been no recent expert evaluation of the dam. In terms of modern standards, many of the key design and construction aspects of the dam were inadequate. The most critical deficiencies were:

- The fill materials were of variable quality and strength, indicating poor standards of construction and quality control.
- The internal drainage consisted of toe drains, which in the critical areas were not functioning adequately. High water pressures were evident on the dam's downstream shoulder, consistent with the poor quality fill and inadequate internal drainage.
- There was no formal monitoring of the dam.
- There was little or no background documentation, such as design or construction reports or as-built drawings.

Dam remedial works

The first geotechnical examination of the dam was undertaken in 1992 after concern was expressed by NSCC personnel who work at the treatment plant about excessive seepage on the downstream face of the embankment. This initial investigation found that the concrete diversion culvert was cracked and that urgent work was required to prevent erosion of embankment materials. Remedial works were undertaken in 1993 and resulted in injection of significant volumes of grout into the suspected void in the embankment.

After these works were completed a SEED examination of the dam was recommended. A rating of POOR was given and further remedial works were recommended. The reason for the poor rating was that there was a recognised potential for a piping failure. Piezometric levels in the dam were high, and the embankment incorporated zones of topsoil and organic materials.

Remedial works were designed and constructed in 1994. They included:

- Excavation of poor quality material from the toe of the highest section of the dam in strips and replacement with a compacted GAP 35 scoria material.
- Widening the dam crest by 3 m and flattening the downstream batter to 3:1.

- Incorporating a filter blanket between the existing dam and the new fill on the downstream shoulder. This connects to a toe filter drain which allows for seepage monitoring.
- Extension of the culvert to allow for the additional downstream fill.

Monitoring of the new drains indicates that seepages are low at less than 0.5 litres per minute. Piezometric levels within the original dam embankment do not appear to have been significantly lowered by the filter drain; however, the drain ensures that seepage does not emerge at high levels on the downstream batter.

Flooding risks

The lake has a surface water catchment of about 200 ha. Inflows to the lake occur from treated effluent (up to around 3 cumecs in wet weather), and from stormwater in extreme circumstances when the capacity of the diversion pipe of around 5 cumecs and the stormwater detention ponds in the upper catchment are exceeded. Reservoir outflows are limited by the capacity of the tunnel outfall to the Hauraki Gulf of about 1.0 cumecs. A grassed emergency spillway was incorporated in the original design to prevent the dam overtopping in extreme circumstances, but has not operated since the mid sixties when the stormwater cutoff drains were installed above the lakes. However, the spillway came close to operating in heavy rains in the winter of 1998 and 2000. These recent events, the resource consent renewal process and a review of the flood hydrology highlighted the following aspects:

- With the rapid downstream development and increased environmental awareness, a discharge of treated effluent into the downstream waterways from the spillway was viewed by some as highly undesirable.
- Modern safety criteria require that the spillway can pass the PMF without overtopping the dam. In order to safely discharge the PMF the dam crest level would have to be raised and the spillway improved.
- Although many downstream stakeholders were very aware of the presence of the spillway, many of the immediate neighbours to the grassed emergency spillway were totally unaware of its presence and its intended function.
- A grass spillway has a more environmentally friendly appearance than a concrete structure which has an obvious intention to pass large quantities of water!

The raising of the earth dam and improvements to the spillway were undertaken in the 1999/2000 summer. The main elements of the works were:

- The dam crest was raised by about 600 mm for greater flood freeboard and wave run-up resistance, and to discharge the PMF without overtopping the dam.
- The grassed emergency spillway was improved by regrading, gabion protection, grass reinforcement utilising Tensarmat, and improved geometry. The PMF design flow was 25 cumecs, or 0.8 m^3/sec/m of crest length.
- A small concrete wave wall retained the additional fill on the dam crest.

The upgrade works required resource consents from Auckland Regional Council (ARC) and North Shore City Council and a building consent. The ARC consents were granted on a non-notified basis. Three independent commissioners were appointed by NSCC to evaluate the land use application for the works. These were granted on a non-notified basis when the approval of all adjacent landowners to the spillway area and the local iwi was gained.

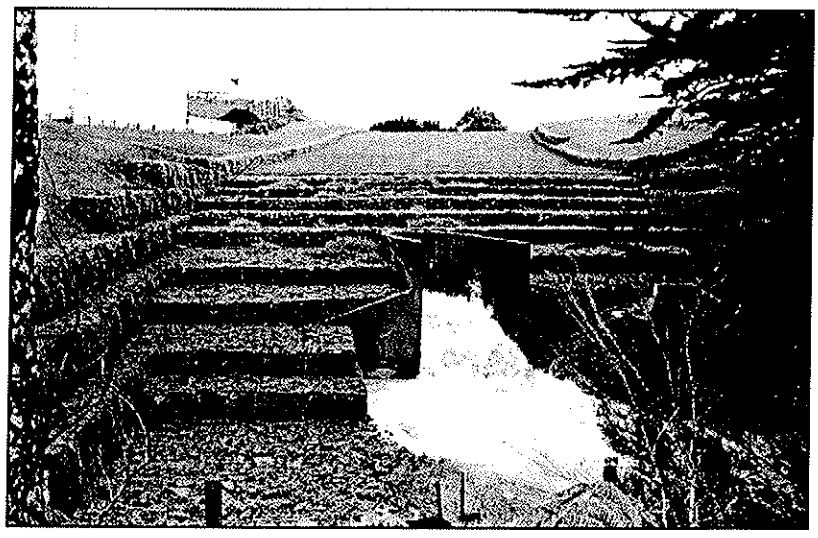


Figure 5. Emergency spillway, stormwater diversion operating.

Project Rosedale

Project Rosedale was established by NSCC to obtain consents under the Resource Management Act (RMA) to allow continued operation and development of wastewater treatment and treated effluent re-use and disposal facilities for the city. Project Rosedale is being coordinated with Project Care, a second project established by NSCC to protect the City's beaches. Over a period of several years an extensive consultation process was undertaken, and a wide range of alternatives considered. The application has been lodged with the Auckland Regional Council, and the hearing is expected in late 2000. Consents are required for the dam structure, and to discharge excess flows via the emergency spillway.

Many of the improvements resulting from Project Rosedale will also have a beneficial impact on dam safety. These include:

- Providing additional storage within the lakes by lowering the normal operating level.
- A new final effluent pipeline to the coast and an ocean outfall from the lake is envisaged, which will have significantly greater capacity that the existing outfall (4 to 6 cumecs versus 1 cumec). This will also enable the disused existing outfall to be used to augment the stormwater system at all times other than when maintenance is planned on the new pipeline.
- Further stormwater control measures will provide additional storage, by raising the existing stormwater channel and raising an existing stormwater detention pond. Although the main benefits of the above works are environmental, the combined effect is to reduce rises in the lake level compared to the existing situation.

The consultation process highlighted that there would be strong opposition to effluent discharges to the Oteha Stream via the emergency spillway. Oteha Stream ultimately discharges into Lucas Creek and the upper Waitemata Harbour. This opposition has influenced the decision to minimise the risk of overflows occurring by the planned capacity improvements described above. However, the essential need for an emergency spillway for a high-hazard earth dam was eventually accepted.

Dam management

Routine monitoring and surveillance of the dam is undertaken by Riley Consultants Ltd under contract to NSCC. As the various investigations and upgrading works have been undertaken over a relatively short time span the monitoring regime has evolved to the present time. Recent investigations have been undertaken to further resolve areas of uncertainty, and to provide additional monitoring points. The present monitoring regime includes:

- A series of piezometers in 7 machine drill holes, concentrated at key locations.
- Measurement of drain flows from the new filter drains, and the section of the original drains which are still operable.
- Physical inspection at regular intervals.

Conclusions

The hazard rating of the Rosedale dam has escalated from medium to high because of rapid downstream development since the dam and treatment plant complex were commissioned in the 1960s. The importance of continual re-assessment of the hazard rating is highlighted in the NZSOLD dam safety guidelines. Many seemingly innocuous flood detention dams are located in urban areas in New Zealand. It could well be that the hazard rating of these structures is underestimated if evaluated under dam design criteria such as the NZSOLD guidelines.

The increased hazard rating, along with significant inadequacies identified in the original dam design and construction, has prompted major upgrade works on the dam.

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