Paradise Dam: Decisions on risk, obligation, and demolition

A framework for managing risk So Far As Reasonably Practicable (SFARP)

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Paradise Dam Overview

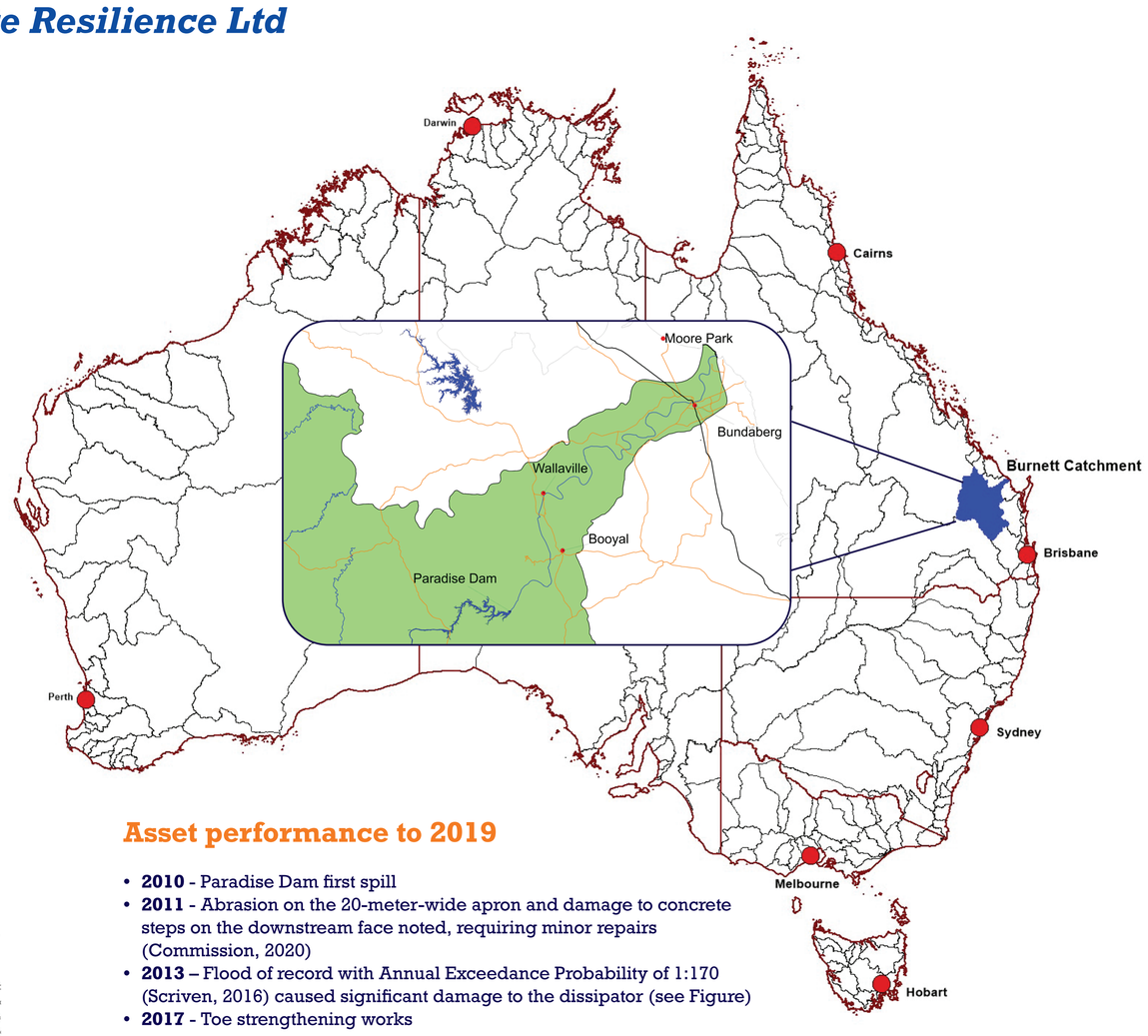
- **Location** - Paradise Dam is situated upstream from Bundaberg, Queensland, along the Burnett River approximately 250km northwest of Brisbane
- **Catchment area** - 31,000km^2, with elevations ranging from 1000 meters Australian Height Datum (mAHD) to sea level
- **Climate** - Sub-tropical with a November to April wet season
- **Flood history** - Major events in 1893, 1942, 2011 and 2013 (Bureau of Meteorology, 2019)
- **Capacity** (design) was 300,559 Mega Litres (ML) with outlet works capable of passing 270m3/s
- **Structure** - Roller Compacted Concrete (RCC) gravity dam, constructed between October 2003 and December 2005 for irrigation
- **Primary spillway** stands 30.8 meters above the foundation
- **Category** - Extreme consequence with a population at risk of 4,434 individuals as of 2022 (Sunwater, 2022)
- **Unusual** – at PMF, dam is close to being drowned meaning highest incremental failure comes from more frequent floods
- **Delivery model**: Burnett Water was established to oversee dam construction, with ownership transferring to Sunwater in 2005

2019 new information

Roller Compacted Concrete
- 2019 testing revealed probable widespread debonding and segregation zones
- The assessed lift joint shear strength (friction angle) was 39°, indicating only residual unbonded shear strength (no cohesion) likely caused by construction issues

Updated hydrology focused on three areas
- **Frequency of the PMP** using new Research on estimates of the Probable Maximum Precipitation (Nathan, 2015)
- **Archives** - a thorough review of archive information uncovered a number of flood peaks previously not identified
- **Paleohydrology** study of slack water deposits. Results dated several floods at the damsite in 1088, 1307, 1507, 1643, and 1737 (Sunwater, 2021)

Stability analysis
- Revised information on lift joints showed a factor of safety below 1 during a repeat of the 2013 flood and marginal factors for more frequent floods



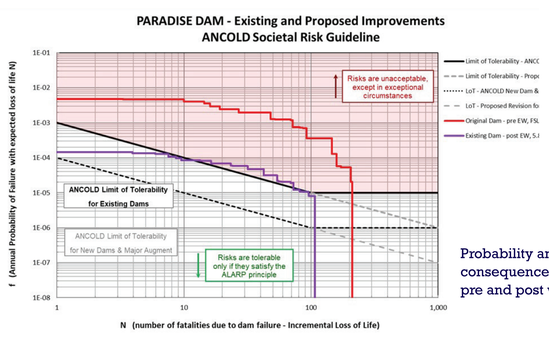
Asset performance to 2019

- **2010** - Paradise Dam first spill
- **2011** - Abrasion on the 20-meter-wide apron and damage to concrete steps on the downstream face noted, requiring minor repairs (Commission, 2020)
- **2013** – Flood of record with Annual Exceedance Probability of 1:170 (Scriven, 2016) caused significant damage to the dissipator (see Figure)
- **2017** - Toe strengthening works

The Problem – Demonstrating appropriate risk management

Duty of Care Context
- New information required risk assessment revision
- Real prospect of a failure in a repeat of the 2013 event
- Structural mitigation wasn't feasible prior to the 2019-2020 wet season
- Industry ALARP guidance was problematic as requirements to manage risk ALARP still apply above precautionary limits

SFARP Vs ALARP
- ALARP and SFARP require demonstration of a process
- ALARP and SFARP should have the same outcomes
- Context of decision makers, timing, and information mean they are not the same
- ALARP has 3 variables. SFARP has 1
- Both require a detailed record keeping exercise with demonstrable boundary on what is regarded as practicable
- SFARP is relevant bar dam owners
- Likelihood and consequence ideas were the focus – including engineering



Probability and life safety consequence of the dam pre and post works

Flood of record - January 2013

Downstream damage - February 2013

Action taken on consequence

Emergency Action Plan revision
- Trigger levels set on time required for decson making implementation
- Post failure planning required to manage risk SFARP that included sourcing temporary mobile towers to ensure communication channels

Flood Prediction and Monitoring
- Focus on redundancy and ensuring continued supply of information during any failure
- Gauge boards installed with a cameras to reduce risk from traditional pressure line gauging stations
- Locations identified for safe reading on gauge boards at key locations in the event of equipment loss

Warning and communication
- Focus on areas with poor mobile reception. Siren installed with 6km range
- Pre-prepared radio broadcast text included briefing of media organisations
- VHF radio installed to link with disaster network ensuring communication channel

Action taken on likelihood

Multiple options considered for structural risk reduction

Decision to reduce the height of the primary spillway by 5.8 metres was based on
- Water security and supply
- Future options given unknowns
- Frequency of failure (1:200 to 1:5000, annual chance)

Sequencing of works
- Sequencing of works went through several iterations to minimise risk profile
- Choice of flat crest reduced exposure time

Reduction in reservoir level - temporary full supply level
- Provided confidence for downstream communities
- Site response time for inflows
- Outlet works refurbishment brought fwd to ensure maximum capacity for controlling lake fro smaller inflows

A Spillway crest demolition - July 2020
B - Works underway July 2020
C - Cut down Ogee visible
D - First spill November 2021

SFARP Framework

A SFARP framework was required demonstrating clear, justifiable decision making, reflecting organisational risk appetite with appropriate record keeping.

SFARP framework
1. Ideas generation for risk reduction should come from a broad cohort
2. Assume 'on paper' approval for the risk reduction idea
3. Any decision to not proceed with an idea required documented reasoning
4. Solutions must be specific to Paradise Dam and downstream

Outcomes
- It engaged the organisation. All ideas were accepted. Everyone had a voice
- Risk appetite became a conversation that could be escalated
- A documented process that established 'practicable' boundaries
- Ideas required approval to not proceed; a contrast to a traditional approach
- Outcomes aligned with legal requirements
- Bespoke

Learnings: Managing Risk So Far As Reasonably Practicable (SFARP) learnings

Culture and inclusive decision environments are a pre-requisite for dam safety risk management.

Risk management SFARP requires input from engineering, disaster, legal and corporate professionals.

Like ALARP, SFARP requires ongoing demonstration of a process. It is not a destination.

ALARP has 3 variables, SFARP has 1 variable.

To assess a risk management in SFARP, its necessary to assume failure has occurred.

There is no formula for SFARP or ALARP. Each decison is based on the judgment of risk owners and is unique to the location and owner.

Engage: downstream population at risk must know their risk, and how it changes.

SFARP has a greater focus on actuals as opposed to estimates associated with ALARP. It also includes some post event arrangements.

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