DEVILS GATE DAM

Tasmania

Submission for an

HISTORIC ENGINEERING MARKER

from

The Engineering Heritage Committee
Tasmania Division
The Institution of Engineers, Australia

September 2000

DEVILS GATE DAM

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INTRODUCTION

Devils Gate Dam was built on the River Forth in north-western Tasmania, at a deep and narrow gorge shown on the aerial survey map as the Devils Gate. The site was originally known as Hells Gates but there were several of those elsewhere in Tasmania. The purpose of the dam is to provide water at a high head to the adjacent 60 MW hydro-electric power station which forms part of the Mersey-Forth Power Development.

The Dam

Devils Gate Dam is a fine example of a modern arch dam and is one of the thinnest arch dams for its height (84 m) in the world. It is the third highest arch dam built in Australia after Gordon Dam (140 m) in Tasmania and Tumut Pond Dam (86 m) in the Snowy Mountains Scheme.

Design commenced in 1964 and the dam was completed in 1969. Both the design and construction were carried out by the then Hydro-Electric Commission, Tasmania (now known as the Hydro-Electric Corporation, Tasmania).

The small thickness of the arch (5.1m at the base, reducing to 2.1m at the crest) and the resulting economical concrete volume of 22 000 cubic metres were made possible by the following:

- the narrow gorge;
- careful geological mapping of imperfections in the rock abutments, aided by photogrammetric survey;
- the resulting confidence in safely adopting high contact stresses between the arch concrete and the rock abutments;
- the use of a double-curvature shape, the most efficient shape for resisting water loads, and
- the calculation of arch stresses and deflections, using a large computer program developed in-house by the HEC.

This computer program enabled the complex mathematical calculations for the whole range of load combinations (water, gravity and temperature loads) to be carried out in a few days, whereas manual calculations of two or three load cases would have required several engineer-years.

As an additional check on the correctness of the design calculations, two 600mm high plaster models of the dam were built, one at the Portuguese LNEC laboratories in Lisbon and the other by the HEC in Hobart. The accurately carved models were loaded with mercury to simulate water pressure at this scale. Dial gauges measured deflections and electric strain gauges glued to the plaster measured strains. These measurements were then converted to deflections and stresses for the full size dam. The development of the plaster model laboratory by the HEC was in itself a significant achievement.

The Spillway

Floods up to 2040m^3/s with a surcharge of 4.5m are allowed to fall freely from the dam crest, making it one of the world's largest spillways of this type.

When floods of this magnitude impact on the concrete-lined rock at the base of the dam, they have great erosive potential. To avoid erosion, the spillway was lengthened as much as possible so that a significant amount of the falling water landed on the steep sides of the gorge. The rock in the impact area was armoured with concrete slabs which were oriented so that the two deflected jets of water, one on each bank, were directed towards each other. The resulting collision destroyed most of their energy before they fell to the base of the dam. The behaviour of the water was determined on a model of the spillway in the HEC's hydraulic model laboratory at the University of Tasmania.

A similar arrangement was adopted at Bendora Dam (ACT, 1961) for a smaller flow and a lower head.

Construction

During construction, foundation problems arose in the form of free graphite (a low friction material) in the rock at the base of the dam. It was also known that weak rock occurred in the top six metres of one abutment. Concerns in both areas were overcome by anchoring the dam foundation with steel prestressing cables. On the right abutment there was a loose shell (or "onion peel") of rock beneath part of the spillway slabs and it too was stabilised with prestressing cables.

Concrete was delivered to each pour of the arch dam by an overhead cableway and flying fox suspended from three towers. By playing out or reeling in steel suspension cables from the various towers, the flying fox could be positioned over any part of the dam and spillway to deliver concrete just where required. This system was designed by HEC engineers and is probably unique.

Aesthetics

The relatively narrow reservoir (Lake Barrington) nestles in a 100-200m deep thickly timbered gorge. On the east the gorge is below the rich rolling plateau of the Sheffield district with its reddish-brown soils. On the west the gorge is ringed by outcrops of chert rock.

The arch dam is very picturesque, not only where the curved crest is viewed against the reservoir and the backdrop of timbered hills, but also where the spectacular overhanging downstream face is framed by the near-vertical rocky gorge. At the dam the rock of the gorge remains in view for 50m or so above the dam crest.

During small floods, overtopping is confined to the central 60m of the crest and the free-falling nappe adopts a classical shape before it splashes against the concrete apron below. At larger floods the overflow is much wider and the power of the falling water becomes apparent. The spill is awe-inspiring if not some what disturbing.

Public amenity

The reservoir, Lake Barrington, is 20km long and is generally sheltered from the prevailing winds. An international-standard rowing course has been established in a 3km long straight stretch of the lake with lanes marked by lines of buoys attached to submerged steel cables. One sloping bank forms a natural grandstand, while the viewing area has been landscaped and appropriate facilities have been provided for the rowers. The course has been first choice for State championships and national Kings Cup regattas in Tasmania. In 1990 the course received international acclaim when the World Rowing Championships were held on the lake

Main dimensions:	Dam type	Thin double-curvature concrete arch
	Height	84m
	Length	134m
	Thickness	2.1m at the crest
		5.1 at the base
	Concrete volume	22,000m^3 in the shell
		31,000m^3 overall.
	Spillway capacity	2040m^3/s
	Storage volume	180,000ML
	Lake area	7km^2

Commemorative Plaque Nomination Form

Date.....***September 2000***

To:

Commemorative Plaque Sub-Committee
The Institution of Engineers, Australia
Engineering House
11 National Circuit
BARTON ACT 2000

From…***Tasmania Division***
Nominating Body

The following work is nominated for an ***Historic Engineering Marker***

Name of work.....***DEVILS GATE DAM***

Location, including address and map grid reference if a fixed work.....***On the Forth River, 20km south of Devonport. Grid ref***: ***E 438400 N 421900 Tas Map Sheet 8115 Scale 1:100,000***

Owner.....***Hydro-Electric Corporation***

The owner has been advised of the nomination of the work and has given approval:

Copy of letter attached

Access to site.....***by road from Devonport***

Future care and maintenance of the work.... ***Will be maintained by the Hydro-Electric Corporation as part of the Mersey-Forth Power Development.***

Name of sponsor.....***Engineering Heritage Committee, Tasmania Division***

……
Chairperson of Nominating Committee

……
Chairperson of Division Heritage Committee

ADDITIONAL SUPPORTING INFORMATION

Name of work..... ***DEVILS GATE DAM***

Year of construction or manufacture..... ***Completed 1969***

Period of operation ..... ***Continuous since 1969***

Physical condition ..... ***Excellent***

Engineering Heritage Significance:

Technological/scientific value …… ***Yes***

Historical value ..... ***Yes***

Social value ..... ***Yes***

Landscape or townscape value..... ***Yes***

Rarity..... ***Yes***

Representativeness ..... ***Yes***

Contribution to the nation or region..... ***Yes***

Contribution to engineering..... ***Yes***

Persons associated with the work..... ***Yes***

Integrity..... ***Yes***

Authenticity..... ***Yes***

Comparable works (a) in Australia..... ***Yes***

(b) overseas..... ***Yes***

Statement of significance, its location in the supporting doco… ***Next page***

Citation (70 words is optimum)…..

HISTORIC ENGINEERING MARKER

DEVILS GATE DAM

COMPLETED IN 1969, THIS 84M HIGH CONCRETE ARCH DAM IS ONE OF THE THINNEST ARCH DAMS IN THE WORLD. THE NARROW GORGE, THE DOUBLE-CURVATURE SHAPE AND STRESS ANALYSIS BY COMPUTER ENABLED ENGINEERS TO REDUCE THE CONCRETE VOLUME TO 22,000m^3. FLOOD WATERS FALL FREELY FROM THE CREST ONTO CONCRETE SLABS WHICH PREVENT EROSION OF THE VALLEY SIDES AND UNDERMINING OF THE DAM.(76 words)

Dedicated by the Institution of Engineers, Australia 2001

Attachments to submission (if any)..... ***See contents***

Proposed location of plaque (if not a site)..... ***Not applicable***

CROTTY DAM

STATEMENT OF SIGNIFICANCE

GENERAL

Crotty Dam has been nominated for listing on the Register of the National Estate. For that purpose a comprehensive Nomination was prepared in accordance with Australian Heritage Commission requirements. In that document the heritage significance of the dam was tested against nine National Estate criteria. Much of the material for this submission has been extracted from that document.

TECHNOLOGICAL/SCIENTIFIC VALUE

Devils Gate Dam is a fine example of a double-curvature concrete arch dam and is one of the thinnest arch dams in the world. Its overhanging downstream face and its large spillway clearly show the advances in engineering technology in the 113 years since construction of the Parramatta Dam, Australia's pioneer arch dam built in NSW in 1856.

The availability of a stress analysis program written by HEC engineers shortly before Devils Gate Dam was designed saved many engineer-years of manual computations. While the program used the trial load method developed by the US Bureau of Reclamation, the HEC program was running before the USBR had written the code for their version.

Because of its complex shape, a mass of setting out data was required for construction, and these computations were also carried out efficiently on a mainframe computer.

The capacity of the free fall spillway is very large by world standards and the dissipation of the energy of the falling nappe was an innovative solution although somewhat similar to the arrangement adopted at Bendora Dam (ACT, 1961).

The construction of the dam presented many challenges, including the excavation of the steep abutments, and the forming of the arch dam overhang. A novel three-tower cableway was designed to suit the site topography and provide full coverage for the delivery of concrete to the dam and spillway.

HISTORICAL VALUE

The dam represents the state of the art of arch dam design at the time. It was only the second dam to take advantage of the HEC stress analysis program.

SOCIAL VALUE

Lake Barrington, the reservoir created by Devils Gate Dam, is the site of a rowing course which is the first choice for Tasmanian rowing regattas and which attracted international acclaim when its hosted the World Rowing championships in 1990.

LANDSCAPE VALUE

The dam is readily seen from an access road on the right bank. The arch dam makes a good picture, not only for its curved crest and attractive lake, but also for its overhanging face and the free-falling water during floods.

RARITY

It is the third highest arch dam in Australia. See list under comparable works.

REPRESENTATIVENESS

While it is representative of nine double-curvature arch dams in Australia, it is easily the thinnest.

CONTRIBUTION TO NATION OR REGION

The construction of the Mersey-Forth Power Development in the period 1965-74 provided productive employment and an economic boost to the north-west region of Tasmania. On completion Devils Gate power station has contributed valuable energy for the State's power system, using a renewable resource.

CONTRIBUTION TO ENGINEERING

A paper describing the Devils Gate spillway (and two other spillways) was presented at 13th Congress of the International Commission on Large Dam in New Delhi in 1979.

PERSONS ASSOCIATED WITH THE WORK

The following HEC engineers were associated with the work:

Gordon Colebatch	Chief Civil Engineer
Harry Thomas	Deputy Chief Civil Engineer
John Wilkins	Engineer for civil Design (later Chief Civil Engineer)
Bill Mitchell	Engineer Design Group 3 (later Chief Civil Engineer)
Jack Fidler	Section Engineer Dams
Frank Kinstler	Senior design engineer
Bruce Lord	Senior hydraulics engineer
Frank Navin	Hydraulics laboratory engineer
Mal Maddox	Civil Testing Engineer
Lloyd Lack	Structural model engineer
Guy Ward	Project Manager Mersey-Forth (later Chief Civil Engineer)
Ted Hofto	EIC Devils Gate
Wilf Weldrick	EIC Devils Gate

INTEGRITY

The dam remains in its as-constructed condition. Its behaviour in service is monitored regularly and its performance continues to be satisfactory.

AUTHENTICITY

The dam was designed and constructed by the HEC by applying the latest arch dam technology to this particular site.

COMPARABLE WORKS

(a) The nine double-curvature arch dams in Australia are listed below in date order:

NAME	HEIGHT	YEAR	STATE
Tumut Pond	86m	1958	NSW
Bendora	47m	1959	ACT
Moogera	40m	1961	Qld
Sturt	40m	1966	SA
Murray 2	43m	1968	NSW
Repulse	42m	1969	Tas

Devils Gate	**84m**	**1969**	**Tas**
Carcoar	52m	1970	NSW
Gordon	140m	1974	Tas

(b) There are many arch dams in other countries, particularly in the European alps where the topography is particularly favourable for this type of dam.

REFERENCES

1. HEC, 1964. "Mersey-Forth-Wilmot Power Development", Internal *Report*, Hydro-Electric Commission, Tasmania.

2. KINSTLER F L, 1970. "Devils Gate Dam Design Report", Internal *Civil Design Report* CDR212, Hydro-Electric Commission, Tasmania, November.

3. NAVIN W F and KINSTLER F L, 1979. "Three Tasmanian Spillways and Associated Model Studies", *Proceedings 13th International Congress on Large Dams* (New Delhi), 1979, Vol. 2, Question 50, Paper R17, pp.303-308.

Hydro

Hydro-Electric Corporation
ARBN - 072 377 158

GPO Box 355D
Hobart Tasmania 7001

4 Elizabeth Street
Hobart Tasmania 7000

Telephone (03) 6237 3400
Fax: (03) 6230 5823

Our Ref.
Your Ref.
Ask for

24 February 2000

Mr K C Drewitt
Chairman
Engineering Heritage Committee
The Institute of Engineers
2 Davey Street
Hobart Tas 7000

Dear Mr. Drewitt,

Thank you for your correspondence of 14 February 2000, advising of the eight dams which have recently been nominated for national heritage listing on the National Estate Register.

The Hydro is very pleased to approve the nominations and we look forward to hearing the outcome of the proposed public recognition awards.

With kind regards,

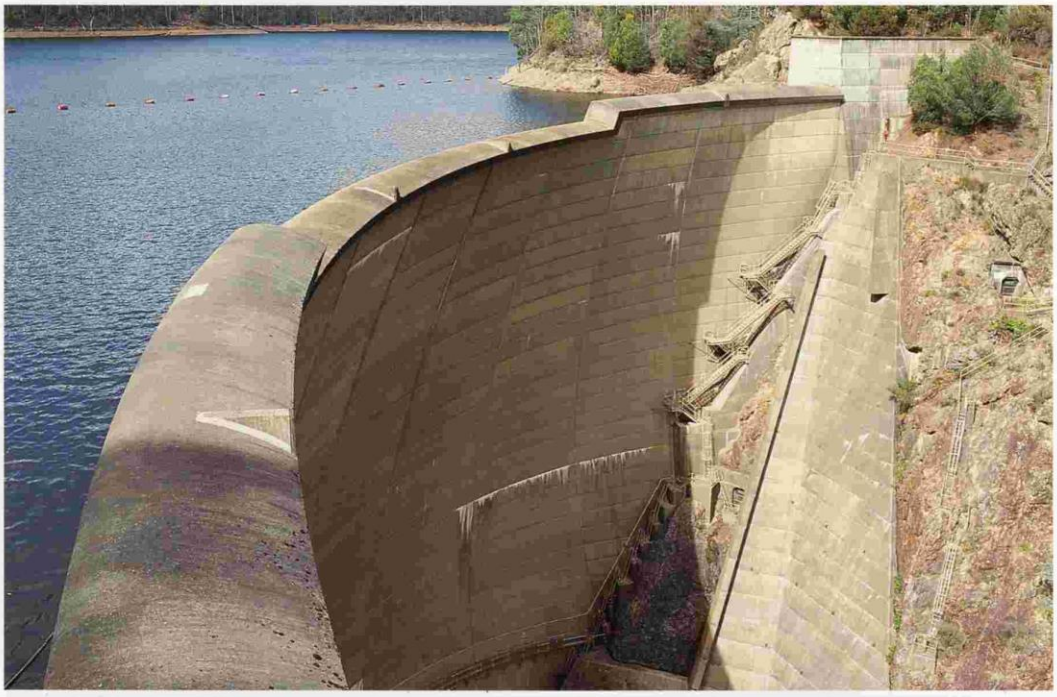
Yours sincerely,

Roger Gill
Generation Manager Generation

c.c. Andrew Pattle, Dam Safety Manager
Peter Grierson, Manager Power Schemes

DEVILS GATE DAM

AUSTRALIA



TYPE: Double-curvature concrete arch
HEIGHT: 84 m CREST LENGTH: 134 m
CONCRETE VOLUME: 31 000 m^3
STORAGE VOLUME: 180 million m^3
SPILLWAY CAPACITY: 2040 m^3/s
COMPLETED: 1969
OWNER: Hydro-Electric Commission of Tasmania

Devils Gate Dam is a double-curvature, multi-centred arch dam on the Forth River in north-western Tasmania.

The concrete thickness varies from 2.7 m thick at the top to 5.1 m at the base. The overhang at the crown of the arch is 6.9 m.

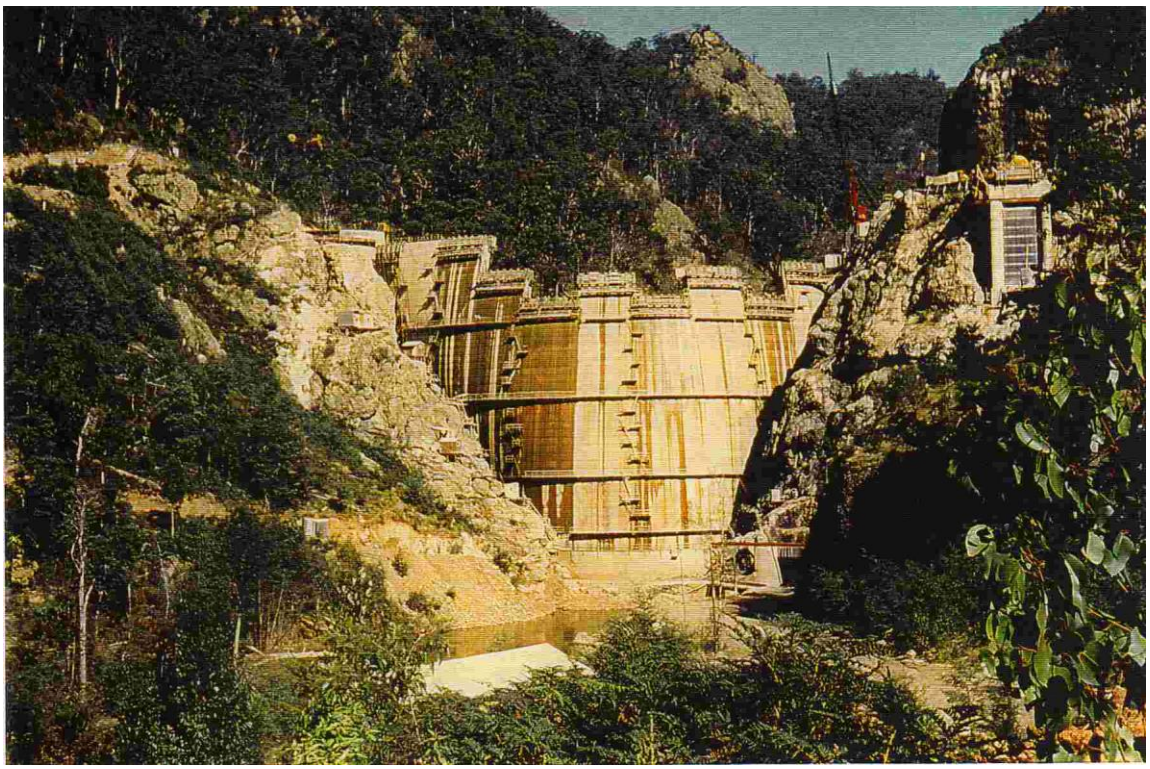
The design flood discharges at 2040 m^3/s over the crest of the arch with a surcharge of 4.9 m. Part of the nappe falls on the protected sides of the gorge, from where it is deflected to impact against the central nappe, thus dissipating a large part of the energy.

A large concrete block or pulvino was provided at the base on one abutment to improve the shape of the arch foundation. This was prestressed to the rock for added safety.

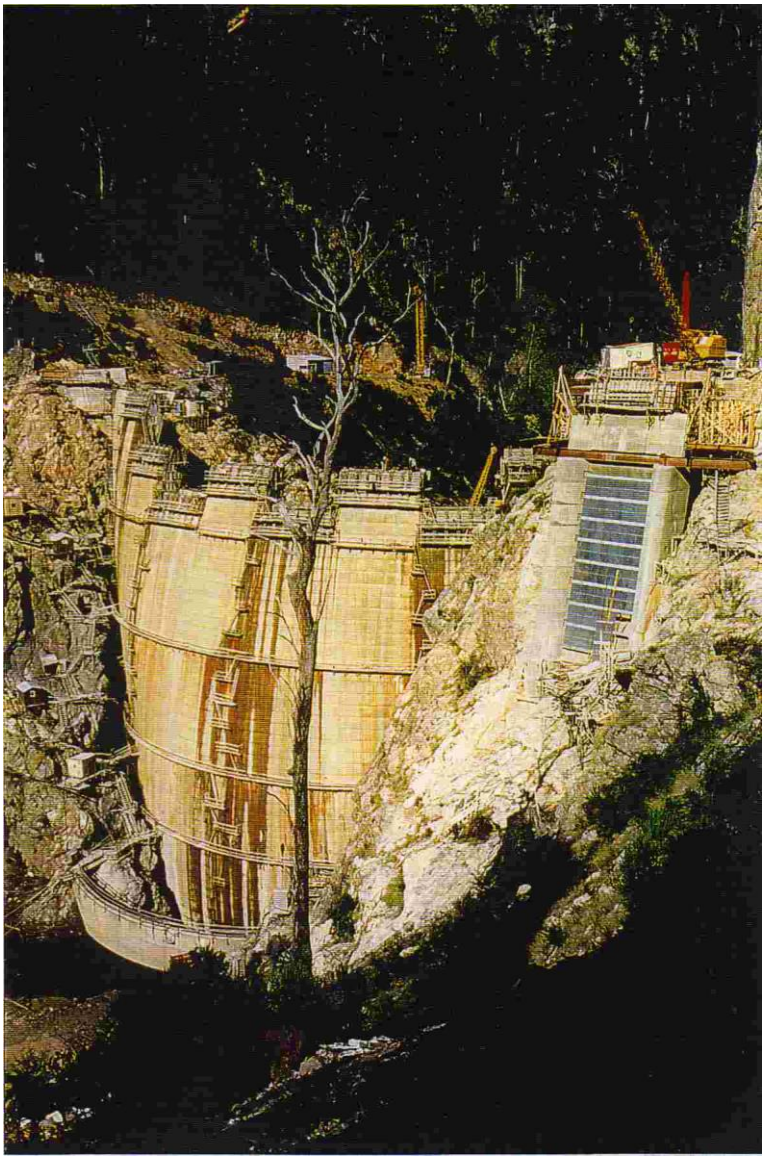
Services Provided

Feasibility study, investigations, detailed design, documentation, supervision of construction, operation and maintenance.

HEC



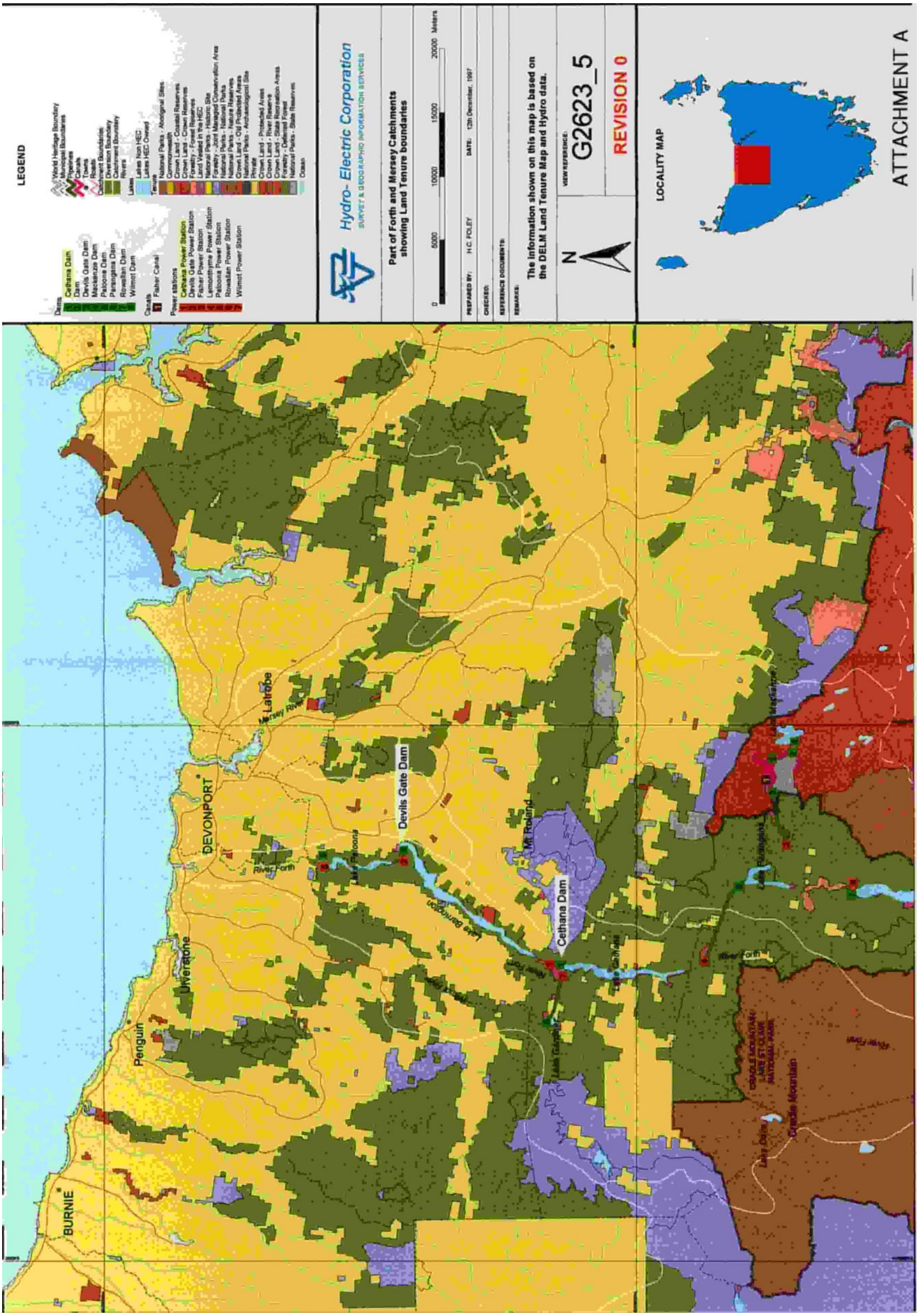
Devils Gate Dam – Upstream view during construction



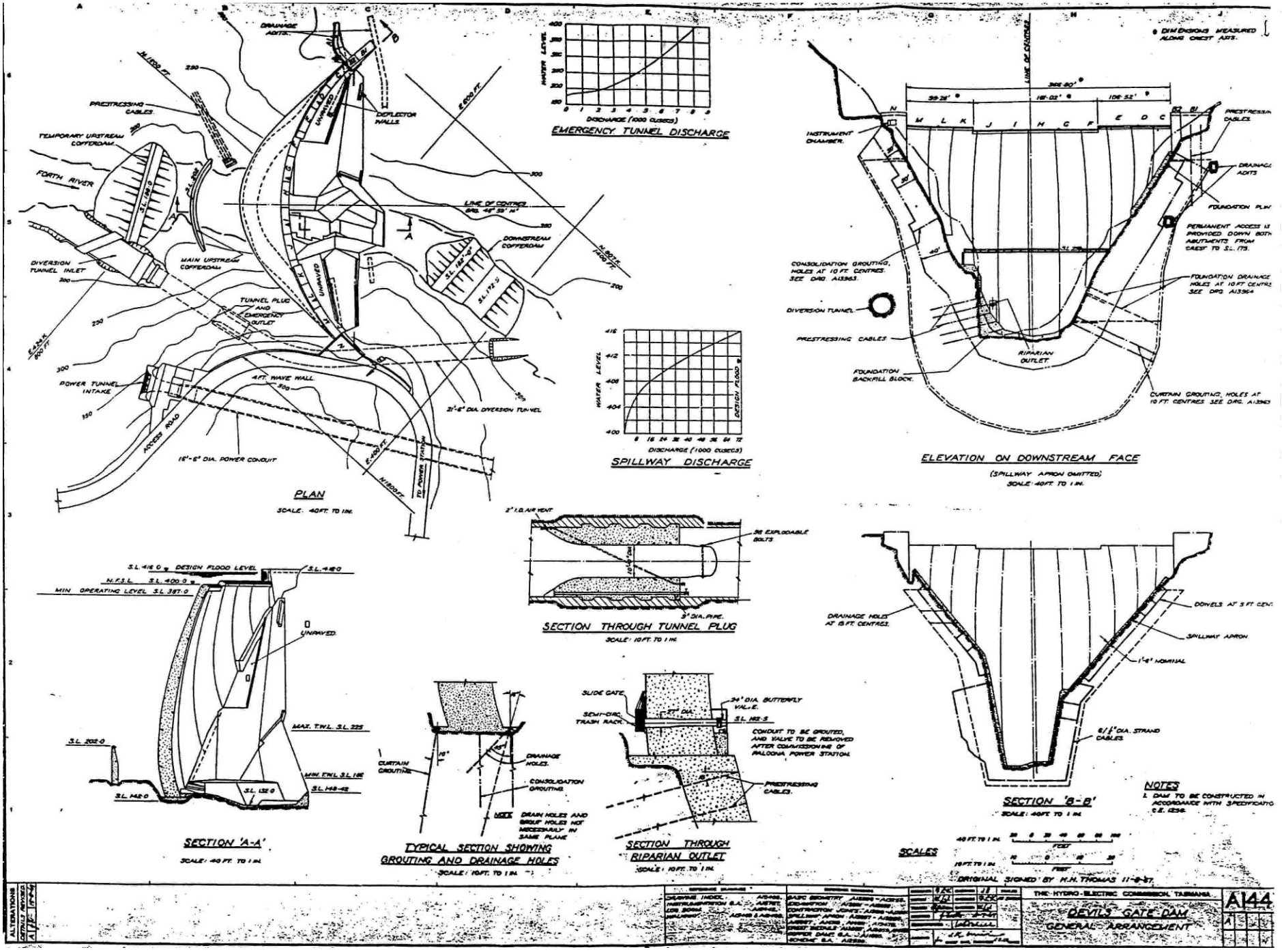
Devils Gate Dam – Upstream face during construction, with power tunnel intake trashrack on right.

Devils Gate Dam – lower spillway in operation

Devils Gate Dam – whole spillway in operation



LEGEND
Hydro- Electric Corporation
SURVEY & GEOGRAPHIC INFORMATION SERVICES
Part of Forth and Mersey Catchments showing Land Tenure boundaries
0
5000
10000
15000
20000
Meters
PREPARED BY: H.C. FOLEY
DATE: 12th December, 1997
CHECKED:
REFERENCE DOCUMENTS:
REMARKS:
The information shown on this map is based on the DELM Land Tenure Map and Hydro data.
N
VIEW REFERENCE:
G2623_5
REVISION 0
LOCALITY MAP
ATTACHMENT A
BURNIE
Penguin
Ulverstone
DEVONPORT
Latrobe
Mersey River
Devils Gate Dam
River Forth
Lake Paloona
Lake Barrington
Mt Roland
Cethana Dam
Lake Cethana
River Forth
Cradle Mountain
Lake Dove
CRADLE MOUNTAIN-LAKE ST CLAIR NATIONAL PARK


PLAN
SCALE: 40FT. TO 1IN.
EMERGENCY TUNNEL DISCHARGE
SPILLWAY DISCHARGE
ELEVATION ON DOWNSTREAM FACE
(SPILLWAY APRON OMITTED)
SCALE: 40FT. TO 1 IN.
SECTION 'A-A'
SCALE: 40 FT. TO 1 IN.
SECTION THROUGH TUNNEL PLUG
SCALE: 10FT. TO 1 IN.
TYPICAL SECTION SHOWING GROUTING AND DRAINAGE HOLES
SCALE: 10FT. TO 1 IN.
SECTION THROUGH RIPARIAN OUTLET
SCALE: 10FT. TO 1 IN.
SECTION 'B-B'
SCALE: 40FT. TO 1 IN.
NOTES
SCALES
ORIGINAL SIGNED BY H.H. THOMAS 11-8-57.
THE HYDRO-ELECTRIC COMMISSION, TASMANIA
DEVILS GATE DAM
GENERAL ARRANGEMENT
A144