CATAGUNYA DAM

Tasmania

Submission for an

HISTORIC ENGINEERING MARKER

from

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

September 2000

CATAGUNYA DAM

CONTENTS

INTRODUCTION

What is a prestressed gravity dam?

A normal concrete gravity dam relies on its own weight to resist the large forces, which result from the pressure of the reservoir. In simple terms, the water pressure on its upstream face tries to overturn the dam or to make it slide downstream. Overturning is resisted by the weight of the dam and sliding is resisted by friction (also dependant on weight) between the dam and its foundation.

A prestressed dam is a gravity dam anchored to its foundation by steel cables. These cables are tensioned (i.e. prestressed) before the water load from the reservoir is applied. Otherwise the cables would stretch by up to say 150mm when the water load is finally applied, allowing the dam to rotate which would lead to other difficulties. The vertical force in the cables enables an equivalent weight of concrete to be omitted. For safety against overturning, the cables in effect attach a large mass of rock to the base of the dam and, for safety against sliding, the force in the cables ensures that the friction is maintained.

Provided the cost of the prestressing is less than the cost of the omitted concrete, there is a cost saving on the dam.

Catagunya Dam

Catagunya Dam is a 49m high prestressed gravity dam on the River Derwent in Tasmania and was completed in 1961. Its purpose is to divert the river to the Catagunya Hydro-electric Power Station 1 kilometre downstream and to provide head on the turbine. The dam is 282m long and has a central spillway with a capacity of 3600 cumecs.

The dam was designed and constructed by the then Hydro-Electric Commission, Tasmania. The Cementation Company (UK) was the specialist contractor for the supply and installation of the prestressing cables (i.e. tendons).

The technique of anchoring dams with high tensile cables was first used on the construction of the Allt-na-Lairige concrete gravity dam in Scotland in 1956. Its use was then extended to the strengthening of existing gravity dams at the Steenbas Dam in South Africa and the Waitaki Dam in New Zealand in the late 1950s. The Cementation Company was the specialist contractor at both these latter dams.

Catagunya Dam followed in 1961 using the Cementation system. Thus Catagunya was the second dam in the world designed as a prestressed gravity dam from the outset. It was also the highest at the time. At Catagunya the cost saving due to the use of prestressing was estimated to be 20 percent.

Prestressed rock anchors

Dam prestressing techniques were introduced into Australia at Catagunya. The technique has spread widely in Australia with the strengthening of many existing gravity dams including Hume, Warragamba, Manly, Chichester (NSW) and Ridgeway and Lake Margaret (Tasmania).

New structures using prestressing in Tasmania included Cluny Dam spillway, Clark Dam raising, Meadowbank Dam buttresses, and the thrust blocks at Repulse and Devils Gate arch dams.

Prestressed rock anchors have since been used for other purposes including the stabilisation of dam foundations, rock slopes, bridge foundations, etc.

Prestressing details at Catagunya

The prestressing cables are vertical and are located close to the vertical upstream face within the concrete.

In each 15m wide spillway block, there are forty nominal 200 tonne prestressing cables consisting of a bundle of 102 high tensile 5mm diameter wires, separated at regular intervals by thin wire spacers. Each cable was inserted into a 106mm diameter drill hole drilled 15m deep into the dolerite rock foundation from a high level of the dam. The holes were first filled with water and then a thick cement paste (i.e. grout) sufficient to encase the cable for a distance of 4.2m was placed at the bottom of the hole.

After the grout had set, the wires at the top of the cable were splayed out and concreted into a cylindrical stressing head about 700mm diameter. After this had hardened, three hydraulic jacks were placed under the head and then simultaneously jacked up to a load of 220 tonnes. Supports were placed under the head and the cable left on the supports under load for several days. During this time the load would fall off slightly due to a property of steel known as creep. The load in the cable was then checked and, if greater than 212 tonnes, the cable would be left on the props. Otherwise it would be retensioned to 220 tonnes and the testing procedure repeated.

For protection against corrosion the remainder of the hole including the spaces between the wires was filled with a thick cement grout. The heads were finally embedded in the dam concrete.

A proportion of the cables had electrical cables attached at each end to allow their electrical resistance to be monitored on a regular basis. An increase in resistance would indicate that the thickness of the wires was being reduced by corrosion. This has been found not to be the case.

Spillway

At Catagunya the central 125m spillway has a capacity of 3590 cumecs with a maximum surcharge of 5.1m. Floodwaters flow down the face and then are thrown clear of the dam by a curved “ski jump” to avoid any erosion at the toe of the dam.

The profile of the downstream face is practically standard for all gravity overflow spillways but, to take advantage of the thinner dam base width allowed by the prestressing, the dam crest has been designed with a 7.8m overhang upstream. The heavy concrete overhang of the crest is anchored back to the concrete below the cable heads by heavy steel reinforcement. Thus the cross section of the Catagunya is unlike any other gravity dam.

The amount of concrete saved by the prestressing is the volume under the overhang.

Prestressed abutments

Some of the highest abutment blocks were also prestressed. These blocks have a vertical upstream face and a very much steeper than normal downstream face giving a concrete section which would obviously overturn if not prestressed. Other prestressed dams have similar sections.

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 a ***Historic Engineering Marker***

Name of work.....***CATAGUNYA DAM***

Location, including address and map grid reference if a fixed work.....***On the Derwent River, 80km northwest of Hobart. Grid ref***: ***55GDP665001 Tas Map Sheet 8213.***

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 the Lyell highway near Wayatinah***

Future care and maintenance of the work.... ***Will be maintained by the Hydro-Electric Corporation as part of the Derwent River power developments.***

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

……
Chairperson of Nominating Committee

……
Chairperson of Division Heritage Committee

ADDITIONAL SUPPORTING INFORMATION

Name of work..... ***CATAGUNYA DAM***

Year of construction or manufacture..... ***1957-61***

Period of operation..... ***Continuous since 1961***

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

Engineering Heritage Significance:

Technological/scientific value..... ***Yes***

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

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

Landscape or townscape value..... ***No***

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)…..

CATAGUNYA DAM

CATAGUNYA DAM IS A 49M HIGH PRESTRESSED GRAVITY DAM. THE DAM IS ANCHORED TO THE FOUNDATION ROCK WITH HIGH TENSILE STEEL CABLES, THEREBY REDUCING THE VOLUME OF CONCRETE AND THE COST OF THE DAM. COMPLETED IN 1961, IT WAS THE SECOND DAM IN THE WORLD AND THE FIRST IN AUSTRALIA DESIGNED AS A PRESTRESSED DAM. MANY OTHER GRAVITY DAMS IN AUSTRALIA HAVE SINCE BEEN BUILT OR STRENGTHENED BY THIS MEANS. (72 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***

CATAGUNYA DAM

STATEMENT OF SIGNIFICANCE

GENERAL

Catagunya 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. Some of the material in the present submission has been extracted from that document.

TECHNOLOGICAL/SCIENTIFIC VALUE

The use of multi-wire tendons in a drilled hole was a significant advance on the technique used at Allt-na-Lairige Dam where macalloy bars were anchored in pits excavated in the foundations, and then extended upwards as the dam was constructed. The pits were expensive to excavate and the process had the potential to damage the integrity of the foundation rock.

The protective grout was mixed in a colloidal grout mixer which greatly reduced the settlement of the grout column during the setting process. However it was found at a later dam that this was not enough to prevent a few small defects in the grout column due to settlement. This problem was overcome by a methocel additive which became universally adopted. Thus later dams benefited from the initial experience at Catagunya.

The use of prestressed rock anchors has extended to the strengthening of many gravity and arch dams, and to other important applications such as the stabilisation of rock slopes, dam foundations and bridges, etc.

HISTORICAL VALUE

Catagunya Dam is the first dam in Australia and the second in the world to be designed to be anchored to its foundation with prestressed cables (not to be confused with existing gravity dams stabilised by prestressing). It was also higher than its predecessor.

SOCIAL VALUE

The village of Wayatinah was created initially for the construction of the Liapootah and Wayatinah power developments, but it also served the next four developments down the Derwent River including Catagunya. It housed both families and singlemen, and was a centre of social activities for all the residents. While the size of the village shrank when construction ended, it continues to house operation and maintenance personnel and forestry workers.

LANDSCAPE VALUE

No particular significance. The dam appears as a solid grey concrete structure astride the Derwent Valley at the site, feeding water via a flume to the power station just downstream. The various features add interest to the area.

RARITY

Catagunya Dam is relatively rare in that only four prestressed concrete dams were built in Australia.

REPRESENTATIVENESS

The dam is a good representative of its class. The slender abutment blocks and the spillway overhang make the saving in concrete readily apparent.

CONTRIBUTION TO NATION OR REGION

Catagunya Dam supplies water to the Catagunya Power Station, one of seven stations on the well-regulated Derwent River. The main benefit is in supplying reliable power to the State grid using a renewable energy resource.

For construction of this scheme and other power developments both upstream and downstream of Catagunya, a construction village of Wayatinah and singlemens camps at Wayatinah and Meadowbank were established, providing continuous employment and greatly increased economic activity in the region. After construction a much smaller number of power station operators and maintenance personnel continued to live in the area.

CONTRIBUTION TO ENGINEERING

Papers published in Australia and internationally on the design and construction of Catagunya Dam created considerable interest amongst dam engineers. The use of ground anchors extended rapidly to the strengthening of gravity and arch dams and to rock anchors in various applications, such as slope stabilisation, dam foundations, bridges etc.

Papers on the design of Catagunya Dam were published by the Institution of Engineers, Australia and the International Commission on Large Dams. The prestressing experience was shared with members of the Australian National Committee on Large Dams at annual conferences, resulting in modifications and improvements over time.

PERSONS ASSOCIATED WITH THE WORK

The following HEC engineers were associated with the work:

G T Colebatch	Chief Civil Engineer
H H Thomas	Deputy Chief Civil Engineer
J K Wilkins	Engineer for Civil Designs
J Fidler	Dam Design Engineer
M D Fitzpatrick	Engineer, Dam Design Section
K C Webster	Engineer, Dam Design Section
I G Tulloch	Engineer Civil Construction
R Franks	Resident Engineer Wayatinah
L Hughes	Engineer-in Charge Catagunya

Cementation Company (UK-Contractors)

J Carlile	Agent on site

INTEGRITY

The structure remains in good condition. The concrete is sound. There is some concern that there is no independent method of verifying the condition of the cables upon which the stability of the dam depends.

AUTHENTICITY

While the design concept came from Allt-na-Lairige Dam in Scotland in 1956, the choice of cables installed in drill holes instead of Maccalloy bars anchored in large anchor pits was a significant departure. Not only was it a much cheaper option but it avoided unnecessary disturbance of the dam foundation.

COMPARABLE WORKS

(a) The only comparable works in Australia were constructed after Catagunya Dam:

Cluny Dam spillway	Tasmania	1967	
Middle River Dam	South Australia	1968	
Porters Creek Dam	NSW	1968	

Many existing dams were strengthened using prestressed anchors:

Sooley Dam	NSW	1959	
Wyangala Dam	NSW	1968	
Awoonga Dam	Qld	1970	
Harvey Dam	WA	1971	and 16 more to 1994.

(b) Details of comparable works overseas are not known, except for Allt-na-Lairige Dam in Scotland which preceded Catagunya.

NOTE

The following pages from the Nomination for listing on the Register of the National Estate form part of this submission: page 8.

REFERENCES

1. HEC, 1956. *Report on the Catagunya Power Development*, Hydro-Electric Commission, Tasmania, Hobart.

2. J K WILKINS and J FIDLER, 1959. "Design of Catagunya Prestressed Dam", *I E Aust Civil Engineering Transactions*, Vol. 1, pp.47-64.

3. G T COLEBATCH G T and J K WILKINS, 1961. "Design of Catagunya Prestressed Dam", *7th International Congress on Large Dams Proceedings (Rome)*, Vol. 3, pp.261-288.

4. KNIGHT A W, BENJAMIN A H and COLEBATCH G T, 1962. "The development of hydro-electric power in Tasmania", *Sixth World Power Conference (Melbourne)*, Paper 65.

5. J A BANKS, 1957. "Allt-na-Lairige Prestressed Concrete Dam", *Proceedings Institution of Civil Engineers* (UK), March.

6. ICOLD, 1984. *World Register of Dams*, International Committee on Large Dams, Paris.

ATTACHMENTS

DATA SHEET

PHOTOS (page 8 from RNE nomination)

LOCATION MAP

DRAWING Catagunya Dam General Arrangement Drg A6379

NOTE: NEW PRESTRESSED CABLES IN 2010

Due to the uncertainty about the long term integrity of the cables, potentially subject to corrosion at random gaps in the protective grout caused by grout settlement, large replacement cables have been installed in 2009-2010. In the spillway the new cables are downstream of the existing tendons. In the abutments the new cables are between the existing tendons. Each new cable has a capacity of almost 2000 tonnes, about 10 times the original cable loads. The new cables are also designed to ensure stability for a substantial increase in the design flood.

Hydro

Hydro-Electric Corporation
ARBN - 072 377 158

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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,

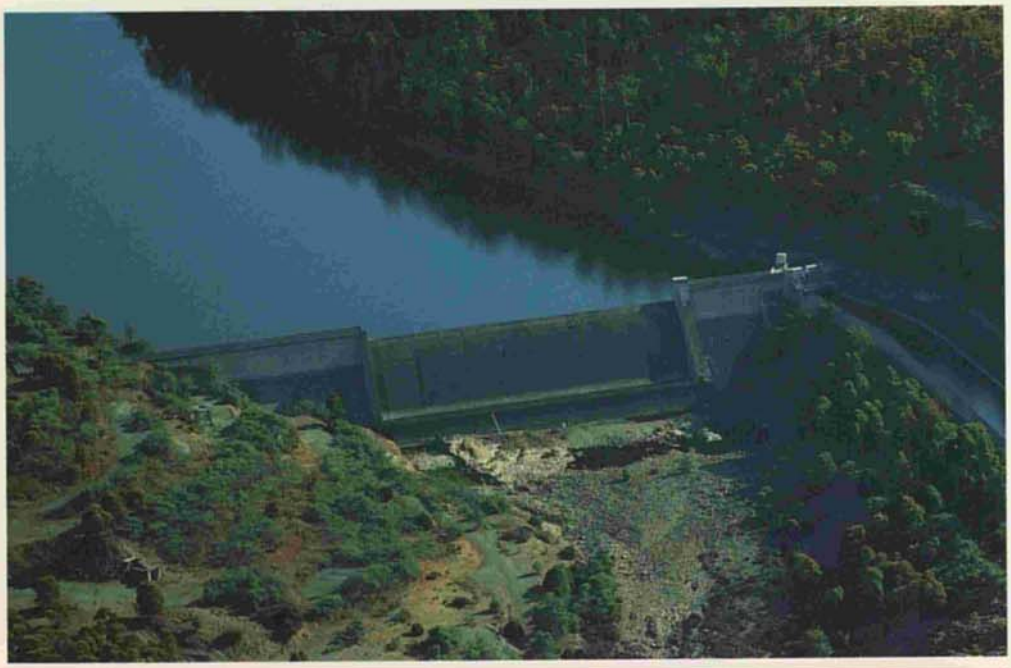
Yours sincerely,

Roger Gill
Generation Manager Generation

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

CATAGUNYA DAM

AUSTRALIA



TYPE: Mass concrete prestressed to foundation
HEIGHT: 49 m **CREST LENGTH:** 282 m
VOLUME OF DAM: 92 000 m^3
STORAGE VOLUME: 26 million m^3
SPILLWAY CAPACITY: 3600 m^3/s
COMPLETED: 1962
OWNER: Hydro-Electric Commission of Tasmania

Catagunya Dam lies on Tasmania's largest river, the Derwent, at an elevation of 125 metres above sea level. The impounded water is fed to Catagunya Power Station via a short flume and a pair of concrete-encased penstocks. Between the flume and the penstocks is a reinforced concrete structure housing twin radial gates and transitions to the circular penstock cross-section.

The dam is narrow in cross-section, with a vertical upstream face and a downstream face slope of about 1:0.65. The vertical prestressing force, which is applied just behind the upstream face, varies from zero near the abutments to 5000 kN/m across the spillway. The tendons are embedded 12 metres into the foundation, and their electrical resistance is measured periodically with a view to detecting any serious corrosion.

The spillway is a free-overflow ogee crest which occupies the central 107 metres of the dam.

Services Provided

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

HEC

Figure 1 *Catagunya Dam*

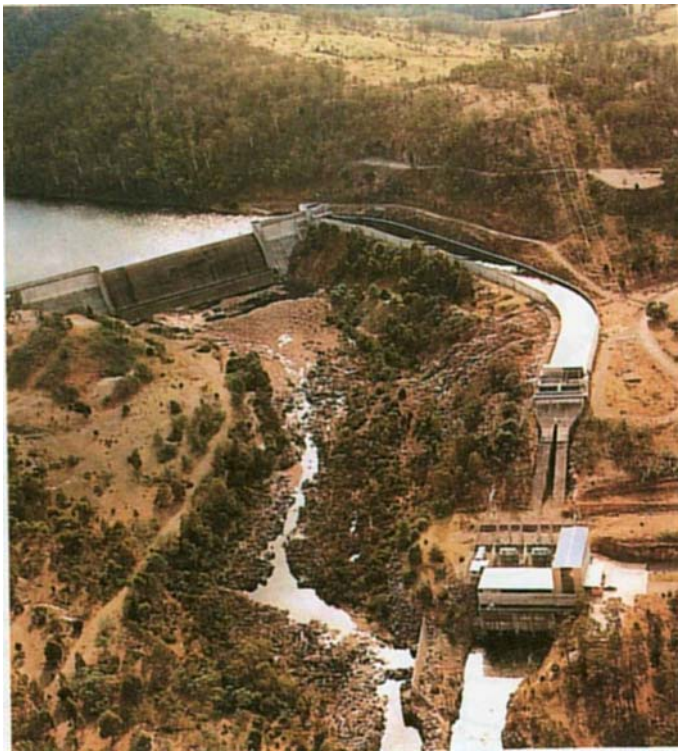


Figure 2 *Catagunya Dam, Flume & Power Station*

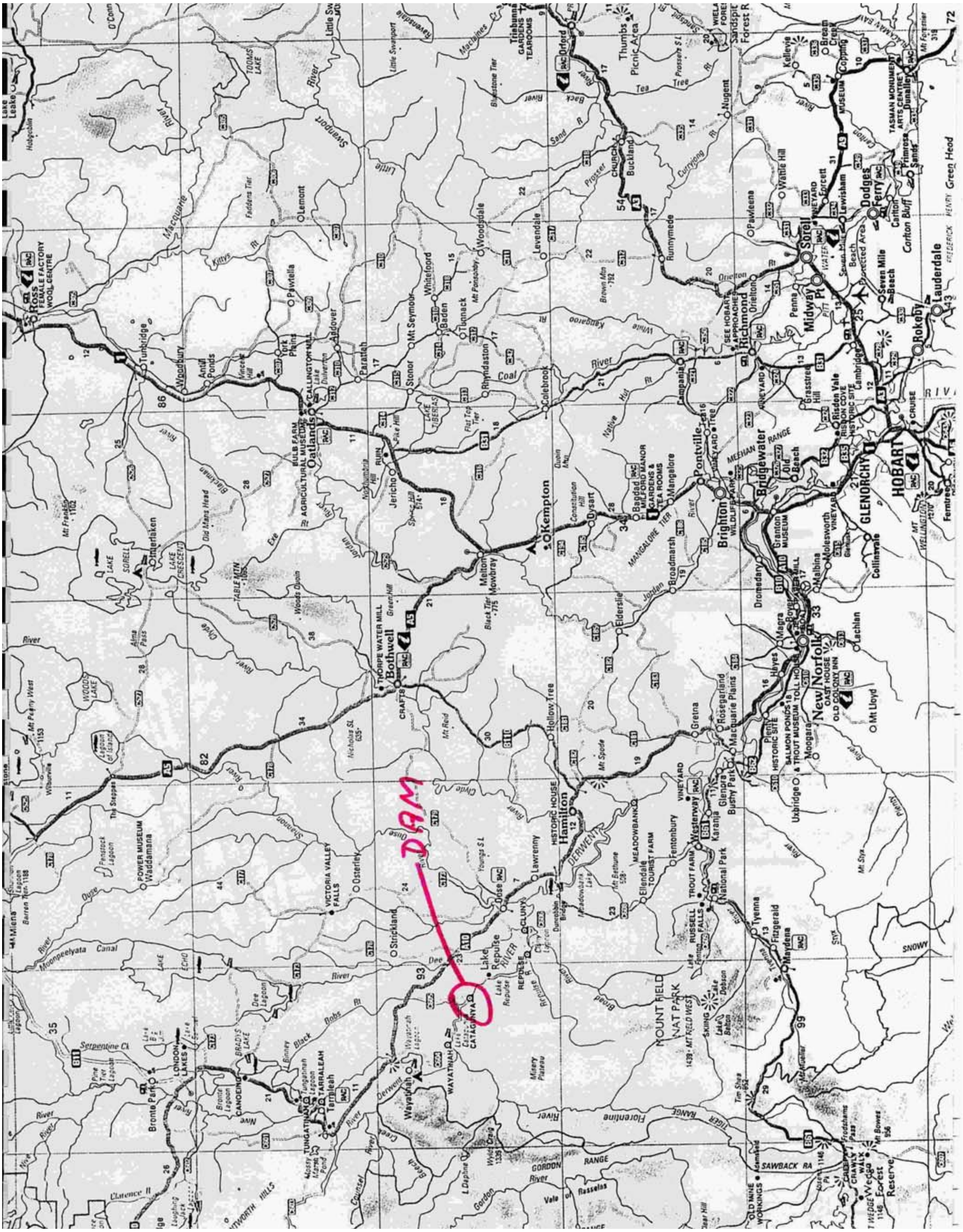
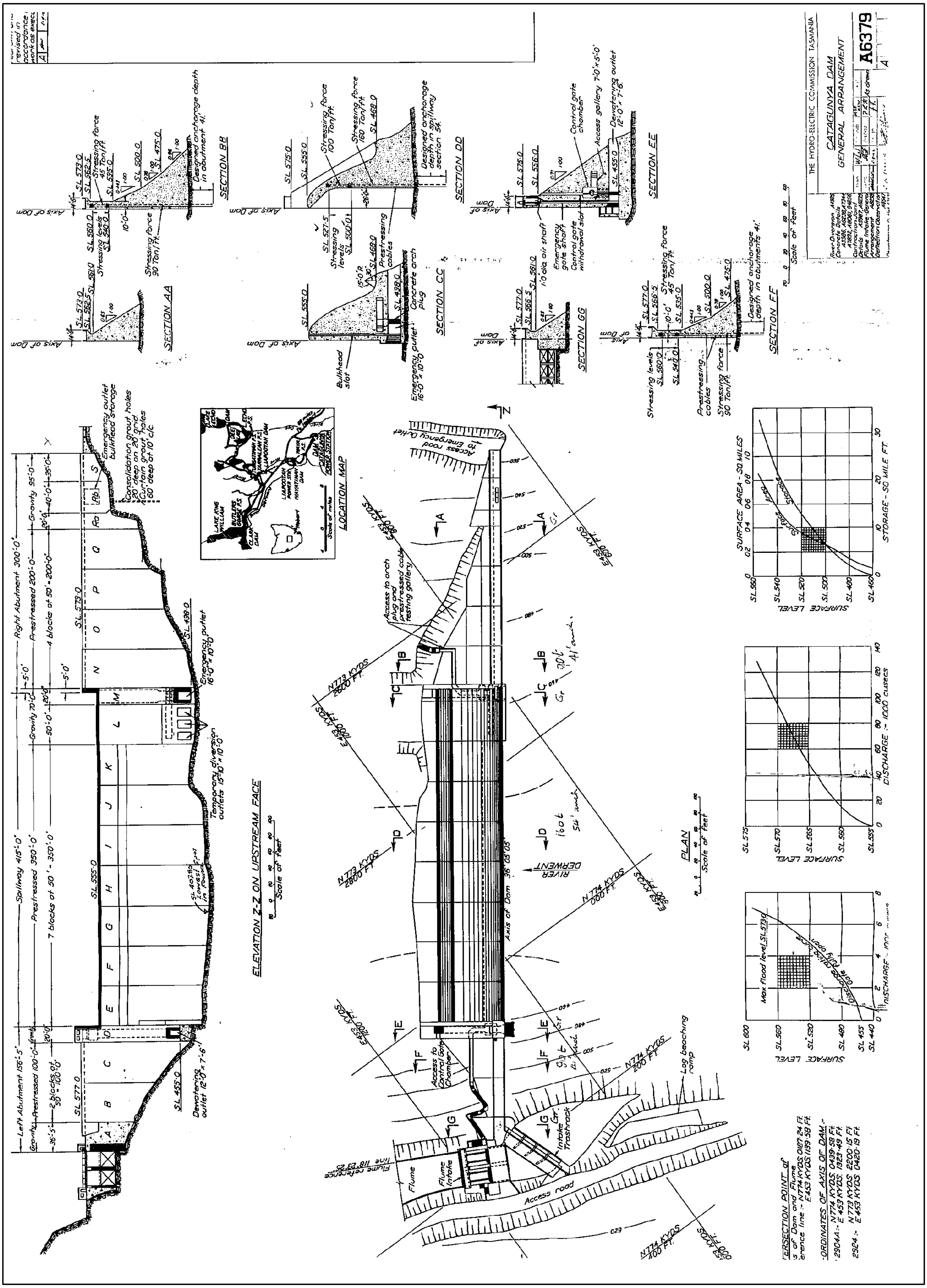


Figure 3 *Location Map*


THE HYDRO-ELECTRIC COMMISSION TASMANIA
CATAGUNYA DAM
GENERAL ARRANGEMENT
A6379
SECTION AA
SECTION BB
SECTION CC
SECTION DD
SECTION EE
SECTION FF
SECTION GG
ELEVATION Z-Z ON UPSTREAM FACE
PLAN
LOCATION MAP
RIVER DERWENT
Access road
Flume
Flume Intake
Intake Gr. Trashrack
Log beaching ramp
SURFACE AREA - SQ MILES
STORAGE - SQ MILE FT.
SURFACE LEVEL
DISCHARGE - 1000 CUSECS