COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1966/7

GORDON RIVER DAM SITES SEISMIC RECONNAISSANCE SURVEY,

TASMANIA 1963

by

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ILLUSTRATIONS

Note This Record supersedes Progress Report No. 1964/13

SUMMARY

Reconnaissance seismic refraction surveys were made in response to a request by the Hydro-Electric Commission of Tasmania to determine the quality of the bedrock and the thickness of the river detritus at four dam sites on the five-mile stretch of the Gordon River, Tasmania, between Butler Island and the junction of the Gordon and Franklin Rivers.

One dam site (near Butler Island) was eliminated from consideration by the Hydro-Electric Commission of Tasmania before this report was finished. Of the three remaining sites the furthest upstream (Dam site 4) is to be preferred on the results of the seismic survey. At this site the river detritus may be up to 20 feet thick and the bedrock velocity is between 10,500 and 12,000 ft/s in the survey area.

At Dam site 4 the best foundation for a dam is probably upstream from bench mark 4127, and at Dam site 2 downstream from bench mark 4132.

1. INTRODUCTION

The Hydro-Electric Commission of Tasmania (HEC) proposes to develop the water resources of the Gordon River and its tributaries, on the west coast of Tasmania, for the generation of hydro-electric power. In the preliminary investigation of the scheme, four sections along a five-mile stretch of the Gordon River, between Butler Island and the junction of the Gordon and Franklin Rivers, have been selected as possible sites for a dam. The approximate co-ordinates of the four dam sites hereafter referred to as DS1, DS2, DS3, and DS4 are respectively 369764, 371763, and 374761 (two sites) on the Queenstown sheet of the Australian 1:250,000 map series (see Plate 1).

To assist in assessing each dam site, HEC requested the Bureau of Mineral Resources to carry out a seismic reconnaissance survey to determine the approximate thickness of the river detritus and the quality of the bedrock in the river. The survey was done between 6th March and 3rd April 1963 by a geophysical party consisting of P.E. Mann (party leader), [illegible] Jewell (HEC geophysicist), and four field assistants supplied by HEC.

Numbered pegs were surveyed on the right and left banks of the river by HEC to aid in locating the hydrophone spreads at three dam sites, viz. DS4, DS3, and DS2. At Butler Island, the furthest site downstream, the party established permanent marks to be surveyed at a later date. A few months after the seismic survey was completed, HEC decided to discontinue any further investigation of the Butler Island site, and therefore a topographical survey of the dam site was not carried out. To make this Record complete, a brief reference to the seismic results is given, although they could not be fully calculated or plotted.

The easiest access to each dam site is by boat. The two dam sites furthest upstream (DS3 and DS4) are located in a narrow section of the river upstream from a dangerous rapid. HEC supplied a 10-ft fibre glass dinghy, two 14-ft wooden punts, and two outboard motors. The party camped at the tourist hut (Plate 1) and travelled to and from the dam sites in the three boats. The time to get to the dam sites ranged from about 10 minutes to Butler Island (DS1) to about 50 minutes to DS4. For the survey, one punt was fitted out to carry the seismic equipment, and the other two boats were used for placing and detonating the gelignite charges in water and as general work boats. Preparatory work on fitting-out the boats, work on the seismic equipment, and organization of the camp required about three days; about two days were spent repairing the seismic equipment during the survey. Geophysical work at the four dam sites lasted sixteen days; three days were lost because of heavy rain and river flooding.

2. GEOLOGY

Plate 1 shows the geology of the area, based on the reconnaissance mapping carried out by Spry (1963). The stratigraphy of the area is as follows :

Age	Rock
Quaternary	Alluvium; landslide material
Devonian	Minor intrusions
Ordovician	Gordon Limestone Caroline Creek Sandstone Owen Conglomerate (not present at any of the sites)

The Caroline Creek Sandstone underlying most of the area investigated consists of sandstone, quartzite and some shale, conglomerate, and dolomite. The sandstone is generally a uniform quartz sandstone, mechanically strong and chemically resistant. Generally, the fine-grained, tough quartzite is massive with bedding planes three to ten feet apart, but in a few places it is thinly bedded.

The Gordon River cuts through a broad symmetrical anticline, whose north-south axis is indicated in Plate 1. The anticlinal ridge of quartzite is flanked to the east and west by north-trending synclines containing Gordon Limestone. The dip in the Caroline Creek Sandstone is between 20° and 30° on the limb of the fold; the dip increases to about 40° to 50° in the Gordon Limestone west of DS1 and east of DS4.

Geological evidence suggests that a major fault (F1 in Plate 1) may occur on the eastern side of the quartzite ridge at Butler Island. A fault, a continuation of F2, probably occurs parallel to the river close to DS3. The most prominent and regular structural feature measured in the sandstone and limestone is a set of joints dipping approximately vertically and trending about 125°. Spry (1963) considers that the joints exercise a close control on the river course and strong jointing parallel to the river is to be expected at DS2 and DS4.

At DS4 the valley section is U-shaped; the river is narrow, tidal, and about 30 feet deep. Massive to well-bedded quartzite striking approximately north and with a small dip upstream crops out continuously at water level on both banks of the river.

At DS3 the V-shaped valley section is steep; the river is narrow, tidal, and about 30 feet deep. Massive quartzite striking at 150° and dipping flatly to the east crops out near water level on both banks.

At DS2, located in the centre of a slightly curved open stretch of the river at the crestal zone of the Elliott Range Anticline, the dip and strike of the bedrock is variable. The rock exposed on both banks is thickly bedded to massive quartzite with minor conglomerate and shale. The main joint system trends about 125° and the river trends about 330°. The V-shaped valley section is steep.

At Butler Island, the Gordon River has breached a ridge of massive Caroline Creek Sandstone. There appears to be no structural break between the banks; vertical jointing at 115° to 125° is well developed. Butler Island, a large diamond-shaped rock outcrop, splits the river into two channels; one about 150 feet wide and 70 feet deep, the other about 30 feet wide and 20 feet deep. A possible fault dipping to the west may occur about 100 yards upstream from Butler Island.

Spry (1963) considers the sites in decreasing order of suitability as follows : DS4, DS2, DS3, and DS1.

3. METHODS AND EQUIPMENT

The seismic refraction method was used. A general description of the seismic method and computational technique used to determine the bedrock depths in a river with steep banks was given in a report of a reconnaissance survey carried out for HEC at the Pieman River (Mann, 1964). The same seismic equipment was used for both surveys.

Each hydrophone spread is referred to survey marks established on both banks of the river. The distance of a hydrophone from a survey mark was either calculated from the arrival time of the direct water wave from small charges detonated at shot-points whose positions are known or, wherever practicable, found by direct measurement.

The hydrophone spreads that were roughly parallel to the axis of the river (here referred to as 'normal spreads') were anchored upstream and downstream by tie lines to both banks. At each end of a spread, charges were placed and fired on the river bed, one beneath the end hydrophone and one at a distance of about 250 feet from the end hydrophone and in line with the spread. At DS4, DS3, DS2, and DS1, this distance was increased to about 500 feet on several spreads in an attempt to record a refractor with a seismic velocity greater than that observed with the shot distance of 250 feet. No such refractor was found.

The hydrophone spreads that were across the river were anchored to each bank by a strainer wire attached to the hydrophone cable. At DS4 the curvature of the hydrophone cable was small and in Plate 2 the spreads are plotted as straight lines. At DS3 and DS2 (Plates 5 and 7), the curvature of the hydrophone cable is taken into account. Shot-points were located about 200 feet upstream and downstream of the spread and roughly at right angles to the centre of the spread (this kind of shooting is here referred to as 'broadside shooting'). The distances from the shot-point to the individual hydrophones were computed from the arrival times of the direct water wave (velocity about 5000 ft/s). Corrections were made for the variation in shot distances, assuming that the seismic velocity in any direction is constant in the surveyed area. This assumption might not be completely true because of the jointing system in the area.

The depths to bedrock with broadside shooting are relative values only. The depth at one of the hydrophones must be determined either from drill hole information or by reference to a hydrophone on a normal spread. Further, velocities cannot be measured, but must be determined from nearby normal spreads.

The assumption is also made that the refracted first arrivals recorded by a hydrophone for the two broadside shots originate from the same "limb" of a dipping refractor boundary. On the cross-sections, the bedrock profile is drawn as a smooth curve through a set of arcs. Each arc, centred at a hydrophone position, represents the minimum distance to the highest velocity refractor boundary. The minimum distance shown on the cross-sections actually represents the minimum distance between bedrock and hydrophone in three dimensions.

4. RESULTS

Table 1 shows the observed velocities of the longitudinal seismic waves that are characteristic of the different media.

TABLE 1

Rock type	Seismic velocity (ft/s)
Water	5000 ±
River detritus	5500 to 5800
Weathered jointed bedrock	7500 to 8500
Partly weathered and jointed bedrock	9500 to 12,000
Unweathered bedrock	16,500

Plates 2, 5, and 7 and 3, 6, and 8 show the layout of the hydrophone spreads and the seismic cross-sections at DS4, DS3, and DS2 respectively. The method adopted for plotting the seismic cross-sections of the spreads across the river allows for the fact that the seismic method gives the minimum distance to a refractor and not necessarily the vertical depth beneath a hydrophone.

In Plate 3 the minimum distance to bedrock for broadside spreads was determined from intersecting normal spreads where available. Those plotted on cross-sections C and G are based on the mean of the minimum distances at stations L12 and M12 projected onto Traverse C.

The seismic velocity of the river detritus at DS3 and DS4 is greater than at DS1 and DS2. This suggests that the unconsolidated deposits at DS3 and DS4 are coarser unsorted material with a lower porosity than at DS1 and DS2.

The seismic velocity gives an indication of the quality or strength of a rock; in general the higher the velocity the stronger the rock. At DS4, DS3, and DS2, the seismic velocity of the bedrock (deepest refractor) ranges respectively from 10,500 to 12,000 ft/s, 7000 to 9500 ft/s, and 7500 to 8500 ft/s. Hence from a consideration of seismic velocity alone the bedrock at DS4 is expected to be stronger than the bedrock at DS3 and DS2.

The cross-sections of the spreads along the river plotted in Plates 3, 6, and 8 suggest that the river detritus at DS2 is thicker than at DS3 and DS4.

Plates 4 and 9 show contour plans of the bedrock at DS4 and DS2 from the data shown in Plates 3 and 8. At DS4 the depth to bedrock increases sharply between Traverse K and Traverses L and M. The relatively shallow bedrock observed on Traverses K, J, and E may prove advantageous for the construction of a dam.

At DS2 a dam located downstream from BM 4132 would miss the subsurface gully suggested by the bedrock contours near peg 13.

At DS1 the thickness of the river detritus ranges from about 20 feet in the left branch of the river at Butler Island to about 50 feet, 150 yards upstream. An isopach plan of the detrital thickness at the dam site cannot be given because the location of hydrophone spreads is not known accurately (see Introduction). The seismic velocity of the bedrock ranges from 9000 ft/s to 16,500 ft/s. The highest velocity was recorded in the left branch of the river at Butler Island. Upstream from Butler Island the bedrock velocity ranges from 9000 ft/s to 12,000 ft/s.

5. CONCLUSIONS

Rock with a seismic velocity of about 7500 ft/s, which may be suitable as a foundation for certain types of dam, is present at DS2, DS3, and DS4. At DS4 rock with velocity 10,500 to 12,000 ft/s underlies the 7500 ft/s layer on each traverse. At DS3 rock with velocity 9500 ft/s underlies the 7500 ft/s layer only on Traverse D. This higher velocity rock may provide a more suitable foundation for a dam.

At DS4 the better quality, higher velocity rock is more extensive and shallower than at DS3. The river detritus is probably thinner at DS4 or DS3 than at DS2. These observations suggest that DS4 is to be preferred.

The bedrock contour plan of DS4 and DS2 suggest that within each of the surveyed areas the best place for a dam is respectively, upstream from BM 4127 and just downstream from BM 4132 (Plates 4 and 9).

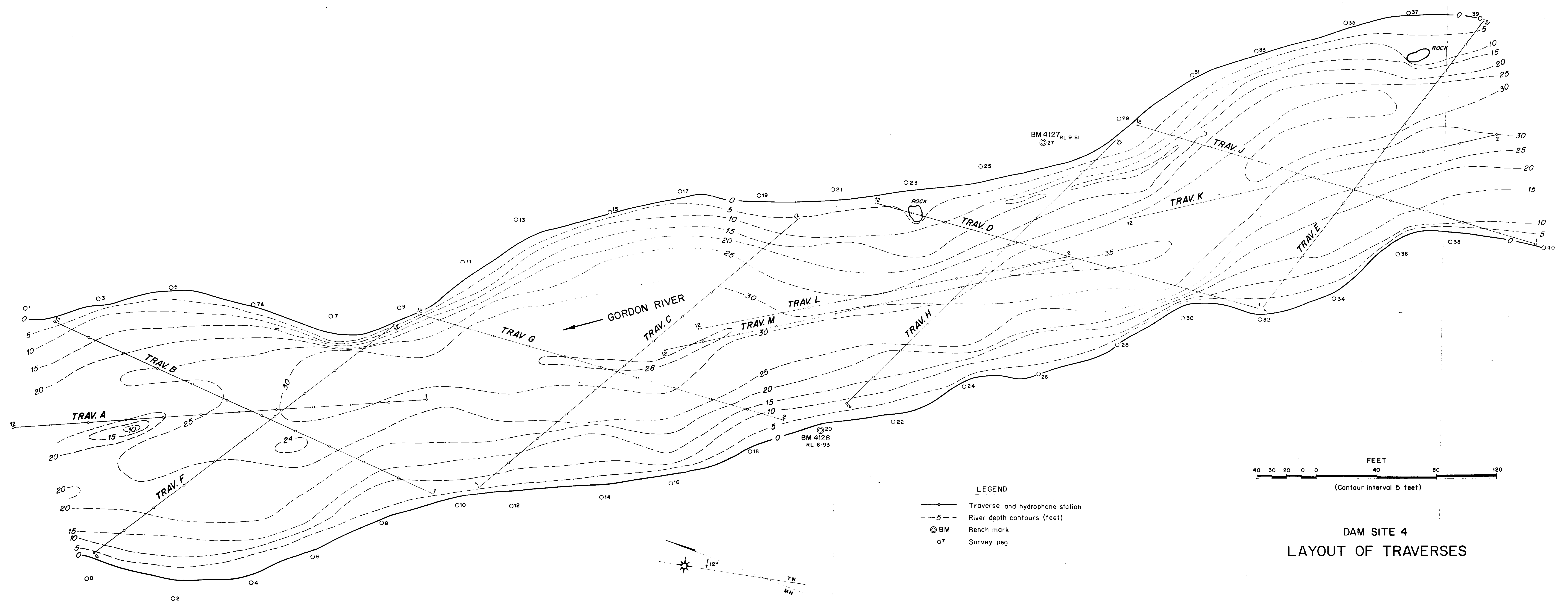
6. REFERENCES

MANN, P.E. 1964 Pieman River seismic reconnaissance survey, Tasmania 1962. Bur. Min. Resour. Aust. Rec. 1964/83

SPRY, A.H. 1963 Gordon River investigation; geological reconnaissance Butler Island to Franklin River junction. HEC Geol. Rep. 644-190-1 (unpublished).

GORDON RIVER TAS 1963

PLATE 2



DAM SITE 4
LAYOUT OF TRAVERSES

Based on HEC Plan A10,101

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

To accompany Record No. 1966/7

K55/B5-43

GORDON RIVER, TAS., 1963

PLATE 3

DAM SITE 4
SEISMIC CROSS-SECTIONS

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS K55/B5-46

To accompany Record No. 1966/7

To accompany Record No. 1966/7

PLATE 5

DAM SITE 3

LAYOUT OF TRAVERSES

Based on HEC Plan A 10,100

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

To accompany Record No. 1966/7

K55/B5-44

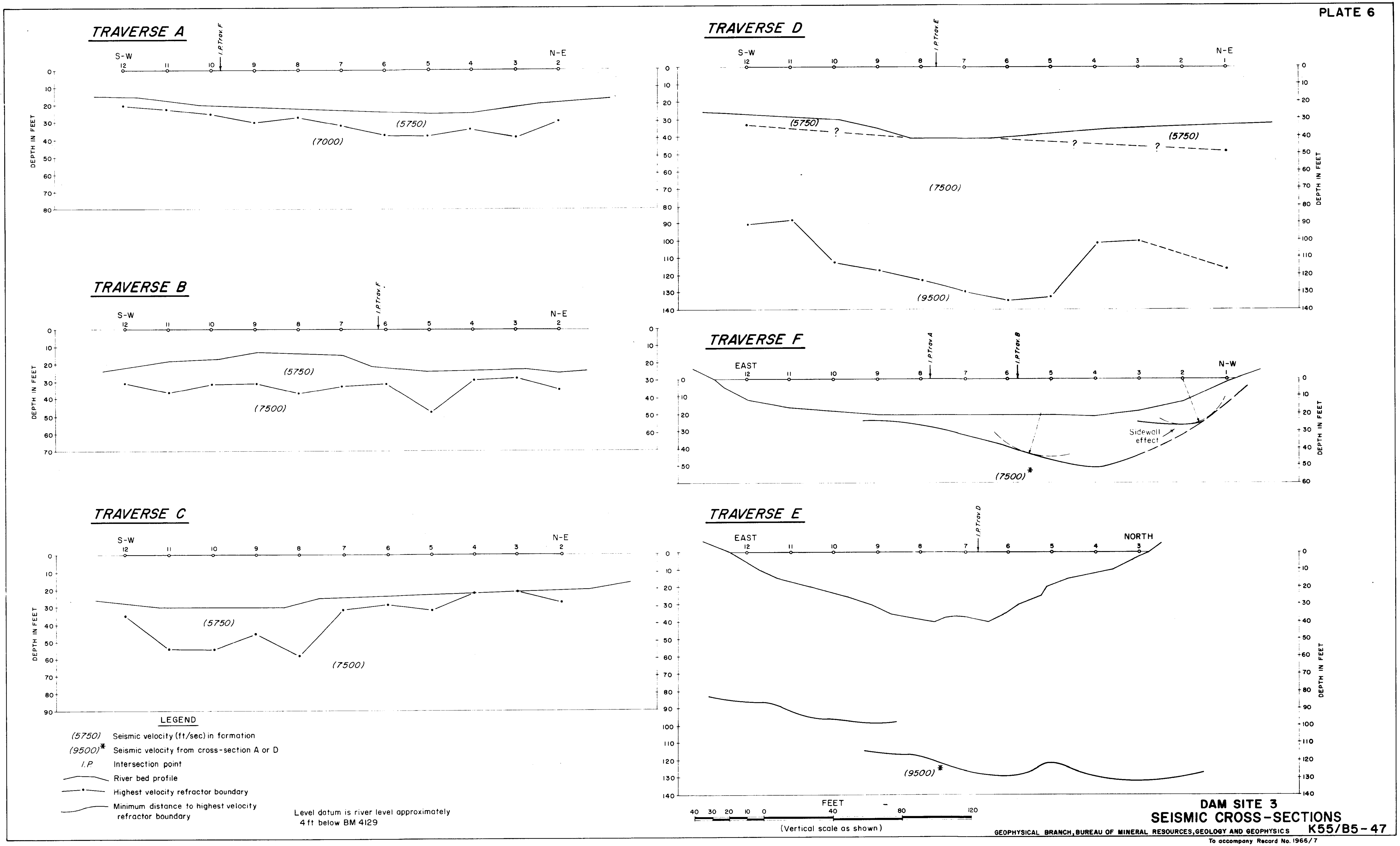


PLATE 6
TRAVERSE A
I.P. Trav. F
S-W
N-E
DEPTH IN FEET
(5750)
(7000)
TRAVERSE B
I.P. Trav. F
S-W
N-E
DEPTH IN FEET
(5750)
(7500)
TRAVERSE C
S-W
N-E
DEPTH IN FEET
(5750)
(7500)
TRAVERSE D
I.P. Trav. E
S-W
N-E
(5750)
(5750)
(7500)
(9500)
DEPTH IN FEET
TRAVERSE F
I.P. Trav. A
I.P. Trav. B
EAST
N-W
Sidewall effect
(7500)*
DEPTH IN FEET
TRAVERSE E
I.P. Trav. D
EAST
NORTH
(9500)*
DEPTH IN FEET
LEGEND
(5750) Seismic velocity (ft/sec) in formation
(9500)* Seismic velocity from cross-section A or D
I.P Intersection point
River bed profile
Highest velocity refractor boundary
Minimum distance to highest velocity refractor boundary
Level datum is river level approximately 4 ft below BM 4129
FEET
40 30 20 10 0 40 80 120
(Vertical scale as shown)
DAM SITE 3
SEISMIC CROSS-SECTIONS
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
K55/B5-47
To accompany Record No. 1966/7

PLATE 7

DAM SITE 2
LAYOUT OF TRAVERSES

Based on HEC Plan A 10,099

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

K55/B5-45

To accompany Record No. 1966/7

GORDON RIVER, TAS., 1963

LEGEND

(5500) Seismic velocity (ft/sec) in formation

(8500)* Seismic velocity from cross-section B or L

I.P. Intersection point

River bed profile

Highest velocity refractor boundary

Minimum distance to highest velocity refractor boundary

Level datum is river level approximately 6 ft below BM 4132

FEET

40 30 20 10 0 40 80 120

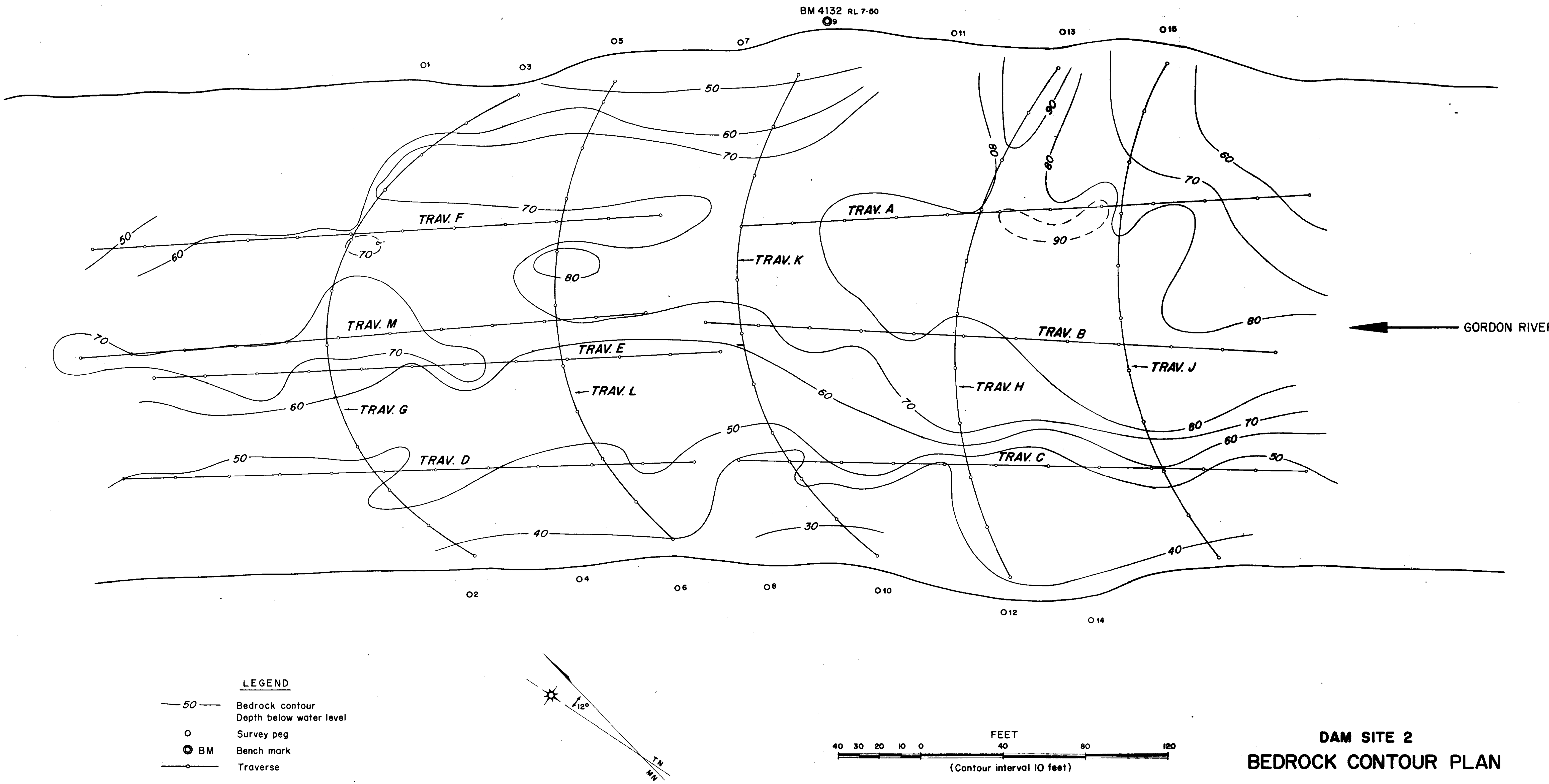
(Vertical scales as shown)

DAM SITE 2
SEISMIC CROSS-SECTIONS

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS K55/B5-48

To accompany Record No.1966/7

PLATE 9



DAM SITE 2
BEDROCK CONTOUR PLAN

GORDON RIVER, TAS., 1963