DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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Googong Water Supply Project, Queanbeyan River, NSW - Statements prepared by BMR for inclusion in an Environmental Impact Statement

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Summary

At an informal meeting in March 1973 the Geological Branch of BMR was requested by the Commonwealth Department of Works to prepare at very short notice several reports for inclusion in an Environmental Impact Statement relating to the proposed Googong Dam. The reports were on aspects in which the BMR was considered to have expert knowledge.

Introduction

The Googong Dam will, by impounding the Queanbeyan River, create the next reservoir for town water supply to the cities of Canberra and Queanbeyan. Preliminary development of the site is planned to begin in 1973 with completion by 1978, when projected population growth will have created a demand for water beyond the capacity of the present water supply system.

The proposed dam is a major construction for which no Environmental Impact Statement had been prepared, as the planning had taken place before such statements were required. The National Capital Development Commission has now called for a statement to be prepared by itself and the Commonwealth Department of Works. It contains contributions by a number of Departments and scientific organizations. The final statement was submitted to Cabinet through the Department of Urban and Regional Development, before it was released to the public.

Two points relating to this statement should be noted; (i) the units are in the British System in accord with the requirements of the Department of Works (ii) figures referred to in the text are to be prepared by the Department of Works and are not available for inclusion in this Record.

Analytical data are available in BMR Records 1971/37 and 1972/72. Stream flow data may be sought from the Department of Works.

RIPARIAN RIGHTS: QUALITY OF WATER.

(i) Water quality in relation to the use of pyritic materials in the construction of Corin Dam, ACT.

The experience and data resulting from investigations at Corin Dam, ACT may be used to provide a basis for assessing the possible effects of any pyrite which may be contained in the materials used in the construction of Googong Dam. It is stressed that the conditions at Corin Dam are extreme and were publicly reported in a paper presented at the 1st Congress of the International Association of Engineering Geology, Paris, 1970.

At Corin Dam the material used for the rock embankment was obtained from a deposit of quartzite containing up to 1% of disseminated pyrite. The deposit also contained mineralized veins and pods of a fissile chloritic rock carrying abundant pyrite.

The disseminated pyrite exposed to weathering on the broken faces of the rock fill has oxidized chemically over a period of years to produce a brown iron staining of the dam wall. This has no effect on the downstream water quality. The amount of bisulphate ion from this process is so small and is released over such a period of time that it would have no measureable effect on the acidity of the water flowing away from the dam. As only pyrite is involved no metallic pollutants can be introduced into the water. The iron from the pyrite remains as the brown staining of the exposed rock face.

Because of its relative softness and fissile character, the chloritic rock accumulated in the finer materials deep in the dam wall. Here it can retain rain water, which falls on the rock fill, for long periods, and provide favourable conditions for the biological oxidation of the contained pyrite. Under these conditions all the pyrite is exposed to oxidation and secondary products resulting from the associated break-down of the chloritic material are released. At Corin Dam rain water and leakage from the dam leach the oxidation products from the dam wall and carry them downstream. The maximum effect on water quality is after a dry period, at the beginning of increasing drainage flow following rain with a low discharge from the dam.

The effects of pyrite oxidation on water quality found at Corin Dam are:

(i) acidification in the immediate vicinity of the dam

(ii) addition of metallic pollutants; iron, manganese, and aluminium

(iii) addition of nutrients; phosphate and nitrate

(iv) increase in salinity, magnesium, and sulphate

(v) increase in total hardness

The natural processes of stream recovery rapidly correct (i) and (ii) by neutralisation and precipitation. Manganese may not be removed at this stage.

(ii) <u>Assessment of pyrite oxidation as a factor influencing water quality down stream of the proposed Googong Dam.</u>

Pyrite has been reported to occur in some of the material intended for the construction of Googong Dam. It occurs in disseminated form in dacite and associated quartz veins. Geological investigation of the proposed materials quarries has not revealed the presence of any veins or pods of a fissile pyrite-rich rock. In this important factor the proposed Googong Dam is completely different from Corin Dam and no deterioration in water quality is anticipated downstream of the dam.

Pyrite exposed in the rock facing may give rise to surficial iron staining over a period of years.

On the information available there is nothing to suggest that pyrite oxidation could occur at the proposed Googong Dam of a magnitude sufficient to affect water quality downstream of the dam.

(iii) <u>Variation of zinc concentration with river flow</u>

In order to estimate the likely zinc concentration in the Molonglo River downstream of its confluence with the Queanbeyan River and hence in Lake Burley Griffin, under conditions of small or zero flow in the Queanbeyan River, a study has been made of the zinc concentration river flow relation from July 1970 to September 1972. For the Molonglo River the gauging station

GS 410705 at Burbong has been taken as the reference point for initial zinc concentration entering the system and for river flow. The data available comprises pH, specific conductance, total iron and zinc concentrations on samples taken weekly for the entire period and daily for the period 1.12.70 to 30.12.71 together with continuous recording of stream flow. Results for zinc concentration of daily sampling during 1972 are not yet available. For the Queanbeyan River the zinc concentration is taken as 0.012 ppm Zn, which is the average for the period January 1966 to February 1973 (range 0.01 to 0.05); it is independent of river flow. The Queanbeyan flow rate is estimated as the difference between the Molonglo flow at Burbong and the combined flow of the two rivers at Oaks Estate just downstream of the confluence.

Zinc is the major pollutant entering the Molonglo River from the abandoned mine and associated dumps at Captains Flat. It was chosen for study as its known toxicity to trout sets the control limit in assessing water quality. In this respect 1 ppm Zn has been accepted as the tolerance level: The analytical results for zinc for weekly samples is given in Fig. 3.7.1.1. and for daily samples is illustrated in Fig. 3.7.1.2. Figs 3.7.1.1., 3.7.1.2., and 3.7.1.3. illustrate stream flow data for Burbong and Oaks Estate. Fig. 3.7.1.4. shows the general features of the Molonglo River /Lake Burley Griffin system and sampling points.

The period of observation includes unusually dry periods; stream flows are generally less than 50 cusec for the Queanbeyan River and less than 10 cusec for the Molonglo River. During the period September 1970 to February 1971 flows of over 1000 cusec were recorded in both rivers and this period is treated in some detail.

Commencing on 1.6.70, both rivers show a pattern of falling flow from a 3-day average peak of 32 and 260 cusecs to a steady state of 5 and 32 cusec for the Molonglo and Queanbeyan Rivers respectively. Both rivers reached a steady state and were virtually at constant flow from mid-July to mid-August.

During this steady period the zinc concentration in the Molonglo River stabilized at average values of 1.6 ppm at Burbong, 0.17 ppm at Honeysuckle and 0.07 ppm throughout Lake Burley Griffin.

River flows rose sharply on 20 August to reach average 2-day peaks of 150 cusec (Molonglo) and 210 cusec (Queanbeyan) on 27-28 August. This depressed the dilution ratio, i.e. Queanbeyan River flow rate / Molonglo River flow rate, from an average value of 5.7 to 1.4 indicating that the Queanbeyan River can be less effective as a means of dilution at moderate flows than at low flow. This will have an important bearing on the attainable zinc concentrations in Lake Burley Griffin.

As the river flow increased, the zinc concentration at Burbong increased to 1.9 ppm on 26 August then to 3.8 ppm on 2 September falling to 3.2 ppm on 9 September.*

The 3.8 ppm Zn peak at Burbong is the result of 1"-2" of rain in the latter part of August associated with river flows of 100 to 200 cusec. Following this event the river flow fell to a steady state of 8 cusec in the Molonglo and 44 cusec in the Queanbeyan (dilution ratio 5.7) with the zinc concentration at Burbong falling steadily to a value of 1.0 ppm on 23 September. The delay between the time when the river had re-established constant flow (6 September) and the minimum zinc concentration (23 September) is considered to be due to the retention of polluted water in the mine dumps at Captains Flat which then slowly drained into the river. The drainage characteristics of the source of the zinc are thus superimposed on a steady pattern.

A further 2"-3" of rain on 20-23 September and approximately 1" on 27 September resulted in river flows of 700-900 cusec in the Molonglo River and 1600-1900 cusec in the Queanbeyan River (dilution ratio 2.2 average). This

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* The maximum zinc concentration may have been greater than 3.8 ppm and may have occurred earlier than 2 September. No reliable estimate is possible at this stage of the river transit time between zinc entering the river at Captains Flat and it reaching Burbong. This is obviously a function of flow rate. It can only be noted at present that there is a variable time delay and that events at Captains Flat are not instantly reflected throughout the river. Transit times for Captains Flat to Lake Burley Griffin of ½ to 7 days are expected for moderate to high flows.

had the effect of first depressing the zinc concentration at Burbong from 1 ppm to 0.3 ppm Zn followed by a maximum value of 1.3 ppm Zn on 1 October. After that, the zinc concentration generally decreased to a value of 0.1 ppm at Burbong on 28 October. This is in marked contrast to the effect of the smaller flow at the end of August.

Rain continued frequently from November 1970 to mid-February 1971 with some daily falls over 2". Corresponding peak river flows ranged from 1000 - 10,000 cusecs. During the whole of this wet period the zinc concentration at Burbong only once exceeded 1 ppm and that on 3 - 5 February, 1971. This peak occurred during the period of daily sampling and is considered to be accurate in magnitude and time. It was during a period of increasing river flow but 8 days before the peak flow of 7000 cusec at Burbong on 11 February and therefore cannot correspond with this peak.

On two occasions of high flow in the Molonglo River, 2200 cusec on 11 November and 1100 cusec on 23 December, there has been no corresponding high flow in the Queanbeyan River consequently the Molonglo flowed virtually undiluted into Lake Burley Griffin. In neither case did the average zinc concentration rise above 0.10 ppm Zn in Lake Burley Griffin or above 1 ppm at Burbong. Other peak flows did not correspond with clearly definable increases in zinc concentration.

Summarising the period 1.6.70 to 15.2.71, we find that following a dry period of about 6 weeks a moderate rainfall, increased the flow in the Molonglo River to 100 to 200 cusec and caused a rise in zinc concentration (measured at Burbong) to approximately 4 ppm Zn. The zinc level then fell to 1 ppm over the next 3 weeks as the mine dumps slowly drained. Further rainfall with river flows up to 7000 cusec did not result in zinc concentrations at Burbong significantly above 1 ppm.

The behaviour described above may be explained as follows: oxidation products from the sulphide minerals contained in the mine and mine dumps accumulated in the dumps during the dry period. The first rain flushed out these products which drained into the river raising the zinc concentration. (There was no accumulation of oxidation products during this period). Consistent rain over the next 4½ months both prevented accumulation of oxidation products and further leached the dumps, reducing the zinc level at Burbong to 0.2 ppm by the end of February 1971. It should be noted that the higher summer temperatures and abundant moisture of the dumps would accelerate biological oxidation of sulphides.

Given the known loss of zinc by precipitation and some dilution by storm water and sewage effluents entering the river between Burbong and Duntroom Bridge, there would have been a maximum period of 3 weeks during which the zinc concentration in Lake Burley Griffin could have exceeded 1 ppm if no dilution by water from the Queanbeyan River had taken place. To achieve a level of 1 ppm Zn in the 3 weeks would require a constant flow of 150 cusec at 4 ppm or an equivalent zinc lead. In fact these conditions pertained for only 2-3 days so that at no time between 1.6.70 and 15.2.71 would the zinc concentration in Lake Burley Griffin have exceeded 1 ppm even with no dilution by the Queanbeyan River.

From mid-February 1971 through to mid-January 1972 the river flows steadily decreased with minor resurgences, to rates of less than 1 cusec in the Molonglo River and a minimum of approximately 10 cusec in the Queanbeyan River. At no time did the zinc level at Burbong exceed 1 ppm and there were no peaks to correlate with river flow variations. Obviously the zinc level in Lake Burley Griffin could not exceed 1 ppm Zn even if the lake were filled with undiluted Molonglo River water. The average dilution ratio calculated for steady state conditions during this period is 5.8 at 40-50 cusec combined flow. This compares with two previous values of 5.7.

From mid-January 1972 the pattern underwent another change. Although the river flows for January to July 1972 are essentially similar to those obtained during 1971, i.e. low flow generally with minor peaks rising to 100-300 cusec, the zinc concentration varies markedly showing values of 0.6 to 4.0 ppm Zn with an average 1.7 ppm Zn as compared with 0.5 ppm for 1971. There is again no correlation between stream flow and zinc concentration.

In mid-January 1972 a similar situation is found to that at mid-August 1970: a period of very low flow in the Molonglo for the preceeding 3 months followed by an increase in river flow over 12 days to a maximum value of 500 cusec. The August 1970 increase was over 7 days to a peak of 160 cusec. As before, zinc concentration increased, in this case to at least 3.3 ppm Zn and then declined with falling river flow to 1.6 ppm Zn. At this point further rain caused an increase in river flow to a peak of 280 cusec. The rain causing this flow was not sufficient to exhaustively leach the mine dumps and the zinc concentration in the river was maintained at approximately 2 ppm Zn until 5 March 1972 when another increase in river flow to 60 cusec was associated with an increase in zinc concentration to approximately 4 ppm Zn. The zinc level then fell with decreasing river flow and leaching of accumulated oxidation products from the mine dump was complete at the end of March 1972.

The zinc level at Burbong remained virtually constant throughout April and May, at an average of 0.74 ppm Zn. This is taken to represent the base level of zinc maintained by leakage of polluted water from the mine. It should be noted that on two occasions in April and May flows of 20-40 cusec were not reflected by the zinc concentration.

A broad peak in zinc concentration of average 3.5 ppm Zn, occurred over the last three weeks of June - a period of virtually constant river flow of 4.5 cusec. This high concentration can be explained by the introduction of a small flow of water with a very high zinc content from, for example, the northern dumps eastern spring or the explosives adit and adjacent bedrock seepage. Both were mine water leakage and could be expected to continue long after surface run-off and dump drainage had ceased.

Flow in the Molonglo River past the Lake George Mine could cease during dry periods if draw-down of the town reservoir exceeded the recharge. In such circumstances the flow in the Molonglo downstream from Copper Creek would be entirely made up of drainage from Captains Flat township plus leakage from the mine, and high zinc concentrations could be established.

The conditions established in June 1972 persisted at a reduced level throughout July, August and September (1.7 ppm Zn average) when there was a gradual decline in zinc concentration to 0.2 ppm Zn on 30.12.72.

River flow and rainfall data are not available after August so that further analysis cannot be made at present.

During the period discussed above the zinc concentration at Burbong varied between 0.7 and 4.0 ppm Zn and for nine months had an average value of 1.7 ppm. These data for Burbong indicate the average and maximum zinc level and flow of water entering the lake, assuming no dilution by the Queanbeyan River and no loss of zinc. From this it is possible to approximate the corresponding zinc concentrations for the Lake Burley Griffin as follows.

There are four sampling points in the lake from which water samples have been taken regularly over a number of years. Salinity and zinc concentration data for these points show a marked degree of uniformity of composition throughout the lake even during periods of inflow of over 10,000 cusec. The original design studies for the lake also indicated good mixing and absence of stagnation throughout the lake. It is therefore valid to assume efficient mixing of water entering the lake. The same data indicates a fairly constant zinc concentration with respec to time. The average values for 1971 and 1972 were 0.052 and 0.035 ppm Zn respectively.

From January to 17 August 1972, a period of 230 days, the total inflow of water was 4550 acre feet and the total zinc load 19,300 lb. The total discharge of zinc from the lake assuming outflow of water to equal inflow, is 500 lb. As the zinc concentration in the lake does not increase with time zinc must be precipitated to maintain the ionic zinc level at 0.03 to 0.04 ppm. Hence the rate of loss of zinc is approximately 60 lb per day. Using these figures the following values can be obtained for average and maximum concentrations in Lake Burley Griffin, over the period studied, if there had been no inflow of water from the Queanbeyan River and no loss of zinc between Burbong and the lake.

Period	Average	Maximum
Jan to mid-Feb	0.04 ppm	-
mid-Feb to May	0.15 ppm	0.17 at 28 Mar
June to mid-Aug	0.13 ppm	-
	0.04	-

These calculated values are considered to be high.

No allowance has been made for a minimum flow of 2.7 cusec in the Queanbeyan River after Googong Dam is built; it is made up from 1.7 cusec sewage effluent and 1 cusec minimum prescribed discharge from the proposed Googong Dam.

Although levels of 4 ppm Zn occurred at Burbong during the first half of 1972 the flow in the river was so small that the Molonglo waters could flow undiluted into Lake Burley Griffin with only a minor increase in zinc concentration. At no time would the zinc level rise above 1 ppm irrespective of whether water was available from the Queanbeyan River for dilution of the Molonglo River.

In summary, the effect on water quality of substantially reduced flow in the Molonglo River/Lake Burley Griffin system resulting from the construction and operation of Googong Dam may be listed as follows:

(i) Molonglo River upstream of Queanbeyan River confluence is not affected in any way and has not been considered.

(ii) Molonglo River downstream of the confluence; with the reduced dilution by water from the Queanbeyan River zinc concentration in the Molonglo will increase above its present levels. The increase will be greater at periods of low flow (5-10 cusec) than at high flow (200 cusec and above) for most conditions.

(iii) Lake Burley Griffin has been dealt with in detail for three periods of its history from July 70 to August 72 and relate to different rainfall conditions but all with low to moderate river flow. In none of the cases examined would the water quality with respect to zinc have deteriorated beyond accepted limit of 1 ppm specified by the NSW Maritime Services Board.

There are not sufficient data at present relating to major flood conditions to assess their effect on Lake Burley Griffin water quality in detail.

The subject of zinc pollution of the Molonglo River and its influence on Lake Burley Griffin is under examination by a joint Commonwealth/ NSW Mines Branch Committee. A preliminary report by this group is in the final stages of completion.

Other factors for which data are available but not discussed here are pH, specific conductance and total iron. Some brief comment may be made on the first two.

The depression of pH by the introduction of acid water at Captains Flat has fully recovered before the Molonglo River enters the ACT at Burbong. As both streams are essentially neutral to their confluence it is of no consequence whether the Molonglo River is diluted by the Queanbeyan River or not.

In the absence of water from upstream of the township of Queanbeyan there will be an increase in salinity due to sewage effluent and undiluted Molonglo River water. The anticipated maximum is approximately 300 ppm total dissolved salts.

EFFECTS ON REGIONAL DEVELOPMENT:

Mining: extraction and treatment of minerals and construction materials.

The catchment areas of the Queanbeyan River upstream of Googong damsite is known to contain minor occurrences of lead, zinc, and copper similar in type to that encountered at Captain's Flat; testing of the occurrences, in some cases, geophysical methods, pitting and drilling, has failed to reveal any potentially economic deposits. Other base metal deposits including other types of minerals may also be present; however, the area has been closely investigated. The catchment area is reported to be completely covered by Authorities-to-Prospect.

Establishment of the Googong Reservoir, from which unpolluted water would be required, would impose the need to either prohibit or rigorously control the exploitation of mineral deposits within the catchment area. In the event of prohibition any economic mineral deposits would remain undiscovered and undeveloped. In the event of control, the added cost of anti-pollution measures at all stages of prospecting, proving and exploitation would tend to discourage the search for minerals and would set a higher cast-off grade for economic exploitation of any deposit found than in an uncontrolled area; otherwise useable national mineral resources could then be left in the ground.

Sand, limestone and other potential construction materials are present in the catchment area. Those which lie within the proposed storage area would no longer be available for use after the reservoir filled. Construction materials in the catchment area, but outside the storage area, would be affected similarly to other mineral deposits. Banning of the extraction of materials from the catchment area could possibly disadvantage the Commonwealth financially at some future time by requiring materials for Commonwealth works in and near the ACT to be obtained from some other, more distant, source.

Construction of the dam will require the quarrying of materials for the dam's earth core and rock fill. It is proposed that the rock-fill material be quarried from the spillway excavations and from an area below the spillway. The material for the earth core would be excavated from an area to the east of the dam, most of which will be inundated by the impounded waters; however, the parts of this excavation above water level may require treatment to ensure stability of the cut when subjected to wave action.

EFFECT OF THE CONSTRUCTION OF GOOGONG RESERVOIR ON GROUNDWATER

It can be assumed that the groundwater catchment area to the proposed Damsite is roughly the same as the surface water catchment area and therefore that any major effects from the construction of the Dam and filling of the reservoir will only be felt upstream of the Dam and for a few hundred feet downstream of the Dam. Groundwater will only be affected to a minor extent downstream.

The filling of the storage reservoir would result in seepage of reservoir into the ground near the reservoir for a period of several years until equilibrium is achieved. The potentiometric gradient of the groundwater would therefore be flatter than the pre-reservoir conditions. (Seepage from the catchment could occur if the groundwater divide is at a level below the top water mark of the storage reservoir. There is no evidence however, to determine the position of the divide because of the lack of bores within the storage area).

This would lead to a rise in water levels in bores within the catchment; the affect would diminish markedly with distance from the reservoir. The higher groundwater levels would in turn result in increased available drawdown, increased bore capacity, and almost certainly in increased and more constant bore yields. A rise in groundwater levels is also likely to cause springs and seepage areas to appear within the catchment, particularly at lower levels. Insufficient investigation has been carried out to determine likely areas of seepage and spring activity. New springs will provide new watering points for stock, but could also, along with the seepage areas, provide areas of a boggy nature that could be detrimental to stock and agriculture.

Control of river flow downstream of the dam may result on reduced recharge of river banks and flats as they are thoroughly recharged at times of flooding and the incidence of flooding below the dam will presumably be reduced. The reduced normal flow of the river is not expected to have a marked effect on the volume of groundwater stored along the river valley. Bores located downstream of the dam site have different surface catchments from those upstream. Consequently recharge to the bores will not be affected except as described above. Groundwater levels should generally continue their existing trends.

The possibility of changes in the pattern of groundwater movement occurring as the result of the flooding of limestone bodies containing solution channels, was examined in the course of the reservoir mapping. It was concluded that no risk exists of such changes taking place.

No deleterious changes are foreseen in the quality of groundwater in the region, as a result of the filling of the reservoir.

Effect of the Reservoir on Stability of Reservoir Banks and Slopes

In the geological investigation of the reservoir area, particular attention was paid to the possibility of slope instability occurring on the completion of the dam and the filling of the reservoir.

Calculations by the investigating engineers have indicated that waves in excess of two feet in height could be expected on the reservoir under extreme storm conditions. Waves of this order could cause undercutting and erosion at water surface level. The undercutting and erosion may be increased where the waves move into confined areas of the reservoir such as at Bradley's Creek (the northeast corner of the reservoir) and upstream of a point approximately 6000 metres south of the Dam. Some slumping of slopewash and weathered rock may occur as a result of the undercutting of steeper slopes in such areas. The magnitude of such failures has not been assessed in detail but is expected to be generally minor and to be controllable by the provision of protective rock armour. Some slopes may fail even if protected by rip-rap. Undoubtedly some local scarring of slopes will occur by slope failures if preventive measures are not taken.

It is believed that there is no risk of failures of a magnitude that would (a) affect land beyond the area being resumed by the Commonwealth,

(b) adversely affect the quality of the water drawn from the reservoir (other than temporary discolouration of the water),

(c) significantly reduce the volume of water storage in the reservoir, or

(d) set up a wave of water that could overtop the dam embankment or saddle dam.

It is considered that the amount of soil, scree and weathered rock around the proposed Googong reservoir that would slide into the reservoir would be less than has occurred around the Corin reservoir.

Geology and natural features

The dam will submerge lenses of slate and limestone, sheared dacite and some dolerite dykes, and will prevent future examination of these outcrops; however, the area has already been mapped in considerable detail as part of the geological investigation of the damsite and its storage area. Fossils have not been found in the limestone lenses, and if fossils do exist, their value would be marred by the strong shearing and attenuation of the limestone.

The only natural rock formation of wide interest known to exist in the area is London Bridge, a natural bridge of limestone over the Queanbeyan River about 6 miles upstream of the Googong damsite. London Bridge is well known but not visited a great deal as it is on private property. At present the property owner does not permit access to the area by the public. The rock formation has, none-the-less, the potential to become a popular tourist site. The rock forming London Bridge is sound and massive and is an integral part of the local bedrock; it is probably totally immersed by high floods.

Filling of the reservoir would, it is understood, bring full supply water level to the base of the arch and flood water would presumably continue to inundate the arch. The bridge would therefore not be subjected to conditions differing substantially from those existing at present. The main change would be a rise of a few feet in the normal water level and this is not expected to affect the rock significantly in the life of the Dam. London Bridge would continue to be a potentially attractive tourist site.

EARTHQUAKE HAZARD

Present seismicity in the area.

The Googong Dam Site and the proposed reservoir lie in a zone of relatively low seismic activity; in the period 1960-1970 only one tremor was recorded near the dam site; it occurred in 1969 and had a magnitude of

2.1 (Richter) and may have been associated with the Queanbeyan Fault. Tremors of this magnitude occur in the Snowy Mountains area, on average, every three months.

The seismicity of the dam site was monitored from 8.9.71 to 6.12.71. The instruments used were capable of detecting microtremors as small as 0.3 on the Richter scale for local tremors. No tremors were detected during this period.

Seismicity induced by the filling of the reservoir.

It is well established that the filling of a reservoir can induce seismicity owing to the increased load on the earth's crust and to the reactivation of faults caused by increased fluid pressure along the fault plane.

Considering the size of the Googong reservoir, the recorded local seismicity and the expected groundwater changes on the Queanbeyan fault, and comparing those with previously documented cases of induced seismicity, it is concluded that the probability of increased seismic activity of significant magnitude subsequent to the filling of the reservoir is very low.

The additional loading is also not expected to produce significant deflections in the earth's crust, i.e. depression of a magnitude that could affect any engineering or natural features.