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Clerk of the Senate

PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS

P A P E R S

to be laid
on the

TABLE of the SENATE.

R E P O R T

together with

MINUTES of EVIDENCE and DIAGRAMS

relating to the proposed

DAMS for ORNAMENTAL WATERS at CANBERRA.

1916.

COMMONWEALTH OF AUSTRALIA.

PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

REPORT

TOGETHER WITH

MINUTES OF EVIDENCE AND DIAGRAMS

RELATING TO THE PROPOSED

DAMS FOR ORNAMENTAL WATERS AT CANBERRA.

By Authority:
ALBERT J. MULLETT, GOVERNMENT PRINTER, MELBOURNE.

F.9343.

MEMBERS OF THE PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

(*First Committee.*)

EDWARD RILEY, ESQUIRE, M.P., Chairman.

Senate.	*House of Representatives.*
Senator the Honorable John Henry Keating.	James Edward Fenton, Esquire, M.P.
	William Fyfe Finlayson, Esquire, M.P.
Senator Patrick Joseph Lynch,* Vice-Chairman.	The Honorable Henry Gregory, M.P.
	Sydney Sampson, Esquire, M.P.
Senator William Harrison Story.	William Henry Laird Smith, Esquire, M.P.*

* Ceased to be a member of the Committee, 14th November, 1916.

INDEX.

LIST OF WITNESSES.

EXTRACT FROM THE VOTES AND PROCEEDINGS OF THE HOUSE OF REPRESENTATIVES.

No. 59 OF 24TH JUNE, 1915.

14. PUBLIC WORKS COMMITTEE—REFERENCE OF CITY RAILWAY AND DAMS, CANBERRA.—Mr. Archibald moved, pursuant to notice, That in accordance with the provisions of the *Commonwealth Public Works Committee Act* 1913-1914, the following works be referred to the Parliamentary Standing Committee on Public Works for their report thereon, viz. :—

City Railway, and Dams for Ornamental Waters incident to the schematic plan of Canberra, prepared by Mr. Griffin, and dated 20th March, 1915.

Mr. Archibald laid on the Table a Plan and Reports.

Debate ensued.

Question—put and passed.

PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS.

DAMS FOR ORNAMENTAL WATERS—CANBERRA.

REPORT.

THE PARLIAMENTARY STANDING COMMITTEE ON PUBLIC WORKS, to which the House of Representatives referred for investigation and report the question of the Dams for Ornamental Waters incident to the Schematic Plan of Canberra, prepared by Mr. Griffin, and dated 20th March, 1915, has the honour to report as follows :—

INTRODUCTORY.

One of the conditions always insisted upon in considering any site suggested for the Federal Capital was that it should possess ample water for the formation of ornamental lakes. Apart from the practical advantages of minimizing the effect of floods and being a healthy adjunct to a city, there seems to be no question but that the possession of a water element materially enhances the attractions of a Capital, and makes it possible to create a number of drives and prospects wholly picturesque.

2. When the selection of Canberra as the site for the future Capital was under consideration, one of the advantages claimed for it was that the River Molonglo flowing through the area in a westerly direction afforded facilities for the conservation of water for ornamental purposes. Before any design for the city was prepared, Mr. District Surveyor Scrivener—afterwards Director of Commonwealth Lands and Surveys—following upon a close examination of the country, reported that by damming back the waters of the Molonglo to the 1,825 feet level a considerable area of water of beautiful form could be obtained at a minimum expense for earthworks.

DESCRIPTION OF THE PROPOSED WORK.

3. The proposal as outlined on the schematic plan and subsequently explained by Mr. Griffin to the Committee, is to construct two dams on the Molonglo River and by certain earthworks form a chain of five ornamental lakes through the city area.

These lakes are known as—

(*a*) *The Eastern Lake*—an irregular sheet of water having a surface level of 1,845 feet above sea level, an area of 1,672 acres, and an average depth of 11½ feet.

(*b*) *The Eastern Circular Basin*—a formal circular lake, approximately 1,133 yards in diameter, having a surface level of 1,825 feet, an area of 218 acres, and an average depth of 10½ feet.

(*c*) *The Segmental Basin*—a formal sheet of water, approximately 1,866 yards long and 766 yards wide, circular on the northern side and with a straight base on the southern side, having a surface level of 1,825 feet, an area of 238 acres, and an average depth of 11½ feet.

(d) *The Western Circular Basin*—a formal sheet of water approximately 1,133 yards across at its widest part, circular on its north-eastern and south-eastern boundaries, but irregular for the remainder of its perimeter. It has a surface level of 1,825 feet, an area of 157 acres, and an average depth of 12¾ feet.

(e) *The Western Lake*—an irregular sheet of water having a surface level of 1,825 feet, an area of 860½ acres, and an average depth of 18 feet.

4. These lakes will have a total area of 3,145½ acres, a total capacity of 1,809,392,000 cubic feet, with a shore line of 34½ miles. During a period of average rainfall it is estimated that the flow of the Molonglo will fill them in 13 months, but that it would take 28½ months during a period of minimum rainfall.

5. In order to maintain the flow of the Molonglo throughout the year and provide water to compensate for evaporation, absorption, and seepage in the ornamental waters at the city site, it is proposed to construct a concrete dam on the Queanbeyan River, about 6 miles up stream from the town of Queanbeyan. This dam, which is estimated to cost £100,000, will have a capacity of 6,400,000,000 gallons (*vide* report by Public Works Committee, Parliamentary Paper 1915, No. 64.)

6. It is proposed that the shores of the eastern and western lakes shall be as far as practicable left in their natural state, but the three basins with a shore line of about 7 miles are to have a formal border of about 4¾ miles. This border will consist of concrete steps, five in number, reaching from a height of 2½ feet above water level to water level; thence the concrete is to be carried down on the slopes of the basin in the shallow waters to a depth of 18 inches, and there a sill is to be provided on a system of piling which is to be embedded in the solid earth. This will always be below the water level, so that it will be of a permanent character. In deep water, of course, the use of this retaining piling is not practicable. The shallow shore treatment will extend to a depth of 5 feet. Elsewhere there is provision for a rough stone pitching on a concrete toe, or sill, 1 foot thick, and resting on the bottom of the lake so as to obviate any possibility of a slide. In every case the concrete runs down to a mean depth of 18 inches below water level.

7. Around the whole system of formal basins the designer suggests the construction of a boulevard 100 feet wide, divided as follows:—

5 feet slope from water's edge to footpath.
11 feet pathway.
12 feet parkway.
24 feet roadway.
12 feet sloping parkway.
24 feet motor way on a different level.
12 feet sloping parkway.

100 feet.

8. Incidental to the formation of the boulevards and to provide means of communication between the northern and southern sides of the lakes, seven bridges are proposed in addition to the eastern lake causeway, and the highway at the Yarrolumla dam which serve as bridges. Some of these bridges will only come into requisition a long time hence, but they are submitted as being all that will be necessary for the use of the city.

ESTIMATE OF COST.

9. In endeavoring to arrive at an estimate of the cost of the whole of the work involved in the project under consideration, the Committee was faced with considerable difficulty.

Apart from the difference in the estimated price per cubic yard of handling the material, which might be understood to vary according to the practical experience of the person making the estimate, and the method which might be adopted in carrying out the work, a considerable disparity was apparent in the quantity of material to be handled as estimated by the departmental officers, and by the Federal Capital Director of Design and Construction.

10. With a view to comparing the estimates and at the same time ascertaining where the differences occurred, the Committee asked for a schedule of the quantities and prices in a certain form, but although this was supplied by the departmental officers, Mr. Griffin stated that he was unable at the present time or within a definite period to comply with the request. As this considerable difference in quantities ostensibly estimated on the same sections should not occur, the Committee is forced to the conclusion that in addition to calculating on the sections supplied, certain assumptions have been made with the result that the estimates have been furnished with totally different conceptions of the work requisite. This, it is thought, might have been avoided had perfect frankness existed between the designer and the departmental officers. Under these circumstances, the Committee has decided to include here a statement of the various estimates furnished to it, and endeavour to adduce from same an approximation of what the work will eventually cost.

DESIGNER'S ESTIMATE.

11. At the outset of the inquiry Mr. Griffin explained that he was not then in a position to estimate the cost of providing the ornamental lakes as indicated on his schematic plan.

Later, however, after the conference arranged by the Committee, at which Mr. Griffin agreed to certain modifications of the schematic plan, he furnished to the Committee his estimate of the cost of providing the ornamental lakes and necessary adjuncts in accordance with such modifications.

This estimate was as follows:—

	£	£
Lakes—		
Earthworks—		
1,333,500 cubic yards at 4¾d. per cubic yard	25,559	
Revetments, pitching, &c.	19,285	.. 44,844
Eastern Dam—		
Cutting and Filling— ..		
503,300 cubic yards at 6d. per cubic yard	12,582	
165,700 cubic yards at 1s. 4d. per cubic yard.. ..	11,047	
	23,629	
Add 10 per cent. for contingencies ..	2,362	
	25,991	
of which amount, however, Mr. Griffin claims only £14,879, should be charged against the lakes.		
Excavation for staunch wall—	£	
9,700 cubic yards at 2s. per cubic yard ..	970	
Excavation for syphons—		
75,000 cubic yards at 2s. per cubic yard ..	7,500 ..	8,470
Concrete—		
8,620 cubic yards at 50s. per cubic yard ..	21,550	
Reinforced concrete—		
6,176 cubic yards at 70s. per cubic yard ..	21,616 ..	43,166
Concrete for staunch wall—		
4,850 cubic yards at 50s. per cubic yard ..	12,125	
Concrete facing for staunch wall—		
2,100 cubic yards at 50s. per cubic yard ..	5,250 ..	17,375
.. ..	..	69,011
Add 10 per cent for contingencies ..	..	6,901
		75,912
Add proportion of earthworks ..		14,879
		90,791
therefore total cost of dam, eliminating railway proposition ..		90,791
.. .. ..Forward		.. £135,635

	£	£
Forward		135,635
Yarrolumla Dam—		
Excavation—		
30,600 cubic yards at 2s. per cubic yard	3,060	
Concrete—		
27,657 cubic yards at 50s. per cubic yard	69,142	
Reinforced concrete—		
1,195 cubic yards at 70s. per cubic yard	4,182	
	76,384	
Add 10 per cent. for contingencies ..	7,638	
		84,022
Bridges—(not including cost of approaches)—		
Commonwealth Avenue	45,056	
Federal Avenue	44,176	
West Beach Boulevard	31,500	
Aboretum	35,000	
Aquarium Pond Inlet	5,000	
Domain Harbor	10,000	
Australasia Circuit	20,000	
		190,732
		410,389
Adding to these figures the estimated cost of Regulating Dam over the Queanbeyan River		100,000
Making of Boulevards around the lakes		48,720
the total estimated cost would be		£559,109

DEPARTMENTAL ESTIMATE.

12. At the request of the Committee, Mr. Hill, Engineer, Department of Home Affairs, submitted an estimate of the work involved in the provision of the ornamental lakes and necessary adjuncts as shown on the schematic plan, using that plan and the levels thereon.

This estimate worked out at—

	£	£
Filling and forming	330,000	
Cutting	75,000	
Filling approaches to bridges ..	27,000	
Pitching..	30,000	
		£462,000

Subsequent, however, to Mr. Griffin agreeing to modify his plan to some extent, Mr. Hill furnished the following estimate :—

	£	£
Lakes—		
Filling and forming—		
3,204,386 cubic yards at 1s. 2d. per cubic yard ..	186,922	
Excavation—		
665,529 cubic yards at 1s. 6d. per cubic yard	49,914	
Pitching—		
600,000 square feet at 8s. 6d. per square yard	28,333	
Filling approaches to bridges	25,000	
		290,169

If the Committee's recommendation be approved, however, this amount will be subject to still further reduction.

Forward		290,169

	£	£
Forward		290,169
Yarrolumla Dam—		
Preliminary and river protection	10,000	
Concrete—		
25,000 cubic yards at £2 per cubic yard	50,000	
Reinforcing concrete	2,000	
Granite facing—		
20,000 square yards at 30s. per square yard	30,000	
Rendering—		
8,000 square yards at 2s. 6d. per square yard	1,000	
20 gates and chambers at £500 each	10,000	
Gearing	3,000	
Gangway and columns	1,800	
	£107,800	
Mr. Hill subsequently stated that the granite facing could be replaced by concrete, which would effect a saving of ..	25,000	
		82,800

Eastern Dam—

The original estimate for the Eastern Dam, as furnished by Colonel Owen, and concurred in by Mr. Hill, was calculated on 26th May, 1915, on the basis of the schematic plan, and set down at £381,000. Subsequent, however, to the section of the dam being furnished by Mr. Griffin, an amended estimate was supplied as follows :—

	£	£
Embankment—		
644,074 cubic yards at 1s. 3d. per cubic yard..	40,255	
Concrete, including coffer dams, excavations to bedrock and all charges—		
30,935 cubic yards at 50s. per cubic yard, say,	75,000	
Puddle Core—		
96,300 cubic yards at 7s. 6d. per cubic yard, say	36,000	
Excavation from surface to bedrock from puddle core, including timbering 6,000 lineal feet at 30s.	9,000	
Bridges, retaining and abutment walls, &c.—Item	150,000	
Regulating gates—Item (provisional) ..	20,000	
Approaches, contingencies, 5 per cent. ..	18,159	
	£348,414	
Mr. Hill, however, stated that, eliminating the railway proposition, the estimate could be taken at		200,000
Adding to these figures the estimated cost of—		
Bridges		190,732
Regulating dam over the Queanbeyan River		100,000
Making of boulevards around the lakes		48,720
The total estimated cost would be		£912,421

13. In adopting 4½d. per cubic yard as the average price at which he could win and transport the material, the Committee is convinced that Mr. Griffin is unduly sanguine, as apart from the experience of the departmental officers, the evidence given by Mr. Catani, Chief Engineer, Victorian State Public Works Department, who has carried out a large amount of excavation work with the most up-to-date machinery, and Messrs. Cooper and Davies, private contractors, who had large earthwork contracts in connexion with the Waranga Basin and Preston Reservoir, Victoria, and the Yanko Irrigation scheme, New South Wales, shows that under the most favorable conditions likely to obtain at Canberra, it is improbable that the work can be done for anything less than an average price of 1s. per yard, while that price will be largely exceeded in those section where unploughable material predominates, or where labour-saving devices could no be employed at their maximum efficiency.

COMMITTEE'S INVESTIGATIONS.

14. The Committee visited Canberra and traversed practically the whole of the area which will be submerged by the proposed system of ornamental waters. Careful examination was also made of the plans and sections submitted by Mr. Griffin, and by the Department of Home Affairs.

15. In addition to examining a number of witnesses, including Colonel Owen, Mr. Griffin, and Mr. Hill, conferences between these latter gentlemen were arranged by the Committee with a view to their discussing quantities, plans, and sections, and suggested alterations, and, as a consequence, Mr. Griffin modified his original proposals with the idea not only of effecting economy in various directions but also of enhancing the beauty of the lakes.

16. This modification has been arrived at principally in the following directions :—

(*a*) by eliminating a considerable amount of excavation on the north side of the eastern circular basin, and allowing the water to follow practically the natural contours ;

(*b*) by bringing the southern boundary of that basin 150 feet south for nearly half of its circumference and thus avoiding a large quantity of filling ;

(*c*) by abandoning the idea of filling up the low lying area on the north of the segmental basin and allowing the water to occupy the depression known as the aquarium pond ;

(*d*) by bringing the southern boundary of the western basin 600 feet further south and adopting the natural contour—thus saving a large amount of filling ; and

(*e*) by following more closely the natural contours of the north-eastern boundary of the western lake.

17. After careful investigation and consideration of all the evidence, and a comparison of the figures furnished by private contractors, it appears to the Committee that Mr. Griffin's estimates are low, and members are inclined to the view that Mr. Hill's figures are a nearer approximation to what the various works will ultimately cost.

18. In the opinion of the Committee, as far as can be foreseen, the estimate of the complete proposal may be taken at—

	£	£
Lakes—		
Earthworks, pitching, &c.		275,000
Dams—		
Yarrolumla	82,800	
Eastern	200,000	
		282,800
Bridges—		
(Mr. Griffin's estimate)		190,732
Queanbeyan Dam—(already reported upon by the Public Works Committee, *vide* Parliamentary Paper 1915, No. 64)		100,000
Making of Boulevards		48,720
		£897,252

19. The fixing of the lake levels at 1,825 feet (with the exception of the eastern lake) is determined mainly by the formation of the country, and by the fact that that is the level reached in the year 1891 by the highest recorded flood. The formation of the eastern lake at the same level is not practicable, and a level of 1,845 feet was proposed by Mr. Griffin in that instance to give a more uniform depth of water.

20. At the outset of its investigations, the Committee made careful inquiries as to the supply of water that might be expected from the Molonglo, and the capability of that river to supply a sufficiently large volume to fill the lakes and keep them filled through a series of dry years. A considerable amount of evidence was taken and calculations submitted as to the water which might be expected in years of minimum and average rainfall, and the losses by evaporation, seepage, &c., for which allowance should be made. After giving the matter considerable thought, the Committee is satisfied that the safest course to adopt would be to postpone the formation of the

proposed eastern lake indefinitely. Provided the regulating dam on the Queanbeyan River be constructed, the flow of the Molonglo then would be sufficient to maintain all the remaining lakes proposed, even in a series of years equal to the driest yet recorded.

21. Attention was given to the questions of silting, to the growth of weeds, and to the possibility of nuisance from mosquitoes, but evidence showed that it was not likely that any great trouble in those directions need be anticipated, although it is possible that some provision may have to be made in the future to deal with silt deposits.

22. It is realised that care must be taken to guard against the contamination of the ornamental waters by preventing storm water or other city drainage from finding its way into the lakes. Furthermore, as the water supply for the lakes will be dependent upon a supply which receives the surface drainage of Queanbeyan, it is, in the opinion of the Committee, essential that prior to the formation of the lakes the Commonwealth should be satisfied that the sanitation of the town of Queanbeyan is properly controlled.

23. In the course of its inquiries the Committee ascertained that most of the river beds at the Federal Capital contain strong coarse gravel, which is suitable for concrete work. There is also excellent sand to be found in places. As these materials will be of considerable value in connexion with the works to be carried out in Canberra, it is not advisable that any steps should be taken to fill the lakes until such materials, as well as alluvial soil required for garden and other purposes, shall have been utilized to the fullest extent. Further, as the existence of the lakes will form a barrier between the northern and southern parts of the city it is advisable, in the opinion of the Committee, to defer the filling of the lakes until bridges sufficient for essential communication shall have been constructed.

24. Evidence taken showed the existence of areas of fertile land in positions which will ultimately be submerged by the formation of the lakes. As some time must necessarily elapse, however, before the lakes are filled, the Committee suggests that these areas be leased for agricultural or other purposes, but under such conditions of permissive occupancy as will enable the tenancies to be determined without compensation at any time at the will of the Minister for Home Affairs.

25. In the best interests of the inhabitants of the future city the Committee recommends, subject to the preceding paragraph, that a strip of land at least 100 feet wide around the whole of the lake system should be reserved from lease or occupation.

26. In regard to the Government Group, which faces the segmental basin, the Committee was impressed by the fact that the possible requirements of the Commonwealth for departmental buildings are somewhat liberally provided for by an allowance of approximately 260 acres. As a large amount of filling is required to form this area, it is thought that the straight line constituting the base of the segmental basin might very well be reduced to a length of about 1,600 feet on each side of the Ainslie axis, and thus save a considerable amount of the expenditure necessary to give effect to Mr. Griffin's proposal.

27. Considerable thought was given by the Committee to the question of the construction of the eastern lake at the 1,845 feet level, but in view of the expense involved and of the large area of land which would be submerged, added to the facts that the area of ornamental water provided is already considerable and an earthen dam in the position proposed would not be a harmonious feature in the landscape, it was decided to recommend that such lake be eliminated from present consideration. By this omission it is estimated that a very large saving will be effected. In the event, however, of future generations requiring a larger ornamental water area than at present recommended, it is suggested that leases granted in respect of any land comprised within the proposed eastern lake area should be of limited duration.

28. In view of the modification in the shape of the western lakes agreed to by Mr. Griffin, and the saving which it was shown could be effected by following the natural contours of the country, the Committee considers that the expense involved in the construction of the formal geometrical basins originally proposed is open to serious objection. The Committee therefore recommends that, with the exception of the straight line forming the base of the segmental basin and extending for a distance of approximately 1,600 feet on each side of the Ainslie axis, the lakes be formed with the

object of following generally the natural contours at the 1,825-ft. level, subject to such modifications in the direction of formal treatment as time and experience may show to be necessary. It was stated in evidence that this could be effected at a cost of approximately £30,000, spread over a number of years.

29. As a consequence the construction of the boulevards, which Mr. Griffin claims to be one of the *raisons d'être* of the ornamental waters, will have to be delayed. It was intended that the operation of making the lakes should also *form* the boulevards, and the cost of such formation is included in the estimates given for the formation of the lakes. No estimate was furnished to the Committee by Mr. Griffin however of the cost of *making* such boulevards according to the design laid down by him, but the Committee ascertained that the cost of making a somewhat similar highway in Victoria worked out at £116 per chain. It may, therefore, safely be assumed that the cost of making the 5¼ miles of boulevards originally suggested would cost at least £48,720.

30. As all the evidence goes to show, and the designer himself admits, that the construction of the lakes is not in any way an urgent matter, the Committee recommends that this work be delayed for a period of years. Some attention, has, however, been given to details involved in the provision of the lakes because, although it is not intended that they should be undertaken for a period of years, it is realized that it is essential that the general principle of the ultimate course to be followed should be carefully and definitely laid down as early as possible, so that other works to be carried out may be proceeded with.

31. Although the Committee is aware that the ideal of the City of Canberra is that it should be the official and social centre of Australia, and designed in accordance with the most modern ideas of town-planning, it has endeavoured to bear in mind also that this perfection should be attained by degrees in proportion to the increase of the population and as requirements demand.

32. The fact also must not be lost sight of that the actual building of the city will be carried out by private individuals, and care must be taken that the financial aspect is not overlooked. As a business proposition the City of Canberra should eventually be self-supporting, and Mr. Griffin claims that the residential areas should be looked forward to as a revenue-producing feature of the Capital. Under these circumstances an endeavour should be made to see that the expenditure involved in providing Government buildings and ornamental features for this immense area shall not raise the price of the land and increase the rates and taxes to such an extent as to defeat the very object in view and prevent settlement.

33. In dealing with this and other questions affecting the Federal Capital the Committee has been strongly impressed by the fact that it is most advisable that a programme should be drawn up outlining the successive stages in which the various necessary works should be carried out. This subject is important in its bearing upon the time that must necessarily elapse before the erection of public buildings can be begun and upon the provision which should be made for the distribution of expenditure over several years. A clear, definite, scheme of development requires to be formulated and approved so as to determine how far the Federal Capital, as proposed by the schematic design, can be made economically independant and self supporting, or to what extent the Federal Government is likely to be called upon to meet annual losses on initial capital and subsequent maintenance charges. A great deal of the work must be more or less interlaced, and to avoid waste of effort, future trouble, and expense, no part should be begun prematurely. Probable future expansion of population must be considered, and engineering and other designs should provide for meeting eventual developments whilst permitting of part construction to meet the first requirements. It is feared that neglect of this principle would lead to complications, expensive alterations, and reconstruction at a later date.

COMMITTEE'S RECOMMENDATIONS.

34. Summarized, the Committee's recommendations are :—

(*a*) that the suggested eastern lake be indefinitely postponed ;
(*b*) that the provision of the other ornamental waters be delayed for a period of years ;
(*c*) that the construction of the boulevards be delayed in consequence ;

(*d*) that prior to the formation of the lakes the Commonwealth be satisfied that the sanitation of the town of Queanbeyan is properly controlled ;
(*e*) that full advantage be taken of sand, soil, and gravel deposits on the area proposed to be submerged, before the lakes are filled ;
(*f*) that 1,825 feet be adopted as the surface level of the lakes recommended ;
(*g*) that a strip of land at least 100 feet wide around the ornamental water system be reserved from lease or occupation when the lakes are provided ;
(*h*) that pending the formation of the lakes the area to be submerged, as well as the 100-ft. reservation around them, be utilized for agricultural or other purposes on permissive occupancy ;
(*i*) that the straight line forming the base of the segmental basin be restricted to a length of about 1,600 feet on each side of the Ainslie axis ;
(*j*) that the lakes should be formed following generally the natural contours ;
(*k*) that a definite programme be drawn up outlining the successive stages in which various necessary works should be carried out.

ECONOMY EFFECTED.

35. The approximate saving, based upon departmental estimates of cost, which would be effected by the adoption of the Committee's recommendations as against the modified scheme shown on the schematic plan, would be as follows :—

	£
(*a*) omission of Eastern Lake	200,000
(*b*) modification of formal basins	260,167
(*c*) modification of Yarrolumla Dam	25,000
(*d*) elimination of boulevards	48,720
	533,887
from which might be deducted, however, an amount to cover greater cost of longer bridges, estimated at	93,887
or an approximate saving of	£440,000

DECISIONS.

36. The decisions arrived at by the Committee are shown in the following extracts from its Minutes of Proceedings, viz. :—

Mr. Finlayson moved—That the formation of the Eastern Lake be indefinitely postponed.
Seconded by Mr. Gregory. Carried unanimously.
Senator Story moved—That the Western Lake and Lower, Central, and Circular Basins be approved as permanent features of the City plan, subject to such modifications as the Committee recommends.
Seconded by Mr. Finlayson.
The Committee divided on the motion.

Ayes, 5.	Noes, 3.
Senator Lynch,	Mr. Fenton,
Senator Story,	Mr. Sampson,
Mr. Finlayson,	Mr. Laird Smith.
Mr. Gregory,	
Mr. Riley.	

and so it was resolved in the affirmative.

Edward Riley

EDWARD RILEY,
Chairman.

Office of the Parliamentary Standing Committee on Public Works,
120 King-street,
Melbourne, 28th November, 1916.

CANBERRA (ORNAMENTAL WATERS).

MINUTES OF EVIDENCE.

(Taken at Melbourne.)

WEDNESDAY, 14TH JULY, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Sampson,
Senator Story,	Mr. Laird Smith.
Mr. Fenton,	

Walter Burley Griffin, Federal Capital Director of Design and Construction, sworn and examined.

1. *To the Chairman.*—The system of artificial lakes proposed in my plan is no novelty, and is entirely practicable from economical and other points of view. They might be made wholesome and hygienic additions to the city, and might be formed without any fear that they would be a nuisance in any way. It is acknowledged that any scheme of landscape gardening is incomplete without a water element. Referring to the lakes proposed in my plan, I may inform the Committee that the Eastern Lake comprises an area of 1,672 acres, with a capacity of 838,400,000 cubic feet. The average depth is 11½ feet, and the greatest depth 30 feet. That is, the high-level lake at the eastern end of the city. The upper circular lake, which is perhaps better described as the Eastern Basin, comprises an area of 218 acres, with a capacity of 97,408,000 cubic feet, and an average depth of 10¼ feet.

2. *To Senator Story.*—It would not require a great deal of excavation to attain the circular form of this basin.

3. *To Senator Lynch.*—The idea is to have a boulevard right round this water area. The fact that the river winds through this basin increases the average depth, but there are portions of the basin in which the depth would be only 8½ feet. I should mention that as shown on the plan before the Committee this circular basin is drawn 100 feet too far north in the schematic plan.

4. *To the Chairman.*—The Central Basin or segmental lake comprises an area of 238 acres, with a capacity of 116,160,000 cubic feet, and an average depth of 11¼ feet. The Western Basin comprises an area of 157 acres, with a capacity of 86,304,000 cubic feet, and an average depth of 12¾ feet. The Western Lake comprises an area of 860½ acres, with a capacity of 671,120,000 cubic feet. The average depth is 18 feet, and the maximum depth 50 feet. The total lake area proposed is 3,145½ acres. I have not computed the mileage of water frontage, but that can be very easily supplied. The members of the Committee will notice that it is proposed in connexion with the Eastern, Central, and Western Basins to surround them with embankment boulevards as a spectacular feature of the city. The idea is that these boulevards shall be made upon levels permitting speeding if desired without any necessary crossings. It is arranged in the design of this portion to provide for footpaths underneath the boulevards, giving pedestrians access to the water's edge. The design provides for drives around the basins, which will not be affected by bridges. The idea is to have the necessary bridge crossings mark the dividing lines between the separate lake schemes. In that way the maximum of effect is obtained.

5. *To Senator Lynch.*—In connexion with the Western Lake some excavation will be required. Some filling will also be required on the north near the athletic grounds for the university, the land there being so near the level of the water. I have not computed the total lineal mileage of water surface from the western end of the Western Lake to the eastern end of the Eastern Lake, but that information can be very easily supplied.

6. *To the Chairman.*—With the information at hand I am not in a position to estimate the cost. On this account the present investigation is premature. I want to be in a position to give the Committee the costs, but I cannot do so until I get the necessary information. When I am asked whether it would be possible to secure as good an effect without submerging so large an area of land, I say that the area covered by water, according to my plan, is practically the area within the flood line. The land that would be submerged by the proposed lakes is liable to be submerged by flood waters. It would consequently be wasted, so far as the city is concerned, and it should be used for recreation purposes. It is admitted that by far the most effective way to use land under such conditions for recreation purpose is by providing a water area. In the event of the formation of the lakes as proposed flood waters in future will be under entire control. They can be released at one end as fast as they come in at the other. The lake area is treated as a reservoir, and the levels and depths for normal and for flood condition will be approximately the same. The existence of the lakes will offer a direct inducement to people to occupy residential portions near the lake. There is nothing to compare with a lake frontage as an attraction for residents, and this is particularly true where the climatic conditions are similar to those at Canberra. If the lakes are properly designed there need be no fear that they will breed mosquitoes. The flow of the water has really nothing to do with the breeding of mosquitoes. I could keep the water in a barrel in a back yard free from mosquitoes all the year round, and without use of oil or artificial means whatever. The Committee need fear no danger at

the breeding of mosquitoes in these lakes. It can be prevented by proper aeration of the water, by suitable subaqueous growths, and by the introduction of animal life. That, of course, will have to be provided for, and provision for it can be made in the formation of the lakes. When water is isolated in patches by the rise and subsequent fall of a river ideal places for the breeding of mosquitoes are created. But if we keep the water deep enough, and prevent the isolation of patches of water it will be possible to prevent the breeding of mosquitoes. It is necessary to avoid creating shallow marshy places which small fish—minnows—could not get at.

7. *To Mr. Laird Smith.*—The total capacity of the ornamental lakes proposed in my plan is 1,809,392,000 cubic feet.

8 *To Mr. Sampson* —I think that the water along the edges of the proposed lakes can be kept constantly purified by the motion in conjunction with the life in it. Although there will be no perceptible current, I think there would be no difficulty in nature's aerating the water properly. In the summer season there will be practically no flow in the lakes, and the currents in water will be controlled by the wind.

9. *To. Mr. Laird Smith.*—I believe that the average flow of the Molonglo River is estimated at 20 cubic feet per second in a minimum year.

10. *To Mr. Sampson.*—The growth of rushes and reeds will be kept down because of the depth of the water. Beaches and banks suitable for bathing can be made of sand. Though it might be necessary to weed certain places occasionally, the water will not be shallow enough to promote the growth of weeds and rushes. I have seen Lake Wendouree, at Ballarat, and I understand that trouble has been experienced there in connexion with the growth of weeds and rushes, but I do not suppose that the average depth of that lake is more than 3 feet. The lakes proposed in my plan represent an entirely different proposition.

11. *To Mr. Fenton.*—I do not think it would be possible to maintain the depth of the lakes independent of the Queanbeyan reservoir proposal. The Molonglo River might stop flowing at any time. I believe that it has practically stopped flowing before now. That has to be provided against. The Director-General of Works, Colonel Owen, in his letter of 14th April, 1915, estimates the evaporation at 36 inches per annum.

12. *To Mr. Laird Smith.*—I have not computed how long it will take to fill the lakes after they were finished. It would not take long, and an estimate could easily be arrived at by considering the flow of the river. Assuming the completion of the impounding reservoir there should be no danger of the lakes drying up, even in the driest season. I wish to be in a position to take up this question when Colonel Owen has explained the matter from his point of view, which is quite opposed to mine.

13. *To the Chairman.*—Assuming that it is decided to construct a railway between the Eastern Lake and the Eastern Basin, when I am asked what should be the next work undertaken in connexion with the formation of the lakes, I say that I do not think that it makes much difference which is first constructed, except that the railway will itself supply the material required in connexion with the construction of the Eastern Lake, and the two works could then, perhaps, be best undertaken at the same time. It does not follow that it is necessary to make the lake at the same time as the railway, but the two jobs might be combined. The level of the outer lake is 1,845 feet.

14. *To Senator Lynch.*—The boundaries of the lakes as proposed are within the natural flood level of the country.

15. *To Mr. Finlayson.*—The depth of the water at the shallowest part of the Western Lake would be 5 feet. The construction of the lakes is not immediately urgent, and it might preferably be deferred for some time, because quantities of gravel and other material which would otherwise be submerged might in the meantime be secured. Temporary bridges might be constructed in the meantime, and the saving of interest on the expenditure incurred in the immediate construction of the lakes would no doubt be worthy of consideration. Assuming that the lakes will ultimately be made, I do not advise their construction as a matter of urgency in the construction of the city. I would, however, suggest that stringent action should be taken to prevent the erection of any building at lower than a certain level. I should allow a margin of 5 feet elevation at least between the site for a building and the water level. I think, perhaps, it would be better to take the flood mark of 1891, the average level of which was 1,835 feet. The levels fixed might be 1,850 feet at the extreme east, and 1,830 feet at the extreme west. The average level drops below 1,825 feet towards the west, and rises above that level in the east. I think it would be even better to say that there should be no construction work of a permanent character permitted below a level of 8 or 10 feet above the flood level. In my view the lakes represent an essential feature of the city scheme. I have made provision for an area of 3,145 acres for water purposes. One important reason for this is that that area would in any case be submerged by flood waters. It is better in such a case to allow nature to dictate to you. To try to reduce the area which nature has shown to be required for water would involve a greater expense than to allow nature to take its course. I am aware that on some of the lower levels there are extensive alluvial flats that would be useful for agricultural purposes. But I think that the loss of these for agricultural purposes would be compensated many times over by the advantages which would follow from the formation of the lakes. I have suggested that some of the soil of these alluvial flats might be used on some of the more barren regions, and I feel sure that the people taking up those portions would be glad to take that soil. I should advise deferring the submerging of the lower levels until we have taken the full toll of the soil for which there is a demand.

16. *To the Chairman.*—I have said that I would not urge the immediate construction of the lakes, and when I am told that the construction of the railway as proposed would itself result in the formation of a lake, I can only say that the disposition of the waters should be provided for. Every time a railway is taken across a flat a lake is not necessarily formed. All that it is necessary to do to prevent the formation of a lake by the embankment of a railway is to allow of sufficient openings in the embankment to let the water pass through.

17. *To Mr. Sampson.*—I believe that a big business centre and settlement with provision for municipal institutions can be established on the site to the north of the river and of the Executive Centre, and that establishment of such a centre there has nothing whatever to do with the places where the working members of the different families are employed. When it is suggested that what I propose would lead to the development of two rival cities with the lakes between them, I answer that we would have authority and control over the development of the city. The leading residential area should be made as attractive as possible to induce people to remove there from Sydney and Melbourne. It should be looked forward to, especially as a revenue-producing feature of the Capital. When you suggest that people settling in both centres will require certain business conveniences in both places, and that although a big business centre may be established in the residential area to the north of the Executive Centre, people settling in the southern residential area will claim the right to have independent business centres, and separate provision for recreation to suit their own convenience, I can say that they probably will not desire to do so. If the southern residential area is to be developed for the purpose for which it is best adapted, the very existence there of the conveniences, which you suggest as necessary, would be detrimental to local values. The residents there might prefer not to have them. They might prefer to try to keep them out of that area. I admit that provision will have to be made there to meet ordinary local requirements, but that would be very different from the establishment of a general business centre. People would not go from the one place to the other for their immediate local requirements, but they would do so if that were necessary to get bargains, for instance, from big stores.

18 *To Mr. Fenton.*—When I am asked what there is to prevent a big store being established in the southern centre, and whether it would not naturally be established there to meet the demands of a centre of population, I say that could be prevented by the distribution of our facilities. We need, in considering the matter, to establish the preponderence of business facilities, in view, not of the conditions that are likely to exist during the next five years, but in view of what we desire that the conditions of the Capital City shall be in, say, the next fifty years.

(Taken at Melbourne.)

TUESDAY, 20TH JULY, 1915.

Present:

Mr. RILEY, chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Percy Thomas Owen, Director-General of Works, Department of Home Affairs, sworn and examined.

19. *To the Chairman.*—I made two reports to the Minister regarding the artificial lakes, &c., one dealing with the general question of the supply of water for the whole ornamental area, and the other with the cost of the dam or bank running between the eastern lake and the eastern basin. The first, with its covering letter, was as follows:—

FEDERAL CAPITAL.

SUPPLY OF WATER FOR ORNAMENTAL WATER AREA.

The Acting Secretary—

I forward herewith data and deductions regarding the supply of water for the proposed ornamental water area at Canberra.

I am not in a position to supply estimate of cost, such estimate would entail a careful consideration by me of the city plan recently submitted by Mr. Griffin to the Minister. I understand that the lay out is now being transferred to the contour plan of the locality. When the plan is available I shall further investigate the matter if the Minister desire.

In the meantime, the information which I am submitting discloses that I consider the Molonglo and Queanbeyan Rivers an unsatisfactory source of water supply for the whole area of the ornamental waters proposed on the city plan.

(Sgd.) P. T. OWEN,
Director-General of Works.

14th April, 1915.

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1. *Data Ornamental Waters—*

The approximate areas of the two proposed ornamental lakes or water are, in round numbers—

Upper lake, 2¼ square miles.
Lower lake, 3 square miles.

The evaporation per annum is laid down at 36 inches, of which about a half would occur during three summer months.

2. *Data Catchment Areas—*

The Molonglo River, at Canberra, is fed by the Queanbeyan and Molonglo Rivers; the Queanbeyan River has a catchment area above the dam site of 335 square miles, and the Upper Molonglo a catchment area of 150 square miles. The annual rainfall is low, the minimum recorded at Queanbeyan being 19.42 inches, and the minimum for the catchment areas should be stated at 12 inches.

3. *Run Off—*

The amount of run off which can be relied upon during years of prolonged drought is low. The country is sparsely timbered, the soil is not readily absorbent on the hills, grazing and resulting stock tracks have formed small channels, which contribute to a quick delivery during heavy rains, whereas the baked and cracked soil affords no run off when only a few points fall at a time during dry periods. A comparison between the rainfall and gauging discloses that the run off has been as low as from 8 per cent. to 5 per cent. It would be unwise to assume a greater annual run off than 5 per cent.

4. *Stream Losses—*

There are stream losses above and below the proposed lake sites.

The gaugings at the Queanbeyan, when correlated with those of the Molonglo (near Yarrolumla dairy) disclose a 20 per cent. falling off when the latter is flowing at 15,000,000 gallons per diem.

5. *Hydraulic Deductions—*

(a) The volume of water which would fall on the two catchment areas during a year of lowest rainfall would be 80,000 million gallons; the run off would be, say, 4,000 million gallons.

(b) The evaporation over the area of the the impounding basins of the Queanbeyan and Molonglo, assuming this area at 11 square miles, would be, in round numbers, 800 million gallons. Thus the volume available for flow for compensating rivers and lakes would be 3,200 million gallons.

(c) The evaporation over the upper and lower lakes, assuming the areas thereof at 5¼ square miles, would be 2,650 million gallons per annum.

(d) The volume which will be contained in the upper and lower lakes, assuming an average of 20 feet deep all over, would be 20,000 million gallons.

(e) The seepage and river losses cannot be assumed at less than 10 per cent. of the volume discharged from the impounding basins.

6. *Requisite Flow—*

My opinion is that the average flow of compensating waters at the junction of the Molonglo and Murrumbidgee should be 10,000,000 gallons per diem, thus the discharge from the dams, rivers Queanbeyan and Molonglo, irrespective of volume required to meet lake evaporation, should be 11,000,000 gallons per diem, or 4,000 million gallons per annum.

7.—The flow into the upper lake must, however, provide also for evaporation at the rate of 2,650 million gallons per annum—thus the total flow per annum, from the two dams for compensating water and to make good evaporation, should be—

Evaporation losses, 2,650 million gallons per annum.
Stream losses, 4,000 million gallons per annum.
Total, 6,650 million gallons per annum.

As against these figures the average total annual flow which can be counted upon, during years of minimum rainfall, from the two dams is, 3,200 million gallons.

8.—In making the foregoing computations I have regarded it as a cardinal principle that they should be based on not greater than the minimum recorded rainfall, and stated data for run off.

9.—My deductions are that, if it is accepted that, during protracted droughts, there shall not be a fall in the lake levels, and that a compensating river flow of at least 10,000,000 gallons must be maintained in the lower reaches of the Molonglo, the Queanbeyan and Molonglo Rivers cannot be regarded as a satisfactory source of water supply for all the proposed lake area.

(Sgd.) P. T. OWEN,
Director-General of Works.

14th April, 1915.

I have assumed an average depth of 20 feet in all the lakes. I had no data to go on except the schematic plan. I had nothing to show what depths were proposed We have the far eastern end on the 1825-feet contour, and the 1815 feet contour in the middle of the lake, the depth thus varying from 10 feet to nothing in the north-eastern corner. The worst place to have a piece of shallow lake is at the eastern end of the fetch; there will be a considerable wave action with consequent beaches. I have assumed the 20-feet depth as sufficient to avoid the growth of water plant, and to cope with silting up, which is bound to occur delta-wise where the discharge is from one lake to another. I have referred to the compensating flow which should occur at the junction of the Molonglo and the Murrumbidgee. That is purely arbitrary, but I have laid down that figure as the minimum. It has been said that the area of water proposed by Mr. Griffin for the city is the same as originally proposed in the departmental plan That statement is a mistake. For normal conditions the upper lake area of 2½ square miles is added. The Board never calculated on the 1845-feet level and the upper 2½ miles of lake. As a member of the Board I was opposed to having areas of ornamental water, but I ultimately gave way on that point. I argued whether we should have enough water for the lower lake areas. I concluded that we would just have enough—that we could rely on the Molonglo and the Queanbeyan giving enough water to maintain the loss by evaporation, compensating flow, and seepage. The second report was as follows:—

UPPER LAKE.

The Acting Secretary—

In accordance with the Minister's instructions I have had borings made and shafts sunk over the route of the proposed railway crossing at Molonglo, and have prepared the estimate based on the information available, which must be taken as approximate only.

It is found that the average depth of the rock below the surface is about 30 feet, and, on the basis of the levels furnished by Mr Griffin, giving a railway level of 1855, that the height of embankment would be from 20 to 25 feet over a bed lit above bedrock 55 feet, with a length of 1 mile.

The railway bridge is to be 800 feet long with a capacity of two tracks, roadway bridges to be of similar length, two in number, 40 feet wide (one on either side of the railway), the embankment to be water resisting, with slopes of 3 to 1 and 2 to 1, inner and outer respectively, and a water proof core of puddle clay or concrete.

The discharge notch is to be constructed of concrete, placed immediately in front of the bridges, to have a length of 500 feet, with sufficient depth of notch to discharge flood waters without appreciately rising the water level of the Upper Lake.

It would appear that the cost, as nearly as can be estimated without the assistance of finished drawings, would be as follows:

	£	s.	d.
Embankment—1,171,000 cubic yards at 1s. 3d.	73,187	0	0
Concrete, including coffer dams, excavations to bedrock and all charges—37,935 cubic yards at 50s.	75,000	0	0
Puddle core—96,300 cubic yards at 7s. 6d.	30,000	0	0
Excavation from surface to bedrock from puddle-core, including timbering—6,000 lineal feet at 30s.	9,000	0	0
Bridges, retaining and abutment walls, &c. —Item	150,000	0	0
Regulating gates—Item (provisional) ..	20,000	0	0
Approaches, contingencies—5 per cent. ..	16,169	0	0
Total	£371,346	0	0

LOWER LAKE.

This will involve the construction of a concrete dam, approximately 70 feet high, at a site opposite the Yarrolumla home-tend. The borings and levels are not sufficiently advanced to give a close estimate, but it may be taken approximately, at the present stage, as at least £75,000.

The above does not include any dredging, formation of slopes, basins, or protection for banks, which, in the absence of information as to the proposals, I am unable to estimate.

(Sgd.) P. T. OWEN,
Director-General of Works.

26th May, 1915.

My only available data in making that estimate was the width shown on Mr. Griffin's plan for the railway avenue The only levels we had were those shown on the schematic plan. The levels and widths of roads are therefore subject to modification If the Committee desires me to give a further estimate, I should like to be given figures showing what is the proposed section across the embankment. I understand Mr. Griffin has that section I have taken what was shown on the schematic plan in the absence of anything else to go on. Puddling would not be required round the banks of the lakes, but they would have to be either concreted or pitched, because strong protection against erosion is absolutely necessary. In parts we have a depth of 25 feet, which will give big wave action, according to the length of the fetch. Members of the Committee can see the strength of the wave action, even on the Albert Park Lake, which is only a few feet deep. If the outside or eastern lake shown on the plan were eliminated the country covered by it would, undoubtedly, be subject at rare periods to floods It would still be necessary to allow for the roadway, which I presume would go across whether we had an ornamental lake or not. The elimination of that lake would render unnecessary a certain amount of the protection of the eastern side of the formation, the puddled core, the dam, and a certain amount of expense on wing walls. The Committee should remember at the same time that I have not, at present, data showing what the real proposal is. The only plan which the Home Affairs Department has seen to my knowledge is the schematic plan. We ought, for several reasons, to postpone the actual filling of the lakes with water. We would use the material from the bed of the river.

20. *To Mr. Laird Smith.*—My general objections to having artificial lakes have always been these That even with only the lower lakes it was a close thing whether we would get the amount of water that would be required to allow for evaporation, compensating flow, and seepage, that there would be too large an area of water combined with large areas of park and unoccupied land—an æsthetic objection; that there would be a tendency to increase the relative humidity; and that there would be a danger of mosquitoes unless great care were taken. The cost involved in making and maintaining the lakes was also, to my mind, a big objection. It will, undoubtedly, cost money to maintain the lakes after construction, because the tendency will be for them to fill with silt. The whole of the great Molonglo plains have been formed by the action of the rivers. Much of the formation deposited in the course of many years is carried away again, because there is an open river there providing for high velocity, and the river takes away in its successive floods part of what has been left in previous floods. Immediately you put in an intercepting weir the velocity is lowered, and the deposition of silt goes on, because velocity is the main factor in preventing the settling of silt. There is no doubt that the lakes would fill, as is evidenced by the fact that, since we backed the river for the power house, the Jerrabomberra Creek, which is a back water, has practically filled up to water level.

21. *To Mr. Sampson.*—If I could not have all the lakes eliminated I would eliminate the upper or eastern one, but I know there are difficulties about it. Part of the land is close to the 1825-feet level, which was arbitrarily assumed as water level. That level need not be 1825; it might be 1822. I understand that the eastern lake is to be formed there because that country must be flooded at times. This might occur once in twenty years or less, and, therefore, the land cannot be built on without danger of loss.

22. *To Mr. Laird Smith.*—The level of the eastern lake will be maintained by an 800-feet notch in a weir. I do not believe the Commonwealth will be able to allow this shallow area of lake to remain. Portions of the bed are at the 1820-feet level, and others on the 1815-feet level This gives only 5 feet of water, which is too little to start with.

23. *To Mr. Sampson.*—The eastern lake means that 2½ square miles of additional country are submerged. It is not necessary to have the eastern lake at the 1845-feet level in order to regulate the waters of the lakes lower down. Its purpose is not as a regulating lake. A regulating lake is one from which you can draw off water to supply it elsewhere, but the moment we would start to draw water off the 1845-feet level we would have mud flats. I have never heard it suggested that it should be a regulating lake. I believe it is meant to serve simply the æsthetic purpose of a large water frontage, and a large area of water.

24. *To Mr. Laird Smith.*—The whole of the land which the eastern lake will cover has been covered by flood in the past, and may be covered by flood again. Much more land would not be flooded with a lake there than if there was no lake there. With heavy floods the river slope would flood a little more at the eastern end, but the normal level would be horizontal. There may be a rise over the notch of 18 inches, or 2 feet, which means bringing it up to 1847 feet, plus the river slope. The periods between the floods will probably be so long that I would not worry much about it.

25. *To the Chairman.*—The dam on the Queanbeyan river will tend to regulate the floods, but you cannot say absolutely that you will not get floods. If we got heavy rains after the dam is practically full, we would still get the same flood flow, but it can be safely assumed that the dams on the Molonglo and the Queanbeyan will tend to lessen the floods. I have had experience of lakes and artificial dams as a military engineer, but the question is almost entirely a geological one The risk of mosquitoes is greater with weedy vegetation, combined with shallow water and shade, or floating water plants. I think there will certainly be a risk of mosquitoes. Continuous oil protection over that area will be practically impossible, but the risk can be minimized by fish and wild fowl Albert Park Lake, which has no vegetation growing close around it, or in it, is a striking example of the production of mosquitoes.

26. *To Mr. Sampson.*—I think the upper or eastern lake ought to be eliminated. The western lake wants also to be carefully investigated, as there are shallow water difficulties there also. The scheme which appeals to me is to drop the level of these lakes 1 foot, or 18 inches, and reclaim the low-lying ground on the 1,825-feet level, which would be flooded, by pumping the silt on to it.

27. *To Mr. Fenton.*—Floods are going to be so infrequent that they can be practically disregarded, although the lower-lying ground could never be built on. The supply of water in the eastern lake is dependent on the Queanbeyan-Molonglo scheme being carried into effect. The dam on the Queanbeyan will be a kind of supply for all the lakes. My contention is that, if the supply from the Queanbeyan is not forthcoming for the eastern lake, it will mean that through the loss of water by seepage, evaporation, &c., large portions of the area will be nothing but mud flats. The normal flow from the compensating weirs, allowing for the flow at the junction of the Molonglo and Murrumbidgee, and allowing also for evaporation and seepage, is going to be insufficient.

28. *To Mr Sampson* -As a member of the Departmental Board, I proposed a scheme of modification and elimination of the lake proposals, to take out the kinks in the river at certain places without absolutely straightening it, to ease its convolutions and widen it, and then lock it, to form reaches of water that is, reaches of a ribbon of water more from an æsthetic point of view, but I cannot separate that view-point altogether from the engineering view-point.

29. *To Mr. Fenton.*—My plan would not give the same area of water. I have not calculated what area of water it would give, but I would treat the river somewhat in the way the Yarra has been treated, but avoid long, straight stretches, and try to retain pleasing curves. I suppose my plan would reduce the area of water to about one-eighth, or one-tenth, of what Mr. Griffin proposes.

30. *To Mr. Sampson.* — The river might be widened out to 400 or 500 feet. It is 400 feet now between banks in one or two places. I would put, perhaps, a couple of weirs in. If it were enforced on the public, the proposed scheme of lakes dividing the business from the Parliamentary centre would, I think, create a risk of having two towns established simultaneously, one on each side There is a great chance that a commercial or financial centre will be established only on one side or the other. If we have a parliamentary and administrative city, with certain functions that must be allied to administration on one side, and the other settlement or city on the other side, there is a danger of them becoming too independent cities in the course of time.

31. *To Senator Keating.*—If the lake scheme is adhered to there will be a tendency to destroy community of interest, especially in view of the fact that the city is being created as a seat of Government and administration. The figures given by the Statistician do not indicate that it will be a very populous city, and that fact would tend to accentuate the destruction of community of interest. I have not taken into consideration the value of the land which will be necessarily submerged by the creation of lakes. Protecting walls will be required for every part of the banks where you get a depth of more than 5 feet, unless rapid erosion is to be allowed. About 20 miles of protecting walls would possibly be required, but it would vary according to the nature of the land. That is a matter on which we must look for guidance to the city designer An example of that is to be seen in the central lake, shown on the plan, with one straight side and one curved side. Wherever there is a fetch of 1½ miles, and a depth of 25 feet of water, every time a west wind blows there will be considerable wave action. So far as regards the question of silting up, I have shown on the plan the approximate sites of the dam on the Molonglo and the dam on the Queanbeyan. The catchment area above these would deliver water into the impounding reservoirs, but there is a considerable area which would not deliver into impounding reservoirs. Roughly, there is an area of 140 square miles which would deliver its water, without any impounding reservoir to deposit the silt, into the eastern lake. The amount of silt that will be carried from there is considerable. There is a lot of shale country, and the Yarrolumla shale is most finely divided. It will break up and be carried down, and if allowed to stand in the lake areas it will sedimentate. The areas above will sedimentate into the impounding reservoirs, which will become silt traps for the country below. Those are interesting facts for the Committee to know, because the whole of the water that we are getting in the Molonglo will not be intercepted by the two weirs. If the lake area were considerably lessened, a large area of land would not be submerged. I think that is good land which, so far as I know, could be used for agriculture, or gardening, or might be laid out as park lands. Even if they were submerged once in twenty years, as the botanical gardens in Brisbane were, it would probably not damage them much. I have not examined closely the protective works on the banks of the Yarra between the entrance to the Victoria Dock and the Sugar Works Any protective work on these lakes would *have to be heavy in places. It is doubtful whether* loose stone can be always used as the effect of wave action is to draw out the finely-divided silt, or clay, at the back of them. The effect of the waves caused by the passage of vessels in a river is considerable, but it is intermittent. With the depth of water proposed, and the extent of fetch, we shall get on some of these lakes waves big enough to wreck a sailing boat.

32. *To Mr Finlayson.* -I believe, as a general rule, the levels of the lakes as now proposed follow the flood levels, except *that there is no provision* for flood or river slope If the lakes were made to the full capacity, shown on the plan, they would approximately cover the land that would be under water in flood time If the land were not covered by lakes it could not be built on, but it could be used for parks or gardens It is a question for the Committee to decide whether they will have water there permanently, or water at rare intervals, and land normally. My estimates, as to wave action, are based on a depth of 20 feet. If Mr. Griffin has given the Committee a return, showing that the depths average 11 feet over the five lakes, I would say that, where the banks are fairly steep, and the water fairly deep, it might be all right, but average figures are of absolutely no use in the consideration of the question of wave action. I assume a minimum of 10 feet. You might get a shelving beach, and the first result is that it piles up, and the beach extends out, and you get a mud flat or shallow water in the course of time. I thought that we would have certainly nothing less than 10 feet in these ornamental waters. Bathing places might be provided at one to two spots, with a sloping or shelving bank. I dare say the engineering proposal will be to have sloping banks going right down into the deep water. I do not know that the proposal is simply to allow the water to spread over the low-lying land, and find its level, as a flood does without any artificial deepening of the banks. In the schematic plan there is an evident intention to modify some of the banks. Wherever there is any considerable fetch of water the banks must be protected, or erosion allowed to proceed. Constant erosion would mean that the banks would recede. The question of whether the banks above the 1,825-feet level would be seriously endangered by wave action would depend on the nature of the soil. Alluvial deposit would cut away very quickly. I do not lay it down arbitrarily that the lake should be artificially deepened so as to give an average depth of 20 feet. I put down a minimum of 10 feet as requisite; otherwise we should have water-weed trouble. It would not mean a very great expenditure to secure a 10-feet minimum except in the eastern lake. There would be work in it, but it would not be a very heavy proposition. My idea always was to use the excavated soil for reclamation purposes. It would be advantageous to confine the city settlement to one side or the other. The distance between the two sides would be too great for a country town. Our financial and other businesses are to be started in proximity to the Parliament and administrative offices. After Parliament accepted Yass-Canberra I was on a Committee appointed by the Government to decide which part of the region should be accepted as a city site. My colleagues were Colonel Miller, Colonel Vernon, and Mr. Scrivener. We looked at various sites, and we all came to the conclusion that Canberra was the best in the region. We then started to investigate Canberra *itself. After going all over it Colonel Vernon* proposed the city site, which has been called Vernon, after him. I went to Yarroluma, and was greatly taken with the view of the mountains and the possibility of ornamental waters there, but Mr. Scrivener, who had lived in the place, said the only thing to be done was to put the city site under the protection of the hills. We others were finally convinced that this was so by the strength of the west wind. I was constrained by this consideration to abandon my predilection in favour of Yarroluma. I told Mr. Griffin this *when he came out, but he would never believe me.* The experience of men like Mr. Scrivener, who have lived there, and my own opinion—and I have been there constantly for years—is that, if we wish to get the best results of natural protection there is only one place for the city, and that is to the south-east of Kurrajong. My own view has always been that the reason for the city is Parliament House, which must be the pivot on

which the existence of the city turns. If the artificial lakes were created, after crossing the lake area on two or three cold, windy days in mid-winter, a distance, say of 1½ miles from the administrative offices on the south to residences on the north, the men would demand a more protected residential site much nearer to their offices. *It is purely a matter of distance. The intervention* of the lakes will mean crossing them on bridges. That is certainly an objection to settlement on the north side. The 800-feet opening, in the embankment mentioned previously, is to let the flood waters flow through—to take the discharge of the two rivers during flood. The notch would be under the bridge. I think an opening of 800 feet is about what is necessary. We understand that that is what Mr. Griffin proposes. My estimate of the cost of the embankment is based on the 800-feet opening. A concrete weir 800 feet wide would be required under the bridge. The end supports of the bridge would rise from the wings or abutments of the dam. The 800 feet would be bridge above and weir below. If we retain the waters at a height the velocity will be great to discharge through the notch. The erosion of the banks on the eastern shores of the lakes during west and north-west winds, which are prevalent there, would, with any depth of water, be considerable, unless the banks were protected. With a depth of 20 feet, and a good fetch, you will get big waves. I see no reason why the river should not be allowed to find its natural level beyond certain points. My estimate, that the flow of the Molonglo and Queanbeyan would be insufficient to allow for evaporation, seepage, &c., is based on an estimate of a 20-feet depth, shallow water and long shelving banks would greatly increase the evaporation. Both dams would not be sufficient to supply all the lake areas, especially in view of the fact that, in Australia, we are apt to get dry years. I am willing to concede that the lower lake areas could be kept supplied. That would be an area of 3 square miles. There is an area of 2½ square miles in the upper lake. The deduction of 2½ square miles makes a considerable difference in the evaporation. There would be no difficulty in keeping a fairly good level and flow if the river were widened and the corners taken out. River-bank treatment, to a certain extent, to counteract river-flow action, would be necessary. If the water levels came down there would be a risk of the frontages of the lakes being exposed and mud flats forming, but this would depend on the slope of the banks. I presume Mr. Griffin will propose sloping pitched banks. Dredging would be necessary, in course of time, to keep the lakes in good order.

33. *To the Chairman.*—I do not think the question of the lakes is stopping the lay out of the streets and avenues, and the planting of trees. You could not lay out a piece of the town without the railway question being settled. Mr. Griffin will tell you that each part of the plan is more or less connected up with the rest.

34. *To Mr. Gregory.*—I cannot give the Committee exact estimates of cost; I can only do this approximately until I know exactly what is proposed to be done. As soon as I am told what is proposed—and, I presume, such information has been prepared—I can make estimates. For instance, in March, Mr. Griffin sent in plans. In April and May, he asked for borings. In the middle of June we sent particulars of a number of borings, and we have the remainder nearly ready. That is work that takes time We cannot get any further ahead if Mr. Griffin estimates on one basis and I on another I shall be glad if we can get on to one basis.

(Taken at Melbourne.)

WEDNESDAY, 21st JULY, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith,

Percy Thomas Owen, Director-General of Works, Department of Home Affairs, recalled and further examined.

35. *To the Chairman.*—I can give an approximation of the information asked for by the Committee yesterday in regard to the saving that could be effected by omitting the upper or eastern lake. The estimate can be an approximation only, because there seems to be some doubt about the level of the railway right across. The Committee can take it roughly that, if we omit the puddled core and the pitching, while still retaining the two roads, the railway bridge, and the two road bridges, it will save about £160,000 There will be a certain small amount of pitching still required. £160,000 is a conservative estimate of the saving, because if the embankment is not going to retain water, it does not have to be consolidated so much as if it is to retain water, and a saving can be made in that way. There will be some pitching to be done on the lower edge, but not the amount of pitching that would be necessary with a fetch of a mile and a depth of close on 20 feet of water. The work remaining to be done would include the bank for the railway to go across. I am working in this estimate on the level shown on Mr. Griffin's schematic plan. I presume I will be given the sections. I worked on the 1,857 feet level. My estimate assumes also that the railway bridge and the road bridges will be built in a substantial manner with concrete piers and steel girders. I do not think we should be justified in making them of wood. There may be timber decking. My plan would not interfere with the supply of water for the other lakes. An opening would be left of a width of 800 feet, or more if necessary, to let the water go through. My estimate does not include the cost of the laying of the railway track. It refers simply to the embankment. I have made no estimate of the railway to the northern side of the city, as proposed in Mr. Griffin's plan. That would be a matter for Mr. Bell, and I have had no information to go on in that regard. It may be interesting to the Committee to know that a great geological authority, Professor Geikie, at showing the erosive effects of river action, estimates that there is in the average river one part of suspended matter in 1,500 parts of water, which if we got a flood of 1,000,000 cubic feet a minute, would mean matter in suspension to the extent of 46,000 tons coming down in twenty-four hours. That, of course, would not be all deposited. In this river probably the erosion, in view of the nature of a great part of the soil, would be perhaps even quicker. It is necessary to study the flow of the river to know whether the deepest parts will be

filled up first, but, as a rule, when a stream enters a lake the effect, as in the case of a river entering the sea, is frequently to form a delta. It is impossible to estimate what proportion of silt is likely to be deposited, because we have not the conditions now which will exist later on, but we can safely assume that there will be a rapid deposition of silt. The dams on the Queanbeyan and the Molonglo will stop a certain amount, but, as I explained yesterday, the drainage from a large area does not go through those dams. The Cotter is singularly free from deposit carried.

36. *To Senator Lynch.*—My calculation of 46,000 tons of deposit carried is not based on existing conditions in the Molonglo and Queanbeyan water-sheds. It is difficult at this juncture to give even an approximate idea of what the quantity will be, because we are going to rectify present conditions to some extent by putting in two dams. In course of time it will be necessary to suction-pump out the deposit. Probably the river will form a deep channel, and keep it.

37. *To Mr. Gregory.*—I have never been in favour of having any lakes in the area. I do not see that there would be any engineering advantage gained by making the large eastern or upper lake. A dam between the eastern lake and the circular basin would cause sediment to deposit on the eastern side, and, to that extent, save the western lakes, but you would simply be saving sedimentation in the lower lakes by making a mud flat of the upper. Undoubtedly the greater deposit would occur in the eastern lake, and much less in the western. If the western lakes are made, and a dam or catchment is put in where the railway is supposed to cross, thus causing greater silting in the eastern lake, it will involve in the course of time the dredging out of the latter, so that the question is almost as broad as it is long. The proposition I have had is to dredge the large circular basin, and with the matter thus secured reclaim what might be swampy ground on the edge of the site of the proposed eastern lake. I would not say that only one-fifth of the 46,000 tons of silt would be actually deposited. I do not think it would be the wisest course to have a weir of some sort at the entrance to the circular basin in the event of it being decided to construct the western lakes. I would fill the low country, let the silt come in, and use it for reclamation purposes. The greatest deposit of silt is more likely to be in the circular basin. The deposit of silt depends on the velocity of water which has it in suspension. There will be so much more still water in the circular basin that the deposit of silt will be correspondingly greater. I did not assume yesterday that the sides of the lakes, especially the circular basin, would be vertical. The expense in that case would be enormous. My idea has been that there would be as few vertical walls as possible, on account of the expense. I base my fear of the erosion of unprotected banks on the fact that there is likely to be considerable wave action. The best course would be to have the banks with a slope of two in one. The treatment may vary with each lake. As to the question of whether it would not be an advantage to proceed now with the laying out of the streets and the planting of them with trees, so as to take advantage of this winter, it depends on whether the plan is going to be adopted as it stands. If there is any doubt as to where the railway is to be put, it will hang up the laying out of the city, but it is possible that some tree planting could be gone on with now in the northern parts of the city. Even then, however, the necessity for some modification of the streets might arise. The question of laying out and making roads will have to be done as one big concern, with surveyors, engineers, and tree-planters working as one corporate body. The roads and tree-planting will have to come under the question of engineering. The point will have to be settled when the general control of the Territory is settled. The motto *festina lente* applies here just as it does at Delhi, in India, where time is being taken to lay out the Capital. We are undoubtedly spending money all the time, but it is all preparatory work, which will, I hope, have good results.

38. *To Mr. Laird Smith.*—The puddled core in the embankment is of varying width and thickness; its depth is somewhere about 50 feet. At its thickest at the base it means 9 feet of puddle, but it depends on the class of puddle put in. I was allowing for a 200 feet width of highway at the top. We have no suitable puddle in the Federal Territory, so that it would have to be brought there. If there is a width of 200 feet of highway at the top you must get a greater width at the base. I did not know that Mr. Griffin had given evidence that it will be 200 feet wide at the base. The schematic plan shows a width of 200 feet of highway, so that the embankment must be more than 200 feet wide at the base. My estimate, based on a width of 200 feet at the crest, gives a quantity of 1,171,000 cubic yards. Mr. Griffin estimates 570,000. The cost of the puddled core depends on the section of the embankment proposed, and that is information which I have not yet got.

Walter Burley Griffin, further examined.

39. *To the Chairman.*—I produce a sectional plan of the embankment. It shows a road for a railway 25 feet wide at the very top, with a lower road on one side 30 feet wide, and another lower still, and of greater width on the other side, 500 feet south of the Molonglo crossing. This embankment is 200 feet wide at the base. The height of the second road is 1,830 feet, or 5 feet above the water line on the lower lake. There is to be no notch in this embankment. It is to be a continuous bank with sluiceways below the water level reached by a vertical shaft. As soon as I get the data of the volume of water to be carried away, I can give an estimate of the cost. I was told by Colonel Miller that there was a flood in this very spot in 1913. All I want is the flood data for the last year or two.

Percy T. Owen, further examined.

40. *To the Chairman.*—I assure Mr. Griffin that there are no such flood records for 1913. We have no flood data for the area, and it will probably take twenty years to get them.

41. *To Mr. Laird Smith.*—If the upper or eastern lake is abandoned, I do not think the core could be put in afterwards, and the lake established at a reasonable expense. It would become a difficult proposition, which ought not to be contemplated. If water is to be put in the upper lake, a core must be put in when the dam is being built. I thought it would be better to trestle the railway across, but Mr. Bell thought otherwise. With a longitudinal section, I can give an estimate of what is involved in the earthwork and core. I can also take the possibility of trestling the railway into consideration in making the estimate.

42. *To Mr. Fenton.*—Mr. Bell thinks he can get a certain amount of stuff from along the railway for building the embankment, but in doing

that you can reach a stage where it costs more than to get it close to the spot by mechanical means. I have put down a low price for earthworks—1s. 3d. per cubic yard, including getting, transporting, settling, rolling, shifting, and spreading. I should like to see the section from Mr. Griffin before I say whether sufficient earth to make the embankment can be obtained from the tunnellings and cutting along the railway

43. *To Mr Sampson.*—I am not urging the riband water scheme I am merely giving my views in respect of it. If there were a riband scheme, in the course of years, with the knowledge gained of the biggest floods experienced, I would be able to form an idea of the extent to which the place would be submerged. In the course of an experience of fifty years, for example, it might be found that a flood would never rise to the height of the flood of 1891, and, if so, that would have the effect of throwing open more land. I can suggest no better way of utilizing the area represented by the depression along the river than that of converting it into market gardens. Most rivers are liable to floods The city of Brisbane has a river running through the centre of it, and it is liable to floods. The only use to which the land at the Federal Capital, which is liable to floods, could be put would be that of gardens or parks. Consequently, it would not matter if the area were submerged occasionally. In the earliest days of Canberra it will probably be used for market gardens. In the long run, however, I suggest that it should be used for ornamental gardens. I do not know of any other use to which it could be put. In my opinion, that land cannot be utilized for any purpose except for ornamental gardens or for agriculture. It seems very doubtful whether we shall ever have a repetition of the 1891 flood. The whole thing is problematical, and I do not pretend to make any forecast. There are so many factors to be considered which make the problem an exceedingly difficult one. There are, for example, contemporaneous rains over certain areas, and the meeting of flows from particular areas, which have to be considered Whether any particular obstruction existed in 1891, of which we are now unaware, I cannot say The only course open to us is to take our catchment area, and to make a forecast of what the flood level will be.

44. *To Mr. Gregory.*—I say now that we cannot afford to disregard the flood level reached on a former occasion. At the same time nobody can affirm that we shall have a repetition of the experience of 1891.

45. *To Senator Keating.*—There are no records in New South Wales of the flood levels of this river prior to the time when Mr. Hunt was transferred to the Commonwealth. No gaugings had been taken of these rivers. If once we knew the volume of these streams we could soon calculate their velocity. It is entirely an engineering proposition.

46. *To Mr. Finlayson.*—I would recommend that the connexion between the lakes and the basin should be maintained over a notch—over really a concrete weir. A cutting in the embankment would be required, and a bridge would have to be constructed across it. By being concreted the river bed could be made the means of communication at a sufficiently low level to take whatever water was required to the adjacent basin, but it would mean a heavy expenditure We should probably have to carry our pipes down till we got them on a good foundation.

47. *To Mr. Gregory.*—A very great risk would be involved in that work. Inverted syphons would have to be used. The cost of the earthwork in the dam would not be a heavy item

48. *To Mr. Sampson.*—It would not be necessary to artificially protect all the edges of the water around the 20 odd miles of lakes. The work would have to be judiciously done to prevent erosion.

49 *To Mr Gregory* I could only say whether the waters of the Molonglo are as heavily charged with sediment as are those of the Goulburn River, after I had made a comparison between the two waters. I have seen the Waranga Basin, but I do not know what is the amount of sediment deposited in it, nor does anybody else. But certainly the process of deposition is in progress I do not know that I previously conveyed the idea that enormous mud flats would be formed almost immediately. I said that, in course of time, there would be mud flats, and as to that I have not the slightest doubt.

50. *To Senator Keating.*—The percentage of the deposition of mud is 1 in 1,500. That represents the amount of solids carried in water. The rate of deposition really depends on the velocity of the water.

51. *To Mr. Fenton.*—Although the Waranga Basin simply catches water that runs into it from all points, the work of erosion is undoubtedly in progress there. I cannot say whether there would be larger deposits of solids in that basin than there would be in connexion with a scheme like that which we are now considering. Before I could offer an opinion on that point, I would have to examine the Waranga Basin. Of course, a lot depends on the surrounding vegetation, and upon the class of country.

52 *To Mr. Finlayson* I do not remember it being suggested that the deposition of solids was a difficulty at one of the creeks which we visited in the Monbulk ranges But we know that the Molonglo River is a very muddy stream.

53. *To the Chairman.*—Most of the river beds at the Federal Capital contain strong, coarse gravel, which is suitable for concrete work. These deposits of gravel are a great asset as they make excellent concrete. It would not detract from the laying out of the lakes if we utilized this material for building purposes. We should merely be killing two birds with one stone. It is the intention of the Department to utilize the gravel for building purposes. There is also excellent sand to be found in the river beds. This sand is nearly pure silica, and there is no shell in it. Sea sand, as we know, often contains a large proportion of shell. There is no other part of the Capital Territory where we could obtain gravel or sand cheaper.

54. *To Mr. Fenton.*—If the railway proposal and the lakes scheme were postponed for a time, the carrying out of works of utility within the capital area would not be delayed. I was of the opinion before Mr. Griffin came to Australia that the lakes would not be undertaken at once.—that the engineering works would be first proceeded with.

55. *To the Chairman.*—There is nothing to prevent building operations proceeding, and the streets and avenues being laid out without delay. I have no desire to express an opinion on the proposed railway of Mr. Hobler.

56. *To Senator Lynch.*—I adhere to the necessity for having the railway station close to Parliament House, and close to what I believe will

be the initial town. I do not think it is necessary in the initial stages of the city to take the railway across the water The site was selected in order that the city might be established on the southern portion of it. It will not be necessary to settle 30,000 people within an area of 6 square miles at the Capital, assuming that it develops on the same lines as Geelong has done. There is an extended area of country running to the south, which can be utilized for settlement, and which is shown on Mr. Griffin's developmental plan Fifteen thousand inhabitants is the number that we estimate the city will possess in its initial stages Six square miles would be a sufficient area within which to settle that number.

(Taken at Melbourne.)

THURSDAY, 22ND JULY, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson.
Mr. Fenton,	Mr. Laird Smith.

Thomas Hill, Engineer, Department of Home Affairs, sworn and examined

57 *To the Chairman.*—The only estimate I have made in regard to the lakes has been in regard to the Yarrolumula dams. We got out an approximate estimate of £75,000, but I think I would be able to give you a closer one. We have checked the rock levels, and taken the sections; and I am preparing plans for submission to you if it is thought necessary. The only other estimate prepared is one furnished by the Director-General for a combined dam and railway; but in the absence of information there has been no endeavour to act upon that. An estimate of what it would cost to complete the lake, as shown on the plan, has been prepared; but I do not know what Mr. Griffin proposes.

58. *To Mr. Sampson.*—The construction of the eastern lake is not necessary to the successful carrying out of the lake system within the Territory. It would not be necessary to have any embankment between the eastern basin and the eastern lake if we were to remove the railway line from the proposed site below the basin and the eastern lake to a route proposed by the director-general between the central basin and the eastern basin I regard these as two lakes—two separate propositions.

59 *To Mr. Finlayson.*—The upper lake would have some value as regulating the flood storage.

60. *To Mr. Sampson.*—It would be practicable to confine the area of the lake scheme to a ribbon of water like the Yarra. We could devise a scheme for straightening up the course of the Molonglo River, and so avoid flooding. This would mean levee banks, and you could aim at regular uniform sections, and regular slopes, turning the river more into an actual channel. I have not worked out the expense of such a scheme, but it is certainly feasible. It would then be safe to build right down to within a reasonable distance of the channel. By a system of levees and excavation you could make the Molonglo quite safe as to flood discharge; similar action has been taken in connexion with the Goulburn and other streams. We could confine the water within a computed section necessary to the discharge. I think this would cost less than the present proposal, but the artistic effect is another question The regular shape of the two basins could be secured by artificial embankments. You could trim the banks and pitch them at water-scouring level. I think the effect would be somewhat that of the Yarra at Princes-bridge, and the stream would be somewhere about the same width.

61. *To Mr. Finlayson.*—If the section were regulated as suggested by Mr. Sampson, the flood level would be reduced very appreciably, and kept within a few feet. That is a matter which might be left until you were ready to construct the walls; but once you raise the levels, the whole of the work must be done.

62. *To Mr. Laird Smith.*—There is enough water in the river to fill the lower lake, but not the upper lake. It is a matter of doubt whether there is sufficient water for the upper lake in a dry year. I think there will be considerable siltage in the upper lake; but, as to that, it might be possible to give the Committee some idea by means of the little lake in front of the power-house. It is difficult to give the rate of silting per year. For instance, this year we have had very little, there having been no freshets to bring it down, though next year there might be a flood to bring it down some inches. There is, however, distinct evidence of silting. At the Cotter, for instance, two successive freshets in three weeks brought down each of them an inch. As to confining the water within the three regular basins, there must be certain excavations, embankments, beaching, and slopes.

(Taken at Melbourne.)

WEDNESDAY, 4TH AUGUST, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

John Montgomery Coane, civil engineer, sworn and examined.

63. *To the Chairman.*—The country to the north of the lake is suitable for building purposes, being nice, undulating land, and there seems to be no reason why the city should not extend in that direction. The most suitable land for industrial purposes seems to be that to the north or to the south-east, or even that part shown on the plan as the eastern or upper lake. Some of that might be good building land; but, of course, great expansion in that direction would mean a tremendously large city. The tendency would be for officials and others connected with the administrative block to settle to the south, so as to get as near to their work as possible. Certain leading principles ought to be followed in designing a lake system. The first is that there should be sufficient water to keep the lakes at a steady level, so that there may be no mud banks in the summer, causing exhalations and breeding mosquitoes. I would limit the lake area to the capacity of the water that can be brought in to keep it full. The eastern lake shown on the plan extends a very long way.

Speaking from memory, the quantity of water which competitors for the design were told would be available in a dry season is 20 cubic feet per second. I therefore do not think it would be wise to make your lake area more than from 1,000 to 1,200 acres in extent. Otherwise there would be a danger of it drying off, with the bad effects I have mentioned. I know that mosquitoes lay their eggs in mud, and these hatch out in millions when rain comes. Roughly, your water area should not exceed from 50 to 55 acres for every cubic foot per second available in a dry season On the plan I now see before the Committee, there is, I think, too much land under water. I would not put so much water there. I should cut out the big eastern lake altogether.

64. *To Mr. Gregory.*—I do not know anything about the proposed big dam on the Queanbeyan. I am assuming that the data given to competitors were correct.

65. *To the Chairman.*—My recollection of the original plan was that the eastern lake was supposed to be 5 feet higher than the circular basin, and 10 feet higher than the western lake. If a man wanted to travel in a motor boat from one end of the lake system to another, my recollection is that, unless there were locks, he would have to pull his boat out of the water twice. If I am assured now that the difference in the levels is 20 feet, I would say it is too much, and probably as the water fell it would leave too many shallow, muddy margins in the upper or eastern lake. I should try in a lake system to have the banks fairly steep, and avoid long stretches of slightly sloping ground which would, with shallow depths, mean increased evaporation. The lakes could be made narrower by reducing the high-water level. In any case, I would try to keep the water area down to 1,000 or 1,200 acres. If I am told that Mr. Griffin's plan is based on the flood level, I should say that that depends a good deal upon the capacity of the waste weir. It would not be necessary to keep the level of the western lake at 1,825 feet. You could arrange that the level should not rise above 1,822 or 1,823 feet, or less. If a dam was erected on the Queanbeyan to regulate the flood waters, and there was a greater supply than 20 cubic feet per second, your lake area might be made correspondingly larger, so long as the raising of the water level did not spread the water out over a lot of ground with very small depths, which I should not like to advocate.

66. *To Mr. Fenton.*—I have always advised against making cut-offs in river channels. Nature makes it own grades for rivers, and it has been found that cut-offs lead to complications and alter the grades. The ground cannot stand the scour, and the river eventually returns to its original course, or makes itself a new one.

66A. *To Mr. Sampson.*—I would not make artificial stone borders all round the western lake. It would not be necessary to make a quay of the borders. To let the margin of the lake follow the contours of the ground would save expense, and would not look so stiff and formal. The western lake might be allowed to reach the flood level of 1891, but the presence of a large eastern lake at a level of 1,845 feet would, by acting as a flood moderating basin over which the water would spread and rise, have the effect of reducing the flood level in the western lake. No matter what dam is erected, I would not have the eastern lake, and I would not have so much water in the western lake as is proposed on the plan, as my recollection is that the edges would be shallow.

67. *To Mr. Finlayson.*—With a small lake in between the northern and southern parts of the city there would be no difficulty of access from the south to the north. I do not remember the adjudicating Committee looking on Parliament House as the pivot of the design. What was in my mind was that Parliament House was in a very good place. Men employed in the administrative offices in Melbourne perhaps do not all live close to their work, but Melbourne is not a parallel case. This is to be a new city, which will be largely populated to begin with by officials. They would not care to go out on the northern flats, or even away out on the western part, and build their houses there with large areas of vacant land between them and their work. It would be like a man employed in Melbourne going to Mordialloc to live. Mt. Vernon, as a residential area, would be convenient to Parliament House and to the administrative centre. The civic centre, as shown on the plan at Mt. Vernon, is about a mile and a half from Parliament House I regard half-a-mile as easy walking distance. If you had water enough to keep up the level in both the big eastern lake and the western lake, it would be all right as regards mud; but the level would depend on the waste weir. It is much more necessary to maintain the level of the lower basins and lakes regularly than to maintain the level of the upper lake. The level of the lower lakes should decidedly be maintained. The upper lake, with its reserves of water in a dry season, would serve a useful purpose in enabling the level of the lower lakes to be maintained; but if the 1,845-ft level in the upper lake was lowered for this purpose, there would be a tendency to form shallow, muddy margins. If any lake at all is formed to the east as proposed, it should be kept full all the time. If navigation is to be considered, it would be necessary, if you did not equalize the levels, to have a lock connecting the one system with the other.

68. *To Senator Lynch.*—The maintaining of the levels of the lakes permanently should be a leading principle. I would not favour making the higher lake, as my recollection of the ground is that it is too nearly level. Even if we had enough water to maintain the level, I would content myself with the lower lake. To combat mosquitoes, I would advocate the filling up of all shallow holes, the prevention of the formation of mud banks, and petrolizing. I do not think mosquitoes will breed in a clean lake of fair depth.

69. *To Mr. Laird Smith.*—It should not be necessary to pitch the whole of the border of the lower lake. On its northern side, the levels indicate that, as now designed, a 10-ft. wall would be necessary. Pitching might be necessary where erosion took place, but I would put revetments in only at certain points where the necessity arose. Lakes undoubtedly add great beauty to a city, as is seen at Geneva and other places. My experience is that nearly all the town planning of late years has been done in cities already built up, and is more or less confined to the suburbs. I do not know any case except this of Canberra where a completely new city has been designed, but the tendency is to confine each section of the community to its own part.

70 *To Senator Story.*—Without criticising the details of Mr Griffin's amended design, which I assume is settled, and must be abided by whether it is judicious or injudicious, my general impression is that it is too scattered. I would not have the civic centre so far away from the parliamentary centre.

71. *To Mr. Fenton.*—The lakes as at present designed cover, I am told, 5¼ square miles, or about 3,500 acres Even if I had an area of only 1,000 acres in the lower lakes, I would not have the eastern or upper lake at all My recollection is that there are gentle slopes, which, without a tremendous lot of excavation and banking, would mean very shallow water at the edges I do not advocate having a level of 1,825 feet in the lower or western lakes I would prefer to have the level lower, and over about 1,000 acres. That would, as far as I remember, have a tendency to do away with shallow water With an area of only 1,000 acres of water the tendency would be to keep the water within the steeper ground. It would not reach certain outlying portions marked on the plan This would mean a lake of more consistent depth My recollection is that about 1,820 feet would be a suitable level for the western lake system.

(*Taken at Melbourne.*)

THURSDAY, 5TH AUGUST, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

John Howard Lidgett Cumpston, M.D. (Melb.), B.S. (Melb.), D.P.H. (Lond.), Director of Quarantine, sworn and examined.

72. *To the Chairman.*—With regard to the effect on health of the proposed lakes at Canberra, I think that the matter may be dismissed, presuming always that the water will be kept in a clean condition. As regards mosquitoes, practically the whole of the surface of the main body of water may also be dismissed. Mosquito larvæ depend for their continued existence on a calm water with some vegetable matter to supply them with food. Where you have a large sheet of water with a ruffling by the wind you will find that mosquitoes will never remain in the portion which is disturbed by the wind, and that they will only be found within a foot or so of the bank. If the bank be kept free from vegetable matter, that is, overhanging weeds which will give them shelter, the amount of mosquito breeding will not be large. If, in addition, a lake has some fish of a type which will eat mosquito larvæ, I think that the question of mosquito larvæ need not receive very serious consideration. Besides, at Canberra, the winter is probably so cold, and in portions of the year so windy, that mosquitoes, I imagine, would never be likely to become a trouble. Probably there will always be some mosquitoes at Canberra, as there are in almost all parts of Australia right through the year, but never sufficient to be a nuisance Curiously enough, only last night, in my own house at Armadale, I caught the first mosquito for the forthcoming warm season, indicating that mosquitoes will always exist in the warm corners of houses, right through the winter. But it is very exceptional to get them until the first warm weather, and it is unusual here to get them until about November. There are always a few from the summer disappearing with the onset of the cold weather. That in the main is the position, I think. I do not consider that the proposed large sheets of water are likely to be so much of a nuisance with regard to mosquito breeding as the domestic water tanks, that is, the small 400-gallon iron tanks round houses. In places where mosquito campaigns have been instituted, it is the common experience that the breeding places are mainly and primarily the water tanks for the houses. There is a danger of mosquitoes breeding in the cisterns of water-closets, but only in such places where the water remains unchanged for a considerable period. In 99 per cent. of the houses, of course, the water in the cistern is changed several times a day, and for the full development of mosquito life it is necessary that the water should remain undisturbed for anything up to ten days. Consequently, it would only be in an unoccupied house that the cistern could be a source of danger. On the whole, I should think that with a proper water supply, a proper drainage of the ground surface, and a proper system of underground sewerage, as, of course, there will be provided, the mosquito danger at Canberra will be negligible, practically speaking. Provided always that the water in the lakes is clean, and does not contain much decomposing body of organic material, I should say that the effect of the lakes on the health of the citizens would not be deleterious. I cannot conceive of any reason why it should be. I have had no first-hand experience of the lakes at Ballarat. I went into the figures some time ago in connexion with mining. The figures for ordinary diseases at Ballarat are no higher than the figures for any other town in Victoria. I do not know of any town in Victoria, other than Ballarat, where artificial lakes exist. I have never heard of any complaints in respect to Albert Park lake in South Melbourne, and I do not know of any justification for assuming that that lake, bad as it is, has any ill-effect on health. Possibly a parallel case may be found at a place like Perth, where there is a large body of water somewhat similarly situated to the Albert Park lake, and that body of water can only be regarded as a very valuable asset to the city. I do not see any reason why, from the point of view of health or of mosquitoes, this Committee should hesitate to recommend the provision of artificial lakes at the Federal Capital.

73. *To Senator Lynch.*—I do not remember saying that if the body of water were sufficiently deep there would be no danger of mosquito larvæ occurring. It is a question of the extent of the surface of the water allowing the wind to blow over, and keep the surface ruffling; it is a continual movement of the surface of the water which prevents mosquitoes from developing. For their continued existence it is requisite that they shall breathe the air above the water through a small breathing hole in their tail, and, as you have seen them no doubt, they wriggle up to the surface and attach themselves to it by the tail and breathe through a small tube. If the water is in continual motion, mosquitoes cannot remain attached to the surface; consequently, they cannot breathe, and die of asphyxia. They do not prefer still water; they must have a perfectly still surface. For their power of attachment to the surface they depend on the surface-tension of the water, which is disturbed if the wind is playing over it. As regards the body of water indicated on the map here, I should think there is no doubt that the natural

wind will be enough to prevent any mosquito trouble arising I know Victoria Park, in East Perth. Mosquitoes are pretty active there; but, in the open water at the park, you will not find mosquito larvæ As you know, at Victoria Park and right along the Swan River, especially at Burswood Island, the river itself is free of larvæ, but all the swampy ground along the foreshore, where the rushes grow, used to teem with larvæ—simply pools of them. I know a little about this matter, because for two summers there we carried out a scheme of mosquito destruction. We spent about £500 in each summer, and I think we can say that for the time being we practically freed East Perth from mosquitoes. Incidentally I might mention that the reason why we did not entirely free that locality was that every householder was breeding mosquitoes in his own tanks. But, in a small place like a puddle with water half-an-inch deep, caused by the mark of a cow's hoof, which is very common just near the cricket ground, mosquito larvæ are very common, but along the edge of the river there were no larvæ to be found. The existence of mosquitoes in Victoria Park is only due to the presence of the river by reason of the fact that the river is surrounded by swampy ground to such a great extent that the width of the swampy ground is from five to ten times the total width of the river there. As regards preventive measures for removing the pest, the best method, I think, is to free the area under consideration from small collections of water which are protected by vegetation, and which are supplied with a certain amount of vegetable material, this being the food on which the larvæ live. The use of petrol is only necessary where you cannot accomplish the same result by draining or removing the water. The extermination of mosquitoes is simply and only a question of removing the water which is their breeding ground. If you can do that, you exterminate the mosquitoes; but if you cannot do so your only alternative is to oil the surface of the water in order to prevent the insects from breeding.

74. *To Senator Story.*—I have been to Canberra. I have been along the Molonglo River in summer time, when the water had ceased to flow. At that time a question arose of providing a water supply for the Military College. I was asked to go up the river, and I did go up its course for several miles. In its then condition, when there was no constant flow along the bed, but merely a chain of isolated pools, the Molonglo formed an ideal breeding ground for mosquitoes. I remember noticing that we did not see a single mosquito. Still, there would be a possibility of mosquitoes breeding in the river as it is at present. If mosquito life is introduced, as it will be by the advent of population, the river, in its present condition, offers a more certain danger of breeding mosquitoes than it will after carrying out the proposed scheme. If the lakes are formed there will be less danger of mosquitoes infesting the capital than if the river is allowed to remain as it is, for two reasons: First, the vegetation in the river offers an ideal harborage, and ideal feeding, but with a properly-controlled lake under satisfactory management the banks will always be kept clean. There will not be sufficient food, and, in my opinion, the danger will be considerably less.

75. *To Mr. Fenton.*—The life of an adult mosquito in the winged condition is somewhat uncertain; it may be up to two years, but very rarely. I am speaking of rather controlled conditions; but we do know that from summer to summer mosquitoes live in the winged condition, being one of the ways in which they are carried over from season to season. The other way is the storing of the eggs in mud. As regards the twists and turns in the river, a recess or sheltered corner with some vegetation might form a breeding ground where the mosquitoes would be left undisturbed by the wind, especially if the water were somewhat shallow. But with an active attendant, it could never become a serious matter at all. Five minutes' work a week at the corner would prevent any possibility of a serious nuisance arising. It will simply be a question of the attendant keeping the bank clear of vegetation, or, if necessary, pouring a cupful of oil on the corner. The mosquito uses its sting for feeding purposes. Of course, the main food of mosquitoes is vegetable material, not animal material. If they have been feeding on infected or putrid material they do produce slight local diseases. That is not a serious thing from the health point of view. But, on the other hand, mosquitoes may become the spreaders of certain varieties of infectious disease. Suppose that you have a disease in a locality, a mosquito feeding on one man and then for a time feeding on another man, would transmit quite a variety of diseases; but, then there are a good many conditioning factors For example, with particular diseases particular species of mosquitoes are healthier. So far as we know, yellow fever is only spread by one species, and then always by the female. In any species of mosquito the male never bites humans. The only mosquito that stings humans with its bite is the female. If mosquitoes feed on germ-laden or diseased matter, and afterwards bite a human being, they may convey disease. In some cases it has been suspected that epidemics have arisen in that way, but the occurrence is rare, and probably will always remain rare. Flies, for example, are a much greater danger in that respect. I do not think that one can say that a moist area is absolutely essential to the life of a mosquito. Water is essential for breeding; but I do not think that necessarily a moist atmosphere is essential. For instance, on the Toorak hill, where the atmosphere could not properly be described as a moist one, mosquitoes are quite common during the summer. In Kalgoorlie, they are becoming quite common, and there the atmosphere is anything but moist. Mosquitoes are not good travellers; their range of flying is limited. Probably half-a-mile is the maximum; more likely it is a quarter of a mile or less. They are carried by the wind up to possibly a mile or two, but the method of transmission from place to place, say, from Perth to Kalgoorlie, which is a case in point, is by water tanks.

76. *To Mr. Gregory.*—It is possible that a lot of mosquitoes were taken from Perth to Kalgoorlie with vegetables; but, as a rule, they are carried; they do not fly, which is the main point. The mosquitoes are not blown up to Toorak from the Yarra River; they breed at Toorak. I know of certain house tanks where they have been breeding in the summer.

77. *To Senator Keating.*—I am acquainted with the climatic conditions of Canberra, but, apart from those conditions, a congenial climatic condition is necessary to the breeding of mosquitoes. Invariably, the cold winter kills off the adults,

except a small number which find a refuge in a warm corner, such as a kitchen, and so on. They survive the winter; they do not live through the winter in a state of suspended activity, for they are able to fly about, and so on. They do not, as a rule, bite through the winter. In my opinion, the climate of Canberra is not a climate in which we may expect to get mosquitoes. I think that you will never get a large number of the insect in a place like that, because the winter will always kill off the adults. If the proposed lakes are desirable for other reasons, I should say that the mosquito question need not be considered. Alongside other issues it will be quite insignificant, because it could easily be controlled. In its natural state the river offers distinctly a favorable breeding ground for mosquitoes, and I should say a more favorable ground than would the lake scheme. But, on the whole, I do not think that the other surrounding conditions are such as to cause any apprehension of a serious problem being presented by the mosquito.

78. *To Mr. Finlayson.*—As regards the insistence of general conditions of hygiene, which will secure the health of the population, I can only say that there are certain gentlemen who are concerned with the planning of the Federal Capital, all of whom are well known and have had a very extensive experience with such questions. There are certain main issues to be considered, such as a proper water supply, a proper scheme of sewerage, the provision of adequate natural ventilation by establishing open spaces within the city at a sufficient distance from each other, and by controlling the height of buildings with a minimum width of streets, the restriction of the number of persons resident on any given area, the efficient drainage from the first point where the refuse may be deposited, whether it be in the house or on the street, including all details down to the final disposal area, and the properly-controlled distribution of various trades. The principal trade question which stands out, of course, is that of noxious trades. It will always be necessary, in a centre of population, to have certain noxious trades. Butchers, of course, will be necessary, and the disposal of their by-products will always have to receive consideration. That means that the area for noxious trades, whatever they may be—they are well defined, of course—would have to be set apart in a suitable place, so as to be near enough to the city for business convenience, but far enough from the city to avoid any possibility of a nuisance arising. With regard to certain kinds of factories, I should imagine that, from a health point of view, there would be no marked objection to their location within the confines of the city. It is rather a big order to pronounce offhand whether their aggregation into one group is desirable. There seemed to me to be a number of factors involved. If the whole of the manufacturing industries were concentrated in one area, I think it would be a question of whether the population necessary for the maintenance of those factories could be grouped within a sufficiently close distance of that factory area. The provision of residences for the workmen engaged in the factories seems to me to be one of those matters which should be carefully considered in dealing with any question of the grouping of industries. A man should have as little distance as possible to go to his work; yet he should be provided with hygienic surroundings in which to spend his home life.

79. *To Mr. Gregory.*—I think it would be an added advantage to the Capital to have the proposed lakes. The provision of a continuous supply of water is, I imagine, a necessary engineering factor in forming the lakes. If the supply of water were allowed to decrease in the summer, and mud flats to be created, I imagine that there would be a danger arising from mosquito life, but I should think that the engineers who were responsible for the formation of the lakes would take steps to see that there would not be any mud flats. There might be a certain fall in the level of the river, but it is rather a question of engineering than of anything else. I assume that, for their own sakes, the engineers would make provision for maintaining the lakes at the proper level. I think it is necessary that there should be a proper storage of water for the purpose. I should say that it is desirable to have the lakes maintained at a constant level through the summer, but the means by which that should be done is, of course, a matter outside my scope. Assuming that those precautions are taken, I think it would be conducive to the health of the community to have the lakes at the Capital. I would not allow any of the storm water drainage to run into the lakes. I should say that most decidedly such water ought to be carried beyond the lakes, otherwise there would be constant pollution. An instance of that kind is furnished at Queanbeyan itself. The storm water from the main street of that town is discharged through a brick channel into the Molonglo just at the Queanbeyan bridge. A band of silt is quite visible, existing half way across the river, and composed of washings from the main street of the town, and it is exposed to a depth of a foot or so through the summer. I have been to Queanbeyan and noticed certain insanitary conditions. As the water supply for the proposed lakes at the Capital will be dependent upon a supply which receives the surface drainage of Queanbeyan, I should say it is emphatically essential that the sanitation of that town ought to be properly controlled. It is outside my jurisdiction, however, to suggest how it should be done, but Queanbeyan should certainly be above reproach if the sanitary conditions of the Capital are to be considered satisfactory. I would fix a minimum area for each dwelling at the Capital. Most distinctly that is one of the axioms in town planning at present. I am not prepared to state what area would be essential for each household. I do not think that one could do so. But, in addition to fixing a minimum area, it has always appeared to me very desirable to fix the minimum distance between the walls of adjacent houses, and also to prohibit the erection of terraced dwellings or semi-detached dwellings.

80. *To the Chairman.*—Semi-detached dwellings are undesirable, from the point of view of hygiene, because it adds to the expense.

81. *To Mr. Sampson.*—Whether the body of water in the proposed lakes will be large enough to preserve its purity during the whole of the summer is largely an engineering question. I should say that it would be desirable to maintain the lakes at a constant level, and not to allow a reduction of the whole volume of water. The real danger from mosquitoes would occur in the shallow portions of the lakes, but if the slope of the bank were made reasonably steep, and the unnecessary vegetation were kept away from the water level, I should think that the mosquito question would probably be insignificant.

(Taken at Melbourne.)

TUESDAY, 24th AUGUST, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Thomas Griffith Taylor, B.Sc., B.E., Sydney, B.A., Cambridge, F.G.S., F.R.G.S., Physiographer to the Commonwealth Meteorological Bureau, sworn and examined.

82. *To the Chairman.*—I am aware that the Committee has under consideration the question of the possibility of silting in the artificial lakes from the Molonglo River. In company with Mr. Mahony I made a geological survey of the Territory some time ago, and therefore I am conversant with the rainfall conditions of that area. Owing to the peculiar features of the Molonglo I do not think that much trouble from silt need be anticipated, but I imagine that a certain amount of silting may be expected in the Queanbeyan River. The watershed of these rivers is among the most complicated in Australia. The Molonglo rises in the south-east of the Capital City area, and after flowing normally for some distance, about 10 miles, I think, it crosses an extensive plain, and it is there that all the silt is deposited which has been brought up to that point, where there is a very big change in the profile of the river.

83. *To Senator Lynch.*—This point, where the silt is deposited, is about 12 miles from the junction with the Queanbeyan River. Silt coming down the Queanbeyan River is much more important than silt coming down the Molonglo. The structure of the country through which the Queanbeyan flows is practically identical with that generally on the western side of the Divide of New South Wales, so that if the Committee has any data as regards silt from any of those rivers on the western side, it could be applied to the Queanbeyan with safety. Geologists are agreed that the sediments of those rivers running over silurian shale and sandstone are identical with the Queanbeyan and the Molonglo. The granite at the head of the Queanbeyan will probably not contribute so much silt as the other formations. The only direct evidence I know of in this district as regards silt deposition was that prepared some years ago by me with regard to Lake George, which is only 10 miles away. I have on this question some other data which I think might be of interest to the Committee. It refers to the amount of silt carried down by some rivers of a somewhat similar size in America. For instance, it has been found that the Merrimac at Lawrence contains 10 parts by weight of sediment per 1,000,000 parts of water. The River Hudson at Albany contained 15 parts of sediment, the Alleghany at Pittsburg 50 parts, and the Potomac at Washington 80 parts. Reference to this matter will be found in Hubbard's work on "Water Supply," to be found in the Melbourne Public Free Library. These streams are approximately of the same order as the Molonglo.

84. *To Mr. Gregory.*—The geology of the country through which these rivers pass is also somewhat similar to that in the Federal Capital country, but I think the rainfall is a good deal heavier. I have not made a comparison of the geological features of the different rivers I have referred to, but the general characteristics compare with the Molonglo and the Queanbeyan.

85. *To Senator Lynch.*—I have not made any tests to ascertain the proportion of sediment to water in the Molonglo, but it is probable that in New South Wales there are some settlement tanks for silt in creeks which closely approximate to the size of the Queanbeyan. I am only speaking of the characteristics from the geological point of view.

86. *To Mr. Fenton.*—I think the Queanbeyan contributes more silt than the Molonglo. The water in the latter river may be "pea-soupy" in colour, but this characteristic varies according to the time of the year.

87. *To the Chairman.*—My impression is that the volume of water in the catchment will be sufficient to maintain the artificial lakes. The Molonglo, however, dries up, and is practically only a trickle for a month or two during the year, and it would not be possible to maintain a big sheet of water 10 feet deep, and subject to evaporation, without a weir on the Queanbeyan. If a large dam were constructed on the Queanbeyan River that would pretty well do away with the likelihood of any silt difficulty in the artificial lakes, and in this connexion I would suggest to the Committee that they should get data from the New South Wales Government with regard to the Burrenjuck dam, because that has been constructed in exactly the same type of country, and the same problem must have been dealt with there. I think that provision is made there for scouring by sluice gates.

88. *To Mr Gregory.*—I do not think the Burrenjuck is of too recent construction to supply useful information. The New South Wales authorities took rainfall statistics over a period before the Federal Capital Site was fixed.

89. *To the Chairman.*—I have only seen one flood in the Molonglo River, and that was just before the time fixed for the ceremony of laying the foundation-stone of the Capital City in February, 1912, I think it was. The river had ceased flowing for some months, and after a heavy rainfall it rose rapidly in the course of a few hours, and carried away the mail as the mailman was driving across. I suppose the river rose 6 or 7 feet in an hour or two. The biggest flood, I think, was in 1891, when in the month of June there was a total rainfall of 8 inches, as compared with an average of two inches. I have not had any experience of artificial lakes, so I can offer no opinion on that subject, though I think the silt difficulty will not interfere with a lake. For instance, Lake Geneva is practically unaffected by silt, except just where the Rhone enters it, and there a shallow delta is forming. I do not think there is any danger of the artificial lakes in the Capital City area being affected by silt, in the sense that they will become offensive, provided the conditions with regard to a regulating weir are carried out. If I were asked for my opinion as to the advisability or otherwise of constructing artificial lakes in the Capital City, I would say that, from a scenic point of view, they would become the biggest attraction in the whole scheme.

90. *To Mr. Finlayson.*—Regarding the lakes from a utilitarian point of view, I cannot at the moment think of any advantage to be gained from them apart from the scenic point of view. The water supply is adequate. But open spaces in a city, whether covered by water or not, are always advantageous.

91 *To Senator Keating* —I think the lakes as proposed will minimise the disadvantages of flooding There would have to be a tremendous downfall at Queanbeyan, to cause any appreciable rise in the level of the lakes, and to cause any danger of flooding, provided, of course, that the retaining walls were sufficiently high.

92. *To Senator Lynch.*—I do not think that the geological character of the country indicates that the rivers flowed in an opposite direction at one time. Geologists are fairly sure that in tertiary times all the rivers flowed to the north-west. The probable assumption is that at a late date in geological history the Great Divide occupied the position of the present coastline, and naturally all the rivers flowed away from it to the west. But in the Territory itself it is probable that the Divide has not altered its position materially, and so the course of the rivers close to the site has not been changed *materially*, except in the case of Lake George. The Upper Murrumbidgee, however, it is believed, used to flow into the Snowy River, but that was so long ago that it can have no bearing on this question.

93. *To the Chairman.*—The nearest point on the Snowy River from the Federal territory is near Cooma. Over the Capital territory the intrusive rocks are what we call the porphyries. All the region west of the Murrumbidgee consists of grey granite.

94. *To Senator Lynch.* -It might be said that the topography of this region indicates that the area is subject to earthquake action That remark will apply to the whole of the area in the south-eastern portion of New South Wales But there has never been an earthquake that matters in that locality. Earth shocks, however, are more common in that area than elsewhere in New South Wales. Canberra is about the middle of the area subject to little shocks of earthquake The topography of the western part of New South Wales shows that that part of the State is free from earthquakes.

95. *To Mr. Sampson.*—It is difficult to say how closely any of the American rivers to which I have made reference approximate in geological formation to the Molonglo, but they have the same general type of sandstone and shale, and they are about the same age. For instance, some of the limestones are pretty well the same as the limestones in the Federal Capital areas.

96. *To the Chairman.* — There is no freestone suitable for building purposes in the Federal Territory.

97. *To Mr. Sampson.* - I surveyed the Fairy Meadows limestone deposit, which I think will probably supply all that is required. This deposit is being worked, and drives are now being put in. I think this is a valuable limestone deposit. I do not think the lakes are likely to suffer seriously from silting, and the weir will contribute a very great deal to keep the lakes free. The Molonglo settles much of its silt in the big plain about ten miles away, and I think the Committee could confine their attention to the Queanbeyan as the probable silt producer likely to cause any difficulty. Silt in a stream depends upon the velocity of the water and the characteristics of the soil Granites vary as to their state of decomposition The granites at the head of the Queanbeyan, if like those near Tharwa, are comparatively fresh, and should not give rise to much silt.

98 *To Senator Lynch* There is not the slightest doubt that the Upper Molonglo deposits most of its silt on the flat 10 or 12 miles from Canberra. So long as the grade of a river is fairly uniform there is not much danger of silting. The Queanbeyan and Molonglo Rivers, like the Murrumbidgee, are comparatively young streams, and are still cutting their courses. No silt is ever deposited in the upper part of a river. This deposition only occurs when a river-bed gets a little flatter. I should say that if the Queanbeyan is depositing silt, most of this will be near the town of Queanbeyan, but it would be necessary to get a profile of the stream to work out this estimate accurately.

99. *To Mr. Sampson.*—If a weir has been constructed on the Queanbeyan useful information could be obtained regarding the entrance of silt into the Molonglo, and to the artificial lakes. It would then be possible to find out the depth of silt.

100. *To Senator Lynch.*—With respect to the dam at Yarrolumla, I should think that the lake would act as a settlement bed, and, to some extent, purify the water passing through it. These artificial waters will be 4 or 5 miles long, and it is not likely that any water passing through them will deposit impurities. I should like to make it clear, however, that I am speaking from a geological point of view, and not from a point of view of a hydraulic engineer.

101. *To Mr. Gregory.*—I do not think it likely that any serious erosion of the banks of the artificial lakes will take place. The bank on the western side of the suggested lake is largely of rock, and generally the banks of the proposed lake will consist of old stream terraces formed by the river in a preceding epoch. The map I have prepared shows granite country near the head of the Queanbeyan, and on the whole I should say that there would be less silt there than if the formation were of sedimentary rock, but I want to point out that the term "granite" is applied by geologists to a formation which may be decomposed, or which, on the other hand, may be comparatively fresh. I am not able to say from my own experience whether the granite at the head of the Queanbeyan is fresh, or whether it is decomposed granite. My impression, from what I have seen of neighbouring granites, is that it is rather fresh, and therefore would not be liable to erosion. Microscopic tests have not been made to test the presence of silt in water, and I think in the case of the Molonglo more direct results would be obtained by getting settling samples.

102. *To Mr. Fenton.* -The character of the valley walls influences the silt formation. For instance, the steep *débris*-covered walls near the Cotter junction must give rise to much silt in the Murrumbidgee River below them. I have seen boulders as big as one's hand in the bed of the Molonglo at Canberra, and it is probable that they have been derived from the slopes of Mount Ainslie, and from similar erupted rocks from the slopes of Mugga. When I was in that district I did not make any personal examination as to the entire drainage in the Molonglo and Queanbeyan. Mr. Mahony and I were up there chiefly looking for limestone, and traversed a good deal of country without examining intervening portions very carefully.

103 *To Mr. Gregory* —There is nothing in the geological characteristics of the locality to suggest that the Molonglo has changed its course. It has always flowed to the Murrumbidgee River.

104. *To Mr. Finlayson.*—While I was in the district I gave some attention to the shale deposits for brickworks There is one deposit near the civic centre, at Mount Vernon, which, as far as I remember, is fairly extensive, but it is not so good as the existing site on the western portion of the City area. At the latter place there is a very large outcrop, and I have the impression that the idea was to plane the top of the hill off without spoiling the contour of the country. The deposit at Mount Vernon is lower down, and if worked would result in an unsightly quarry being established there. Another deposit is at Red Hill, and there is yet another just where the road to Queanbeyan junctions with the railway. There is a fair outcrop of brick shale there. So far as I remember there is no shale deposit in the valley north of the site. That valley consists of alluvial flats. That area, however, has not been examined, because it would be necessary to put down shafts. I do not know on what information Mr. Griffin based his opinion as to a site for brickworks in that particular locality. The only brick shale in the north that I remember is at Mount Vernon. If I am asked, if I think the brickworks as at present located are in the most suitable place, I would like to point out that when I went up there I was asked to indicate the most suitable site from a geological point of view. I understand from Mr. Griffin that it has been proposed to set apart the western portion of the area for residential purposes, and obviously brickworks are not desirable in the middle of a residential district.

105. *To Mr. Gregory.*—The deposit which is at present being worked is the best that we examined. There may be others, of course. The granite quarry at Tharwa was located by Mr. Mahony and myself. The whole of the south-west region is granite, and this was the nearest accessible point for the granite. This deposit extends for miles practically to Mount Kosciusko, and there is an unlimited supply. This material, however, has not been thoroughly tested, but the outcrop promises very well, and it is a fair thing to say that the present indications are good. I am not sure if any mechanical tests have been applied to the stone, but its spalling quality is good. It breaks into cubes fairly, readily, and freely, and microscopic tests have shown that it is of suitable quality. I am not aware if any compression tests have been made to prove its suitability for building purposes. A great earth fracture runs along the Murrumbidgee and the granite close by appears to have been somewhat crushed and laminated (arranged in layers) to some degree. Hence it is probable that the deeper portion of the granite would be sounder than that near the region of disturbance.

106. *To Mr. Finlayson.*—This granite, I should say, could be used for foundations, for bridge pillars and for the lower courses of buildings. Judging from appearances it is about as strong as most other grey granites, but it has not been tested sufficiently. The porphyries are not so plentiful as the granite. These could be used for road purposes. They do not spall readily, and thus do not furnish suitable blocks, so far as they have been tested up to the present. There are limestone deposits at Fairy Meadow, and this material could be used for building blocks, as is the case in Adelaide. There are also deposits at Michelago, eight miles south-east from the Territory. We inspected some marbles at Michelago, but these have not been proved yet. I cannot say that the Territory and its immediate surroundings would provide practically all the material that would be required for building purposes, because there is no freestone there, but there are large deposits of brick shale, as well as granite.

107. *To Mr. Fenton.*—I have not seen the base of the Queen's statue in the Queen's Hall at Parliament House, and I am not aware if it is porphyry. There are porphyry deposits in the north-east of Victoria. These are allied to the Canberra porphyries.

108. *To Senator Lynch.*—The country between Mount Ainslie, Majura, and Black Mountain is alluvial. It has not been geologically examined yet by shafts. Underneath will be found silurian shales and sandstone. I should think the alluvial would be about 20 feet deep.

(Taken at Sydney.)

SATURDAY, 4th SEPTEMBER, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Henry Musgrave Robinson, Assistant Architect, State Government Architect's Department, New South Wales, sworn and examined.

109. *To the Chairman.*—In my view the lakes as shown on my plan are an essential portion of the city.

110. *To Mr Laird Smith.*—The construction of the upper lake is a matter for engineers to decide, from the point of view as to whether the natural flow of the river and the rainfall will provide sufficient water to keep that lake full A very objectionable feature to the lakes, as shown in Mr. Griffin's plan, is the construction of roads bordering the lakes and down to the water's edge. I do not approve of that proposal at all. In the lake shown on my plan no roads of that description are shown, but I provide for a considerable area round the lake to be reserved as a public park and a recreation ground The open space round these waters as shown in Mr Griffin's plan is not nearly sufficient Building blocks and houses are brought very close to the water's edge, separated only by the road In my view, that building area should be perpetually reserved for public use.

111. *To Senator Story.* — It is very desirable that lakes should be provided, though Mr. Griffin's proposal would probably entail considerable cost I do not contemplate the provision of anything in the nature of a retaining wall round the lakes. I propose to leave the banks in their natural state. It may be necessary to dam now and again in order to secure deeper water, but I do not propose to finish the lake in the manner suggested by Mr. Griffin. The roads in the ground surrounding the lake would be nothing more than pathways for public use.

112 *To the Chairman.*—If the water were not sufficiently deep round the edges of the lake they *might become a breeding ground for mosquitoes.*

113. *To Mr. Sampson.* -I do not know what the area of the lake shown in my plan would be. I have not the actual levels. I have taken the lake as indicated on the contour plan by the flood level, and have followed the flood level all round except in places where I thought it desirable to vary it so as to increase the amount of land available for recreation purposes. I have adopted

the 1,823-ft. level, and provide only one dam in the western extremity. I do not think there will be any danger from the erosion of the banks. Once the dam is constructed and the water level formed, the banks will, I think, be preserved in their natural state. It might be advisable to increase the depth of the water in several places by making excavations into the bank, and where that is done, it might be desirable to strengthen the bank, but I would not allow the Molonglo to follow its normal course, and utilize the space intended in the plans for lakes for park purposes. It would be a great pity not to have a lake in the centre of the city. It would be one of the attractions of the Capital.

114. *To Senator Lynch.*—I have fixed the level of my lake at 1,823 feet, and in fixing the amount of lake area I was influenced by the natural basin as shown by the flood level. It is easier to take the natural basin than go in for enormous excavations. I did not consider the possibility of the flow of water from the hills not being sufficient to fill a larger area, and I never contemplated the possibility of constructing a second lake above that provided by the natural level, as shown in Mr. Griffin's plan. If a sufficient supply of water could be guaranteed for the purposes of the larger I would most certainly favour its construction, though I would leave sufficient vacant land on the south-east for the recreation ground purposes. I would be in favour of erecting a bank 20 feet high for the purposes of the lake if it could be proved that there was sufficient water to keep it full. I would have as extensive a lake area as possible within reasonable bounds.

115. *To Senator Keating.*—I had no data as to the flow of the Molonglo, and I did not take that aspect of the question into account in providing for the lake as shown on my plan. I simply adopted it from the contour plan. I did not go into the matter scientifically, anyway.

(Taken at Sydney.)

TUESDAY, 7TH SEPTEMBER, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Ernest Macartney de Burgh, Chief Engineer for Water Supply and Sewerage, Department of Public Works, New South Wales, sworn and examined.

116. *To the Chairman.*—I understand that the number of acres covered by the proposed ornamental waters at the Federal Capital City is 3,145, and that the average depth of the lakes is proposed to be 14½ feet. Inquiries were made from me on the point by Mr. Davis, Director-General of Works, and I have a number of figures bearing upon the question as to whether the available volume of water will be sufficient to maintain the lakes at that level. I will give the results to the Committee, who will probably notice any point of divergence between my assumptions and those of Colonel Owen I have examined this proposal on the following data. It is assumed that the reservoir as constructed on the Queanbeyan River catchment area of 335 square miles will contain 7,500,000,000 gallons—the level of the river bed being 2,000 feet, the height of the dam 100 feet, and the water surface at that level 1 square mile. In connexion with the Federal Capital, I am informed that it is proposed to call upon this reservoir to supply 9,000,000 gallons a day to compensate for evaporation and seepage, and to keep the ornamental lakes fresh. Further, the reservoir will be called upon to supply circulating water for a generating plant of 3,500 k.w. It is assumed that this circulating water will not be allowed to escape into the lakes to assist in keeping them up to the normal level, and will not be used again, but will be in addition to the 9,000,000 gallons of compensation water. If the electric plant, to which I have referred, were run for 24 hours, I would take the circulating water required at approximately 6,000,000 gallons a day. The water proposed to be sent down, therefore, is 15,000,000 gallons per day of 24 hours. I desire that point should be clearly understood. That 15,000,000 gallons a day is the estimated draw on the Queanbeyan reservoir—of the storage supply at the valves. I have not yet dealt with any other losses that may occur. I assume that 9,000,000 gallons will be required to keep the lakes fresh, and 6,000,000 for the electric plant, per day.

On the figures of gauging supplied to me by the Federal Government extending over three years, the reservoir on the Queanbeyan could easily supply this volume during years of average rainfall. Taking, however, the group years 1900, 1901, 1902, the storage might be assumed as full at the end of 1900. During the years 1901-1902, the run-off from the Queanbeyan catchment could not be depended upon for more than 4,202,000,000 gallons in 1901, and 1,515 000,000 gallons in 1902. Allowing 348,000,000 gallons for evaporation annually on the storage, 15,000,000 gallons per day as previously stated—that is for the lakes and electric plant—and 1,260,000 gallons per day for loss in transit from the storage to the lakes, and 150,000 gallons per day for the supply of Queanbeyan, or a total demand of 6,338,000,000 per annum, the storage would be depleted to approximately 541,000,000 gallons, or, say, one month's supply at the end of 1902. It will be seen, therefore, that the margin is baro, and that it would be advisable to use the condensing water over again. These assumptions are exclusive of the discharge from the Molonglo River, from which the gaugings show a very similar result to those on the Queanbeyan. Assuming that the flow from the Molonglo in normal seasons will be utilized instead of drawing from the Queanbeyan storage, the stability of the proposal would be greatly improved during such periods of drought as that of 1901 and 1902.

117 *To Senator Lynch.*—In the figures I have given I include the eastward lake, taking a total surface area of 3,145 acres.

118. *To Mr. Sampson.*—The position in such a year as that of 1914 would not have been so critical as that of the earlier drought period. The rainfall in the years 1913-1914 on the Queanbeyan catchment was 35.99 inches, and in the years 1901 and 1902 it was 27.89 inches.

119. *To Senator Story.*—On the figures I have given, if the year 1903 had also been a dry year, the lakes could not have been maintained.

120. *To the Chairman.*—I will now turn to the requirements of the lakes. The surface area is 3,145 acres, and I estimate the daily average evaporation amounts to 9,400,000 gallons. The proposed volume of 15,000,000 gallons, therefore, would be barely sufficient. If, however, the electric plant were working only eight hours a day, or if the condensing water were used over and over again, the volume required would be reduced to either 11 or 9½ millions a day, as the case might be, but in a prolonged dry spell, when the evaporation would be at the maximum, the provision is still very meagre. It must, however, be borne in mind that the storage reservoir need not be called upon in wet or showery weather, and that the flow of the Molonglo is to credit. Taking all these factors into consideration, it would appear as if the lakes could with careful management of the available water, be kept in good condition. But the margin is very narrow.

The 9,400,000 gallons which I have referred to as likely to be the extent of the evaporation from the surface of the lake differs somewhat from the figure given by Colonel Owen. It was arrived at in this manner: We took the evaporation on Lake George, which we know, and we took the evaporation on the Burrenjuck reservoir, which we also know. Canberra being in a position somewhere between these two places, we decided to estimate the evaporation on the mean of the other two places. I think I also differ from Colonel Owen in the estimate of 1,250,000 gallons for loss in transit. I think Colonel Owen allowed for a 20 per cent. loss. My estimate is calculated upon a loss of 0.7 per cent. per mile, which is, I think, applicable to that stream. The banks are solid, and the bed is fairly rocky in parts. The matter, however, is one which will largely depend upon good management. It is not always advisable, for instance, to allow water to trickle down the river. It might be advisable to pass a large volume down promptly in order to save loss in transit. It would be much safer if waste could be avoided by turning the circulating water into the lake, if that could be done without causing too serious a rise of temperature. I have not had time to go into that question, but if that were done, I think there would be sufficient water to pull through. But if that condensing water is drawn off, the proposition will be a very bare one, particularly in a bad cycle of years.

121. *To Mr. Gregory.*—I do not see why there should be any wastage upon condensing water. I do not know the volume likely to be contained in the lakes, or I could judge the possible rise of temperature. In any case, I think it would be trivial.

122. *To the Chairman.*—In my view it would be safer to postpone the construction of the eastern lake until the supply for the other lake is assured. It would always be possible to construct the eastern lake if it were discovered subsequently that calculations as to the quantity of water available had been too pessimistic.

123. *To Mr. Gregory.*—The only objection to turning the condensing water back into the lake is that it might affect the temperature.

124. *To the Chairman.*—I find from the figures that have just been handed to me that the area of the proposed eastern lake is 1,672 acres, out of a total of 3,415 acres—approximately 50 per cent. of the total lake area. I find, also, that the eastern lake has a capacity of 8,384,000 cubic feet, and that the total capacity of the lakes is 1,809,392,000 cubic feet My personal opinion is that a sheet of water in the vicinity of the Capital City would be a most desirable feature. I do not think there could be any more desirable feature Whether the lakes as contemplated in the selected design are rather on the ambitious side is a matter of opinion, but I do not think you can have too much lake surface, if it is possible to obtain it without extravagance.

125. *To Mr. Laird Smith.*—I do not think that much difficulty need be anticipated from the erosion of the banks, nor do I think difficulty need be anticipated from silting. The Molonglo does not carry much silt-age, and if any silting occurred in the lower lake it could be got over very easily by means of a pump dredge, and the silt would be available for garden purposes. The cost of this would not be very great, seeing that plenty of electric power will be available, but in any case I do not think the Committee need trouble itself very much about silt. Country like that through which the Molonglo flows does occasionally yield silt, but I do not think there would be much here. If there were it could be dealt with easily by the erection of a small silt dam.

126. *To the Chairman.* — There would be no difficult engineering problems involved in the construction of the eastern lake 20 feet higher than the ornamental lake. What difficulties are likely to occur are those that will be the outcome of a defective water supply, having regard to which I think I should be inclined to hold my hand for the present in the construction of the eastern lake.

127. *To Mr Fenton.*—The supply from the Molonglo would not be sufficient for the purposes of the lower lake, apart from the Queanbeyan storage. The latter will be necessary.

128. *To Mr Sampson* - My opinion regarding silt is that if the reservoir is constructed on the Queanbeyan, and if a little silt dam is put in, the amount of silt that will flow down into the lakes will be no more than could be dredged out at very little cost.

129. *To Mr. Laird Smith.*—No great engineering difficulty would be met with in taking water from the upper lake, assuming its construction were decided upon. I take it that there would be a sluice to release the water when it was not high enough to pass over the dam, and a spillway acting as a weir on occasions of flood. If the bank of the proposed eastern lake were wide enough for railway purposes it would be quite wide enough to act as a dam.

130. *To Mr. Finlayson.* — I cannot estimate what width of spillway would be sufficient to take away surplus water in time of flood; 800 feet, however, would be ample. At the Burrenjuck reservoir, which is fed from a catchment area covering 5,000 square miles, 80,000 cubic feet of water pass over a spillway of 800 feet each second, with a depth of 8 feet. In this case we have to deal with nothing like the same amount of water, and 800 feet could be relied upon to give you any amount of room. In the estimates I have given I have made no provision for regulating the flow of the Molonglo as well as of the Queanbeyan. I have only taken into account the natural flow of the Molonglo. If the big lake is to be provided a dam on the Molonglo, as well as on the Queanbeyan, may be necessary. The construction of such a dam, even

though it might not be immediately necessary, would be desirable in view of future possibilities and extensions.

131. *To Mr. Fenton.*—I do not think the Molonglo would of itself be sufficient to provide water for a lake of 1,473 acres. I do not think any of these rivers would be sufficient without regulation.

132 *To Mr Finlayson* - If the upper lake were not constructed, the dam on Queanbeyan, apart from the flow of the Molonglo, might keep the lake up, but in a season like 1901, 1902, and 1903 it would be necessary to run very close to the wind. If the Molonglo were regulated its flow would be very useful during the critical period, and the dam would reduce any possibility of silt. Apart from this, however, the regulation of the Molonglo would strengthen the whole position. The lake water would be brighter in appearance, cleaner, and purer in every way, as a result of regulating dams. It would be an advantage to the lakes from the point of view of supply and from the point of view of appearance, if dams were constructed on both rivers.

133. *To Senator Lynch.*—I selected figures for the years 1900, 1901, and 1902, because that was the most critical period in the history of this district, taking its length and its dryness both into account. The rainfall statistics were gathered from observation stations in the vicinity, and may be regarded as a fair indication of the rainfall over the whole catchment area. I never would accept syphons by themselves as a means of carrying off flood water. Whatever calculations may have been made, one can never be quite certain that the flood will not be bigger than was reckoned upon. A few inches rise will often bring down a tremendous amount of water, and the moment the syphons get to their carrying capacity there is trouble. Syphons would not satisfy me at all, and they would cost much more than a spillway. For the present I would postpone the construction of the upper lake on account of the very narrow margin left in such years as those of 1901 and 1902. If the Molonglo River were dammed, it might be possible to construct the upper lake with safety, but the wiser course would be to make a start with the other lake.

134. *To Mr. Gregory.*—The city railway line, as shown on Mr Griffin's plan, might be constructed at the point where it passes the projected lake with a possibility of the lake's future construction in view. I can express no opinion as to whether the quantity of spoil recovered from railway construction higher up will be sufficient for the dam.

135. *To Senator Story.*—I have already stated that I think the banks of the lake might be left in their natural state; the design as I understand it presupposes excavations and the erection of retaining walls. I cannot say how costly the construction of lakes on Mr. Griffin's plan would be, but if retaining walls are built they will, no doubt, involve considerable expenditure. If the ground on the edge of the lakes is to be made up - if there are to be promenades and drives along the edge of the lake - retaining walls will no doubt be necessary to prevent erosion underneath; but I would not anticipate any difficulty in the matter of erosion if the banks are left in their natural state. They might be pitched with stone to a little above water level to meet the lap of the water, but that is all.

136. *To Mr. Finlayson.* — I assume from the contours of the ground that unless it is proposed to create a considerable park area round the lake, taking in all the small indentations that are likely to occur, the bank might very well be left in its natural state. If streets are to be constructed near the lake, then it would be necessary to strengthen the bank. All the indentations would have to be done away with if promenades were contemplated I can only give an opinion like that of any other citizen on this point, but I am strongly of the opinion that the more natural these lakes are left the better I would sooner see an open space surrounding the large lake than all the retaining walls in the world. You can get walls and streets anywhere, but you cannot always get water in a town, and I would like to see this lake a beautiful sheet of water, without a brick or stone near. I do not think any danger need be apprehended to any permanent buildings erected on the 1,830 feet level).

137. *To Mr. Sampson.* — If the water rose higher than the 1,825 feet level I think the length of weir provided will be quite sufficient to take it all away. It would be possible to get rid of any flood water very safely and very cheaply by allowing it to run over the weir, but I do not think the rise would be very great.

138. *To Mr. Fenton.*—It would be absolutely essential in a lake scheme like this to prevent pollution. There is a clause in the Federal Territory Act which stipulates that the State Government of New South Wales shall co-operate with the Commonwealth Government in preventing the pollution of rivers on this area, and I understand that a scheme for the sewage of Queanbeyan, which would prevent any pollution getting into the Queanbeyan River, is now in contemplation. If the town of Queanbeyan were sewered, and had a good water supply, the only possibility of pollution would be from the scourings of the city streets, and I could hardly regard that as a serious possibility. At the same time, I think it is very desirable that the sewage scheme for the town of Queanbeyan should be established. I do not think much difficulty need be apprehended from the presence of any disagreeable slime on the banks of this lake. If there were any small arms of the lake in which the water were only 8 or 9 inches deep, I would have them filled in, but I think, generally, I would suggest that pitched stone be used on the banks up to 2 feet or 3 feet away from the water level, and then allow grass to grow. There would be nothing unseemly about that. But I certainly should not allow any shallow places in the lake to remain. If the Committee propose to go on with the big scheme they might just pull through if the Queanbeyan River alone were regulated. On the other hand, they might not If the Molonglo River were also regulated, I think they would be fairly safe I do not know that there is anything injurious in the water to prevent its being used for boiler purposes.

139 *To Senator Lynch.* — To my mind, the great charm attached to the presence of water in a town is in the water being allowed to occupy its natural boundaries. In case where the contour shows small areas in the lake itself above the water level, small islands might be created and suitable aquatic plants placed on them. Subject always to considerations of the area it is proposed to keep under water, I think it is desirable that the level of the water should be kept as far as possible at the level of the weir. The great

essential is that the weir should be a long one, so that any surplus of water can be discharged quickly, and so that in flood time there could be no possibility of the flood water rising and doing damage. Possibilities of flood can be adequately met by the erection of an adequate spillway, and if the 1,825 feet level would suit the lay-out of the city I should keep the dam up to that level. From what I have seen of the plans, that seems to be a very suitable level.

140. *To Senator Story.*—The site of the proposed dam is just below Yarrolumla, where the banks are high, and the river narrow. I do not think, however, that that circumstance need make any difference, as there appears to be sufficient width to construct a spillway long enough to discharge the floods without undue rise in the level of the lake. Flood water tumbles much more rapidly over a weir than it flows down a gorge, and if there is a 2 feet depth of water there will be a rise of 2 feet on the lake, unless tremendously costly sluice gates are put in.

141. *To Mr. Fenton.*—I do not regard sluice gates as at all necessary. The advantage to be gained from them would not justify their expense With a regulating dam on the Queanbeyan the rise and fall of flood water is not likely to be very great, and in any case I do not think the possible rise will be sufficient to cause any disfigurement. If the water were to rise up to a height of 4 feet on the eastern lake over a period of perhaps one or two days, there would not be any serious disfigurement of the landscape. Take, for instance, the beautiful gardens in Brisbane. There are times when the Brisbane River has completely enveloped them without any disadvantage.

The Committee have been good enough to ask me a number of questions on matters which fall outside the purely professional sphere. I do not desire it to be thought that I am criticising the design of a man like Burley Griffin in any reference I have made to these lakes. I have seen in Europe, in places like Dresden, Paris, and other large towns beautiful effects produced by the construction of boulevards round lakes such as those contemplated at Canberra I only wish to say that, in my own individual view, and especially in a hot climate, the effect of water running between trees and along natural banks is more pleasing than the effect would be if retaining walls were constructed, and any number of beautiful kiosks and lights, &c., added. But that is only my individual view.

(Taken at Canberra.)

WEDNESDAY, 15TH SEPTEMBER, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson.
Mr. Fenton,	

Colonel David Miller, C.M.G., V.D., I.S.O., Administrator Federal Territory, sworn and examined.

142. *To the Chairman.*—I have known the Territory for over five years. The highest flood on record in the Molonglo was in 1891, when the 1,825-ft. level was reached. No subsequent flood has reached within 10 feet of that mark. Last Sunday a small flood brought down considerable *debris*. It would be unsound to attempt to put up a low level temporary bridge. After each flood a considerable deposit of silt was left on each bank, from 2 or 3 to 18 inches thick. The latest left silt 12 inches deep on Acton bridge. This deposit would have a serious effect on artificial lakes, but the engineers propose to intercept it by settling places, which, to be effective, must be close by the ornamental water. The Queanbeyan dam will be too far away. The silt is due to the formation of the country, the ring barking of timber on the Molonglo and Queanbeyan catchments, and the presence of rabbits and stock Within the last 30 years the Molonglo at Yarrolumla, was only about half a chain wide There will be risk of the lakes silting up It is extremely doubtful if the Molonglo and the Queanbeyan Rivers will be sufficient to maintain the ornamental waters at a constant level should the upper lake be included, especially in the dry season. This is borne out by the gauging of those rivers in the engineers' report and the evaporation figures in the meteorologists' report I have no doubt about the water supply for the western lake. Even if there were sufficient water I would not favour the eastern lake which is unnecessary, and would submerge a considerable area of valuable land, including some of the best alluvial flats. The other ornamental lakes would be a very important feature of the city.

143 *To Senator Keating* —I have not been able to get an approximation of the cost of the eastern lake In any case it would be wholly disproportionate to any useful purpose the lake might serve The vast volume of water that comes down the Molonglo in flood time is highly discoloured, and has a distinctly disagreeable odour due to the presence of decaying vegetable matter In spite of published figures showing the comparatively small proportion of silt in suspension in rivers in other countries. I adhere to my view that there is a serious possibility of the lake silting up. The large body of water in the eastern lake would necessitate a solid embankment which would be expensive. It would be necessary to go down 30 feet on the average for the foundation, and it is doubtful whether the water would be held after putting in a core. Without the eastern lake it would still be necessary to have a crossing at the spot, but not so high.

144. *To Mr. Gregory.*—An embankment on that spot would prevent the silt entering the lake unless the flood went over the weir. On the banks now, where there are no obstructions, there is a deposit of from 4 to 18 inches of silt.

145. *To Mr. Sampson.*—I favour the bolder scheme to cover all the area marked for the western lake rather than to have a narrow strip of water with gardens on each side. The lakes will undoubtedly divide the city into two, one side becoming official, residential, and business, and the other devoted to other purposes. It will not mean a large population resident on both sides. The population will always be on the southern side. I have always favoured the expansion of the city south-easterly rather than northerly. The northern side will be used for university, hospitals, &c. The green city area marked on the map indicated what was, in the opinion of the Advisory Board, the most suitable country to contain the site, not in any way indicative of the boundaries of the site. If future settlement extends below the southern line, and the north is

left practically without population. it will absolutely carry out the original intention of the plan.

146 *To Mr. Fenleyson* —I submit the following statement, which is a condensation of a vast mass of material.—

The *Seat of Government Act* 1908 provides that the Seat of Government of the Commonwealth shall be in the Yass-Canberra district, in the State of New South Wales.

On the 21st December, 1908, the Hon. H. Mahon, M.P., Minister of State for Home Affairs, issued the following instructions to Mr. District Surveyor Scrivener:—

The duty which I propose to intrust to the surveyor is that of making a thorough topographical investigation of the Yass-Canberra district, with the object of placing such facts before me as will enable Parliament to decide on the most suitable territory for the purposes of the Seat of Government within the district referred to, in which connexion I am of opinion that the work to be carried out by the surveyor should be divided into three phases, as follows:—

(1) Preliminary reconnaissance, covering the whole of the district and embracing the catchment area of the water supply governing the same.

(2) Topographical investigation of that portion or portions of the district which, during the reconnaissance, are shown to possess the requisite characteristics for the Commonwealth territory.

(3) Contour survey of suggested site or sites for the Federal Capital city.

The primary essentials of the territory may briefly be summarized as follows:—

(a) That it includes a site or sites possessing the necessary topographical characteristics for the Federal Capital.

(b) That it includes the catchment area of the water supply for the Capital—such water supply must be of sufficient magnitude to place the question of volume at all seasons and purity beyond doubt.

Note.—*It is desirable that the catchment* area shall be in the proximity of the Capital site, but should the topographical examination of the district disclose the fact that such a condition is not practicable, then the catchment area must be connected with the territory, including the site for the Capital—that is to say, severance must be avoided.

(c) Sanitation.—That the site provides for a perfect system of sanitation, not only so far as the city itself is concerned, but generally.

(d) Accessibility.—It is requisite that the site be easy of access with Sydney and Melbourne, and, through them, to the other capital cities, also with a suitable harbor on the coast.

In the consideration of (a), the surveyor will bear in mind that the Federal Capital should be a beautiful city, occupying a commanding position, with extensive views, and embracing distinctive features which will lend themselves to the evolution of a design worthy of the object, not only for the present, but for all time, consequently the potentialities of the site will demand most careful consideration from a scenic stand-point, with a view to securing picturesqueness, and also with the object of beautification and exhibited.

The foregoing covers the main essentials which occur to me, and I have no doubt that the experience of the surveyor will enable him to realize what is required from him.

I should be glad if the surveyor could enter upon the work at the earliest possible date, and, in the first instance, conduct the reconnaissance of the district, from which possibly certain territories will be shown to stand out as possessing the necessary advantages. These territories could then be more critically examined and reported on.

Mr. Scrivener, on the 26th February, 1909, submitted his report upon the sites in the Yass-Canberra district.

This report was referred by the Minister for Home Affairs to the Advisory Board, consisting of Colonel David Miller (chairman), Colonel P. T. Owen, Colonel W. L. Vernon, Mr. C. R. Scrivener, for consideration, and report as to the portions of the district demanding closer investigation and survey, and generally.

On the 8th March, 1909, the Advisory Board reported that in their opinion the most suitable sites were about Canberra, on lands comprised in Duntroon and adjoining holdings, where the physical and scenic qualifications for the Capital City of the Commonwealth were best met. The Board agreed with Mr. Scrivener in his recommendation respecting the territory to be acquired by the Commonwealth, because it included the site for the Capital City and the catchment areas required for the water supply of the City and the catchment areas of the streams passing through the City, all of which will be required in its development. This recommendation embraced an area of approximately 1,000 square miles. The Board suggested the necessity for certain contour surveys of possible city sites, and some further investigations.

A survey was made of some 35 (*thirty-five*) square miles, being portions of Duntroon, Yarrolumla, Acton, and Jerrabomberra Estates.

The plans of the surveys and Mr. Scrivener's reports were referred by Mr. Mahon to the Advisory Board to consider the results of the preliminary investigations, and to advise the Minister as to the site or sites which conform most closely to the requirements of the Seat of Government.

On the 16th June, 1909, the Advisory Board, in their report to the Minister, deemed it necessary to give particular prominence to certain essential qualifications and factors, viz.—Contour and physical features, area available, aspect and shelter, panoramic value, railway *facilities and approach, facilities for classification of* city areas, ornamental water areas, disposal of sewage, suitability of soil, water supply (domestic), water supply (power), water supply (ornamental), environment and park lands, suburban settlement.

With the foregoing in view, the Board advised that the area most suitable for the purposes of the Federal Capital City was that which had been adopted.

The Board also advised as follows:—

The site may be briefly described as a rectangular area, the eastern and western boundaries of the northern part resting on the slopes of Mount Ainslie and the Black Mountain, the southern boundary being intersected by the Narrabundah Range, running from Mugga Mugga Mountain towards the Molonglo River. This river, which flows through the area in a westerly direction, affords facilities for the conservation of water for ornamental purposes.

The whole area is generally suited for building purposes, the feature contours being more marked or bolder south of the River Molonglo than on the north.

The area of about 3 miles square is recommended, advisedly, in order that the fullest scope may be given for the projection of the city design, and the most effective location of the official centre.

Sewerage.

Respecting the sewerage of the proposed Federal Capital City, we consider that no engineering difficulties will be encountered in the satisfactory disposal of sewage and the effluent from treatment works. It will be necessary to make provision for *dealing with the storm waters, in which* connexion the general fall of the land favours a satisfactory scheme.

Ornamental and Flood Waters.

Ornamental water may be conserved at the city by means of a weir at any one of the sites indicated on the map of the contour survey of Canberra. It will be necessary, however, to preserve a constant level in the lake so formed, which object will be attained by the construction of a weir above the town of Queanbeyan—on the Queanbeyan, or on the Molonglo River, as shown on the map of the Federal Territory. A weir on either river would impound sufficient water to maintain the flow of the Molonglo below the junction of the two rivers (during dry periods), and thus compensate for the loss by evaporation on the city ornamental waters. It is also pointed out that weirs on the upper reaches of these rivers will regulate the flood waters.

On the 20th July, 1909, the Hon. A. Deakin, Prime Minister, addressed a communication to the Premier of New South Wales, inviting him to take steps under section 111 of the Constitution to pass the State Act for surrender to the Commonwealth of the area recommended by the Advisory Board for the purposes of the Federal Territory and the area for a Federal Port at Jervis Bay.

Negotiations ensued between the Commonwealth Government and the Government of New South Wales on the subject of the area to be by the State of New South Wales surrendered to the Commonwealth for the purpose *referred to, and on the 14th December, 1909, the Seat of Government Surrender Act* 1909, N.S.W., was assented to. The area surrendered does not embrace the catchment areas of the Molonglo and Queanbeyan Rivers, but includes the catchment areas of the Nass, Gudgenby, *and Paddy Rivers.*

The *Seat of Government Acceptance Act* 1909 (Commonwealth) was assented to on the 13th December, 1909.

On the 30th April, 1911, the Government of the Commonwealth issued invitations for designs for the laying out of its Capital City, undertaking to remunerate the authors of the designs placed respectively first, second, and third in order of merit at the final adjudication upon the designs in accordance with the "Conditions of Competition," as follows:—

For the design placed first—premium £1,750.
For the design placed second—premium £750.
For the design placed third—premium £500.

A memorandum containing information, conditions, and particulars for guidance in the preparation of competitive designs for the Federal Capital City was issued and made available throughout the world. Carefully *prepared models of the city site were accessible for* reference at the principal centres, and, in addition, each competitor was furnished with a complete set of maps and information of various description.

One hundred and thirty-seven designs for the lay out of the city were received.

On the 2nd March, 1912, a Board of Assessors was appointed in connexion with the investigation of the competitive designs for the city. This Board was constituted as follows:—Chairman—Mr. J. M. Coane, Licensed Surveyor, F.V.I. Surveyors, Member Council Vic. Inst. Engineers, Member Am. Soc. C.E., Member N.S.W. Inst. Surveyors. Members.—Mr. James Alexander Smith, Past President Victorian Institute of Engineers; Mr. John Kirkpatrick, Architect.

Assessors' Report.—The Board of Assessors, on the 14th May, 1912, reported that the Board remained divided in its judgment. Messrs. J. A. Smith and J. Kirkpatrick selected three designs which were different *from the three chosen by Mr. Coane.*

Adjudication.—On the 23rd May, 1912, the Minister of State for Home Affairs, the Honorable King O'Malley, M.P., adjudicated upon the designs, and decided as follows:—

Design submitted by Walter Burley Griffin, Architect and Landscape Architect, 1,200 Steinway Hall, Chicago, Illinois, U.S.A.—Awarded first premium of £1,750.

Design submitted by Eliel Saarinen, Architect, Helsingfors, Finland.—Awarded second premium of £750.

Design submitted by D. Alf. Agache, Architect, Diplome par le Government Français; Professeur au College libre des Sciences Sociales, 11 Rue Eugene Flachat, Paris.—Awarded third premium of £500.

Designs prepared in collaboration by Messrs. W. Scott Griffiths, Robert Gibbon Coulter, and Charles Henry Caswell, of 32 Royal Chambers, 3 Castlereagh-street, Sydney, placed by Mr. Coane first in his minority report, was subsequently purchased by the Government for the sum of £400.

On the 7th June, 1912, I submitted to the Minister the following minute:—

The adjudication of the designs has been completed, the results have been published, and, under your instructions, the designs are being exhibited at the Town Hall, Melbourne. Arrangements have also been made for their exhibition publicly at Sydney, where a suitable room at the Town Hall has been placed at your disposal by the Lord Mayor.

Under the eighteenth condition of competition, the premiated designs are now the property of the Government for its unrestricted use either in whole or in part, the authors having no claim for further remuneration beyond the premiums which have been awarded.

Condition 19 provides that the Government, in consideration of the undertaking to pay the premiums, became entitled to call for, and to be furnished with, additional information, including such elucidating plans, sketches, and reports as it may be advised by the Board referred to in clause 12 are requisite.

As far as I am aware, the Board appointed to investigate the designs and report to the Minister have not suggested that any further information should be called for. It would, therefore, appear *that each competitor is entitled to the payment of* the full amount of the premium, but before making this payment it is suggested that the advice of the Crown Solicitor be obtained.

The seventh condition of competition provides that the designs must be prepared so as to facilitate their successful reproduction, it being the intention of the Government to furnish the leading technical journals interested in the subject, and willing in the public interests to publish them, with copies of the more important of the drawings, in which connexion authority is sought to incur the necessary expenditure to at once secure full sized copies of the premiated designs. At the same time instructions are *sought as to the necessity for obtaining either the* originals or copies of the three designs referred to in the minority report, and the two designs which received special commendation in the majority report.

*It now becomes necessary for a design for the lay*out of the city to be adopted, such a design should satisfy the requirements and comply with your instructions that the Federal Capital shall be a model city, designed in accordance with the most modern ideas of town planning, embracing those distinctive features which are requisite to place this—the Capital City of the Commonwealth of Australia—in the forefront of all cities.

I, therefore, submit for your consideration the advisableness of referring the eight designs previously referred to herein to a Board, comprising—

The Director-General of Works,
The Director of Commonwealth Lands and Surveys,
Colonel W. L. Vernon, F.R.I.B.A.,

for investigation and report as to the suitability of any one of them for adoption in its integrity as the design for the lay-out of the city and its extension *in the future.*

Each of these gentlemen has been associated with the subject for many years past, and has a most intimate knowledge of the requirements of the city, its aspirations, the local conditions, and generally, in addition to which they are specially qualified professionally.

This Board would also be in a position to furnish an estimate of the cost which will be involved in the adoption of any design.

Cuff after such a report shall have been furnished, and a design adopted, it will be impossible to invite competitions for the design of any structure to be erected in the city.

Appointment of Departmental Board.—On the 27th June, 1912, the Minister for Home Affairs appointed a Board, consisting of—

Colonel D. Miller, Secretary for Home Affairs (chairman);
Colonel P. T. Owen, Director-General of Commonwealth Public Works, Department of Home Affairs;
Mr. C. R. Scrivener, Director of Commonwealth Lands and Surveys;
Mr. G. J. Oakeshott, Commonwealth Works Director for New South Wales;
Mr. J. S. Murdoch, Senior Assistant, Public Works Staff, Department of Home Affairs;
Mr. Thomas Hill, Commonwealth Works Director for Victoria;

to investigate and report as to the suitability of the selected and purchased designs.

Board's Report.—On the 25th November, 1912, the Board above-mentioned reported to the Minister as follows:—

In conformity with the instructions contained in your minute of the 27th June last, the Board assembled at Melbourne on the 3rd July, 1912, but it was *not until the 14th August that the designs were* available for the use of the Board.

The Board, having settled certain governing principles, continued deliberations at the site of the Seat of Government, where the three premiated designs, and *the designs* purchased by the *Minister*, received consideration on the ground, having regard to the requirements of the city, the configuration of the site, together with local and general conditions.

The Board is unable to recommend the adoption of any one of the designs, and advises approval of the plan for the lay-out of the city prepared by the Board.

This plan incorporates features from the premiated and the purchased designs, wherever, in the opinion of the Board, such a procedure is warranted.

The general idea governing the Board's plan for the lay-out of the city is expressed in the "Requirements" issued officially for guidance in the preparation of the competitive designs, which reads as follows:—

The Federal Capital City will be the permanent Seat of Government of the Commonwealth of Australia, the place at which the Federal Parliament will meet, where all Commonwealth legislation will be enacted, and where the Governor-General will have his official residence. The city will, therefore, be primarily the official and social centre of Australia.

Consequently, the dominating feature of the city is the Houses of Parliament. The site for those buildings must be suitably situate, commanding extensive views, and prominently visible on approach from the surrounding country. The lay-out of that portion of the city embracing Parliament House, the Capitol, and the official section follows broadly that expressed in the first premiated design.

The Board has taken full advantage of the effect of the great natural features of the city site, and, wherever possible, use has been made of the principle of introducing public buildings and other architectural features where they may be clearly viewed at convenient distances from approaching streets and avenues.

The Board gave great consideration to the location of the railway.

Prospect of the city from approaching railways and roads has been kept in mind. Communication through the city from prominent outlying districts has been secured.

Wherever possible, the cardinal idea of securing sunlight to the city blocks by planning them at suitable angles to the meridian has been observed.

Some considerations guiding the location of the more important structures and features are as follows:—

Vice-Regal Residence and the Prime Minister's Residence.—Within easy access of Parliament House, but affording privacy, and with commanding views of the Capitol, Parliament House, with official centre, and the ornamental waters.

Public Offices.—Within the official precincts of Parliament House, so as to facilitate administration, and architecturally to support the group of national buildings.

Civic Centre and Business Centre.—Conveniently located with respect to the Central Railway Station and the official centre, also sheltered on its west by hills.

Amongst other matters which the Board dealt with in connexion with the design was the necessity for providing adequately for courts of justice, places of public worship, university, schools and school playgrounds, hospitals, ornamental lake system, and control of flood waters, avenues and boulevards, residential areas, park lands, recreation areas, lake drives, grand drives round the city, centres for distributing traffic, gradients, diagonal streets, treatment of streets, facilities for handling freight, markets, tramway system, disposal of storm waters, bridges, provision of city expansion.

The Board considers that the design herewith submitted fulfils requirements; it provides for the present and the future, and should result in the creation of a city which will be practical as well as beautiful.

The Board records appreciation of the services rendered by Mr. W. A. Newman, the Secretary.

Minister's Comment.—The Minister for Home Affairs wrote as follows on the 26th November, 1912:—

Report received. Arrange for copies of the report to be tabled in each House, and for the original plan and the sketch which accompanied the report to be exhibited in the Queen's Hall, Parliament House, the plan and sketch to be first photographed, with a view to reproduction.

I desire to convey to the Board my appreciation of their valuable services, and of the amount of thought and care bestowed upon their work.

It appears to me that a city laid out on the lines indicated in the Board's design, incorporating as it does the salient features of the premiated and purchased designs, should be both practical and beautiful.

Adoption of Design.—On the 10th January, 1913, the Minister for Home Affairs wrote in the following terms:—

Design for the Lay-out of the Federal Capital City.—After discussion in Cabinet, it has been decided to adopt the design for the lay-out of the Federal Capital City submitted by the Departmental Board with its report of 25th November, 1912, and I, therefore, formally approve of such design. Let the survey of the city site and the other work incidental to the laying-out of the city be at once proceeded with.

Initiation of the Survey.—On the 20th February, 1913, the Minister of State for Home Affairs, the Honorable King O'Malley, drove the first peg in connexion with the projection of the design for the lay-out of the city, marking the centre line of the main avenue from the Capitol towards Mount Ainslie. The Honorable Charles McDonald, M.P., Speaker of the House of Representatives, drove the second peg, marking the axis of the avenue directed towards Mount Vernon.

It was decided by Cabinet, on the 28th July, 1913, to invite Mr. Walter Burley Griffin, the author of the first premiated design, to visit Australia, with a view to consulting with the officers constituting the Departmental Board. Mr. Griffin accordingly arrived in Sydney on the 18th August, 1913, and proceeded to Canberra on the following day. To enable Mr. Griffin to form his own conclusions as to the Board's departure from his plan, his meeting with the Board was postponed until after his visit to Canberra, where Mr. Murdoch was detailed to afford him any information he desired. On Monday, the 25th August, the Assistant Minister explained to Mr. Griffin that the Board the course he wished their deliberations to follow. Mr. Griffin's plan was to form the basis of their discussion, with such improvements as might be suggested by Mr. Griffin's fuller knowledge of the locality, and the engineering, topographical, and financial problems involved.

The Board met Mr. Griffin both in Melbourne and at Canberra—the conferences were practically continuous, and extended over a period of some six weeks.

On the 16th October, 1913, the Board assembled at Melbourne to consider the sketch which had been prepared by Mr. Griffin for his amended design for the lay-out of the city. After examination of the sketch design, and hearing Mr. Griffin's explanation of the main principles, the Board decided that they were unable to concur with the amended design as submitted by Mr. Griffin.

At this juncture the Assistant Minister for Home Affairs personally informed the members of the Departmental Board that their services as a Board would no longer be required by the Government, but that he would avail himself of the individual services of the members of the Board as necessity arose.

On the 18th day of October, an agreement was made by the Minister for Home Affairs with Mr. Griffin.

The Federal Capital City is being founded consciously, purposely, and for definite ends.

The people of the States of New South Wales, Victoria, South Australia, Queensland, Tasmania, and Western Australia agreed to unite in one indissoluble Federal Commonwealth under the Crown of the United Kingdom of Great Britain and Ireland, and under the Commonwealth of Australia Constitution Act, which provides, amongst other matters, that—

> The Seat of Government of the Commonwealth shall be determined by the Parliament, and shall be within territory which shall have been granted to or acquired by the Commonwealth, and shall be vested in and belong to the Commonwealth, and shall be in the State of New South Wales, and be distant not less than 100 miles from Sydney.
>
> Such territory shall contain an area of not less than 100 square miles, and such portion thereof as shall consist of Crown lands shall be granted to the Commonwealth without any payment therefor.
>
> The Parliament shall sit at Melbourne until it meet at the seat of Government.

The Commonwealth Parliament has determined that the Seat of Government shall be at Canberra, lying within the Federal Territory. Lands within the Territory have been granted to and acquired by the Commonwealth, and now the time has arrived for the adoption of a design for the lay-out of the Federal Capital City.

The consideration of any such design is inseparable from the question of finance.

Whilst the Government will have to provide funds for the following, viz.:—

(a) Laying out the city, including the provision for every description of communication, i.e., roads, bridges, &c.;
(b) The erection of Houses of Parliament, residence of the Governor-General, public offices, courts of justice, printing office, central power station, markets, parks and gardens, city beautification;
(c) Railway and tramways;
(d) Water supply;
(e) Sewerage;

the residential and business section of the city must be constructed by private enterprise.

The cost of the establishment of the Federal Capital City is not, in my opinion, a fair charge against the Consolidated Revenue of the Commonwealth, for the reason that the city is being built for all time, and consequently the cost should not be charged against the revenue for the period of construction.

Until after the design for the lay-out of the city shall have been adopted, it is not practicable to form an estimate of the expenditure involved, but I believe that the revenue to be derived from the lands will not exceed £120,000 per annum for some considerable period, consequently, from the stand-point of administration, the expenditure upon the acquisition of lands and the establishment of the city should not exceed £3,000,000. To achieve this result it is obvious that, whilst keeping in mind the necessity for the creation of a beautiful city, there must not be any extravagance.

Every proposition should be most carefully scrutinized, and only essential services should be undertaken.

The complete scheme should be organized on sound lines, and carried to completion in regular sequence.

The catchment area of the Molonglo and Queanbeyan Rivers outside the Federal Capital Territory is 760 square miles, with a rainfall of from 23 inches to 45 inches on the Ranges. The Designs Board expressed and repeated the opinion that the Commonwealth should have sovereign rights over the catchments of those rivers, but it has not got them yet.

147. *To Mr. Gregory.*—The £3,000,000 is my own basis. I presume that in addition to paying interest on the loan, a sinking fund would also be created, which in 60 years would extinguish the liability, working back from the estimated revenue of £130,000.

148. *To Mr. Finlayson.*—From the beginning the provision of ornamental waters has been a most important feature of the city. It would be desirable to begin the construction of the lakes at a very early date to avoid having the Molonglo meandering through the city at varying depths under varying conditions of flood or drought. The bed of the river is very rich in gravel and sand deposits which are valuable for making concrete. A certain amount of economy might be effected by postponing the construction of the lake, but I still think the work should be undertaken at an early date. The lake system should be regarded as an essential feature of the city. The 1,825-ft. level is peculiarly suitable. If Mr. de Burgh, Engineer for Water Supply in New South Wales, says from the records in his office that the flow of the Queanbeyan alone would just about keep the lakes full with no margin in ordinary circumstances, but that if the Molonglo is included, there is no question as to the available supply, I must bow to his opinion as an engineer, but will always hold to my opinion that it would be an extremely risky proposition, and quite unnecessary, to construct the eastern lake. Eliminating that, there would be no question as to the volume of water available maintaining the other lakes at the 1,825-ft. level. I favour the waters being allowed to find their ordinary level as determined by the contour of the country under certain conditions, and not restricted by artificial or conservative banks. I favour the unconditional reservation of a piece of park land bordering the lakes. I would not allow any public buildings at a lower level than 1,835 feet, although there are some which might be allowed. I believe in a lake drive close to the border of the ornamental waters, with a strip of park land between. It is absolutely essential to form the banks at certain parts to prevent erosion, particularly on the east and south side, but would lay down no hard and fast rule regarding retaining wall until the necessity was demonstrated.

149. *To Senator Story.*—The Molonglo in flood is a different proposition from American rivers. I can see no similarity between it and the Potomac, Merrimac, and other rivers mentioned by Mr. Griffith Taylor, the Molonglo may cease running for 30 days in the year. Prior to the 1891 flood, the channel of the Molonglo was very much smaller, but only in certain places. It was originally a clear crystal brook. There is hardly the same danger of the recurrence of a big flood, the width of the channel has increased only in certain parts, and at Yarrolumla, for example, it is not likely that the flood level would rise so quickly to 1,825 feet as it did in 1891. There is every probability, however, that under similar conditions the flood level would reach 1,825 feet in certain places. I do not think the lake construction should be begun before beginning Parliament House and the administrative offices, but the ornamental water scheme should be completed before the occupation of the city proper. Colonel Vernon was for some time of opinion that Parliament House should be placed on Mount Vernon to the north. If Parliament House and the administrative offices were placed north of the Molonglo, settlement would be concentrated to the north, because in the construction of the city from 1,500 to 4,000 or more persons will be employed, and must be accommodated within a reasonable distance from the works. For practical purposes you cannot move a population of that sort simply to fit in with any particular design. Parliament House should never be put on the north, but if it was the official city would have to be near it, and settlement would extend northwards. The lake should be a dividing line.

150. *To Mr. Fenton.*—The Molonglo is undoubtedly polluted by the presence of the village of Queanbeyan on its banks and in its present position is insanitary. Under the agreement which the New South Wales Government entered into with the Commonwealth, as given in schedule 1 of the Seat of Government Acceptance Act, New South Wales undertook to protect the Molonglo from pollution. Representations have already been made to that Government regarding the pollution of the Molonglo, with the result that the State authorities have raised the question whether the Molonglo is polluted or not. That control puts this matter in a most unsatisfactory condition. Mr. Davis, the Director-General of Public Works for New South Wales has reported that the waters of the Molonglo are not polluted, notwithstanding that the whole of the township of Queanbeyan drains into it. It is unnecessary to analyze the water to ascertain pollution, because there is ocular demonstration of the fact. When the water recedes from the banks the condition is most insanitary, evidences that the water is polluted being left. We have been instructed by the Health authorities not to use the Molonglo waters for domestic purposes. That was Dr. Norris' advice. In spite of these reports the New South Wales authorities still persist that the waters are

not polluted. The next step is that the matter should go to arbitration. The pollution is undoubtedly due to the presence of the village of Queanbeyan on the banks of the river, and Queanbeyan is in an insanitary condition. A proper drainage system for the township would undoubtedly remove a great deal of the trouble. With polluted water the ornamental lakes scheme would be a menace to the health of the city. It will be no detriment to have a lake system on one side only of the population of a new city.

151. *To Senator Lynch.*—Six inches would be a fair average of the amount of silt brought down by the last flood. That amount would be a serious drawback to the lakes unless the engineers dealt with it effectively. It would not be so bad as to destroy the purpose of the lakes. Even if there were enough water from the watersheds of the Molonglo and Queanbeyan to maintain the eastern lake at the 1,845-ft. level, I would not favour its creation on the ground of expense, and also because it would submerge a considerable area of very fine alluvial ground. The best of this would not be worth more than £10 an acre at the present time, and there is not a very large area of that value. With the lower lakes at the 1,825-ft. level not very much of that land would be submerged. I believe that the city will extend in future beyond the arbitrary lines shown in green on the map. These were merely placed there for the direction of competitors to indicate the boundaries of country, including the site most suitable for the city, and not with any idea of restricting the city. The lakes will be in the centre of the whole scheme for the city, but in my opinion the northern area will be occupied by Government institutions, such as hospitals and universities, and not for residential and business purposes. If there were no serious difficulty in the way of taking the railway across on a high embankment, I would still favour cutting out the upper lake.

152. *To Mr. Gregory.*—The Board proposed that Parliament House should face practically north-east as in the premiated design. I would build the Government offices on lines closely allied to those in that design. Mr. Griffin's site for Parliament House was viewed with the greatest favour by the first Advisory Board, which included Colonel Vernon, Government Architect for New South Wales. It was always realized that that site possessed greater potentialities for the purpose than any other. According to the premiated design Parliament House and the public buildings would all face the segmental lake. It is difficult to see why people should wish to live on the areas to the north, except in certain suburbs which might be arranged in the foot hills of Mount Ainslie. I would keep the population to the south and east. The areas to the north are a long way from the centre of the city. The Advisory Board suggested the establishment of a university, with 700 acres of ground, on the height known as Vernon, and the hospital on grounds to the west.

153. *To Mr. Sampson.*—The Board were unable to concur in the amended plan submitted by Mr. Griffin in 1913. In the early part of that year the Board's plan was approved by the Minister. I have heard that there was a further ratification by the Minister, and have read of it. But that is where the matter stands to-day. Personally, I am not aware of any further ratification. I have heard that Mr. Griffin's plan was approved by the Minister, but I have not seen the document. I am advised that Mr. Griffin's plan was approved by the Minister subsequent to the date when the Board failed to agree to it, but I have been at Canberra, and the documents have not reached me.

154. *To Senator Keating.*—I hope the Federal City will contain a Commonwealth University. I do not suppose there is a prospect of establishing a seventh university in Australia within any measurable distance of time, but we had in Australia only three universities when that was proposed. We have now six. It was not indicated to competitors that the northern area was not for residences. They had an absolutely free hand. Every one of the eight designs provided for settlement on the northern side, or in other words, for settlement on both sides of the lakes. It would not have been better for me, holding the views that I do on this subject, to make the Molonglo the northern boundary of the city, and bring the southern boundaries still further south, because we (the Board) used the areas lying to the north of the ornamental waters for the specific purposes mentioned. There was nothing to indicate to competitors that it was desirable to use the northern part for universities and hospitals. None of the designs met the requirements in their entirety. The plans are useful so far as we are concerned only for the part to the south of the Molonglo. One design was purchased, and three were premiated.

(Taken at Canberra.)

FRIDAY, 17TH SEPTEMBER, 1915.

Present:

Mr. RILEY, Chairman.

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson.
Mr. Fenton,	

Walter Burley Griffin, Federal Capital Director of Design and Construction, recalled and further examined.

155. *To the Chairman.*—To clear up the question of supply of water, I submit the following data regarding the lakes scheme:—

AREAS AND RESPECTIVE DEPTHS IN LAKES AND BASINS, CANBERRA.

Depths in feet ..	..	5	7½	10	12½	15	17½	20	21	25	27½	30	35	45	50	Capacity in Cubic Feet.	Average Depth.	
	Full Level Area.	Areas in Acres.															Of Full Content.	Excluding River Bed.
	Acres.																Feet.	Feet.
1. Eastern Lake ..	1,672	717 ..	45	308 ..	410 ..	..	..	101	..	..	31	..	..	..	..	838,460,000	11½	10½
2. Eastern Basin ..	218	86 ..	87	..	..	..	..	..	45	..	..	..	..	..	..	97,408,000	10½	6½
3. Central Basin ..	238	36½ ..	154½	..	23½	..	..	..	..	23½	..	..	..	..	..	116,160,000	11½	9½
4. Western Basin ..	167	20½ ..	82½	..	36½	..	½	..	..	..	16½	..	..	..	..	85,361,000	12½	10½
5. Western Lake ..	809½	.. 342	..	..	..	..	320½	..	66	31½	..	..	38½	30	11	671,120,000	18	16
	3,145½ = 4·915 square miles.															1,809,392,000	13½	12

1·5 square mile, per Col. Owen, for impounding reservoir.

6·415 square mile water area, including impounding reservoir.

13.4.15.

WATER SUPPLY CAPABILITY OF MOLONGLO AND QUEANBEYAN RIVERS AT CANBERRA, COMPILED FROM RAINFALL STATISTICS OF COMMONWEALTH METEOROLOGICAL BUREAU.

Isohyetals.	Area Enclosed.	Annual Rainfall.			Total Rainfall Per Annum.		
		Minimum Year.	Average Year.	Maximum Year.	Minimum Year.	Average Year.	Maximum Year.
	Square miles.	Inches.	Inches.	Inches.	Cubic feet.	Cubic feet.	Cubic feet.
30 inches-35 inches	129	24·73	33·32	46·50	7,408,406,016	9,961,788,672	13,917,733,632
25 inches-30 inches	260	17·48	30·89	50·08	16,185,920,000	17,911,872,000	29,020,800,000
20 inches-25 inches	256	12·42	21·11	41·28	7,359,976,512	14,345,109,504	24,456,834,176
20 inches ..	42	11·09	18·73	28·94	1,077,221,376	1,826,592,768	2,821,851,648
Totals ..	677	..	..	..	26,942,623,904	44,046,362,944	70,911,219,456
Run off = 5 per cent. of total					1,297,126,195	2,202,268,147	3,545,560,972
Evaporation of 36 inches per annum on 6·415 square miles, in cubic feet					536,519,808	536,519,808	536,519,808
Net run-off per annum, cubic feet					766,600,387	1,665,748,339	3,009,041,164
Net run-off per diem, cubic feet					2,083,800	4,563,700	8,243,000
Net run-off per second, cubic feet					24	52	95
Rainfall over entire catchment (per totals)					16¼ inches	28 inches	45 inches
Time of filling three lakes (1,809,392,000 cubic feet) ..					28½ months	13 months	7½ months
Time of filling impounding reservoir on Queanbeyan River (1,000,000,000 cubic feet)					16 ,,	7¼ ,,	4 ,,
Additional water supply operating to preserve lake levels after first *filling = 95 per cent. of annual* rainfall on water surface (6·415 square miles); at *local* rates rainfall = minimum year, 11 inches; average, 20 inches; maximum, 35 inches					Cubic feet. 165,740,000	Cubic feet. 283,160,000	Cubic feet. 495,530,000

Capability of Molonglo and Queanbeyan Rivers, as Given in Col. Owen's Letter, F.C. 15/240, B. 66, Dated 14th April, 1915.			Corresponding Item per Calculations Submitted.	
Catchment area		485 square miles		677 square miles
Depth of annual rainfall in minimum year		12 inches		10½ inches
	Gallons.	Cubic feet.		Cubic feet.
Total rainfall in minimum year	60,000,000,000	12,800,000,000		26,042,823,004
Run-off = 5 per cent. of total rainfall	4,000,000,000	640,000,000		1,297,126,195
	Square miles. Gallons.			Square miles.
Evaporation from impounding reservoir—	1¼ = 800,000,000		Impounding reservoir—	1·5
Evaporation from lakes—	5¾ = 2,650,000,000		Lakes—	4·015
	7 3,450,000,000	3,450,000,000	552,000,000	536,519,808
				0·415
Net run-off in minimum year		550,000,000	88,000,000	760,606,387
Further deduction made for "stream losses"		4,000,000,000	640,000,000	Nil
Deficiency		3,450,000,000	552,000,000	Surplus *916,346,387
Water volume in lake system		20,000,000,000	3,200,000,000	1,809,392,000
Average depth of lake system		..	20 feet	13½ feet
Evaporation depth per annum		..	36 inches	36 inches

* The situation of the lakes in immediate contact with considerable areas of the most effective watershed of the entire catchment predicates a very large percentage of run-off from local storms in driest years affording thorough lake flush, besides greatly increasing this indicated surplus.

Water Supply Available for Filling and Preserving Proposed Lake System at Canberra.

Statistics Furnished by Colonel Owen.	Remarks Submitted.
(a) Gives catchment area above dam site as 335, 150=485 square miles, on which an annual rainfall of 12 inches in a minimum year yields 13,500,000,000 cubic feet = 80,000,000,000 gallons	The catchment area used in my calculations is that of the Molonglo and Queanbeyan Rivers and tributaries at the junction of Jerrabomberra Creek and Molonglo, where an embankment is proposed to carry railway and separate the Eastern Lake (R.L. 1,845) from the basins (R.L. 1,825). This area is given by the New South Wales Water Supply Department as 677 square miles, which is in substantial agreement with the areas obtained by me from Mr. Scrivener's map of Federal Territory, dated 22nd May, 1909, and accordingly has been adopted. In a report, dated 26th May, 1909, Mr. Scrivener states that the "Combined Watersheds of Molonglo and Queanbeyan Rivers above points marked *P* and *X* would not be less than 450 square miles"—only 35 square miles less than that given by Col. Owen as the basis for *total available catchment area*—and as shown by the map, this area of 450 square miles omits the whole available catchment of Molonglo, in Duntroon Valley, and the Jerrabomberra Creek, containing the Queanbeyan Plains.
(b) Annual rainfall over whole catchment taken as 12 inches.	This average depth over the whole catchment area is too low, according to the rainfall statistics of the Commonwealth Meteorological Bureau, which furnishes estimates of the depth of rainfall that may be expected over different areas of the catchment in years of minimum, average, and maximum rain. The depth of rainfall shown in the accompanying table (minimum 10½ inches, average 28 inches, maximum 45 inches) has been derived by computing the total rainfall of the whole catchment, according to the figures furnished by the Meteorological Bureau, and dividing by the catchment area. From the figures so deduced, it appears that an estimate of 12 inches per annum is 25 per cent. below the average rainfall likely to occur in the driest year over the whole area. Mr. De Burgh, in a report enclosed by the Premier of New South Wales, under date 29th May, 1909, says: "There are no rainfall gauges on Queanbeyan River catchment, the nearest is at Captain's Flat, where the mean annual rainfall of seven years ending 1906 was 27 inches, and the lowest record in 1902 was 18·69 inches. The figures furnished by the Meteorological Bureau for that portion of catchment, which includes Captain's Flat, are—average year 30·83 inches, minimum year 17·48 inches.
(c) Ratio $\frac{\text{run-off}}{\text{rainfall}}$ = 5 per cent.	Ratio of run-off/rainfall is assumed by me also as 5 per cent., as per tables attached. In connexion with this proportion of run-off to rainfall, the following data are submitted:— Mr. Scrivener reported (26th May, 1909) "that the annual flow of Cotter River is equal in volume to a rainfall of 5·6 inches over the whole area of its catchment. The run-off from either the Queanbeyan or the Molonglo watersheds would be less than that of the Cotter, but might reasonably be taken at ⅔ of that quantity = 3·7 inches over the whole watershed." Assuming that the run-off in a year of minimum rainfall were as low as half that in a year of average rainfall (although the meteorological records show it, in most cases recorded over the whole territory, to be from $\frac{1}{10}$ to $\frac{1}{20}$, and ⅛ is a commonly accepted proportion), the average run-off over the whole catchment area would be 1·85/16·5 = 11 per cent. for a rainfall of 10½ inches, and 1·85/12 = 15 per cent. for a rainfall of 12 inches against 5 per cent. assumed.

Water Supply Available for Filling and Preserving Proposed Lake System at Canberra—*continued*.

Statistics Furnished by Colonel Owen.	Remarks Submitted.
	Mr. De Burgh, of New South Wales, in reporting on the water supply of the Federal Capital, gives the following estimate of the flow of the Molonglo and Queanbeyan Rivers *made* by Mr. Pridham:— "Assuming the minimum annual rainfall on the higher catchment of the Queanbeyan at 20 inches, and the run-off at 10 per cent. (= 2 inches a year), or half that taken for the steeper and higher Cotter catchment, about 0,860,000,000 gallons would be discharged in a very dry year at proposed dam 'site X' (about half way between junction of Burra Creek and Queanbeyan township)." 0,860,000,000 gallons = 1,576,000,000 cubic feet. In other words, this officer estimated that the catchment area of the Queanbeyan River alone at the point X would yield 1,576,000,000 cubic feet in dry year, against 1,297,000,000 cubic feet which I have arrived at for the whole of both Molonglo and Queanbeyan Rivers down to Canberra itself, by taking the proportion of run-off as 5 per cent. From these figures we may conclude that the proportion of run-off adopted, viz., 5 per cent., is, to say the least, a conservative one. In the conditions issued by the Department for guidance in the preparation of competitive designs for the Capital, it was stated:— "The catchment area of Molonglo and its tributaries may be taken as 700 square miles, over which the annual rainfall is approximately 23 inches, and the annual evaporation from extensive areas of water may be assumed to be 40 inches." "Regulating weirs at least 14 miles above the city site will be constructed on the Molonglo and Queanbeyan Rivers to control flood waters, to equalize the flow of the river, and to maintain a constant level behind any weir within or near the city site." "It may be assumed that a flow, *if not less than* 20 *cubic feet* a second could be maintained at the site during successive years of minimum rainfall." In connexion with the conditions, I may point out that my estimate of the run-off from the catchment area in driest year is 23 cubic feet a second, according to meteorological records, and that a rainfall of 23 inches in an average year corresponds with 15½ inches in a minimum year, according to methods of estimation usually employed.
(d) Evaporation 3 feet per annum on a water surface of 7 square miles = 3,450,000,000 gallons=552,000,000 cubic feet.	Evaporation of 3 feet per annum on 0·415 square miles = 536,519,000 cubic feet. The only data supplied to me as to the rate of evaporation that may be expected from a sheet of water at the Federal Capital show that the gross evaporation on the surface of Lake George amounts to 25·18 inches per annum; while, as shown above, 36 inches has been allowed by Col. Owen and by me.
(e) *Stream Losses.*—There are stream losses above and below the proposed lake sites. The gaugings at the Queanbeyan (? where) when correlated with those of the Molonglo (near Yarrolumla dairy), disclosed a 20 per cent. falling off when the latter is flowing at 15,000,000 gallons per diem.	The losses of rainfall from the catchment, that is the difference between the total rainfall and the amount discharged in a given time at any particular point is provided for by the assumption made, viz., that only 5 per cent. of the total rainfall is discharged at that point, the remaining 95 per cent. being allowed as "loss." Moreover, the effective sealing of this final outlet dam with bed rock may be expected rather to increase the percentage of measurable and effective run-off above this 5 per cent., by eliminating sources of loss other than evaporation. The falling off of 20 per cent. between two points on the river, as referred to by Colonel Owen, affords no basis on which any final conclusion as to probable net discharge could be based.
(f) States that there should be an annual average flow of 4,000,000,000 gallons from the dams, Queanbeyan and Molonglo Rivers (irrespective of evaporation), at the junction of Molonglo and Murrumbidgee, as compensating water. (This opinion has since in evidence been admitted to be purely arbitrary.)	Having consulted with the officers of the Water Department of New South Wales, I can say that there is no obligation on the Federal Government to keep such a volume constantly supplied to the Murrumbidgee. Assuming for a moment that such an obligation existed, a proportion of this quantity (probably one-fourth) would be supplied by the catchment area of the Molonglo River below the lake system. The amount of compensating water (if any were required) derivable from this source has been ignored, and the entire contribution of 4,000,000,000 gallons has been classed as a "stream loss" and placed against a net discharge of 550,000,000 gallons, thus converting his own calculated surplus supply of 550,000,000 gallons into a deficit of 3,450,000,000 gallons, as shown on attached table.

My estimate of the time that it would take to fill the impounding reservoir and the ornamental lakes includes the eastern lake. I have taken 5 per cent. as the allowance for the run-off, but the water that falls on the lakes—an area of six and four-tenths square miles—contributes its total, as 100 per cent. of it will be conserved.

156. *To Mr. Finlayson.*—Ninety-five per cent. is a very liberal estimate for loss by soakage and evaporation.

157. *To Mr. Gregory.*—The catchment of the Queanbeyan impounding weir is 335 square miles, or about half the total watershed contributing to the lakes. The average rainfall on the watershed of the Queanbeyan is considerably above the average on the lower reaches. Taking, however, half of the whole catchments at the same rate of rainfall would give a supply to that reservoir of 380,303,000 cubic feet per annum in the driest year. Deducting that from the evaporation losses would give a net reduction by evaporation of 158,216,000 cubic feet per year. That could continue for three years and a half, which ought to be quite ample to carry us through a more prolonged drought than we have any record of, without making any allowance for the other sources I have indicated as contributing an extra supply to the lakes. I am working now on designs for bridges, weirs, dams, earthworks, and revetments, most of which are nearly finished. When these are done, I will supply an estimate of the cost of the lakes. From the first I have been treating the lakes scheme, including the eastern

lake, as a whole. To omit the eastern lake means a modification of many other things and changing the city plan, and omission of any of these changes would hardly afford a fair comparison.

158. *To the Chairman.*—I can supply an estimate of the cost of the other lakes if the Government decide to leave the eastern lake for future construction. I will include the cost of railway crossings and traffic bridges.

159. *To Mr. Fenton.*—To carry out the full lake system, including the eastern lake, I should say it was entirely unnecessary to dam both the Molonglo and Queanbeyan Rivers above the lakes. I recommend the Queanbeyan scheme, and not the Molonglo. Mr. de Burgh thought it would be a safe scheme without impounding both rivers.

160. *To Mr. Sampson.*—It would not be practicable to bring the eastern lake down the same level as the others. Twenty feet is the most practicable difference. The land lies too high. In my original plan the eastern lake was on the higher level.

161. *To Mr. Finlayson.*—I have in my office a map showing the amount of excavation wanted in forming the basins, and the spots where banking will be required.

162. *To Mr. Gregory.*—The statistics in regard to the loss by evaporation and seepage at Lake George were for a period of 40 years. I did not take Mr. Hunt's calculation of 26 inches for that lake without going to him and catechising him for some time, and then I was satisfied. The question of silting does not worry me. It will take a long time to precipitate an appreciable amount, and we can meet the difficulty when we see it threatening by taking measures to prevent the silt coming down. There would always be a good velocity of water in flood time through the lakes.

163. *To Senator Keating.*—We will have to take the water out of the lakes as fast as it comes in. Ordinarily, all the silt will be deposited in the upper lake, but with floods there will be silt passing through. There is always a certain amount of deposition of silt during a flood, and that amounts to large quantities in a long period, but it is not a practical consideration here. The difference in our conditions is not so great as to make what is practicable everywhere else impracticable here, and we have a very large area over which to deposit the silt.

164 *To Senator Story* —The siltage below the Queanbeyan reservoir, except under unusual conditions, would be slight Geologically speaking, the lower lakes would silt up in time, but it is not very expensive to take silt out even if it has to be dredged out. We will eliminate most of the mud brought into the system except by very occasional floods.

Percy Thomas Owen, Director-General of Works, Department of Home Affairs, recalled, and further examined.

165. *To the Chairman.*—I took the catchment area above the impounding dams after very careful consideration. The catchment areas that discharge into the Molonglo and Queanbeyan below these dams are negligible in very dry years The compensating water for the ornamental lakes must come from above the dams. Some of the biggest mistakes over hydraulic schemes have been caused through putting on rose-coloured spectacles in estimating the rainfall. The meteorological data for this region are of little use; we must take the worst possible rainfall for large numbers of years. I have based my 12-inches estimate more on general knowledge of what we may expect in New South Wales away back from the coastal regions, and I would not allow more than 12 inches, notwithstanding any data that may be quoted from isolated stations in the Federal Territory. Mr. Griffin thinks 5 per cent. is low for the run-off. When I gave 5 per cent. I considered it a high figure. Ninety-five per cent. seems a very great waste, but any comparison between a rainy and a dry season is hopeless. In a wet season you may get a run-off of 30 per cent., but in a dry season a great deal of the rain never reaches the stream. It is only the thunderstorm that counts, and the run-off is not in direct proportion to the rainfall. In the Avoca River, Victoria, the run-off was .4 per cent. In the Loddon River, *with a 10-inch rainfall, it was 2.3 per cent.*, and the catchment area of the Loddon is 1,590 square miles. The figures for the Campaspe for 1902 were .2 per cent. run-off, 10-inch rainfall, and 1,300 square miles catchment. That is the sort of year we have to look to. The average is worthless, the maximum rainfall is worthless, and we must take the minimum as our guide. In this case, I have taken a percentage which I would be very afraid to say that we will always attain in these regions. I am afraid Mr. Griffin has misunderstood my evidence regarding compensating waters. He has put the question to the Committee as though we had to compensate the flow of the Murrumbidgee. That is absolutely ridiculous. I never intended to convey any such thing. Once you conserve water in a dam you will be constrained to pass water down the river for the sake of the people living below the dam. I, therefore, arbitrarily assume a certain amount as compensating water. You cannot safely estimate the run-off at more than 5 per cent. Mr. Griffin takes the run-off loss as covering the river loss, but there must be river loss, which adds considerably to the run-off loss. One source of river loss which we have not been able to investigate is the loss that may occur through distributing water to surrounding areas of country by subsoil distribution. I have allowed nothing for that loss, although it must occur to a certain extent, if we fill the upper lake to the 1,845 feet level. The shafts we have sunk have disclosed strata of coarse grit which hold water, and may tend to distribute it. Mr. Griffin also said with regard to compensating waters on the lower regions that the areas below the dam would contribute 25 per cent., but we know that, notwithstanding the sources of supply from above, the Molonglo in bad years is dry, and those are the very years in which you want compensating water. Instead of getting 25 per cent. of compensating flow below the dams, you will get nothing. As regards silt, Mr. Griffin said the capacity of all the lakes was 1,809,000,000 cubic feet. With a flood of 1,000,000 cubic feet per minute, which is a moderate flood discharge, the water in the lakes would be changed in 24 hours. That means 24 hours' deposition of silt, which would be considerable. Where you get wide areas the velocity, which is the great factor in this question, becomes low. He does not apprehend any trouble with silt, but I apprehend a considerable annual expense as times goes on in keeping the lake to its proper depth. The whole of the Molonglo plains in front of Duntroon have been deposited by that very process.

166. *To Mr. Fenton.*—It will take with exceptional rainfall eight months, and with average rainfall thirteen months, to fill the lakes. It is not only the big flood that will be the source of danger with silt. A moderate freshet after a dry spell brings down a tremendous amount in this river. I saw a new deposit of 6 inches of mud in a little backwater of 40 feet or 50 feet. We made a dam near the power-house, and I am already considering how we are going to get the silt out of it, notwithstanding it is subject to the scour of the stream. I do not say that the trouble from the silt will be insuperable, but it will cost money. I do not think Mr. de Burgh has actual gaugings of these rivers, as I believe there is not any gauge in the district, except the one we put up. Gaugings, to be any good, must extend over 30 to 40 years, and all the information we have available is that obtained from the last two or three years of gauging. I do not want the Committee to think that I have failed to supply Mr. Griffin with any information I could possibly make available.

167. *To Senator Keating.*—The gauge was put in the Cotter in 1911. The State Government were gauging before that, but they had not a notch. We also have a gauge in the Molonglo, just above Yarrolumla, and have had another on the Queanbeyan for about three years. The Cotter catchment area is totally different from this. *It is ideal for conservation, but the Queanbeyan* and Molonglo are the reverse.

168. *To the Chairman.*—It would be risky to make provision at present for the eastern lake. Mr. de Burgh said the Queanbeyan supply would be a close shave, and, with the Molonglo, would be sufficient; but the Molonglo has a very small catchment area, and a very poor impounding basin. You will not get much from the Molonglo. The Queanbeyan is the main source of supply for the lakes, with the biggest and best catchment area, and the best impounding basin. No one with a knowledge of evaporation in Australia will give less than 36 inches as the loss by evaporation. Mr. Hunt told the Board the loss at Lake George was 25 inches, but, in my opinion, the records there were not sufficient to give the true result in that regard.

169. *To Mr. Gregory.*—The run-off figures for the Campaspe and Loddon were, I take it, for the upper areas, right up to the source—areas of high rainfall, from 50 to 20 inches, and nearest the Dividing Range. There is certain to be an amount of seepage through the beds of grit disclosed by our shafts, and not until the levels in the lakes came down would we get back any of the water. Mr. de Burgh, as an engineer, would have thorough knowledge of water conservation propositions of this kind. Even, however, if he said that with water storage on both the Molonglo and Queanbeyan there would be enough water for all the proposed lakes, I have lately had contour surveys made of the basins, which were not made before, and we find such different propositions for the basins that the Molonglo catchment area will not be very satisfactory. One extends over a large area with a depth of 15 to 20 feet, and the other is a small basin. The evaporation for 15 or 20 feet will consume a large quantity of water. A deep basin is wanted as a conservation basin. I am afraid we will not get that easily on the Molonglo, although we will have it on the Queanbeyan. I will not say I approve of one weir for the Molonglo and the western lake system, but on the Board I gave way on it. I was afraid that we would not have enough water, but I have put my signature to a scheme which would admit the forming of the lower lakes. I am satisfied now that there will be sufficient water for the lower lakes. The silt difficulty will occur whether we have the eastern lake or not. With heavy floods the eastern lake would intercept a certain amount; with intermediate or small floods it would hold enough volume to practically precipitate the lot. Without the upper lake, we must have silt difficulties in the lower. The only way to get over *these is by pumping and distributing.* About two-thirds of the area of the circular basin varies in depth from 10 feet to nothing, shoaling away towards the banks, and necessitating excavation to make a suitable lake. I would pump this stuff out if there was no eastern lake, and reclaim the area of land lying below the *1,825-ft.* level to the east of the proposed bank. As an engineering work, the proposed boulevards around the geometrical lakes are 1,000 feet out. The conventional design, as shown on Mr. Griffin's plan, will bring the boulevard walls in places actually across the present river bed. The Molonglo originally flowed west, and was diverted south and east by limestone beds. Mr. Griffin's arbitrary plan will cut across the natural flow, making unnatural, ugly projections at two angles, where the curved side of the segmental basin joins the two circular basins, in an endeavour to get what I may call an "aeroplane" view. These should be cut away, and the water allowed to run in what should be its natural channels. I cannot understand Mr. Griffin's plan to take the river away from its present course. He now tells me that the plan is 100 feet out, but that does not account by a long way for the variation, and I do not approve of the huge banks which his proposal would throw out across the proper course of the water. The natural surface at Scott's *Crossing is 15 feet below the future water level.* This conventional treatment flies in the face of all ideas of economy, and there has been apparently no thought given to making the design subservient to the topography of the country. At one point where we will have 20 feet of depth, we may have a sluice of water of *1,000,000* cubic feet a minute coming round, which is absolute madness to think of. While still allowing the rest of Mr. Griffin's design to stand, the wall could be brought approximately alongside the present course of the river, although it would not give the effect of two circular lakes joined by a segment. On the western circular lake the wall is going to be built, according to the plan, 600 feet inside the flood level! If what I have described is the outcome of town planning, then town planning has run riot. My Department has given an estimate of the cost of excavating and forming banks, and I will take the responsibility of it. Mr. Hill is prepared, without having the benefit of Mr. Griffin's plan, and merely following the scheme shown on the map, to estimate the cost of the water work, following all the formal faces, but not including the cost of protecting the water fronts, many of which will be exposed to heavy wave action. One part in particular will melt away like soap unless protected, so that something must be added to Mr. Hill's estimate.

(Taken at Sydney.)

MONDAY, 27TH SEPTEMBER, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Grogory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

John Sulman, F.R.I.B.A., Consulting Architect, and President of the Town Planning Association of New South Wales, sworn and examined

170. *To the Chairman.*—I have retired from general practice as an architect. During my professional career I have dealt also with engineering matters. I have always taken a keen interest in town planning, and initiated the movement in Australia. I have seen Mr. Griffin's plan, and have visited the Federal Territory. At a meeting of the Australian Association for the Advancement of Science, in Melbourne, in 1890, I read a paper on the laying out of towns, which was widely discussed. My view is that in a new country the planning of cities has an important bearing on the social, moral, and physical welfare of the population. In 1909 I examined the whole area from Yass to Queanbeyan, and pitched upon that part of the present site lying to the north of the Molonglo as the best. I published the result of my researches in a series of articles in the Sydney *Daily Telegraph*, and afterwards published them in pamphlet form. I produce a copy. I have since done everything in my power to help forward the planning of the city, and wrote a paper for the Town Planning Conference in London on the proposed Capital, giving my general ideas, and stating that I would not be a competitor, but that I would give any assistance possible in the way of local information to foreign competitors. The desire of the New South Wales Town Planning Association is to see that Australia gets the best possible city for her Capital that modern science can provide. Artificial lakes should undoubtedly be created to beautify the city, the climate being fairly dry. They will be not only a source of beauty, but increase the possibilities of vegetation, especially tree growth, which is badly needed, owing to the cutting winds to which the southern side of the city will be exposed. The lake scheme is, however, conditioned by the amount of water supply, which depends on the average rainfall and the run-off of the catchment. Not knowing anything about the rainfall, I cannot say whether Mr. Griffin's lake proposal is too large.

171. *To Mr. Laird Smith.*—The construction of the eastern lake would depend on the water supply. In a dry season, evaporation will lower the level if the area is too big, and leave mud banks. If it is proved that sufficient water is available, I would favour the largest lake area obtainable. If the river brings down a large amount of silt, there might be danger of the lakes silting up. There cannot be bank erosion if the water is kept at a dead level. If there is wave action its effect on the banks will depend on the soil. Plenty of material is available to reinforce the banks if necessary. The question of providing sufficient by-wash or sluices to prevent flooding is an engineering problem, but the bigger the area of lake the greater the space for the flood water to spread itself over.

172. *To Mr. Finlayson.*—The only limits I would place on the area of artificial water would be to see that the lakes did not get in the way of the expansion of the city, and the availability of water supply to keep them full. The fact that Parliament House is to be on the south side of the river would not cause unreasonable division of the city if there are sufficient means of communication across the lakes by dams or bridges. I selected the northern site from a purely practical stand-point. The prevailing winds are south-west, and in the winter, when Parliament mostly sits, they are very keen. It would, therefore, be wise to place the city under the lee of Black Mountain. You have also a more level site there on which it would be less costly to build. I fully recognize the advantages of the southern side for picturesqueness and for making a fine city, but it is open to the winds. Mr. Griffin agrees with me to a certain extent on that point, but believes he can counteract their effects by sufficient tree planting. If that can be done, I quite admit that, from the æsthetic stand-point, the southern site is the best, because, on the general area, the position selected for the Capitol and Parliament House cannot be beaten. My original idea was that these structures should be on an easy rising grade under Black Mountain. This would not be nearly so effective, but from a practical common-sense point of view it was more sheltered and cheaper. With good means of communication I anticipate no difficulty through the lakes being in the centre of the city. Most other cities have grown. They have a habit of growing on both sides of a stream or sheet of water, provided that it is not too large. This city is going to be planned. If one side has special advantages the city may grow more on one side than on the other. I have travelled a great deal, but nearly all the cities I can recall at the moment are more or less on both sides of natural waters. The lakes running through the centre of the city will be a valuable asset from the point of view of beauty and pleasure. To decide whether the lakes should be formal in design or follow the natural contours, one would need to go to the site and follow the contours carefully. I am inclined to think at this moment that if it is desired to make the city the fine city that Australians intend that it shall be, regular lines for the central lake, at any rate, will give greater dignity; but I quite agree with the plan to follow the natural contours for the lowest and highest lakes. The general effect of having one lake at each end following the natural contours, with one or possibly two or three of formal design in between, would be pleasing rather than otherwise.

173. *To Mr. Sampson.*—I contemplate the lakes being in the centre of the city with a population on both sides, rather than on one side of the city. There will probably be a residential suburb to the north as well as to the south. I think it will be possible to confine the commerce of the city to the north, as planned by Mr. Griffin. The science of modern town planning is to divide a city into constituent parts. In this case the Government will occupy one section, trade another, and manufactures should undoubtedly have a section to themselves. I see little reason to doubt that the city can be developed generally on the lines shown on the plan. I would control that matter by Ordinance. If residents are given an absolutely free hand, there is a possibility of developing two sides in competition with one another; but I take it that

in planning a city of this kind its development will be regulated. I would agree to the commercial centre being on the north, and the parliamentary and residential centres on the south, with the condition that I think residential suburbs will develop on the north also. The lakes will furnish a desirable separation of two distinct activities. I understand that the factory area is to be to the north, along the railway line. That is a suitable position, and the ground is fairly level. It would be a pity to restrict your water scheme to the existing channel of the Molonglo by building levee banks, even if it was widened a little, if you have sufficient water to form lakes. The question of having an area of park land between the boulevards and the water is one that must be settled on the spot.

174. *To Senator Lynch.* If the water can be impounded in the hills at not too great an expense it would be a good thing, because of the variation of the seasons. An impounding reservoir would help to keep the lakes at a permanent level. The only question is whether it is worth the cost. It would be a wise precaution to store water in the hills, so as to increase the lake area, if it is not too costly. With suitable material an earthen dam could be constructed to hold back the water in the upper lake at a level 20 feet higher than the lower lakes, if it is decided not to construct a big embankment to carry the railway across. Twenty feet is not a very great head of water. No doubt a concrete core in the centre would make the dam water-tight, but it would also mean money. It should be easily possible to build a dividing dam without a concrete core to hold back that head of water. A puddled clay core would do. If there was any doubt about the sufficiency of the water supply, I would try to make the upper and circular lakes on the one level, taking the railway across on a viaduct. The conditions are water and money.

175. *To Mr. Fenton.*—To decide whether an earthen dam, with a puddled clay core, would be sufficient to hold back a lake whose area would be practically half that of the whole proposed lake system, it would be necessary to go into the question of material, the thickness of the dam, the batter, and whether it would be necessary, owing to the prevailing winds, to face the inner side of the dam. That class of embankment would have to be made much wider than one with a concrete core. A lake system running through the centre of the city will not have a tendency to divide the city against itself, because no less than four means of communication are shown on the plan. Broadly and generally, I would, having located the business centre in one spot, prevent other parts of the city having business places, but there are exceptions to every rule. It might be necessary to provide the people in southern or south-eastern suburbs with retail trading facilities, but most town planners agree that it is wise to confine the business of the city as much as possible to one centre. We all know how upsetting it is to a residential suburb to have isolated business places set up in it. It frequently spoils an excellent residential area, and destroys the value of property. In this city, with governmental control, it should be easily possible to indicate where people can establish shops. The matter ought to be regulated. The application of the leasehold principle will give the governing authorities full control. I favour government by a Commission of three, as in Washington, where the system has produced excellent results. If you have three of the most capable men in the community they should be able to run the city and Territory to pay for itself. My suggestion would exclude municipal government. In this instance, government by Commission should be given a good trial, even to the extent of application to the full 1,000 square miles of territory. Over 300 cities in the United States have found government by Commission successful in substitution for municipal government.

176. *To Senator Story.* On the whole, it would be desirable to make the central lake artificial in form in connexion with the lay out of the governmental centre, and if the cost is not too great it might also be advisable to give the two flanking lakes a geometrical form. It is simply a matter of cost, especially if, as you inform me, the boulevard plan for the segmental basin and the western circular basin crosses the existing river bed in two places in each case. No doubt the cost, if that is so, would be considerable. It is advisable to have the central basin regular in form; the shape of the other two could be conditioned by the cost. The increased beauty would justify the expense in the case of the central lake, which would help to make the whole of the centre of the city of ordered architectural form. I look on that central or segmental lake as a fine part of the whole scheme.

177. *To Senator Keating.* -When visiting the place as leader of one of the excursions for scientists of the British Association last year, I did not examine the locality in detail in relation to the proposal to put the lakes there. I would prefer, if possible, to see the upper lake constructed as planned at the 1,845 ft. level rather than to cut it out and canalize the stream to the east. It would be a great advantage to the city to have a lake there, because a canalized channel above the city would hardly be beautiful. On general principles, I know nothing against Mr. Griffin's proposal to pass the water from the 1,845-ft. lake to the 1,825 ft. lake by means of a series of syphons. With a sufficient current the lake water would not stagnate. I know of no city where anything like so large an artificial lake area has been created. Lake George is very shallow, and has dried up in dry seasons. The artificial lakes in London have a very limited supply of water, but I have never heard of them becoming stagnant.

178. *To Mr. Sampson.*—I would prefer that the eastern lake, if formed, should follow the natural contours, as a contrast to the others. Outside the city the natural form is the best. If it was possible to make an eastern lake at the 1,825-ft. level, I would rather have that than none at all there.

179. *To Mr. Laird Smith.*- As the lakes will considerably enhance the beauty of the city, the Committee would be justified in recommending the expenditure of a fairly large sum on their construction.

Francis Ernest Stowe, Architect and Engineer, Honorary Treasurer of New South Wales Town Planning Association, sworn and examined.

180. *To the Chairman.*—Our association deputed Mr. Sulman and myself to come before the Committee in our private capacity, and the opinions we give are purely personal. I am familiar with the city part of the Territory. From my personal knowledge of the country I am afraid it will not hold water. Its broken nature makes me fear some difficulty in preventing a

large amount of seepage. I examined the country as an engineer without going below the surface. I took particular notice of the flats and the ridges, and I would not think it possible to impound water there without a great deal of wastage. That applies to the whole area in which it is intended to impound water. I favour the construction of lakes as an adjunct to a city and for its beautification, but it is quite a mistake to have geometrical lines on the lake sides. There is nothing more distasteful or unæsthetic. The natural contours should be followed, particularly in the segmental lake. The road could still follow the natural contour. I have seen the artificial lakes in London, and Washington, New York, and other big American cities. The same objection applies to the Botanical Gardens at Farm Cove, Sydney. A good deal of their beauty was destroyed when the retaining wall was built around the foreshore. Most of the other cities of the world preserve the natural contour. In some cases the lakes are formed irregularly. The road can be carried near the water's edge, or gardens can be constructed between the road and the water. The scheme can be artistically treated by a landscape gardener. At Washington most of the frontages are left in their natural state, with grass slopes running down to the water. In London the Kensington Pond is artificial, but the Serpentine, as far as I remember, is natural in form. To follow the natural contour would save money, and give a more artistic effect. It would not increase the danger of silting. The proposed 20-ft. drop between the eastern lake and the basins would be objectionable. A high embankment at that spot would not be a very happy feature in the landscape, however it is treated. If it was at all possible, I would prefer to have the whole of the lake water at the same level, but I have not studied the contour of the country sufficiently to know whether that can be done. On both my visits the river was very low, and it was mainly the examination of the banks that led me to the conclusion that it would be very difficult to retain water there in a restricted locality, unless very extensive damming was done. I cannot say that I have had much experience of the Territory, except that I walked over the whole of the ground as a military officer during manœuvres, and also went there and studied it with regard to the planning of the city. I was only two or three days about the city area on the latter occasion.

181. *To Senator Keating.*—I would rather have the eastern lake than no water at all; but, if possible, I would like to bring the other lakes up to the same level. I could not say what common level I would bring the water up to without making a careful study of the contour. I would not necessarily bring them all up to 1,845 feet. I cannot see the purpose of the eastern lake at all. If to leave the eastern lake at the 1,825-ft. level would mean making it merely a series of pools, I would form it at a higher level, but not necessarily as high as 1,845 feet. If at all possible I would suggest the erection of an equalizing dam further east in the catchment area, beyond the eastern extremity of the proposed upper lake. You cannot control the water level in the western lakes by using the water from the eastern lake without spoiling its effect. If you use it as a balancing lake you will have varying levels in it; this would be objectionable. The impounding dam should be common to all the lakes, and should be further east.

182. *To Senator Lynch.*—It was more about the city area that I observed the country with regard to the risk of seepage. I did not get down as far as Yarrolumla, where it is proposed to make the dam. What I am thinking of mostly in that regard is the proposal to keep the eastern lake 20 feet above the other. My opinion is that the country adjacent to the proposed embankment at that spot would not retain the water, a good deal of which would get away by seepage through the city area. Even at Yarrolumla, I would presume that there may be a difficulty through fissures in the rocks, as the whole country is very much broken. My fears in regard to wastage apply to the lakes generally, but more particularly to the proposal to have the eastern lake 20 feet higher than the other. It does not follow that the wastage would follow the channel of the Molonglo, because radiating from the city area there are depressions. There may be a possibility of the water getting away due north through the flats. The whole city is planned on too liberal a scale so far as area is concerned, so any increase of the lake surface shown would be objectionable. As it is now, to go from the Capitol to the civic centre means a journey of 2 miles. When you get to the roadway near the Capitol you still have a quarter of a mile to travel to reach it. One objection I found to Washington was the distance between the public buildings. It is not a poor man's city. Where the trams do not serve you require a motor car to get about. Any increase of the lake area in this city would accentuate that difficulty. The two and a half square miles of water given, without including the eastern lake, are quite enough. Even if sufficient water came down to give a larger area, I would not favour it. Rather than form a larger lake area, I would prefer to see the water running down the Molonglo. I see no æsthetic virtue in these "graceful curves" shown on the plan. I would prefer the water to find its own level, or even exaggerate the irregularity of the shores. Roads could still be carried round, but far enough back from the water to give the necessary level. At Washington a little stream meanders through Buffalo Park, and a road has been made to follow its whole course. In no case has the road been straightened out or the stream diverted. This plan gives several miles of lovely roadway. The pond in Hyde Park, London, always impressed me as being too severely geometric. In case of flood, the only effective way to prevent a sudden rise in the level of the lake is a spill-way. From a cursory glance at the figures I am afraid that Mr. Griffin's proposed valves or syphons could not cope with the enormous body of water likely to come down. I see it is suggested to have an 800-ft. spill-way, which would indicate that the volume of water to be dealt with is enormous. The spill-way must be of sufficient capacity to take the flood water, but if my proposal to have all the lakes on the same level were adopted, a good deal of the cost would be cut down, because the crossing between the eastern lake and the circular basin would become only a causeway for road and railway traffic, without having to act as a dam. The creation of a large body of water at Canberra would not be detrimental from a health point of view. Aquatic growths can be effectively dealt with and controlled.

183. *To Mr. Finlayson.*—The eastern lake should certainly be omitted from the plan if the levels cannot be equalized. At the 1,825-ft. level it would be practically a series of

canals. I cannot say, without the sections, whether to raise the western lake another 10 feet would mean covering a larger area. Naturally, that might be the effect. I would be against it if it had that effect, but if filling and cutting are done at the edges of the lake it may not involve a much larger area. As regards Mr. Sulman's idea of limiting the lake area only by the amount of water available, you can have too much of a good thing.

184. *To Mr. Sampson.*—There is no justification for geometrical lines even in forming the lakes lying in the centre of the city. To allow the water to follow the natural contour would not necessarily considerably increase the water space between the civic centre and the parliamentary centre. Judging by the contour lines, it would be more likely to lessen the area of water. The conventional form does not give economy in water space. Burrenjuck might, but I do not think Lake George would give reliable data regarding possible evaporation and seepage at Canberra. Borings would help to show the holding character of the country, but these would not always show fissures. The Government have hit upon a fissure in the rock under the harbor in Sydney, in spite of their boring, and it is costing them a few thousands to overcome the difficulties created. All I can say is that there is a risk of loss by seepage at Canberra. I travelled recently through America and Canada. Washington is the only city I know of whose development has been controlled by a central authority. Not only could one central authority take charge of the Federal city and develop it in accordance with Mr. Griffin's plan, but it would be desirable. The ultimate lay-out of the city depends on its growth. Mr. Griffin's plan will do if the city is not going to be a manufacturing centre, but my objection is that the city is too much spread out. It will develop only in proportion to its manufacturing development, and it will not become much of a manufacturing centre unless cheap power is provided. An arsenal will employ a large number of men, but private enterprise will have to be responsible for the development of a large portion of the city, and that will not go there unless cheap power is provided. If the commercial centre was taken away from the northern side, the only thing to be done would be to push it out eastward. The question of the city being divided into two rival sides by the lakes will always be controlled by the method of alienation of land. I presume the Government will alienate the ground only for certain purposes. That system will naturally regulate its use. The lakes should be in the centre of the city. If the Government desire to do so, they can prevent the bifurcation of the city by conditioning the alienation of the land.

185. *To Mr. Fenton.*—The condition of a good deal of the lake formation at Chicago is unspeakable. I saw the lake front at Cleveland being reclaimed with garbage, while it is usual also to discharge the city sewage into the lake and drink the water thereof. The lake fronts round Michigan are generally disappointing, because the lake has sunk, leaving most of the country round the shores very flat. Before any lake scheme is launched at Canberra, there should undoubtedly be a minute geological examination of the area. If the quantity of water to be passed from the higher to the lower lakes is large, the syphons and valves, if that system were adopted, would have to be so increased in number, that you might as well adopt the spill-way at once. In Parramatta Park ducts and valves are used to take the ordinary flow, but the whole of the causeway itself forms a spill-way; the hand-rails are made to drop and fit into a cover, and the flood water flows over the causeway, blocking traffic for the time being. I would not depend on valves and syphons unless they can be put in in sufficient number and extent to deal with the flood water, otherwise there would be a calamity. Some country rivers lose themselves underground through the clearing away of undergrowth and timber causing silting. The Castlereagh, for instance, travels for miles without showing any water.

186. *To Senator Story.*—There is sure to be some difficulty from silting. Most of the silt could be intercepted by a balancing lake to be constructed further east—local silting is not very important. The flood waters of most of our rivers bring down a great quantity of silt, which can be intercepted. I know the Torrens Lake, Adelaide, silts up, and when I was there recently the water was much loaded with foreign matter. If the designer of that lake claims that the floodgates under the weir would provide a scour, and practically keep the lake free from silt, he was a very bold man, because in a comparatively large area deposition of silt must go on. The floodgates would have only a local effect. It is advisable, so far as the lower weir is concerned, to have flood-gates or valves at the bottom, as well as a spill-way on top, but at the dam between the upper lake and the circular basin it would only mean transferring the stuff from one unit to the other. It is always advisable, in any artificial body of water, to have the means of lowering it if necessary. The only practical way of maintaining the levels through drought conditions is to have the catchment balance lake higher up. If a storage lake is constructed about 6 miles above Queanbeyan, as recommended by the officers of the Department, it would intercept a great deal of the silt, most of which comes from higher up on the catchment area, but the local run-off between there and the lakes will always bring in some débris. The whole question of preventing local silting will be got over by the proper control of the Territory, particularly if the Commissioners stop the denudation of the local catchment area of timber, and allow grass and foliage to grow thereon. When the dams are constructed, the lake shores should be allowed to follow the natural contour of the country. To do away with the conventional design of the three central lakes would, to some extent, interfere with Mr. Griffin's lay-out. The straight side of the segmental basin might be maintained, but there is no necessity to make the other side formal in design. To follow the natural lines on the circular basin would also interfere to some extent with Mr. Griffin's lay-out, but a natural appearance can be created with filling. I would make the lakes fit in with the lay-out of the streets, but get away from stiff artificial lines. I would be in favour of diverting the river where necessary.

187. *To Mr. Gregory.*—With Parliament House facing the north, it is not advisable to go to the expense of giving the segmental basin a regular frontage. The loss by seepage might not be only temporary. If the rocks in the vicinity of the dams were broken, or if there was a fissure in the rocks along the northern bank, the water might get away continuously. The country itself might absorb a lot. In the official statement the loss by seepage is put down at 10 per cent.

(Taken at Sydney.)

SATURDAY, 2ND OCTOBER, 1915.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Laird Smith.
Mr. Fenton,	

Charles Robert Scrivener, Director of Commonwealth Lands and Surveys, sworn and examined.

188. *To the Chairman.*—I have been connected with the Federal Capital from its inception in 1901. Before any competition took place an Advisory Board was appointed, consisting of Colonel Miller, Colonel Owen, Colonel Vernon, and myself. I had already selected an area within which I thought the city should be, and the Board confirmed that view, but there were divergent views as to where the site should be. Ultimately we arrived at a unanimous decision that the city proper should lie under the Narrabunda Range, with Parliament House and the Capitol on a spur from that range which rises from 100 to 700 feet above the general level, falling as it approaches the river. The principal reasons for putting the city on the eastern side of the range was to obtain shelter from the strong westerly gales. This had considerable weight with the Board. One member had a strong inclination to put it down towards Yarrolumla, on the western side, but he had been very little in the country, and, after making frequent visits, he was pleased that he had not got his way, because his site was too exposed and extremely difficult to screen, even by extensive tree planting. The selected site had other advantages, the idea being that the railway would first come from Queanbeyan, which would give direct communication with Sydney and indirectly with Melbourne, without the heavy cost of construction of a large bridge over the Molonglo. South of the city, the Narrabunda Range also provided large areas of very fine country for suburban occupation. I marked out the square on the map for the city site. Long before there was any Advisory Board or any design submitted I recommended the construction of a lake at the 1,825-ft. level. Ultimately that level was adopted by the officers who drew the departmental plan, in which the lake follows the contour of the country with very slight modifications. I suggested the 1,825-ft. contour because it gave a considerable area of water of beautiful form, and a minimum depth of 7 feet, at a minimum expense for earthworks. I made sections at the time right across the country at intervals, and showed the sections and the amount of cutting and filling right through, in order to get that minimum depth. My estimate of the cost for the earthworks, without concrete walls, and following the natural contour, did not exceed £100,000. My plan would give, roughly, 2,000 acres of water, with an average depth of 20 feet. I doubt if there is any record in the office of my estimate, which was simply made for consideration of the Board appointed by the Minister. We were asked by the Minister to meet Mr. Griffin, and see if we could come to a common agreement with him regarding his plan, which we could not, one of the points of contention being the form of the lake. I regard the artificial form as much less beautiful than the natural contour. It gets rid of the bays and indentations, which are the principal charm of Sydney Harbor. It also entails very heavy cutting. The plan now before the Committee is a considerable modification of that submitted by Mr. Griffin to us originally. In that the promontory now shown on the segmental basin was to have been a part of the lake, entailing a cut of 50 feet. He has reduced the cutting very much, but his plan is still open to the general objection of formality. That would not matter very much if it were a fish pond, but it is a considerable lake. In the original plan the difference of level between the upper and lower lake was only 10 feet, leaving the upper lake to run out very shallow. Over a considerable area of that lake the ground level is 1,840 feet, giving a depth of only 5 feet. The evaporation in a shallow lake of that kind would be enormous, and it would be necessary to ascertain if there was an ample supply of water to keep it going. If there was any doubt about the supply of water, I should confine myself to the lakes at the 1,825-ft. level, modified slightly as shown on the departmental plan. I would not adopt the 1,825-ft. level without any artificial embankments or cutting away, but it is the cheapest level on which to construct the lakes, and will give a finer effect than any formal scheme. Very few of the ornamental waters in other cities, plans of which were before the Board, do anything but follow the natural contour.

189. *To Mr. Laird Smith.*—I should have expected the upper dam to cause most trouble in regard to holding water. I do not think there would be much trouble in impounding the water for the lower lake, because there the rock shows on both sides of the river and in the bed. Professor David thought there would be no difficulty in getting a rock foundation, but that it would be very expensive. We cannot say that there will be no leakage at any other part, but we have a gauge at Yarrolumla and another on the Queanbeyan, miles up, and from the difference between the discharges at the two points it is possible to arrive at a conclusion as to the seepage. I do not think there will be much seepage on the lower part, because, on one occasion, when we wanted a temporary water supply, we thought we could get water filtering through from the river by sinking on the flat. We did strike water, but found that it was not river water at all; only an isolated water-hole. Until we got within a chain of the river there was no seepage at all. That was on the flat near Acton, north of the river. There is sure to be some trouble from silting. On the crossing of the Molonglo, between the church and the administrative building, after a fresh, a little below bank high, I have seen the silt in the cutting deeper than the horses' knees. The more extensive the area the more silt you are likely to have, because the velocity of the water is lower. A dam on the Molonglo would hold up a certain amount, but the cause of the silt is the ring-barking of the timber and fairly heavy stocking by sheep. In 1830 the Molonglo had no steep banks. It was clear, running water, with large water-holes at intervals. It will not be costly to keep the lakes clear of silt. My original proposal included in the Federal Territory the whole of the watershed of the Molonglo and Queanbeyan Rivers, the object being to allow the Commonwealth to reafforest the valleys.

190. *To Mr. Gregory.*—The Narrabunda Range would be a considerable screen from the westerly wind to settlement on the south side of the Molonglo River. We marked about 10 square miles on the plan with the idea of having that area prepared for city purposes. We approved of one lake only, with a dam at Yarrolumla. We proposed to have Parliament House facing north-east, directly towards Ainslie. The Board, when asked if they regarded any of the designs as suitable for adoption, said "No," but that the dominating feature in Mr. Griffin's plan, including the location of Parliament House and the Capitol, with their radiating avenues, was a very fine idea. We adopted them, but that was the only feature adopted from any plan submitted by any competitor. It was intended that ultimately there should be settlement on the north. A University, covering about 400 acres, was placed on Mount Vernon, and a hospital practically where the administrative centre now is at Acton. The whole area between the University and the river was for parks and gardens. The northern country would be more wind-swept. I have been on Mount Vernon when it was very difficult to stand upright. Afforestation will help considerably. The range stops at the river, and there is a gap to the north through which the wind sweeps. Business will start on the south-east, near the present power-house, and round about the Capitol hill, because the railway goes through to the north. The country under Black Mountain is sheltered, but that is a long way from the civic centre as shown on Mr. Griffin's plan. If you get far east from the Narrabunda Range you feel the wind. The siltage in the river will be large, but not sufficient to create a nuisance. The lake will have to be dredged. The Board told Mr. Griffin that a geometrical form for that part of the segmental lake facing Parliament House would have a fine effect. I do not think that the cost of making that part will be great. From the records for some years I should not expect seepage to occur, but I have not much knowledge of the nature of the country. If the gaugings do not show much loss, it is obvious that there is not much seepage. Every little water-hole in that part holds water well. I am against placing the civic centre to the north on Mount Vernon. Before you have a business centre to the north you must build a bridge. You have the railway to the south-east, and it would be difficult and inconvenient to put the business centre to the north of the river. My first idea would be to make the city attractive. If the Government are really going on with the Capital they should get the people to take some interest in it. They take very little at present. The lake undoubtedly will be a great attraction. Considering the generally dry character of the climate, I approve of having an extensive sheet of water there. I would limit the lakes to an area which I was absolutely sure I could maintain at or near a uniform level. I did not recommend the 1,825-ft. level because it was the level of the highest known flood, but for the reason I stated earlier to the Chairman. The fact that it roughly coincides with the level of the flood of 1891 makes the proposition easier to handle. The Board adopted a resolution that no buildings should be erected below the 1,835 or 1,840 level. I still recommend that idea, and would keep the remaining area for gardens and roadways. So far as the contour of the country will allow, I approve of an open park space right round the edges of the water, with drives at varying distances from the water level. I would have winding roads also following the natural contour. I would approve only of formal lines for the foreshores where they were essential for landing or other special purposes. I do not fear much erosion of the banks through wave action. Any difficulty of that kind could be overcome by pitching. The lakes in the centre of the city would not impede settlement, because the bridges have to be at the 1,835 or 1,840-ft. level, lakes or no lakes. Instead of being the cause of any serious division of the city, the lakes will be an attraction, because, in places, they will be nearly a mile wide. The matter would be one for the convenience of the people themselves. The first thing to build is the dam. This implies a regulating weir on the Queanbeyan to prevent a fluctuating level in the lakes. This work must be undertaken before there is very much settlement. The lakes could then be formed, and the banks improved as the needs of the city require.

191. *To Senator Lynch.*—If enough water is available to maintain a larger lake area the question of making the upper lake would be one of expense. Another bank or weir would be required about three-quarters of a mile long, and passing for the greater part of its length over ground which has been gradually formed by silt deposition. You would have to sink some distance to reach solid foundations. The embankment would be better for a concrete core. It would be subject to wave action on both sides, but it might be possible to construct it without a concrete core. The upper lake would also waste a large amount of good land, and I would cut it out. If the railway is to go across at that point it must go over either on trestles or on a bank. If you decide on a bank it will facilitate the making of a weir for the water. The upper lake could be confined to narrower limits than those marked on the plan, but you must first determine whether you have water enough to supply it. In itself, there is no particular objection to it.

192. *To Mr. Fenton.*—In any case, there would be some water to the south of the embankment. The city would be well supplied with lake surface without the eastern lake. The flood waters would gradually fill the upper weirs, and, in the meantime, the water could be allowed to escape from the lake at the other end. I do not think it would be necessary to dam the Molonglo, but you certainly require to dam the Queanbeyan. If you had both it would help a great deal to modify flood effects. Pretty big syphons would be required to take the water from the upper to the lower lakes. It is not at all uncommon to have from 10 to 20 feet rise in the Molonglo, which gives a very large body of water to handle. The flow in the Molonglo itself at the Capital should be very much higher than that of the Cotter from the catchment area, but it has not the same proportions of run-off. The Cotter catchment gives more water on a given area than the Molonglo and Queanbeyan.

193. *To Senator Story.*—The materials to be excavated from the bed of the lakes would have to be taken out before the water was let in. A good deal must be done before the water is put in. You can get on a long way with the weir without creating the lakes. With sluices open in the weir the work could still go on.

194. *To Senator Keating.*—The upper lake, if constructed, should be kept at the 1,845-ft. level,

otherwise, on the slopes, you would have objectionable mud deposits. If the Molonglo rises the run-off must be regulated to equal the amount of water coming in. To raise one of these lakes 1 foot would take an enormous quantity of water. Any syphon that I can imagine would be absolutely useless for the purpose of passing the flood water from the 1,845-ft. level to the 1,825-ft. level. It would be absolutely necessary to have a spill-way. I have seen some of the Victorian artificial lakes, such as Wendouree. They have had trouble there with vegetation, but it is shallow. These would hardly be comparable, because you can have a constant flow of water through them. There will be very little vegetable growth if the minimum depth is 7 feet. It is very unlikely that the water hyacinth will be introduced to Canberra, seeing the knowledge that people of New South Wales have of its effect in the northern rivers. There should not be any great difficulty in keeping the artificial waters free from noxious growth. There will be a large area of settlement, and the lake area, although relatively large, is not out of the way to handle.

(Taken at Melbourne.)

THURSDAY, 2ND MARCH, 1916.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Thomas Hill, Engineer, Department of Home Affairs, recalled and further examined.

195. *To the Chairman.*—In accordance with the instruction of the Committee, I have prepared an estimate of the cost of earthworks involved in basins 1, 2, and 3, as shown on the schemated plan. Using that plan and the levels thereon, I have prepared sections at different points numbered 1 to 54, and at such intervals as would make possible a reasonable estimate of the quantity of earthworks, cuttings, and protection of banks against erosions involved in the proposal of Mr. Griffin. On these sections the excavations are shown in pink and the fillings in green. My estimate of quantities is:—Filling, 5,434,720 cubic yards; cutting, 950,413 cubic yards; and filling of approaches to bridges, approximately 362,446 cubic yards. I have assessed the filling at 1s. 2d. per cubic yard, equal to £330,000, including forming, which allows for making good the natural settlement of the earth, obtaining the material and putting it into position, and making the work ready for use The cutting I have estimated at 1s. 6d. per cubic yard, and I have marked on the plan the nature of the strata to be met with at certain sections where the cutting will take place. The cost of cutting works out at £75,000, and the filling of approaches to bridges, £27,000 I then provided for the protection of the banks on the area shown, and allowed for concrete or stone pitching similar to that used on the Yarra Bank near Melbourne. I have allowed 8s 6d per square yard for pitching approximately 5 feet above and below water level. Of course, in certain places the pitching would require to be taken right to the bottom in order to get a natural bed. The quantity works out at a little less than 600,000 square feet, which, at 8s. 6d. per square yard, represents £30,000. That brings the estimated total cost of the earthworks involved in basins 1, 2, and 3, and portion of basin 4, to £462,000. The Committee will remember that when they were at Yarrolumla in November last, I suggested that before submitting to them sections and plans for a modification of the design, I should place my proposal before Mr. Griffin, and see if he concurred. I accordingly interviewed Mr. Griffin, and subsequently he returned the plan to me showing amendments by cutting out a good deal of the excavations on the north side of basin No. 1, and allowing the water level to follow practically the natural surface, as shown by the blue line on the plan. The southern boundary of that basin was also pulled south some 150 feet for nearly half of its circumference in order to avoid a lot of filling. By so doing we reached the 1,825 contour, whereas previously the basin was shown on about the 1,800 feet level. Basin No. 2, section 14, the level of which varies between 1,820 and 1,825, has now been amended by the introduction of water, where previously filling had been provided for. Also, near section 28, in basin 3, the perimeter of the circle on the southern end has been brought 600 feet to the south. Again, the natural contour has been adopted, and the bridge slightly removed in location. Thus the water area of the Molonglo is increased, and a fair amount of filling is saved. In basin No. 4, a good deal of the curved line shown on the plan has been amended so as to follow more closely the natural surface. In conjunction with Mr. Griffin, I have prepared for the Committee a list showing in detail all the figures involved in these amended sections. Reference to the original sections will disclose in darker red and darker green the amendment which has now been submitted by Mr. Griffin. In cross section No. 1 the levels of the finished bank have been raised from 1,830 to 1,839.6, and in No. 2 from 1,830 to 1853. Cross section 9 has also been amended, thus raising the level of portion from 1,830 to 1,840. I now submit to the Committee amended sections kindly supplied by Mr. Griffin, and the quantities I am about to state are based on those sections. In No. 1 basin the filling will be 897,371 cubic yards, and the excavation 291,703 cubic yards; No. 2 basin, filling 913,917 cubic yards, excavation 303,685 cubic yards; basins 3 and 4, filling 1,648,313 cubic yards; totals, filling, 3,459,601 cubic yards; excavation, 595,388 cubic yards. I have omitted from those figures the railway bank and dam, but they still include the approaches to the bridges up to the abutments. I have estimated £45,000 for the excavation at 1s. 6d. per yard, and £200,000 for the filling at 1s. 2d. per yard. My estimate for pitching is the same as for the previous scheme, namely, £30,000, and for filling in approaches to bridges, £25,000. The total estimated cost of the amended work is approximately £300,000, as against £462,000. It will be seen that the excavation represents only about one-seventh of the work to be done, and the work of removing or using the spoil will not affect the total to the extent of more than 1d. per yard. On the other hand, I think that that price will be required over and above the estimate for fillings, the leads being unsuitable. It is not as if the materials were being deposited alongside the excavation; it must be taken to the place where it can be used for filling at that time. Some of it may have to run to spoil. I may say that the estimate for filling is based on the material being obtained from inside the basin, with a view to improving the basin as much as possible, and also because such material is the most suitable. It is calculated at the usual rate for excavating with suitable machinery, namely, 4d. to win the material and deliver it into trucks; the balance of the cost represents distribution, running the material to the site, forming, sloping, making good substances, and generally placing the soil in position I have calculated on the use of steam excavators, and the work proceeding steadily and continuously. In regard to the estimate of 1s. 2d. for handling the material after it has been delivered into trucks, it must be borne in mind that most of the filling is 100 feet wide on the surface. In many cases, also, it will be necessary to go a considerable distance in order to get the material. At the southern end of basin No. 1, for instance, there is a bank 100 feet wide, and to get the filling it is necessary to go 200, 300, and 400 feet. The bank has to be raised by from 5 feet to 20 feet It will not be advisable to take the material too close to the point at which the banks are being made, because the sloping difficulties will be increased, and as filling follows, in many places, the edge of the river, it may be taken for granted that to win it the average length of lead will be quite 200 feet. I am aware of certain excavating machines which are making channels at the present time, and on uniform sections are delivering the material 100 feet away for a total cost of 3½d. to 4d. per cubic yard. My estimate of 4d. is based on much the same conditions. After that the material has to be spread, but even here the conditions are not so favorable for that class of work. In that case the excavating is in a uniform channel running in straight lines, and the material is being delivered to spoil on the other side. At Canberra, the material has to be raised in the manner shown by the coloured sections, and in the excavation of material from the bed of the river the work will be liable to damage by flood and to delay.

196. *To Senator Story.*—The work for which I have allowed 8s. 6d. per square yard on the sea wall will be either concrete or stone pitches. So far, we have not been successful in finding suitable stone for pitches, so I am estimating concrete pitches 2 feet long, 1 foot wide, and 9 inches thick, just laid on the sand with a breaking joint. The estimate for the earthworks takes into account the wages paid at Canberra, holidays, payment for wet weather, maintenance of the excavating plant, and allowance for damages by flood. I have reckoned the interest and maintenance expenses in connexion with the plant at 20 per cent per annum.

197. *To Mr. Sampson.*—With the pitching I am suggesting, this work should be perfectly practicable and safe.

198. *To Mr. Finlayson.*—The figures show that the alteration in the line of the lakes so as to follow more closely the natural contour reduces the cost to the extent of £160,000 In basin No 3 the new lines are a distinct improvement, in my opinion. I believe they are on the lines suggested by the Director-General of Works to improve the waterway of the Molonglo, and they obviate a large amount of filling. In No. 4 basin also I consider the natural lines are an improvement on the formal treatment previously proposed. I do not regard basin No. 2 as so good, it will require more treatment. In regard to basin No. 1, the suggestion to adopt the natural surface on the northern end is altering the plan considerably, and doing away with the circular effect of the basin to a large degree. I think that is an improvement The adherence to the natural contours would not prevent the circular effect being obtained at some subsequent time, but I rather prefer the natural contours to the formal lines previously proposed. These alterations have been arrived at harmoniously by consultation with Mr. Griffin I think we have arrived nearer to a satisfactory scheme, but I would prefer to see the natural surface followed to an even greater extent. For instance, I would prefer that to be done on the whole of the north bank of No. 3 basin; on the southern side the formal treatment would still be adopted Also in basin No. 2, the formal treatment of the water should be retained, but in basin No 1 the natural contour line could be followed with advantage on the south side. I believe such alterations would mean a very considerable economy. The adoption of this suggestion would not prevent a subsequent reversion to the lines shown on the schematic plan, and that plan would be just as practicable in future, allowing, of course, for the fact that the lake would require to be emptied for a considerable time while the works were being carried out We have reckoned on getting most of the filling to carry out the formal treatment from the lake bed, and I do not think that could be done very well if the lake were full I have not had an opportunity of investigating Mr Griffin's evidence in regard to utilizing the spoil from the formation of avenues for filling up the approaches to bridges, but I understand that, in the Parliament Terrace, there will be 600,000 cubic yards of filling. Any spoil from the formation of the avenue will be required for that terrace, and there will not be much left for the approaches to bridges. I have estimated the earthworks for the approaches to the four bridges at £25,000. I fancy, however, that Mr. Griffin must have been reckoning for only two of the bridges. In any case, I think it would cost more to fetch material from the avenues to put in the abutments than to get the material from the river bank. I should hesitate to take the material from the avenue leading to the south-west to the approach of either No. 1 or No. 2 bridge, because the distance is over a mile. I do not know that there would be much economy in carrying out those two works simultaneously; the avenues will not have much effect on the approaches to the bridges. Most of the material for the formation of the boulevard round the lake will be taken from the lake bed. Once the making of these banks were commenced with machinery, it would pay to get the material from the bed of the lake and work steadily along. Some advantage might be taken of the material from the cutting, but investigation would be necessary as to whether the carrying of the material to the point at which it would be wanted would not make the filling more costly than if the material were taken from the lake. It certainly would not pay to carry the material three-quarters of a mile.

199. *To the Chairman.*—I am not reckoning on any concrete work for the formation of the lake banks. I am proposing to merely pitch the natural surface as a protection against the action of the waves.

200 *To Mr Gregory.*—I have given the Committee the amount of filling required for the embankments, but if the excavated material is run to the fillings a deduction from the total can be made accordingly. It must not be assumed that some of the filling will cost 2s 8d. per cubic yard. The winning of the filling and the putting of it into place will cost 1s. 2d. per cubic yard, and excavation and disposal of the material, not necessarily in the filling, will cost 1s. 6d. per yard. The 600,000 yards of excavation might be utilized on the bridge abutments, or in the railway bank.

That excavation would be required in order to obtain the levels shown on the sections, even if the material did not go into the embankment. As can be seen by reference to section 13, this filling is work of a different character from the ordinary disposition of soil alongside a channel. The banks have to be raised a certain height, and then formed. A great portion of the bank is in circular form, and that fact increases the cost of placing the earth in position. It will not be possible to put the material into the bank indiscriminately. The material will require a certain amount of selection. It would not do to put very fine sandy material into the front of the slope near the water. At such a place we shall require a layer of gravel and sand on which to place the pitchers in order to prevent the leakage of sand from behind. Generally speaking, clayey material would be placed in the front of the bank, and fine material at the back. The material could not be taken from the lake and thrown into place without some selection. It would be necessary to specify that work accordingly. We shall not get a great amount of gravel from the excavation. There is a large gravel bed at about section 7 in lake No 1, and a moderate-sized one about section 20 in lake 3. Between those points the lake bed is all alluvium. Recently we investigated a mile of the Molonglo for gravel for the Small Arms Factory, and, as a result, we found that it would be necessary to take gravel from the present pit near the power house. The pitching will be required in basins 1, 2 and 3, and the eastern portion of basin 4, and I have reckoned on the pitching being 5 feet above and 5 feet below the water along the whole extent. The points where there is hard rock which would resist wave action are very few. I assume that when the lakes are filled the maximum rise and fall of water will be from 3 feet above the 1,825 feet level to 3 feet below, and during floods, unless there is a quick operation of the dams, we shall get a slope on the water surface of the lakes of from 5 feet below to 5 feet above the normal water level. We have agreed on a 2 to 1 slope for the lake banks. Concrete pitchers made of river gravel will be cheaper than granite Researches have not disclosed any granite near the site which would make a decent pitcher With the faces roughened, the joints left open, and sods inserted between the pitchers, the wall would look very well. I think the average distance of the excavation from the point where the earth would be received would be somethine like 200 feet. I have closely studied the conditions, and have arrived at the conclusion that at least 1s 2d per yard must be allowed for distributing the material from the excavation. That figure is based on the use of excavating machines for winning the material, and distribution by trucks on rails. We have worked out the cost of both horse and electric traction. I do not think that the spoil from the avenue formation could be utilized on the approaches to the bridges because of the length of the lead. The distance which the spoil has to be carried is a dominating consideration in estimating the cost of work of this character Other important considerations are the nature of the material and the character of the place at which it is to be won My estimate of 1s 6d for excavation includes the cost of laying the material where it is required. I kept the estimate at as low a figure as possible All the information upon which the estimate is based is to be found on the plans and sections in the possession of the Committee, but the officers of the Department would be glad to assist any outside expert whom the Committee might ask to look into these estimates.

201. *To Mr. Finlayson.*—The cost of having a formal perpendicular bank fronting the boulevard would be considerable, because the walls in places would be 20 feet and 30 feet high, and they would require substantial foundations. I may explain to the Committee that all the quantities which I have given them were prepared by one officer and checked by another. They are based on a plan scaled at 400 feet to the inch, and there were no definite pegs for the guidance of the officers such as they would have in working up a contract. Their calculations had to be made from the contours, and represent a very fair approximation. No doubt, however, economies could be made by a careful laying out.

202. *To Senator Story.*—The proposed modification of basin No. 1 will effect an economy of £31,750. Of that saving £28,250 is represented by cutting, and the balance by alterations in earthworks. In that basin there is 1,500,000 cubic yards of filling at 1s. 2d., and 291,000 cubic yards of excavation at 1s. 6d. per cubic yard. The modification of the design reduces the cost of the earthworks from £110.000 to about £80,000.

203 *To Senator Lynch.*—In my opinion a sheet of water following the natural contour of the country would be more beautiful than the same water confined within a formal plan. Of course, I would not adhere rigidly to the flood line. In some places the shore line could be improved, just as the banks of the Yarra have been improved. My design would be influenced by the nature of the country encountered, and by the depth of water Where adherence to the natural surface would result in flat shoals, I should be inclined to contract the shore line a little in order to get a better depth of water. I should aim at a minimum depth of about 5 feet of water, and to that end would either contract the banks or deepen the bed Rather than go to the expense of removing rock in order to secure a formal plan, I would prefer the irregularity in the shore line to remain for the time being Then if in years to come the formal design were desired, and the money were available, the rock could be removed without difficulty, because it would be above the water line. The adoption of my proposal would slightly increase the cost of road making along the shores, but I would expect to effect very considerable economies by cutting out the mathematical formation Such economies would more than compensate for the increased cost of road-making. The modification of the lake design does not materially alter the water area It is the same in each plan to within about one-tenth of a square mile. I should like a minimum depth of water of from 2 to 5 feet, and wherever the contours rise sharply I should adhere to the natural surfaces.

204. *To Senator Lynch.*—I propose to retain the formal treatment on the south side of basin No. 2 fronting Parliament Terrace. It might be sharpened a little to take advantage of the natural features.

205 *To Mr Sampson.*—I do not think we need fear that by utilizing the natural lines the basins would protrude far into the ground on each side. There is a sufficient reserve of ground on both sides of the water to allow of the proposed departure from the formal scheme.

206. *To Mr. Fenton.*—The estimate of expenditure for the earthworks includes the cost of taking the plant to Canberra and erecting it, and also an allowance of 20 per cent. to cover interest, maintenance, and depreciation. I am of opinion that the 1 825 feet level allows of a scheme which gives a uniform depth of water, and conforms better to

the nature of the country than would a scheme carried out at the 1,820 feet level. I am not in favour of further contracting the water surface.

207. *To Senator Keating.*—The adoption of the 1,825 feet level contour would mean a considerable departure from the circular form of the basin. My idea is that the face should be pitched wherever there are formed embankments that are subject to erosion. I have calculated the pitching at just under 600,000 square feet, and it would extend for, roughly, 9 miles. Practically the whole of the shore line of the circular basin, the segmentary basin, and the third basin would be faced. If the natural formation of the lake were followed, the facing would be less.

PROPOSED WEIR AT YARROLUMLA.

208. *To the Chairman.*—Early consideration was given by the officers of the Department to the selection of a locality for the construction of such a dam as would be necessary for the formation of a lake at the 1,825 feet level. Trial sections of the river from a point near Black Mountain down to Yarrolumla were made. Shafts and bores were sunk, and the investigation showed that, at the foot of Black Mountain, the rock for mation was not economical, being some 20 feet below the surface. Also the rock kept very low on both sides, not reaching the 1,825 feet level for some distance on each bank. This would have necessitated the use of a large amount of material to form a dam. The most economical section was found to be directly opposite Yarrolumla Homestead. I have prepared a proposal and an estimate for such a dam as I think would be necessary at that spot. The foundations as disclosed by the bores would be on shale, and would be solid throughout. The shale approaches to within 15 feet of the surface on the south bank, and outcrops on the north bank. The weir raises the water level to 1,825 feet. The depth from the raised still water surface to the river bed is 60 feet. The weir is 900 feet in length over all. The body of the work is cement concrete, to be built as a monolithic structure, and faced on the down stream side with granite. The waterway in the upper portion of the weir will be occupied by twenty flood gates, each having a clear opening of 20 feet horizontal by 10 feet vertical. They will be worked by lowering into a chamber in the body of the weir, and will be regulated to maintain the water level of 1,825. The gate chambers will be lined with iron, and the front of the wall will be reinforced to take the water pressure, irrespective of the concrete envelope. Each gate will weigh about 7 tons, and will be raised by electric gearing. Hand-gearing also will be provided as an emergency. A gangway carried on cast-iron columns runs the whole length of the flood gates. The clear area of waterway up to the bridge girders would be about 6,800 square feet. With the gates fully lowered, and the surface of the water above the weir at the 1,825 feet level, a discharge of 2,274,000 cubic feet per minute would be obtained. The weir is estimated to cost £107,800, made up as follows:—Preliminary and river protection, £10,000; 25,000 cubic yards of concrete at £2, £50,000; reinforcing, £2,000; granite facing, 20,000 square feet at 30s., £30,000; rendering 8,000 square yards at 2s. 6d., £1,000; twenty gates and chambers, at £500, £10,000; gearing, £3,000; and gangway and columns, £1,800. The reasons for the proposal for the gates are as follows:—Should a flood be recorded as coming down the Molonglo, any rise in the level of the water inside the city area could be prevented by immediately lowering the gates and dropping the level of the weir, thus regulating the flood level so that it would not rise above 1,825 feet. Without such a provision it might happen in a big flood that for an hour or two there would be an increase in the height of the water to the extent of 5 feet between the Yarrolumla end and the top of the weir. The provision that I am suggesting will be sufficient to avoid any increase above the 1,825 feet level over the whole length of the lake. Another consideration is that if this 1,825 feet lake be formed, there will be a considerable deposit of mud in the upper portion, and we shall have to face the problem of its economical removal. The gates will enable the level of the lake to be lowered 10 feet at its deep end, and the mud easily removed either by stirring it and passing it on, or by removing it, and using it in the surrounding locality. In the event of it being desired to further reduce the level of the lake I have provided through the body of the weir three gateways of pipes of 36 inch diameter, which can also be used for flushing through at any time The maximum average discharge of the Molonglo may be estimated at 3,000,000 cubic feet per minute That estimate is based on a comparison with other watersheds, upon observation of the Molonglo and upon statistics in regard to a recent flood there That flood took place on the 20th September, 1915 At Acton Bridge, the water reached a level of 1,811 feet, the river bed is approximately 1,797 feet Near the foot of Black Mountain the level was 1,798 feet, and at a point opposite the Military College it was 1 831 feet During the flood instruments were set up, and observations of its velocity were taken. From these it was gauged that the maximum discharge was 1,500,000 cubic feet per minute The flood reached the 1.181 feet level at a point where we knew it has reached the 1 825 feet level, and there is little reason to doubt that, if there had been snow on the watershed of the Molonglo, coupled with that heavy rainfall, the flood would have again reached the 1,825 feet record. Taking a weir crest 600 feet long, where the depth over the crest equals 5 feet, and the velocity of approach equals another 1 33, the discharge would be 2,200,980 cubic feet per minute. To discharge 3,000,000 gallons per minute the crest requires to be 900 feet in length and 5 feet deep Another method of calculation is by comparison with other watersheds of known capacity The Loddon River weir, near Laanecoorie, with a drainage area of 1,590 square miles, discharged 4.4 million cubic feet per minute in the flood that took place on the 20th September, 1909. It has not such a steep watershed as the Molonglo, nor is it subject to heavy snow, but it is the nearest one comparable with the Molonglo. In calculating from the rainfall on the area, the discharge depends on the following —(1) The length of time required for the water from the most remote part of the watershed to reach the point of discharge; (2) the maximum rate of rainfall of a duration equal to this time; (3) the percentage flowing off Smaller watersheds will have a comparatively higher percentage of run-off, and a more rapid rate of discharge. The Boston Waterworks, where the watershed areas vary from 20 to 75 square miles, allow in their waste weirs for a flood discharge of 161 cubic feet per second per square mile, reckoned with a rainfall of 6 inches in twenty-four hours. In the Johnstown flood disaster, where the total rainfall was much heavier, two-thirds of an inch per hour falling for several hours, and the rain being continuous for forty-eight hours, the flood discharge was calculated to be 215 cubic feet per

second per square mile. In watershed areas of 500 square miles and upwards, it is a most exceptional thing to find any flood discharge greater than 70 cubic feet per second per mile. Taking as an instance the Molonglo watershed as 700 square miles, and the heaviest rainfall as 6 inches in twenty-four hours, 4 inches falling, say, in six hours, the flood discharge would take about twenty-four hours to reach its maximum point at Canberra, and would approximate to 70 cubic feet per second per square mile, making a discharge of 2,940,000 cubic feet per minute. Therefore, having regard to known discharges of other watersheds, and the figures we have relating to floods on the Molonglo, it appears as if some provision for a maximum flood of 3,000,000 cubic feet per minute is necessary. The scheme I have submitted makes that provision, and would prevent the lake level rising inside the city area.

209. *To Senator Keating.*—The weir would be 60 feet in width at the foot, and would have a height to the 1,825 feet level of about 60 feet.

210. *To the Chairman.*—Before there can be any lakes this weir must be constructed.

211. *To Mr. Finlayson.*—The regulating weir at Queanbeyan would be necessary in addition to this proposal. The Queanbeyan weir is for the purpose of counteracting the minimum flows, and providing water to keep the lake full. It will also assist in regulating the floods, but on occasions the dam will be full, and the flood will pass over the top. The Queanbeyan proposition is for an overflow weir, the water coming over the top. In this case, gates are provided to let the water through. The Queanbeyan proposition is imperative for storage, and will be of assistance in regulating floods, but by no means could flood gates at Yarrolumla be dispensed with by any provision made at Queanbeyan. A series of fifty 6-ft. sluices in the body of the weir would release the water in sufficient quantity to counteract flood, but the difficulty with such sluices is that when anything goes wrong with them, they must be repaired through another valve chamber. Flood gates are cheaper and much safer. I contend that they will meet any emergency, and yet are not an excessive provision. The granite facing of the weir would be more enduring than a concrete facing. It must be borne in mind that there will be twenty streams of water flowing through the gates, and hitting the wall at some point. Then there will be logs and other *débris* coming down stream, and it might do damage. I have provided for 20,000 square feet of granite facing at 30s. per foot. I am convinced that the Queanbeyan dam, in conjunction with this dam at Yarrolumla, would be sufficient to create a lake at the 1,825 level, and provide against all contingencies of flood or drought. A flood which happened a few days ago rose to nearly that level within a few hours. Although the rain was not at Acton, but nearly all fell at Queanbeyan, the water rose in three hours to within a few feet of the level I mentioned.

212. *To Senator Keating.*—The facing of the weir with granite would be carried out by letting big stones into the concrete, the ends of them being shaped and formed to conform to the sweep of the back of the weir. The work would have a masonry appearance, stone being laid upon stone with cement. I have taken into consideration the possibility of the lakes becoming silted up, but I am of opinion that the floods would afford an opportunity of moving away some of the mud and silt which had accumulated. I do not regard the deposition of mud in the lakes as a serious problem. My proposal makes provision for overcoming the mud accumulation.

213. *To Senator Lynch.*—The advantage of lowering the flood gates into chambers in the weir instead of raising them is that a clear way is made for logs and other big *débris* which the flood may bring down. I consider that the existence of a compensating dam at Queanbeyan would not obviate the necessity for these flood gates. It is difficult to calculate to what extent the height of the water on the lakes would be raised in flood time if the gates were not there to regulate the levels. With a known section of channel and a known slope of water, one can compute the head required to discharge a certain quantity of water, but with an irregular channel of water widening out into broad sheets, an estimate can be arrived at only by comparison with other water channels, and by working out different sections along the river. I have investigated the matter closely, and am of opinion that without these gates it would be possible during maximum floods for the water to rise at least 5 feet above normal. In a big known flood at a point where the lakes will run out the water reached the 1,827-ft. level. Towards Yarrolumla, it was at the 1,815-ft. level. So that there was a difference of 12 feet between levels that would approximate closely to the lake levels. I think it is quite possible to get a rise of 5 feet from one end of the dam to the far end of the 1,825-ft. level. Much depends upon the treatment of the banks.

(Taken at Melbourne.)

FRIDAY, 3RD MARCH, 1916.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Thomas Hill, Engineer, Department Home Affairs, recalled, and further examined.

214. *To Mr. Gregory.*—It has always been intended to build a concrete dam. I have no knowledge of any proposal to erect an earthen dam at Yarrolumla. The estimate of £75,000 was made some four or five years ago before borings were taken, and before the actual surveys were carried out, but it was based on a concrete dam. No estimate has been framed as to what an earthen dam would cost; such a dam has never been considered in any shape or form. I do not know whether Mr. Griffin proposed to have one at this spot. I have never heard what his proposal was. I cannot see how an earthen dam, however well rubbled, would prove effective for such a large body of water. In any case, it would need to be a composite dam. The gates would have to be carried on concrete foundations. I could not imagine anything else between the gates and the rock. Small economies might be effected by putting in the wings with an earthen section. It would not save much. By the time wing walls were built to back up the end of the earthen bank as much concrete would be used as would carry the dam out on the wings on the proper level in ordinary concrete sections. I do not think that

an earthen dam would be as safe as a concrete structure. I remember the weir on the Campaspe River, at Rochester. The river outflanked it, and washed away the structure. I do not see how an earthen section can be built to that level on the Molonglo, and give safety. If the gates were not carried to the rock in concrete, it would be necessary to cut a by-wash on one of the flanks with a capacity of at least 2,000,000 cubic feet per minute. I am inclined to think that an earthen bank with a sufficient by-wash, or rendered sufficiently secure in regard to the safety of its ducts, would cost nearly as much as the proposed concrete section. I certainly anticipate the Molonglo coming down with a capacity similar to that of the Campaspe. The conditions are somewhat similar, but the Campaspe passes through very flat country on the lower levels; at Rochester it has twice the watershed area of the Molonglo. I would not care to consider any proposal to build a wooden weir 60 feet high, nor to construct one. I do not think that it would hold. There is nothing like concrete for economically and efficiently retaining water. It is the only safe structure to put down. The chief object in having flood gates is to regulate the level of the lake, to prevent its rising too high when the floods come down, and to enable the height to be kept within reasonable limits. They also serve the object of disposing of the silt. A fluctuation of 10 feet in the lakes would begin to affect the beachings. The maximum flow will raise the height only 5 feet, with an opening 600 feet wide at the gates. If that area of discharge were contracted a higher level would be obtained. A discharge 900 feet wide, with a flow of 3,000,000 gallons, would only raise the water level 5 feet, but I have planned for a discharge 600 feet wide. If that width is contracted to 300 feet the water must be backed up more. I have allowed for a depth of 10 feet in my sluice gates.

215. *To Mr. Sampson.*—The flood of September, 1915, represented 30 feet of water over an area of 3 square miles in three days. An inch over 3 square miles represents 7,000,000 cubic feet, and this quantity of water can be discharged in 3½ minutes. In other words, 7,000,000 gallons would be discharged over the whole lake in 3½ minutes. Five feet of water over an area of 3 square miles represents 364,000,000 cubic feet, so that if you anticipate a flood coming down by lowering the gates 5 feet, you can discharge 364,000,000 cubic feet. But if the water were discharged at the flood rate, flood conditions would be repeated below the weir, that is, by discharging it at the rate of 3,000,000 cubic feet a minute. I have therefore accepted a discharge of 250,000 cubic feet per minute as a reasonable rate which should create no damage. At that rate, the lake would be lowered 2 ft. 6 in. in twelve hours. The floods in the Molonglo generally meet their maximum in twenty-four hours, though, of course, discharges commence before that time. Assuming that the lake is reduced 2 ft. 6 in. in height in twelve hours, at the same time the incoming water has reached a flow of 2,000,000 cubic feet a minute. That would be about the inflow for the first twelve hours. Within the next twelve hours it would be about 3,000,000 cubic feet per minute. But by that time the lake would be down 2 ft. 6 in. in the twelve hours, and would be discharging through the notch at the rate of 2,000,000 cubic feet a minute. However, assuming that the flow of the incoming water rises from 2,000,000 cubic feet per minute to 3,000,000 cubic feet, it will take 240 minutes to reach the 1,825-ft. level. There would be 2,000,000 cubic feet running out through the notch, and there would be 3,000,000 cubic feet coming in, and still it would be 3½ hours before the peak was reached. These figures are based on contingencies that I think may arise, on what I think will be the maximum flood in the Molonglo valley. This height would still give 5 feet to come and go on, a sort of safeguard in case the flood should exceed what we anticipate. Of course, the level might be lowered at a greater rate than 250,000 cubic feet per minute, as the full capacity of the gates would be close on 3,000,000 gallons. If intelligence arrived that a big flood was coming down it might be necessary to utilize the whole capacity of the discharge gates, and thus anticipate its arrival by an hour or two. I have designed the dam to meet the worst conditions for the 1,825-ft. level, allowing for a reserve of 5 feet.

216. *To Mr. Fenton.*—The Goulburn weir dam near Nagamble is built of concrete with granite on the back. Our proposal is almost a replica of that dam. It holds the water back for 14 miles, but the distance back of water is not a factor. The main factor is the head of water. A concrete dam takes up very much less space than an earthen dam. The latter requires slopes of 2 to 1 and 3 to 1. An earthen dam of the height proposed would require a bottom 350 feet wide as against 60 feet in this case.

217. *To Mr. Laird Smith.*—If a breakaway should take place through the construction of a cheap dam, everything down below would be swept away. I would not care to live close to the bank of the Molonglo River below an earthen dam.

218. *To Senator Story.*—Three 3-ft. openings are provided at the bottom of the weir, and they should prove effective for the discharge of silt should the dam be emptied, but I trust rather to the main gates for the general silt removal. I anticipate that the greater part of the silt deposit will be at the top end of the lakes, where there will be a fall of 10 feet over a big extent of ground. By dropping the sluice gates all this mud could be stirred up, and passed right through over the weir through the main gates. The body of water could be moved quickly before the silt would have time to deposit. The smaller openings at the bottom will have a local effect only. I do not think that by the time the water reached the weir some of the heavier silt will have got nearer to the bottom than the top. Most of the deposit of silt will be at the top end of the lakes. By dropping the sluice gates we create such a velocity that the water will be taken through them very quickly, before the silt has time to be deposited. The bottom sluices can be opened at the same time, but I do not suggest that this should be done, because I do not think that doing so will have much effect.

219. *To Mr. Gregory.*—The estimated cost of a concrete weir is 40s. per cubic foot at 10 to 1 in the body, and 5 to 1 on the face, just as was done in the case of the Cotter weir. It will be 3 feet in width on the face, front and back, where it is not protected by granite.

220. *To Mr. Finlayson.*—The granite backing is to protect the weir from damage by *débris* and logs, and from the continuous discharge of a jet of water through the gates impinging on a certain point. These logs, which come from the Molonglo watershed, could be intercepted higher up the stream by a series of piles. A decently constructed bridge with 100-ft. openings, and built well above the flood level would not be injured by logs carried down by a flood, but it would be a good idea to intercept them higher up. The granite blocks would add to the cost of the weir.

The estimate of £107,000 could be reduced by £25,000. The granite could be cut out and replaced by good concrete. If the *débris* could be anticipated by placing piles higher up the stream the granite blocks could be eliminated safely.

221. *To the Chairman.*—Apparently, Mr. Griffin proposes to deal with the surplus water in the higher lake by putting in 6-ft. rectangular syphons, falling vertically about 45 feet, and then running along the ordinary surface with a semi-circular top, for about 250 feet. I think about sixty of these syphons would be required. As there would be about 18,000 feet of 6-ft. concrete piping with a face of about 500 feet in all, there would be about as much concrete work as in a dam, and in not so good a form. The syphon action is not satisfactory. A considerable rise in the level of the water would be necessary to get the water into the pipes, and I think that the screens would become choked, while there would be a tendency through settlement for a vertical pipe 44 feet high to snap with the pressure of water. To sum up, I think that Mr Griffin's proposal to take off the surplus water by a syphonic system would not be efficient, while it would be just as costly as a weir. If the screens become choked, or if anything went wrong causing accumulations of air in the syphons, a flood might surmount the whole structure, and once this happened, the whole thing would simply go. There are no valves controlling the syphons in case of any blockage or syphonic trouble, and in case of a flood there would be no chance of getting at them to repair them, and it would be very difficult to clear the screens without *débris* getting in front of them. It may be said that as they would be 5 feet below the water line, they would not choke, but we find that there is *débris* right to the bottom. It seems to work itself down 10 or 15 feet when it comes in contact with a structure. I would expect the screens to choke. I would certainly advise the Committee to consider the alternative of a weir. It would not cost as much, and would be safer. If anything happened to a structure built on the lines proposed by Mr. Griffin, the whole thing would go. If it were built between the upper lake and the lower with the object of discharging the water from the upper lake quickly into the lower, I would not like to father it.

222 *To Mr Laird Smith* —Mr. Griffin's proposal, speaking from the particulars shown on the plan, does not seem to be sufficiently strong to stand the water pressure.

223 *To the Chairman.*—Mr. Griffin's proposal for the eastern lake discharge would not meet the requirements at Yarrolumla, either economically or safely.

221. *To Senator Lynch.*—The silt trouble will not eventuate for a good many years, and it would not be a good idea to leave certain portions of the eastern part of the lakes below their ultimate level for the purpose of pumping the silt there by means of a suction pump. It would probably pay better to pump it a further distance away where it can be put to use on a sandy area. If we assume that the upper lake will not be constructed for many years, a splendid place for depositing silt would be the area in front of the military college—a back flat on the south side of the Molonglo. Failing that, I would go further up stream for some spot where the silt could be used to improve the ground. In Melbourne, silts are eagerly seized upon by gardeners. In course of time every dam becomes filled with silt, but that length of time is increased by removing the silt or by excavations. But why not put up a structure that will increase the life of the lakes and dams without the need to re-excavate them. Suction pumps are very effective. They work at as low a cost as ½d. a cubic yard.

225. *To the Chairman.*—I do not think that Mr. Griffin's scheme of having a dam with syphon pipes at the lower end of the eastern lake will be sufficiently suitable. Any failure of the syphons would mean that a large body of water would be suddenly released, and might cause considerable damage in the lower lake, because there is a suggested difference of 20 feet between the upper and the lower lake. Furthermore, I think that the cost would be very high, certainly as high as a more durable form of construction, should it be desired to make a dam in that place, treating it as a dam proposition only, and excluding any question of bridges or railway over it. Treating it in such a way, Mr. Griffin's proposal is not suitable enough. Another form could be adopted for the same money that would give stability and strength. The use of an earthen bank without an ample by-wash, simply trusting to syphonic pipes, is very much open to doubt. I prefer a concrete structure with some other method of disposing of the flood waters. In my opinion, it is not the best site for a weir for the purpose of making an upper lake at the 1,845-ft. level. The distance between the 1,845-ft. levels at that point is over 4,000 feet, and the bedrock keeps at 20 feet or more for practically the whole of the width, making it a most uneconomical spot for the erection of a weir. A much more economical point could be obtained about 3,000 feet lower down the stream, where the rock is practically on the surface, and the distance between the 1,845-ft. levels is about 2,000 feet. A weir could be built there suitable for the purpose at about half the cost.

226. *To Mr. Gregory.*—In that case the water would be 5 feet above the floor level of the power house. In any case, Mr. Griffin's proposed weir will be a very costly structure.

227. *To the Chairman.*—The artificial lakes could be constructed without the eastern lake. The absence of an eastern lake would render the railway proposition much cheaper because there would be no need to have a mile of bank waterproof, or put a puddled core into it. The crossing of the Molonglo could be dealt with purely as a railway bridge proposition. The presence of a dam renders it necessary to make provision for the passage of flood waters through the dam structure. The absence of an upper lake would certainly cheapen the railway proposition, and there would still be the ornamental lakes in the city at the 1,825-ft. level. I do not approve of the proposition to have a lake at the 1,845-ft. level, because I am a little doubtful whether, without further storage on the upper regions, we can retain that level successfully, as against the evaporation. I also think that 5½ square miles of water surface would be excessive. It would mean flooding a large area of land without any object in doing so, an area of land similar to other land in the district—good grazing and cultivatable land.

228. *To Mr. Sampson.*—In the absence of the upper lake, I would simply leave the river channel untouched, except that I would put a levée bank on the southern side. There would not be the body of water proposed by Mr. Griffin, but I would allow the 1,825-ft. level to reach to its full extent, though I would confine it to the existing river bank by a levée giving 5 feet of water. On the northern side the bank rises steeply. It would be necessary to run the levée up for 4 or 5 miles

in order to protect the settlers against floods. If a weir were made for the purpose of forming an upper lake the flood water could be taken through gates over the top, while the ordinary flow could pass through discharge pipes at the bottom.

229. *To Mr. Gregory.*—The matter of the quantity of water available has been gone into very carefully in connexion with the evidence given with regard to the Queanbeyan weir. We arrived at the conclusion that there was only sufficient water to insure a supply for the lower 1,825-ft lake, and that we would not be able to maintain an upper 1,845-ft. lake in a series of dry years. An estimate of the cost of Mr. Griffin's combined railway roadway and water regulation dam was framed some months ago, and in evidence given before the Committee on the 19th July, 1915, it was shown that the expenditure would total £381,000.

230. *To Mr. Finlayson.*—If it were decided to take the railway across the Molonglo at that spot, I would carry it on an embankment much similar to Mr. Griffin's proposal until I approached the Molonglo River; then I would have a concrete structure. If there was to be no upper lake, I would not have a puddled core, and there would not be the same need for care in the formation of the bank. An ordinary railway embankment would be sufficient, with slopes of 1½ to 1, as against the 3 to 1 slopes which would be required with 24 feet of water against the embankment. In the latter case the material would have to be carefully selected, laid in layers and rammed. In the absence of the upper lake, using only a plain embankment, the necessity for a concrete dam and regulating gates would be avoided, and the work would be confined simply to the construction of an ordinary railway bridge. Treating the matter purely as a railway proposition, there should be a saving of £200,000. There would be no engineering difficulty in taking the railway across at that spot, but it would not be such an economical situation as the one I have suggested lower down. For one thing, the rock is deeper. The immediate construction of a railway crossing would not prejudice the erection of a weir higher up if later on it were decided to have an eastern lake. There was a proposition to put the dam a little higher than the bridge, sufficiently far away to enable any *débris* flowing over the weir to pass under the railroad bridge. That would simplify matters considerably. A concrete dam would be quite sufficient. Its construction would be a simple matter. There is no possibility of securing a better situation for a dam higher up the river, at least not for some distance up. The 1,845-ft level is very wide, practically to the end of the proposed eastern lake, some 2 or 3 miles up. If the railway embankment were made with a puddled core, so that it would resist water pressure, the slopes could be added to at any time in the future should it be decided to make the eastern lake.

231. *To Mr. Fenton.*—In that way we would have to revert to our original estimate for the earthworks, but not to the full total of £380,000, because the regulating gates would be cut out. A distinctly better and more economical railway crossing could be secured 3,000 feet lower down the river. It would save at least £50,000 as against a crossing at the point shown on the plan. It is doubtful whether, without very big storage up stream, we could make provision to maintain the eastern lake at the 1,845 ft. level. We have recently had a reconnaissance survey on the Molonglo watershed, which shows that dams would be expensive in comparison with the amount of water stored.

232. *To Senator Story.*—If we do not have the eastern lake, and if the railway crosses the river 3,000 feet lower down, there will be no necessity for a huge embankment. Thus a big quantity of earthworks will be avoided. There will be no need for an embankment at the spot marked on the plan unless the lake is provided, and a railway or roadway is built there. To place a weir at the lower end of the basin where a railway crossing can be secured at a very much less cost than the point suggested in Mr Griffin's scheme—in other words, to do away with the circular basin, and have one large lake, would inundate a lot of land surrounding the present circular basin, and interfere with Mr. Griffin's plan, unless protective works were built at the 1,845-ft. level, or the boulevard raised from 1,830 feet to 1,850 feet in order to protect the land to the south, which is below the 1,845-ft. level. The original proposition was to have the upper lake at the 1,835-ft. level. That height would give a very decent sheet of water. It was Mr. Griffin's original proposal. The area covered by water would be much reduced. The proposal would be quite practicable, and no existing works would be injured.

(Taken at Melbourne.)

TUESDAY, 7TH MARCH, 1916.

Present:

Mr. RILEY, chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson.
Mr. Fenton,	

Walter Burley Griffin, Federal Capital Director of Design and Construction, recalled and further examined.

233. *To the Chairman.*—The eastern lake is shown on the plan as part of the general scheme, but I have never proposed that it should be made at once. The time when the work shall be carried out is a matter of expediency. By deferring the creation of that lake, a saving will be effected in respect to the earthworks for the railway, which can be carried as a construction line on a temporary trestle bridge. In October last I was asked by letter from the Secretary to supply (1) quantities, rough sections, and an estimate of cost of fillings and excavations which will be necessary before the ornamental lakes proposed by me can be provided, (2) details of proposed treatment of banks of ornamental waters showing depth of water at edges, (3) quantities and sections of dam between eastern lake and eastern circular basin, showing in detail proposal to deal with water flowing into circular basin; (4) estimate of cost of constructing dams, as suggested by me, between eastern lake and eastern circular basin, and also at Yarrolumla; (5) estimate of cost of dams, eliminating from consideration the formation of the eastern lake. On 30th October, I replied, giving the desired data, as follows:—

Canberra Lakes.

(1 and 2). Formation, inclusive of bottoms, bathing benches, esplanades, and promenades —Earthwork, 1,333,700 cubic yards; estimate of cost, £25,300.

The Department's estimate of this work was upwards of four times this quantity, which discrepancy I will explain.

Typical sections and details herewith show depths and proposed treatment of banks.

(3, 4, and 5). East lake impounding dam and spillway, railway and highway causeway—Earthwork, 770,700 cubic yards; concrete work, 21,746 cubic yards; estimate of cost, £91,200.

Sections and details herewith.

Western lake system, impoundment—(Yarrolumla dam), estimate of cost, £84,000.

Those figures are based on a number of considerations, which I had expected to explain to the committee when called upon. I adhere to the estimates contained in that letter. When last giving evidence on this subject, I had commenced to explain the bases for my designs and estimates, but I had only portion of my notes with me at that time. If the committee is taking evidence in full on this subject, I desire that the further matter which I have prepared be taken. In my last testimony before the committee, a table of areas and depths was given, and I now propose to place before you an enumeration of shore frontages which I did not give at that time. There are the naturalistic shores of the lakes, providing park with incidental access to water totalling 29¼ miles, of which 13¾ miles are on the east lake, 3 miles on the three basins, and 12¼ miles on the west basin. As opposed to the naturalistic, there is a certain extent of formal thoroughfares which are boulevards, with general access to the water. The total mileage of them is 5¼, of which half-a-mile is in the west lake, and 4¾ miles in the basins. Altogether there are 13¾ miles of frontage in the east lake, and 20¾ miles in the basins and the west lake, making a total water frontage of 34½ miles of which only 5¼ miles are formal. I submit that evidence in answer to the opposition that has been raised in regard to the formality of the lakes The formality is only incidental to the lakes The fact that that so small portion of the design exclusively impresses itself on the mind, when looking at the plan, is an indication of what would be its impressiveness in the city. In the main the lakes are informal; with the exception of only a small fraction, they follow the natural contour.

I have also investigated the matter of the rainfall for the supply of the lakes, and I hope to be able to show you that there is an adequate water supply. On the occasion of my former testimony I analysed the evidence of other witnesses on this subject, but I did not deal with the evidence of Mr. Davis, which had been taken previously. Mr. Davis estimates that if an impounding reservoir, containing 7,500,000,000 gallons, were constructed on the Queanbeyan River, it would easily supply a uniform flow of 1,500,000 gallons per day, or 5,475,000,000 gallons per annum, which is equal to 876,000,000 cubic feet per annum, and that if the Molonglo is taken into consideration, then there can be little question that the stability of the proposal would be vastly improved, even in periods of drought, such as 1900-1902. My estimate of the net run-off from the combined catchments of Queanbeyan and Molonglo, at a point 10 miles below the site of dam referred to, is 760,606,387 cubic feet per annum in the year of minimum rainfall without any previous storage. Comparison with the figures submitted by Mr. Davis indicates that the ratio of run-off to rainfall adopted by Colonel Owen, and used in my calculations, viz., 5 per cent., is, in fact, a low one Mr Davis shows the evaporation from 1 square mile of water surface in the impounding reservoir as 348,000,000 gallons or 55,680,000 cubic feet per annum. This evaporation allowance corresponds to a depth of 2 feet per annum. Mr. Davis allows for an evaporation from 3,145 acres of water surface in the lake system of 9,460,000 gallons per day, or 3,452,000,000 gallons per annum, equal to 552,464,000 cubic feet per annum. This allowance corresponds to a depth of 4 feet per annum. Thus, the total evaporation allowance of Mr. Davis is 55,680,000 cubic feet, plus 552,460,000 cubic feet, or 608,144,000 cubic feet per annum. My estimate of evaporation, at 3 feet per annum, on 1¼ square miles of reservoir, is 125,452,000 cubic feet. On 3,145¼ acres in the lake system it amounts to 411,067,000 cubic feet, making the total for the lakes and reservoir 536,519,808 cubic feet. The amount allowed by Mr. Davis for evaporation from the lake system alone (552,464,000 cubic feet per annum) practically agrees with the total evaporation allowed by Colonel Owen on the combined water area of the lake system and impounding reservoir (3,450,000,000 gallons per annum = 552,000,000 cubic feet per annum), and gives a depth of evaporation of 4 feet per annum, which is more than twice the net evaporation (total evaporation minus rainfall on water surface) per my deduction submitted herewith.

I propose now to deal with the evidence which has been given in regard to the actual supplying capacity of the impounding reservoir on the Queanbeyan River, which we propose to utilize for maintaining the lakes. I wish to show that, with this, the Queanbeyan River alone is capable of keeping full the whole system of lakes whenever they are carried out. I arrive at my estimate on the same basis as was employed for figures which I gave for the catchments of the two rivers, leaving the question of impoundment open. In the catchment on the Queanbeyan, there are 129 square miles between isohyetals 30 and 35 inches, 164 square miles between 25 and 30 inches, and 62 square miles between 20 and 25 inches. I have taken out the actual annual rainfall for minimum, average, and maximum years over these three different areas as classified by the Meterological Bureau. The total rainfall in the minimum year was 15,857,406,000 cubic feet per annum over the whole enclosed area of 355 square miles. The run-off, reckoned at 5 per cent. of the total, would be 792,870,300 cubic feet in the driest year. The evaporation on 1¼ square miles of the impounding reservoir at 36 inches would amount to 125,452,800 cubic feet, leaving a net run-off per annum of 667,417,500 cubic feet, or 1,828,520 cubic feet per day, or 21 cubic feet per second. The average minimum rainfall over the catchment is 19 inches. The time of filling the impounding reservoir with the supply would be in a minimum year 18 months, in an average year 11 months, and in a maximum year 7 months. The additional water supply operating to preserve the reservoir level after the first filling, i.e., 95 per cent. of the annual rainfall on a water surface of 1¼ square miles at local rates of rainfall (10½ inches in a minimum year) is 34,760,480 cubic feet. From the above data in connexion with the report submitted by me at

Canberra on 17th September last, it is seen that the net rainfall for this catchment during the driest year of 10 years records 19 inches, and that on the assumption of 5 per cent. gross run-off, the net run-off for the reservoir is 667,417,500 cubic feet, plus 34,760,480 cubic feet; total, 702,178,000 cubic feet, of which only 530,519,808 minus 121,000,000 (or 415,500,000) cubic feet is with proper regulation required for the Canberra lakes, leaving a controllable surplus to let down the lower Molonglo, below the Yarrolumla weir, of 286,500,000 cubic feet, regardless of Molonglo or local storm accessions. Therefore if the actual run-off were as low as 3 per cent., no storage would be required from previous years to provide against any number of driest years on record. Furthermore, if no run-off whatever occurred in the catchments the impounding reservoir would supply the lake losses for three consecutive years, which, of course, is the *reductio ad absurdum* of the limiting conditions, since heretofore the minimum rainfall has been approximated in only three isolated years in 44 years, and was in the worst instances both preceded and succeeded by good years of rainfall. That is shown by reference to the complete record of the nearest observation points, also by comparison with the history of catchments of streams elsewhere, whose behaviours accord with different characters.

234. *To Mr. Fenton.*—Mr. de Burgh said: "If the Committee proposed to go on with the big scheme, they might just pull through if the Queanbeyan River alone were regulated. On the other hand, they might not. If the Molonglo River were also regulated, I think they would be fairly safe." I think my figures show conclusively that the Queanbeyan River alone has a sufficient capacity to maintain easily all the lakes without worrying about the Molonglo. I do not know whether Mr. de Burgh has had time to go into this matter thoroughly, and give consideration to the rainfall records taken piecemeal over the territory. Mr. de Burgh's statement is certainly on the safe side, but I have had plenty of time to investigate this matter, and I think my calculations are correct.

235. *To Senator Lynch.*—I am aware that Mr. de Burgh said that "if the Molonglo River were dammed it might be possible to construct the upper lake with safety, but the wiser course would be to make a start with the other lakes," but the figures I have used in making my calculations are the actual rainfall statistics collected by the meteorologist. If Mr. de Burgh were asked to make a report on this project, he might be able to give a more comprehensive answer. Naturally, in merely answering questions before the Committee, he had to be very conservative. In the year 1900, there was a rainfall of 30.41 inches at Queanbeyan, 35.61 inches at Mount Campbell, and 46.50 at Snowball. In 1901, the rainfall dropped to 17.34 at Queanbeyan, 21.79 at Mount Campbell, and 24.74 at Snowball; whilst in 1902, it was 10.45 at Queanbeyan, 14.39 at Mount Campbell, and 34.56 at Snowball. Without receiving any run-off whatever this Queanbeyan reservoir would make good our evaporation losses, but those statistics show that there was rainfall in the driest year. Then in 1903, the year following, the rainfall at Queanbeyan was 20.30, at Mount Campbell 26.81, and at Snowball 33.63.

236. *To Mr. Fenton.*—Mr. de Burgh says that taking into consideration all the facts relating to the years 1900-02, the margin is bare. When I prepared this information, I had not seen Mr. de Burgh's evidence, but I will be glad to analyze his statement carefully. In regard to the provision for flood waters in the Canberra lakes, no flood having been measured, it is difficult to make assumptions that will cover the worst cases in regard to the discharge from the catchment of the Queanbeyan and Molonglo Rivers at the lake dams. I have, however, approached the problem in different ways with varying results, and it is a matter of precautionary judgment determining which should be taken. Presumably, the result will be the construction of a much larger dam than we should regard as necessary if we had more flood records to guide us. The records of the Commonwealth Meteorologist show that 8 inches of rain fell in June, 1891, which was four times the average for the same month over a period of 43 years, and produced the highest known flood in that locality. Of this quantity, 4.31 inches fell from 1st June to 24th June, and 3.69 inches from the 26th to 28th June, three days. The assumption is that the fall on the last of these days was on ground so saturated that the whole of the rainfall was discharged in the watercourse, and reached the lake sites. Water from the southern extremity of the catchment, 70 miles distant, would reach the lake area in not less than 18 hours. On these assumptions, the discharge would be 29,854 cubic feet per second, which equals a rate per square mile of catchment of 44 cubic feet per second. Turning now to the departmental contour plan, I submit to the Committee cross sections between flood levels. Of these, sections 1, 2, and 3 only might possibly be relied on as giving an approximate discharge in this flood, because it is only in this reach of the stream (where the cross sectional area approaches uniformity for a reasonable distance) that ordinary stream line action can be anticipated. Combining these areas with the average hydraulic grade exhibited by the plan, we get the following discharges:—Per section No. 1, 57,321 cubic feet per second; per section No. 2, 49,000 cubic feet per second; and per section No. 3, 106,000 cubic feet per second—the last-named discharge obviously impossible The flood discharges estimated in this way should, with accurate records, form the most reliable basis on which to make provision for dealing with such water in the future, as they correspond to an actually measured quantity, but the discharge thus obtained is so large by comparison with the maximum rainfall and with other rivers in New South Wales and Victoria that only verification of the assumptions made in connexion with the channel would afford any justification for provision evidently so vastly in excess of requirements. The following figures from rivers of nearest similarity in conditions and areas show how great is this discrepancy: — The Tumut River has an area of 980 square miles, and has a record maximum flood discharge of 20 cubic feet per second per square mile; the Snowy River, with an area of 680 square miles, has a discharge of 25 cubic feet; and the Kiowa River, 434 square miles, 30 cubic feet. The grade of river bed, however, is not fully shown; in some places the level of river bed is shown, in others the level of the water in the river without showing depth of water. Again rocky bars are shown in existence, but the depth of these bars (*i.e.*, height of river

bed immediately above and below them is not shown), and though these do not seriously affect the hydraulic problem under consideration, both further records and surveys are wanted for check. The hydraulic grade of flood waters shown by the plain is from R.L. 1830 on the east to 1812½ on the west, a fall of 17½ feet in 29,000 feet, or on an average 1 in 1700. The value of the co-efficient of roughness used is as low as would be applied to the flow of river with serious obstructions (such as boulders, detritus, vegetation, &c.). However, evidence of old residents of the district indicates that erosion has in recent years very seriously altered the configuration of the river, and increased width of channels at this locality, so that, as the criterion, the channel must subserve rainfall information, most especially, since the occasion of the one preponderant flood was an occasion of very exceptional duration, not of an unprecedented rate, of fall. Allowance for about 50 cubic feet per second per square mile of catchment, therefore, will only err on the side of excess cost. Various authorities can be quoted in support. Mr. Chamier, of Sydney, gives the run-off on flat country, sandy soil, or cultivated land, as from 25 to 35 per cent. of the rainfall; on meadows, gentle declivities and absorbent land, 35 to 45 per cent.; wooded hills, slopes, and compact or stony ground, 45 to 55 per cent.; mountainous or rocky ground, or non-absorbent surfaces, 55 to 65 per cent.; and naked unfissured mountains, very steep ground or paved streets, 80 per cent. I submit also from the engineer in charge of river gaugings, New South Wales Conservation and Irrigation Commission, a list of maximum rates of run-offs in cusecs per square mile of catchment, compiled for New South Wales and Victorian records. He says:—

"The figures given are approximations based on production of the volume curve from lowest gauged stages or combining waterway areas with mean velocity curves produced."

"In the case of the Tumut river, where gaugings were obtained within 2 feet 3 inches of the highest recorded flood, and the Kiewa, in Victoria, which was gauged within 2 feet 8 inches of the maximum, the figures are held to be practically correct. The Hunter was gauged at the maximum height.

River.	Station.	Year.	Catchment Area in Square miles.	Cusecs per Square mile.
New South Wales — Naomi ..	Narrabri ..	1908	9,820	4
New South Wales — Murray ..	Albury ..	1889	6,500	6
New South Wales — Wollondilly ..	Goulburn ..	1911	300	15
New South Wales — Tumut ..	Tumut ..	1891	980	20
New South Wales — Snowy ..	Jindabyne ..	1912	690	25
New South Wales — Hunter ..	Belmore Bridge	1913	7,000	29
New South Wales — Chichester ..	Fernside ..	1912	76	153
Victoria — Ovens ..	Wangaratta ..	1903	2,090	7
Victoria — King ..	..	1889	620	8
Victoria — Goulburn ..	Murchison ..	1912	3,055	10
Victoria — Mitta ..	Tallangatta ..	1887	1,990	12
Victoria — Broken ..	Casey's Weir ..	1905	730	14
Victoria — Kiewa ..	Kiewa ..	1903	434	30

"For estimating the Molonglo run-off the Tumut, Snowy, and the Victorian tributaries of the Upper Murray can be considered. These streams have their sources in the highest ranges in the continent, and are greatly swelled by melting snows in winter. Their maximum rate varies from 12 to 30, and averages about 22 cusecs per square mile."

"The Molonglo drainage area is much less rugged in character, receives less than half the average rainfall enjoyed by the streams quoted above, and is generally inferior in efficiency. I have no hesitation in suggesting 15 cusecs (cu. ft. per sec.) per square mile as the maximum rate of flow for the Molonglo."

I have prepared tables regarding Victorian and New South Wales rivers, compiled from the reports of the Victorian State Rivers and Water Supply Commission, for the years 1908 and 1912, and of the Commission for Water Conservation and Irrigation in New South Wales, and a careful comparison of the facts contained therein, with the conditions of the Molonglo, shows that there can be no question as to the safety of the allowance I have made for floods.

VICTORIAN RIVERS, MAXIMUM FLOODS, ETC.

DATA COMPILED FROM REPORTS OF STATE RIVERS AND WATER SUPPLY COMMISSION DATED 1905 AND 1912.

River.	Gauging Period Years.	Length Catchment. Miles.	Area of Catchment. Square Miles.	Maximum Flow in c.f.s.	Maximum Flow per Square Miles Catchment.	Date of Maximum Flow.	Highest Average Fall on Catchment.	Lowest.	Average.	Variation in Average Rainfall during Period of Gauging.	Ratio of Run-off to Rainfall. Variation.	Remarks.	As to Running Dry.
Murray (Albury)	29	110	6,470	59,570	8½	1889	51	26	..	Between 26 inches and 57 inches for eleven successive years	10% to 34%	20 to 28 per cent. seven successive years; 17 to 18 per cent. two successive years	No
Loddon (Laanecoorie)	22	40	1,600	74,000	47	Aug., 1909	32	16	29	Between 16 inches and 32 inches for eight successive years	2·3% to 22%	Below 5 per cent. two years in succession once	No
Avoca	23	82	1,029	4,329	4½	June, 1893	28	12	26	Between 12 inches and 18 inches for eight successive years	3·10% to 12%	Below 5 per cent. eight successive years	Yes
Campaspe .	27	72	1,362	10,700	8	June, 1899	36	16	23	Between 16 inches and 24 inches for eight successive years	3% to 18%	Below 5 per cent. two years in succession three times	Yes
Wimmera	28	50	768	7,367	9½	Sept., 1891	31	13½	31	Between inches and 20 inches for eight successive years	2% to 15%	Below 5 per cent four years, two years, eight years in succession	Yes
Kiewa ..	27	55	434	13,300	30	Oct., 1906	55	26	46	Between 26 inches and 35 inches for eight successive years	10% to 44%	10 to 25 per cent. three years in succession; 25 to 30 per cent. four years in succession	No
Ovens .	26	88	2,090	15,300	7	Aug., 1909	60	27	43	High and low rainfalls evenly distributed	5% to 32%	5 per cent. once, and range becomes 14 to 32 per cent.	Dry twice 26 years
King	23	30	620	5,000	8	Aug., 1909	60	21	39	High and low rainfalls evenly distributed	6% to 35%	9 to 15 per cent. eight years in succession	No

NEW SOUTH WALES RIVERS, MAXIMUM FLOODS, ETC.

DATA COMPILED FROM REPORTS OF COMMISSIONER FOR WATER CONSERVATION AND IRRIGATION

Rivers.	Gauging Period Years.	Length Catchment.	Area Catchment.	Maximum Flow in c.f.s.	Maximum Flow in c.f.s. per Square Mile of Catchment.	Date of Maximum Flow.	Average Rainfall on Catchment — Highest.	Average Rainfall on Catchment — Lowest	Average Rainfall on Catchment — Year of Maximum Flow.	Variation in Average Rainfall during Period of Gauging. Remarks.	Ratio of Run-off to Rainfall. Variation.	Remarks.	As to Running Dry.
Indi ..	7	40	490	4·880	10	Sept., 1912	56	35	55		37% to 24%		No
Swampy Plain ..	9	16	320	6·560	20	Oct., 1909	85	42	62		63% to 35%		No
Murray (Bringenbrong)	9	50	820	10·840	13	June, 1909	71	34	49		55% to 37%		No
Tooma	5	23	713	6·710	9	Sept., 1912	53	36	41		28% to 21%		No
Tumut	13	78	980	17·810	18	July, 1905	63	38	49		57% to 22%		No
Murrumbidgee (Gundagai)	27	130	8,100	120·200	14	June, 1821	44	22	39		37% to 6%	Only as low as 6 per cent once, next lowest, 9 per cent.	No
Lachlan (Cowra) ..	21	50	4,470	147·000	33	July, 1900	38	17	32	Between 16 inches and 23 inches five years in succession	22% to 7%	Below 5 per cent five years in succession twice	Yes
Macquarie (Dubbo)	29	120	7,690	48·040	6	March, 1820	40	11	27	Between 27 inches and 11 inches five years in succession	18% to 1%	Below 5 per cent five years in succession twice	No
Snowy	12	60	680	15·360	22	Sept., 1912	45	19	38		103% to 37%		

The question of the deposition of silt in the lakes has been raised. The only way to deal with this subject is to take the actual conditions and presuppose their effect on these lakes, knowing the water in the lakes and the flow into them. Some very absurd statements have been made regarding the silt that may be expected in lakes in this locality, and I have gone to great pains to ascertain the quantity of silt that could be brought down and deposited. The question of silt depositing in the Canberra lakes, because of the impoundment provisions allowed for and easily effected in the upper reaches, effectually clarifying ordinary flow and many floods, is reduced to the problem of unusual floods. An estimate of the siltage in rivers in flood in Victoria is about 50 grains per gallon, or about 1-1400th by weight, and rivers in normal clear condition carry about 10 grains per gallon. The proportion carried by the Mississippi has been determined as 1-1500th by weight, which figure I am adopting in the calculation. I may add that Colonel Owen's evidence gives 1-1500th as the silt carrying capacity of water (1-1500th by weight = 1-2250th by volume, since the ratio of weight of earth to weight of water is approximately 1½). Assuming that a maximum flood of 33,000 c.f.s. will rise and subside in 24 hours, $\frac{33,000}{2} \times 3,600 \times 24 = 1,425,600,000$ cubic feet flood water, carrying $\frac{1,425,600,000}{2,250} = 633,600$ cubic feet of suspended silt = 28,300 tons. If all the silt remained in the lakes the average depth of deposit would be $\frac{633,600}{137,017,660} = 1/216$th feet or = 1/18th inch, but this implies that the water entered the system turbid and left it quite clear, manifestly impossible. The proportion that might be expected under the conditions operating are shown by the following calculations:—

The flood entering the East Lake and distributed by dilution through 1,425,600,000 + 838,400,000 = 2,264,000,000 cubic feet of water = 10,500 tons precipitates $\frac{633,600 \times 838,400,000}{2,264,000,000} = 234,634$ cubic feet in East Lake.

Area of East Lake = 1,672 acres = 72,832,000 square feet.

Depth of siltage in East Lake = $\frac{234,634}{72,832,000}$ feet = 1/26th inch on this area.

The quantity of suspended silt carried into Basins and Western Lake is 633,600 − 234,634 cubic feet = 398,966 cubic feet distributed by dilution through 1,425,600,000 + 970,992,000 cubic feet = 2,396,592,000 cubic feet of water, precipitating $398,966 \times \frac{970,992,000}{2,596,592,000} = 161,700$ cubic feet = 7,300 tons.

The area of Basins and Western Lake is 1,473½ acres or 64,185,660 square feet; the depth of siltage produced in this system = $\frac{161,700}{64,185,660}$ feet or = 1/32nd inch.

The balance of silt 633,600 − (234,634 × 161,700) = 237,266 cubic feet = 10,500 tons is carried past the lake system by flood waters.

237. *To Senator Story.*—If the eastern lake were omitted, its clarifying action would not occur, and there would be a greater deposit in the western lake. In that event, the deposit in the western lakes would be somewhat less than 1-26th inch. I am calculating on 1-26th inch as likely to be the deposit in the eastern lake, which has a lesser volume. I am allowing for the dilution of the water in the lake by the water that flows through it. That flow would carry a good deal of the silt through the lake. The eastern circular basin would probably deposit at the same rate as other portions of the lake. The water would be turbid all through in a big flow. I am showing that, in any case, the quantity of silt deposited is inconsiderable. So far as we can estimate the rate of deposition, many generations would elapse before the silt would present a problem. I have made a second estimate on the assumption of a flood larger than can be anticipated, say water rising from zero to 33,000 cubic feet per second for 12 hours, maintaining that maximum for 24 hours, and then falling to zero again in another 12 hours. The volume of flood water on that basis would be 4,276,800,000 cubic feet, which divided by 2,250, would mean 1,900,000 cubic feet of silt in suspension, brought down = 85,000 tons.

Flood water, plus water in East Lake = 4,276,800,000 + 838,400,000 = 5,115,200,000 cubic feet. Deposited in East Lake = $\frac{838,400,000}{5,115,200,000}$ × 1,200,000 = 312,000 cubic feet = 14,000 tons. Depth deposited in East Lake = $\frac{312,000}{72,852,000}$ foot = 1 20th inch. Carried to West Lake, 1,200,000 - 312,000 = 1,588,000 cubic feet. Flood, plus water in West Lake, 4,276,800,000 + 970,992,000 = 5,247,792,000 cubic feet. Deposited in West Lake, $\frac{1,588,000}{5,247,792,000}$ × 970,992,000 = 294,000 cubic feet = 13,200 tons. Depth in West Lake, $\frac{294,000}{61,180,650}$ foot = 1 20th inch. Balance 1,200,000 - (312,000 + 294,000) = 1,294,000 cubic feet = 57,800 tons carried past. These calculations show that large floods will not appreciably increase the deposit of silt in the lakes, because the increase in the total quantity of matter in suspension brought down by such floods is nearly counterbalanced by the decreasing value of the ratio of lake volume to flood water plus lake volume. It is only the matter held in suspension by the lake volume which will be eventually deposited as silt in the lake system when flood waters are removed as quickly as they arrive, and my proposals herewith embrace provision for such removal. We can, therefore, conclude that no difficulties will arise from the deposit of silt in the lakes carried down in suspension by floods, and this, I may say on authority, has also been the experience of the Victorian State Rivers and Water Supply Commission at the numerous dams and weirs under their control.

238. *To Senator Story.*—I do not think it would be necessary to lower the level of the lake in the event of floods; in fact, I do not see how that could be managed. The only safe method would be to discharge the water as fast as it came down, and I would prefer that to be done automatically rather than to depend on notice of floods, which come down very rapidly, as we know from a recent experience. The difference in deposits in the western and eastern lakes during a big flood would be negligible. I saw no evidence of silt having been deposited in the Molonglo Basin during the recent flood. I cannot see why the circular design of the lake and the narrow outlet should lead to a deposition of silt. During floods the deposition would not be large, because there would be a strong current through the lake. Colonel Miller stated that he had seen a 12-in. deposit of silt on the top of the Molonglo bridge. That is a physical impossibility, because the current would be carrying the silt in suspension. Transposition by undermining is often confused with silting. Another question that has been raised is that of the effect of wave action on the shores of the lake, and the proper precautions to be taken for their protection. According to the Stevenson formula, which is commonly used for computing the action of wind on water, in the longest fetch of this lake we shall have waves measuring 3½ feet from crest to trough. In other portions of the lake the fetch is calculated as being 1 mile, and the waves as being 3 feet from crest to trough. The bank protection methods adopted have been based on these figures. In regard to the likelihood of trouble from mosquitoes, I should like to quote from a report of a statement by Dr. J. A. Leach, in the course of a lecture on "The Deadly Mosquito," delivered in the Melbourne Town Hall, on the 12th October, 1915:—

> "In one of the fire buckets at the Exhibition, examined during the A.N.A. Exhibition of 1914, he found no fewer than 53 egg rafts, containing about 15,000 eggs, and scores of larvæ and pupæ. The idea that mosquitoes bred on the pools in the Exhibition gardens and such places was fallacious. There were too many enemies in the shape of sticklebacks, water scorpions, the larvæ of the dragon fly, or mosquito hawk, to allow them to breed."

239. *To the Chairman.*—It will not be possible to state accurately what the cost of the earthworks will be until the method of handling has been determined, and the method will depend on the quantities to be handled. I have made assumptions as to cost, based on the use of a certain type of excavator, allowing for capital cost, depreciation, interest, cost of operation, wages, and coal. I have reckoned 2½d. per cubic yard for the actual excavation of the material by a Lubecker land dredge, operating on a construction line railway, but, perhaps, by the use of some other type of machine that figure could be bettered. That estimate is only for lifting and transposing the material within range of the machine; it does not include transport. For the latter we have to make allowance for the cost of the locomotives and trucks, and depreciation, repairs, and interest charges on them. These are 72s. per day; coal, 20s.; and wages, 60s.; making a total of 162s. per day, for 600 cubic yards—the estimate of a day's haulage, equal to 3½d. per cubic yard to haul the material any distance. Away from the railway we should probably employ traction engines. A 1-mile haul and return would occupy 40 minutes; 12 trips per day of 10 cubic yards, or 12½ tons each, would amount to 150 tons. The capital cost of a traction engine for a 12-ton load would be not over £2,000; the depreciation would be £200 per annum and interest £80; total £280, which, distributed over 250 days, equals 22s. 5d. per day, or 2.24d. per cubic yard. The operation of the engine would cost 52s. per day for a crew of five men, and 12s. for coal, or 0.4d. per cubic yard. For a haul of one mile the cost would 8.04d. per cubic yard; ½ mile, 4.32d.; ¼ mile, 2.16d. per cubic yard, or with allowance for swelling and handling, 9d., 4½d., and 2½d. respectively.

240. *To the Chairman.*—The cost of this excavating may be compared with the cost of the Lang Lang swamp reclamation, where the machine is now excavating 3,000 cubic yards of muck per week at a cost, including the provision of railway tracks for operating it, of 1.903d. per cubic yard, with the expectation of bettering this average where attempts in the past with bullock teams and scoops have generally resulted in both animals and scoops becoming hopelessly bogged. Removing the muck at Lang Lang by ordinary methods would cost not less than 1s. per cubic yard, if practicable. In the construction of the eastern lake at Canberra practically no earthwork is involved. In the east basin I estimate that there would be 361,000 cubic yards of excavating, in the central or "Molonglo" basin 98,500 cubic yards on the north boulevard, and 177,000 cubic yards on the south boulevard. This estimate includes provision for the bottoms, beaches, boulevards, and esplanades. In the west basin on the north there would be 99,500 cubic yards, and on the south 181,500 cubic yards. In the west lake, there would be 361,000 cubic yards, including the boulevard and esplanade. In addition there would be 20,000 cubic yards in the island. On the circular cross road there would be 10,000 cubic yards. Around the aquarium pond, north boulevard, there would be 25,000 cubic yards. In the east basin the whole of the work would be in silt. There would be 38,000 cubic yards which would require to be hauled an average distance of 275 feet; 13,500 cubic yards, which would have to be hauled an average distance of 250 feet; 59,000 cubic yards, which would need to be hauled an average distance of 900 feet; 3,000 cubic yards, which would have to be hauled an average distance of 350 feet; 11,000 cubic yards, which would require to be hauled an average distance of 450 feet, 31,500 cubic yards that would need to be hauled an average distance of 1,100 feet; 205,000 cubic yards that would require to be hauled an average distance of 800 feet. In the Molonglo basin there would be 7,300 cubic yards of shale, which would have to be removed a distance of 250 feet, 24,000 cubic yards of alluvium, which would need to be hauled an average distance of 525 feet; 45,000 cubic yards of silt, which would necessitate an average haulage of 250 feet; and 22,500 cubic yards of alluvium which would have to be hauled an average distance of 700 feet. On the south boulevard, in the Molonglo basin, 82,500 cubic yards of silt would require to be hauled an average distance of 300 feet, and 94,500 cubic yards would require to be hauled an average distance of 500 feet. In the west basin, on the north boulevard, 77,500 cubic yards would have to be hauled an average distance of 300 feet, and 22,000 cubic yards of loam would require to be hauled an average distance of 200 feet. In the south boulevard there would be 116,500 cubic yards of alluvium which would require to be hauled an average distance of 400 feet, and 65,000 cubic yards which would have to be hauled an average distance of 300 feet. At the aquarium pond 25,000 cubic yards would need to be hauled an average distance of 300 feet. On the west beach boulevard there would be 30,000 cubic yards which would necessitate an average haul of 750 feet; 50,000 cubic yards of loam, which would require to be hauled an average distance of 600 feet; 7,000 cubic yards of alluvium, which would need to be hauled an average distance of 400 feet; 34,500 cubic yards, which would require to be hauled an average distance of 500 feet, and 113,500 cubic yards, which would have to be hauled an average distance of 300 feet. On the esplanade, there would be 39,000 cubic yards of alluvium, requiring an average haul of 300 feet; 30,000 cubic yards necessitating an average haul of 450 feet; 18,000 cubic yards requiring an average haul of 700 feet; 39,000 cubic yards, which would require to be hauled an average distance of 600 feet. In the island, there would be 20,000 cubic yards of alluvium, which would have to be hauled an average distance of 300 feet, and approaching the bridge across the bay there would be 10,000 cubic yards, which would have to be hauled an average distance of 400 feet. These make a total of 1,333,500 cubic yards, and I estimate the cost of handling that quantity of excavated material at 4⅜d. per cubic yard. That cost covers the earthworks in the ordinary acceptation of the term, but I do not say that it would suffice to cover the cost of grading the excavated material into beds. My estimate of the cost of haulage is based upon an average cost of 8.04d. per mile.

241. *To Senator Lynch.*—My estimate of 4⅜d. per cubic yard represents the total cost of the work, including earthworks and haulage. I have not allowed anything for levelling. In handling this material probably locomotives would not be employed at all, though it might prove to be more economical to put it into dump carts, and remove it on a tramway.

242. *To Mr. Fenton.*—I stated previously that I estimated the work done by the machine at 2½d. per cubic yard. That was based upon the assumption that it would handle 600 cubic yards per day. The removal of the 1,333,500 cubic yards of material would cost 4⅜d. per cubic yard, but 2½d. per cubic yard would represent the cost if the work were done by a machine standing on a finished track. In such circumstances the work would cost less than if the machine had to lay its own track upon which to move backwards and forwards. In the latter event, the cost of the work, if done by machine, would be 3½d. per cubic yard. In some instances, the earth would be completely handled by the machine, and no haulage would be required.

243. *To Mr. Sampson.*—My estimate of 4⅜d. per cubic yard includes the cost of operating the machine and the transport of the material to the place where it has to be deposited.

244. *To Mr. Fenton.*—The total cost of the operation from beginning to end, I estimate at 4⅜d. per cubic yard. That would be the average price, but in some instances the cost would range as high as 1s. per cubic yard.

245. *To the Chairman.*—I have already submitted details regarding the shore embellishment and protection of the lake, including the beaching and access steps. It will be seen by reference to the diagram submitted that the finish around the three basins there is a formal border. That consists of concrete steps, five in number, and reaching from a height of 2½ feet above water level to water level; thence the concrete is to be carried down on the slopes of the basin in the shallow waters, to a depth of 18 inches, and there a sill is to be provided on a system of piling, which is to be embedded in the solid earth. This will always be below the water level, so that it will be of a permanent character. In deep water, of course, the use of this retaining piling is not practicable. The shallow shore treatment extends to a depth of 5 feet. Elsewhere I have provided for a rough-stone pitching on a concrete toe or sill 1 foot thick, resting on the bottom of the lake, so as to obviate any possibility of a slide. In every case, the concrete runs down to a mean depth of 18 inches below water level. In the east basin boulevard the concrete employed would amount to 1,000 cubic yards, which, at 50s. per cubic yard, would involve an expenditure of £2,500. The rough pitching would represent 19,200 square yards, and would cost £2,020. the concrete toe would cost £950, whilst the 6 x 9 x 2 inch piling would total 1,600 lineal feet, which, at 4s. per foot, would cost £320. On the north side of the central Basin there would be 860 cubic yards of step revetment, which, at 50s. per cubic yard, would entail an expenditure of £2,150, whilst the rough pitching would cost £228. The concrete toe would represent 90 cubic yards, which, at 50s. per cubic yard, would cost £225, whilst the piling would involve 5,800 lineal feet, which, at 4s. per foot, would mean an outlay of

£1,160, *making a total of £3,763.* On the south boulevard, the concrete step revetments would represent 706 cubic yards, which, at 50s. per cubic yard, would mean £1,764. The rough pitching would cost £797, the concrete toe £463, and the piling, which would represent 2,000 lineal feet, would cost £485. In the west basin, north boulevard, the concrete step revetments would represent 480 cubic yards, and would cost £1,200, the rough pitching would be equivalent to 120 cubic yards, and would cost £443; the concrete toe would absorb 120 cubic yards, which, at 50s. per cubic yard, would necessitate an outlay of £300, and the piling of 800 lineal feet would cost £160. On the south boulevard of the west basin, the concrete step revetments would represent 145 cubic yards, and would cost £365; *the rough pitching would involve an* outlay of £330; and the concrete toe would cost £200. The rough pitching of the bridge approach on the east side would involve an outlay of £360; that on the west side would represent a similar sum, and the concrete toe for that pitching, *namely, 60 cubic yards,* would cost £300. On the west beach boulevard the rough pitching, covering 96 cubic yards, including labour, would necessitate an expenditure of £273, and the concrete toe of 45 cubic yards would involve an outlay of £121. The esplanade concrete step revetments, of 374 cubic yards, would cost £935, the rough pitching £300, the concrete toe £250, and the piling £320, making a total of £19,285. For the rough work on the top, I would use concrete cast in place and made of local material. I have calculated for practically no earthwork in connexion with the east lake, with the exception of the dam, which is intended to impound the water at the railway crossing. The materials for this dam would be obtained chiefly from the railway cutting, and it is a question of whether their cost should be charged against the railway *or against the lakes, or* how it should be proportioned between both. I have proportioned it. The borings in connexion with the earthworks disclose several kinds of material. There are 140,000 cubic yards of alluvium, 30,600 cubic yards of loam, 30,000 cubic *yards of sand, 63,700 cubic yards* of gravel, and 236,000 cubic yards of clay, making a total of 500,300 cubic yards of earthy material. Then there are 49,000 cubic yards of schist, and 116,700 cubic yards of granite and decomposed granite, or a total of 165,700 cubic yards of rock. The *materials that would be* used in the construction of the dam aggregate 666,000 cubic yards. Taking the cost of the earthy materials at 6d. per cubic yard, and adding 10 per cent. for contingencies, this would represent an expenditure of £13,750. Then I estimate the cost of dealing with the rock at an average of 1s. 4d. per cubic yard. Making an allowance of 10 per cent. for contingencies, the cost of this material would represent £12,150. This means that an expenditure of £11,030 would have to be charged against the railway, and the sum of £14,879 against the lakes. *In addition* there is excavating work to be done for the staunch wall down to rock, so as to prevent any possibility of percolation below the present grade of the earth. This represents 9,700 cubic yards, and would cost 2s. per cubic yard. For the installation of *the flood discharge syphon,* excavation would be involved to the extent of 75,000 cubic yards, which, at 2s. per cubic yard, would represent £7,500, making a total for the excavation of £8,468 The concrete work, allowing for a syphon with a discharge of 33,000 cubic feet per second, would run into 8,620 cubic yards of plain concrete, which, at 50s. per cubic yard, would represent an outlay of £21,605, and 6,176 cubic yards of reinforced concrete, which, at 70s. per cubic yard, would involve an expenditure of £21,066, making a total of £43,531. The construction of the staunch wall would run into 4,850 yards of plain concrete, which, at 50s. per yard, would represent an expenditure of £12,125; whilst the staunch facing would represent 2,100 cubic yards, or an outlay, at 50s. per cubic yard, of £5,250; a *total of £17,375. Adding 10 per cent.* for contingencies, the aggregate outlay under this heading would be £76,311, which, with £14,879 for earthworks, would bring the total cost of the whole embankment up to £91,190. The upper lake is 20 feet higher than is the lower lake. By means of the syphons which I propose, and which would be bedded on the bedrock, we would be enabled to take the water from the upper lake to the lower without in any way imperilling the embankment, and in addition we should get the benefit of the total difference of head between the levels of the two sites. This means a reduction in the area that would otherwise be necessary to discharge the water through the causeway.

246. *To Mr. Sampson.*—A syphon is preferable to an overflow. The latter would cost much more *money, and would require to cover* a much larger area, in addition to which further expense would be involved in the construction of bridges. I prefer the syphon method to the overflow on the grounds of economy in first cost, and economy in maintenance. There is no possibility of any *débris* coming down the river, entering the syphon and closing it up. By the use of the syphon, we would also be able to keep the water level within 6 inches of its mean height A rise of 6 inches in the upper lake would set the syphon operating to its full capacity, whereas a rise of several feet would be necessary in the case of a weir.

247. *To the Chairman.*—I have not seen any of these syphons in operation in Australia, but I know engineers who have constructed them elsewhere.

248. *To Mr. Sampson.*—The capacity of the syphons which I propose would be equal to the discharge of the flood waters of the highest known flood, and would provide an ample margin by way of reserve. I am of opinion that the actual flood discharge would not approach the maximum discharge of the syphon, namely, 33,000 cubic feet per second. *Débris* could not possibly interfere with the syphon, because the mouth of the latter would be several feet below the surface, as well as fended with grill of vastly greater orifice area extending clear to the bottom. The *capacity* of the syphon is exactly similar to that of the weir at Yarrolumla at high flood level. The syphon would be 352 feet in length, and would thus comprise a small waterway as compared with a weir. Altogether there would be about 50 syphons of a diameter of 7 feet, *including the* wall. In the case of overflow weirs, floating *débris* is liable to inflict damage upon bridges and embankments where the current is fast. I do not know of any instances in which syphons have been used in Australia, but I do know that they have been employed extensively *in Africa* and also in the United States. There is nothing theoretically novel about the action of a syphon.

249. *To Senator Lynch.*—The 1,333,500 cubic yards of excavation, which I estimate would be necessary to complete the group of lakes, are in terms of filling.

(Taken at Melbourne.)

WEDNESDAY, 8TH MARCH, 1916.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson.
Mr. Fenton,	

Walter Burley Griffin, Federal Capital Director of Design and Construction, recalled and further examined.

250. *To the Chairman.*—I have prepared a *tabulated statement comparing* my statements with those of Mr. de Burgh, in order to show that his figures corroborated those at which I had arrived as to the sufficiency of the supply of water. The statement is as follows:—

—	Mr. de Burgh's Figures.		Alternative as Submitted.	
	Gallons.	Cubic Feet.		
Impounding reservoir, assumed full end of 1900 ..	7,500,000,000 =	1,200,000,000		
Water received during 1901 from catchment	4,202,000,000 =	672,320,000	Compare deductions as submitted by me, 17th September, 1915, and 7th March, 1916:—	
Water received during 1902 from catchment	1,515,000,000 =	242,400,000		
Total water, after two years	13,217,000,000 =	2,114,720,000		
Evaporation from reservoir, 1 square mile	348,000,000 =	55,680,000	Gallons per annum.	Cubic feet per annum.
Loss in transit from storage to lakes, 1,200,000 gallons a day	459,000,000 =	73,584,000	Equivalent Losses—	
Totals ..	807,000,000 =	129,264,000	784,000,000 =	125,462,500
Draw-off for lake supply	3,285,000,000 =	525,600,000	3,353,248,800 =	536,519,808
Totals ..	4,092,000,000 =	654,864,000	4,137,248,800 =	661,972,608
Further demands conceded by Mr. de Burgh, but not by Mr. Griffin—				
Queanbeyan village water supply, 150,000 gallons a day	54,750,000 =	8,760,000	.. ..	Nil
Draw-off for electric plant	2,190,000,000 =	350,400,000	.. ..	Nil
Annual depletion	6,337,050,000 =	1,014,024,000	4,137,248,800 =	661,972,608
Compensating rainfall on surface of lake system ..	.. ..		973,425,000 =	155,740,000
			3,163,823,800 =	506,232,608

Therefore, in view of the fact that this engineer has been required to make additional allowance of more than half those actually necessary, his conclusions as to the ample sufficiency of this supply for the purpose intended agrees with the deductions which I independently arrived at.

Mr. de Burgh, although conceding the fact, has evidently made no definite allowance for the effect of rainfall on surface of lakes and reservoirs, which, as pointed out, goes to reduce evaporation losses, and amounts to 3,353,248,800 gallons, equal to 155,740,000 cubic feet per annum; making the net amount necessary for preserving levels of lake systems 506,232,608 cubic feet per annum, as heretofore submitted.

251. *To Senator Story.*—There is plenty of water for the supply of the people of Queanbeyan from the Queanbeyan dam, but I do not allow it as a necessary qualification of these works for another purpose. Mr. de Burgh has allowed a certain amount for a population of 3,000 or 4,000 at Queanbeyan, but that might have to be increased enormously later. He assumes that 9,000,000 gallons per day will be required to keep the lakes fresh, and 6,000,000 gallons for the electrical plant. He is adding two-thirds to the actual requirements. Mr. de Burgh's evidence confirms Mr. Davies' statement that the water supply is ample for the entire system of lakes, including the eastern lake. In Mr. de Burgh's estimate, there is an excess of two-thirds, and a doubtful quantity is changed into a certainty, if that excess be eliminated. I refer to the electric plant. There are 9,000,000 gallons per day for the freshening of the lakes, and 6,000,000 gallons additional for the electrical plant; this means 66 per cent. of the necessary supply, and it makes the question doubtful. I have allowed that 6,000,000 excess to put the question beyond any doubt. There is no need for the item relating to the electrical plant; the water can be returned to the lakes without any loss. As to Queanbeyan, that is a relatively small item; but I included it because I wanted to make a comparison with the figures. To cover that already I have allowed sufficient excess for evaporation—more than Mr. de Burgh. The only point of disagreement is the 6,000,000 gallons, so far as his evidence on water is concerned. With that exception, I accept his evidence, and, further, I took one of his allowances, which he just mentioned and did not quote as a quantity, but which I put in quantitative form, still further improving the situation. This will *give the Committee a figure* instead of an indefinite amount, and it is still a considerable amount. The amount is 3,353,248,800 gallons per annum, I refer to the rainfall direct on the surface of the lakes, which is an addition to the supply It is a reduction of the demand on the reservoir—*an additional supply—not* allowed for That is an estimate for the driest year.

252. *To Mr. Sampson.*—I have arrived at my conclusion entirely from meteorological information relating to the driest years, though, of course, I have also considered the average year and the maximum year.

253. *To the Chairman.*—The rainfall is over the whole of the water surface, and it goes to counteract the evaporation figures as recorded.

254. *To Mr. Fenton.*—I have *included* seepage in my allowance for evaporation. I may say that the dam on the Yarrolumla Station has never been dry in the driest year. The pressure depends on the height of the water on the top of the ground, and that is not great in the instance we are considering. *I can see no likelihood of* the eastern lake going down in the same way as Lake George. In the matter of seepage, Colonel Owen said it was 20 per cent. of the loss in transit, whereas Mr. de Burgh said it was .7 per cent. per mile, or about 8 per cent. Mr. de Burgh, in

his evidence, said that he could not estimate what width of spillway would be sufficient to take away surplus water in time of flood, but he thought that 800 feet would be ample; in other words, that 800 feet would be an outside length. Mr. de Burgh also suggested that a weir on the Molonglo would have a good effect in clarifying the water of the lake. That is the point I raised—that a small dam would be quite sufficient for this, irrespective of supplying water for the lake There is no dispute between us here Mr de Burgh further on said:—

> "Flood water tumbles much more rapidly over a weir than it flows down a gorge, and if there is a 2 feet depth of water there will be a rise of 2 feet on the lake, unless tremendously costly sluice gates re put in I do not regard sluice gates as at all necessary The advantage to be gained from them would not justify their expense With a regulating dam on the Queanbeyan the rise and fall of flood water is not likely to be very great, and in any case I do not think the possible rise will be sufficient to cause any disfigurement. If the water were to rise up to a height of 4 feet on the eastern lake over a period of perhaps one or two days there would not be any serious disfigurement of the landscape"

You can gauge from that something of his estimate of the amount of water to flow over this weir. He says that if the water were to rise up to a height of 4 feet on the eastern lake it would still be no disfigurement; but I have, in the syphon system, provided for an excess considerably over that. To pass over this 800 feet weir an amount of water equivalent to that discharged by the syphons would mean a rise of 5 ft. 4 in., whereas passing through the syphon it means a matter of only a few inches. Mr de Burgh said that he "never would accept syphons by themselves as a means of carrying off flood water." He went on to say:—

> "Whatever calculation may have been made, one can never be quite certain that the flood will not be bigger than was reckoned upon A few inches rise will often bring down a tremendous amount of water, and the moment the syphons get to their carrying capacity there is trouble Syphons will not satisfy me at all, and they would cost more than a spillway."

In making that statement he is talking about the discharge of waters from one lake to another, and not considering the question of railways and roadways That is a point on which he was not questioned, but which might very seriously affect the problem to be dealt with, which is to conduct the water underneath two lines of roadway and one line of railway. In addition to the cost of the weir, it means a considerable cost of passing through a large embankment for the spanning of this 800 feet of opening for all these thoroughfares. This dam is one of the main direct through line connexions in the city plan, intended to take a large traffic, and including the main railway line. Under such conditions, the problem is different from that met by Mr. de Burgh in his statement, which must be accepted with the limitations he admits. The question of economy is altogether altered when these other elements are taken into account. What is not economical in one case becomes extremely economical in another.

255 *To Senator Story*—We should have to make allowance sufficient so that there would be no rise of water to the top of the dam. If there were any doubt we could have some sluice gates through the bottom; but in the case of syphons, preparation is made for more than can reasonably be anticipated—much more than is allowed for in the case of a weir. If the unexpected happened, and the water went over the earthen dam, the same thing would happen as in the case of the weir—a gully would be washed through.

256 *To Mr Finlayson* —I do not suggest that the water going over the weir would wash it away, but the water would operate directly on the earthen bank. The dam is not designed for water above a certain point, and water above that point would find a way through I think I may say that Mr de Burgh's remarks in the last paragraph of his evidence are not within his sphere as an expert. I have not mentioned that his suggestion for pitching practically corresponds with that I submitted to the Committee He would pitch up to a height of 3 feet, while I would put it up to a height of 2½ feet.

257. *To Senator Lynch.*—I do not dispute Mr. de Burgh's figures as to the driest years, because they are sufficient for my purpose. The only difference between us is as to the Queanbeyan town supply, and the supply for electrical purposes. He did not give in his evidence the basis of his assumptions about the water supply, and all I know is that the supply is quite sufficient. I have shown that, without any supply for three years, the impounding reservoir would keep the city going. The figures in the table I have already quoted show that Mr. de Burgh, after his two years of drought, has more than enough left for another year without accession from any run-off whatever. His figures are substantially mine, though arrived at in a different way, after excluding the electrical supply.

258 *To the Chairman.*—I did not complete my evidence yesterday in regard to the cost of the lakes. I have a drawing for the west lake impounding dam, spillway, and highway. It is also a crossing The whole is in concrete, and takes care of the water in the same way as the other dam. There will be 30,000 cubic yards of excavation, at 2s per cubic yard, equalling £3,060; 27,657 cubic yards of plain concrete work, at 50s. per cubic yard, equalling £69,167; and 1,195 cubic yards of reinforced concrete work, at 70s. per cubic yard, equalling £4,182, or a total of £73,349 for concrete work. Including the cost of excavation, the total will be £76,409. Adding 10 per cent. to correspond with departmental procedure—that is, £7,641—the grand total will be £84,050. Deducting the value of a highway bridge, 876 feet long and 36 feet wide, which can be allowed at £31,550, the net cost of the dam and syphon discharge can be put down at £52,500. However, the two things have to be taken together. In addition to the East lake railway causeway and the high-way crossway at the Yarrolumla spillway, which serve as bridges, there will be seven bridges—one at the Federal-avenue, one at the Commonwealth-avenue, one on the West Beach boulevard, one across the bay on the Australasia Circuit-road, one across the Domain Harbor, one on the North boulevard across the aquarium inlet, and one on the lower reach of the Molonglo, connecting the different continental subdivisions of the Arboretum Some of these bridges will only come into requisition a long time hence, but they can be accepted as being all that will ever be necessary for the use of the city. The first bridge needed will be that on the Commonwealth-avenue, connecting the Capitol with the civic centre. It will answer all

purposes for some time to come Later, as the north side develops, there will be a bridge connecting directly with the Military College and Terminal-square. The bridge on the West Beach boulevard is purely a matter relating to the recreation uses of the city The other bridges are also part of the boulevard system, making short cuts to the civic centre and pleasure drives, when the south-western suburbs are occupied. The small bridge over the inlet to the aquarium pond will be necessary when the boulevards are built round the lakes We have made preliminary designs and estimates for these bridges. The Commonwealth avenue bridge will be 950 feet long by 55 feet wide, but it is designed so that it may be extended laterally to double that width. It will be of reinforced concrete. When I prepared my estimate I did not anticipate giving evidence upon the avenues. As I have included in the estimates of the cost of the avenues the cost of the approaches to the bridges, I now omit those figures from the cost of the construction of the bridges, and estimate the cost of the Commonwealth-avenue bridge as follows:—

	£
Excavation for the sub-structure, 19,000 cubic yards at 2s. per cubic yard	1,900
Plain concrete, 8,400 cubic yards at 50s. per cubic yard	21,000
Reinforced concrete, 5,150 cubic yards at 70s. per cubic yard	18,050
Total excavation and concrete cost... ...	40,950
Add 10 per cent.	4,095
Grand to'al	£45,050

259. *To Senator Story.*—At present prices, a steel bridge would cost more, but in any case a reinforced concrete bridge would be much cheaper in the long run. The cost of maintenance would be practically nil, whereas it would be a large item on a steel bridge. As the proper policy in regard to Commonwealth investments is "long life," I have suggested reinforced concrete.

260. *To the Chairman.*—The Federal-avenue bridge will be of the same design. I estimate that it will cost £44,176. For the West Beach boulevard we have prepared a design for a lighter bridge 900 feet long by 35 feet wide, estimated to cost £31,500. It will not carry such heavy traffic. For the Arboretum bridge, because of the depth of the water, we have designed a steel suspension structure with long spans, which is estimated to cost £35,000. For the aquarium pond inlet bridge we have estimated the cost at £5,000; for the Domain Harbor bridge, 300 feet long, we estimate the cost will be £10,000; for the Australasia Circuit bridge, 600 feet long, figuring on the basis of £1 per square foot, which is practically what the other designed bridges work out at, we estimate that the cost will be £20,000, but that bridge has not yet been designed.

261. *To Senator Story.*—All the straight and regular are lines of the lakes will be faced with steps; that is to say, all the regular portions of the east basin, the central basin, and the west basin, and the esplanade on the west lake. Below the steps there will be pitching covering the slopes of the ground. In the shallow depths the concrete stepping and pitching will be held on a system of piling, but in the deep parts the pitching will be carried to the bottom of the lake and anchored to a concrete mass. There will be 5 feet of steps with a 1-foot tread and a 6-inch rise. I estimate the cost of that work at 50s. per cubic yard. The concrete will be 4 inches thick. This should be quite sufficient. It will be as permanent as any stone, and is quite a common thickness in pavements. There will be concrete work where there is filling to be done, but I would not do it for a period of years after the filling has taken place The pitching will be carried down in a straight slope below the steps. It will be rough pitching, as it will not be exposed to sight I estimate that the cost of pitching not including the labour of putting it in position, will be 1s. 9d per cubic yard, because a large part of the material can be got close alongside I refer to stone broken into about 4-inch sizes The pitching will not be in the nature of a pavement, it will be set in a face commencing at 14 feet below water level In the case of the west lake esplanade, I estimate the cost at 1s. 9d. per cubic yard, and the cost of labour at 2s. per square yard. In another spot the cost will be 1s. 4½d. per cubic yard, because the material will have to be carried a lesser distance. Much of the stone can be picked off from the surface of the hills. It is now broken up to a suitable size, and has merely to be raked up. There is hardly any possibility of any variance between my estimate and Mr. Hill's estimate as to the size and shape of the lakes. The original scheme has been modified, and, in making my calculations, I have adopted the approved design. The excavation required to maintain the circular form of the eastern basin will be 361,000 cubic yards allowing for the promontories to remain, because of which it will not be entirely circular.

262. *To Senator Keating.*—I have not said that around many parts of the lake there will be a retaining wall, such as runs around Farm Cove, Sydney Harbor I have never had that idea before me My idea has always been to give immediate access to the water, so that one can walk right down to the water's edge anywhere. My description in my preliminary report will settle that point. However, the whole of the step revetment can be omitted, if necessary, for economy's sake, and we might have a sandy beach only but I have put this down as the ultimate scheme. A sandy beach could replace a great portion of the step revetment with considerable effectiveness.

263. *To Mr. Finlayson.*—The water follows the natural contours to the extent of 30 miles against 5 miles of artificial shore line. It will be economy to carry out the step revetment and pitching at the beginning, before the lakes are filled. If it is proposed to carry out any portion of that work at a later period, the lakes will have to be drained in order to do it. The boulevards, also, which are one of the *raisons d'être* of the ornamental waters, will have to be delayed, because they are formed right to the edge of the water. My estimate is not merely that of the cost of making the lakes, for the same operation forms the boulevards, wherever they adjoin the lakes, and those boulevards are essential thoroughfares of the city. We take stuff from the lakes to make them, and we form banks with the material we obtain in cutting them down. In fact, we combine the two operations in one, so that I have had to include the making of the boulevards I estimate that the Yarrolumla weir and roadway can be built for £84,050 The roadway will be 36 feet wide on the top. I estimate the value of a roadway crossing there at £31,550 The weir will be 867 feet long. It will be a decidedly ornamental feature of reinforced concrete There will be a great many short semi-circular arches in the cored top The roadway will be about

8 feet above the water. Syphons of the same capacity as at the causeway will provide for getting the water away. I object to the introduction of a series of flood gates on grounds of expense, because the action will not be automatic, because, as the gates will be of metal, they will have to be replaced in time, because the cost of maintenance will be high, and because of their unsightliness. On the other hand, my scheme will be an imposing massive masonry structure, a substantial, handsome monumental feature of the city. The flood gates system will be much more costly. There would be a much greater water-area way. The flood gates should account largely for the difference between Mr. Hill's estimate of £107,000 and mine of £84,050. The concrete work in the syphon structure would be no greater than that in the proposed weir. The syphons would be accommodated in the mass of the structure, and piers would carry the top. The structure would rest solidly on the bed rock. The best method of satisfying the Committee as to the efficiency and reliability of the syphon system would be an exposition of the principles of hydraulics. The discharge of water through pipes under a head produces certain rates of flow that vary directly with the head. A hydraulic engineer could give the Committee reliable advice on this point. I should like to keep all *débris* out of the lake. A syphon system is the only method of dealing effectively with *débris*, and the lower lake should be clear of all flood matter of any appreciable size. If the eastern lake is not constructed it would probably be well to erect a boom in the upper reaches, in order to keep back flood *débris*, but I do not know where that system has been tried successfully.

264. *To Mr. Fenton.*—I have not said that I would not have a sluice gate for the purpose of draining the lake so as to control the water at the bottom, but that is a very small affair. Such a gate would clear away anything that might accumulate at the bottom; it could also be used for the purpose of clearing silt from the face of the dam, but it would not justify itself on that account alone. It would not be the cheapest method of accomplishing that end. I prefer to do without sluice gates, except for the purpose of draining the lake. That is, however, such a small item that it is not necessary to consider it in framing an estimate. If I had a sluice gate, it would be at the bottom of the weir for the purpose.

264A. *To Senator Keating.*—Possibly I have suggested that sluice gates might be put in for the purpose of supplementing the syphons; but, on the ground of economy, I do not advise that it should be done. I would rather have more syphons, since they would be more economical. The bottom sluice gates and the syphons would have the same rate of discharge.

265 *To Senator Lynch.*—My estimate of the amount of filling, namely, 1,333,500 cubic yards, is what will be required to finish the lakes system on the adopted plan. In some cases the material will be obtained from the bottom of the lakes; in other cases it will be obtained from the top in the making of the boulevards. The shallowest portion of the lakes is in the eastern basin. Where the lakes are quite shallow we strip the bottom to form the banks at the side. Of course, the material is sometimes of smaller quantity *in situ*, except in the case of alluvium. The other materials are taken to differ to the following extent:—Loam, 1.1; sand and gravel, 1.2; clay, 1.15; schist, 1.4; decomposed rock, 1.3. We have had to assume that the geological survey is correct. The borings we have taken are accepted as an index of the material there, and they are presumably not far out in the classification of it. The filling really represents work that would have to be done in order to build the roads in the neighbourhood of the lakes, while in the eastern basin, where we require a greater depth, we shall effect an improvement to that basin by taking from it the material required for the boulevard alongside. As I have not my drawings with me, I cannot say what proportion of the filling represents the amount of cutting on the banks of the lakes. It is, however, a very large proportion; in fact, we have chiefly resorted to taking material from the lake in the eastern basin and in the west lake for the west shore boulevard. I do not think that this fact has led to confusion between Mr. Hill and myself in respect to our calculations So far as I am aware, we have allowed the known hard places in the bottom of the lake to remain. Practically all the material which will be used from the bottom of the lake is silt. This work should have priority over the Yarrolumla weir. I have considered the question of building the weir first, and flooding the country, and afterwards removing the stuff by means of a suction pump; it might reduce the cost somewhat; I have not gone into it in detail, but as the work is scattered over such a large area, and as we are using different materials in special ways to form an earthbank, I consider that the simplest method, and the cheapest, would be to use dry material. If we merely had a basin to fill up, without any forming to be done, it might be cheaper to have silt suction. In connexion with a work involving such a large amount of earthwork, running into millions of cubic yards, we must bear in mind that it can be handled in a wholesale way at nothing like the same rate that applies to small operations, because we can use heavy machinery to handle the material rapidly and in large quantities. Such a plant would be fully justified. I know that in some reclamation works material is shifted at a fraction of a penny per cubic yard, and I have investigated the method of removing silt in Port Philip, but I have come to the opinion that because of the particular places where we will require to place this material, everything favours dry handling. We are taking it quite a distance in some cases—too far to move it with a suction dredge. It will be used for building the approaches to bridges and will be moved several hundred feet away, and as high as 25 feet above water level. The proposed thickness of the concrete step revetment—4 inches—will be ample. The highest wave action will be 3 feet, but as that means a rise above mean level of only 1½ feet, and as the revetment will be lying at an average pitch of 1 to 2, there will be ample protection from erosion by wave action. That action will not be continuous. Scarcely ever more than 3 inches of concrete is placed on basement floors, which have to stand the heavy impact of solid material. Where there has been any filling on the bank, the ground will have to stand for years before the step revetment is built. I prefer a concrete frontage to a grass frontage to the lakes in the centre of the city. It will be easier to maintain. It will always be ship-shape It will give the crowds access to the water's edge at all time for the whole length. We want the use of the water uninterfered with. I propose to put this concrete frontage on the basins and on the other formed regular portions of the water's edge.

266. *To Senator Keating.*—I have not discussed this method of formation with Mr. Hill. The section showing the step revetment has been prepared for the last six months, but I have had that method of formation in mind for the last three or four years. I propose to have this revetment only on the regular lines of the basins. The shore of the western lake, with the exception of the boulevards, will be left in its natural state. Ultimately the step revetment system would have to be undertaken, because of the economy of maintenance; but the primary ground for having this revetment is its effectiveness. Certainly the first cost would be greater, but it is not a large item, not as much as I thought it would be. At first, on the score of economy, I thought it would be necessary to recommend sandy beaches. Most of the shore can be made in a regular form with sandy beaches, and it is possible to do so even where I propose to have the steps, but in the city these beaches, will not have anything like the effectiveness of steps, speaking from an architectural point of view. I do not think that continuous stretches of step revetment will be monotonous. On the other hand, I think they will be very impressive. This stepping is the stylobate of the Greek temple. It will be easy to get up and down. Boats can come right alongside the steps as in Venice. It will be useful for children playing with model boats. Apart from that, there is no mechanical or engineering advantage in having them, but the step formation will least display any variation in the water level, such as a plain revetment would, and it will also minimize the effect of wave action.

267. *To Senator Story.*—Speaking from memory, the cutting and filling is about balanced—half of each. It is all plotted on plans. The filling must stand for at least two years before it will be fit for steps or pitching to be placed upon it. In regard to the east basin, I estimate the cost of the rough pitching at 7½d. per cubic yard in one spot, and 9d. in another. In the former case the material will be taken from a railway tunnel to the north, and brought down by cars and dumped where it is to be used. Most of the charge in regard to that material is already included in the estimate of railway construction. The 7½d. per cubic yard refers to the additional cost of moving it from the cutting to the basin.

268. *To Senator Lynch* —I do not know of any problem in the Commonwealth exactly like this, in which a large amount of earthwork is handled at one time by machinery. There is very little of it done. On the other hand, in countries where they do handle large quantities of material, the prices are low in comparison with my figure, which is 4½d. In any case, portion of the calculation by which I arrive at that figure is based on actual experience in the Commonwealth, the best being that of Mr. Catani, the Victorian Engineer for Works. I cannot say that, as a contractor, I would undertake to do the work at the figure. I have no motives in submitting an estimate above or below the truth. The nearer the truth it is, the nearer the result will check out in the end. That is what counts with me. It is my opinion that the work can be done for that amount, and if it is carried out on these lines I shall have the responsibility.

(Taken at Melbourne.)

THURSDAY, 9TH MARCH, 1916.

Present:

Mr. RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson.
Mr. Fenton,	

Thomas Hill, engineer, Department of Home Affairs, recalled and further examined.

269. *To the Chairman.*—I produce a plan, to a scale of 400 feet to the inch, on which is shown in blue what would be the outline of the artificial pieces of water at Canberra were the natural contour of the 1,825 level adopted for their limits. From Yarrolumla to the west lake the water area would be practically the same as that shown on the schematic plan, except at the southern bend, where what is known as the esplanade appears on Mr. Griffin's plan. The surface area of the whole body of water would be about the same in extent on both plans, but the regularity of outline shown on the schematic plan is not obtained by following the natural contour line As Senator Lynch wished to know if the length of roads would be increased by following the natural contour line for the limit of the lakes, I have taken rough measurements, and find that the roads round the lakes would be much the same in length in both cases. The 1,825 contour line was suggested by Mr. Scrivener as that which would give the best depth of water for the lakes. I have taken out a number of sections within the city area, and find that to give a depth of 2 feet 6 inches at the edge of the lakes, which I deem to be desirable, would require the excavation of about 250,000 cubic yards of material This excavation would cost £15,000, at 1s. 3d. per cubic yard.

270. *To Senator Story.*—At 5d. per cubic yard, it would cost £5,000.

271. *To the Chairman.*—The work could be done with ordinary ploughs and scoops, because the leads would be short.

272. *To Mr. Fenton.*—No excavation of the lake bottom would be necessary. The general depth of the lake would not be interfered with.

273. *To the Chairman.*—To fill in the bay shown on the map to the right of the area set apart for zoological gardens would require about 390,000 cubic yards of material. As for the terrace on the south side of what is known as the segmental lake, its construction for about 1,600 feet on each side of the Ainslie axis would be easy, but further out on each side you would get into deep water.

274. *To Mr. Gregory.*—Some formal treatment of this frontage, whether the line be made straight or curved, would be an improvement, though I cannot see that it would interfere with the general plan to leave out the proposed wall.

275. *To Mr. Fenton.*—To leave out that wall would not interfere with the construction of the bridge at the upper end of the segmental lake.

276. *To the Chairman.*—The construction of that wall is a work that could be done at any time

277. *To Senator Lynch.*—A depth of from 2 ft. 6in. to 3 feet at the edge of the lake would be sufficient to prevent trouble being caused by aquatic growths. Ultimately it would be necessary to pitch or beach the lake edges in places.

In my opinion, it would be best to protect, directly it was made, any cutting that was likely to fall in or to be scoured out.

278. *To Mr. Fenton.*—I would suggest the pitching of the bank or wall in front of the area on which the Parliament House would be situated, and probably pitching would have to be undertaken in other places. When a bank is pitched," it is faced with regularly cut stones or concrete; "beaching" is to cover a bank with rock or gravel, crushed to a certain size, and laid on thickly.

279. *To Senator Lynch.*—I would not undertake any excavation until it became absolutely necessary. The lake level could be lowered sufficiently at any time to do the work that I suggest. There would be no immediate necessity for this excavation.

280. *To Mr. Sampson.*—It would be done a bit at a time, as funds would allow.

281. *To Senator Lynch.*—The pitching or beaching should be done immediately after the excavating, in order to give the banks the protection that they needed. I do not think that the Yarrolumla dam should be constructed until there had been taken from the river bed all the gravel and sand needed for the construction of the capital. The deposits of these materials are too valuable to be submerged. Furthermore, some of the soil within the limits of the lakes may be needed for surrounding slopes. The construction of bridge foundations, and similar work, should be carried out before the flooding of the lake area. The construction of the Yarrolumla dam is a work that could wait for some years, because to impound a large body of water in the middle of the city area, before the means of communication across it had been completed, would interfere with construction. In the early years of the city it should be possible to cross the Molonglo at a number of places without having to cross bridges. Although the Molonglo could be allowed to flow through the dam, so that the lake area would not be flooded until everything was ready, I do not think that it would be economical to erect the dam years before it was needed. I do not consider the dam necessary at this stage. Some years must elapse before it will be necessary. I consider that a railway and a road bridge over the lake area is the first work that should be performed in connexion with the lake scheme, because it is important to provide uninterrupted communication across the Molonglo. I should not do any work to the lake basins, or commence the dam, until the construction of the city was well advanced We cannot obtain gravel and sand in the district except from the river bed I think that the parliamentary buildings, though not then completed, could be made ready for occupation within three years, if sufficient funds for their construction were available, and our preparations for supplying light, power, and a sewerage service are so well advanced that they would be finished within that time.

282. *To Mr. Gregory.*—I think that a decision should be come to regarding the general plan of the lakes, but it is not necessary to make the dam to fill the lakes at the present time In my opinion, it would not interfere with Mr. Griffin's plan if the straight frontage of the segmental lake were reduced, and a considerable saving would be made by terminating the straight wall at points 1,000 feet on each side of the Ainslee axis. The departmental plan provided for a circular bank or wall. I do not think that a large quantity of earth will be needed for filling in the roadway round the lake. We have tried to limit the excavations and filling to a depth of 5 feet. There would, however, be pockets beyond the road which it would be necessary to fill. The amount of filling to be done would be reduced by following the natural contour at the 1,825-feet level for the limit of the lakes. The lakes could be filled before the deepening of the edges was undertaken, and dredges or suction pumps could be used to do the excavation, but the material to be removed is so fine that that would not be an economical arrangement. In my opinion, it will be at least ten years before the lakes can be filled. We have discovered that the deposits of gravel and sand within the district are not so large as they were at first supposed to be, and they are pretty widely spaced. We have exhausted the deposits near Acton, the next nearest deposit being close to the power house. There we have tested the river bed over an area of 800 square yards, and have proved it to a good depth. The deposit is sufficiently large to meet the requirements of a town of 20,000 inhabitants. The next deposit is 3 or 4 miles higher up the river, beyond the College. The cost of building the city would be increased if this sand and gravel were submerged. Below Yarrolumla there is no sand or gravel in the river bed.

283. *To Mr. Fenton.*—The excavation at the lake edges, of which I have been speaking, would be necessary to give a minimum depth of 2 ft. 6 in. It would cost about £15,000, and as time went on, about the same amount would have to be spent in beaching or pitching the lake shores, but that expenditure could well be spread over a number of years. The whole work could wait until we had taken from the river bed the material needed for building purposes.

284. *To Mr. Sampson.*—Nothing need prevent the execution of Mr. Griffin's design for the lake basins ten or twenty years hence if the erection of public buildings were commenced in the meantime. The lake basins ought to be formed before the lakes were filled.

285. *To Mr. Finlayson.*—Probably the exact outline of the lakes could be better determined at a later period, when the construction of the city had been advanced to some extent. There would be nothing to prevent the adoption of any design that might be approved of at some subsequent date, if it were determined beforehand to make the 1,825 contour line the limit of the lakes.

286. *To Senator Story.*—A road bridge and a railway bridge across the Molonglo should be made before the construction of Parliament House, or at the same time. Those works are correlated. It is not, however, imperative that these bridges should be constructed before, or at the same time as, Parliament House, because the existing railway would serve.

287. *To Senator Keating.*—Once the lakes were filled, it would be difficult to carry out bridge work, or the construction of formal basins. Of course, the water could be run off, and the lake area be left empty for six months or a year, but, if that were done, the mud and decaying vegetation at the bottom would probably cause a nuisance. If possible, the lake basins should be constructed before the filling of the lake. Apart from the trouble, the nuisance caused by the emptying of the lakes, the work of making the basins could, of course, be as easily carried out after the water had been drained off as before it had been allowed to accumulate, but it would probably take at least a month to drain the lake surface sufficiently. My estimate of £15,000 provides only for excavation work round the lake shore, to provide a minimum depth of 2 ft. 6 in. In the lower parts, away from the city, the slopes would be left untouched. At the Yarrolumla end, the lake shore would be the natural surface of the ground, and there would be beaches. That, I think, would be the arrangement under any plan.

(*Taken at Melbourne.*)

WEDNESDAY, 17TH MAY, 1916.

Present:

Mr. RILEY, Chairman;

Senator Lynch,	Mr. Finlayson,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Walter Ernest Cooper, Builder and Contractor, Melbourne, sworn and examined.

288. *To the Chairman.*—In my evidence I am speaking also on behalf of Mr. Davies, of Davies Brothers, contractors, of Melbourne, who have just completed the Preston Reservoir. I have had a large experience in earthworks. I had contracts in connexion with the inlet and the outlet channels to the Waranga Basin, the outlet channel from the Goulburn Weir, under the State Rivers and Water Supply Commission of Victoria, and the earthworks and canal connecting the Murrumbidgee with Yanck at Narrandera for the Yanco irrigation scheme, under the New South Wales Government. On these works we used extensively steam scoops and steam ploughs and other methods which are suitable where required. I have used steam scoops for cuts 26 feet deep, with 1½ to 1 slopes, and in some cases with leads of from 80 feet to 200 feet. Some of those machines are still available and can be secured if the Government wish to use them. We carried out the work at Waranga very cheaply, reducing the cost in some cases with the scoops to 3d. and 4d. a yard. It was particular work, easily shifted, and the cuttings were such as made it pay to put large machines on. We carted them over to New South Wales, although they were heavy, and worked very profitably with them there. I visited the Federal Capital site in April, with Mr. Davies, and spent the whole of Tuesday and Wednesday inspecting the sites for proposed avenues. I viewed the terraces, embankments, and lake sites in company with the local engineer and Mr. Whiteford, and made exhaustive inquiries into the quality of materials to be excavated and the distances the material would require to be hauled, and have carefully read the evidence of the engineers before the Committee and find that they disagree with regard to quantities. The stone would have to be blasted and loaded by mechanical means into trollies and taken by gravitation or other means, as the situation warranted, to the long distances as required to be filled. A great quantity of this stone could be squared and used for pitching the banks of the lakes. Owing to the want of information, I cannot give an accurate estimate of the cost of these works, but will give a schedule of rates that, when extended against the quantites, nature of material and distance of leads, computed by the engineers later on reliable data, will be the best I can offer to the Committee, viz.:—

Earthworks that can be ploughed or scooped—

Up to 2 chains lead, using steam scoops, 6d. per cubic yard.

Up to 4 chains lead, using steam scoops, 8d. per cubic yard.

From 4 chains to 10 chains lead, mechanically handled, 1s. per cubic yard.

If material carted—

10 chains to 40 chains, 1s. 6d. per cubic yard.

20 chains to 80 chains, 1s 9d. per cubic yard.

If stone excavations have to be blasted, add 6d. per cubic yard.

Estimates for blasting and loading by hand are based on present rate of wages paid.

It is not possible to give the Committee a rough estimate of the cost of shifting material until we have a knowledge of what the material is. We might find 2 feet of soil on the surface and 20 feet of schist underneath It would cost 6d a yard more to blast out the rock than if we could plough the material out all the way down. Soil can be handled mechanically much cheaper than schist or stone Judging by the surrounding country we think it will be found that two-thirds of the cuttings are stone, but there are no bore pits to judge by We cannot estimate how much it will cost to shift per yard unless we have plans showing the different quantites of dirt and stone and the amounts to be deposited in the different sections.

In regard to pitching—

Stone quarried from hills and cuts for 9-inch pitching, to set on lake beds and banks, would cost 6s. 6d. per super. yard.

Concrete pitchers set on lake beds and banks would cost 9s. per super. yard.

Massed concrete for puddled cores, &c., 35s. per cubic yard, with cement at present prices.

None of the engineers agree about quantities in the evidence they have given to the Committee, the reason being the same as in our case, that they had no reliable data as to quantities. The rates quoted by me are only for a large section or for the whole of the work. They would not apply to a small section, because it would not pay to put in a proper plant We estimate on an economical plant that can be shifted from one spot to another. If the Government required the work done more quickly, the plant could be duplicated It might be possible to get the work done at those rates in third or quarter sections, but the Government could not ask half a dozen contractors to tender for half a dozen bits of the work at those prices. If the sections were too small, the price would go up. For filling the banks and the sides of lakes, material could be got from pits in the lake beds, which could be ploughed and scooped and shifted more cheaply than stone

289. *To the Chairman.*—The filling and cutting around the lakes could be taken on the same schedule as the streets, as the materials are practically the same, and the leads could be found by the engineers. The pitching should be taken from the toe of the bank up to the high-water level We had experience with schist pitchers in the Waranga Basin, and these were got from in and

around the vicinity, and used successfully. They are quite as good as concrete blocks, and would cost about 2s. 6d. a yard less.

290. *To Mr. Laird Smith.*—The erosion of the banks would not be very great if they are properly pitched. I would carry the pitching high enough to allow for the wave action. At Waranga Basin, after the work was completed, the erosion at the bottom and a little erosion between the pitchers caused the pitching to slip down, and the work had to be repaired.

291. *To Mr. Finlayson.*—I would not use a smaller pitcher than 9 inches, except for packing between the stones. The pitching must be done before the water is allowed into the lakes. By high-water level" I mean the point reached by the highest wave. That can be computed by the engineers. The wave action on the Waranga Basin is considerable Where the bank is composed of hard rock, there will be no need for pitching. I have not estimated the quantity likely to be required.

292 *To Mr. Sampson.*—It is six or seven years since we finished the Waranga Basin channels. The only difference is in the cost of labour. At Waranga, our price was 1s. 1d. a yard up to 80 chains, with labourers' wages at 6s and 7s. a day. Wages at Canberra are now between 13s. and 14s. per day. We had a contract for four miles of inlet channel at Waranga, following the contour of the country, 80 feet on the bed, at an average depth of 5 or 6 feet, for 5d. a yard, all ploughable stuff. On the outlet channel we had a section of rock 26 feet deep, which had to be blasted, gone through afterwards with a mechanical plough, and scooped out with a mechanical scoop. Our contract for that was 1s. 2d. per yard. Only our experience in carrying out the work at Waranga enables us to compare the work there and at Canberra. You could not do it. Where the loads are not long, you can use horse or steam scoops, but when you get over a ten-chain lead you have to carry the material in trollies or trains, which means laying down a line, ballasting, &c. We are allowing 1d. per yard extra over the 5d. rate we received at Waranga to cover the increased cost of engine-drivers for the work on the banks of the lake. There will be no labourers required there.

293. *To Senator Story.*—It would not be safe to use lighter pitchers than 9-inch. We considered Mr. Griffin's evidence, in which he estimated the cost of rough pitching at 1s. 9d. per cubic yard, but we could not arrive at the depth of pitching he proposed in order to get his cubic measurement. We got four yards of super. out of one cubic yard, with a nine-inch depth. If he stated his depth of pitching, we could criticise his estimate. I do not think Mr. Griffin's proposal to use stone broken to about four inches, dumped roughly down the banks, and spread there, with pick or shovel, would be effective. I have had experience where that plan has not been effective in practice. Nine-inch pitching is the only permanent way of doing the work. At the Waranga Basin, a certain area was done by dumping rough stone up to the line where the waves struck the bank, and then putting regular pitching on top of that, but it did not work. Four-inch concrete steps, as suggested by Mr. Griffin, if put on made-up ground on the banks of the lakes above the pitching would not be solid enough, unless reinforced. I put a concrete bottom on the Elwood Canal on a sand filling without reinforcing it, and it went to pieces, although sand is not nearly as likely to yield as earth. An immense amount of filling would be required at the ends of the segmental basin in the hollows between the proposed avenues and the straight edge of the basin. If the proposed Commonwealth-avenue running between the segmental basin and the western circular basin is constructed at the high level proposed by Mr. Griffin, the filling required in the low-lying country at the side will be enormous from a builder's point of view. If that land was filled in it would be impossible to build on the filling because you would have to go down, in some cases, to a depth of two or three stories before reaching the solid foundation, and, therefore, the only buildings that could be put there would be warehouses. The question of using that land for parks is a matter for the engineers. The quantities of filling given by the engineers to make that avenue, and the other which runs across at the other end of the segmental basin, do not include the filling that would be required on each side to fill up the low portions of the ground, which would be of no use unless filled up. If the ordinary contour of the country was followed by the lakes, instead of the proposed geometrical design, it would be far better and more economical, and enhance the beauty of the lakes. The proposed regular line of the segmental basin will, when made, look just like a wharf; and the land that it is proposed to fill up to secure a regular shape will be useless in any case for anything but gardens A good deal of filling will also be required on the curved side of the segmental basin, and there will be a lot of filling in required at each corner on the straight edge.

(Taken at Melbourne.)

MONDAY, 13TH NOVEMBER, 1916.

Present:

Mr. RILEY, Chairman:

Senator Keating	Mr. Finlayson,
Senator Lynch,	Mr. Gregory,
Senator Story,	Mr. Sampson,
Mr. Fenton,	Mr. Laird Smith.

Walter Burley Griffin, Federal Capital Director of Design and Construction, sworn and examined.

294. *To the Chairman.*—I submit new diagrams in respect of sections 11, 12, 31 and 33 on the embankments for the lakes, to replace those which, as originally supplied to the Committee, were incomplete. I have received from the Committee a request for replies to the following questions:—

1. In connexion with the earthworks involved in the formation of the water areas in accordance with your modified design, please state—

Eastern Basin—
Excavation.—Number of cubic yards, average price per cubic yard, total.
Filling.—Number of cubic yards, average price per cubic yard, total.

Molonglo or Segmental Basin—
Excavation.—Number of cubic yards, average price per cubic yard, total.
Filling.—Number of cubic yards, average price per cubic yard, total.

No. 3 or Western Basin—
Excavation.—Number of cubic yards, average price per cubic yard, total.
Filling.—Number of cubic yards, average price per cubic yard, total.

Western Lake—
Excavation.—Number of cubic yards, average price per cubic yard, total.
Filling.—Number of cubic yards, average price per cubic yard, total.

2. Is there any instance where earth excavated is to be used for the purpose of filling? If so, indicate the number of the section, what quantity of excavation is to be so used, and where is it to be disposed of as filling?

3. You are also requested to furnish the Committee with diagrams of those sections of the banks which, as supplied to the Committee in the first instance, were incomplete.

It has not been possible for me to prepare answers for that series of questions. I arrived at the estimate which I have placed before the Committee by calculating that so many yards of material would have to be excavated here and there, carried various distances, and deposited as filling, but to divide up the work in the manner required by the questions submitted to me, and to compute the quantities of excavation separately, would take a great deal more time and energy than I have at my disposal. Perhaps the members of the Committee do not understand what is involved in their request. When I gave my estimate to the Committee, I accompanied it with all the information that was available. To make out the estimate in another form, with other details, would require a great deal of time. I have had further surveys made, and I have sent abroad for information from those who excavated the Panama Canal, as to methods for handling this material. It will be some time before I can receive that information. I stand by my estimate as correct—that is by the aggregate estimate, the details, and the prices To divide up that estimate under another system of details would mean that I should have to go through the whole work again from the beginning. I first satisfied myself that the filling would be in excess of the excavation, and therefore treated it all as filling. To say exactly how much would be excavated from certain points, how much would be deposited at other points, how much would have to be allowed for shrinkage, and so on, is a thing that I could not do at a few weeks' notice. If an engineer were asked to undertake such a job, he would charge 2½ per cent. on the cost, or £2,500, which is more than the cost of my office for a period of six or eight months. I have already supplied the Committee with details relating to my estimate. I have given the best information at my disposal, and have said how my computation was made. To make the computation on a system suggested by some one else, I should have to start all over again. It took some months to prepare the estimate that I have already furnished. I have stated the quantity of filling, but I cannot give the quantity of excavation. Nothing would be gained by figuring on both filling and excavation, as one cost covers both operations. Instead of dividing my estimate, and putting down so much for excavation and so much for filling, I have given the cost of removing earth from one place to another, and the distances over which material will have to be transported. Before I can furnish more accurate estimates, I must have the whole plan of operations determined, the lay-out of the tracks, the equipment and machinery. I have given you the best information now available on general cost data. I cannot give you more details until I know definitely how the work will be carried out In my opinion, my figures are more accurate, and were more carefully worked out than those of the Department of Home Affairs.

295. *To Mr. Fenton.*—I have furnished the Committee with details which cover two or three pages of evidence. I have stated the quantity of material to be moved, the nature of that material, and the cost of moving it, but before I can say exactly where material is to be excavated, I must have more information as to the methods to be employed. I know that certain quantities will not be exceeded. That is all that it is necessary to know in connexion with the present estimate

296 *To the Chairman.*—In stating that an engineer would charge £2,500 to furnish the information for which you ask, I am stating the regular fee of an engineer for the class of work required I am aware that my estimate differs from that of the Home Affairs Department, but I am not responsible for the difference. I stand on my figures, having done everything possible to make sure of their correctness. They are only an approximation, and when I have laid down a plan for the whole work, I shall be able to get nearer to the actual cost.

297. *To Senator Keating.*—My estimates of cost are contained in paragraphs 233 to 240 of my evidence, given to the Committee on the 7th March last. My estimate was not a mere guess, it was the result of computation. I lumped the excavating and filling grossly, without going into the details on which the Committee now ask for information. As the filling was greatly in excess of the excavating, I dealt with it only. My plan is to utilize the excavated material for filling. Nothing would be gained by estimating separately the cost of excavating and filling. One price covers both operations. In my estimate the cost of excavation is included in the cost of filling. I have seen the estimate of the departmental officers. They have not lumped together the excavation and filling, but as nearly as I can make out, have double-banked their estimates, giving a price twice, once for excavating and once for filling. That is an entirely improper procedure. I believe that the departmental officers took out the excavation quantities separately; but no additional information is conveyed by such detail. If material is taken from one place, and deposited in another place, one price covers the whole operation. It would create confusion to deal with excavating and filling separately. You cannot divide the charge between the two operations.

298 *To the Chairman.*—I have taken into account the cost of haulage, and have stated the distances over which material will have to be hauled.

299. *To Mr. Fenton.*—It would not be easy to say how much should be charged against excavation, and how much against filling. All I can say is that the filling exceeds the excavation. Some filling will have to be borrowed, because of the difference between excavation and filling.

300. *To the Chairman.*—I have made an estimate of the quantity of material that will have to be borrowed. I furnished the Home Affairs Department with the drawings on which my estimate was computed, and gave the officers of the Department all the information that they wanted about those drawings.

301. *To Senator Keating.*—To determine in detail where the excavated material shall be placed requires a knowledge of the lay-out of the plan of operations, including a knowledge of the size and cost of the machinery that is to be used, and of the methods of transportation. I am trying with the help of the best information obtainable to reduce costs to the minimum. I am not prepared to commit myself to statements as to the actual handling of the work until I have got the whole programme laid down. There are alternative methods, and it is necessary for me to get further information before I can speak as to the cheapest way of doing the work.

302. *To the Chairman.*—I have not departed from my original estimate of cost; I am seeking

information from America because this is an important undertaking I have sent to America maps showing where the cuttings are to be made, and where the material lies. I furnished all the information that a contractor would furnish, that is, an estimate of cost, no contractor would give away the details of his business if he were asked how he proposed to economize. I have stated prices for excavating and filling, but you are now asking, in effect, what plant I propose to set up, and how I am going to transport material. I have treated the whole scheme as one work; I have not dealt with each lake basin separately. That could not be done without affecting the cost of construction. If the Committee will say what particular work it wishes for information about, taken by itself, I shall try to get out figures relating to that work alone But I do not commit myself to any quantity of filling or excavation for any separate portion of the lakes scheme. I am trying to distribute the excavation and filling in the most economical way possible, having regard to the scheme as a whole.

303. *To Senator Story.*—I have given information to the Committee regarding the quantities of filling They are separate so far as I was in a position at the time to make such estimates. Paragraph 240 gives detailed information, cutting and filling being dealt with as one operation. My estimate of 361,000 cubic yards for the eastern basin is an estimate of filling which includes excavating. I could not say, without going through my figures again, whether all the filling required for the eastern basin would be excavated from that basin. The total cost, which was worked out on separate prices, averages 4.3-5d. per cubic yard. As to the estimate for the central, or Molonglo, basin, I cannot say that the price of the excavating and filling would be the same, but the average price for the whole lake scheme would be 4.3-5d. per cubic yard That average was obtained from a number of individual prices. You must remember that this is merely a preliminary estimate, to be verified by the laying out of the work. I reserve the right to vary my estimate if I can obtain greater economy. The present estimate is not mere guess work. It is based on items that were taken out, but I do not wish to commit myself to details

304 *To the Chairman.*—My estimate is a more detailed estimate than that of the Department, and the cost of the work may be lessened, though some details may be increased in price while others are reduced.

305. *To Senator Story.*—The sum of 4.3-5d. per cubic yard covers excavating, haulage, and depositing filling in position.

306 *To Mr. Fenton.*—I stand by my statements to the Committee, but I cannot commit myself in respect of each individual item. That cannot be done until the work has been properly laid out.

307 *To the Chairman.*—To carry out a part of the scheme would increase the cost, but I cannot say now much The prices that I have given depend on the cost of machinery being charged against the whole work. If the cost of machinery were charged against part of the work, it would increase the cost of that part. If I were to state a price for the construction of any one lake, I could not say that other parts of the whole work would be carried out for the same price. The earthwork can be handled for the prices I have given only by treating the whole of the city excavation and filling as one work. That reduces the unit cost.

308 *To Mr. Finlayson.*—My remarks apply to the causeway, because its construction will depend on the machinery provided for the work as a whole.

309. *To Mr Fenton.*—I understand that the departmental officers used the information that I furnished in supplying their revised estimate. In the first instance, they used drawings which did not conform to mine.

310. *To Senator Story.*—My reference to the cost of excavation at the Lang Lang swamp was merely to give an illustration of the economy that can be effected by using certain machinery. Having gone into the merits of various machines, I have come to the conclusion that that used at Lang Lang would not be adapted to the work that has to be done at Canberra. I was present when Mr. Catani stated before the Victorian Society of Engineers that the excavation at Lang Lang had cost 6d. per cubic yard over a period of twelve months At the time that I gave my evidence the cost of excavation there was only 1.903d. per cubic yard. Since then, they have had trouble with their machine, but they are now getting better results. My estimate was not based on the price I quoted. In my opinion, the material at Canberra will be easier to remove than that at Lang Lang. Only a very small proportion of the material at Canberra is hard shale—less than 1 per cent. There is also a small quantity of gravel and sand, but most of the material is alluvial soil and silt. Bores have not been put down over the whole area, but some bores have been put down, and there are natural water sections in parts of the area where bores have not been made. To estimate the actual quantity of excavation would be very laborious, and I do not think that much advantage would be gained from the possession of this information. You can take it for granted that every bit of the filling will have to be excavated. What affects the estimate is the fact that the quantity of filling will be greater than the quantity of excavation. I do not ask the Committee to take anything for granted. Every contractor measures his earthworks in the terms of the greater operation. If that were not done, there would be confusion. I cannot answer for what the officers of the Home Affairs Department have done. It would be a very big job to make an estimate of the excavation alone. It took me some months to arrive at my estimate of the amount of filling to be done. To do what the Committee has asked would mean going right through the figures again. I only know that the gross total of excavation is much less than the quantity of filling required, that all the excavated material would be used in the earthworks. To give details regarding each excavation is to go further than is necessary for a preliminary estimate. To do the work rightly would be a big undertaking. We are taking every precaution to avoid uneconomic methods. It is physically impossible for me to furnish an estimate of the amount of excavation that must be undertaken. For some months I have been in attendance on a Royal Commission, and I ought to have been present this morning at the meeting of that Commission. What I am asked to do now is to make up a new estimate, using a different method from that which I adopted. I know that all the filling has to be excavated, and just where the excavation will take place does not affect the price so far as the preliminary estimate is concerned. The officer who first went into these matters with me is dead, but the work has been done over in my office three or four times, and completely checked. Separate officers made calculations, each in his own way, and this furnished a check.

I have given you the results of the various estimates There are in my office hundreds of pages of notes containing calculations. I have stated that the whole of the excavations in the eastern basin will be in silt. There is a shale projection on the south side that will be cut through, and used in another way, though I cannot now say just where it will be used. That information has been given to the Committee.

311. *To the Chairman.*—I cannot say how long it would take to furnish the information for which the Committee asks I could not say that without knowing how my other work in connexion with Federal Capital matters stood.

312. *To Senator Story.*—It is impossible to furnish closer estimates until information has been obtained regarding the plant to be used and the methods to be followed. To give merely the quantities of excavation without any statement of cost would be very misleading, because the cost of excavation has been taken into account in the estimate already put before the Committee. In asking me to say where every yard of material is to be obtained and to be placed, you are asking me to commit myself to a detailed plan of operations, which it is not possible for me to do now. I wish to adopt the most economical methods. As soon as the plant has been decided on, the methods of work to be followed will be determined, and more detailed information will be possible. I cannot give now more reliable information than I have given, and to attempt to do more would be misleading. I have not taken out the quantities of excavation necessary to give the eastern basin a circular form. More filling than excavating will be necessary to give it that form. I have given the quantities of the excavation in terms of filling necessary to do that. I have given the Committee evidence regarding the railways and the streets, and have computed the earthworks in one form or another. Were I to alter the form of my present estimate, it would affect my previous evidence, and cause confusion. My estimate was made in the form invariably adopted by engineers, and it would take me some months to recast it in the manner you desire. I am not unwilling to do what the Committee wishes, and have devoted every ounce of energy to meeting the Committee's wishes. No man could work harder than I do. The Committee must pay some regard to the conditions under which I am working just now. It is not fair to demand of me the work that is now asked for. Of course, if I were free of my other work, I could undertake the task that the Committee wishes to impose upon me, but at the present time my staff is engaged on works that are being carried out, or are to be carried out, at the Federal Capital. These include the erection of buildings for the Military College, the alteration of the operation of the brickworks, putting it on a practical basis, estimating the plant requirements of the plan of operations for the construction of the city, the designing of two alternative townships for the Commonwealth arsenal, the planning of a route for a railway to the arsenal, the erection of workmen's homes at Canberra and the arsenal, the construction of roads to give communication through the town and to the arsenal, the planting of forest reserves and parks, and numerous administrative duties connected with the power plant, the maintenance of roads, the leasing of properties, and the management of stores. It must not be forgotten that it is necessary to prepare estimates and plans before a work can be referred to the Public Works Committee. I have given you a general estimate, and I stand by it, individual estimates would be on a different basis.

313. *To Senator Lynch.*—My estimate of earthworks was calculated on the same plan as I furnished to Mr Hill I never discussed with Mr Hill an alteration of the outlines of the lakes. Many months ago I altered some of the details myself, but I made no alteration in consultation with Mr. Hill I showed a modified plan to the Committee at Canberra. The modifications were made on my own initiative, without consulting any one. I furnished to Mr. Hill the drawings on which my estimate was made, together with, I think, fifty additional sections that he asked for My calculation, and that of Mr. Hill, were based on the same plan, a plan showing elaboration in details I am prepared to stand by my estimate. I do not think that there is any error in it I admit that the difference between my quantities and those of Mr. Hill is extraordinary, but I have no explanation to offer regarding it. Of course, all estimates of this kind based on drawings are merely approximations. In addition to the quantity of filling, I have stated the distances over which material must be hauled My cost of 4 3-5d per cubic yard includes rough formation, but further work would be necessary to carry out horticultural improvements and paving I do not think that Mr Hill's estimate provides for finishing off the work beyond what would be necessary to prevent injury by weather It would be a waste of money to do more I provide merely for the rough forming of the boulevardes, bringing the earthwork up level with the pegs Mr Hill does not particularise as to his intentions regarding the finishing of the work, but I do not think that he would propose to do more than I have estimated for As to whether I am prepared to have my estimate checked by an independent authority, and to stand by the result, that would depend on the authority chosen I can furnish independent expert evidence in support of my estimate

314. *To Mr. Gregory.*—I do not remember that any of the filling for the lakes is to be taken from any of the roads except those along the shores. All that road work is included in my estimate of filling—that is, the shore drives. I do not think that anything else is included, except an intersection that is practically a shore drive. I do not see how I can give any reasons for the difference between my estimate of quantities and that of the Department.

315. *To Mr. Sampson.*—I propose to get the whole of my filling from the necessary cuttings, and, in addition, to borrow from other places. Any detailed information regarding the quantities of excavation in the lakes would hardly be reliable unless the work were planned out in detail, which is the next step to be taken. If Mr. Hill's estimate for filling alone does not agree with mine the two estimates could not be reconciled by further detail regarding my filling. The sections already submitted are intended to show exactly what must be done. The filling that I would borrow would be taken chiefly from the bottom of the lake. I do not think that any material will be taken from any point at any distance from the lake shores, except that used for the railway crossing, which is an entirely different work from that under discussion. The road and railway crossings are treated separately. How the work is to be handled is a matter now under consideration, and I do not wish to bind myself to further details until it has been

finally dealt with. I have given information regarding the cost of excavation, transport, and levelling, and I have stated that I do not think that Mr Hill has provided for more levelling than I have provided for. The levelling would not be carried beyond the point at which it could be left until further work was necessary. My estimate of 4 3-5d. covers the cost of excavation and distribution. It will not be possible to state accurately what the cost of earthworks will be until the method of handling has been determined. I believe that there are in operation in Australia machines such as I propose to employ. My estimate is based on practical experience in the use of machines elsewhere. I am prepared to furnish evidence in support of it, and to suggest a witness. I indicated how I arrived at my estimate of the cost of hauling, but I do not bind myself to any particular method, because there are several alternative methods. We shall use the plant that will do the work best and is most adaptable. In paragraph 240 I stated the distances that various quantities of filling would have to be hauled. The price of 4 3-5d. per cubic yard includes the 2½d. per cubic yard allowed for actual excavation. In making my estimate I took Australian conditions into consideration, and would ask you to call Mr. Anderson as a witness in support of it. He is a consulting engineer, and has been a contractor's engineer I have not given you a contractor's estimate, which, of course, would make provision for profit, I have given you only an estimate of cost price. I have not seen Mr. Cooper's evidence regarding the cost of this work. It may be that Mr Hill is willing to commit himself at the prices which he has allowed, to the exact location of the work to be undertaken, but I am not willing to do that until I have arrived at the best method for doing the work. The allocation of the work is a different thing from the making of a general estimate of cost. I have not only made an estimate of cost, I have also shown how it was arrived at. I have studied various methods and relative prices. There are at least three alternative methods for doing this work, but I am not yet in a position to say which of the three will be adopted. I am going into that matter in the minutest way possible. I have put down 4 3-5d. as the average price of the various items included in the estimate, but, before committing myself to exact quantities, I should have to go through my figures again from the beginning. The officer who made the original estimate, and with whom I went into the matter closely, died shortly afterwards, but the estimate given to the Committee is based on figures arrived at in my office by three different engineers. Before I could give the details for which the Committee ask, I should have to go again through all their figures. My estimate was based on figures prepared by my officers, and I am responsible for it. I have not accepted the figures of any one officer, but, knowing how their results compared, I have made an estimate based on their figures, by which I stand. I have satisfied myself as to the correctness of my estimate, though, of course, I did not make all the calculations required for it. There are hundreds of pages of computations in my office, but they would be useless to the Committee. It is not an easy matter to take an engineer's notes, and work out an estimate. What you ask would have been simpler to supply had I merely accepted the calculations of one officer; but I did not do that. If the Committee wished to deal with any part of the scheme by itself, I should have to make an entirely new estimate of the cost of that part. My estimate is an estimate of the cost of the whole scheme; the cost of any part of it, if dealt with alone, would be greater than I have estimated. I have given you more detailed information than you have received from any other officer.

316. *To Mr. Fenton.*—I have given full details, but the Committee now asks me to re-cast my estimate in a different form.

(Taken at Melbourne.)

TUESDAY, 21st NOVEMBER, 1916.

Present:

Mr RILEY, Chairman;

Senator Keating,	Mr. Finlayson,
Senator Story,	Mr. Gregory,
Mr. Fenton,	Mr. Sampson.

Carlo Catani, Chief Engineer, State Public Works Department, Victoria, sworn and examined.

317. *To the Chairman.*—I have been in my present position since 1912. Prior to that I was engineer for roads and bridges and reclamation. During my connexion with the Victorian Public Works Department I have carried out reclamation works at Koo-wee-rup, Condah, Moe Swamp, and several smaller works. The Koo-wee-rup swamp reclamation involved an outlay of £180,000, and the Moe Swamp £81,000. The work in connexion with the Condah swamp is not yet finished, though we have spent a good deal there already. There is a heavy deposit of peat there, and it keeps subsiding considerably. I carried out some reclamation work at the Yallock swamp, which is the only place for which I employed up-to-date machinery, namely, a land dredger with continuous action. This dredger deposits the spoil in the bank in one operation. It has an ordinary ladder, which is articulated, and a conveyer. When I was in England—in 1912—I saw three of these dredgers at Frodingham, one with a conveyer 150 feet in length. On that visit I also went to Doncaster, Lincoln, Manchester, and Glasgow; and I consulted with the engineer of the Manchester Canal, Mr. Reid, who informed me that the excavation and loading into trucks with the land dredger cost only 1½d. per yard; but in addition to that, of course, there was the cost of transport. On that work the dredger worked on a face of 47 feet, and was cutting in level ground. I have seen the plans dealing with the suggested work in connexion with the ornamental lakes at Canberra, and I understand that the excavation amounts to about 670,000 cubic yards. I have looked at the location of the excavations, and I notice that, generally, they are in spurs projecting or jutting into the area of the lakes, and running into a depth of something like 25 feet. The Committee should understand that a work like that cannot be done economically. Figures dealing with cheap excavation work refer chiefly to suction dredging, with a dredger afloat, and depositing material by means of flues; or an alluvial bed where the formation is fairly uniform, and where the machine gets a full load at every cut. If it can only scrape at the face of a work, it will be found that about 50 per cent. of the cost is involved in moving the machine. With this land dredger, the cost is 100 per cent. greater in dry clay than in peaty ground or sandy loam. That is to say, if the machine could do 100 yards per hour on an alluvial flat, it would do only 50 yards in hard, dry ground. We demonstrated this

when we were working in the hard ground at Lang Lang. We had to divert the water so as to have a continual flow in the excavation to lubricate the material. Prior to that, the material used to clog in the chute, and we had to stop the dredger; but we found that with an ample supply of water in the cutting, the material came away freely, and discharged very satisfactorily. I have not heard of any better results with a land dredger in Australia than my record at Yallock. Some important reclamation works have been carried out in South Australia, but I understand the best results there come out at about 8d. per yard. If, at Canberra, the banks are made in the immediate vicinity of the lakes by the dry process, and the space at the back is filled by means of sluicing, it might be possible to get it done at 3d. or 4d. a yard; but if the engineers have to lead the material a distance of 15 chains by means of engines and trucks, the expense would be increased considerably. The work at Yallock swamp cost us about 5d a yard, but I want the Committee to understand that nowhere in the world could better material be obtained for this class of dredger. It is beautifully soft, peaty stuff, and does not clog. I did estimate that it would cost 4d., and the figures show that during the best periods of the work it cost only 1½d. per yard; but now we are in stiffer clay, and the machine is not doing so much work as formerly, though it is still working economically, and with five men is excavating 600 yards a day.

318. *To Mr. Fenton.*—We pay £1 a day to the dredge master, who is supposed to be an engineer capable of making necessary repairs to the machinery. Then we have an engine-driver who is paid 10s. a day, and the other men are getting 8s. 6d. per day. Three of the men are on the engine, and the other two are employed shifting the road. The dredger works on two adjoining sections of a tramway track, and while employed on one section the two men referred to are employed shifting the other section in front so as to be ready for the machine when it has worked out one length.

319. *To the Chairman.*—I have not visited Canberra, nor have I seen samples of the material to be moved; but if it is dry clay the excavation should cost about 6d.

320. *To Mr. Sampson.*—The excavation work at Canberra must, of course, be done according to the design; but for the balance required for the embankment the engineer in charge of the work would use the softest material obtainable. He could spread the ladder and take off the top 10 feet and load it into the trucks. As I have already said, it will be necessary to excavate according to the design of the engineer who has located the formation and it will be expensive work in any case.

321. *To the Chairman.*—If the ground is sloping, the machine will only cut with one corner, and with the cost of transportation added it will cost not much less than 1s. or 1s. 3d. for the 670,000 yards; but for the balance, whether it be 1,500,000 or 3,000,000 cubic yards, the engineer would find the easiest material obtainable.

322. *To Mr. Sampson.*—Any class of material will do to fill up to 3 or 4 feet below the surface, but there is always some difficulty in building on 20 or 30 feet of made ground. We reclaimed the Elwood swamp in 1891 with soft material, and eight years ago I had a skin of 3 feet of dry stuff put over the area. There are now buildings everywhere; in some places on 14 feet of filling.

323 *To Senator Keating.*—The dredger I am referring to is being used on the Yallock swamp, near Lang Lang, and is 45 miles from Melbourne In the best fortnight the cost was only 1½d. per yard; but, in addition, we have to take account of breakdowns, repairs, and the time the machine is lying idle.

324. *To the Chairman.*—I have not shifted any hard material with the land dredger, but when we were working in the hard clay we noticed a difference in the output. The average cost at the Yallock swamp is 5d. a yard. The work there is equivalent to loading into trucks. Instead of shooting the material into a truck, the conveyer distributes it in one operation opposite the cut.

325. *To Mr. Gregory.*—At Frodingham, in England, a conveyer was distributing the material a distance of 150 feet by a revolving belt of iron trays.

326. *To the Chairman.*—It would not be difficult for a quantity surveyor to take out the quantities for the different basins of the ornamental lakes at Canberra. The sections on the plan before the Committee show the mode of disposing of the material, and with the contour lines also on the plan, it should be easy enough for a quantity surveyor to take out the quantities fairly approximately. Mr. Anderson is the quantity surveyor to the Contractors' Association in Melbourne. His business is to take out quantities for any big job, and he guarantees his figures. If there is a shortage of quantities, he must pay for it himself. Any engineer with a staff could take out the quantities for the ornamental lakes easily enough from the plans before the Committee. I should certainly want to know the quantities before I could make any recommendation as to plant. It must be understood that if material is to be borrowed for embankments, the engineer would get it from the handiest location, because if it could be obtained by sluicing and deposited behind the bank, it would cost only about 2d. or 3d. per cubic yard. We landed, by the sluicing process, the whole of the material on the West Melbourne swamp, over an average distance of three-quarters of a mile, for something over 3d. There is a large amount of filling to be done at Canberra, and if, as I have said, the bank could be made by the dry process, and if the filling could be obtained by sluicing from the nearest basin, this latter filling ought to be done for 2d or 3d. If, however, the work is done with dry material, which will have to be transported, the work of loading alone under the best conditions would cost at least 5d. I have seen land dredgers at work in Hamburg, and at Frodingham, and I ascertained in England that it is actually supplanting coolie labour in India, where coolies were paid only 2s. a week. There were three of these machines working one above the other at the Kiel Canal, and each had a full cut of 45 feet.

327 *To Mr. Gregory.*—The land dredger will work in any material that can be ploughed, including loose gravel It has been used for excavation work in the chalk at Dover The conveyer is part of the machine itself, for I have not heard of any conveyer of a greater length than 150 feet. There are conveyers independent of the machine itself, but their use would mean an additional cost. If the material were raised by the dredger, and deposited in tip trucks with a lead of 2,000 feet, the cost, of course, would be greater than the figures I have given concerning Yallock swamp, because the transportation

charge must be added. The 5d. per cubic yard I have given simply means lifting the best class of material and dropping it to spoil, or placing same into trucks. I should think that a lead of 2,000 feet costs more than 2d. per yard extra. We carried out the widening of the Coode Canal for the Harbor Trust, and for that work we used three engines—three are needed to keep two going—and three sets of trucks, so that while one was on the tip, another was travelling, and a third filling. Transportation cost us pretty well 7d. per cubic yard. We let the bulk by contract, and the cost was about the same.

328. *To Mr. Fenton.*—I should say that half-a-dozen dredgers would be required for the work at Canberra. One machine shifts about 100,000 or 150,000 cubic yards per annum, so five dredgers could not do the work in less than about two or three years. The cost of each dredger is about £5,000. The dredger works most economically on a flat because then it can cut the full quantity; but with depths averaging from 5 to 10, 15, or 30 feet, it would have to begin at the bottom and be pushed forward until it was working at its maximum capacity. It is likely that for the first 200 or 300 feet, the machine would only scrape 1 foot or 18 inches off, and it would not be working at its full capacity until it got well into the face of the excavation. Up to that point the work would be costly. In order to show the best results, the machine must get a full load every time. The 5d. I speak of as being the cost of excavation would not apply to ground like that in the eastern basin; but, as I have already said, if the engineer in charge is going to borrow the additional material, he will select a nice, flat stretch where the machine can work under the best conditions, and where the cost will probably be 4d. or 5d., plus transportation charges. I should say that for the greater part of the work on the eastern basin a steam shovel would be most suitable; but you can get more reliable information on this point from the Engineer for Railways, because the Railways Department has been doing a good deal of this class of work at Armadale and Camberwell. In America the most economical steam shovel has a capacity of 5 or 6 yards for each shovel. I have not used the steam shovel myself, but I know it costs more to do excavation by this means than with a land dredger on flat even ground, working under the most favorable conditions. I should say that the light schist, which the plan shows to exist in portion of the segmental basin, would cost twice as much to excavate as the other material. Hard schist could not be removed by this machine.

329. *To Mr. Finlayson.*—The excavation work at the petrol harbor at Hamburg cost 2d. per cubic metre, but that did not include the cost of transport. I do not know what that cost would be, but of course it varies with the distance and the locality. The only basis I can give for a calculation of this cost is the transport charges in connexion with the Coode Canal, where it costs close on 7d. a yard for a distance of a little over a mile. We began at the sea end and raised the ground 1½ inches to the chain, up to a height of 14 feet. If the material is dry, it costs very little to unload and spread with the use of tip trucks. I should think that 5d. or 6d. per cubic yard should cover transportation charges up to a quarter of a mile, the spreading, of course, would be additional. The wages paid at Hamburg were 3s. per day for labourers, 4s. for leading hands, and 6s. to 7s. for engine-drivers, estimating the mark at 1s. I should say that about 75 per cent. of the cost was represented in wages. The life of a land dredger is estimated at from ten to twelve years, and as it is a very bulky plant, it would not pay to shift it very far after a job has been finished.

330. *To Senator Story.*—It is very difficult to estimate what tunnelling would cost, but if it is in the rock I should say it would amount to about £1 a yard, and it would cost about 8d. a mile for transport.

331. *To Mr. Sampson.*—Excavation in alluvial soil, and under the best conditions, with a land dredger would cost about 5d. a yard. The work in the eastern basin, so I judge from the plan, is limited to the north, and in sandy soil, limestone, gravel, and clay. It would probably cost about 9d. a yard on the average to excavate and load that material in the trucks. In the segmental basin the excavation would be in sandy soil and fairly hard shale. The sandy soil ought to be removed for 4d., but the shale, if it is hard material, would probably cost from 1s. 3d. to 1s. 6d. a yard loaded into trucks. In the west basin the excavation is limited to sandy soil and shale, which latter I should think would cost about 1s. 3d. I should not care to offer an opinion upon the figures given by Mr. Griffin in Question No. 239. I can only give the results of work within my own experience. The work of widening the Coode Canal cost about 1s. 4d. (transport 7d.), an average distance of about one and a half miles, and spreading 1½d. That was done about eight years ago, and at a time when there was considerable unemployed difficulty, and part was done by contract, the plant being already provided to contractor free of charge. There was no provision in that price for depreciation, but I will furnish to the Committee a memorandum showing the actual position. The extra cost now would be due principally to the cost of material and increased wages. Eight years ago men were glad to work for 7s. 6d. a day, but we could not get competent navvies today for less than 9s. or 10s.

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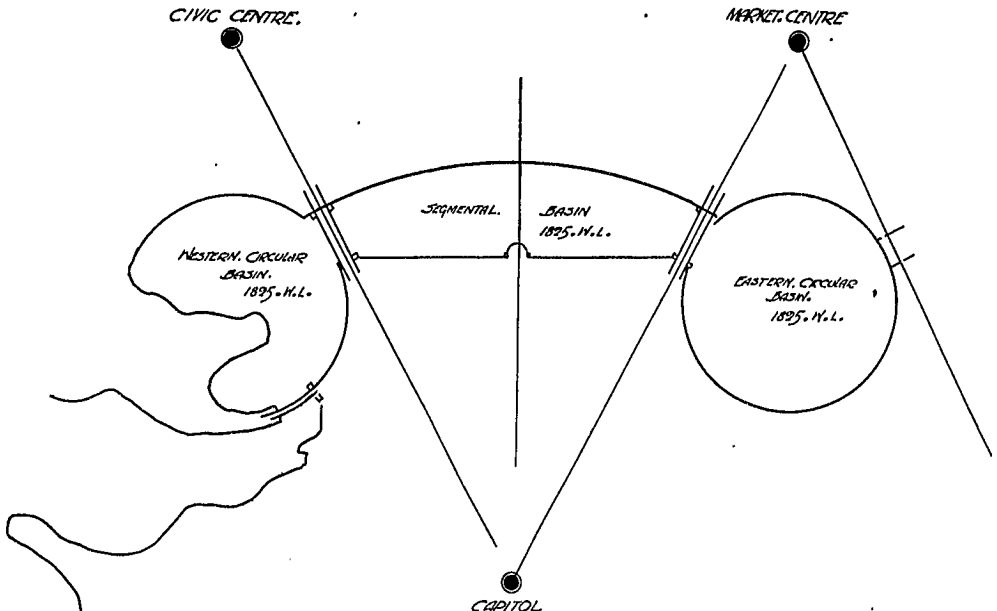
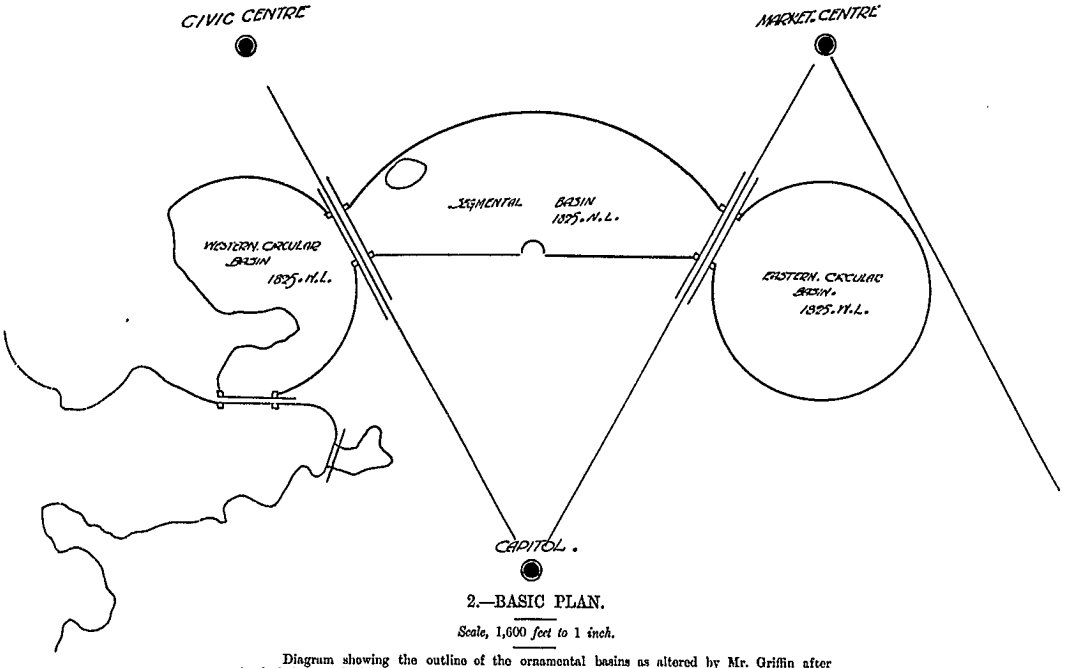


1.—PREMIATED PLAN.

Scale, 1,600 *feet to* 1 *inch.*

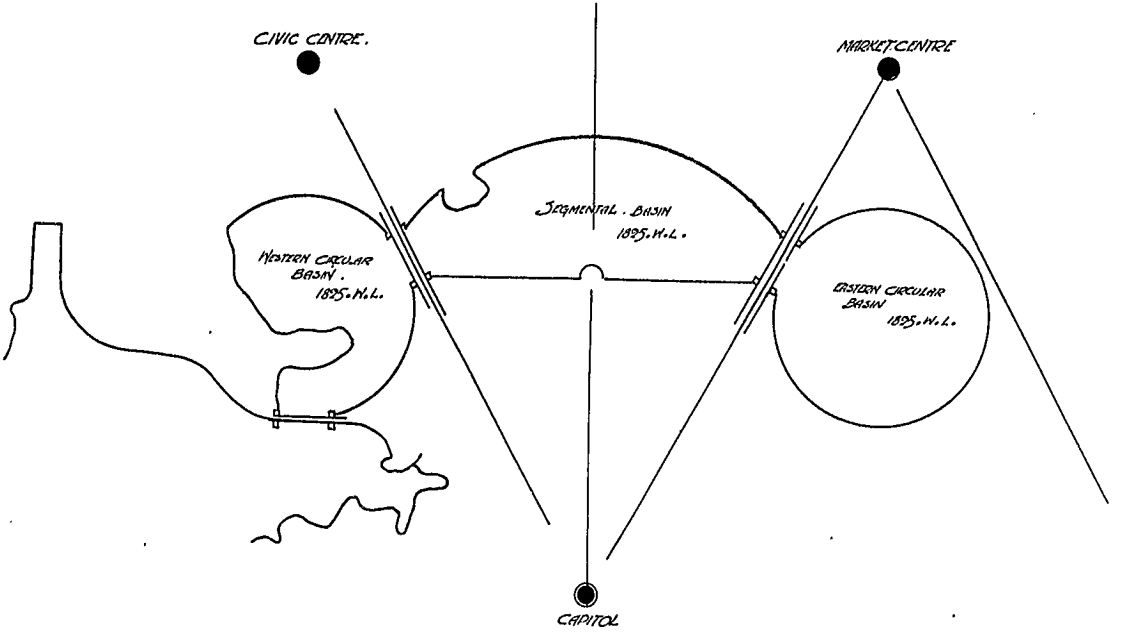
Diagram showing the outline of the ornamental basins as projected by Mr. Griffin on the plan which was placed first in the Federal Capital competition.



2.—BASIC PLAN.

Scale, 1,600 feet to 1 inch.

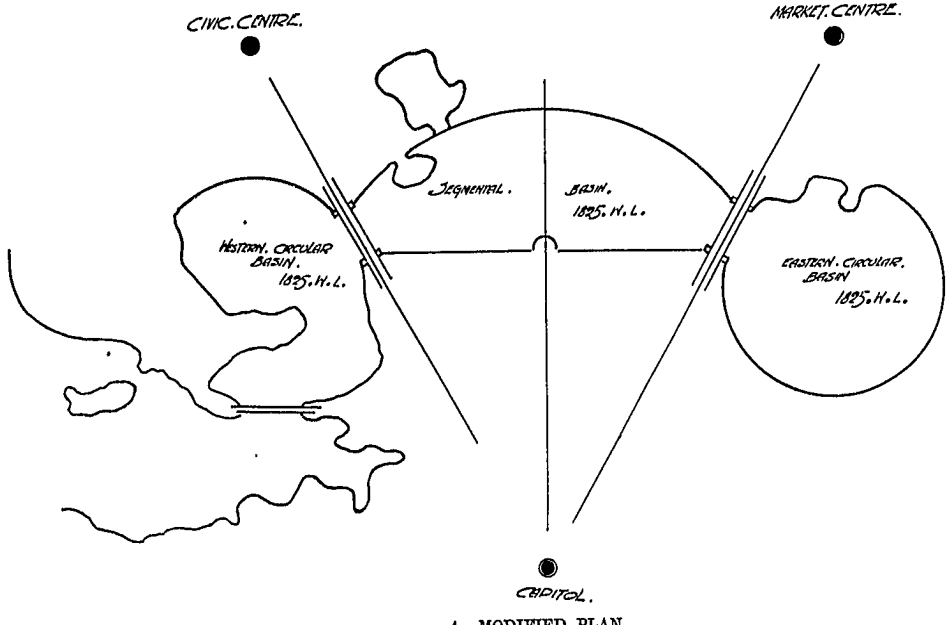
Diagram showing the outline of the ornamental basins as altered by Mr. Griffin after he had inspected the country.



3.—SCHEMATIC PLAN.

Scale, 1,600 *feet to* 1 *inch.*

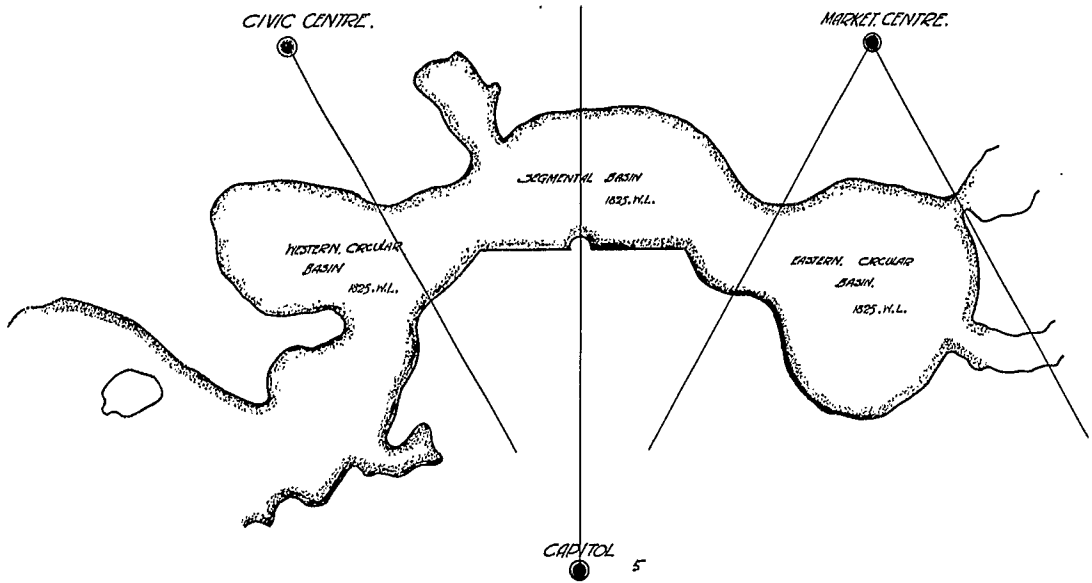
Diagram showing the outline of the ornamental basins to construct which authority was requested.



4.—MODIFIED PLAN.

Scale, 1,600 *feet to* 1 *inch.*

Diagram showing the outline of the ornamental basins as modified by Mr. Griffin after conference arranged by the Public Works Committee with officers of the Department of Home Affairs.



5.—NATURAL CONTOURS.

Scale, 1,600 *feet to* 1 *inch.*

Diagram showing the approximate form the basins would assume if the Public Works Committee's recommendation that the lakes should follow generally the natural contours, with such modifications as time and experience may show to be necessary, be adopted.