

ORIGINAL AND READJUSTED REPAYMENT

CONTRACTS, BOULDER CANYON

PROJECT

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Synopsis

The Boulder Canyon Project, after a generation of investigation, planning, and political debates, progressed to actual construction in 1930. First commercial power production occurred in October, 1936, with additional generating units still being installed as of 1944. Since June, 1943, the power output has exceeded 1,000,000 kw, the first time in history for a single power plant; so the project's record of breaking records is continued. The ultimate capacity of the plant is announced as 1,332,300 kw.

The great dam, 726 ft high, controls the flow of the Lower Colorado River on the Arizona-Nevada boundary and creates a storage reservoir of 32,000,000 acre-ft capacity, called Lake Mead. It was built and is owned and operated by the United States because of the complexity of its interstate and international problems, which were the more involved due to its being the pioneer in the field of large multiple-purpose hydro-power projects. In addition to improving navigation (for judicial purposes, at least), controlling floods, and regulating the river flow for irrigation, domestic, and municipal uses, the power production is sufficient to amortize the project's construction cost and guarantee payments to Arizona and Nevada in lieu of taxes, plus contributions to a basin development fund. Silt control and regulation of water quality are important incidental results.

The power rates were adjusted in 1941, on an amortization instead of the previous competitive market rate basis. The reasons for this change are explained in this paper, with detailed comparison of the two plans as regards allocation of construction costs.

The Boulder Canyon Project has now gone to war in a big way, of course; but, even before the war boom and the earlier defensive rush period, its success was assured, with power output and cost repayments running far ahead of advance estimates. As of 1944, however, one near-by metallurgical (magnesium) plant requires 200,000 kw and every available kilowatt-hour is devoted to the war industries of Southern California. Stored water is also pumped for these industries

and the municipalities around them through the Colorado River Aqueduct.

BOULDER CANYON PROJECT ACT

The Congress of the United States, by the terms of the "Boulder Canyon Project Act," approved on December 21, 1928, authorized the Secretary of the Interior

"**** to construct, operate and maintain a dam and incidental works in the main stream of the Colorado River at Black Canyon or Boulder Canyon **** for the purpose of controlling the floods, improving navigation and regulating the flow of the Colorado River, providing for storage and for the delivery of the stored water thereof for reclamation of public lands and other beneficial uses exclusively within the United States, and for the generation of electrical energy as a means of making the project herein authorized a self-supporting and financially solvent undertaking;**** also to construct and equip, operate and maintain at or near said dam, or cause to be constructed, a complete plant and incidental structures suitable for the fullest economic development of electrical energy from the water discharged by said reservoir;***."

As indicated by this preamble to the Act, the solution of the Colorado River problems, as plans were gradually formulated after investigations over a period of many years, necessarily required a multiple-purpose project. This was perceived long before such a conveniently descriptive term became so widely used and accepted in discussions of engineering economics. Largely to this diversity of objectives, and the serious international as well as interstate complications that were involved, was due the final authorization for the construction by the Bureau of Reclamation, U. S. Department of the Interior, with federal appropriations. Indeed, the Boulder Canyon Project is generally recognized as having been the pioneer in the field of major multiple-purpose hydro-power developments.

In addition to the numerous general purposes as listed, the removal of Colorado River silt (long infamous as often "too thick to flow even though too thin to plow") has proved of vital importance, for without such silt control, neither power installations nor water diversions could be considered as economically and permanently feasible. (The reservoir has an estimated 300-yr life, as a minimum, which will be indefinitely prolonged by the construction of numerous planned upstream dams.) Likewise, the improvement of the

quality of Colorado River water by decrease of its low-flow salinity and hardness, due to storage and mixture of the previously wasted and relatively pure flood flows, was immediately of real value. Such quality improvement has become even more evident as the first filling of Lake Mead (Arizona-Nevada) and two years (1941 and 1942) of large discharges (fortunately chiefly through the gates rather than from the purer surface stratum over the spillways) have continued the leaching of the gypsum-mixed sands included in the desert reservoir's flooded area. This improvement is only temporarily retarded by the 1943 low inflow of but 70 % of normal. Even the improvement of navigation, generally dismissed as merely a legal fiction, has permitted the barging of ores, previously inaccessible, on a commercial scale, as well as a recreational patronage for fishing, bathing, sailing, and motor boating, to a most unexpected extent. Visitors to the power plant until it was closed to the public on December 8, 1941, averaged more than 1,000 per day for a total of nearly two million, besides still larger numbers who merely admired the dam and scenic vicinity. Evidently the Boulder Canyon Project has really accomplished a multiplicity of purposes.

A draft of the Swing-Johnson bill, as the project Act was generally known, was introduced in Congress as early as 1923, but enactment was delayed during five years of nearly continuous and heated debate over the basic policy of governmental ownership and construction of power dams. The question of a single-purpose versus multiple-purpose project also played a part in the controversy, as some opponents of government control of the high power dam favored instead a separate, relatively low dam at another site to be built by the United States solely for flood control, the immediate need for which seemed unquestioned. This would have left the canyon section of the Colorado River for private power development, probably taking the form of a series of several relatively low dams. The apparent economy of a multiple-purpose dam was a deciding factor in finally securing favorable Congressional action, as advocates of government ownership asserted (correctly, as is now proved) that power and other revenues would be amply sufficient to repay the cost of the project with interest. That the approval of the Boulder Canyon Project Act established a notable and important precedent is now very evident. Although the Bureau of Reclamation had previously constructed about fifteen power plants, incidental to its irrigation projects, their combined cost was less than 1 % of the authorized investment for the Boulder Canyon Project. Few of these small installations had encountered serious opposition from public utilities, as they had offered little or no competition and were mostly in remote and undeveloped localities at the time unprofitable for private power installations. On the other hand, the Lower Colorado River was considered a choice prize, for the control of which the competition was energetic and prolonged. Congressional and public sentiment finally swung definitely in favor of governmental construction

of such hydro-power projects, as the decade following the passage of the Boulder Canyon Project Act has confirmed, with its series of great federal dams.

In line with the arguments that the project would be self-liquidating in fact, a definite plan of cost repayment was written into the Act (section 4-b)-

"Before any money is appropriated for the construction of said dam or power plant, or any construction work done or contracted for, the Secretary of the Interior shall make provision for revenues by contract, in accordance with the provisions of this act, adequate in his judgment to insure payment of all expenses of operation and maintenance of said works incurred by the United States, and the repayment, within fifty years from the date of the completion of said works, of all amounts advanced to the fund under sect. 2(b) for such works, together with interest thereon****(at 4%)."

This requirement for bona-fide, enforceable repayment contracts, covering the estimated project cost, was followed strictly by the then Secretary of the Interior, Ray Lyman Wilbur, M. D., before President Herbert Hoover, Hon. M. Am. Soc. C. E., approved the first appropriation for initiating construction work on July 3, 1930.

Such an advance guarantee of cost repayment with interest made the Boulder Canyon Project unique among national developments, a record unshared as yet but only emphasized as to its rarity by the cases of numerous subsequent and comparable power dams constructed under federal auspices. The record is more notable in view of the rigid interpretation and enforcement given the repayment clauses of the Act, quite at variance with the long-established repayment practices on irrigation and other government projects (leniency having been often allowed, generally for good and sufficient reasons). The several contracts negotiated with the Los Angeles (Calif.) City Power Bureau, the Southern California Edison Company, and The Metropolitan Water District of Southern California, which were later supplemented by contracts with various other power distributors, represented probably the largest power transaction to date. They called for then-estimated payments over a fifty-year period of about one-half billion dollars for merely the primary project, not including costs of long transmission lines and complex distribution facilities. The enormity of such repayment promises and the seriousness and importance to all concerned of these contracts are now difficult to realize under subsequent changed conditions of more easily promoted projects as items of progressively greater relief, defense, and war budgets. The support of the Southern California Edison Company, in underwriting a large portion of the cost of this governmental and municipally-favored development, is especially notable, as inaugurating

a period of enlightened public relationship and ending, regionally at least, a prot acted and "totalitarian" war of uneconomic competition.

COLORADO RIVER DAM FUND

Early drafts of the Swing-Johnson bill provided for financing by a project bond issue but the Act as finally passed relied instead on normal Congressional appropriations. Patterned to some extent after the regular Reclamation fund, a special fund was established, designated as the Colorado River Dam Fund, to be available only for carrying out the provisions of the Act. Greatly simplifying the accounting procedure, and cost or repayment auditing reports, it has somewhat the relation to the U. S. Treasury of a subsidiary to a parent corporation. It appears to have served as a "small-scale" precedent for the subsequent depression era's Reconstruction Finance Corporation (as a means of financing public construction) and other government corporations and funds, which have become such a favorite and accepted method of federal administrative and accounting practice.

All advances to the Colorado River Dam Fund from the U. S. Treasury were required to be repaid with 4% interest, but a definite allocation of \$25,000,000 was made to flood control to be repaid out of 62.5% of excess revenues, if and when available. If this repayment were not completed within the general fifty-year amortization period, ending May 31, 1987, repayment was to be continued out of the same proportion of the project's net revenues. Thus deferment was permissible for the repayment of the flood-control allocation, if this became necessary, but provision was made for full repayment finally, with 4% compound interest. The amount of this flood-control allocation appears to have been fixed arbitrarily, so far as is now evident, but is approximately the sum that might have been needed for a program of flood control by means of a low dam for this purpose solely, and a system of raised and strengthened levees. This solution would have given immediate, but evidently only temporary, relief from flood damages, due to relatively rapid filling with silt of a small reservoir. The federal obligation to furnish some degree of flood control on the Lower Colorado River was recognized, however, and this is probably the only case to date in which repayment (even though possibly on a deferred basis) of a government flood-control structure, or its allocated share of the construction cost, has ever been required or promised.

In addition to the flood-control allocation, other excess revenues of the Colorado River Dam Fund were allotted as follows:

"If during the period of amortization the Secretary of the Interior shall receive revenues in excess of the amount

necessary to meet the periodical payments to the United States as provided in the contracts executed under this act, then, immediately after the settlement of such periodical payments, he shall pay to the State of Arizona 18 $\frac{3}{4}$ % of such excess revenues and to the State of Nevada 18 $\frac{3}{4}$ % of such excess revenues.

"After the repayments to the United States of all money advanced with interest, charges shall be on such basis and the revenues derived therefrom shall be kept in a separate fund to be expended within the Colorado River Basin as may hereafter be prescribed by the Congress."

Records of Congressional Committee hearings indicate that the intent of Congress was that Arizona and Nevada should receive some payments in lieu of taxes which would have been levied if the project had been privately developed. The amount is stated as having been determined on the basis of a fairly parallel case, the leasing of public oil lands, where the rule had become established that the state involved should receive 37% of the net revenue in lieu of taxes. The disposition of the balance of excess revenues, after completion of repayment of U. S. Treasury advances to the fund, was such a remote problem as not to excite immediate interest, so that it was merely left to future action of Congress, though allotted for Colorado River Basin developments if and when available.

ORIGINAL REPAYMENT CONTRACTS

As repayment contracts were required by the Act in advance of even the beginning of construction, their terms were necessarily based on estimated project costs. Power production had also to be estimated from stream-flow records and reservoir operation studies, at first being called 4,240,000,000 kw-hr annually of firm power initially, subject to some gradual depletion. This amount was taken as 100% in the allocations of power, although a later decision to add 25 ft to the proposed height of the dam (550 ft) yielded a further block of 90,000,000 kw-hr of firm power annually. Applications for the power originally totaled more than three times the estimated production, with the City of Los Angeles and the Southern California Edison Company each asking for all of the available power. Final power allotments were made only after prolonged hearings and many protests and compromises, with eight contracts resulting from twenty-seven applications, some of which were conditional or indefinite, however. The repayment guarantees involved three main contracts:

City of Los Angeles.....	37%
Metropolitan Water District.....	36%
Southern California Edison.....	27%

Available power..... 100%

The City of Los Angeles underwrote 6% for other municipalities (which finally amounted to 4.0946%), the Southern California Edison Company similarly underwrote 0.9% for each of two other power companies, and the city and the company each were subject to a drawback of 18% by the states of Arizona and Nevada. As the Metropolitan Water District had not at the time held its aqueduct bond election, legal questions were anticipated as to the strict enforceability of its contract. The guaranteed portion of the project cost was therefore finally covered by the City of Los Angeles and Southern California Edison Company contracts for but 64% of the estimated power production.

These contracts were required to provide revenues sufficient in the judgment of the Secretary of the Interior to amortize the project cost, except for the flood-control allocation; but in addition the Act required that the contracts "shall be made with a view to obtaining reasonable returns as found to be "justified by competitive conditions at distributing points or competitive centers." The latter condition would necessarily have been a determining factor in fixing the power rate even in the absence of such a statutory direction. In this case, the only significant power market was in Southern California, located over large oil deposits, so that the cost of energy provided by oil and gas necessarily fixed the comparative value of Colorado River hydro power, with proper allowance for transmission costs. Studies made for the Secretary of the Interior on this basis indicated a value at the switchboard for the use of the available falling water of about 1.63 mills per kw-hr. Therefore, power allocations were made on the basis of this rate, with the corresponding secondary power rate fixed rather arbitrarily at 0.5 mill per kw-hr.

ORIGINAL COST ALLOCATIONS

With firm contracts executed on April 26, 1930, for the entire power production, and the power rate fixed and agreed to as described, it was widely assumed that an allocation had been arrived at not only for the project cost but also for a dependable surplus, payable to Arizona, Nevada, and the Colorado River Basin Development Fund. Technically, to be strictly accurate, no such definite allocation of costs really had been made, because the Act prescribed that upon the demand of either party to the power contracts, at the end of fifteen years (in 1945) and every ten years thereafter, the power rate should be readjusted as found

by the Secretary of the Interior to be justified by changed competitive conditions. In 1930 this factor seemed to mean little, as the first adjustment date was so far into the future, and elaborate, detailed computations and studies were prepared on the assumption of a uniform rate of 1.63 mills per kw-hr. Misleading conclusions resulted and the expenditure of anticipated surplus revenues was budgeted by those interested as if the fund accumulation were certain and automatic. As the national economic depression became more severe and protracted, affecting seriously both power markets and the all-important price of oil, or equivalent cost of gas, it became apparent that under prevailing competitive conditions the power rate had been set higher than was warranted or than could be maintained, in all probability, after the 1945 readjustment. Various alternate studies of anticipated revenues, with corresponding allocations of cost, were prepared as a basis for discussions of the resulting problems among representatives of the government, the power contractors, and the states interested in excess revenues. Several of these studies that were officially issued by the Bureau of Reclamation and are still of interest, for purposes of comparison, have been tabulated in summary form herein, following a listing of the project costs that serve as a base for the amortization computations.

Cost estimates used in negotiating the original power contracts for the Boulder Canyon Project are derived from a statement by Secretary Wilbur:

Estimated cost (including interest during construction but excluding flood control).....	\$ 82,674,907
Interest at 4% during 50-yr period, excluding flood control	108,107,007
Interest charges on accumulated deficit	63,973
Estimated operation and maintenance (O&M)	7,262,557
Estimated depreciation.....	8,875,553
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Total requiring "guaranteed" repayment.....	\$206,983,997
Anticipated power revenues at 1.63 mills per kw-hr	
City of Los Angeles.....	121,310,549
Southern California Edison Co.....	88,523,915
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Subtotal.....	\$209,834,464

Metropolitan Water District of
Southern California..... \$118,031,886

Total estimated falling
water revenues..... \$327,866,350

The distribution of surplus revenue, if and when realized, according to the terms (as then interpreted) of the Boulder Canyon Project Act is:

Repayment of flood-control allocation	\$ 25,000,000
Interest at 4% on flood-control allocation.....	20,981,303
18 3/4% of surplus to Arizona.....	22,665,441
18 3/4% of surplus to Nevada.....	22,665,441
Balance for Colorado River Basin Development Fund.....	29,570,168

Total estimated surplus at 1.63-
mill rate for fifty years..\$120,882,353

In addition to the foregoing totals, power machinery costs were estimated at \$17,717,000. It was originally contemplated that this investment would be financed by the power-plant lessees, so that its repayment was not covered in the original power contracts. Therefore, although finally financed with federal funds, along with the remainder of the project, power equipment costs are being repaid over a 50-yr period with interest by means of separate contracts with the generating agents, the City of Los Angeles, and the Southern California Edison Company. Actual project construction costs, as of September, 1940 (presented at the Rate Adjustment hearings at Los Angeles) can be summarized in abbreviated form as follows:

FEATURE	COSTS
DAM AND RESERVOIR	
Right of way and mining claims.....	\$ 782,219
Surveys, tests, and examinations(field)	766,335
Stripping canyon walls.....	627,499
River diversion, cofferdam, dredging..	2,348,984
Diversion works (four tunnels).....	26,996,604
Main dam and miscellaneous.....	23,578,724
Spillways.....	5,868,792
Outlet works.....	16,337,587
Permanent cableway and landings.....	607,913
Subtotal.....	\$ 77,914,657

POWER PRODUCTION

Power-house substructure.....	\$ 5,094,098
Power-house building, water, oil, and air systems.....	3,726,170
Penstocks.....	3,330,950
Electrical equipment.....	13,624,964
Hydraulic, mechanical, and general station equipment.....	6,620,512
Switchyards.....	3,265,609
Subtotal.....	\$ 35,662,303

GENERAL PLANT

Roads, railroad, construction and concrete plant.....	\$ 2,491,967
Boulder City, Nev., government buildings, telephone system, etc.....	2,182,565
Materials and supplies (field).....	305,511
Subtotal.....	4,980,043

Total investment(field)..... \$ 118,557,003

OVERHEAD AND UNDISTRIBUTED

Engineering and Inspection (Denver, Colo., office).....	2,875,341
Concrete and other research.....	624,431
Colorado River Board and consultants..	83,887
Legal, general, printing, furniture, etc. (Denver).....	406,602
General and overhead (Washington, D. C., office).....	282,076
Secondary investigations, Colorado River Basin.....	314,416
Subtotal.....	\$ 4,586,753

Total project cost to September, 1940..... \$ 123,143,756

Installations of additional power-plant equipment, continuing into 1944, and other permanent work of a minor nature, raised the project cost to approximately \$130,000,000, with the completed cost to be somewhat greater. The most recent available studies, dated February 19, 1941, indicate a final reimbursable cost of \$82,878,131 for the new power (falling water) rate determinations, not including generating machinery and the deferred flood-control allocation. This is not exactly comparable with the 1930 estimate of \$82,674,907, as the latter includes interest during construction

at 4% and also interest during construction at the same rate on the deferred flood-control allocation of \$25,000,000. Under the present revised Act and regulations, the latter is considered to be the sum of the first project expenditures instead of being an amount deducted from the construction cost on May 31, 1937, as previously, so that interest during construction on this amount is now omitted, and on the remainder of the cost is computed at a 3% rate. This adjustment for revised interest during construction is estimated as amounting to about \$5,000,000 which may be considered the approximate overrun on the cost of the dam and power-plant building, as compared with the 1930 estimates. Most of this increase appears to have resulted from the inclusion of exceptionally thorough and costly research, basin surveys not directly related to project construction, very considerable overhead, and unanticipated expenditures for Boulder City and for guide, scenic, and protection facilities, etc. The actual field construction cost of the dam and power-plant building evidently has exceeded the 1930 estimates but slightly, if at all.

Early rapid progress on the dam was aided by the lowest runoff year (1934) on record, and, with the favorable depression prices of the same period, financial studies made in 1936 (Denver Drawing No. 45-D-10,327 dated September 18, 1936) were allowed to become optimistic to the extent of estimating the reimbursable cost as of May 31, 1937, at \$75,927,921. Due apparently to cost accountants being overworked, a considerable lag occurred before the effect of large overhead and indirect costs became fully evident. Annual O & M costs were estimated at but \$102,000, compared with \$145,000 in 1930 (present studies include O & M costs at \$554,000 annually) and, on the other hand, allowances for secondary power and water storage revenues were somewhat more liberal than in either 1930 or at present (1944). The combined effect of these various factors, in addition to the previously mentioned faulty assumption of a 1.63-mill rate for fifty years, was to increase the estimated payments to Arizona and Nevada by 30% and to the Colorado River Basin Development Fund by about 90%, as compared with the quoted 1930 anticipations. Naturally, these larger amounts became fixed in the minds of those interested as being so certainly available within the near future that subsequent smaller but more accurate versions of probable surplus revenues were correspondingly unpopular and dismissed as propaganda.

Beginning in 1937, however, such financial studies were revised to conform to the quoted requirement of the Act (section 5) that payments into the separate Colorado River Basin Development Fund should not be made until completion of all repayments to the United States. Earlier interpretations had assumed that amortization of the dam's cost would cover the permitted 50-yr period whether such a long time was necessary or not, with surplus funds first amortizing the

flood-control allocation and then being paid to the separate fund. On the corrected basis, however, the federal government share of the surplus was devoted to accelerated project cost amortization, with initial payments into the separate fund being postponed from about 1960 to the very end of the amortization period, 1985 or later, as well as being greatly decreased in amount. The last such study, prepared by the Bureau of Reclamation as of May, 1940, conforming to the original Act but with then-current assumptions for the reimbursable total and estimated O & M costs, and involving varying future power rates, both firm and secondary, after 1945, is available in print. Detailed tabulations are shown for firm power rates of 1.30 and 1.08 mills after 1945, with the secondary rates proportionately decreased. Using identical assumptions and computation methods, similar tabulations have been prepared for 1.63 mills and other future firm rates. These several studies were then brought a step further up to date by corrections for the 1941 estimate of future O. & M. costs of \$554,000 annually (instead of \$270,000 annually). They are summarized in Table 1 on a present-value basis, to show the varying allocations of revenues and costs that might have occurred under the terms of the original Act, according as future competitive power conditions more or less severely affected the contracted revenues. Conforming to the May, 1940, O & M estimate, the fixed charges have a present value, computed at 4% as of May 31, 1937, of 100.3 million dollars, including past and deferred investment of 91.2 million dollars in dam and power-plant building (but not hydraulic machinery), plus operation and maintenance, depreciation, and replacements. All of these costs would have been repaid with any firm power rate, after 1945, of 1.08 mills per kw-hr or greater. Correcting the O & M estimate to the 1941 basis, the present value of all such fixed charges is increased to 105.3 million dollars. A firm power rate of at least 1.163 mills per kw-hr is required to amortize this amount within fifty years at 4% interest. The lower rate of 1.08 mills, if applied after 1945, would have repaid only 95% of the reimbursable project cost, in addition to O & M and depreciation charges. The varying amounts of surplus, and its allocation for the several specified purposes for different firm power rates after 1945, are given in Table 1 for comparison.

This tabulation is an extremely condensed summary of voluminous, detailed cost and revenue studies, referred to previously but not included herein because they are now obsolete and of interest only in reviewing the evolution of the present power contracts and rates. A full explanation of their engineering, legal, and accounting complexities would also be most voluminous, and likewise obsolete. In further explanation of Table 1, however, it may be noted that in all cases included, except the first (1.63 mills power rate for fifty years and preliminary estimate of O & M cost), the present value of the hypothetical payments to Arizona and Nevada is 37.5% of the corresponding present value of the surplus, as is specified in the Boulder Canyon Project Act.

TABLE 1 - ESTIMATED SURPLUS REVENUES AND VARYING ALLOCATIONS^a
IN PERCENTAGE OF ACTUAL-PLUS-DEFERRED INVESTMENT^b

Firm Power rate after 1945 (mills per kw- hr)	Surplus		Arizona and Nevada		Development ^c Fund		Repayment ^d	
	Millions of dollars	Percent- age of invest- ment	Millions of dollars	Percent- age of invest- ment	Millions of dollars	Percent- age of invest- ment	Millions of dollars	Percent- age of alloca- tion

(a) Annual Cost of Operation and Maintenance as Estimated in May, 1940 (\$270,000)

1.63	45.0	49	17.3	19.0	2.7	3.0	25.0	100
1.555	40.0	44	15.0	16.4	0.0	0.0	25.0	100
1.40	29.7	33	11.1	12.2	0.0	0.0	18.6	74
1.30	22.9	25	8.6	9.4	0.0	0.0	14.3	57
1.163	14.0	15	5.2	5.7	0.0	0.0	8.8	35
1.08	9.0	10	3.4	3.7	0.0	0.0	5.6	22

(b) Revised Annual Cost of Operation and Maintenance as Estimated
in February, 1941 (\$554,000)

1.63	40.0	44	15.0	16.4	0.0	0.0	25.0	100
1.555	35.0	38	13.2	14.5	0.0	0.0	21.8	87
1.40	24.7	27	9.3	10.2	0.0	0.0	15.4	62
1.30	17.0	20	6.7	7.3	0.0	0.0	11.2	45
1.163	9.0	10	3.4	3.7	0.0	0.0	5.6	22
1.08 ^e	9.0	10	3.4	3.7	0.0	0.0	5.6	22

a-Expressed as present values, at 4% interest rate, as of May 31, 1937. b-Taken as 91.2 million dollars on a present-value basis as of May 1, 1937. c-Colorado River Basin Development Fund. d-Flood-control allocation. e-With a firm power rate of 1.08 mills, \$5,000,000 (present value) of project investment would have been unpaid in a 50-yr period.

With the assumptions of the first case, however, the flood-control allocation of \$25,000,000 would have been amortized in about thirty-eight years, as a result of the larger revenues. Then for the next nine years the government's 62.5% share of the surplus would have been applied to accelerating the amortization of the project construction cost. During the last three years of the life of the contracts, Arizona and Nevada would not have shared in the surplus (the Act limited their payments to the amortization period), but instead the entire surplus would have been paid into the Colorado River Basin Development Fund, for subsequent appropriation by Congress. The actual disposition of the surplus revenues would thus have been as follows, on a present-value basis:

	Million dollars
Net surplus (1.63 mills rate for fifty years).....	45.0
"Surplus" applied to project cost amortization.....	+ 3.8
Surplus of last three years for Colorado River Basin Development Fund.....	- 2.7
	<hr/>
Portion of surplus shared by Arizona and Nevada.....	46.1
37.5% to be divided between Arizona and Nevada.....	17.3
(or 38.5% of net surplus and 35.5% of full 50-yr surplus)	

As some estimates of the probable firm power rate after 1945, revised on the basis of changed competitive conditions, ranged as low as 1.0 mill per kw-hr, and as this rate would have repaid (within fifty years and at 4% interest rate) only 88% of the investment in the dam and power-plant building, considerable concern arose as to the solvency of the project finances. By the terms of the original Act, the readjustment of the power rate in 1945, and at 10-yr intervals thereafter, was to be the responsibility of the Secretary of the Interior, as might be justified by competitive conditions. The opinion was frequently expressed that a rate lower than required to amortize the reimbursable portion of the project investment within fifty years was not permitted by the Act; but the legality of this idea was in disagreement and was indeterminate. This result was not improbable, however, as the manner of such a rate redetermination was left vaguely undefined by the Act and would be complex and difficult as well as seriously controversial. Even if the rate could be maintained high enough to insure repayments to the U. S. Treasury, however, the payments to the states and the basin fund were obviously in jeopardy. General recognition of this fact was the cause and basis of the negotiations for a revision of the original Act.

REVENUES FROM WATER STORAGE

Project cost allocations and amortization have been analyzed without special reference to anticipated water revenues because estimates of the latter, as included in the various official financial studies of the Boulder Canyon Project, have amounted to only 2.5% to 3% of the total expected revenues. Furthermore, no adjustment was required or has been made with respect to water charges, all recent discussions having involved power questions only. Water storage revenues are incidental and relatively minor in importance, in the case of this multiple-purpose project, partly because conditions were so favorable for power development. The high head and large generating units, rated at 82,500 kva, made possible a low power cost; and the large power demand, even with competitive marketing conditions of the depression period, has kept the project self-liquidating. More direct and fundamental factors control the water revenue that can be secured for the project.

The Boulder Canyon Project Act specifically exempted lands in Imperial and Coachella valleys, California, from any water storage charge. The first area is now, and the latter will soon be, supplied by the All-American Canal, also constructed by the Bureau of Reclamation under the authorization of the same Act. The justification for this exemption is that large appropriative water rights of very early priority had been established by such Lower Colorado River projects as Palos Verdes, Imperial, and Yuma valleys. Upstream developments gradually encroached on these prior water rights, causing more and more frequent shortages of irrigation water. These were climaxed by the most severe drought on record in 1934, just a few months before storage began in Lake Mead on February 1, 1935. Such water shortages were largely limited to the Imperial Valley because its diversion point was then below all others on the river, and litigation against junior upstream diversions had seemed unavoidable until the Colorado River Compact was negotiated. Due to these circumstances, the California ratification of the Compact was conditional on the construction by the federal government of a reservoir of at least 20,000,000 acre-ft capacity, at or below Boulder Canyon on the Colorado River.

A considerable portion of the investment in the Boulder Canyon Project may therefore be conceived as a contribution to prevent threatened litigation, and to stabilize past as well as future water rights and diversions in the Upper as truly as in the Lower Colorado River Basin. Except for the effect of such upstream diversions, now legalized by the Compact and the storage operations of Lake Mead, the natural unregulated flow of the Colorado River would have been practically sufficient for Imperial Valley irrigation. Present exemption from reservoir storage charges is merely a recognition of this fact.

Other diversions from the Lower Colorado River are not definitely exempt from Boulder Canyon Project storage charges, and the reasonableness of such a charge (fixed at \$0.25 per acre-ft) as a contribution toward the repayment of the cost of the project was recognized, for example, in the water contracts for the Colorado River aqueduct of The Metropolitan Water District of Southern California and for the City of San Diego, Calif. Even with the later priority of the water-right appropriation for the aqueduct, however, diversions might have been made during half or more of the time in most years from the river's natural flow, without dependence on storage. The present (1944) charge of \$0.25 per acre-ft for all water diverted by the aqueduct, therefore, is in effect, about a \$0.50 charge for water really derived from Lake Mead storage. Incidental benefits are obtained as regards desilting and improvement of water quality during non-flood periods, so that the charge on all water diverted was agreed to, it being realized that no accurate or practical separation or determination of natural flow could now be made. A rate of \$2.00 per acre-ft was demanded at various times by Arizona representatives, but this was considered to be inequitable and impossibly exorbitant, amounting to a 22% increase in the \$8.00 per acre-ft base price of water furnished by the \$200,000,000 aqueduct. The rate of \$0.25 per acre-ft as determined by the Secretary of the Interior was found justified on a showing that, if the portion of the Colorado River runoff made utilizable for the first time by Lake Mead regulation (about 10,000,000 acre-ft annually) was charged approximately this storage fee, the actual reservoir cost, omitting power production features and the flood-control allocation, could be amortized within fifty years from this revenue source alone, disregarding power revenues. Power revenues are available, of course, amounting (at the average reservoir power head) to \$0.73 per acre-ft with the original rate of 1.63 mills per kw-hr, and to \$0.52 per acre-ft with the 1941 adjusted rate of 1.163 mills per kw-hr.

On this comparative basis, the water charge does not seem disproportionate to the relative services rendered. It must be emphasized, of course, that the charge is not for the sale of water but rather for storage service only. Prior to 1943, the only contracts for water deliveries other than to the exempt irrigation projects were with The Metropolitan Water District of Southern California and the City of San Diego. Whether a water charge would be made for other projects, proposed or under construction, that will involve diversions from the Lower Colorado River, was not previously evident, as no delivery contracts had been issued for such projects. To be conservative, therefore, all previous financial studies for the Boulder Canyon Project have neglected the possibility of such additional water revenues. In May, 1943, a water contract was announced with the State of Nevada for diversions from Lake Mead, above Boulder Dam, with a charge of \$0.50 per

acre-ft for storage service and \$0.35 per acre-ft as compensation for kilowatt-hours lost at Boulder Dam. In present drafts of a proposed water contract with the State of Arizona (not as yet approved by the Secretary of the Interior) the same charge is fixed for diversions from Lake Mead, and a maximum of \$0.25 per acre-ft for downstream diversions. An actual storage charge of \$0.15 per acre-ft for such agricultural diversions now seems probable. In view of these recent developments, the project's total water revenues by 1987 may considerably exceed the \$7,500,000 previously estimated.

BOULDER CANYON PROJECT ADJUSTMENT ACT

The 50-yr amortization period of the project began on June 1, 1937, with the announcement of the Secretary of the Interior that storage and installed generators were sufficient for the production of 1,250,000,000 kw-hr annually for the first power contractor, the City of Los Angeles. Power had already been sold at the secondary rate, however, amounting to \$247,000 under interim contracts. During the construction period of seven years after the execution of the contracts, various events had occurred which forced the conclusion that the 1930 power rates were inequitable and excessive, and could not long be sustained. The competitive value of the hydro power had fallen, as a result of decreases in the cost of fuel and in the capital costs of steam plants, as well as improvements in the art of steam power generation. The record indicated that advances to the construction fund by the U. S. Treasury had been secured at an interest rate averaging about 2.75% and that to charge the project a rate in excess of 3% would involve an unintended and undue profit. The United States had constructed or initiated numerous large multiple-purpose projects in other sections of the nation on a rate basis which abandoned the competitive plan previously applied, in favor of a power rate fixed by the amount needed to amortize such part of the investment as was determined to be allocable to power, plus costs of operation, maintenance, replacements, etc. This policy was later generalized by statute as to all reclamation projects. Several early determinations of allocations, particularly for navigation and flood control, appeared to be on a relatively liberal basis, resulting in power rates very unfavorable for the Southwest, as regards regional competition for heavy industry and electro-metallurgical plants. Consequently, the Boulder Canyon Project power contractors found themselves obligated to pay, until 1945, a rate considered excessive whether measured by the requirements of the Act or externally, by comparison with the newer projects.

Accordingly, a request for a review of the rates was filed in 1937 with the Secretary of the Interior, in line with a right granted when the initial allocation of the project energy was made. Preliminary conferences showed that a change from the competitive to the amortization basis, however,

involved unavoidable differences of interest among the seven states of the Colorado Basin. Two years of almost continuous discussion and negotiation followed, with frequent formal conferences, before all such interests were brought into agreement. As the surplus revenues of the original Act would be entirely eliminated on an amortization basis, determination by compromise and agreement was necessary as regards payments to be made in lieu of taxes to Arizona and Nevada, and additional payments to the Colorado River Basin Development Fund, for the benefit of all seven of the states involved.

Numerous water problems had required previous conferences, in efforts to avoid litigation among the states, so that the power problems came naturally before the same conference groups under the auspices of the several governors and most frequently under the chairmanship of the late Hon. Henry H. Blood, then governor of Utah. As the governors were generally unable to give the time personally for the more frequent conferences, and the difficulty of changing personnel and lack of continuity of program between sessions became apparent, the now well-known "Committee of 14 and 16" began to function. It consists of two representatives of each of the seven basin states, appointed by each governor or by state boards appointed by him, as its only authority is derived from the various governors, being without legislative authorization. To this Committee of 14 are added, for consideration of power problems, two representatives of the California power contractors (Los Angeles and the Metropolitan Water District) which has the further effect of equalizing the basin representation. The committee has operated under the very able chairmanship of Clifford H. Stone of Colorado, to whom in a large measure is due the credit for reaching an harmonious agreement among the states in 1939 on the question of allocation of Boulder Canyon Project revenues. The committee recommendation that Arizona and Nevada should each receive \$300,000 annually, with \$500,000 annually going to the Colorado River Basin Development Fund, was adopted by Congress in the Boulder Canyon Project Adjustment Act, approved July 19, 1940.

In view of the immediate benefits to be derived by the three Lower Basin states, a further agreement was made that expenditures from the Development Fund should be limited to the Upper Basin states until 1955. The first three annual payments were applied to the completion of surveys and studies for a "Comprehensive Plan of Basin Development," long under way by the Bureau of Reclamation. Division of the fund among the Upper Basin states was required to be on an "equitable" basis (whatever that might mean), and not until October, 1941, was agreement finally reached to interpret this as meaning "equally." This is an example of the committee's help in avoidance of litigation over the allocation of the project revenues, although protracted discussions

were required at times. Without such a forum to give an opportunity for thorough debate of the controversial problems, and final agreement by compromise before the questions could become political issues at Washington, it seems that passage of the Adjustment Act would have been impossible. Even then, however, difficulties were not ended, as this Act required definite repayment contracts to be entered into by June 1, 1941, covering 90% of the firm power or otherwise the Act would be void. Not until May 29, 1941, were the contracts finally signed, making the Adjustment Act effective.

Hearings on these contracts had been convened at Los Angeles on August 12, 1940, continuing until December 6, before a special board of three representing the Secretary of the Interior. The resulting record included about 2,000 pages of transcript of oral evidence and argument, besides 91 exhibits, many of these being lengthy reports. Chief questions at issue involved details of the agency (generating) contracts; generating charges; time and method for future readjustments of rates, to insure full repayment to the government; O & M cost estimates; allowances for replacement and depreciation; estimates of firm and secondary energy, available and also marketable; and of greatest interest, the new energy rate. Only the latter point appears to be of importance to the purpose of this paper, as its determination finally achieved the definite cost and revenue allocation that had been lacking under the terms of the original Act. Slight readjustments are still provided for, as of June 1, 1947, and at 5-yr intervals, to correct for excesses or deficiencies in estimated revenues; and annually, to allow for the effect of variations in actual cost of operation, maintenance, and replacements. The latter adjustments increased the firm power base rate (fixed at 1.163 mills per kw-hr for 1937 to 1942) to 1.172 for 1943 and 1.190 for 1944. A proportionate decrease to 0.34 mill per kw-hr for secondary power in the years 1937 to 1942 was changed to 0.346 for 1943 and 0.357 for 1944. The annual secondary rate is to be computed from future adjusted firm rates as the average of (1) a rate which bears the same ratio to the firm rate as 0.3 to 1.1, and (2) a rate which is 0.8 mill less than the firm rate; or otherwise expressed, as the firm rate times 0.6363636, less 0.4; but not less than 0.2 mill per kw-hr.

With similar infinitely detailed and legalistic exactitude, every possible or imaginable contingency of the future as affecting the power rate structure has been provided for at painful length in the several contracts and general regulations, now in force and effect. Revising the original power allocations to allow for the increased power production with the 25-ft higher (575 ft) dam, which change had caused the first allocations to total in excess of 100%, the present power contracts result in the following firm energy allocation:

ALLOCATION	PERCENTAGES
Metropolitan Water District of Southern California (for aqueduct pumping only)...	35.2517
State of Nevada (for use in Nevada only).	17.6259
State of Arizona (for use in Arizona only; no contract as yet).....	17.6259
City of Los Angeles, Calif.....	17.5554
Southern California Edison Company.....	7.0503
City of Glendale, Calif.....	1.8475
City of Pasadena, Calif.....	1.5847
California Electric Power Company.....	0.8813
City of Burbank, Calif.....	0.5773
Total.....	100.0000

The power blocks for the two states are equally underwritten by the City of Los Angeles and Southern California Edison Company, with drawback privileges as formerly. Not to exceed 20,000-kw peak demand is reserved for the United States, to be charged equally against the Los Angeles and Edison Company allocations for distribution in Boulder City or for other government camps and uses. This is in addition to power for dam operation, which is to be furnished without charge and included with station losses.

Conforming to the exact terms of the Adjustment Act, the general regulations and the foregoing contracts, a detailed financial operations study now indicates estimated project revenues over the 50-yr period to May 31, 1987, of \$256,303,360, which are sufficient to repay the reimbursable investment in the dam and power-plant building (estimated for rate determinations at \$82,878,131 as of June 1, 1941, including 3% interest during construction, or about 82.5 million dollars present value as of June 1, 1937, including some allowance for deferred construction), within fifty years amortized at a 3% interest rate. In addition, all estimated operation, maintenance, and replacement costs are covered, and Arizona and Nevada will each receive \$15,000,000 during the fifty years, with \$25,000,000 going to the Colorado River Basin Development Fund.

These allocations are compared in Table 2, on a present-value basis, as in Table 1, with the results under the original Act for various firm power rates after 1945, and with the various payments capitalized at 3%. Table 2 shows that, under the terms of the Adjustment Act, Arizona and Nevada will each receive 4.2 times as much revenue in lieu of taxes from the Boulder Canyon Project as they were assured of receiving by the original Act, and that only in case the average revised firm power rate after 1945 had exceeded 1.52 mills per kw-hr would the states have received as much revenue as they are now assured of getting. This is equivalent, on a present-value basis, to 18% of the investment in the dam and

TABLE 11- ALLOCATION OF ESTIMATED REVENUES AND COSTS,
AS PRESENT VALUES, AT 3%, AS OF MAY 31, 1937

Firm power rate (mills) per kw-hr	Dam and Power-Plant Building ^a		Repayment ^b		Arizona and Nevada		Colorado Fund ^c	
	Million dollars	Percentage of investment	Million dollars	Percentage of allocation	Million dollars	Percentage of investment	Million dollars	Percentage of investment
(a) Power Rate, Etc., of the Adjustment Act								
1.163	82.5	100	... ^d	... ^d	14.9	18	12.4	15
(b) Varied Power Rates After 1945 ^e for Comparison with Adjustment Act								
1.00	97.0	118	5.7	23	3.5	4	0.0	0
1.08	103.6	126	5.7	23	3.5	4	0.0	0
1.163	110.3	134	5.7	23	3.5	4	0.0	0
1.30	110.3	134	12.8	51	7.7	9	0.0	0
1.40	110.3	134	18.6	74	11.3	14	0.0	0
1.555	110.3	134	26.3	105	15.8	19	0.0	0
1.63	110.3	134	30.2	121	18.1	22	0.0	0

a- Repaid within fifty years. b-Flood-control allocation repayment. c-Colorado River Basin Development Fund. d-Deferred beyond the 50-yr amortization period. e-Present values of costs and payments required by the original Act but capitalized at 3% interest rate (as allowed by the Adjustment Act).

power-plant building. Likewise, the Colorado River Basin Development Fund will receive annual payments with a present value of 15% of the project investment, instead of the probability (almost certainty) of obtaining nothing under the original Act. A general understanding of these comparisons, at least on an approximate qualitative basis, explains the high degree of agreement that was finally attained in compromising the interests of the various states of the Colorado River Basin.

By the Adjustment Act, the government obtained certainty as to the amortization of its investment, less the flood-control allocation, within a 50-yr period, at a 3% interest rate, pronounced reasonable under the circumstances. Repayment of the flood-control allocation is definitely deferred beyond the 50-yr period; but the 1945 revision of power rates, under the original Act, would almost certainly have accomplished the same effect, at least as to 77% of the allocation.

On the other hand, assuming for purposes of illustration that the new firm power rate of 1.163 mills per kw-hr is fair and reasonable on a competitive market basis (as seems indicated by its acceptance by all of the power contractors), it may be considered that, on a 3% present-value basis, the government surrendered the possibility of a profit of about \$27,800,000 (the difference between 4% and 3% interest charges) besides deferring for fifty years the dependable repayment of \$5,700,000 toward the flood-control allocation. The recipients of this relinquished profit vary for different assumptions of future competitive rates, but, on the basis of the present rate as stated, the "Split-up" would appear to be as follows:

Arizona (additional revenue).....	\$ 5,700,000
Nevada (additional revenue).....	5,700,000
Colorado River Basin Development Fund (additional revenue).....	12,400,000
Power contractors (reduced payments, 1937 to 1945).....	9,700,000
Total.....	<u>\$ 33,500,000</u>

The savings to the power contractors will be divided among power consumers in Arizona, Nevada, Utah (slightly), and Southern California, the chief beneficiary; but this is considerably less than the 100-million-dollar gain which the power contractors were often asserted to be obtaining, during the years of consideration of the Adjustment Act. With the Colorado River Basin Development Fund probably to be divided about equally among the four Upper Basin states until 1955, the indicated advantage of the Adjustment Act to each Upper Basin state is computed at

\$2,600,000, and to each of the states of Arizona and Nevada, \$6,700,000 in addition to \$1,750,000 apiece to the latter two under the terms of the original Act (all amounts as of June 1, 1937, discounted at 3%). After 1955 it may benefit Nevada and Arizona projects also. California is most unlikely to share in the fund then, because of the earlier completion of all projects having an available water supply. It is not implied that the 1945 revised firm power rate, by the original Act on the basis of competitive market conditions, would have been exactly 1.163 mills per kw-hr or even approximately this amount; but a similar comparison of individual benefits can be derived from Table 2 for any other revised rate that may be assumed. The illustration given, however, shows at least that the division of the benefits allocated by the Adjustment Act was not merely or solely in proportion to the Congressional voting strength of the various states, for example. Other factors also received consideration, such as anticipated receipts under the terms of the original Act and competitive power market conditions, regional as well as local. The government, of course, ends by owning the entire project including replacement and depreciation funds for items subject to loss with use, and also retains final discretion as to the expenditure of the Colorado River Basin Development Fund. The foregoing "split-up" of this fund within the Upper and Lower basins, prior to and after 1955, is simply in accordance with the recommendation of local interested officials, which Congress may or may not follow exactly.

In refreshing contrast, from an engineering point of view, to the foregoing allocations, which are so largely dependent on legal and accounting, as well as political, considerations, is a novel rate item in the November, 1941, issue of INTAKE (Los Angeles Water and Power Department publication). New concepts in physics establish a definite relationship between energy and matter, making it possible to assign a weight to electrical energy and compare it with other commodities on the basis of cost per pound. At present Los Angeles retail prices, electricity costs about \$20,000,000 per lb or two thirds the price of radium. As the power production from the Boulder Canyon Project in 1943 was about six "pounds" of electrical energy, on this futuristic basis, the adjusted falling water charge is equivalent to \$900,000 per lb, or about the market valuation for fine, large cut diamonds. Although this fact certainly was not given much, if any, consideration in the project's cost allocation and power rate determination, to an engineer fully appreciative of the Boulder Canyon Project, it does not seem too far-fetched to value the output of the project as highly as precious jewels.

SUMMARY

Revised power contracts for the Boulder Canyon Project (Arizona-Nevada), dated May 29, 1941, provided for the amortization of the cost, at 3% interest rate, by terms of the Adjustment Act of July 19, 1940. A power (falling water) charge of 1.163 mills per kw-hr was reduced from the 1930 rate of 1.63 mills per kw-hr, as the original Act's competitive basis for power rate determination was abandoned. Depression conditions had affected adversely the competitive rate factors (price of oil and natural gas, cost of steam plants, etc.) so that the rate revision required by the original Act, in 1945, would probably have resulted in approximately the same or perhaps a greater rate reduction.

This loss of revenues would have decreased or even eliminated the project payments to Arizona and Nevada, which are considered to be in lieu of taxes, and also would have ended the chance of payments to the Colorado River Basin Development Fund which were not available in any case until about 1985. Even the repayment of the government's investment in the dam and powerplant building might not have been completed within fifty years as planned. Therefore, by agreement among the United States, the power contractors, and the seven Colorado River Basin states, as represented by their "Committee of 14 and 16," the interest rate was reduced from 4% to 3%, repayment of \$25,000,000 flood-control allocation was deferred beyond the 50-yr period, but amortization of balance of investment was made certain within this period, and definite annual payments to states were provided. These include \$300,000 apiece to Arizona and Nevada, and \$500,000 to the Colorado River Basin Development Fund, limited to use in the Upper Basin only, until 1955.

In this paper, project revenues made available by the present revised contracts and the Adjustment Act, derived from power sales and also water storage service charges, are tabulated by allocations to repayment of investment, payments in lieu of taxes, contributions to the Colorado River Basin Development Fund, and flood-control allocation repayments. For comparison, similar allocations under the terms of the original Act and contracts are presented in Table 3, assuming varied power rates after the 1945 adjustment date, and computing present values at both the adjusted 3% interest rate and at the 4% rate of the original Act. The change in interest rate was made on a showing that the interest cost to the U. S. Treasury for long-term loans during the project construction period did not exceed 2.75%.

25.

TABLE 111 - ALLOCATION OF BOULDER CANYON PROJECT COSTS EXPRESSED AS PERCENTAGES OF INVESTMENT FOR DAM AND POWER-PLANT BUILDING,^a ON THE BASIS OF PRESENT VALUES OF JUNE 1, 1937, AT INTEREST RATES OF 3% AND 4%

Power charges, in mills per kw-hr	Investment in Dam and Power Plant ^a		Arizona and Nevada in Lieu of Taxes		Development Fund ^b	Flood-Control Allocation of \$25,000,000			
						Normal ^c		Alternate ^d	
	3%	4%	3%	4%		3%	4%	3%	4%

(a) Adjustment Act and Revised Contracts

1.163	96% ^e	...	18%	...	15%	... ^f	... ^f	... ^f	... ^f
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(b) Original Act and Contracts

1.63 ^g	130% ^c	97% ^h	22%	16.4%	0	36%	27%	121%	100%
1.163 ^g	130% ^c	97% ^h	4%	3.7%	0	7%	6%	23%	22%
1.0 ^g	114% ^c	85% ^h	4%	3.7%	0	7%	6%	23%	22%

a-Less \$25,000,000 flood-control allocation. b-Colorado River Basin Development Fund. c-In terms of the remainder of reimbursable project cost. d-Expressed as a percentage of the flood-control allocation of \$25,000,000. e-Water storage charge, 4%. f-Deferred until after 1987, or the end of the 50-yr amortization period. g-Power rate, as it might have been revised after 1945 by the terms of the original Act. h-Water storage charge, 3%.

