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COLLBRAN PROJECT, COLORADO

LETTER

FROM

ASSISTANT SECRETARY OF THE INTERIOR

TRANSMITTING

A REPORT ON THE COLLBRAN PROJECT, COLORADO, PURSUANT TO SECTION 9 (a) OF THE RECLAMATION PROJECT ACT OF 1939 (53 STAT. 1187)

JULY 4, 1951.—Referred to the Committee on Interior and Insular Affairs and ordered to be printed, with illustrations

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CONTENTS

		Page
1.	Secretary's letter of transmittal of report to the Congress on the Collbran project, Colorado, July 3, 1951	V
2.	Comments of Director, Bureau of the Budget, June 19, 1951	1
3.	Secretary's report to the President, May 9, 1950	5
4.	Final report of the Bureau of Reclamation May 8, 1950, approved by the Secretary May 9, 1950	6
5.	Comments, Governor of Arizona, January 12, 1950	8
6.	Comments, California Department of Public Works, April 5, 1950	9
7.	Comments, Colorado Water Conservation Board, March 28, 1950	15
8.	Comments, New Mexico State engineer, January 24, 1950	23
9.	Comments, Utah State engineer, January 18, 1950	24
10.	Comments, Wyoming State engineer, January 17, 1950	24
11.	Comments, Department of Agriculture, April 26, 1950	25
12.	Comments, Department of Commerce, March 10, 1950	26
13.	Comments, Secretary of the Army, April 12, 1950	27
14.	Comments, Federal Power Commission, April 14, 1950	28
15.	Proposed report of the Bureau of Reclamation, December 9, 1949, approved and adopted by the Secretary, December 30, 1949	31
16.	Report of the regional director, Bureau of Reclamation, November 18, 1949	45

LETTER OF TRANSMITTAL

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., July 3, 1951.

Hon. SAM RAYBURN,
Speaker of the House of Representatives,
Washington, D. C.

MY DEAR MR. SPEAKER: My report on the Collbran project, Colorado, is transmitted herewith pursuant to the provisions of section 9 (a) of the Reclamation Project Act of 1939 (53 Stat. 1187).

The Collbran project is a multiple-purpose project designed to utilize waters of Plateau Creek, a tributary of the upper Colorado River in western Colorado, for irrigation, municipal water supply, and hydroelectric-power production. The area to be served by the municipal water-supply features of the project includes the city of Grand Junction, Colo., now experiencing industrial expansion as a result of the nearby deposits of oil-bearing shales, uranium ores, and other minerals. Irrigation supplies would be provided for about 20,000 acres of land in Plateau Valley east of Grand Junction, and hydroelectric-power plants having an installed capacity of 7,400 kilowatts' capacity would be installed along the pipeline required to serve the municipal water users.

The report has been transmitted to the States of the Colorado River Basin and to the Secretary of the Army for their views and recommendations as required by the provisions of the Flood Control Act of 1944 (58 Stat. 887); to the State of Colorado for the comments of the head of the agency exercising administration over the wildlife resources of that State, as required by the provisions of the act of August 14, 1946 (60 Stat. 1080); and to the Federal agencies which might have an interest in the proposed project, in accordance with interagency agreements. Copies of all the comments received in response to these transmittals are enclosed with the report.

The report and the comments received were submitted to the President with a request for advice concerning the relationship of the proposed project to his program. A copy of the comments of the Director of the Bureau of the Budget is enclosed with the report.

Sincerely yours,

WILLIAM E. WARNE,
Assistant Secretary of the Interior.

COLLBRAN PROJECT

LETTER FROM THE BUREAU OF THE BUDGET TO THE SECRETARY OF THE INTERIOR

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D. C., June 19, 1951.

The honorable the SECRETARY OF THE INTERIOR.

MY DEAR MR. SECRETARY: This acknowledges your letter dated May 9, 1950, submitting your Department's report on the Collbran project, Colorado, prepared by the regional director, region 4, Bureau of Reclamation, and requesting advice as to the relationship of the proposals in that report to the President's program.

The proposed Collbran project, in west central Colorado on the west slope of the Continental Divide, would supply additional water for irrigation purposes to lands in the Plateau Valley; supplemental water to Grand Valley and vicinity for industrial, municipal, and domestic purposes; and hydroelectric power for use in central Colorado. The irrigation features of the project would consist of Vega Dam and Reservoir on Plateau Creek with a storage capacity of 30,000 acre-feet, the Leon Creek-Park Creek feeder canal to divert flows of these two creeks into the reservoir, and the Southside canal extending 30 miles from the reservoir to project lands to furnish a supplemental water supply for 18,340 acres now inadequately irrigated and a full irrigation supply for 2,310 acres of new irrigated land. The industrial, municipal, and domestic water-supply features include Bonham Reservoir on Big Creek enlarged to a storage capacity of 6,300 acre-feet, together with eight natural lakes in the headwaters of Big and Cottonwood Creeks with an aggregate storage capacity of 3,830 acre-feet, two feeder canals to divert flows into the reservoirs, a pipeline approximately 44 miles long with a minimum capacity of 20 second-feet to convey water from the reservoirs to an equalizing reservoir near Grand Junction to be built by potential water users. Hydroelectric power would be generated by the 20-second-foot pipeline flow at two power plants, one located about 3½ miles from Molina, Colo., with an installed generating capacity of 5,000 kilowatts, and one near Cameo of 2,400-kilowatt capacity. These two power plants would produce approximately 51,600,000 kilowatt-hours of firm power and 6,670,000 kilowatt-hours of nonfirm power annually.

The estimated construction cost of the project is $13,299,000, and the estimated annual operation, maintenance, and replacement costs total $108,800. An amount of $257,000 of the total construction cost is allocated to nonreimbursable fish and wildlife. The remaining $13,042,000 is considered reimbursable, of which $3,987,000 is allocated to irrigation, $2,742,000 to municipal water, and $6,313,000 to

power production. A payment period of 50 years is assumed for irrigation-water users, and it is estimated the net revenue will total $1,000,000, or $2,987,000 less than the cost allocated to irrigation. It is proposed to make up this deficiency by diverting the necessary amount from the interest payments on power. The total annual cost to project farmers is estimated to be $41,000, or about $1.98 per acre on the basis of 20,650 acres of irrigated land. The annual amount to be applied to maintenance and operation of irrigation works is estimated to be $21,000, leaving $20,000 available for repayment of capital costs.

The amount of $6,313,000 allocated to power-production cost represents nearly $850 per installed kilowatt capacity. The repayment period for power is assumed as 60 years with interest at 3 percent. The average annual operation, maintenance, and replacement costs for power production are estimated at $80,000 annually. On the basis of disposing of the output of both plants at the rate of 5.6 mills for firm power and 3 mills for nonfirm power, it is estimated that the annual revenue would be $308,960. The interest component would amount to $7,285,584 in 60 years, and it is proposed to divert $2,987,000 of this to the repayment of the cost allocated to irrigation. The report submits a study indicating that electric-energy requirements in the project area would increase from 59,450,000 kilowatt-hours in 1946 to 144,000,000 kilowatt-hours in 1960, but indicates that existing facilities generated 156,814,000 kilowatt-hours in 1946, most of which was sold outside the project area. It also states that all of the market area is not immediately available to project power, and construction of the necessary transmission system would prove too costly.

It is proposed to repay the allocation to industrial, municipal, and domestic water supply over a 60-year period with interest at 2 percent. Users would be charged at rates sufficient to provide an annual revenue of $78,800 in addition to operation and maintenance costs. The report does not develop these rates nor the anticipated number of customers to be attached. It does state that the present system at Grand Junction can supply 430 gallons per capita daily and is considered adequate to meet present peak demands for the 18,500 people served. Based on the assumption of steady population increases, it is estimated that the project system could serve 31,000 customers at the end of 50 years.

In its letter dated March 28, 1950, the Colorado River Board of California questions the ability of the project to develop sufficient quantities of firm commercial power to produce the assumed annual power revenues throughout the repayment period. It also comments on the proposal to extend pay-out periods permissible under existing law and the diversion of the interest component of power revenues, and expresses the opinion that this would not comply with existing reclamation law.

The Department of Agriculture, in its letter dated April 26, 1950, states that the proposal to furnish supplemental irrigation water to Plateau Valley seems to be economically sound but suggests that a separate evaluation be set out in the report to substantiate such conclusion. The Department also questions the validity of certain assumptions made in the report in estimating benefits resulting from irrigation, particularly those credited as indirect benefits. It is noted, however, that, aside from the strictly favorable benefit-cost comparison

used in the report to justify the project, the irrigation features which primarily are for supplemental water approach an average cost of approximately $200 per acre, three-fourths of which is proposed as a Federal subsidy in addition to the interest-free money on the one-fourth that is reimbursable.

Included in the comments submitted by the Federal Power Commission in its letter of April 14, 1950, is a reference to the contrast between the 50- and 60-year repayment periods assumed and the 100-year period used for purposes of benefit-cost analysis. The Commission states that experience has demonstrated that no period longer than 50 years is justified for economic analyses, at least with respect to power projects.

It is also noted that combinations of various methods have been applied in estimating benefits and cost allocations. Based on the information made available, it is impossible to determine the effects of other methods of computation on the feasibility of the project. The Federal Inter-Agency River Basin Subcommittee on Benefits and Costs has recently developed a proposed manual for the use of all agencies in the economic analyses of river basin projects. With regard to the evaluation procedure adopted for the Collbran project, we can only question its justification in the absence of accepted methods. It would seem important that an agreement be reached at an early date on mutually acceptable methods for determining benefits and cost allocations. It would be perfectly clear then that evaluation methods employed were not adopted for the purpose of placing the economics of the project in the most favorable light.

The proposed repayment plan contemplates the use of a portion of the interest component of the power revenues as an irrigation subsidy. The President's position, with regard to this proposal, was discussed in the Director's letter of July 17, 1950, on the Palisades project. With respect to the use of the interest component, the Director's letter on the Palisades project stated:

> The President has neither approved nor disapproved such action from the standpoint of national policy. Furthermore, while it is recognized that the Solicitor of the Department of the Interior had issued an opinion that the interest component on the power investment could be so applied, the President has not indicated agreement that the present law should be so interpreted. He is reserving judgment on the issue pending the report of the Water Resources Policy Commission.

The Water Resources Policy Commission has submitted its report to the President and its recommendations are now under review and analysis within the executive branch. Until the President has had an opportunity to appraise the findings of his Water Resources Policy Commission in the light of all available data, his position remains as stated above.

The President's position regarding Federal water-supply projects for industrial, municipal, and domestic purposes is stated in the Director's letter of June 19, 1950, on the Canadian River project, as follows:

> It should be recognized that the Canadian River development would be the first improvement of an essentially municipal and industrial water supply character authorized under reclamation law. While I would not in this case question the authority for considering the proposed project under reclamation law, it would, if approved, place the United States in the position of assuming a new type of primary responsibility in the water-resources field. Up to this time, the

provision of municipal water supplies has been only an incidental feature of multiple-purpose water developments, to such primary purposes as flood control, navigation, or irrigation. * * * The project raises, therefore, the important question of national policy relative to the possible future scope of the responsibility of the Federal Government for providing adequate municipal and industrial water supplies on a Nation-wide basis. * * * There should also be a clear understanding that the total cost of furnishing water supplies would be returned to the Federal Government with interest, in a stated period of years, regardless of whether the cities' population and load growth develop as estimated in the report.

While it is recognized that the Director's letter of June 19, 1950, deals with a project designed primarily for municipal water supply, the principle of repayment should apply regardless of whether the municipal water supply feature of a project is incidental or of major importance. In connection with the Canadian River reclamation project, Texas, Public Law 898, Eighty-first Congress, second session, authorizing the project on December 29, 1950, provides under section 2 (b) that—

Actual construction of the project herein authorized shall not be commenced, and no construction contract awarded therefor, until * * * repayment of that portion of the actual cost of constructing the project which is allocated to municipal and industrial water supply and of interest on the unamortized balance thereof at a rate (which rate shall be certified by the Secretary of the Treasury) equal to the average rate paid by the United States on its long-term loans outstanding at the time the repayment contract is negotiated minus the amount of such net revenues as may be derived from temporary water-supply contracts or from other sources prior to the close of the repayment period, shall have been assured by a contract satisfactory to the Secretary, with one central repayment contract organization, the term of which shall not exceed 50 years from the date of completion of the municipal and industrial water-supply features of the project as determined by the Secretary.

With further reference to repayment periods for reclamation projects, the President stated in his letter of March 29, 1948, on the Provo River project, Utah:

It has been my understanding that reclamation projects, historically, have been based on the principle that the construction costs to the Federal Government would be repaid, without interest, in 40 years, plus, in some cases, a 10-year development period. My attention has been directed to the increasing number of legislative proposals in the last several sessions of Congress which would serve to extend the periods of repayment for certain reclamation projects. While I can understand that instances may occasionally occur which might justify the Federal Government providing for additional subsidies on reclamation projects either through waiver of interest charges over longer periods of time or possibly, in some cases, through extensions of repayment periods beyond what might eventually turn out to be the useful life of a project. I do not wish my action in approving S. 1990 to be construed as endorsing the principle of extending generally the basic 40-year repayment period for reclamation projects.

The data contained in your proposed report and the comments of the Department of Agriculture indicate the irrigation features of the project to be desirable even though the farmers may be able to repay only a part of the irrigation development costs. The indirect local benefits would appear to be of such nature and magnitude as to warrant the United States subsidizing the irrigation improvements cost above and beyond the amounts which the irrigators can repay. A separate evaluation of total benefits and costs for the irrigation features would, however, be required to substantiate such a conclusion. It would also seem proper then to consider adding the water supply and power features as they may be separately justified on the basis of incremental benefits and costs. Such an analysis would also undoubt-

edly result in some changes in cost allocations from those shown in the report, although, of course, it would be proper for all purposes to share in the savings resulting from a multiple-purpose improvement.

Accordingly, you are advised that, while there would be no objection to the submission of the proposed report to the Congress, authorization of the project would be without objection only if, in accordance with above comments:

(1) A separate evaluation of the irrigation benefits and costs as outlined above shows the work to be economically justified.

(2) It is understood that the use of the interest component for aiding the return of irrigation costs in the eventual repayment plan for the Collbran project will be dependent on the policy established by the President after he appraises the findings of his Water Resources Policy Commission; and

(3) The costs of the industrial, municipal, and domestic water supply and the hydroelectric power features of the project would be repaid with interest by the beneficiaries of each over a period of not to exceed 50 years.

If authorized by the Congress, any estimate of appropriation for initiation of the project must be justified in accordance with the policy set forth in the President's letter dated July 21, 1950, which directed that all civil works be considered with the objective, as far as practicable, of deferring, curtailing, or slowing down those projects which do not directly contribute to national defense or to civilian requirements essential to the changed international situation, or as may later be modified.

In submitting whatever report you deem appropriate to the Congress it will be appreciated if you will include a copy of this letter with your report.

Sincerely yours,

F. J. LAWTON, *Director.*

LETTER FROM THE SECRETARY OF THE INTERIOR TO THE PRESIDENT

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington 25, D. C., May 9, 1950.

The PRESIDENT,
The White House.

(Through Bureau of the Budget.)

MY DEAR MR. PRESIDENT: My report on the Collbran project, Colorado, is transmitted herewith pursuant to section 9 (a) of the Reclamation Project Act of 1939 (53 Stat. 1187).

Increased population and industrial development in the vicinity of the Grand and Plateau Valleys of Colorado have resulted in shortages of irrigation, domestic, and industrial water, and electric power. Further industrial expansion expected with the development of nearby mineral deposits, including oil-bearing shales, uranium ores and coal will further intensify the shortages. My enclosed report recommends authorization of the Collbran project at an estimated cost of $13,299,000 to provide water and electric power to meet the immediate needs in this area.

The report has been transmitted to the States of the Colorado River Basin and to the Secretary of the Army for their views and recommendations as required by the provisions of the Flood Control Act of 1944 (58 Stat. 887); to the State of Colorado for the comments of the head of the agency exercising administration over the wildlife resources of that State, as required by the provision of the act of August 14, 1946 (60 Stat. 1080); and to the Departments of Agriculture and Commerce, and the Federal Power Commission, in accordance with interagency agreements. Copies of all the comments received are enclosed with the report.

I shall appreciate having advice concerning the relationship of this proposed project to your program before I transmit the report to the Congress for its consideration and appropriate action in accordance with the provisions of the Reclamation Project Act of 1939.

Sincerely yours,

WILLIAM E. WARNE,
Acting Secretary of the Interior.

LETTER FROM THE ACTING COMMISSIONER OF RECLAMATION TO THE SECRETARY OF THE INTERIOR

DEPARTMENT OF THE INTERIOR,
BUREAU OF RECLAMATION,
Washington 25, D. C., May 8, 1950.

The SECRETARY OF THE INTERIOR.

SIR: Transmitted herewith is my report on the Collbran project, in west central Colorado.

In your behalf copies of the report which you adopted on December 30, 1949, as your proposed report were sent to the Secretary of the Army and to designated officials of the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming for their views and recommendations in accordance with the provisions of section 1 of the Flood Control Act of 1944 (58 Stat. 887), and to the Governor of Colorado for the report and recommendations of the head of the agency exercising administration over the wildlife resources of the State of Colorado in accordance with requirements of the act of August 14, 1946 (60 Stat. 1080). Copies of the proposed report were sent also to the Federal Power Commission and the Departments of Agriculture and Commerce for their comments. Copies of the written views of the States, with the exception of the State of Nevada, from which comments have not been received, and of the Federal agencies are attached with a copy of your proposed report.

The views of the reviewing officials of the States of Arizona, New Mexico, Utah, and Wyoming are favorable to the development of the project in accordance with the plan set forth in your proposed report. The State of California had no official comments to offer. Colorado, the State in which the project works are proposed, concurs in the findings of the report and suggests minor refinements in the project plan which can easily be carried out if found to be feasible at the time the project is under construction.

The Chief of Engineers, writing on behalf of the Secretary of the Army, has advised that the recommended project will not conflict

with any of the interests of the Department of the Army. Comments of the other Federal agencies are favorable.

Informal comments on the report which have been received from Rural Electrification Administration cooperatives and municipalities in the area make it desirable for me to point out at this time that in order to serve energy to preference customers in west-central Colorado in accordance with reclamation law and departmental policy it will be necessary to construct considerable transmission lines in addition to those specifically discussed in the Collbran report. The nature of the power to be produced by the Collbran project does not fit in well with the type of load to be expected from these preference customers, inasmuch as the energy production at the project plants is based upon very high plant factors, while to satisfy the preference load there would be need for peaking power at low load factors. This type of load can best be met through facilities which will be provided following construction of power plants and transmission lines in connection with the proposed Colorado River storage project. The power market in this area and the facilities to serve that load are considered to be a part of the storage project. It is contemplated also that there will be interconnection between the Collbran project power plants and the plants of the Colorado River storage project. This interconnection is expected to take place almost as soon as power can be produced on the Collbran project. Authorization for transmission facilities to serve preferential customers in this area will therefore be requested as a part of the Colorado River storage project. Should there be substantial lag between the time power is produced on the Collbran project and the time Colorado River storage power will be available, efforts will be made to satisfy preferential customers through wheeling arrangements.

After consideration of all comments received, I suggest no change in your proposed report other than your approval of the above clarification with respect to the serving of preferential power customers.

Accordingly, I recommend that you adopt the report which you approved on December 30, 1949, as clarified by this letter, as your final report on the Collbran project, and that you transmit it, together with copies of the attached comments, to the President and, subsequently, to the Congress in accordance with the provisions of the Reclamation Project Act of 1939.

Respectfully,

WESLEY R. NELSON,
Acting Commissioner.

Approved and adopted: May 9, 1950.

WILLIAM E. WARNE,
Acting Secretary of the Interior.

LETTER OF COMMENT FROM THE GOVERNOR OF THE STATE OF ARIZONA

EXECUTIVE OFFICE,
STATE HOUSE,
Phoenix, Ariz., January 12, 1950.

MR. MICHAEL W. STRAUS,
Commissioner of Reclamation, Department of the Interior,
Washington, D. C.

DEAR MR. STRAUS: The Arizona Interstate Stream Commission has reviewed the project planning report on the Collbran project, Colorado, and has addressed to me a letter, the original of which is enclosed to you.

I approve of the action of the Arizona Interstate Stream Commision and have hereby adopted its letter as the official comments of Arizona.

Sincerely,

DAN E. GARVEY, *Governor.*

ARIZONA INTERSTATE STREAM COMMISSION,
Phoenix, Ariz., January 10, 1950.

GOV. DAN E. GARVEY,
State Capitol, Phoenix, Ariz.

DEAR GOVERNOR: We have reviewed Project Planning Report No. 4–8a.5–2 of the Bureau of Reclamation, United States Department of the Interior, on the Collbran project, Colorado, together with the letter of transmittal from the Commissioner of Reclamation to the Secretary of the Interior and the letter of transmittal from the regional director of region IV of the Bureau of Reclamation to the Commissioner of Reclamation.

We assume, of course, that the proposed project has the approval of the State of Colorado and of the people of the project area.

Since the water to be utilized by the project is clearly within the share of Colorado under the Colorado River compact and the upper Colorado River Basin compact, we find no objection to the project nor to the report.

Since it appears to us that the project is urgently needed by the people of the area, we recommend that the State of Arizona join in the recommendation of the Commissioner of Reclamation and of the director of region IV of the Bureau of Reclamation, contained in their letters of transmittal; and, therefore, join in the recommendation that the project be authorized for construction.

Yours very truly,

WAYNE M. AKIN, *Chairman.*
RAY KEENAN, *Executive Secretary.*

LETTER OF COMMENT FROM THE STATE OF CALIFORNIA

STATE OF CALIFORNIA,
DEPARTMENT OF PUBLIC WORKS,
Sacramento, April 5, 1950.

Hon. OSCAR L. CHAPMAN,
Secretary of the Interior, Washington, D. C.

DEAR MR. CHAPMAN: Your proposed report on the Collbran project, Colorado, was received on January 9, 1950. This department has reviewed the report in accordance with the provisions of Public Law 534, Seventy-eighth Congress, second session, and has no comments to offer.

The report was submitted to the Colorado River Board of California for its comments, which have been received and are transmitted herewith for your information.

Yours very truly,

C. H. PURCELL,
Director of Public Works.

STATE OF CALIFORNIA,
Los Angeles, March 28, 1950.

To: A. D. Edmonston, State engineer, division of water resources, Public Works Building, Sacramento, Calif.
From: Colorado River Board of California, 315 South Broadway.
Subject: Review of Federal reports, Collbran project, Colorado.

Reference is made to letter dated January 4, 1950, from the Commissioner of Reclamation to Hon. Charles H. Purcell, director of public works, State of California, transmitting in accordance with the requirements of the Flood Control Act of 1944, copies of the proposed report of the Department of the Interior on the Collbran project, Colorado Project Planning Report No. 4–8a.5–2, dated November 1949, for information and such comments as the State might wish to make. By interdepartmental communication dated January 11, 1950, you transmitted a copy of that report to this office with the request that comments be furnished for incorporation in a report to be submitted by the director of public works. In response thereto the following comments are submitted on behalf of the Colorado River Board of California.

REVIEW OF REPORT

The proposed report of the Secretary was reviewed in considerable detail in this office, particularly with regard to the estimates of water requirements and stream depletion, and the repayment of reimbursable costs.

The regional director states that in addition to a supplemental municipal water supply, the project would provide an average of about 15,900 acre-feet of water annually as a new irrigation supply. It is indicated in the substantiating report by the Bureau of Reclamation that the total depletion of Colorado River caused by the increased municipal and irrigation water use and reservoir evaporation would average 10,700 acre-feet a year. There is insufficient detail in the report to substantiate either of these statements. Attempts to check the figures given have been unsuccessful. The report should set forth

in terms of diversions less returns to the river the total ultimate annual beneficial consumptive use of water that would result from construction and operation of the project, with ample supporting detail.

There is insufficient evidence in the report to substantiate the estimates of average annual commercial power that would be produced by the two proposed hydroelectric plants. On the basis of the information given it is questionable whether firm commercial power could be developed in quantities sufficient to produce throughout the proposed repayment period the average annual power revenues set up in the report.

The evaluation of anticipated benefits that would accrue from the Collbran project has not been studied in detail in this office since the relation of estimated benefits to costs is not considered a proper criterion upon which authorization of reclamation projects should be predicated under existing law.

The repayment plan set up in the report would not comply with the provisions of existing reclamation law. It is proposed to extend the pay-out periods permissible under present law and to divert a part of the interest component of power revenues to repayment of capital costs. Using the data in the report under review independent financial analyses were made with the repayment periods as established by existing reclamation law and with interest on the municipal and power costs considered as fixed charges to be paid as interest into the Federal Treasury and not to be used a second time to repay capital costs. The results indicate that with proper adjustment of municipal water charges and power rates the reimbursable costs of the Collbran project could be repaid in accordance with the terms of existing reclamation law.

CONCLUDING COMMENTS

On the basis of the data in the report, much of which is not substantiated, the Collbran project appears to be a desirable improvement for the reasons that—

(1) A supplemental municipal and domestic water supply is greatly needed in the project area, particularly in Grand Valley;

(2) There appears to be a potential market for the electric power that would be produced;

(3) A supplemental irrigation water supply would be beneficial in the Plateau Valley;

(4) About 2,300 acres of new land could be brought under irrigation.

Although there is some question regarding the quantities set forth in the proposed report as the new water supply that would be made available by the project and the net additional use of water that would be caused thereby, it appears that the actual quantities resulting from the project construction and operation as proposed would be relatively small, and together with the ultimate requirements of existing and authorized projects in the State of Colorado, would not exceed that State's rightful share under the upper Colorado River Basin compact of the beneficial consumptive use of water apportioned to the upper basin States by the Colorado River compact of 1922.

On the basis of incomplete data in the report it appears that the reimbursable costs as allocated therein could and should be repaid

within the periods specified by existing reclamation law, with interest on municipal and power costs paid as such into the Federal Treasury and with annual charges to the water and power users that would be reasonable and within their ability to pay. It is recommended that the repayment plan for the proposed project be revised accordingly. Otherwise, the Colorado River Board of California could not approve the project report, because of the proposed use of the interest on power investment for repayment of capital costs and the unnecessary extention of the repayment period beyond that permitted by existing law.

RAYMOND MATTHEW, *Chief Engineer.*

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OFFICIAL COMMENTS OF THE STATE OF COLORADO

CONCERNING

COLLBRAN PROJECT, COLORADO

(Project Planning Report No. 4—8a. 5–2, of Region 4,
Bureau of Reclamation, Department of the Interior,
dated November, 1949)

PREPARED BY

COLORADO WATER CONSERVATION BOARD

March 27, 1950

LETTER OF COMMENT FROM THE COLORADO WATER CONSERVATION BOARD

COLORADO WATER CONSERVATION BOARD,
March 28, 1950.

Hon. OSCAR L. CHAPMAN,
Secretary of the Interior, Department of Interior,
Washington, D. C.

DEAR MR. CHAPMAN: Enclosed herewith are four copies of the official comments of the State of Colorado concerning the Collbran project, Colorado (Project Planning Report No. 4–8a. 5–2, of region 4, Bureau of Reclamation, Department of the Interior, dated November, 1949).

Respectfully,

RAY E. PETERSON,
Administrative Assistant.

CONTENTS

	Page
Authority for Colorado comments	19
Summary of comments, views, and recommendations	19
Detailed comments	21
Need for project	21
Area population trends	21
Adjacent rural and smaller urban area needs	21
Possibility for pipeline serving Plateau Valley	22

REVIEW OF PROPOSED REPORT OF THE SECRETARY OF THE INTERIOR ON COLLBRAN PROJECT

STATE OF COLORADO,
COLORADO WATER CONSERVATION BOARD,
Denver, Colo., March 27, 1950.

The SECRETARY OF THE INTERIOR.

SIR: On behalf of the State of Colorado, and pursuant to section 1 of the act of December 22, 1944 (58 Stat. 887), there are herewith transmitted the comments, views, and recommendations of the State of Colorado concerning Project Planning Report No. 4–8a.5–2 of Region 4, Bureau of Reclamation, Department of the Interior, dated November 1949, and entitled "Collbran Project, Colorado."

These comments, views, and recommendations are submitted under the authority of chapter 265, Session Laws of Colorado of 1937, creating the Colorado Water Conservation Board and defining its functions, and in accordance with the designation of such board by the Governor, pursuant to section I of the act of December 22, 1944 (58 Stat. 887), as the official State agency to act in such matters.

SUMMARY OF COMMENTS, VIEWS, AND RECOMMENDATIONS

The comments, views, and recommendations of Colorado, submitted herewith, are summarized as follows:

(1) Colorado has long considered as desirable a project which would alleviate late-season water shortages on presently irrigated lands in the Plateau Creek Valley in Colorado, and which would furnish urgently needed domestic and municipal water supplies in the Grand Valley area and for the city of Grand Junction, Colo.

(2) Colorado concurs in the findings of the Project Planning Report that the project therein described has engineering feasibility and will furnish a supplemental irrigation supply for 18,340 acres of lands now inadequately irrigated and a full irrigation supply for 2,310 acres of lands not presently irrigated; and also will provide approximately 14,400 acre-feet of water annually for domestic, municipal, and power supplies and the annual generation of 51,600,000 kilowatt-hours of firm power together with 6,670,000 kilowatt-hours of secondary power. The project plan includes the construction of a pipeline for conveying municipal and domestic water from the potential lower power plant near Cameo to an equalizing reservoir about 4 miles northeast of Grand Junction, such equalizing reservoir to be built by the water users. The ratio of benefits to cost is favorable, being estimated in the report as 2.34 to 1. It has also been estimated that municipal and domestic users would amortize their allocation of capital costs, amounting to $2,742,000, with 2 percent interest in a 60-year repayment period, and pay their share of operation, maintenance, and re-

placement costs. Irrigation users would be able to pay $20,000 annually for a 50-year period toward their allocation of capital costs in addition to operation, maintenance, and replacement. Power revenues are expected to pay powers full operation, maintenance, and replacement costs, and its full allocation of capital cost, with 3 percent interest, in 60 years.

(3) The allocation of capital costs, as between the various project features, including a nonreimbursable allocation to fish and wildlife preservation, is considered reasonable. Such allocation as stated in the report is as follows:

Purpose:	*Allocation of capital costs*
Municipal and domestic use	$2, 742, 000
Power production	6, 313, 000
Irrigation	3, 987, 000
Fish and wildlife preservation	257, 000
Total	13, 299, 000

(4) It is recognized that the allocation to the various project purposes of annual operation, maintenance, and replacement costs has been made to correspond to the allocation of capital cost. Such annual costs are estimated in the report to amount to $108,800 annually and were allocated as follows:

Purpose:	*Allocation of annual operation, maintenance, and replacement costs*
Municipal and domestic use	$7, 800
Power production	80, 000
Irrigation	21, 000
Total	108, 800

Colorado recommends that an authorization of the project shall not preclude a readjustment of operation, maintenance, and replacement charges as between municipal and domestic users and power and irrigation users, which might more accurately reflect the actual use of water by such users.

(5) It is also recommended that an authorization of the project shall provide for the inclusion in the plan of a piped supply of domestic and stock water in the Plateau Valley in lieu of the contemplated bypassing of natural flows in the stream channels, in the event that further studies may indicate the feasibility of the inclusion of such a feature in the project plan due to the increased power production accruing from the utilization of the bypassed water in the power system.

(6) There is an area situated below the potential power and domestic pipeline, and lying between Mesa Creek and potential power plant No. 2, to which no water is at present available. It has been estimated that a small amount of water would make it possible to keep 1,000 additional cattle in the area. Colorado therefore recommends that consideration be given to the possibility of the release from the pipeline of the relatively minor amounts which would be required for such stock water.

(7) Colorado further recommends that the location of potential power plant No. 2, as described in the report, be not considered as limited by such description, and that further study is desirable to

determine an elevation for this power plant which will be compatible with the most economical plan for all uses.

(8) In the acquisition of water rights for the purposes of the project, the view of the State of Colorado is that such water rights shall be considered as junior to all present vested rights to the use of water from the streams on which the project rights are to be acquired.

(9) Colorado strongly recommends, with regard to the project features for the purpose of fish and wildlife preservation, that the entire project area be open to free use of the public, with provisions for access adequate for the recreational needs of the general public, except for such portions as may be reserved for safety, or for the efficient operation of the project.

DETAILED COMMENTS

There has been long-recognized need for additional water for irrigation in the Plateau Valley. Natural stream flows in Plateau Creek and tributaries are low in the late summer months, so that supplemental water is a necessity for good growth of late summer and fall pasture, and for increased yields of forage crops, essential to the livestock industry predominating in the area. In all published and unpublished reports on the utilization of the Colorado River and its tributaries, this valley has been considered a critical area.

Coupled with this urgent need for irrigation water in Plateau Valley, there is a desperate need for additional domestic water in the Grand Valley, including both the rural and urban areas. The city of Grand Junction is handicapped by a water system incapable of supplying the present requirements and the needs of the immediate future. The population of Grand Junction was 12,479 in 1940. The present population is estimated at 18,500, and that of its metropolitan area at more than 35,000. These estimates are based on increases in the number of telephones and electric meters, building permits, postal receipts, retail sales, and average number of manufacturing employees.

The use of uranium for the development of atomic energy and the production of synthetic liquid fuels from oil-bearing shales have both recently become of national importance and interest. The area immediately southwest of Grand Junction contains one of the world's largest known deposits of uranium-bearing ore. At present there are about 1,500 persons, with an annual payroll of $700,000, employed directly or indirectly in the production and processing of uranium ores in the vicinity of Grand Junction, including 200 employees of the Atomic Energy Commission. There are plans for the immediate construction of a plant by Vitro Manufacturing Co., which will mean the addition of 50 families to the area.

To the north of Grand Junction there are rich deposits of oil shale, in quantity sufficient for a supply of liquid fuels for many years at the present rate of national consumption. Extensive experimental work by the Bureau of Mines, including a demonstration plant in operation at Rifle, Colo., for the extraction of liquid fuels from shale, has already accounted for a sbustantial increase in business in Grand Junction.

At the present rate of increase, the city's population should be about 27,000 by 1959, and that of the metropolitan area should be about 70,000.

An extensive field of natural gas immediately north of Grand Junction is being tested, and a dependable supply of gas would bring new industries to the area. It is practically certain that a large paper and pulp plant will be built east of Grand Junction in the near future. Private enterprise is considering the institution of large-scale production of liquid fuel from shale. All of these factors indicate that the rate of increase in population may be much greater in the immediate future than that which has been estimated under present conditions.

The situation with respect to domestic and stock water supplies is fully as critical in the rural and smaller urban areas of the Grand Valley as in the city of Grand Junction. An adequate sanitary domestic supply must be available to such areas in the immediate future. Domestic water for more than 1,000 farm homes must now be hauled from the supplies of the various municipalities and from artesian wells and stored in cisterns at these homes. It is estimated that the cost of hauling water to the rural users is over $2,000 per million gallons. Further, the draft on the artesian wells and the low permeability of the aquifers have contributed to a serious lowering of the artesian head and of the yield of the wells. As a result, there is at present a potential controversy over rights to the artesian water. Local streams and ditches furnish fair supplies for stock water and some domestic use in the summer months, but in the winter these supplies are not available. The shallow ground water is of poor quality, and even the streams and ditches are becoming of worse quality yearly, with increased use for irrigation and industry.

The Collbran project would provide the most feasible means, as determined by extensive studies for the reported plan, as well as of various alternative plans, for the alleviation of the present shortages of late season water on the agricultural lands of the Plateau Valley and for furnishing water supplies of high quality to meet present and imminently potential demands of the farms, industries, and municipalities of the Grand Valley area.

The project would also furnish electric energy which would assist in meeting the increasing demands for power in the area. The plan provides for replacement storage capacity for water which is diverted from the Plateau Valley streams for power, domestic, and municipal purposes, in order that an adequate irrigation supply may be available to the agricultural users in that valley.

The project has been endorsed by the Plateau Valley Water Association, representing those users, the city of Grand Junction, and the Clifton fire-protection district, representing domestic and municipal users outside of Grand Junction. All groups have expressed their extremely urgent needs for additional water supplies.

As stated in the summary of views and comments, Colorado considers the allocations of capital costs, as set forth in the report for the various project features, to be reasonable and equitable. The allocations of operation, maintenance, and replacement costs, as stated in the report, have been made to correspond to the allocation of capital cost. This basis may not reflect accurately the proportionate actual use as between the irrigation users and the domestic, municipal, and power users. Further, as to the methods used in estimating the repayment capacity of the irrigated lands, which were the farm-budget method and the income-to-land method, the types of farms

selected for the analyses are probably representative of average conditions and practices in the project area. However, a considerable acreage in the area consists of pasture-type lands presently being irrigated under junior priority rights. These lands may require a large portion of project water in order to firm up the present inadequate water supplies under those rights. Colorado therefore recommends that an authorization of the project shall be made which will not prevent a readjustment of operation, maintenance, and replacement costs as between users, and that further studies are essential for the determination of the repayment ability of such pasture-type lands, and of allocations of such costs which will be considered equitable for all project purposes.

It is also recommended that the possibility of furnishing a piped domestic water supply to residents of the Plateau Valley shall not be considered as excluded from the project plan. Under the plan, supplies for municipal, domestic, and power purposes are proposed to be collected from Big Creek and Cottonwood Creek, which are tributaries of Plateau Creek. The present practice of water users on those streams is to utilize natural stream flow for domestic and stock purposes. The report indicates that sufficient flow for those purposes is proposed to be bypassed at the collection works during the winter months. This bypassed flow will not then be available for the generation of electric energy in the power system. An interest in a piped supply of domestic and stock water has been expressed by these water users, as it is apprehended that water flowing through the project canal in the summer months will not be of a quality suitable for domestic use, and icing conditions in the winter months will cause substantial loss of the bypassed flow to domestic, stock, and power users. Further studies are desirable to determine the feasibility of applying additional power revenues, due to the potential use of the bypassed water through the proposed power plant No. 1, toward the cost of construction of a stock and domestic water pipeline to distribute the water from the power plant to the users in the Plateau Valley.

Respectfully submitted.

LEE KNOUS,
Governor, State of Colorado.
CLIFFORD H. STONE,
Director, Colorado Water Conservation Board.
R. M. GILDERSLEEVE,
Chief Engineer, Colorado Water Conservation Board.
R. J. TIPTON,
Consulting Engineer, Colorado Water Conservation Board.

LETTER OF COMMENT FROM THE STATE ENGINEER OF THE STATE OF NEW MEXICO

STATE OF NEW MEXICO,
OFFICE OF STATE ENGINEER,
Santa Fe, January 24, 1950.

SECRETARY OF THE INTERIOR,
Washington, D. C.

SIR: On January 9, 1950, we received the Bureau of Reclamation report on the Collbran project in Colorado, which was prepared by

region 4, Salt Lake City, Utah, in November 1949, and is designated as Project Planning Report No. 4–8a.5–2.

In compliance with the provisions of the Flood Control Act of 1944 (58 Stat. 887) the State of New Mexico submits the following comment:

The above-mentioned report indicates that the Collbran project will consume but a small portion of Colorado's allocation under the Upper Colorado River Compact, that the project is feasible from an engineering standpoint, and that it can be constructed under existing reclamation laws without help from the proposed Colorado River Development Fund. New Mexico favors the authorization and construction of the Collbran project.

Very truly yours,

JOHN H. BLISS,
State Engineer.

LETTER OF COMMENT FROM THE STATE ENGINEER, STATE OF UTAH

THE STATE OF UTAH,
OFFICE OF STATE ENGINEER,
Salt Lake City, January 18, 1950.

MICHAEL W. STRAUS,
Commissioner, United States Department of the Interior,
Bureau of Reclamation, Washington 25, D. C.

MY DEAR COMMISSIONER STRAUS: Receipt of two copies of the Bureau of Reclamation report relative "Collbran Project Colorado" together with your letter of transmittal, addressed to me under date of January 4, 1950, is acknowledged.

On behalf of the State of Utah, and pursuant to section 1 of the act of December 22, 1944 (58 Stat. 887) you are informed that Utah reports favorably relative its views and recommendations on the Collbran project Colorado, identified as Region 4 Project Planning Report No. 4–8a.5–2 and recommends its approval.

Respectfully,

HAROLD A. LINKE, *State engineer.*

LETTER OF COMMENT FROM THE STATE ENGINEER, STATE OF WYOMING

STATE OF WYOMING,
STATE ENGINEER'S OFFICE,
Cheyenne, January 17, 1950.

Mr. MICHAEL W. STRAUS,
Commissioner, United States Department of the Interior,
Bureau of Reclamation, Washington 25, D. C.

DEAR MR. STRAUS: This will acknowledge receipt of your letter of January 4, 1950, accompanied by two copies of the report of the Department of the Interior on the Collbran project in Colorado.

Agreeable to your request we have reviewed the above captioned report, and offer the following comment thereon: It appears that the project has engineering feasibility with a benefit-cost ratio of 2.34 to 1, and since the proposed depletion is well within the allocation of

Colorado under the terms of the upper Colorado River compact, we concur in the recommendations of the director of region No. 4 of the Bureau of Reclamation.

Yours very truly,

L. C. BISHOP,
State Engineer and Interstate Streams Commissioner.

P. S. Copy No. 89 of the Collbran project report is being returned to you, together with the twenty copies of the Colorado River report. We have no need for more than one of the Collbran project reports in our files.

L. C. B.

LETTER FROM THE DEPARTMENT OF AGRICULTURE TO THE COMMISSIONER OF RECLAMATION

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, April 26, 1950.

Mr. MICHAEL W. STRAUS,
Commissioner of Reclamation,
United States Department of the Interior,
Washington, D. C.

DEAR MR. STRAUS: With your letter of January 4, 1950, you transmitted for review by the Department of Agriculture, copies of the proposed report of the Department of the Interior on the Collbran project, Colorado.

Your report in reality proposes two projects. One would supply water to Grand Junction and environs for industrial, municipal, and domestic use, with power production as an associated feature. The other would provide a supplemental water supply for irrigation enterprises in Plateau Valley.

We are not prepared to comment on the municipal water supply project. The policy question involved is, we understand, being considered by the President's Water Resources Policy Commission.

The project to increase the supply of irrigation water available to farmers in Plateau Valley is of direct interest to the Department of Agriculture and it has been examined rather carefully. We have previously questioned the validity of certain assumptions upon which the Bureau of Reclamation bases its estimates of benefits resulting from irrigation projects. In particular we have questioned the estimates of indirect benefits. Some of the questionable evaluation procedures have been used in the present report, but we note that the direct benefits appear to be large enough to cover the cost of the project. It seems, therefore, that the proposal to furnish supplemental irrigation water to Plateau Valley is economically sound. We suggest, however, that a separate evaluation of this project be set out in the report.

We have also examined your estimates of the repayment ability of the Plateau Valley farmers. It is our opinion that you are quite safe in assuming that they can repay the amount proposed in your report.

Your report attaches great significance to the fact that the amount of interest on the Federal investment in the power features of the municipal water supply project will exceed the required Federal con

tribution toward the cost of the irrigation project. It seems to us that this is both unnecessary and confusing. If an irrigation project produces benefits in excess of its cost the Federal contribution necessary to put it into effect will be a worth-while investment of public funds. It should only be necessary, therefore, to (*a*) demonstrate that the proposed irrigation project is economically sound; (*b*) show how much the water users and other beneficiaries can and should pay; and (*c*) recommend to the Congress that it authorize the appropriation of the difference between the amount to be paid by local beneficiaries and the cost of the project. Whether the interest component on a power investment is greater or less than this difference has no real bearing upon the justification or desirability of the project, nor upon the amount that must be withdrawn from the Treasury to construct it. We believe that it should be possible to proceed with a good irrigation project even though it cannot be combined with a power project.

We note the proposal to raise the Bonham Dam which is located in the Grand Mesa National Forest. If this is done it would seem desirable to provide for a roadway on its crest, and for the installation of facilities necessary to the development of the recreational potentialities of the lands surrounding the enlarged reservoir. We have no specific suggestions to make at this time regarding other works that you propose to construct in the national forest. You may be sure that your regional office will have the full cooperation of the regional office of the Forest Service in solving any problems that may arise as the project goes forward.

We greatly appreciate the opportunity to review your report and we shall be very happy to cooperate in any way that may be found desirable in making a success of the irrigation project proposed therein.

Sincerely,

K. T. HUTCHINSON, *Assistant Secretary.*

LETTER FROM DEPARTMENT OF COMMERCE TO THE COMMISSIONER OF RECLAMATION

DEPARTMENT OF COMMERCE,
OFFICE OF DOMESTIC COMMERCE,
Washington 25, D. C., March 10, 1950.

Mr. MICHAEL W. STRAUS,
Commissioner, United States Department of Interior,
Bureau of Reclamation, Washington 25, D. C.

DEAR MR. STRAUS: Thank you for sending us your proposed report on the Collbran project, Colorado. We are glad to have this information, and understand that our field offices have no objections to the project.

The United States Coast and Geodetic Survey has the following comments to make with reference to coordinating their services with these project investigations. The comments are particularly applicable to future project investigations:

> The various maps do not have meridians and parallels of latitude shown thereon. Elevations are shown on some, but no indication is given that they are expressed relative to mean sea level.

Triangulation surveys and precise leveling related to the Federal network of control surveys are essential for planning of large public works such as the Collbran project, so that coordination may be obtained for the various engineering surveys.

The United States Coast and Geodetic Survey provides these basic control surveys providing we have information as to where they are needed. Such information should be available to us so that the funds may be obtained and field surveys and office processing of survey notes completed sufficiently in advance so that the resulting data will be available in the preliminary as well as the construction phases of the project.

Sincerely yours,

H. B. McCoy,
Director.

LETTER FROM THE DEPARTMENT OF THE ARMY TO THE COMMISSIONER OF RECLAMATION

Department of the Army,
Office of the Chief of Engineers,
Washington, April 12, 1950.

Hon. Michael W. Straus,
Commissioner, Bureau of Reclamation,
Department of the Interior, Washington, D. C.

Dear Mr. Straus: Reference is made to your letter of recent date to the Secretary of the Army and to the Chief of Engineers inclosing for the information and comment of the Department of the Army, in accordance with section 1 of the Flood Control Act of 1944, copies of your report dated December 9, 1949, on the Collbran project, Colorado. On behalf of the Secretary of the Army, I am transmitting herewith comments on the report.

Your report recommends a project to supply supplemental municipal and domestic water for communities in Grand Valley, Colo., additional water for irrigation in Plateau Valley, and electric energy for use in west-central Colorado. The water for the Grand Valley communities would be collected by eight small reservoirs emptying into a proposed enlarged Bonham Reservoir on Big Creek and into Big Meadow Reservoir on Cottonwood Creek. These creeks are tributaries of Plateau Creek which flows into Colorado River about 20 miles upstream from Grand Junction, Colo. Water would be diverted from the afore-mentioned reservoirs into a pipeline about 44 miles long. The reservoirs are located at an elevation of 10,000 feet. A drop of 5,000 feet to the valley floor would produce an estimated 51,600,000 kilowatt-hours of firm and 6,670,000 kilowatt-hours of secondary power annually. The cost of the improvements proposed is estimated at $13,299,000.

Your report demonstrates the need for development of supplementary water and power in this area. It is noted that the improvements proposed do not involve flood control or navigation. Therefore I am pleased to advise you that the recommended project will not conflict with improvements in the Colorado River Basin in which this Department has interest.

The opportunity to review your report is appreciated.

Sincerely yours,

Lewis A. Pick,
Major General, Chief of Engineers.

87297—51——3

LETTER FROM FEDERAL POWER COMMISSION TO THE COMMISSIONER OF RECLAMATION

FEDERAL POWER COMMISSION,
Washington 25, April 14, 1950.

Subject: Collbran project, Colorado.

Mr. MICHAEL W. STRAUS,
Commissioner, Bureau of Reclamation,
Department of the Interior, Washington 25, D. C.

DEAR MR. STRAUS: The remarks herein with respect to the Department of the Interior's proposed report on the Collbran project, Colorado, are transmitted in response to your letter dated January 4, 1950, in which the Commission's comments were requested. Transmitted with your letter were your report dated December 9, 1949, approved and adopted by the Secretary of the Interior on December 30, 1949; and Project Planning Report No. 4–8a.5–2, consisting of the regional director's report dated November 18, 1949, and substantiating materials. The transmittal of these comments is in accordance with the established procedures of the Federal Interagency River Basin Committee.

From a review of your report and from the results of studies by its staff, the Commission believes that the Collbran project, subject to certain possible modifications, would provide adequately for the economic development of the water power resources available in connection with the project. The details of the project and the specific comments and suggestions of the Commission staff are discussed in the following.

The Collbran project is located in the Plateau and Grand Valleys at the base of Grand Mesa on the western slope of the Continental Divide in west-central Colorado on the Colorado River and in close proximity thereto. The proposed plan would supply water needed in Grand and Plateau Valleys for irrigation and for municipal and domestic use, through water exchanges and through storage regulation of the stream runoff tributary to Plateau Creek, and provide for the development of hydroelectric power. Under the plan a minimum continuous flow of 20 cubic feet per second would be diverted from the headwaters of Big and Cottonwood Creeks and conveyed by pipeline to an equalizing reservoir near Grand Junction, Colo., for industrial and municipal use. The diverted water would be used en route at two proposed interconnected power plants developing a total fall of about 5,000 feet. The two plants would have an aggregate installed capacity of 7,400 kilowatts capable of producing a total of 58,270,000 kilowatt-hours of electric energy annually of which 51,600,000 kilowatt-hours would be firm. As the water that would be diverted is now used for irrigation in Plateau Valley, such water would be replaced by surplus spring runoff from upper Plateau, Leon, and Park Creeks. This surplus water would be stored in the proposed Vega Reservoir until need for irrigation. With regulation at Vega Reservoir these streams would provide, in addition to the required replacement, an average of about 15,900 acre-feet of water annually as a supplemental water supply for 18,340 acres of land in Plateau Valley and a supply for 2,310 acres of new land.

It is recommended in the report that the Collbran project be authorized to be constructed, operated, and maintained by the

Bureau of Reclamation; and that consideration be given in the future to the inclusion of this project in any basin plan which may be developed in the upper Colorado River Basin.

The proposed Collbran project would consist of Vega Dam and Reservoir on upper Plateau Creek with a total capacity of 30,000 acre-feet, and the Leon Creek-Park Creek feeder canal to divert flows of these two creeks into the reservoir; the Southside canal, 30 miles in length, extending from Vega Reservoir to project lands; the enlargement of Bonham Reservoir on Big Creek to a total capacity of 6,300 acre-feet; the use of eight natural lakes in the headwaters of Big and Cottonwood Creeks, with an aggregate usable storage capacity of 3,830 acre-feet; two feeder canals in the headwaters of these two creeks; a pipeline to convey a regulated flow of 20 cubic feet per second from the headwaters of Big and Cottonwood Creeks to an equalizing reservoir to be constructed by local interests for municipal and domestic water supply purposes, at a site near Grand Junction, Colo.; and, en route, the development of hydroelectric power at two power plants to be constructed as a part of the project. It is estimated in the report that the 20 cubic feet per second (13 million gallons daily) would provide the needs for municipal and domestic water supply until about the year 2000.

Power plant No. 1 would be located at Cottonwood Creek about 3.5 miles from Molina, Colo., and would have an installed generating capacity of 5,000 kilowatts. Bonham Reservoir would be utilized as forebay storage in the operation of this plant, and a reinforced concrete afterbay with a capacity of 10 acre-feet would be constructed at the tailrace of the plant, since no natural site is available. The total fall between the Bonham Reservoir and the plant is 2,789 feet. A minimum flow of 20 cubic feet per second in the pipeline and penstock would be maintained throughout the year. Water diverted in excess of 20 cubic feet per second, up to a maximum of 30 cubic feet per second, would be utilized to generate secondary energy at plant No. 1 and this excess flow would then be diverted from the afterbay into the Southside canal for irrigation use. The average annual generation of electric energy would amount to 37,270,000 kilowatt-hours, of which 30,600,000 kilowatt-hours would be firm. The annual load factor operation of the plant would be 85 and 70 percent for average and dry year conditions, respectively.

Power plant No. 2 would be located on the east bank of the Colorado River near Cameo, Colo. It would have an installed generating capacity of 2,400 kilowatts, and would operate at 100 percent load factor. The plant would utilize a constant flow of 20 cubic feet per second which would be conveyed from the afterbay of plant No. 1 through a 17-mile pipeline and a penstock to plant No. 2. The total fall between the afterbay at plant No. 1 and the nozzle at plant No. 2 is 2,238 feet. No forebay or surge tank would be provided under the project plan. Discharges from the power plant would flow through a 13-mile pipeline to the terminal reservoir near Grand Junction. The annual generation would amount to 21,000,000 kilowatt-hours, all of which would be firm.

The capital cost of the Collbran project, on the basis of July 1948 prices, is estimated in the report as $13,299,000, allocated to the various project purposes as follows:

Municipal and domestic use	$2, 742, 000
Power production	6, 313, 000
Irrigation	3, 987, 000
Fish and wildlife preservation	257, 000
Total	13, 299, 000

The allocation of $257,000 for fish and wildlife is proposed to be nonreimbursable, and the remaining $13,042,000 is to be returned in full to the United States. The cost of the equalizing reservoir near Grand Junction, to be constructed by local interests, is not included in the foregoing amounts. Operation, maintenance, and replacement costs are estimated in the report to average $108,800 annually.

As proposed in the report of your Department, the repayment of reimbursable costs would be made as follows: Municipal and industrial water users would be required to repay their share of the construction cost in 60 years with interest at 2 percent, a total of $78,880 annually, in addition to their share of the annual operation, maintenance, and replacement costs amounting to $7,800. Irrigation water users would be required to repay $20,000 annually over a 50-year period, following a 3-year development period, or a total of $1,000,000, in addition to paying $21,000 annually as their share of the operation, maintenance, and replacement costs. Power rates of 5.6 mills per kilowatt-hour for firm energy and 3.0 mills per kilowatt-hour for nonfirm energy would return $308,960 annually, which would pay the operation, maintenance, and replacement cost of $80,000 per year chargeable to power, return the capital costs allocated to power in 60 years with 3 percent interest, and provide a balance at the end of this period of $139,000. The interest payments on the power investment, totaling $7,285,600, would be used in part to repay that portion of the irrigation allocation, amounting to $2,987,000 or about 40 percent of the total power interest component, which is beyond the ability of the irrigation water users to repay.

The average annual direct benefits are estimated in the report to be $716,160, and the indirect benefits to be $412,340, aggregating $1,128,500.

In contrast with the 50-year period for irrigation and the 60-year period for municipal and industrial water and power, used in the repayment analysis, a 100-year period has been used for the entire project for purposes of benefit-cost analysis. The staff points out that, at least with respect to power projects, experience has not demonstrated that a period longer than 50 years for economic analyses is justified. However, on the basis used in your report you have estimated annual costs at $482,800, and using your estimated aggregate direct and indirect benefits of $1,128,500 arrive at a benefit-cost ratio of 2.34 to 1.00. The staff observes that if only the direct benefits are used the ratio becomes 1.48 to 1.00, with the project still remaining well justified.

The Commission staff's estimate of the value of the project power on the basis of a capacity value of $27.79 per kilowatt for capacity, and 2.37 mills per kilowatt-hour for energy, amounts to $311,000 which is in very close agreement with the expected power revenue of $308,960 per year, as given in your report.

The Commission staff's investigation of the feasibility of developing power at the proposed Vega Reservoir and by utilizing the 800-foot drop along the proposed Southside canal indicates that neither of

these potential power developments is economically feasible at this time. The staff suggests, however, that if it is possible to do so without additional expense the 800-foot drop be concentrated at one or two locations along the canal to facilitate possible future power development.

The staff advises that at power plant No. 1 the proposed installation of 5,000 kilowatts is adequate on the basis of the assumed 30 cubic feet per second maximum discharge and the proposed capacity of the afterbay, and is in substantial agreement with the Bureau's estimate of the amounts of firm and secondary energy available.

The staff is also in substantial agreement with respect to the installed generating capacity of 2,400 kilowatts and the annual output at power plant No. 2, if the plant is to be operated at 100 percent load factor as proposed in the report. The staff believes, however, that it would be desirable, in utilizing the power in the area load, to operate the plant at a substantially lower load factor, say 65 percent, requiring an installation of approximately 3,700 kilowatts. Such enlargement would require a forebay at the end of the 17-mile pipeline and near the head of the penstock, a somewhat larger penstock, and a small afterbay to reregulate the variable discharges. Even if the construction of an afterbay and the enlargement of the installation may be impracticable the staff believes that the forebay would substantially improve the operation of the 17-mile pipeline and power plant and would be desirable and, therefore, merits further investigation.

The staff is of the opinion that it would be desirable to enlarge the 17-mile pipeline between power plant No. 1 and the head of penstock at plant No. 2 in order to assure the assumed capacity flow of 20 cubic feet per second throughout at least the repayment period of 60 years. Estimates by the staff of the friction loss in this pipeline, consisting of 13 miles of 30-inch and 4 miles of 22-inch-diameter welded steel pipe, indicate that after 20 to 30 years of service, the loss due to deterioration and increased friction would exceed the available fall to the top of penstock as shown on drawing No. 482–P–31 in the report. Either an adjustment in the location and profile of the pipeline to increase its gradient or larger diameters of pipe than those proposed would be required to assure the desired capacity flow.

The opportunity to review and comment on the report of your Department on the Collbran project, Colorado, is appreciated.

Sincerely yours,

NELSON LEE SMITH, *Chairman.*

PROPOSED REPORT OF THE BUREAU OF RECLAMATION

DEPARTMENT OF THE INTERIOR,
BUREAU OF RECLAMATION,
Washington, D. C., December 9, 1949.

The SECRETARY OF THE INTERIOR.

SIR: This is my proposed report on the potential Collbran project, in the Upper Colorado River Basin in Colorado. My report is based on and includes the accompanying report of the regional director, Salt Lake City, Utah, dated November 18, 1949.

The Collbran project is located in the Plateau and Grand Valleys at the base of Grand Mesa on the western slope of the Continental Divide in west central Colorado. It would supply needed irrigation, municipal, and domestic water, and electric energy.

Population pressure in the Plateau Valley has created an urgent need for additional water for irrigation, but because of the costs involved local interests cannot build the works needed to supply this water. In Grand Valley existing municipal and industrial demands are taxing the existing facilities to capacity. Domestic water for farm homes throughout the area must be hauled long distances or be taken from irrigation ditches. The latter source produces water of doubtful potability. The normal growth of Grand Valley will soon increase the demand for water beyond the physical capacity of existing works. Power supplies in the area are already inadequate, and it is anticipated that industrial development of oil-bearing shales, uranium ores, and coal will aggravate the shortage.

The plan of development for the Collbran project provides for diversion of a minimum 20 second-feet continuous flow from two Grand Mesa streams, Big and Cottonwood Creeks, by a pipeline, which would transport the water for industrial and municipal use, to an equalizing reservoir near Grand Junction. The diverted water would be used en route at two power plants to generate annually 51,600,000 kilowatt-hours of firm power and 6,670,000 kilowatt-hours of secondary power. Stream-flow regulation needed to accomplish this diversion would be provided by enlarging Bonham Reservoir on Big Creek and utilizing eight small natural lakes in the upper reaches of Big and Cottonwood Creeks. As the water that would be diverted to Grand Valley is now used for irrigation in Plateau Valley, it would be replaced by surplus spring runoff from Upper Plateau, Leon and Park Creeks that would be stored until needed in the potential Vega Reservoir. With regulation at Vega Reservoir these streams would provide, in addition to the required replacement, an average of about 15,900 acre-feet of water annually as a new irrigation supply for 20,650 acres of land in Plateau Valley, including 2,310 acres now idle for lack of water and 18,340 acres inadequately irrigated.

The project plan includes provisions recommended by the Fish and Wildlife Service to increase fish and wildlife values. Recreational facilities recommended by the National Park Service would be provided to the maximum practicable extent after project construction. Costs of recreational development are not included as a part of the indicated construction cost. Silt and flood-control benefits from this project are minor. The project does not involve stream-pollution abatement, Indian lands, or navigation.

Rights to the use of the water required for the project could be obtained in accordance with the Colorado State water law. The project would consume less than 1 percent of the Colorado River water, which, it is estimated, will be available for future development in the State of Colorado under the terms of the Upper Colorado River Basin Compact.

The estimated construction cost of the Collbran project is $13,299,000. Operation, maintenance, and replacement cost of the project works are expected to average $108,800 annually. Based on the annual benefits of the project accruing through the preservation and propagation of fish and wildlife over the repayment period, a

nonreimbursable allocation of $257,000 is proposed in the report. The remaining $13,042,000 would be reimbursable and would be allocated as follows: irrigation, $3,987,000; power production, $6,313,000; and municipal use, $2,742,000.

The reimbursable construction costs would be returned in full to the United States. Irrigation-water users would be required to repay $20,000 annually toward construction costs, in addition to paying their share of operation, maintenance, and replacement costs. Over the recommended 50-year repayment period, following a 3-year development period, this would return $1,000,000. The balance of the irrigation allocation would be assigned for repayment from the interest component of the power revenues. Municipal and industrial-water users would be required to repay their share of the construction costs of the project in 60 years, with interest at 2 percent, a total of $78,880 annually, in addition to paying their share of the operation, maintenance, and replacement costs. This would return the municipal water allocation of $2,742,000 plus interest amounting to $1,991,000.

Power rates of 5.6 mills per kilowatt-hour for firm energy and 3 mills for nonfirm energy would return $308,960 annually, which would pay the operation, maintenance, and replacement costs, and return the capital costs allocated to power in 60 years, with 3 percent interest, and provide a balance at the end of this period of $139,000. The interest payments, amounting to $7,285,600, would be used in part to repay that portion of the irrigation allocation which is beyond the ability of the water users to repay.

It will probably be desirable at a future date to consolidate the Collbran project in a basin plan for development of the Upper Colorado River Basin.

I concur in and adopt the recommendations of the regional director as set forth in paragraph 26 of his report.

I recommend that you approve and adopt this report as your proposed report on the Collbran project and that you authorize me, in your behalf, to transmit copies to the States of the Colorado River Basin and to the Secretary of the Army in accordance with the requirements of the Flood Control Act of 1944 (58 Stat. 887), to the State of Colorado for the views and recommendations of the head of the agency exercising administration over the wildlife resources of the State of Colorado in accordance with provisions of the act of August 14, 1946 (60 Stat. 1080), and to other interested Federal agencies for their comments.

Respectfully,

MICHAEL W. STRAUS,
Commissioner.

Approved and adopted: December 30, 1949.

OSCAR L. CHAPMAN,
Secretary of the Interior.

UNITED STATES DEPARTMENT OF THE INTERIOR
J. A. KRUG, Secretary

BUREAU OF RECLAMATION
MICHAEL W. STRAUS, Commissioner
E. O. LARSON, Regional Director

COLLBRAN PROJECT, COLORADO

Region 4, Salt Lake City, Utah, November 1949
Project Planning Report No. 4–8a.5–2

CONTENTS

Regional Director's Report

	Page
Need for development	45
Plan of development	46
Costs and cost allocations	47
Repayment	48
Annual benefits	49
Comparison of benefits and costs	50
Cooperation and acknowledgments	50
Conclusions	51
Recommendations	51

SUBSTANTIATING MATERIALS

Bureau of Reclamation Report

Chapter I. General discussions	53
Project plan	53
Alternative plans	54
Physical geography	55
Climate	55
Settlement	56
History of settlement	56
Population	57
Industrial development	59
Local industry	59
Transportation and other facilities	59
Land uses	60
Irrigation	60
Other water uses	61
Undeveloped resources	61
Economic conditions	61
General conditions	61
Relief situation	62
Community needs	62
Investigations and reports	63
Previous investigations	63
Present investigations	64
Acknowledgments	65
Chapter II. Water supply	66
Water resources	66
Available supply	66
Quality of water	69
Water requirements	69
Consumptive use	69
Diversion requirement at irrigation laterals	69
South side canal conveyance losses	70
Return flow	70
Water requirements for power and domestic use	71
Water rights	72
Present water rights of project area	72
Water rights needed for project	73
Summary of water rights needed for project	75
Method of appropriating water	75
Water utilization	76
Present use of water for irrigation	76
Water operation for power and domestic use	77
Water operation for Vega Reservoir	84
Stream depletion	89

	Page
Chapter III. Designs and estimates	91
Geology	91
Regional geology	91
Vega Reservoir and dam site	91
Bonham Reservoir and dam site	92
Other features	93
Problems of design and construction	93
Accessibility	93
Rights-of-way	94
Design flood	94
Construction period	94
Special problems	95
Project works	95
Storage	95
Canals	97
Other features—pipeline and power facilities	99
Cost estimates	101
Construction	101
Operation and maintenance	102
Chapter IV. Irrigation	103
Project lands	103
General description	103
Soils	103
Topography	105
Drainage	105
Salinity and alkalinity	105
Land classification	105
Standards	106
Methods	107
Results of classification	108
Present agricultural development	109
Type of development	109
Crops	109
Livestock	109
Markets	110
Farms and farmers	110
Finances	111
General economic outlook	112
Anticipated agricultural economy	112
Type of development	112
Crops	112
Livestock	113
Farm improvements	113
Farm settlement	113
Development period	113
Irrigation repayment	114
Analysis of repayment ability of water users	114
Analysis of payment capacity by type of farming	114
Farm budget analysis for dairy farms	114
Farm budget analysis for beef-cattle ranches	118
Payment capacity of project lands	123
Amortization capacity	124
Recommended annual payment	124
Chapter V. Power	125
Present development	125
Power market	127
Present power requirements	127
Future power market	128
Potential development	129
Chapter VI. Municipal and domestic water	131
Present development	131
General	131
Grand Junction water-supply system	131
Palisade water-supply system	131
Fruita water-supply system	132

Chapter VI. Municipal and domestic water—Continued Page
Anticipated needs 132
Population trend 132
Anticipated use of project municipal and domestic water 132
Water requirements 133
Use of municipal water 133
Service requirements 134
Special water treatment 134
Potential development 136
Project plan 136
Chapter VII. Other project uses 137
Fish and wildlife conservation 137
Requirements for fish and wildlife protection 137
Contemplated measures for fish and wildlife protection 137
Effect of project on fish and wildlife resources 138
Recreation 139
Need for development 139
Potential recreational development 140
Estimated cost and returns of development 140
Evaluation of benefits 141
Flood control 142
Sediment control 142
Drainage 142
Stream-pollution abatement 142
Navigation 142
Chapter VIII. Financial analysis 143
Benefits 143
Direct irrigation benefits 143
Direct power benefits 144
Domestic and municipal water supply benefits 144
Fish and wildlife conservation benefits 145
Recreational benefits 145
Indirect irrigation benefits 145
Indirect power benefits 146
Intangible benefits 146
Benefit-cost ratio 146
Annual equivalent costs 146
Summary of benefits 147
Ratio of project benefits to costs 147
Project costs and cost allocations 148
Project costs 148
Cost allocations 148
Project repayment 149
Domestic and municipal water supply repayment 149
Power repayment 149
Irrigation repayment 150
Fish and wildlife nonreimbursable cost 150
Pay-out schedule 150
Repayment organization 150

FISH AND WILDLIFE SERVICE REPORT

Introduction 153
Purpose 153
Authority 153
Status of project 153
Description of basin and project area 153
General 153
Topography 153
Geology 154
Soils 154
Climate 154
Hydrology 154
Vegetation 154

Description of basin and project area—Continued Page
Engineering features of the project 155
Pipeline and power plants 155
Reservoir and canals 156
Effect of the project on fishery values 157
Preproject resources 157
Postproject resources 158
Effect of the project on wildlife values 159
Preproject resources 159
Big game 159
Upland game 159
Fur animals 160
Waterfowl 160
Postproject resources 160
Big game 160
Upland game 160
Fur animals 160
Waterfowl 160
Summary 160
Means of mitigating losses and deriving maximum benefits 161
Summary of values 162
Conclusions and recommendations 162

NATIONAL PARK SERVICE REPORT

Introduction 167
Authority 167
Purpose 167
Summary 168
Findings, conclusions, and recommendations 168
General description of the area 169
Location 169
Purpose of the project and reservoirs 170
Physical characteristics 172
Climate 173
Historical and archeological investigations 173
Present recreational evaluation 174
Types of recreation for which reservoirs are suited 174
Factors influencing recreational development 175
Estimate of recreational need and use 176
Recommended recreational development 177
Vega Reservoir 177
Bonham Reservoir 177
Land acquisition 178
Estimated cost of development 179
Vega Reservoir 179
Bonham Reservoir 179
Estimated monetary benefits 180
Vega Reservoir 180
Bonham Reservoir 180
Recommended agency for administration, operation, and maintenance 180
Vega Reservoir 180
Bonham Reservoir 181
Further study and planning 182
Appendix to National Park Service report 185

TABLES

BUREAU OF RECLAMATION REPORT

Table 1.—Climatic data 56
Table 2.—Plateau Valley population 57
Table 3.—Populations of Mesa County, Grand Valley, and Grand Junction 58
Table 4.—Population characteristics 58
Table 5.—Unemployment and general relief expenditures 62
Table 6.—Average yield of Grand Mesa Reservoir system 67
Table 7.—Project gaging station data 67

Page

Table 8.—Run-off of Plateau Creek near Collbran 68
Table 9.—Estimated monthly distribution of diversion requirement 70
Table 10.—Summary of decreed direct flow rights 73
Table 11.—Summary of decreed reservoir rights 73
Table 12.—Existing reservoirs to be used for domestic, municipal, and power water 74
Table 13.—Water rights required for project operation 75
Table 14.—Diversions to presently irrigated lands within ideal demand 76
Table 15.—Average late season shortage to presently irrigated lands 76
Table 16.—Run-off of Big Creek at the gaging station and run-off available for power, municipal, and domestic use 78
Table 17.—Run-off of Cottonwood Creek at the gaging station and runoff available for power, municipal, and domestic use 79
Table 18.—Summary of reservoir operation for the Big Creek system 82
Table 19.—Summary of reservoir operation for the Cottonwood Creek system 83
Table 20.—Water required for irrigation replacements 84
Table 21.—Storable water at Vega Reservoir 85
Table 22.—Total storage water required for irrigation 86
Table 23.—Summary of Vega Reservoir, operation 88
Table 24.—Annual project depletions, Plateau Creek and tributaries 89
Table 25.—Project stream depletion, Colorado River 89
Table 26.—Estimated construction costs 102
Table 27.—Estimated annual operation, maintenance, and replacement costs 102
Table 28.—Detailed land classification standards 106
Table 29.—Summary of classification, arable lands 108
Table 30.—Summary of project acreage in stream service areas 108
Table 31.—Average crop yields, distribution, and values without project development 109
Table 32.—Number of livestock on project farms 110
Table 33.—Size of land ownership units, Collbran project, 1946 111
Table 34.—Average crop yields, distribution, and values with project development 112
Table 35.—National forest grazing permits held by project ranchers 113
Table 36.—Summary of income and expenses on 50-acre dairy farm without project development 116
Table 37. Summary of income and expenses on 50-acre dairy farm with project development 118
Table 38.—Summary of income and expenses on 120-acre beef cattle ranch without project development 120
Table 39.—Summary of income and expenses on 120-acre beef cattle ranch with project development 122
Table 40.—Estimated annual payment capacity by type of farm with and without project development 123
Table 41.—Estimated annual payment capacity and amortization capacity of project lands 123
Table 42.—Installed power generating capacity within the project market area 126
Table 43.—Power generated in 1946 by plants in Collbran project power market area 126
Table 44.—Distribution of electric energy sales for years 1919–36 127
Table 45.—Electric energy requirements 128
Table 46.—Estimated future power load of area 129
Table 47.—Estimated requirements of Grand Junction for domestic and municipal water 134
Table 48.—Estimated average flow of Big Creek below Bonham Reservoir with project operation 138
Table 49.—Construction costs of recreational facilities 141
Table 50.—Summary of annual costs and values of recreational facilities 141
Table 51.—Summary of annual tangible benefits 147
Table 52.—Allocation of construction costs 149
Table 53.—Allocation of annual costs for project operation, maintenance, and replacement of works 149
Table 54.—Project pay-out schedule Facing 150

FISH AND WILDLIFE SERVICE REPORT

Page
Table 1.—Climatic data 154
Table 2.—Pertinent data, descriptions, and proposed plans for Grand Junction pipeline storage reservoirs 156
Table 3.—Pertinent data, Vega Reservoir 157
Table 4.—Annual fishery values 159
Table 5.—Annual wildlife values 161
Table 6.—Summary of annual fish and wildlife values 162
Table 7.—Recommended flow below Bonham Reservoir 163

NATIONAL PARK SERVICE REPORT

Table I.—Planned total content of Vega Reservoir by months during the period of study, 1933–45 171
Table II.—Vega Reservoir—Area-capacity table 171
Table III.—Planned total content of Bonham Reservoir by months during the period of study, 1921–44 172
Table IV.—Summary of costs and values 181

MAPS AND DRAWINGS

BUREAU OF RECLAMATION REPORT

General map, Collbran project—482–P–1 ..... Facing 44
River profile—482–P–31 ..... Facing 52
Vega Dam, preliminary estimate drawing—482–D–1 ..... Facing 96
Bonham Dam, preliminary estimate drawing—482–4–11 ..... Facing 98
Leon-Park feeder canal—482–P–68 ..... Facing 100
Land classification map—482–P–2 ..... Facing 108
Power market supply area, existing power facilities—482–4–13 ..... Facing 126
Energy requirements—482–P–92 130
Grand Valley municipal and rural populations—482–P–32 ..... Facing 132
Estimated service of domestic and municipal water—482–P–29 135

SUMMARY—COLLBRAN PROJECT

WATER SUPPLY

		Average annual quantities
New irrigation water	acre-feet	15, 900
New municipal water (ultimate)	do	10, 300
Stream depletion:		
Plateau Creek	do	21, 000
Colorado River	do	10, 700

IRRIGATED AREA

Lands receiving supplemental water	acres	18, 340
Lands receiving full water supply	do	2, 310
Total	do	20, 650

POWER

Installed capacity	kilowatts	7, 400
Annual generation:		
Firm power	kilowatt-hours	51, 600, 000
Nonfirm power	do	6, 670, 000
Total	do	58, 270, 000

COSTS AND PAYMENT

Purpose served	Cost allocation	Payment period (years)	Net revenues available in payment period
Irrigation	$3, 987, 000	50	$1, 000, 000
Municipal use	2, 742, 000	60	[1] 4, 733, 000
Power	6, 313, 000	60	[2] 13, 737, 600
Fish and wildlife	257, 000	[3]	
Total	13, 299, 000		[4] 19, 470, 600

[1] Based on annual payment of $78,880, required to retire municipal allocation in 60 years at 2 percent interest.

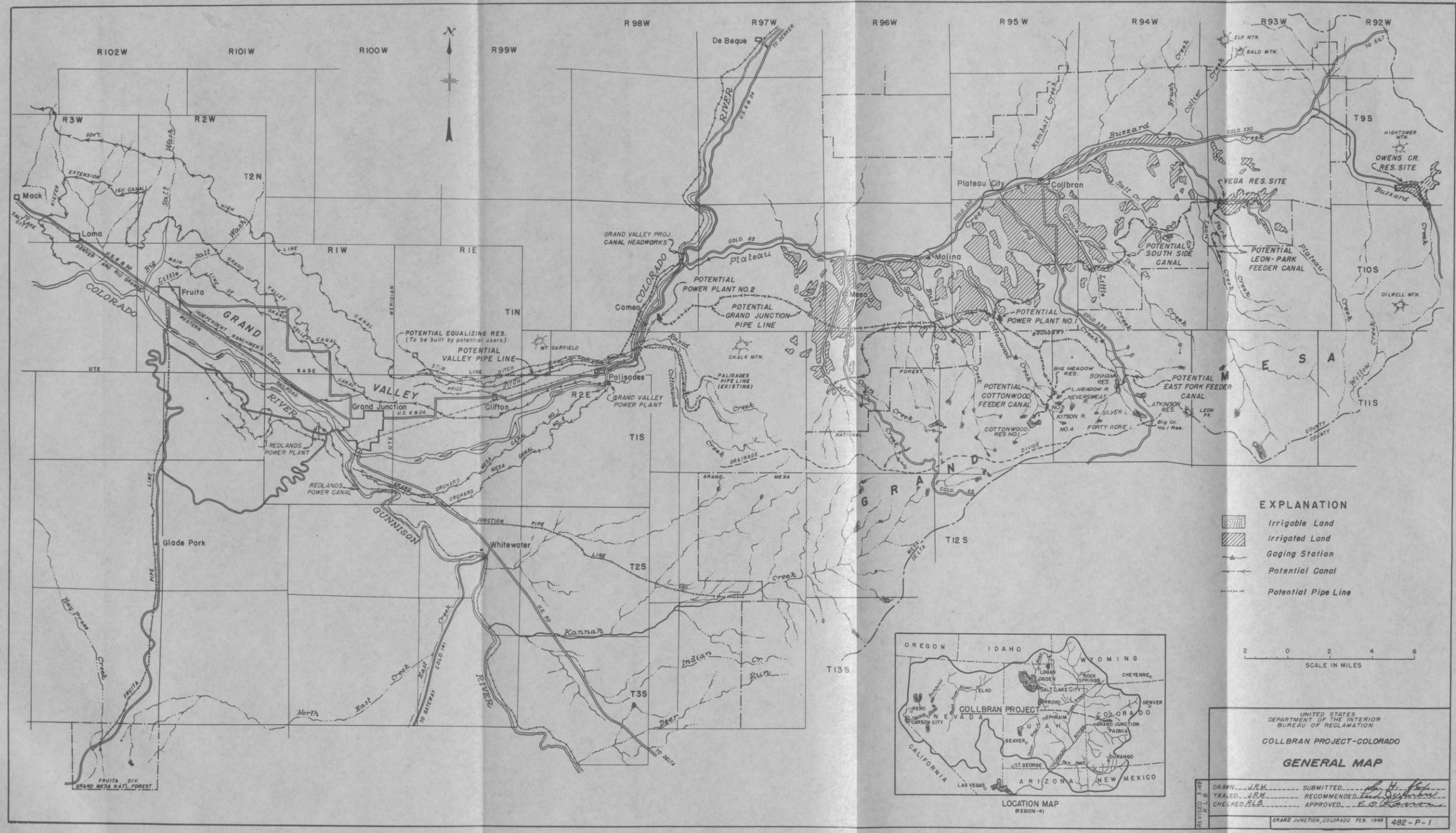
[2] Based on firm power rate of 5.6 mills a kilowatt-hour and nonfirm rate of 3 mills, required to retire power allocation in 60 years at 3 percent interest.

[3] Fish and wildlife allocation considered nonreimbursable.

[4] Returns to Federal Treasury during payment period would exceed project costs, except nonreimbursable costs allocated to fish and wildlife, by $6,428,600.

Benefit-cost ratio, 2.34 to 1

87297—51——4



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLLBRAN PROJECT-COLORADO

GENERAL MAP

REVISED 1-49
R.L.B.

DRAWN J.R.M. SUBMITTED
TRACED J.R.M. RECOMMENDED
CHECKED R.L.B. APPROVED

GRAND JUNCTION, COLORADO FEB. 1948 | 482-P-1

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SUBSTANTIATING REPORT OF POTENTIAL COLLBRAN REPORT, COLORADO

UNITED STATES DEPARTMENT OF THE INTERIOR,
BUREAU OF RECLAMATION,
REGION 4,
Salt Lake City 8, Utah, November 18, 1949.

To: Commissioner.
From: Regional director.
Subject: Report on Collbran project, Colorado.

1. This letter is submitted as my report on the potential Collbran project in west-central Colorado, planned as part of the Colorado River Basin development to supply needed irrigation, municipal, and domestic water and electric energy. Substantiating materials on which the report is based, including detailed reports of the Bureau of Reclamation, Fish and Wildlife Service, and National Park Service, are appended.

2. Authority to make this report and supporting investigations is provided in the Federal reclamation laws, act of June 17, 1902, (32 Stat. 388) and acts amendatory thereof or supplementary thereto, particularly the Boulder Canyon Project Act (45 Stat. 1057) and the Boulder Canyon Project Adjustment Act (54 Stat. 744).

NEED FOR DEVELOPMENT

3. Plateau Valley at the base of Grand Mesa on the western slope of the Continental Divide is in urgent need of additional water for irrigation. As the population pressure has increased the average farm unit has decreased in area and now some units are too small for economic operation. Land characteristics of the valley and its cool climate are ideally suited for the production of livestock feed, but the lack of late summer water results in low farm yields and immature crops and leaves the pastures practically useless after midsummer. Works to supply the needed irrigation water cannot be constructed by local interests because of the costs involved.

4. Grand Valley, lying along the Colorado River west of Plateau Valley, urgently needs additional water for industrial and municipal development and rural domestic use. The municipal water system of Grand Junction, principal city of the valley, is taxed to capacity and has no reserve to meet increasing demands. Domestic water for farm homes throughout the valley must be hauled long distances and stored in cisterns or taken as needed from irrigation ditches. It is becoming progressively more difficult to obtain even this unsatisfactory supply as the rural population is increasing and the stream flow of the area is becoming more and more polluted from intensified use. Present industrial demands for water in Grand Valley are met with difficulty. Increased demands for municipal and

industrial water are anticipated for normal growth and for probable accelerated growth resulting from the development of nearby mineral deposits, including oil-bearing shales, uranium ores, and coal. These and other anticipated developments will require additional power supplies.

PLAN OF DEVELOPMENT

5. The Collbran project would provide the water needed in Grand and Plateau Valleys through water exchanges and through storage regulation of the stream runoff tributary to Plateau Creek on the northern slope of Grand Mesa. It also would provide electric energy for use in west-central Colorado. The project plan includes provisions recommended by the Fish and Wildlife Service to increase fish and wildlife values. Recreational facilities recommended by the National Park Service would be provided after project construction so far as such facilities could be constructed consonant with the use of project water for domestic purposes. The facilities recommended are not included as part of the project plan and their costs are not included in the estimated project costs as recreational development would be dependent on limitations imposed in the interests of public health by domestic water users and various agencies. The estimated costs of recreational development and the benefits that would result if the facilities were constructed have been considered, however, in the comparison of project benefits and costs. The project would only slightly affect silt and flood control. It would not involve stream pollution abatement, Indian lands, or navigation.

6. Runoff of two of the Grand Mesa streams, Big and Cottonwood Creeks, would be diverted by pipeline as a supplemental municipal and domestic water supply for Grand Valley. This water would be utilized in its steep drop to the valley from its origin on the mesa slopes to produce approximately 51,600,000 kilowatt-hours of firm power and 6,670,000 kilowatt-hours of nonfirm power annually. A minimum flow in the pipeline of 20 second-feet would be maintained throughout the year by storage regulation in the Bonham Reservoir on Big Creek and eight small natural lakes on the upper reaches of Big and Cottonwood Creeks. As the water that would be diverted to Grand Valley is presently used for irrigation in Plateau Valley, it would be replaced with surplus spring runoff from upper Plateau, Leon, and Park Creeks that would be stored until needed at the potential Vega Reservoir. With regulation at Vega Reservoir these streams also would provide an average of about 15,900 acre-feet of water annually as a new irrigation supply for 20,650 acres of land in Plateau Valley, including 2,310 acres now idle for lack of water and 18,340 acres inadequately irrigated. All the lands served by these streams would be assured adequate late-season water with only moderate shortages in years of extreme drought.

7. Bonham Reservoir on Big Creek, chief storage feature for municipal and power supplies, would be enlarged to a capacity of 6,300 acre-feet, almost six times its present capacity. The eight natural lakes, having a total capacity of 3,830 acre-feet, would continue to be utilized without further development under the project. The water supply for the power and municipal system would be collected from the Big and Cottonwood Creek watersheds by two canals that would be constructed as project features—the East Fork feeder canal of 30 second-foot capacity and 1.1 miles in length and the Cottonwood

feeder canal of 15 second-foot capacity and 2.1 miles in length. The pipeline that would be constructed to convey the water from the reservoirs to the valley would be approximately 44 miles in length. It would receive water from Bonham Reservoir and from Big Meadows Reservoir, one of the small natural lake basins on Cottonwood Creek. Two interconnected power plants would be constructed along the pipeline course—the upper one near Molina of 5,000-kilowatt capacity and the lower one near Cameo of 2,400-kilowatt capacity. Power supplies would be delivered near the Cameo power plant for distribution. Municipal water would be delivered to an equalizing reservoir that would be constructed by the water users about 4 miles northeast of Grand Junction.

8. Vega Reservoir on Plateau Creek, chief project feature for irrigation development, would be built to a total capacity of 30,000 acre-feet. It would be created by construction of Vega Dam, a rolled earth- and rock-fill structure, 140 feet in height and 1,765 feet in length at the crest. A feeder canal of 200 second-foot capacity and a little more than 2 miles in length would be constructed to convey flows of Leon and Park Creeks to the reservoir. The Southside Canal, 30 miles in length and with a diversion capacity of 225 second-feet, would be constructed to convey the water from the reservoir to the project lands.

9. The Collbran project would consume only about one-half of 1 percent of the upper Colorado River Basin water allocated to the State of Colorado for future development under the terms of the upper Colorado River Basin compact. Rights to the use of the water required for the project could be obtained in accordance with the Colorado State water law.

COSTS AND COST ALLOCATIONS

10. Estimated capital costs of the project features that would be undertaken by the Federal Government are listed in the tabulation following on this page. The estimates include costs of necessary lands or interests in lands and miscellaneous cost items. Costs are estimated at July 1948 prices which are essentially the same as prices of October 1949.

Estimated capital costs

Vega Dam and road relocation	$2, 605, 000
Leon-Park feeder canal	337, 000
Bonham Dam and appurtenant works	1, 787, 000
East Fork feeder canal	27, 000
Cottonwood feeder canal	63, 000
Southside canal	1, 864, 000
Pipeline and penstock	3, 537, 000
Power plants and appurtenant works	1, 511, 000
Service roads for power and domestic features	23, 000
Fish screens	3, 000
Investigations and surveys (reimbursable funds)	28, 000
Operating equipment and operation and maintenance during construction	45, 000
Undistributed engineering and overhead	353, 000
Subtotal	12, 183, 000
Valley pipeline below power plant No. 2 [1]	1, 116, 000
Total	13, 299, 000

[1] Costs based on estimates prepared by R. J. Tipton and Associates, engineering firm of Denver, acting in the interests of the city of Grand Junction.

11. Capital costs of project features have been allocated to the various project purposes by averaging the results of the priority-of-use and alternative-justifiable-expenditure methods. Every purpose of the development would be charged no more than the value of the benefits it would receive and less than the cost of the same benefits under the cheapest alternative development. The allocations made are as follows:

Allocation of capital costs

Municipal and domestic use	$2,742,000
Power production	6,313,000
Irrigation	3,987,000
Fish and wildlife preservation	257,000
Total	13,299,000

12. Operation, maintenance, and replacement costs of the project works are expected to average $108,800 annually over a 60-year period. Of this amount, an estimated $78,500 would be required for general operation and maintenance of project works. The remaining $30,300 would be required for replacements. The portion of these costs required for power facilities was based on July 1948 prices. The remaining costs were estimated from average 1939–44 prices.

13. Operation, maintenance, and replacement costs have been allocated to the various project purposes by the priority-of-use method. These allocations are given in the following tabulation:

Allocation of annual operation, maintenance, and replacement costs

Municipal and domestic use	$7,800
Power production	80,000
Irrigation	21,000
Total	108,800

REPAYMENT

14. Capital costs allocated to irrigation, power, and municipal water would be reimbursable. These costs could be repaid from power and municipal water revenues over a 60-year period and from irrigation payments over a 50-year period. These reimbursement periods are considered to be appropriate for the Collbran project. Reimbursement periods of the same duration will be proposed for projects in the Upper Colorado River Basin that would be aided by revenues of the Colorado River storage project. Subject to approval by the Secretary of the Interior, capital costs allocated to fish and wildlife preservation would be nonreimbursable. If, however, reimbursement of these costs is required, allocations to irrigation, power, and municipal water would be increased slightly but not enough to lengthen the payment periods. Payment of project costs could best be made through a water-conservancy district since such a district could levy assessments on both the project lands and the municipalities and industries served.

15. Municipal and domestic users would be required to pay $86,680 annually for 60 years to amortize their allocation of capital costs with 2-percent interest and to pay their share of operation, maintenance, and replacement costs. The interest component, amounting to $1,991,000 in 60 years, would be paid to the United States Treasury.

16. Rates of 5.6 mills a kilowatt-hour for firm energy and of 3 mills a kilowatt-hour for nonfirm energy would be established for the sale of power. Revenues accruing at these rates, which would total $308,960 annually, would pay power's full operation, maintenance, and replacement costs and in 60 years would pay its full allocation of capital costs with 3 percent interest and provide a balance of $139,000. The interest component amounting to $7,285,600 in 60 years would be used in part to assist in payment of the irrigation allocation. Should firm power be sold for 6 mills a kilowatt-hour for the first 6 years of project operation and 5.5 mills thereafter, payment of the power allocation could also be made in 60 years. If all firm power were sold at 5.5 mills, however, 64 years would be required for payment.

17. A 3-year development period would be desirable after the first delivery of project water for irrigation, during which the irrigators would be assessed only the costs of operation, maintenance, and replacements and would pay nothing on capital costs. In this period they could fully prepare and improve their lands for project operation. After the development period the irrigators would pay $20,000 annually toward capital costs. In 50 years this would retire $1,000,000 of the irrigation allocation. Payment of the remaining $2,987,000 would require 41 percent of the interest component on the power allocation. If the payment period for irrigation were limited to 40 years, assistance in the amount of $3,187,000 or 44 percent of the interest component on power would be required.

18. It will probably be desirable at a future date to consolidate the Collbran project power system with other potential Federal power developments of the Colorado River storage project. An interconnection between the Collbran power plants and these other plants in the Upper Colorado River Basin would permit maximum flexibility of operation and maximum utilization of available water. Such a combination would also permit the pooling of financial operations resulting in a uniform power rate throughout the basin.

ANNUAL BENEFITS

19. Measurable benefits of the project are expected to average $1,128,500 annually, of which $716,160 would be direct benefits and the remaining $412,340 would be derived indirectly from the project as a result of its stimulation on business and industry. Numerous other benefits of an intangible nature would result from the project.

20. The estimated direct benefit of $716,160 annually would be comprised of the following items:

Irrigation (increased crop and livestock production)	$178,800
Power production (gross revenues from sale of power)	308,960
Domestic and municipal water (estimated cost of cheapest alternative equivalent supply)	203,500
Fish and wildlife preservation	9,300
Recreation (should facilities recommended by National Park Service be constructed)	15,600
Total	716,160

21. The expected indirect annual benefit of $412,340 would be derived from the following items:

Irrigation (off-the-farm transportation and processing of increased agricultural products, and increased local sales of goods and services)	$160, 600
Power production (savings in power production costs and increased value of goods and services produced by utilization of power)	251, 740
Total	412, 340

COMPARISON OF BENEFITS AND COSTS

22. The benefits of the development would compare with the attendant Federal costs in a ratio of 2.34 to 1, indicating that an increase in economic value of approximately $2.34 would result from each Federal dollar expended. This relationship indicates the degree of the project's economic justification. The ratio was determined by comparison of the annual benefits, estimated at $1,128,500 on the basis of average prices for the period 1939–44, and the annual equivalent costs, estimated at $482,800 with construction costs based on the much higher prices of July 1948. Actually the benefit-cost ratio may change, depending on the relationship between prices at the time of construction and average prices prevailing through the useful life of the project.

23. For a determination of the annual equivalent cost the project life was assumed to be 100 years. The costs thus computed include $364,700 for amortization of total capital costs at 2.5 percent interest with allowances for salvage values and for interest costs during construction. The annual costs also include $118,100 for operation, maintenance, and replacement costs with the allowance for replacements serving as a sinking fund at 2.5 percent interest. Capital costs of $179,300 that would be required for construction of recreational facilities were included in the analysis, and allowance was made for operation, maintenance, and replacements of such facilities. Indirect private capital costs that would be incurred with the development, such as increased annual investments in labor and equipment, were not included in the analysis as these would be more than offset by the project's intangible benefits.

COOPERATION AND ACKNOWLEDGMENTS

24. The Fish and Wildlife Service and the National Park Service participated in the investigations with the Bureau of Reclamation as a part of the general interagency cooperation in the river-basin-studies program, and their reports are included in the substantiating materials to this report. The proposed report was transmitted for review by the regional offices of the Department of the Army, Federal Power Commission, Department of Agriculture, and Department of Commerce in accordance with the policies and procedures established by the Federal Interagency River Basin Committee for distribution and coordination of reports at regional level. The report has also been reviewed by the Fish and Wildlife Service, Bureau of Indian Affairs, National Park Service, Geological Survey, and the Bureau of Mines in the Department of the Interior, and by the Colorado Water Conservation Board of the State of Colorado. The comments received have been considered in preparing the final draft of the report. In

addition, a number of these Federal agencies, as well as numerous State and local agencies, assisted in the course of the investigations with helpful information and data.

CONCLUSIONS

25. The Collbran project as outlined in this report has engineering feasibility, and its total cost could be retired by the irrigators' paying for 50 years and municipal water users and power users' paying for 60 years. The project benefits would compare with the costs in a ratio of 2.34 to 1. Local and State officials desire the project as planned. Water rights adequate for the project could be acquired.

RECOMMENDATIONS

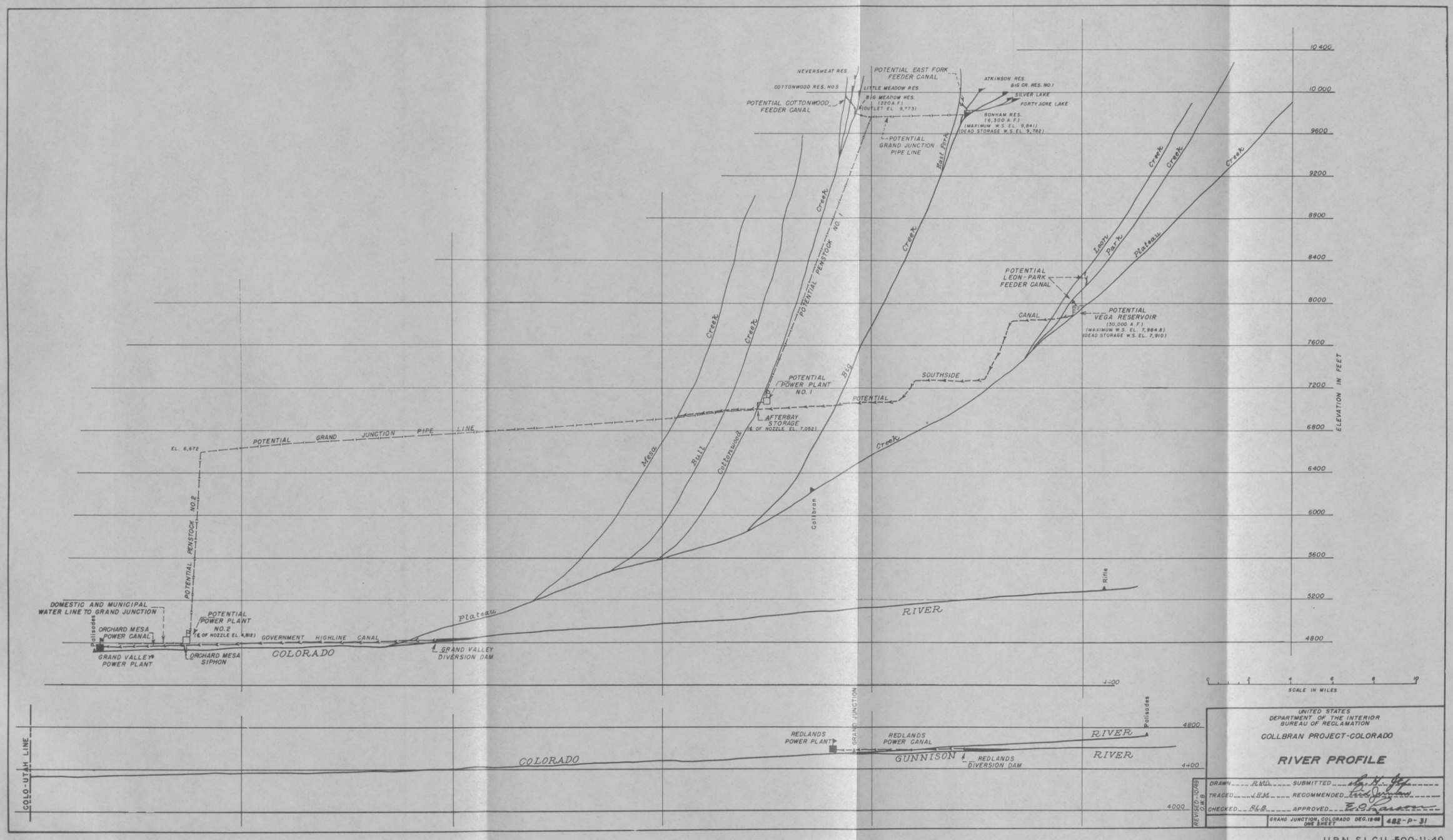
26. It is recommended—

1. That the plan of development as described in this report be approved.

2. That the project features listed in paragraph 10 hereof and such related works as may be incidental thereto, constituting the Collbran project in the Colorado River Basin in Colorado, be authorized to be constructed, operated, and maintained by the Bureau of Reclamation in accordance with Federal reclamation law, act of June 17, 1902 (32 Stat. 388), and acts amendatory thereof or supplementary thereto, except as to repayment period, and substantially in accordance with the plans set forth in the report, with such modifications, omissions, or additions to the works as the Commissioner of Reclamation, with approval of the Secretary of the Interior, may find proper and necessary to meet unforeseen physical or economic conditions.

3. That consideration be given in the future to the inclusion of this project in any basin plan which may be developed in the upper Colorado River Basin.

E. O. Larson.



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLLBRAN PROJECT-COLORADO

RIVER PROFILE

DRAWN	R.M.G.	SUBMITTED	
TRACED	L.B.M.	RECOMMENDED	
CHECKED	R.L.B.	APPROVED	

REVISED-10/49 O.M.B.

GRAND JUNCTION, COLORADO DEC. 19-48 ONE SHEET

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CHAPTER I

GENERAL DISCUSSIONS

The Collbran project plan is the result of extensive investigations conducted by the Bureau of Reclamation to find the means of most beneficially utilizing the limited water resources of the north slope of Grand Mesa in west-central Colorado. The methods used in the Bureau's investigations, the bases of the analyses made, and the conclusions reached are presented in the following chapters in order to permit a thorough appraisal of the plan developed.

PROJECT PLAN

The project plan is to control by storage runoff tributary to Plateau Creek on the north slope of Grand Mesa in order to meet the area's pressing needs for irrigation, municipal, and domestic water and electric energy.

Surplus runoff of Leon and Park Creeks would be diverted by a feeder canal to Plateau Creek. This runoff and runoff of upper Plateau Creek would be stored until needed at the Vega site where a reservoir of 30,000 acre-foot capacity would be constructed. The water would be utilized for irrigation in the long valley formed at the base of the mesa by Plateau Creek. It would provide supplemental irrigation for 18,340 acres and a full irrigation supply for 2,310 acres. The water would be distributed to the lands through the Southside Canal that would extend from Vega Reservoir 30 miles west to a point 4½ miles southwest of the town of Mesa.

The water of Big and Cottonwood Creeks would be utilized for municipal and domestic purposes in Grand Valley, which lies along the Colorado River west of, and approximately 5,000 feet below, the streams' origin. In its drop down the mesa slopes to the valley, the water would be utilized for production of electric energy. An adequate water supply for the winter months would be provided through storage of surplus spring and summer runoff in regulatory reservoirs. Primary regulation of Big Creek flows would be provided by Bonham Reservoir which would receive natural runoff and also some storage releases from four small reservoirs at higher elevations on the stream system. This reservoir would be fed through natural tributary channels and through the East Fork feeder canal that would be constructed as a project feature. Primary regulation of water from the Cottonwood Creek watershed would be provided at the existing Big Meadows Reservoir. This reservoir also would receive natural runoff as well as storage releases from three small reservoirs at higher elevations on the Cottonwood Creek system. It would be fed through natural tributary channels and through the Cottonwood feeder canal that also would be constructed as a project feature. All of the reservoirs are natural lake basins, and with the exception of the Bonham, could be used without further development under the project. The Bonham Reservoir, how-

ever, would be enlarged from its present capacity of 1,070 acre-feet to a capacity of 6,300 acre-feet. The other eight reservoirs have a combined capacity of 3,830 acre-feet.

Releases from the Bonham Reservoir and the Big Meadows Reservoir would be made in separate conduits that would join at a point about 4½ miles northwest of Bonham Reservoir. A single conduit 26 miles long would then carry the water to the head of Grand Valley with penstocks conveying the flow down the steep mesa slopes. En route to the valley the water would be utilized for power generation at a plant of 5,000-kilowatt capacity that would be installed southeast of the town of Molina. Releases from this plant would be reregulated in an afterbay reservoir, and the water would then be conveyed for additional power production to a plant of 2,400-kilowatt capacity that would be constructed northeast of the town of Palisade. When released from the second plant, the water would be conveyed about 13 miles by pipeline to an equalizing reservoir that would be constructed near Grand Junction by the users of domestic and municipal water. Construction of distribution lines, water-filtration plant, and purification works would also be accomplished by the users of such water and would not be included in the project.

Water that would be diverted to Grand Valley for power and domestic use is presently used for irrigation in Plateau Valley. It would be necessary, therefore, to replace all such diversions made adversely to the present users. Full replacement would be made from water provided by storage of surplus runoff of Plateau, Leon, and Park Creeks at the Vega Reservoir. Surplus water from Big and Cottonwood Creeks not required for domestic use in Grand Valley would be utilized to generate nonfirm energy at the power plant near Molina. Water thus used would be released from the power plant for irrigation use in Plateau Valley and would not require replacement.

Alternative plans

Other possibilities for development of irrigation in Plateau Valley have been considered, but the plan of development as presented in this report was found to be the most feasible. Other storage possibilities, such as increasing the capacity of Grand Mesa Reservoirs tributary to Plateau Creek, are costly compared with storage at the Vega site. Storage on Buzzard Creek would not only be more costly than Vega storage but would be limited by available water.

Other plans considered in providing additional water for municipal and domestic use in Grand Valley were the pumping of water from the mouth of Plateau Creek to a treatment plant near Palisade, the pumping of water directly from the Colorado or Gunnison River, and development of new storage on the Kannah Creek watershed. Further large storage on Kannah Creek beyond that now planned would be uneconomical because of the excessive cost of required storage. Water pumped from the Colorado or Gunnison River near Grand Junction would be extremely hard during certain periods of the year and would require costly treatment before it would be suitable for domestic use. The pumping of water from the mount of Plateau Creek would entail high pumping costs and special treatment because of the poor quality of water. For these reasons water developed from these sources would

be more costly than that which would be developed under the Collbran project.

PHYSICAL GEOGRAPHY

The Collbran project area, located in Mesa County, Colo., about 170 miles west of Denver, is bordered on the north by the Bookcliff Range and on the south and west by the Grand Mesa and Uncompahgre Plateau. Grand Mesa jutting from the west slope of the Continental Divide is the principal landmark of the region and rises to an elevation of 10,300 feet. Its northern slope is dotted with many small natural lakes, and it is drained by numerous streams, several of which would contribute directly to the project water supply. The streams all are tributary to the larger Plateau Creek, in turn tributary to the Colorado River.

Plateau Creek flows westward from its origin on the northwest slopes of Grand Mesa to its confluence with the Colorado River near Cameo, Colo. In its course it forms Plateau Valley where the lands to be irrigated under the project are located. The valley is approximately 20 miles long and from less than a mile to 8 miles wide. It lies from 5,500 to 7,000 feet above sea level. The project lands are south of the creek and extend in a narrow, discontinuous strip the full length of the valley. Principal towns in the valley are Collbran, Molina, and Mesa.

Grand Valley northwest of the mesa is traversed by the Colorado River in its course westward into Utah from its source on the western slope of the Continental Divide. The river enters the valley a short distance above the town of Palisade and flows west to join the Gunnison River at Grand Junction, then northwest through the valley. The valley is approximately 41 miles in length. It ranges from 4,500 to 4,850 feet above sea level. Principal settlements in the area are Grand Junction, Palisade, and Fruita.

Climate

The climate of the project area is of temperate, semiarid character. The average relative humidity of the region as determined by a weather station at Grand Junction is only 39 percent. There is a marked difference in temperature and precipitation between Plateau and Grand Valleys as a result of the wide difference in altitude and exposure to storm fronts. The mean annual temperature at Collbran is 45.7°. At Grand Junction it is 52.7°. Average annual precipitation at Collbran is 15.6 inches and at Grand Junction it is 8.7 inches.

Table 1 gives a summary of precipitation and temperature data collected over a period of years at Weather Bureau stations maintained at Collbran and Grand Junction.

TABLE 1.—*Climatic data*

Month	Grand Junction [1] (elevation 4,600)				Collbran [2] (elevation 6,200)			
	Mean precipitation (inches)	Temperature F.			Mean precipitation (inches)	Temperature F.		
		Mean for 55 years	Maximum on record	Minimum on record		Mean for 46 years	Maximum on record	Minimum on record
January	.56	26.0	62	−19	1.16	22.0	56	−26
February	.61	33.5	70	−21	1.20	27.7	62	−30
March	.79	43.3	81	5	1.59	36.2	77	−12
April	.77	52.6	87	14	1.64	45.7	83	1
May	.77	61.6	94	29	1.42	54.0	87	14
June	.41	71.9	104	35	.78	62.5	97	28
July	.66	78.0	105	47	1.18	68.6	99	31
August	1.09	75.6	103	45	1.49	66.7	100	34
September	.97	66.7	98	28	1.58	58.7	96	22
October	.90	53.8	86	16	1.45	47.4	88	7
November	.59	40.1	74	3	1.01	35.2	68	−10
December	.58	28.3	66	−21	1.10	24.1	58	−30
Annual	8.70	52.7	105	−21	15.60	45.7	100	−30

[1] Weather Bureau record 1892 to 1946, inclusive.
[2] Weather Bureau record 1901 to 1946, inclusive.

Daytime temperatures in Plateau Valley generally range from 80° to 90° during July and August. The mean of 66° to 69° for these months results from the cool summer nights. The highest recorded temperature is 100° and the lowest 30° below zero. For Grand Junction the daytime temperatures average 90° during July and August, while the mean minimum for these months is 63°. The highest recorded temperature was 105° and the lowest 21° below zero.

The climate of Grand Valley is satisfactory for the diversified farming practiced within the region. The area has a long growing season with a mean annual frost-free period of 189 days. Collbran, typical of Plateau Valley, is higher in elevation than Grand Valley and has a mean annual frost-free period of only 126 days, extending on an average from May 24 to September 27. The average growing season at Collbran is somewhat longer than the frost-free period, extending 156 days from May 5 to October 7. The colder climate and shorter growing season in Plateau Valley limit farming to the more hardy varieties of irrigated crops. Dry farming has been tried in the valley but has not been successful because of the limited precipitation during the growing season, which averages only 6.45 inches or about 41 percent of the total annual precipitation.

SETTLEMENT

History of settlement

Mining led to the early settlement of western Colorado and brought the area's first railroad service. The lower section of west-central Colorado, including all of Mesa County, was originally inhabited by the Ute Indians. Early efforts by the white settlers to inhabit the area were retarded by hostile Indians until a compromise agreement between the United States Government and the Ute Indians was reached on September 4, 1881. The agreement provided that the Indians leave this area and locate on the Uintah Indian Reservation in the Territory of Utah. Settlers exploring western Colorado had

been advised of the pending negotiations with the Indians, and the agreement had hardly been completed before a large number of whites moved into the area from towns of eastern Colorado and from other States. The location of Grand Junction was selected as a town site in the fall of 1881 and was registered at the land office in Leadville the following year.

Plateau Valley likewise was settled in the fall of 1881. The first settlers comprised a small company from South Park, Colo. They entered the valley over the White River Indian Trail leading from Delta, Colo., across the top of Grand Mesa and descended the north slope of the mesa to what is known as the Meadows on Plateau Creek. This spot is the site of the potential Vega Reservoir. In the early spring of 1882, the company moved lower down the valley and settled at the present site of Collbran. Later in the year a small herd of cattle was trailed into the valley from Greenriver, Utah. Thus the cattle industry of Plateau Valley was started. Extensive summer grazing in the mountains to the south and east of Plateau Valley and desert winter grazing lands to the west presented a favorable situation for stock raising and brought about a rapid expansion in the industry. With the introduction of irrigation, permitting the production of winter feeds for livestock, settlement of the valley progressed rapidly until 1890. Further settlement since that time has been slow, as expansion of irrigation requires the development of costly reservoir storage to provide water during the late summer months.

Population

Census records for 1920, 1930, and 1940, showing the total town and farm population of Plateau Valley, are summarized in table 2.

TABLE 2.—*Plateau Valley population*

Community	Population		
	1920	1930	1940
Collbran	1,173	1,122	1,121
Mesa	544	473	490
Molina	382	324	265
Total	2,099	1,919	1,876

The entire population of Plateau Valley is white and predominantly of English, Scotch, and Scandinavian descent. The people are industrious and thrifty, and all are engaged in farming, livestock raising, and supporting trades. Population trends, therefore, are directly affected by farm and livestock development. The decrease in population (8.6 percent) between 1920 and 1930, indicated in table 2, resulted from the failure of a small irrigation project and the subsequent unsuccessful attempt of the farmers to dry-farm the lands that were to have been irrigated by the project. The population since that time has remained relatively constant, as no further irrigation development has been undertaken in the valley. Many of the younger generation have left the area to seek employment elsewhere. The static nature of the agricultural industry has discouraged the establishment of new homes in the locality.

Census records for 1920, 1930, and 1940, giving the populations of Mesa County, Grand Valley, and the city of Grand Junction, are summarized in table 3.

TABLE 3.—*Populations of Mesa County, Grand Valley, and Grand Junction*

Community	Population		
	1920	1930	1940
Grand Junction	8,665	10,247	12,479
Grand Valley	[1] 19,960	[1] 23,200	30,260
Mesa County	22,281	25,908	33,701

[1] Estimated on the basis of 1940 figures.

The population of Grand Valley increased 16.2 percent from 1920 to 1930 and 30.4 percent from 1930 to 1940. The population of the city of Grand Junction increased 18 percent and 22 percent, respectively, during the same periods. These figures show an increasing tendency for people to settle in the rural areas of the valley adjacent to the larger towns. This is particularly evident in the area adjacent to Grand Junction, where numerous homes have been built in recent years.

Pertinent population data for Mesa County and the State of Colorado for 1940, as reported by the Bureau of the Census, are given in table 4.

TABLE 4.—*Population characteristics*

Classification	Mesa County	State of Colorado
Total population	33,791	1,123,296
Native	32,656	1,051,732
Foreign born	1,135	71,564
Population per square mile	10.2	10.8
Race:		
White	33,629	1,106,502
Negro	74	12,176
Japanese	63	2,734
Indian	11	1,360
Chinese	8	216
All others	6	308
21 years old and over	20,622	713,968
Citizens	20,318	688,410
Aliens	234	19,433
Not reported	70	6,125
Labor force:		
Total population over 14 years of age	25,148	855,116
Total in labor force	11,843	421,493
Employed except on public emergency work	10,010	349,735
Employed on public emergency work	973	31,808
Seeking work	860	39,950
Total not in labor force	13,305	433,623

Between 1930 and 1940, the population of Mesa County increased 7,883 or 30.4 percent, and the total population of the State of Colorado increased 87,505 or 8.4 percent.

INDUSTRIAL DEVELOPMENT

Local industry

Agriculture is the basic industry of western Colorado. All farm products of a temperate climate are grown successfully in Grand Valley, with peaches being the principal crop. Plateau Valley, surrounded by national-forest lands which provide summer grazing, is ideally situated for livestock production, its major industry.

Mining, production of oil, and timbering are also major industries of the region. Coal mines in Mesa County alone produce more than 100,000 tons annually, and vanadium and uranium ores are mined extensively in the region. Huge oil-shale deposits, estimated to contain more than 300 billion barrels of crude oil, are located in the Green River formation of western Colorado, southwestern Wyoming, and eastern Utah. Of this amount 90 percent is in Colorado, particularly in the eastern part of Mesa County and the neighboring counties of Garfield and Rio Blanco to the north. The Rangely oil field, located 72 miles north of Grand Junction, is rapidly becoming one of the major oil-producing areas in the western United States. Large timber resources are provided by more than 570,000 acres of national-forest land in Mesa County.

Several large service industries have developed in Mesa County. The more important of these are railroad shops and fruit- and vegetable-processing plants. Other service industries include a large flour mill, several machine and sheet-metal plants, large bakeries, a drug- and cosmetic-processing plant, butter and ice-cream factories, and other smaller enterprises.

Recreational facilities, which as yet are not fully developed, provide the communities of the area with a substantial source of supplemental income. Great tourist and recreational possibilities exist on scenic Grand Mesa, whose many small fresh-water lakes and streams abound with trout. Elk, deer, and small game are also plentiful. Tourists from all parts of the Nation are annually attracted to existing popular summer resorts and public campgrounds.

Transportation and other facilities

Grand Valley is well served with transportation facilities. The principal towns of the valley are located on the main line of the Denver & Rio Grande Western Railroad, which operates between Denver, Colo., and Salt Lake City, Utah. Grand Junction, a division point on the railroad, lies midway between Denver and Salt Lake City. United States Highways 50 and 6 pass through Grand Valley, and four major trucking companies provide transportation to the surrounding area and to Denver and Salt Lake City. An improved State highway connects Plateau Valley with all transportation facilities serving Grand Valley. Grand Junction is also a main-line stop on air routes from New York City to Los Angeles.

The project area is served by the Western Union Telegraph Co. and the Mountain States Telephone & Telegraph Co. The Public Service Co. of Colorado furnishes electric energy, with distribution being made by that company and by the Grand Valley Rural Power Lines, Inc., a Rural Electrification Administration system.

Grammar schools are accessible to all communities, and high schools are located in the larger towns. An accredited junior college is

located at Grand Junction. Other institutions of higher learning, readily accessible to the area, are located at Gunnison and Denver, Colo. Churches of principal denominations have been established throughout the area.

Land uses

Distribution of landownerships in Mesa County, which comprise 2,130,320 acres, is shown in the following tabulation.

	Percent
Privately owned:	
Cultivated land	5
Grazing and waste land	[1] 21
Total	26
U. S. Government-owned:	
National forests	27
Federal grazing land	41
National parks and other reserves	3
Total	71
All other, including local and State government and unclassified land	3

[1] Includes mineral lands and claims totaling approximately 1 percent.

Approximately 99 percent of all privately owned lands are devoted to agriculture. Of the total income from crops in Grand Valley, one-third is from fruits, one-third from production of livestock feeds, and one-third from truck crops. In Plateau Valley the cultivated lands are used for the production of small grains and forage crops for livestock feed.

Irrigation

In Grand Valley, 70,500 acres of land are furnished a full irrigation supply by direct diversion from the Colorado River above its confluence with the Gunnison River. Of this land, 30,300 acres are served by a canal built in 1883 by the Grand Valley Irrigation Co. The remaining 40,200 acres are served by the Grand Valley project, constructed by the Bureau of Reclamation in 1912. This project includes a diversion dam on the Colorado River 8 miles above Palisade and a canal to serve lands above the existing Grand Valley canal. The land served includes some areas irrigated by other facilities before construction of the project. Additional small acreages are being reclaimed each year.

The appropriation of water for irrigation of project lands from Plateau Valley streams started in 1882. By 1895 the late summer natural flow was fully appropriated. In an effort to expand irrigation further, settlers of the valley constructed reservoirs on high tributary streams and appropriated water for storage purposes. Continued construction of new ditches and enlargement of existing ditches by individuals and partnerships have resulted in a cumbersome, inefficient irrigation system. All irrigation developments are privately owned and operated, and no large administrative irrigation organization exists. The valley has fertile soil but is developed far beyond its usable water resources with the majority of lands suffering acute shortages during late summer months.

Other water uses

Besides irrigation, water is used in the project area for domestic, municipal, industrial, and stock water purposes, power development, and recreation. Canals and ditches are operated intermittently throughout the winter months and supply the rural population with domestic and stock water of questionable quality. Five communities, Grand Junction, Fruita, Palisade, Collbran, and Mesa, are supplied with domestic and municipal water through improved distribution systems. With the exception of Collbran all of these communities now receive their water from sources independent of the project water supply. The quality of water furnished is excellent although the supply for Grand Junction is inadequate.

Hydroelectric power is generated at the Palisade plant of the Grand Valley project and the plant of the Redlands Water & Power Co. Water is used for industrial purposes only in the immediate vicinity of Grand Junction where it is utilized for canning of fruits and vegetables, manufacturing, and in connection with the railroad industry. Fishing within the project area is limited to angling for river salmon, suckers, and catfish on the Colorado and Gunnison Rivers and to game fishing on the clear-water streams of Plateau Valley.

Undeveloped resources

Resources of the region which are not fully developed include timber in the national forest reserves, coal and other mineral deposits, recreational potentialities of Grand Mesa, and hydroelectric power sites. Construction of the Collbran and other multiple-use projects in the upper Colorado River Basin would greatly facilitate development of these resources.

Plateau Valley lands within the project area would be fully developed by the potential Collbran project. Nearby arable lands not included in the project could be irrigated by separate developments, including the pumping of Colorado River water to high land in Grand Valley and the development of Owens Creek Reservoir site on Buzzard Creek. The Bridgeport and Curecanti sites on the Gunnison River could also be developed to provide substantial irrigation supplies as well as large quantities of hydroelectric power.

ECONOMIC CONDITIONS

General conditions

The economy of the region is sound, being based on agricultural development supplemented by railroading, extensive mining, related industries, and wholesale and retail trade.

Good farm management together with an adequate supply of irrigation water at a low cost over a long period has produced a stable agricultural economy in Grand Valley. Recent high prices for farm products have retired indebtedness, reduced tax delinquencies, and greatly increased bank deposits. The centralization of population, resulting from the establishment of numerous small fruit-producing units, and the recently accelerated development of Grand Junction have produced a definite need for supplemental domestic and muncipal water for present needs and for normal growth.

The economy of Plateau Valley is dependent in some measure on the economy of Grand Valley. Because of the importance of livestock

raising in the area, however, the economy is more directly affected by national market conditions and grazing conditions on adjacent forest reserves. By careful management the valley farmers have been able to maintain good credit. Credit houses report no loans in arrears and a 55-percent reduction of previous indebtedness since 1940. These economic gains are the result of the favorable farm parity price ratio of the war and postwar years. To improve their present economy, Plateau Valley farmers must increase production from irrigated fields and pastures.

Relief situation

Welfare expenditures per capita in Mesa County for direct relief, exclusive of aid to physically handicapped, aged persons, and dependent children, are low as compared with those in neighboring counties and in the State as a whole. Relief expenditures usually increase after harvest and reach a peak in February. Table 5 gives the total per capita expenditures from Federal, State, and county funds for unemployment and general relief in Mesa County, the four neighboring counties, and the State.

TABLE 5.—*Unemployment and general relief expenditures*

County	Population, 1940 census	Expenditure per capita			
		1937	1939	1941	1943
Mesa	33,791	$1.57	$1.04	$0.89	$0.82
Delta	16,470	2.33	2.02	1.91	1.76
Garfield	10,560	2.57	3.33	3.37	1.39
Gunnison	6,192	3.38	3.98	3.68	1.76
Montrose	15,418	1.74	1.35	1.84	1.13
Colorado (State)	1,123,296	3.55	3.53	3.35	2.97

Community needs

For proper development of its abundant resources the region needs a supplemental supply of irrigation water for arable lands in Plateau Valley, an adequate supplemental supply of domestic, municipal, and industrial water for Grand Valley, and the development of additional power for industrial and domestic use.

Supplemental water is needed in Plateau Valley to assure a good growth of late summer and fall pasture as well as increase yields of alfalfa and corn silage which are essential to the livestock industry.

Grand Valley, including the rural and urban areas, is urgently in need of additional domestic water. The city of Grand Junction is handicapped in growth and industrial development by a water system capable of supplying only half the present and immediate future needs. The present demand for water by the canneries is met with difficulty, and other industrial development is prevented by the presently limited supply of suitable water. It is essential that an adequate, sanitary domestic water supply system be made available immediately to the rapidly increasing population of the rural area. Domestic water for 1,200 farm homes must now be hauled and stored in cisterns because shallow underground waters are not suitable for domestic use and a piped water supply is not available. A few artesian wells in the area provide a small number of homes with good quality domestic water. Even with this small use, however, there has been a marked drop in

artesian head during the last few years. Pumps have been installed in some instances to increase output and have caused an accelerated decline in artesian head and flow. Hauling of water is costly and does not provide the farm home with enough water for over-all sanitation needs. Local streams and ditches are becoming more polluted each year with increased use of water for irrigation and industrial use. Stock water must be stored for winter use in open ponds with high evaporation and seepage losses.

The use of uranium for the development of atomic energy and the production of synthetic liquid fuels from oil-bearing shales have recently assumed national importance. The area immediately south and west of Grand Junction contains one of the world's largest known deposits of carnotite (uranium rich ore). Offices have recently been set up in Grand Junction by the Atomic Energy Commission and the Geological Survey for exploration, purchasing, and milling of uranium ores. Large deposits of oil-bearing shales are located a few miles north of the Collbran project area. A demonstration plant for the extraction of liquid fuels from shale is in operation at Rifle, Colo. Provided an adequate supply of municipal water and electric energy, the project area is ideally situated for the refining of these important materials so critical to the Nation's security and prosperity. A marked increase in the population of Grand Junction has already been felt from the developments, now only in the experimental stage. With large-scale production of uranium and liquid fuels, the city would become the business center for the population thus employed. Facilities for the generation of electric energy in the region are now taxed to capacity. To supply requirements, electric power is imported long distances from other regions. Present and future domestic and industrial requirements would readily absorb all power developed by the Collbran project.

INVESTIGATIONS AND REPORTS

Previous investigations

The need for additional irrigation water in Plateau Valley and for adequate municipal and domestic water in Grand Valley has long been recognized by local and State officials. Irrrigation investigations of the Collbran area by the Bureau of Reclamation were started in 1937. Several previous reports have been made which apply to various phases of the Collbran project and these were fully utilized in the present planning work. The more important of these reports are discussed briefly in the following paragraphs.

Burns & McDonald.—This report by Burns & McDonald, issued in 1923, discusses improvement of Grand Junction city municipal water-supply system. The report includes designs and estimates for a 13,500,000-gallon treatment storage reservoir and enlargement of the water main from the point of storage into the city. The plan was adopted by the city and construction was completed in 1923.

Bureau of Reclamation.—A preliminary report on the Collbran project dated July 10, 1940, was written by S. A. Kerr. The report summarizes reconnaissance surveys of the Collbran project and discusses the additional data and surveys necessary for completion of a final report on the project. The report concludes that sufficient water could be stored at the Vega Reservoir site as a supplemental supply for inadequately irrigated lands in the valley south of Plateau Creek.

The report also concludes that irrigation of those lands north of Plateau Creek would require development of storage on Owens Creek.

Black & Veatch, consulting engineers.—A report dated 1943 was prepared on the rehabilitation and reconstruction of the Kannah Creek municipal water supply line to the city of Grand Junction. The report is a study of the hydraulic properties of an existing pipeline, made with the primary objective of determining the most economical method of increasing the capacity from 5.3 to 7.56 million gallons a day. The report presents eight possible plans for increasing the pipeline capacity, the most favorable of which would cost approximately $170,000. Reconstruction of the Kannah Creek pipeline was completed in 1948.

United States Department of the Interior.—A report of the Department of the Interior, entitled "The Colorado River," was sponsored and coordinated by the Bureau of Reclamation and released March 1946. It includes the Collbran project among 134 potentialities for development of the water resources of the Colorado River Basin. The report stresses, however, that the water available in the basin is insufficient for development of all potentialities it lists.

Present investigations

Present investigations for irrigation of arable lands in Plateau Valley have been a continuation of the studies begun in 1937. In December 1944 the city of Grand Junction expressed interest in the possibility of providing the city with supplemental municipal water in connection with the irrigation supply. The plan herein reported has resulted from the findings of investigations conducted to that end.

Scope of present investigations.—The investigations of the Collbran project have been directed toward utilizing the surplus water of Plateau Creek and its tributaries for irrigation in Plateau Valley and supplying the Grand Valley area with domestic water. Looking toward full utilization of the water resources, the investigations considered the development of electrical energy in the approximately 5,000-foot drop to Grand Valley from the water's origin on the mesa slopes.

Field work in connection with the investigations has included the following:

1. Topographic surveys of the Vega Reservoir and Dam sites.
2. Geological examination and exploration, by drilling and test pits, of the Vega Dam site and Reservoir basin.
3. Preliminary traverse and profile surveys of the feeder canal from Leon and Park Creeks to the reservoir site.
4. Topographic surveys of Bonham Reservoir and Dam sites.
5. Geological examination and exploration by test pits of the Bonham Dam site.
6. Preliminary traverse and profile surveys of the South side canal.
7. Preliminary traverse and profile surveys of the pipeline location for collecting and diverting municipal and domestic water to the head of Grand Valley.
8. Topographic survey of penstock and power plant locations above Palisade at head of Grand Valley and on Cottonwood Creek, 3½ miles southeast of Molina.
9. Mapping and classification of irrigated and irrigable lands in Plateau Valley.

10. A land and water relationship study of irrigated areas in Plateau Valley.

11. Office work comprised mainly of water supply studies, preparation of plans and estimates for the adopted and alternative plans, and economic analyses of project development.

Acknowledgments

The Bureau of Reclamation is indebted to several Federal, State, and local agencies who supplied needed assistance and information during the course of the investigation. Among these are Bureau of Land Management, Geological Survey, Fish and Wildlife Service, National Park Service, Forest Service, Farm Security Administration, Weather Bureau, Bureau of Census, Federal land bank, Colorado Water Conservation Board, Colorado State engineer's office, Colorado River Water Conservation District, Colorado State Planning Commission, Mesa County treasurer and assessor's office, Colorado Experiment Station of Colorado A and M College, and the Public Service Co. of Colorado, Grand Junction City, and R. J. Tipton and Associates engineering firm.

CHAPTER II

WATER SUPPLY

WATER RESOURCES

Available supply

Streams and watersheds.—The project would develop a new water supply from several of the Grand Mesa streams—Plateau, Leon, Park, Big, and Cottonwood Creeks. This water would supplement that already supplied from these streams and from several other major mesa streams, including Salt, Bull, and Mesa Creeks. Some water is also presently supplied from smaller mesa streams such as Grove, Spring, and Coon Creeks. For the water supply calculations of this report, however, runoff of these smaller streams is included with the runoff of Salt, Big, Cottonwood, Bull, and Mesa Creeks. Stream flow data used for any of these five major streams therefore comprehend data on small adjacent affluents contributing to the water supply of the area.

The watershed of the streams, extending along the entire north slope of the mesa, covers 156 square miles and ranges in elevation from 7,000 feet to more than 10,000 feet above sea level. The area is heavily covered with vegetation, with a dense growth of scrub oak, service berry, and juniper on the lower portion and a heavy cover of quaking aspen, fir, and spruce on the higher reaches. This heavy cover of vegetation, together with the sheltered character of the north slope drainage, results in a much more uniform runoff than is common for other streams of similar altitude on the west slope of the Continental Divide. The sustained summer flows thus permit a relatively large part of the irrigation requirement to be obtained from natural or uncontrolled stream runoff.

Grand Mesa reservoirs.—The runoff of Salt, Big, Cottonwood, Bull, Mesa, and Coon Creeks is now controlled to some extent by the numerous small reservoirs located immediately under the north rim of Grand Mesa. These are filled with surplus winter and spring runoff, and the stored water is released on demand of the irrigators to supplement the low natural flows through the late summer months.

The reservoirs were developed in natural lake basins of the glacial moraine of Grand Mesa by individual water users or small cooperative associations. In general they were constructed with the use of light farm machinery and without the aid of technical engineering design and control. As a result, the reservoirs do not meet present-day standards with respect to freeboard above maximum water surface, spillway construction, and foundation preparation. The reservoirs have operated successfully, however, over a long period of years, some of them since 1890, and their present filling operation is under the close supervision of the State division engineer and the Forest Service. With proper maintenance and continued supervision, these reservoirs should continue to function satisfactorily. The reservoirs

are situated at high elevations not usually subject to the heavier cloudburst storms and are further favored by the slow snow-melt characteristics of such altitudes. Therefore, the hazard of extremely high flash runoff is not great.

Sixty-three storage rights for a total of 20,646.48 acre-feet have been established for the mesa reservoirs. Their storage yield, however, averages 8,800 acre-feet annually as determined from an analysis of reservoir diversions recorded by the State water commissioner for the 13-year period 1933–45. A summary of the average reservoir yield for each stream system is shown in table 6.

TABLE 6.—*Average yield of Grand Mesa Reservoir system (1933 to 1945, inclusive)*

Reservoir systems	Average annual yield (acre-feet)
Mesa Creek system [1]	1,230
Bull Creek system	760
Cottonwood Creek system	2,380
Big Creek system	4,160
Salt Creek system [2]	270
Total	8,800

[1] Because of mutual use of storage facilities, the Coon Creek system is included with that of Mesa Creek.
[2] Reservoirs on Leon Creek tributaries are used to supply Salt Creek lands.

Stream runoff records.—Discharge records of project streams are available as shown in table 7.

TABLE 7.—*Project gaging station data*

Stream	Location of gage [1]	Length of record [2]	Drainage area (square miles)	Operating agency
Plateau Creek near Collbran.	NE¼ sec. 26, T. 9 S., R. 94 W.	August 1921 to present	88	Colorado State engineer USGS.
Plateau Creek at Vega Dam site.	NE¼ sec. 6, T 10 S., R 93 W.	April 1937 to September 1943.	24	USBR, USGS.
Plateau Creek near Cameo.	SW¼ sec. 18, T. 10 S., R. 97 W.	April 1936 to present	64	USGS.
Big Creek near Collbran.	NE¼ sec. 14, T. 10 S., R. 95 W.	April 1938 to July 1944	25	USBR, USGS.
Big Creek at upper station.	NE¼sec. 5, T. 11 S., R. 94 W.	July 1945 to present	19	USGS.
Bull Creek near Molina.	NE¼ sec. 6, T. 11 S., R. 95 W.	April 1937 to September 1943; May 1945 to present.	10	USBR, USGS.
Coon Creek near Mesa.	NE¼ sec. 8, T. 11 S., R. 96 W.	April 1937 to September 1943.	7	Do.
	NE¼ sec. 16, T. 11 S., R. 96 W.	May 1945 to Sept. 1947	4	Do.
Cottonwood Creek near Molina.	NW¼ sec. 29, T. 10 S., R. 95 W.	April 1937 to June 1941	20	Do.
Cottonwood Creek at upper station.	SE¼ sec. 3, T. 11 S., R. 95 W.	May 1945 to present	16	USGS.
Grove Creek near Collbran.	SW¼ sec. 1, T. 10 S., R. 95 W.	April 1940 to July 1941	24	USBR.
Mesa Creek near Mesa.	SW¼ sec. 16, T. 11 S., R. 96 W.	April 1937 to present	7	USBR, USGS.
Salt Creek near Collbran.	NE¼ sec. 10, T. 10 S., R. 94 W.	April 1940 to July 1941	8	USBR.
Spring Creek near Mesa.	NW¼ sec. 26, T. 10 S., R. 96 W.	April 1937 to July 1941	13	Do.

[1] Sixth principal meridian.
[2] Minor lapses occur at all stations especially during winter months.

The stream-flow data, as reported, have been determined in conformance with acceptable standards and are reliable for measurements of total quantity of flow at the gage locations. The stream-gaging records, however, do not reflect natural flow conditions as all stations are materially affected by upstream reservoir operation and ditch diversions. To eliminate the effect of ditch diversions on Cottonwood and Big Creeks, the stations were moved upstream to their present locations in 1945 and more valuable records have been secured since that time. Available data on the operation of Grand Mesa reservoirs are inadequate to permit a day-to-day correction of measured stream flow to natural conditions. Reservoir effect by months has been estimated, however, from comparison with hydrographs prepared for Plateau Creek, Kannah Creek, and White River.

The discharge records for all project streams have been extended to cover the 26-year period 1920 to 1945, inclusive, by monthly correlations with White River near Meeker, Plateau Creek near Collbran, or weighted combinations of both. The runoff of small tributaries to project streams was estimated from unit runoff relationships based on the watershed productivity of adjacent streams. Mesa Creek, the most westerly of the project streams is characterized by an unusually uniform discharge which was found to correlate well with that of White River near Meeker. The runoff of the remaining Grand Mesa streams becomes progressively more flashy toward the east and approaches the characteristics of Plateau Creek. Spring flood flows of Plateau Creek normally exceed 1,000 second-feet, while late fall and winter flows recede to less than 10 second-feet. The runoff of small tributaries to project streams was estimated from unit area runoff relationshps based on the watershed productivity of adjacent streams.

Period of water supply study.—The runoff record of Plateau Creek near Collbran, upon which the development of project water is dependent, provides the basis for the selection of a representative period for detailed water supply studies. As shown in table 8, the years of lowest runoff occurred during the 13-year period 1933 to 1945. The average runoff of this period was 64,200 acre-feet annually as compared to 77,300 acre-feet annually for the long-time record 1920 to 1945, inclusive. Therefore, this 13-year period is considered a conservative basis for estimating future runoff in the area and was selected as the period for analysis of the irrigation water supply. Although shortages would have occurred in a few years, not included in the irrigation study, none would have exceeded the shortages experienced during the critically dry years 1934, 1939, and 1940.

TABLE 8.—*Runoff of Plateau Creek near Collbran*

[Unit=1,000 acre-feet]

Year	Runoff	Year	Runoff	Year	Runoff
1920	[1] 116.1	1930	[1] 78.6	1940	39.2
1921	[1] 122.0	1931	[1] 45.3	1941	83.6
1922	118.5	1932	[1] 103.1	1942	91.4
1923	83.5	1933	[1] 60.2	1943	56.3
1924	65.0	1934	[1] 21.1	1944	88.7
1925	56.2	1935	55.1	1945	79.6
1926	87.7	1936	49.6		
1927	89.2	1937	62.5	Average	77.3
1928	[1] 89.6	1938	104.2		
1929	[1] 117.2	1939	43.1		

[1] No discharge records are available before August 1921. Lapses in records occurred during the winter months 1928–45. Runoffs for these periods were estimated from correlation with Kannah Creek near Whitewater, Colo.

The full 26-year period of extended runoff records (1920 to 1945) was used in making detailed power and domestic water supply studies. Analysis of water supply conditions relative to the production of power required this longer period for a full determination of the amount of water available annually for the generation of firm power and the average amount available for producing nonfirm energy.

Diversion records.—Diversion data for existing irrigation ditches and reservoirs were compiled from records collected by the State water commissioner. These records were obtained from daily observations in the spring and weekly or biweekly observations in the late summer by deputy water commissioners of State water district 42. Flow was determined by Parshall flume measurements on most ditches and by weir measurements and estimates on the remaining ditches.

Quality of water

No chemical analysis has been made of the waters developing from the project area. Long usage demonstrates, however, that the surface waters of the project streams are of very good quality for irrigation and domestic use. Development of these streams from a watershed of igneous origin causes the water to be free of soluble salts, and the dense vegetative cover of the entire watershed brings about a very low silt content. These two factors in conjunction with the high unpolluted nature of the watershed result in an exceptionally high quality of water for domestic purposes.

The quality of project return flow varies with respect to the location of land from which it develops. Return flow developing from the higher project lands near the first points of diversion is of good quality, comparable in character to the surface water of the project. That water developing from cultivated lands along the bottom of the Plateau Valley, however, is heavily laden with soluble salts and alkali, leached from the nearby residual soils. This water is unsuitable for either human or stock consumption but is satisfactory for irrigation.

WATER REQUIREMENTS

Consumptive use

Irrigation requirements for project lands were estimated from a consumptive use determination based on climatic records collected at Collbran. The station is located at approximately the average elevation of project lands and is climatically representative of the area. By use of the curve of relationship between consumptive use of water and accumulated daily maximum temperatures above 32°, as developed by R. L. Lowry and A. F. Johnson,[1] the annual consumptive use of water was found to be 2.0 acre-feet per acre.

Diversion requirement at irrigation laterals

The diversion requirements for irrigation were based on consumptive use with allowance made for effective precipitation, surface waste, deep percolation losses, and ditch and lateral losses. The effective precipitation was conservatively estimated to be 0.7 foot or 80 percent of the 0.9 foot average annual precipitation at Collbran for the 11 driest years of record. Thus 1.3 acre-feet per acre of the consumptive use requirement would have to be supplied from irrigation. Because of the pervious nature of the soils, at least 45 percent

[1] Proceedings of American Society of Civil Engineers, April 1941, Consumptive Use of Water for Agriculture, R. L. Lowry and A. F. Johnson.

of the water applied is expected to be lost through farm waste and deep percolation. Thus a farm application of 2.3 acre-feet would be needed to supply the 1.3 acre-feet needed from irrigation. Conveyance losses by irrigation laterals are expected to amount to an average of 35 percent of the total diversion, making necessary a total annual diversion of 3.5 acre-feet per acre to supply irrigation needs. Allowances for conveyance losses from the Southside canal were made in connection with the operation studies for Vega Reservoir.

A study of prevailing temperatures and the average growing season shows that the irrigation season in Plateau Valley normally begins about May 1 and ends about September 30. The use of irrigation water would not vary directly with temperatures throughout the irrigation season but would be governed somewhat by the cropping program of the land irrigated. For the anticipated cropping program discussed in chapter IV, table 9 summarizes by months the estimated ideal irrigation demands of project lands.

TABLE 9.—*Estimated monthly distribution of diversion requirement*

Month	Ideal demand	
	Percent	Acre-feet per acre
May	20	0.68
June	25	.88
July	24	.84
August	18	.64
September	13	.46
Total	100	3.50

South side canal conveyance losses

From an inspection of the soils and terrain through which the canal would be constructed and comparison with measured losses in other canals similarly located, it is estimated that transmission losses of the Southside canal would amount to 0.5 percent per mile. In reservoir operation studies, discussed later in this chapter, the estimated transmission losses of the South side canal have been added to the storage water required at Vega Reservoir. Water diverted from Bonham Reservoir and the other sources associated with domestic and power water supply would be conveyed largely by pipeline, thus eliminating transmission losses.

Return flow

Analysis of State water commissioner diversion records and field observations show that, even in extremely dry years, irrigated bottom lands adjacent to Plateau Creek and below its confluence with Salt Creek receive their full diversion requirements from return flow developing from the irrigation of higher lands. After project development, irrigation of the upper lands would be intensified and thus more return flow would be available. Because of the apparent adequacy of the present and future irrigation supply, bottom lands have not been included in the project plan.

Most of the irrigable lands of the project are located on elevated flat benches, traversed by deeply entrenched streams. Because of this topography and because of the permeable nature of the subsoils,

any return flow appears in the main channels at elevations too low for reuse on the bench lands. Only a small portion of the project lands, situated at low elevations, would receive any benefit from return flow water. The amount of flow these lands would receive would be too small for consideration in water supply studies.

Water requirements for power and domestic use

Grand Valley.—Estimates of present and anticipated population trends of Grand Valley indicate that within 50 years supplementary domestic and municipal water supply will require 20 second-feet of flow. Under the project plan water for this purpose would be used first for power production en route to Grand Valley. The 20 second-feet of firm flow would be made available by diversion from the Big and Cottonwood Creek drainages. The natural flow of these streams is adequate to supply this requirement during the spring and summer months of normal years. Storage would be required, however, to maintain a firm flow from November through April. The use of 4,900 acre-feet of existing storage capacity on the two watersheds, together with the use of Bonham Reservoir enlarged to a capacity of 6,300 acre-feet, would provide sufficient control to maintan 20 second-feet of firm flow in all years.

Provision would be made in Vega Reservoir for 5,400 acre-feet of capacity to replace irrigation storage that would be used under the project for regulation of the municipal and power supply. Of this capacity 4,900 acre-feet would be for direct replacement of irrigation capacity and 500 acre-feet would be allowed for Southside canal transmission losses (estimated at 0.5 percent per mile from Vega Reservoir to the point of use).

In addition to the replacement of existing storage, it would be necessary to reserve sufficient water in Vega Reservoir each year to compensate for all natural flow that would be diverted from Big and Cottonwood Creeks at the expense of present irrigation demands. Such natural flow diversions would consist of 20 second-feet of firm flow plus any water stored for power and domestic use during the irrigation season. Under present practices water users on Big and Cottonwood Creeks begin diverting natural flow for irrigation about April to insure the maximum use of available water. Irrigation is continued until the end of September. Replacements would have to be made, therefore, for any deficiencies suffered by irrigators during that interval. In normal years replacement would be necessary only during July, August, and September. In April, May, and June of normal years flows of Big and Cottonwood Creeks would meet full diversion requirements for power and domestic purposes without encroaching on the irrigation supply. In providing replacement for the firm flow diversion, however, Vega Reservoir storage requirement must be based on conditions in years of most severe water shortages rather than on average conditions. In 1934, the driest year in the period of study, 7,400 acre-feet of natural flow, otherwise usable for irrigation, would have been diverted for power and domestic use. This amount of water, plus 800 acre-feet to compensate for Southside canal conveyance losses, would have been needed at Vega Reservoir as replacements. Thus 8,200 acre-feet would have to be reserved in Vega Reservoir at the beginning of each irrigation season to provide replacements in the event of another low runoff year like 1934.

Plateau Valley.—The towns of Mesa and Collbran are served domestic water through pipeline distribution systems. Other communities and outlying farmsteads in Plateau Valley are supplied domestic and stock water by ditches diverting from the several Grand Mesa streams. The amount of water actually consumed is small in each case, but excess water must be diverted to maintain usable flows, especially during winter months when diversions large enough to prevent tight freezing must be maintained. Irrigation diversions provide domestic and stock water requirements during the summer. The project as planned would not interfere with present operation practices of any of the Grand Mesa streams except Big and Cottonwood Creeks. Heavy diversions would be made from Big Creek for power and domestic purposes during the winter months, thus requiring a minimum flow to be bypassed to supply present domestic and stock needs. From a study of past winter flows, it is estimated that a bypass of 3.5 second-feet would supply winter stock and domestic needs, and provision for this minimum flow has been included in the operation studies of Grand Valley's domestic and power water supply. Heaviest diversions from Cottonwood Creek would be made during the summer months, and at that time the irrigation diversions would be adequate to supply domestic and stock needs. Undiverted winter flows of this stream would be adequate for domestic and stock needs in all years.

The town of Collbran receives water from Plateau Creek under a decreed right of 0.70 second-foot. This water is diverted through the Hoosier ditch to the town distribution system. This right and the domestic and stock water needs of outlying farmsteads would require a minimum flow of 5 second-feet in Plateau Creek during the winter months, October to April, inclusive. All leakage from Vega Reservoir and water developing from Park and Leon Creeks below the points of feeder canal diversion would be usable in supplying the winter flow requirement. Any part of the requirement not met from these sources would be bypassed through Vega Reservoir so that the full 5 second-feet would be provided at the Plateau Creek gage near Collbran. During the summer irrigation diversions would provide adequate domestic and stock water.

Domestic water for Mesa originates from springs located a short distance southeast of the town and would not be affected by project development.

The minimum flows discussed are adequate for fishery requirements as more fully discussed in chapter VII.

WATER RIGHTS

Present water rights of project area

Plateau Valley streams are in State water district No. 42 in which water rights have been adjudicated in four court actions dated February 1890, November 1905, June 1916, and July 1941. The decree in the last action includes a complete schedule of all water rights for both direct flow and storage, listed in order of priority.

Rights of earliest priority are on the tributary streams. These rights require the entire natural flow of the various tributaries during the summer so that no water is bypassed to the more recently established rights on lower Plateau Creek or the Colorado River.

The number of decreed direct flow rights and the total direct flow water covered by these rights is shown for each project stream in table 10.

TABLE 10.—*Summary of decreed direct flow rights*

Creek system [1]	Number of decreed rights	Total amount of decreed rights (second-feet)
Mesa Creek [2]	111	170.773
Bull Creek	74	112.309
Cottonwood Creek	41	94.195
Big Creek	89	246.552
Salt Creek [3]	26	117.234
Plateau Creek	80	134.356
Total	421	875.419

[1] System named from principal stream serving the area; however, the decrees of all streams within the system are included.
[2] Coon Creek decrees are included.
[3] Since all direct diversions from Leon Creek above its confluence with Plateau Creek serve lands in the Salt Creek system, its decrees are included in this system.

Sixty-three separate storage rights have been decreed in a total of 56 reservoirs on the project watershed. Of these reservoirs, 54 are used for irrigation of lands within Plateau Valley and 2 are used for the irrigation of land in the vicinity of Cedaredge on the south slope of Grand Mesa. The reservoir decrees, as shown in table 11, cover the storage of water for the project streams.

TABLE 11.—*Summary of decreed reservoir rights*

Creek system	Number of decreed rights	Total amount of decreed rights (acre-feet)
Mesa Creek	18	2,921.93
Bull Creek	16	1,464.46
Cottonwood Creek	15	4,867.99
Big Creek	10	7,309.16
Plateau and Salt Creeks [1]	4	4,083.30
Total	63	20,646.84

[1] The 4 reservoirs are located on Leon Creek and tributaries which serve both Plateau Creek and Salt Creek systems. 2 of the 4 reservoirs, with 3,550 acre-feet of the decreed capacity, were constructed and used by water users on the Cedaredge side of Grand Mesa.

Water rights needed for project

Much of the winter and spring flow of all streams in Plateau Valley, with the exception of Big, Plateau, Park, and Leon Creeks, has been appropriated for storage purposes. Essentially all of the natural summer flows of the streams have been appropriated, and in most cases the appropriations are in excess of the total flow available in all but very high runoff years. This condition has been brought about through the extensive development of present irrigation and overlapping of appropriations. At the present time the distribution of existing water rights with respect to irrigated land acreages is by no means uniform. Irrigators operating under senior water rights have a fairly adequate water supply throughout the irrigation season while junior water rights suffer an extreme shortage of water during July, August, and September of all years. To make possible proper operation of the potential project it would be necessary to make appro-

priation of unappropriated water of Big, Cottonwood, Plateau, Park, and Leon Creeks for project storage and direct use and to exchange water with users of Cottonwood and Big Creek flows for the diversion of water from these streams for domestic and power use. The replacement of such water would be made from Vega Reservoir storage.

Water for replacement of that used from Cottonwood and Big Creeks, plus additional irrigation water made available by the project, would be appropriated from Plateau Creek and its two upper tributaries—Park and Leon Creeks. The water thus appropriated would consist of all unappropriated flows of Plateau, Park, and Leon Creeks up to a total of 29,000 acre-feet annually to be stored in Vega Reservoir, plus a direct flow appropriation of 225 second-feet to fill the capacity of the Southside canal at its point of diversion. The direct flow appropriation would only be filled for a short period each year during the early part of the irrigation season but would facilitate complete use of the stream runoff.

The desirability of diverting water from other Grand Mesa streams that would be crossed by the Southside canal in its course through Plateau Valley has been fully considered. Only early season flood flows are available for appropriation from these streams, however, and value of such water to the irrigators would not be sufficient to justify the cost of constructing necessary diversion facilities. The present water supply in Plateau Valley is adequate in the early irrigation season, and the project as planned would provide an adequate supplementary supply during the late season.

Natural flow would be appropriated from Big and Cottonwood Creeks for domestic, municipal, and power use up to the capacity of the individual feeder lines. Thus 30 second-feet would be appropriated from Big Creek and 15 second-feet from Cottonwood Creek. Although these appropriations would exceed the 20 second-feet actually required, they would be needed to allow operational flexibility in the semipeaking of power, generation of nonfirm energy, and in the maintenance of a 20 second-foot firm flow during periods of difficult operation brought about by unforeseen flow conditions or periods of pipeline maintenance. All water appropriated would be replaced on a direct water exchange basis.

Rights to the existing storage capacity on Big and Cottonwood Creeks would be acquired through direct exchange for 5,400 acre-feet of capacity in Vega Reservoir. Table 12 shows the existing storage that would be acquired for storage of domestic, municipal, and power water.

TABLE 12.—*Existing reservoirs to be used for domestic, municipal, and power water*

Drainage	Reservoir	Storage right (acre-feet)	Reservoir capacity (acre-feet)
Big Creek	Bonham	1,446.4	1,070
Do	Atkinson	1,818.9	1,800
Do	Silver Lake	183.7	170
Do	Forty Acre Lake	573.9	330
Do	Big Creek No. 1	2,754.8	550
Cottonwood Creek	Neversweat	320.0	320
Do	Cottonwood No. 5	200.0	320
Do	Little Meadows	116.0	120
Do	Big Meadows	450.0	220
Total		7,863.7	4,900

Enlargement of Bonham Reservoir to a capacity of 6,300 acre-feet (active capacity 6,200 acre-feet) would require appropriation of an additional 4,753.6 (rounded 4,760) acre-feet of water annually for storage purposes. This water would be appropriated from the unappropriated winter and spring runoff of Big Creek. As shown in the above table, present storage rights for Bonham Reservoir total 1,446.4 acre-feet supplied by Big Creek.

Summary of water rights needed for project

Water appropriations required for project operation, both natural flow and storage, are summarized in table 13.

TABLE 13.—*Water rights required for project operation*

STORAGE RIGHTS

Stream or watershed	Storage reservoir	New storage rights needed (acre-feet)
Plateau Creek (including upper tributaries, Leon and Park Creeks)	Vega Reservoir	29,000
Big Creek	Bonham Reservoir	4,760
Total		33,760

NATURAL FLOW RIGHTS

Stream or watershed	Natural flow diversion	New natural flow rights needed (second-feet)
Plateau Creek (including upper tributaries, Leon and Park Creeks)	Southside canal	225
Big Creek	Bonham pipe-line	30
Cottonwood Creek	Cottonwood pipeline	15
Total		270

No action has yet been initiated to appropriate the water required for the project. The water, however, may be appropriated under Colorado law which is briefly discussed in the following paragraphs.

Method of appropriating water

The Colorado Constitution and Statutes authorize the diversion and application to beneficial use of unappropriated water. No applications for permits to appropriate water need be filed, but the appropriator must within 60 days after commencing construction or enlargement of any reservoir, ditch, or canal file a claim therefor with the State engineer together with a map showing the pertinent facts. If the claim and accompanying map are found sufficient for a clear presentation of the facts and adequacy of design, they are accepted for filing by the State engineer. Blueprints or other suitable reproductions are returned to the claimant who shall within 90 days file them in the office of the county clerk and recorder of the county in which the headgate of the proposed structure or in which the proposed reservoir shall lie. The appropriator is required to proceed diligently to construct the works and to utilize the water.

Any owner of an unadjudicated water right may petition the district court for the adjudication of his right. After notice to all

other claimants in the water district and a hearing, the court shall determine the relative priorities of the claimants and enter an adjudication decree which shall become effective when a certified copy thereof has been filed in the office of the State engineer and another in the office of the irrigation division engineer.

WATER UTILIZATION

Present use of water for irrigation

The adequacy of the present irrigation supply has been determined from a summary of irrigation diversions reported by the State water commissioner during the period of study (1933 to 1945, inclusive) and from a comparison of these diversions with the estimated ideal irrigation demand. As shown by the following tables, the water supply within the ideal demand is ample during the early part of the irrigation season but is inadequate during the later months.

TABLE 14.—*Diversions to presently irrigated lands within ideal demand*

[Area, 18,340 acres; unit, acre-feet per acre]

Water year	Monthly diversion					Total diversion	Ideal demand	Total shortage	Percent shortage
	May	June	July	August	September				
1933	0.63	0.88	0.73	0.49	0.22	2.95	3.50	0.55	16
1934	.57	.35	.20	.15	.13	1.40	3.50	2.10	60
1935	.55	.88	.76	.48	.28	2.95	3.50	.55	16
1936	.67	.59	.47	.28	.17	2.18	3.50	1.32	38
1937	.68	.81	.60	.50	.28	2.87	3.50	.63	18
1938	.68	.88	.82	.58	.35	3.31	3.50	.19	5
1939	.68	.66	.51	.30	.23	2.38	3.50	1.12	32
1940	.68	.65	.51	.26	.27	2.37	3.50	1.13	32
1941	.68	.88	.80	.58	.39	3.33	3.50	.17	5
1942	.68	.88	.80	.63	.37	3.36	3.50	.14	4
1943	.64	.73	.58	.50	.33	2.78	3.50	.72	21
1944	.68	.88	.82	.61	.30	3.29	3.50	.21	6
1945	.64	.88	.76	.62	.40	3.30	3.50	.20	6
Average	.65	.77	.64	.46	.29	2.81	3.50	.69	20

TABLE 15.—*Average late-season shortage to presently irrigated lands, period 1933–45*

	July	August	September	Total
Late-season water requirement (acre-feet per acre)	0.84	0.64	0.46	1.94
Average shortage of late-season water (acre-feet per acre)	.20	.18	.17	.55
Average shortages of late-season water (percent)	24	28	37	28

The estimated average annual shortage of 20 percent is based on total annual diversions for the whole area. It does not show the seriousness of seasonal shortages and variations in supply to different lands within the project area. About 80 percent of the shortage occurs during July, August, and September, causing an average overall irrigation shortage of 28 percent for these months. For the six driest years of the 13-year period of study, the annual average shortage was 33 percent. For the same years, the late season shortage was 46 percent of the ideal demand. Serious shortages to some lands are brought about by the nonuniformity of decreed water rights within the presently irrigated lands. Less than half of the project area is

served under senior decreed rights which in some cases provide a water duty as high as 1 second-foot to 15 acres of land actually served. This condition brings about excessive use of water on lands under senior natural-flow rights and during periods of low runoff results in extreme shortages on lands under junior rights. A full water right is available to the junior-right users only during the spring season of high runoff years. Development of the project would assure a late-season supply to all water users, making unnecessary excessive diversions in the high runoff season, and would permit a more uniform diversion of fully usable water.

Besides alleviating the shortages on 18,340 acres presently irrigated, the project would provide a full water supply for 2,310 acres of non-irrigated class 1 and 2 lands.

Water operation for power and domestic use

Available water supply.—Water diverted from Big Creek would enter the power and domestic system at the outlet of Bonham Reservoir. Diversions from East Fork of Big Creek and releases from Atkinson Reservoir would be conveyed to Bonham Reservoir by a feeder canal with a capacity of 30 second-feet. By using this feeder canal and diverting at Bonham Reservoir, runoff developing from about 11.5 square miles, or 60 percent of the total Big Creek watershed above the gaging station,[2] would be available to the system. The portion of the watershed thus contributing to power and domestic water supply contains all of the high drainage area above an elevation of 9,800 feet. From studies of unit runoff with respect to watershed elevation (based on the recorded flow of Plateau Creek and other project streams gaged during the course of project investigations), it was estimated that approximately 76 percent of the runoff of Big Creek, measured at the gaging station, would be available for diversion at Bonham Reservoir. This includes the runoff of East Fork above the point of feeder-canal diversion. Table 16 summarizes the estimated annual runoff of Big Creek at the gaging station, Big Creek at Bonham Reservoir, and East Fork above the point of feeder-canal diversion for the period 1920 to 1945, inclusive.

Although the Big Creek watershed would be the principal source of water supply for power and domestic use, the runoff of the area is inadequate to provide the full 20 second-feet of firm flow required without the construction of costly hold-over storage. From a comparison of construction costs involved in supplementing the Big Creek supply, it was found that diversion from the Cottonwood Creek watershed would be more desirable than additional hold-over storage on Big Creek. Therefore, the project plan includes diversion through a collection feeder canal (capacity: 15 second-feet) heading on Cottonwood Creek immediately below Cottonwood Reservor No. 1 and extending to the Big Meadows Reservoir. Cottonwood tributaries intercepted along the course of the feeder canal would be tapped by a system of intake structures. From Big Meadows Reservoir, water for power and domestic use would be conveyed by pipeline for a distance of 1.9 miles north to join with the main pipeline from Bonham Reservoir.

The watershed tributary to the Cottonwood feeder canal and Big Meadows Reservoir would consist of 8.5 square miles, or 53 percent of

[2] Gaging station located in NE¼ sec. 5, T. 11 S., R. 94 W., operated since June 1945.

the total Cottonwood Creek watershed above the gaging station.[3] Like the area tapped on Big Creek, the contributing area on Cottonwood Creek would all be above an elevation of 9,800 feet. Relationships established between unit runoff and watershed elevation show that the runoff available to Big Meadows Reservoir and the feeder canal would constitute approximately 67 percent of the total Cottonwood Creek runoff at the gaging station. Table 17 summarizes the estimated annual runoff of Cottonwood Creek at the gaging station, tributaries above Big Meadows and Cottonwood No. 5 Reservoirs, and tributaries above the feeder canal.

TABLE 16.—*Runoff of Big Creek at the gaging station and runoff available for power, municipal, and domestic use*

[Unit=1,000 acre-feet]

Irrigation-water year (1)	Total runoff of Big Creek at gaging station (2)	Runoff of Big Creek at Bonham Reservoir (3)	Runoff of East Fork above feeder-canal diversion (4)	Total runoff above the pipeline intake [1] (5)
1920	38.0	14.5	14.0	28.5
1921	41.0	16.3	15.3	31.6
1922	36.5	13.9	13.6	27.5
1923	28.6	11.7	10.4	22.1
1924	23.8	9.7	8.3	18.0
1925	21.8	9.6	7.3	16.9
1926	29.7	12.1	10.4	22.5
1927	30.6	12.2	11.0	23.2
1928	33.2	13.7	11.6	25.3
1929	40.8	17.5	14.8	32.3
1930	26.3	11.7	9.5	21.2
1931	18.4	7.9	6.2	14.1
1932	34.7	13.6	12.5	26.1
1933	24.0	10.2	8.6	18.8
1934	10.5	5.3	3.3	8.6
1935	19.9	8.5	7.2	15.7
1936	21.2	8.8	7.1	15.9
1937	22.7	8.6	8.1	16.7
1938	34.1	13.3	12.6	25.9
1939	18.3	7.9	6.2	14.1
1940	17.5	7.3	5.8	13.1
1941	30.0	11.4	10.8	22.2
1942	30.7	12.3	11.3	23.6
1943	20.5	8.6	7.1	15.7
1944	28.6	10.9	10.8	21.7
1945	28.2	11.3	10.2	21.5
Average	27.3	11.1	9.8	20.9

[1] Total runoff available to the pipeline intake at Bonham Reservoir is equivalent to the sum of columns 3 and 4.

[3] Gaging station located in SE¼ sec. 3, T. 11 S., R. 95 W., operated since May 1945.

TABLE 17.—*Runoff of Cottonwood Creek at the gaging station and runoff available for power, municipal, and domestic use*

[Unit=1,000 acre-feet]

Irrigation-water year (1)	Total runoff of Cottonwood Creek at gaging station (2)	Runoff of tributaries above Big Meadows and Cottonwood No. 5 Reservoirs (3)	Runoff of tributaries above Cottonwood feeder canal (4)	Total runoff above the pipeline intake[1] (5)
1920	16.3	2.4	8.7	11.1
1921	18.7	2.6	10.1	12.7
1922	15.6	2.1	8.5	10.6
1923	13.6	1.9	7.3	9.2
1924	11.6	1.6	6.3	7.9
1925	12.4	1.7	6.7	8.4
1926	14.7	2.0	7.9	9.9
1927	14.5	2.0	7.7	9.7
1928	16.7	2.3	8.8	11.1
1929	21.5	2.9	11.6	14.5
1930	14.7	2.1	8.1	10.2
1931	10.3	1.5	5.9	7.4
1932	15.9	2.3	8.6	10.9
1933	12.4	1.8	6.6	8.4
1934	7.0	1.1	4.0	5.1
1935	9.9	1.4	5.4	6.8
1936	10.7	1.7	5.9	7.6
1937	10.1	1.4	5.4	6.8
1938	15.1	1.9	7.7	9.6
1939	9.9	1.4	5.2	6.6
1940	9.4	1.2	4.9	6.1
1941	13.4	1.8	7.0	8.8
1942	14.4	2.0	7.8	9.8
1943	11.0	1.4	5.9	7.3
1944	12.4	1.8	6.5	8.3
1945	13.1	2.0	7.1	9.1
Average	13.3	1.9	7.1	9.0

[1] Total runoff developed from the Cottonwood Creek watershed above Big Meadows Reservoir and the feeder canal is equivalent to the sum of columns 3 and 4.

Storage for the power and domestic system.—Storage facilities that would be made available for use in the power, municipal, and domestic system are listed by watershed as follows:

	Active capacity (acre-feet)
Big Creek watershed:	
Bonham Reservoir	[1] 6,200
Atkinson Reservoir	1,800
Silver Lake	170
Forty-Acre Lake	330
Big Creek No. 1 Reservoir	550
Subtotal	9,050
Cottonwood Creek watershed:	
Neversweat Reservoir	320
Cottonwood No. 5 Reservoir	320
Little Meadows Reservoir	120
Big Meadows Reservoir	220
Subtotal	980
Total	10,030

[1] Bonham Reservoir has a present capacity of 1,070 acre-feet, which would be enlarged to 6,300 acre-feet (active capacity: 6,200 acre-feet).

Plan of operation for the power, municipal, and domestic system.—To provide ease in year-round operation and efficient use of available water resources, the Big Creek watershed would be utilized as the principal source of supply for power, municipal, and domestic water. An average of 20,900 acre-feet annually, or about 70 percent of the total runoff available to the power, municipal, and domestic system, develops from this watershed. The fluctuating seasonal discharge of Big Creek, however, would permit only a part of the runoff to be diverted at a firm flow rate of 20 second-feet. The enlarged Bonham Reservoir, together with 2,850 acre-feet of existing storage on the watershed, approximately 75 percent of the annual power and domestic requirement of 14,400 acre-feet, would be divertible from this source. Runoff developed from Cottonwood Creek watershed above the diversion facilities would be adequate to supply the additional water needed for a firm-flow diversion of 20 second-feet in all years. Control of such water would be provided by 980 acre-feet of existing storage capacity on the watershed.

Bonham Reservoir would be used to provide final control of water above the pipeline intake. The remaining reservoirs, being less accessible, would be set to release water at a uniform rate during the draw-down period each year. Therefore, considerable flexibility in operation would be possible during periods of high runoff after storage capacity has been filled and while Bonham Reservoir was spilling. At all other times, however, the following plan of operation would be required to insure an adequate water supply. Diversions would be made at the Bonham Reservoir pipeline intake at the rate of 1,000 acre-feet a month during the normal reservoir draw-down period November to April, inclusive. During the same period, 200 acre-feet of supplementary water would be diverted monthly by the Big Meadows Reservoir intake to complete the full 1,200 acre-feet a month required by the power, municipal, and domestic system. The winter diversion from the Cottonwood Creek watershed would be maintained by uniform releases of stored water from the existing reservoirs. Big Meadows Reservoir would be used to collect such releases and provide final diversion control. During the reservoir filling season (May to October) the Cottonwood Creek diversion would be increased to 400 acre-feet a month which would be supplied from the natural flow collected by the feeder canal. This would permit the pipeline diversion from Big Creek to be reduced to 800 acre-feet a month to insure the maximum use of spring and summer runoff for filling reservoirs and to delay draw-down on storage until November. Spring runoff developing above the reservoirs on the Cottonwood Creek watershed would be adequate to fill to capacity the reservoirs of the Cottonwood system without encroaching on the required summer diversion of 400 acre-feet a month.

Reservoir operation for the power and domestic system.—Monthly operation studies have been prepared separately for the Big Creek and Cottonwood Creek Reservoir systems. Individual study of each reservoir in the two systems is deemed unnecessary because all spills and storage releases would be available at Bonham and Big Meadows Reservoirs. Evaporation from open water surfaces at the elevation of these reservoirs (above 9,800 foot elevation) does not exceed the normal evaporation and transpiration losses of the watersheds.

Reservoir seepage losses, estimated at about 1 second-foot for Bonham Reservoir, would be fully recoverable for use by downstream lands. Such losses would therefore be compensated by an equivalent reduction in the necessary minimum bypass requirements of 3.5 second-feet to Big Creek lands. Sufficient surplus flow would be divertible from Cottonwood Creek to offset seepage losses from Big Meadows Reservoir. Seepage would return to the Cottonwood Creek channel and would not deplete the supply of lower lands.

The studies show that in all years of the study period, except 1934 and 1940, the storable flow of the two watersheds would have exceeded the power and domestic system's demand on storage. Total hold-over storage of 5,200 acre-feet in Big Creek and Cottonwood Creek Reservoirs would have been required to supply storage demands for the extremely dry period from August 1933 to April 1935, inclusive. In all years a firm supply of 20 second-feet of water would have been provided for power, municipal, and domestic use. An average of 4,600 acre-feet of water annually would have spilled from Bonham Reservoir, 3,150 acre-feet of which could have been utilized in the production of nonfirm power. Water thus used in the generation of nonfirm power would be diverted into the Southside canal or the Cottonwood Creek channel from the tailrace of power plant No. 1 and would not cause additional depletion of irrigation flow.

The following tables summarize the power and domestic water operation studies for the Big Creek and Cottonwood Creek Reservoir systems:

TABLE 18.—*Summary of reservoir operation for the Big Creek system*

[Total active reservoir capacity, 9,050 acre-feet. Unit=1,000 acre-feet]

Water year	Runoff available above pipe intake	Non-divertible runoff of east fork of Big Creek	Bypass for stock and domestic water supply	Requirement for power and domestic system	Diversion to power and domestic system		Reservoir release to power and domestic system	Minimum reservoir content during year	Water stored in Big Creek reservoirs		Maximum reservoir content during year	Total spill from Bonham Reservoir	
					Surplus flow	Replaceable from Vega Reservoir			Surplus flow	Replaceable from Vega Reservoir		Usable for irrigation	Waste
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1920	28.5	8.4	1.3	10.8	4.2	2.2	4.4	4.8	4.2	----------	9.0	1.4	6.8
1921	31.6	9.2	1.4	10.8	4.6	2.4	3.8	5.0	4.0	----------	9.0	2.4	7.6
1922	27.5	7.8	1.5	10.8	5.4	2.0	3.4	6.0	3.0	----------	9.0	.7	7.1
1923	22.1	4.7	1.5	10.8	4.4	2.3	4.1	4.6	4.4	----------	9.0	2.1	2.7
1924	18.0	2.9	1.5	10.8	4.4	2.5	3.9	5.8	3.2	----------	9.0	2.6	.9
1925	16.9	1.5	1.4	10.8	4.1	3.2	3.5	4.8	4.0	0.2	9.0	2.5	----------
1926	22.5	3.9	1.4	10.8	5.9	2.1	2.8	6.5	2.5	----------	9.0	3.2	3.5
1927	23.2	4.6	1.5	10.8	5.1	2.4	3.3	5.4	3.6	----------	9.0	3.9	2.1
1928	25.3	4.8	1.4	10.8	5.7	2.4	2.7	6.3	2.7	----------	9.0	4.9	3.4
1929	32.3	6.4	1.6	10.8	6.5	2.4	1.9	7.1	1.9	----------	9.0	4.2	9.3
1930	21.2	2.5	1.6	10.8	6.2	2.4	2.2	6.8	2.2	----------	9.0	4.1	2.2
1931	14.1	1.1	1.4	10.8	4.5	2.6	3.7	5.9	3.0	.1	9.0	1.3	.1
1932	26.1	6.0	1.5	10.8	4.9	2.2	3.7	4.9	4.1	----------	9.0	3.0	4.4
1933	18.8	3.2	1.5	10.8	4.5	2.1	4.2	4.9	4.1	----------	9.0	.6	2.8
1934	8.6	----------	1.5	10.8	2.3	3.0	5.5	5.2	----------	1.8	7.0	----------	----------
1935	15.7	2.3	1.7	10.8	2.5	2.8	5.4	----------	5.4	1.0	6.4	----------	----------
1936	15.9	1.9	1.5	10.8	3.5	2.8	4.5	1.9	4.3	1.9	8.1	----------	----------
1937	16.7	2.9	1.6	10.8	2.6	2.7	5.5	2.7	4.4	1.9	9.0	.6	----------
1938	25.9	6.5	1.5	10.8	4.5	.4	3.9	4.6	4.4	----------	9.0	1.1	5.5
1939	14.1	1.4	1.6	10.8	4.0	2.4	4.4	5.4	3.5	.1	9.0	1.1	----------
1940	13.1	1.6	1.5	10.8	2.3	3.3	5.2	3.8	3.7	.7	8.2	----------	----------
1941	22.2	5.2	1.4	10.8	4.2	2.3	4.3	3.2	5.8	.1	9.0	2.5	.7
1942	23.6	4.9	1.4	10.8	5.5	2.0	3.3	6.1	2.9	----------	9.0	.5	6.4
1943	15.7	1.2	1.4	10.8	4.2	2.2	4.4	4.4	3.0	1.5	9.0	2.0	----------
1944	21.7	5.1	1.4	10.8	3.9	1.9	5.0	4.3	4.7	----------	9.0	1.3	3.4
1945	21.5	4.3	1.5	10.8	3.8	2.2	4.8	3.9	5.1	----------	9.0	2.0	2.6
Average	20.9	4.0	1.5	10.8	4.4	2.4	4.0	4.8	3.6	.4	8.8	1.8	2.8

Column 3. Diversions from east fork of Big Creek are limited by feeder canal capacity of 30 second-feet.

Column 4. Includes reservoir seepage losses (estimated 1 second-foot) which would aid in supplying winter bypass requirements of lower lands. Minimum bypass of 3.5 second-feet required for domestic and stock water needs.

Columns 6 and 10. Water available for diversion without encroaching on present irrigation rights.

Column 8. Reservoir releases as shown are distributed over portions of two separate draw-down periods and cannot be derived from other columns in this table.

TABLE 19.—*Summary of reservoir operation for the Cottonwood Creek system*

[Total active reservoir capacity, 980 acre-feet. Unit=1,000 acre-feet]

Water year	Runoff available above pipe intake	Requirement for power and domestic system	Diversion to power and domestic system		Reservoir releases to power and domestic system	Minimum reservoir content during year	Water stored in Cottonwood Creek reservoirs		Maximum reservoir content during year	Total undiverted runoff above pipe intake	Total spill from Big Meadows Reservoir	
			Surplus flow	Replaceable from Vega Reservoir			Surplus flow	Replaceable from Vega Reservoir			Usable for irrigation	Waste
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1920	11.1	3.6	1.8	1.2	0.6	0.4	0.6	----------	1.0	6.3	0.6	0.6
1921	12.7	3.6	1.8	1.2	.6	.4	.6	----------	1.0	7.7	.7	.7
1922	10.6	3.6	1.8	1.2	.6	.4	.6	----------	1.0	6.1	.4	.5
1923	9.2	3.6	1.8	1.2	.6	.4	.6	----------	1.0	4.9	.4	.3
1924	7.9	3.6	1.8	1.2	.6	.4	.6	----------	1.0	3.9	.3	.1
1925	8.4	3.6	1.5	1.6	.5	.5	.3	0.2	1.0	4.3	.4	.1
1926	9.9	3.6	1.9	1.2	.5	.5	.5	----------	1.0	5.5	.4	.4
1927	9.7	3.6	1.8	1.2	.6	.4	.6	----------	1.0	5.3	.6	.2
1928	11.1	3.6	1.9	1.2	.5	.5	.5	----------	1.0	6.4	.6	.5
1929	14.5	3.6	2.0	1.2	.4	.6	.4	----------	1.0	9.2	.8	.9
1930	10.2	3.6	2.0	1.2	.4	.6	.4	----------	1.0	5.7	.5	.4
1931	7.4	3.6	1.4	1.6	.6	.4	.3	.3	1.0	3.5	.2	.1
1932	10.9	3.6	1.9	1.2	.5	.5	.5	----------	1.0	6.2	.6	.5
1933	8.4	3.6	1.8	1.2	.6	.4	.6	----------	1.0	4.2	.4	.2
1934	5.1	3.6	.8	2.2	.6	.4	----------	.4	.8	1.7	----------	----------
1935	6.8	3.6	1.2	1.6	.9	----------	.4	.6	1.0	3.0	----------	----------
1936	7.6	3.6	1.5	1.6	.5	.5	.4	.1	1.0	3.5	.3	.2
1937	6.8	3.6	1.2	1.6	.8	.2	.4	.4	1.0	3.0	.1	.1
1938	9.6	3.6	1.7	1.2	.7	.3	.7	----------	1.0	5.3	.4	.3
1939	6.6	3.6	1.3	1.6	.7	.3	.3	.4	1.0	2.8	.1	.1
1940	6.1	3.6	1.1	1.7	.8	.2	.3	.4	.9	2.5	----------	.1
1941	8.8	3.6	1.7	1.2	.7	.2	.8	----------	1.0	4.6	.4	.1
1942	9.8	3.6	1.9	1.2	.5	.5	.5	----------	1.0	5.4	.3	.5
1943	7.3	3.6	1.7	1.2	.7	.3	.4	.3	1.0	3.5	.1	.1
1944	8.3	3.6	1.7	1.2	.7	.3	.7	----------	1.0	4.1	.4	.2
1945	9.1	3.6	1.7	1.2	.7	.3	.7	----------	1.0	5.1	.6	.2
Average	9.0	3.6	1.6	1.4	.6	.4	.5	.1	1.0	4.7	.4	.3

Columns 4 and 8. Water available for diversion without encroaching on present irrigation rights.
Column 11. Undiverted runoff of Cottonwood Creek above the feeder canal, part or all of which would be usable by present irrigators.

Replacement of direct flow diversions.—An average of 4,800 acre-feet of direct flow, usable by present irrigators, would have been diverted annually during the period 1933 to 1945 for power and domestic purposes. A maximum diversion of 7,400 acre-feet would have been made in 1934. To replace water thus diverted it would have been necessary to make concurrent releases from Vega Reservoir to Big and Cottonwood Creeks lands. Conveyance losses of Southside canal would have necessitated an average annual release of 5,300 acre-feet of water and a maximum release in 1934 of 8,200 acre-feet. It would be necessary to reserve 8,200 acre-feet of water in Vega Reservoir at the beginning of each draw-down season to insure adequate replacement. Only in extremely dry years, however, would the full amount be required. In all other years, any reserved storage in excess of replacement needs would be utilized to mitigate late-season irrigation shortages. Table 20 is a summary of replacements required from Vega Reservoir for the 13-year period covered by irrigation water-supply studies.

TABLE 20.—*Water required for irrigation replacements*

[Unit=1,000 acre-feet]

Water year	Present irrigation diversions to be used for power and domestic purposes					Total replacement required at Vega Reservoir
	Big Creek		Cottonwood Creek		Total	
	Direct diversion	Diverted for storage	Direct diversion	Diverted for storage		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1933	2.1	0.0	1.2	0.0	3.3	3.6
1934	3.0	1.8	2.2	.4	7.4	8.2
1935	2.8	1.0	1.6	.6	6.0	6.6
1936	2.8	1.9	1.6	.1	6.4	7.0
1937	2.7	1.9	1.6	.4	6.6	7.2
1938	2.4	.0	1.2	.0	3.6	4.0
1939	2.4	.1	1.6	.4	4.5	4.9
1940	3.3	.7	1.7	.4	6.1	6.7
1941	2.3	.1	1.2	.0	3.6	4.0
1942	2.0	.0	1.2	.0	3.2	3.5
1943	2.2	1.5	1.2	.3	5.2	5.7
1944	1.9	.0	1.2	.0	3.1	3.4
1945	2.2	.0	1.2	.0	3.4	3.7
Average	2.5	.7	1.4	.2	4.8	5.3

NOTE.—Column 7 includes Southside canal conveyance losses (0.5 percent per mile) from Vega Reservoir to points of lateral diversion.

Water operation for Vega Reservoir

Water available for storage.—Vega Reservoir storage would be supplied from the runoff of Plateau Creek at the dam site and from feeder canal diversions from Park and Leon Creeks. Approximately 90 percent of the runoff developed by the watersheds of Park and Leon Creeks would be available for diversion to the feeder canal. The storage supply, however, is subject to present direct flow rights of 12 small ditches serving 1,641 acres [4] of land below the reservoir basin and above the confluence of Salt Creek and Plateau Creek. All irrigated lands below Salt Creek are supplied full irrigation require-

[4] Of the 1,696 acres of presently irrigated land below the reservoir site, 55 acres are irrigated by water from off-channel springs.

ments from return flow. The bypass requirement to satisfy the irrigation needs of the 12 ditches has been liberally estimated on a water-duty basis of 45 irrigated acres per second-foot of flow. Downstream-irrigation requirements together with 0.70 second-foot of flow for Collbran domestic water supply would therefore require a total of 37 second-feet of flow during the irrigation season. The inflow to Plateau Creek channel between the creek's confluence with Leon Creek and its confluence with Salt Creek averages 7 second-feet during the irrigation season and would be available to the presently irrigated lands. The net reservoir bypass of natural flow required for existing rights therefore would be 30 second-feet from April to September, inclusive. During the remainder of the year 5 second-feet of flow would be needed to satisfy the Collbran right and supply outlying farmsteads with domestic and stock water. About 1 second-foot of this amount would be provided by inflow below the feeder canal diversion, and the remainder would be supplied from reservoir seepage and through the bypassing of water.

A capacity of 200 second-feet was determined as most suitable for the Leon-Park feeder canal. A canal of smaller capacity would leave valuable water undiverted during low-run-off years, while a canal of larger capacity would not materially increase storable water during such years.

Table 21 shows the water available for storage in Vega Reservoir during the period of irrigation water-supply study. Proper allowances have been made for bypassing of water from the reservoir. Feeder canal diversions have been limited to 200 second-feet.

TABLE 21.—*Storable water at Vega Reservoir*

[Unit=1,000 acre-feet]

Irrigation water year (1)	Runoff of Leon and Park Creeks (2)	Runoff of Plateau Creek at dam site (3)	Total available runoff (4)	Total non-storable runoff (5)	Total storable water (6)
1933	49.0	[1] 11.2	60.2	28.8	31.4
1934	17.1	[1] 4.0	21.1	6.6	14.5
1935	45.0	[1] 10.1	55.1	23.0	32.1
1936	40.1	[1] 9.5	49.6	18.9	30.7
1937	52.4	[1] 10.1	62.5	29.4	33.1
1938	86.6	17.6	104.2	54.8	49.4
1939	35.7	7.4	43.1	14.4	28.7
1940	32.6	6.6	39.2	17.4	21.8
1941	64.6	19.0	83.6	38.3	45.3
1942	68.8	[1] 22.6	91.4	36.1	55.3
1943	46.9	[1] 9.5	56.3	19.1	37.2
1944	72.3	[1] 16.4	88.7	43.3	45.4
1945	64.8	[1] 14.8	79.6	35.3	44.3
Average	52.0	12.2	64.2	28.1	36.1

[1] Runoff estimated from correlation with Plateau Creek near Collbran.

Column 2. Runoff determined by subtracting the gaged runoff of Plateau Creek at Vega Reservoir site from the gaged runoff of Plateau Creek below confluence with Park and Leon Creeks near Collbran. No other tributaries enter the main creek between the gages.

Column 3. Gaged runoff of Plateau Creek at the reservoir site.

Column 4. Sum of columns 2 and 3. Runoff of Plateau Creek gaged near Collbran.

Column 5. Nondivertible flow as limited by a 200-second-foot feeder canal from Park and Leon Creeks plus necessary bypass of water to senior rights on lower Plateau Creek.

Storage water required for irrigation.—Project water required for irrigation has been analyzed individually for each of the areas served by the Grand Mesa stream systems and Plateau Creek lands above

and below the Vega Reservoir site. In determining the total irrigation water needed, the requirement to meet ideal demand was computed for the irrigable lands of each system. Requirements thus obtained were used in initial operation studies, based on present water supply as indicated by State water commissioner diversion records, to determine the additional water needed at the ditch heading of each stream system. Proper allowance was made for existing storage on Big and Cottonwood Creeks that would be utilized for power and municipal water supply. Estimated conveyance losses (0.5 percent per mile from the head of the Southside canal to the points of diversion for each stream system) were also considered in determining total storage water needed at Vega Reservoir. Project water required by lower Plateau Creek lands would not be supplied through the Southside canal but would be provided by direct diversions from the creek. The amount of water required for these lands has been determined as the total ideal demand less the water bypassed at the reservoir to satisfy existing rights. Plateau Creek lands above Vega Reservoir would use water as in the past, and in addition 100 acre-feet of stored water a year would be allowed these lands by exchange.

The storage water requirements at Vega Reservoir for all project lands are shown in table 22.

TABLE 22.—*Total storage water required for irrigation (canal conveyance losses included)*

[Unit=1,000 acre-feet]

Year	May	June	July	August	September	Total
1933	1.5	0.4	6.5	6.3	6.0	20.7
1934	3.7	13.1	15.0	10.9	7.3	50.0
1935	3.5	.3	6.1	6.3	4.9	21.1
1936	.7	8.6	11.4	9.1	6.7	36.5
1937	.1	3.0	8.2	6.5	4.9	22.7
1938	.1	.2	3.5	4.7	3.2	11.7
1939	.4	7.3	11.1	9.0	5.7	33.5
1940	.3	7.5	10.9	9.5	5.1	33.3
1941	.3	.1	3.6	4.6	2.6	11.2
1942	.2	.1	3.3	4.1	3.4	11.1
1943	1.2	4.4	9.8	5.2	4.1	24.7
1944	.3	.1	2.4	4.7	4.0	11.5
1945	1.1	.5	4.5	3.9	2.9	12.9
Average	1.0	3.5	7.4	6.5	4.7	23.1

Reservoir operation.—Operation studies of Vega Reservoir consisted of a monthly analysis of reservoir fill and draw-down based on the runoff available during the period 1933 to 1945, inclusive. An estimated 32 inches annually would be lost through evaporation from Vega Reservoir (elevation 7,800 feet). Present losses in the reservoir area, including evaporation and transpiration from irrigated meadows and brush lands in the reservoir basin, are estimated at 19 inches. Thus the net new loss would be 13 inches or approximately 1.1 feet per year. With allowance made for the surface area during reservoir-filling and draw-down operations, the average evaporation loss is estimated at 700 acre-feet annually. Reservoir seepage losses, estimated at about 1 second-foot, would be fully recoverable for use by lower Plateau Creek lands. Such losses, therefore, would allow an equiv-

alent reduction in the amount of water that would have to be bypassed to meet existing rights.

A reservoir with an active capacity of 29,000 acre-feet was found to provide an average annual draft of 20,500 acre-feet during the reservoir draw-down period. Full replacement of water used for power generation and municipal purposes would have been made in every year of the study and irrigation shortages would have occurred in only 4 years. The only serious shortage in irrigation water supply (46 percent) would have occurred in 1934. The average irrigation shortage would have been 7 percent for the 13-year period. The average annual spill from the reservoir would have been 12,100 acre-feet. Operation studies for Vega Reservoir are summarized on an annual basis in table 23.

The total storage capacity required of Vega Reservoir for proper project operation was found to be 30,000 acre-feet. Use of storage capacity would be as follows:

	Acre-feet
Irrigation water supply	15, 400
Power and muncipal water supply	13, 600
Dead storage and silt deposition	1, 000
Total	30, 000

TABLE 23.—*Summary of Vega Reservoir operation*

[Active capacity, 29,000 acre-feet. Unit=1,000 acre-feet]

Irrigation water year	Total storable water at reservoir	Filling season				Maximum active reservoir content	Total spill from reservoir	Draw-down season				Active hold-over at end of season	Total shortage to irrigation	Shortage of diversion requirement
		Inflow to reservoir	Evaporation from reservoir	Replacement of municipal and power diversions	Releases for irrigation			Inflow to reservoir	Evaporation from reservoir	Replacement of municipal and power diversions	Releases for irrigation			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
														Percent
1932												12.0		
1933	31.4	30.5	0.4		1.9	29.0	11.2	0.9	0.3	3.6	18.8	7.2		
1934	14.5	8.0	.2	1.5		13.5		6.5	.2	6.7	13.1		36.9	46
1935	32.1	29.9	.3	1.9	3.8	23.9		2.2	.3	4.7	17.3	3.8		
1936	30.7	26.1	.2		.7	29.0		4.6	.3	7.0	26.3		9.5	12
1937	33.1	31.3	.3	3.6	3.1	24.3		1.8	.3	3.6	19.6	2.6		
1938	49.4	45.8	.3		.3	29.0	18.8	3.6	.4	4.0	11.4	16.8		
1939	28.7	25.5	.3		.4	29.0	12.6	3.2	.3	4.9	27.0		6.1	8
1940	21.8	20.8	.2	1.1	.3	19.2		1.0	.2	5.6	14.4		18.6	23
1941	45.3	44.1	.3		.4	29.0	14.4	1.2	.4	4.0	10.8	15.0		
1942	55.3	53.8	.4		.3	29.0	39.1	1.5	.4	3.5	10.8	15.8		
1943	37.2	33.0	.4		5.6	29.0	13.8	4.2	.4	5.7	19.1	8.0		
1944	45.4	45.4	.6	1.3	2.8	29.0	19.7		.2	2.1	8.7	18.0		
1945	44.3	40.3	.4		1.6	29.0	27.3	4.0	.4	3.7	11.3	17.6		
Average	36.1	33.4	.4	.7	1.7	26.3	12.1	2.7	.3	4.5	16.0	8.1	5.5	7

NOTE.—Reservoir leakage losses would be fully recoverable for use in supplying requirements to lower Plateau Creek rights. These losses were considered in determining storable water as shown in column 2; therefore, they do not appear in the operation study.

Columns 5 and 11. Water required from Vega storage to replace direct flow power diversions made adversely to present irrigation rights on Big and Cottonwood Creeks. Includes Southside canal transmission losses from Vega Reservoir to points of use on Big and Cottonwood Creeks.

Columns 6 and 12. Storage demand of 20,650 acres of irrigable project lands above present water supply. Includes storage depleted by operation of the power and domestic system plus Southside canal transmission losses for all diversions.

Column 14. Total shortage to ideal irrigation diversion requirements.

Stream depletion

Plateau Creek and tributaries.—Operation of the Collbran project would deplete the present flow of Plateau Creek below the project area by the amount of water consumed in providing a supplemental irrigation supply to 18,340 acres of irrigated lands, a full irrigation supply to 2,310 acres of new land, net reservoir evaporation losses, and the water diverted out of Plateau Valley for the generation of power and municipal use in Grand Valley. A summary of these depletions on an average annual basis is given in table 24.

TABLE 24.—*Annual project depletions, Plateau Creek and tributaries* [1]

Water use	Stream depletion (acre-feet)
Supplemental irrigation supply	3,100
Irrigation supply for new land	2,800
Power and municipal water supply	14,400
Reservoir evaporation	700
Total	21,000

[1] Over and above present uses.

Colorado River below Grand Valley.—The depletion of the Colorado River below Grand Valley would be the same as for Plateau Creek less that portion of the 14,400 acre-feet diverted into Grand Valley for power generation and municipal use which finds its way back to the river. Part of the water so diverted would be returned directly to the river from the tailrace of power plant No. 2. The remainder would be used for domestic and municipal purposes in Grand Valley, after which a portion, estimated at 50 percent, would return to the river. Domestic and municipal needs are expected to require an average of 6,100 acre-feet of water a year for the first 50 years and 10,300 acre-feet a year thereafter. Since only half of this would be actually lost to the river, the losses would be about 3,000 acre-feet and 5,200 acre-feet, respectively. The following table summarizes the estimated average annual depletions of the Colorado River that would occur below Grand Valley in over 100 years, considered as the useful life of the project.

TABLE 25.—*Project stream depletion, Colorado River* [1]

Water use	Stream depletion (acre-feet)
Irrigation in Plateau Valley	5,900
Reservoir evaporation	700
Domestic and municipal supply in Grand Valley	4,100
Total	10,700

[1] Over and above present uses.

The stream depletion resulting from the Collbran project would be small in relation to the Colorado River Basin water supply. The Colorado River compact apportions to each of the upper and lower basins in perpetuity 7,500,000 acre-feet of water annually for beneficial

consumptive use. A compact among the upper basin States apportions 50,000 acre-feet of upper basin water annually to Arizona and awards to Colorado the right to use 51.75 percent of the remainder or approximately 3,855,000 acre-feet a year. Present water uses in Colorado, including potential uses under authorized projects, probably consume less than half of the State's total apportionment so that about one-half remains for future development. A depletion of 10,700 acre-feet by the Collbran project would amount to only about one-half of 1 percent of the water available for future development in Colorado under the terms of the upper basin compact.

CHAPTER III

DESIGNS AND ESTIMATES

GEOLOGY

Regional geology

All the project works would be located along the northeastern slope of Grand Mesa. Geologically the mesa is composed of horizontally bedded, tertiary rocks belonging to the Wasatch and Green River formations and capped by a lava flow of Quaternary basalt. During Pleistocene times, the mesa was covered by sheet-like glaciers. Glacial scouring produced the many small mesa lakes and the heterogeneous deposits of glacial debris which mantle a large part of the surface rock. These glacial deposits cover the lava in varying depths from one hundred to several hundred feet.

Vega Reservoir and Dam site

Reservoir basin geology.—Sedimentaries of the area vary in character from place to place, but at the Vega site the shales are a reddish color, with intervening beds of a medium-grained, friable gray sandstone. The rock is compact but generally not hard, weathering easily to form a deeply alluviated country.

The bedrock valley is deeper and wider than the present overburden valley. This former wide valley was filled by alluvial fan deposition, which elevated Plateau Creek and crowded it to the north side of the bedrock valley. The steep channel in which the creek now flows is eroded into the toe of the fan, in places leaving wedges of debris and in other places flowing against rock itself. The climatic conditions which gave rise to fan deposition no longer exist, for the present streams are scouring and dissecting the fan. In a sense, the fan is a large natural dam across the valley, the reservoir basin being aggraded with silts and coarse gravels to the present level of stream scour across the fan. Considering the compact, tight character of the deposit, there is no doubt but that the reservoir will adequately hold water.

Dam site geology.—The dam site is an erosional narrows cut across the toe of a large fan. Overburden debris covers bedrock at the dam site to a depth of 135 feet, becoming progressively deeper to the south. The success of any dam in this channel, therefore, depends upon the acceptance of the fan debris as a foundation. The fan is composed of clayey silt containing basalt boulders of all sizes. It is compact and seepage tests indicate that it is watertight. Even with a high water table, little or no slumping of side slopes has occurred, and other field evidence indicates good stability.

Detailed exploration was made of three possible dam axes (A, B, and C, listed in order moving upstream). Ten holes were drilled, and eighteen test pits were dug, with seepage tests made where necessary. Rock is exposed only at the uppermost (C) axis and there only to a limited extent on the right abutment. It consists of hori-

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zontal, clayey shale. The left abutment and foundation of the dam would rest on the fan material. At both A and B axes the dam foundations and abutments would rest entirely on fan deposit. Of the three possible axes, B is the least desirable since the fan material of this axis is more clayey in character than the other two. Either the A or C axis would be acceptable for dam construction. The A axis, however, is preferable. Bedrock is exposed on the right abutment of axis C, but it would be little or no better than the compact overburden material at axis A. Much less embankment material would be required at axis A than at either of the other sites.

Construction materials.—The only material at hand for dam embankment is the fan debris itself. It appears acceptable for the impervious embankment, although it may be too impervious for the free draining sections. It probably can be adapted, however, and deserves laboratory study.

Acceptable rock for fill and riprap is not plentiful, and exploration would be required to locate the most economical source. The basalt boulders of the fan are too scattered to be used economically. The neighboring Wasatch sandstones are generally too soft for use, but possibly on detailed exploration some suitable ledge may be located. The only other suitable rock, except Mesa Verde sandstone that would have to be hauled a long distance from below Collbran, is the basalt boulders concentrated in workable deposits on the peninsula immediately east of Collbran, 5 to 8 miles from the site.

Collbran is the nearest source of concrete aggregate.

Bonham Reservoir and Dam site

Reservoir geology.—The present Bonhan Reservoir occupies a basin entirely surrounded and underlain by a thick deposit of glacial till. Since the reservoir has operated many years without seepage losses, it is fairly certain that no serious losses would occur with an increase in the storage. The material above the present reservoir surface is essentially the same as that below and consists of sufficient fine clay and silt to render it impermeable to percolating waters.

Dam site geology.—It is planned to construct a new structure slightly upstream from the present dam and dike. Since all material in this vicinity consists of glacial debris, a new structure would be involved with only these sediments. The glacial deposits range through clay, silt, sand, gravel, and large angular blocks of basalt lava. The proportion of clay is sufficiently high to prevent surface perculation. No evidence is visible of any seepage through the abutment or beneath the present structure, even though no cutoff wall has been constructed. Three test pits were dug ranging from 8 to 24 feet in depth in order to test the permeability of the material above the present water surface. The pits were filled with water and the draw-down measured at frequent intervals. Very little loss in these pits was recorded in a 24-hour period.

Sufficient gravel and boulders are scattered throughout the glacial material to assure good stability. This is believed competent to support an earth dam of the height contemplated with no danger of sliding and with only a minor amount of settlement in the abutments.

Since the foundation material is uniform on both sides, there is no geological preference in the location of an outlet works or spillway.

They should be located where construction could be most economically undertaken.

Construction materials.—Except the pits which were dug for percolation tests, no exploration has been made for construction materials. These pits, however, indicate what impervious embankment materials are located in the surrounding area. An unlimited supply of this type of material is doubtless deposited to the east and downstream from the present dam. This is believed to be entirely suitable for impervious embankment materials. This material is expected to yield between 5 and 15 percent of oversize cobbles and angular boulders which can be utilized as rock fill and for riprap purposes. If sufficient riprap rock cannot be obtained from the embankment material, additional rock of excellent quality may be obtained from basalt quarries within 2 miles of the site. Concrete aggregate would probably have to be hauled from Plateau Creek or Grand Valley.

Other features

All project works, except penstock No. 2, power plant No. 2, and the pipeline in Grand Valley below power plant No. 2, would be located either on Grand Mesa or just below the steep escarpments leading to the mesa rim. Most of the excavation for the canals and pipelines would be compact, clayey silt interspersed with basalt stone and boulders. The material through which canals and pipelines above penstock No. 2 would be cut was classified for cost estimate purposes according to the percentage of rock indicated by surface showing correlated with observations of present road and ditch cuts through the respective areas.

In dropping to the floor of Grand Valley, penstock No. 2 would traverse the vertical cliffs of the Wasatch formation east of Palisade. Excellent opportunity exists for anchoring this structure directly to the exposed face of the shale and lensed standstone bedrock. Power plant No. 2 would be constructed on river fill above the high water level south of the Colorado River near Cameo. The municipal and domestic water supply line from the tailrace of power plant No. 2 to the potential equalizing storage reservoir of Grand Junction would traverse the river terrace generally parallel to the Colorado River.

PROBLEMS OF DESIGN AND CONSTRUCTION

Accessibility

Cameo, the railhead nearest the project structures, is located on the main line of the Denver & Rio Grande Western Railroad and is connected to United States Highways Nos. 6 and 24 by a bridge across the Colorado River.

The town of Collbran, being centrally located with respect to all project works, would be the most favorable site for a construction camp. Two buildings would be required at each of the dam sites. The haul from Cameo to Collbran is about 24 miles over an all-weather State highway. Vega Dam site is accessible from Collbran by 6½ miles of State highway and 3½ miles of unsurfaced road maintained by Mesa County. Eleven miles of unsurfaced State highway provide access to Bonham Reservoir from Collbran. Travel on this road is difficult during wet weather, and some surfacing may be necessary.

The lines to be traversed by the potential pipeline and Southside canal are crossed at varying intervals by unimproved, county-maintained roads. Intermediate access to these lines and to Big Meadows Reservoir would require the construction of service roads, which would later be used to facilitate maintenance during project operation. The construction of such roads has been considered in cost estimates of project works.

Rights-of-way

Acquisition of right-of-way would involve purchase of private lands and withdrawal of public lands. The Vega Reservoir site is on privately owned irrigated land on which minor improvements have been made. Bonham Reservoir, including the area needed for enlargement, is entirely on national forest lands. All other structures for the project, including feeder canals, pipelines, power features, and service canals, would be constructed on both private and public lands. Where only the pipeline is involved it may be advisable to acquire easement through private lands rather than purchase the land outright. Essentially all private lands that would be crossed by the Southside canal have been patented since October 2, 1888. Rights-of-way for canals, therefore, are reserved by act of Congress, August 30, 1890.

Design flood

Maximum probable floods at each of the potential dam sites have been estimated in conformance with standard practices. Consideration was given to the runoff that might result from maximum precipitation, snow melt, or cloudburst action, based on the character and size of the contributing watersheds. The maximum probable flood at Vega Dam site was estimated at a peak of 5,900 second-feet with a probable 15-day flood volume of 28,500 acre-feet. The maximum probable flood at Bonham Reservoir would have an estimated peak discharge of 1,400 second-feet. Flood routing studies, using the maximum probable floods, were fully considered in determining proper spillway design for the respective reservoirs.

Construction period

With concurrent construction of Vega and Bonham Dams, a period of 4 years would be required for project completion. Both dam sites are located at high elevations subject to freezing temperatures during the winter months, November to April. Placement of earth embankment and pouring of concrete, therefore, could best be accomplished during the summer months.

The first year of the construction period would be required for preconstruction work, including further testing of dam sites and construction materials, field surveys, preparation of plans and specifications, and acquisition of rights-of-way. The construction camp would also be built the first year, and some stockpiling of construction materials would probably be accomplished. Preparation of dam foundations, further stockpiling of materials, and construction of spillway stilling basins and outlet works could be accomplished during the second year. It may also be found feasible to begin placing of earth embankment for coffer dams during the late summer of the second year. The third year would properly be devoted to the completion of coffer dams, followed by excavation of cut-off trenches, and the

placing of dam embankment. Dam embankment would be completed early in the fourth year with sufficient time remaining for construction of spillways and riprapping of dam faces.

Because construction of the dams would require the greatest amount of work under confined operations, such work has been considered as the limiting factor in the time required for project construction. All work on other features of the project could be completed concurrently with construction of the dams. Construction of the canals and pipeline could be performed by sections or units to expedite completion within the 4 years.

It would be most favorable to complete the canals, pipelines, and power features before or simultaneously with the dams to permit full operation of the project at the earliest possible date. Winter weather which would retard dam construction would also retard construction of canals, pipelines, and other work involving excavation and pouring of concrete. The foundation and superstructure for power plant No. 1 would have to be built during summer months. Interior finishing and installation of equipment, however, could be accomplished during the winter if necessary. Power plant No. 2, transmission lines, and switchyard could be worked on throughout the year.

Special problems

The earth embankment for Vega Dam would rest on a foundation of alluvial fan material. Special care would be required in the final design of a dam structure, spillway, and outlet works supportable by this material. The fan material to be used in dam embankment is uniform in texture and permeability. Careful grading would be required, therefore, to meet zoning requirements in the free draining section of the dam.

The only unusual problem in the construction of the Southside canal is expected in the slide area approximately 770 feet wide between Spring Creek and Coon Creek. The slide terminates on the edge of a sandstone ledge which underlies the talus material. A closed conduit, embedded in the sandstone, would provide the most satisfactory means of spanning this section.

The Fish and Wildlife Service recommends a vertical drop of at least 4 feet in the lower chute from the Leon-Park Creek feeder canal into Vega Reservoir to prevent detrimental upstream migration of fish during the spawning season. The steep natural drop into the reservoir basin lends well to the design of an 8-foot vertical drop structure of this type at little or no extra cost.

Careful study would be required in the design and construction of anchors and hangers needed to tie penstock No. 2 to the exposed sandstone cliffs near Cameo.

The soils below power plant No. 2 are corrosive in nature. Therefore special care would be necessary in selecting construction materials for the pipeline from the power plant to the potential Grand Junction equalizing reservoir. Special care also would be required in making the structural design of the pipeline.

PROJECT WORKS

Storage

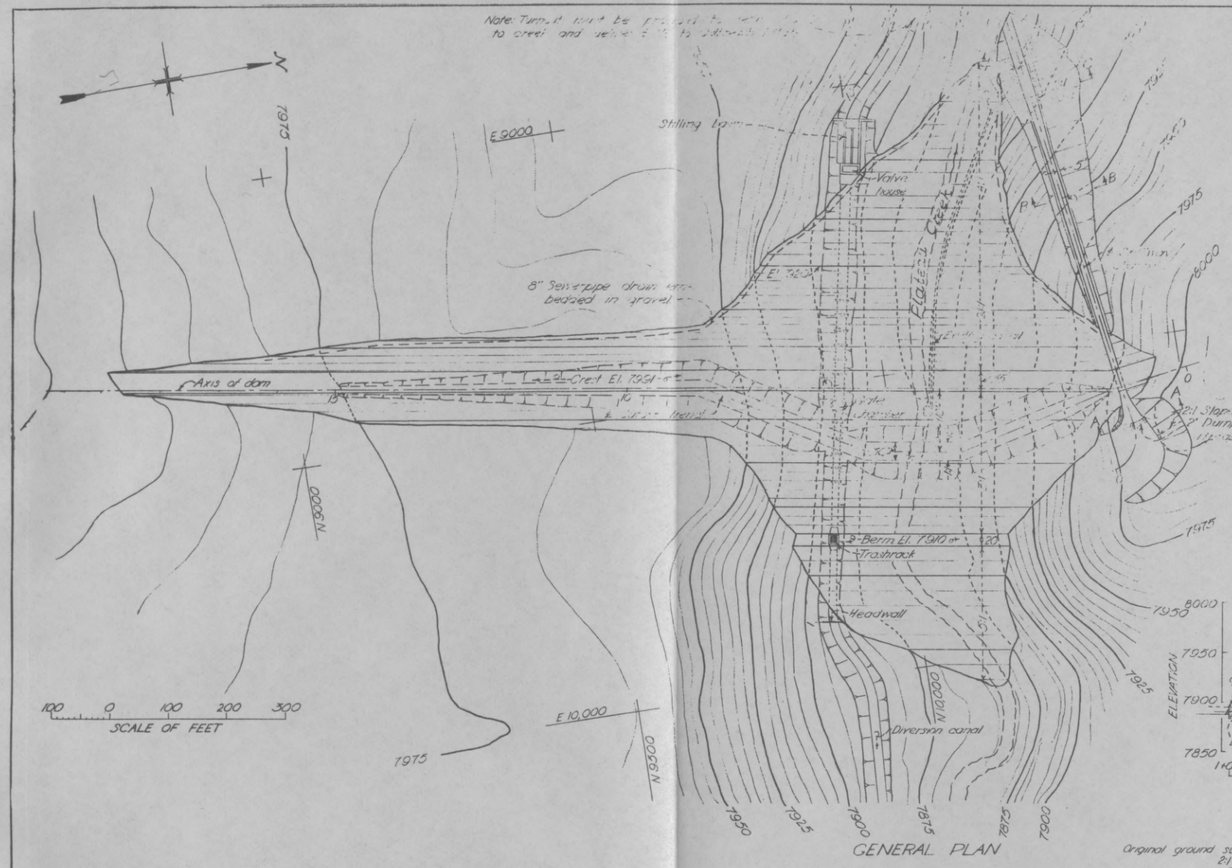
Vega Reservoir and Dam.—The reservoir with a normal water surface elevation of 7,980 feet would store 30,000 acre-feet of water. Of

the total capacity 29,000 acre-feet would be active while 1,000 acre-feet would be dead storage to provide for siltation and maintenance of fish life. The reservoir, when full, would have a surface area of 840 acres and would inundate about 3½ miles of existing secondary road. It would be necessary to relocate this road around the north side of the reservoir basin and to construct an access road across the dam crest to irrigated lands south of the basin. In all, 1,550 acres of privately owned land would be required for reservoir right-of-way. Of this 920 acres are presently irrigated class 1 and 2 lands and 630 acres are brush land and unirrigated mountain pasture. Clearing the area would be relatively simple, requiring the removal of 18 small farm buildings and clearance of a small area of quaking aspen and spruce bordering the irrigated lands.

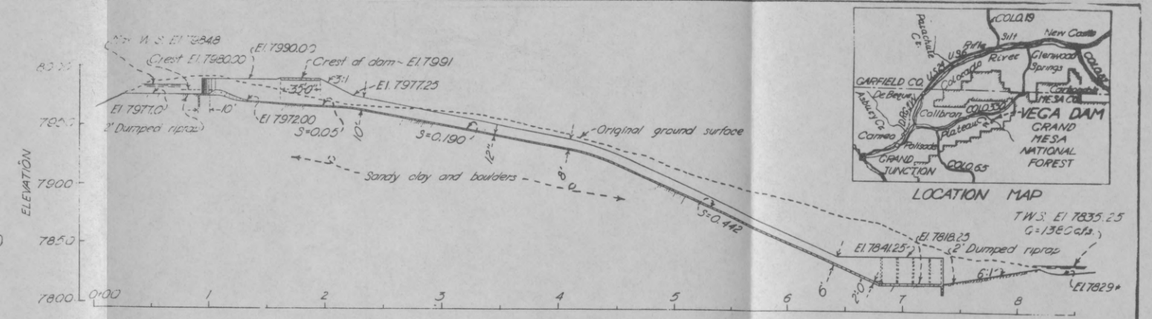
Vega Dam, as shown in drawing No. 482–D–1, would be a rolled earth-and rock-fill structure with a maximum height of approximately 140 feet above stream bed, a crest length of 1,765 feet, and a crest width of 35 feet. The crest would be provided with a concrete parapet and curb. The upstream face of the dam, bound by 3 feet of rock riprap, would have a slope of 3 to 1 from the crest elevation at 7,991 feet down to a 20 foot berm at elevation 7,910. The slope from the berm would continue at 5 to 1 to the ground surface. The downstream face of the dam would have a rock-filled cover with a slope of 2½ to 1 from the crest down to elevation 7,920 and then 4 to 1 to the ground surface. Dam embankment would be of zoned construction so that the more impervious materials would be placed in the central portion and graded to pervious materials toward the outer slopes of the fill. The downstream toe of the dam would be drained by sewer pipe embedded in gravel. The cut-off trench, located 110 feet upstream from the dam axis, would have a bottom width of 30 feet with 1 to 1 side slopes. Cutoff trench excavation would be omitted at the section crossed by the outlet conduit, and underseepage would be prevented by a suitable concrete cutoff structure.

The reservoir outlet, designed for 300 second-feet of capacity, would be placed in a trench on the left abutment of the dam and would consist of a standard concrete horseshoe conduit approximately 800 feet in length. Concrete collars would prevent seepage along the outside of the conduit. The upper 410 feet of the conduit would be 5 feet in diameter and the remainder 8 feet in diameter. At the lower end of the 5-foot section a high pressure emergency gate would be installed. Water discharged from the emergency gate would be conveyed through the 8-foot horseshoe section by a 51-inch steel pipe. The lower end of the steel pipe would be fitted with a wye and two hollow-jet valves to control the outlet discharge. The valves would be protected by a valve house equipped with a lifting crane. Discharge from the hollow-jet valves would be made into a concrete stilling basin. A square trash rack would be placed in the center of the upstream berm of the dam (elevation 7,910 feet) and would be connected to the outlet conduit by a vertical shaft.

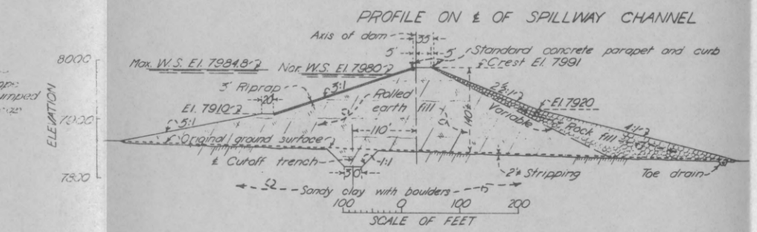
Bonham Reservoir and Dam.—The reservoir with a normal water surface elevation of 9,837 feet would have a capacity of 6,300 acre-feet. Of the total capacity 6,200 acre-feet would be active, and 100 acre-feet would be reserved as a dead storage pool. The reservoir, when full, would inundate 200 acres, including the 70 acres now occupied by an existing reservoir of the same name. Since the reservoir would be



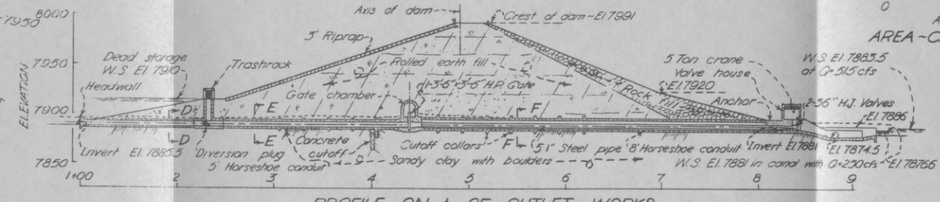
GENERAL PLAN



PROFILE ON ℄ OF SPILLWAY CHANNEL

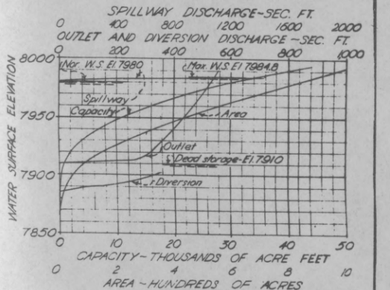


SECTION IN CREEK CHANNEL

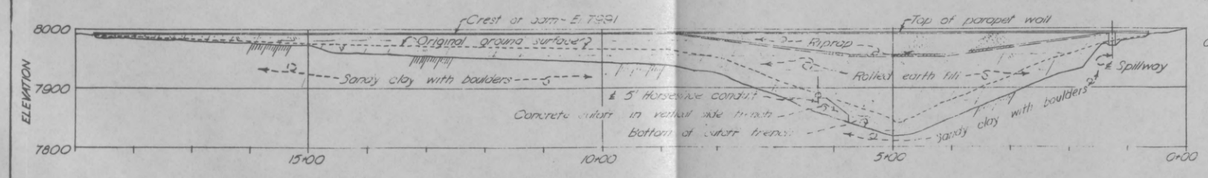


PROFILE ON ℄ OF OUTLET WORKS

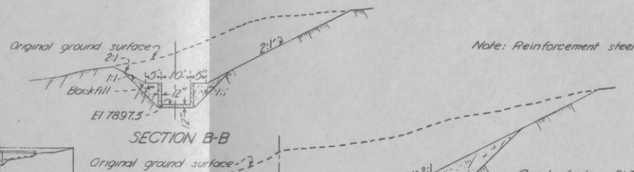
LOCATION MAP



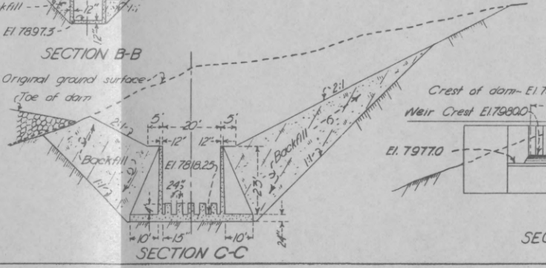
AREA-CAPACITY-DISCHARGE CURVES



PROFILE ON ℄ OF CUTOFF TRENCH



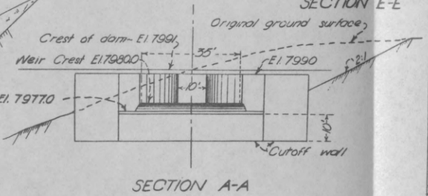
SECTION B-B



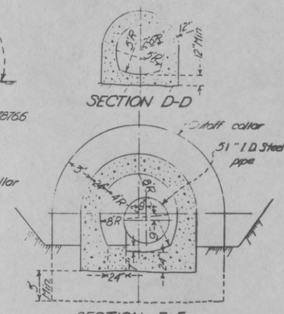
SECTION C-C

Note: Reinforcement steel not shown.

SECTION E-E



SECTION A-A



SECTION F-F

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLLBRAN PROJECT-COLORADO

VEGA DAM

PRELIMINARY ESTIMATE DRAWING
RESERVOIR CAPACITY 30,000 A.F.

DRAWN: J.W.G.	SUBMITTED:		
TRACED:	RECOMMENDED:		
CHECKED:	APPROVED:	ASSISTANT CHIEF ENGINEER	

DENVER, COLORADO NOV. 22, 1948 | 482-D-1

U.S.B.R., S.L.C.U.-200-11-49

entirely within the Grand Mesa National Forest, right-of-way could be acquired almost without cost except for the engineering and legal work involved. Clearing of the reservoir basin would consist of the removal of forest vegetation bordering the existing reservoir.

The dam, as shown in drawing No. 482–4–11, would be a rolled earth-fill structure extending 80 feet above stream bed. The crest at elevation 9,847 would be approximately 2,170 feet long and 30 feet wide. No provision would be made for a roadway across the crest of the dam. The upstream slope would be protected with a 3-foot layer of riprap overlying a rock-fill section of varying thickness down to elevation 9,782, the location of a 20-foot berm, then on a 5:1 slope to the ground surface. The downstream slope would be 2:1 to elevation 9,796, then 5:1 to the stream bed. The rock-fill section downstream would be 5 feet wide at the crest with variable slope to utilize available rock material screened from borrow pit excavation used in the rolled earth-fill portion of the dam. The dam foundation would be stripped to an average depth of 2 feet over the entire area, and a cut-off trench would be excavated to a depth of 30 feet below stream bed. The trench would be 30 feet wide in the bottom, with 1:1 side slopes. The downstream toe of the dam would contain a toe drain.

The reservoir outlet, extending through the dam near its center, would consist of an inlet channel 75 feet long, a trash rack, a concrete conduit 36 inches in diameter and 155 feet long, a gate chamber, a 6.5-foot concrete horseshoe conduit 200 feet long with a 36-inch steel pipe on the inside, a valve house, and a stilling basin connected directly to the stream channel below the dam. Both conduits would have cut-off collars spaced at 20- and 30-foot intervals upstream and downstream, respectively, from the gate chamber. The gate chamber would be located about 5 feet upstream from the axis of the dam and would contain one 36-inch standard wedge type gate valve for emergency operation. The valve house would be a concrete structure 20 feet square and 12 feet high containing a wye transition to the power and municipal pipeline and to a 30-inch emergency outlet to the stilling basin. Each pipe has a 30-inch gate valve for emergency operation and a high pressure sliding gate for regulation.

The spillway located on the left abutment would consist of a 30-foot concrete ogee weir with a crest elevation of 9,837 feet. With a maximum water surface elevation of 9,841 feet the discharge would be 665 second-feet. The open channel below the crest would be concrete lined with a bottom width varying from 30 feet at the crest to 10 feet in the steeper chute section leading to the stilling basin. The height of the vertical side walls would vary from 13 feet at the dam crest to 6 feet in the steeper section. The outlet channel from the stilling basin to the creek channel would be protected by 2 feet of riprap.

Canals

Leon-Park feeder canal.—A feeder canal from Leon and Park Creeks would be constructed to provide adequate water for storage at Vega Reservoir. The canal (capacity 200 second-feet) would head on Leon Creek at elevation 8,300 feet and cross the divide into the Park Creek channel. The natural channel of this creek would be utilized to convey water down to an elevation of 8,000 feet. At this point, the flow would be rediverted and carried by a second section of canal around the divide into Vega Reservoir basin.

Included in the two sections of canal, as shown on drawing No. 482–P–68, are 2.1 miles of unlined earth section. Diversion structures would be constructed on Leon and Park Creeks, and a chute structure would be placed at the end of each earth section of the canal to drop into Park Creek and Vega Reservoir. The chute into Park Creek would be 220 feet long with a vertical drop of 92.6 feet. The chute into the reservoir would be 1,655 feet long with a drop varying from 8 to 83 feet depending on the water surface elevation of Vega Reservoir. The minimum drop of 8 feet would be made by a vertical structure in order to prevent upstream migration of fish through the canal. Outlet gates were incorporated in the design of the two diversion dams to allow the bypass of 42 second-feet of water from Leon Creek and 40 second-feet from Park Creek for the irrigation of downstream lands. The gates would also act as sluiceways for the removal of any deposition above the dams.

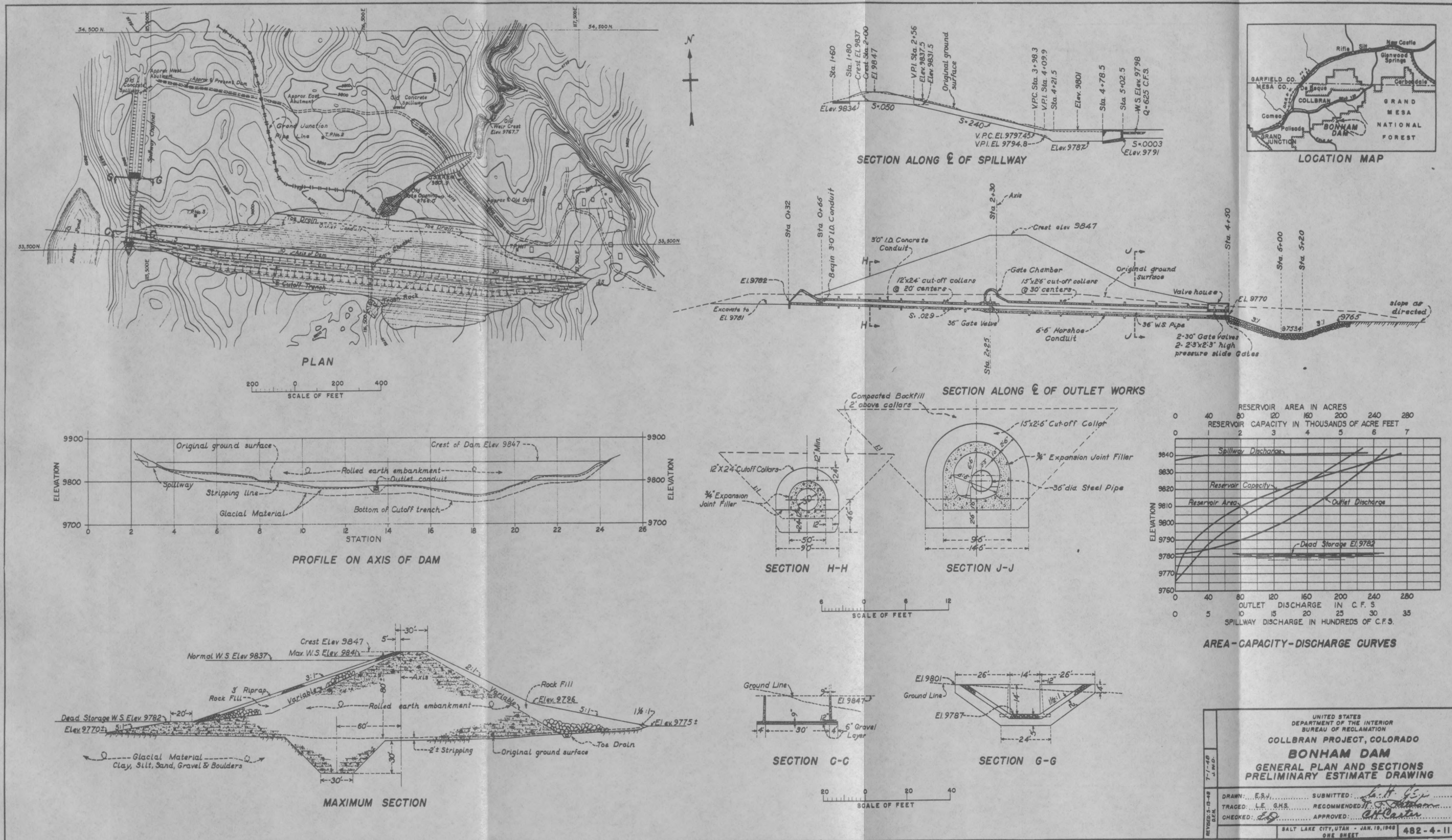
The canal would be constructed through material consisting largely of compact clay, silt, and boulders. The topography of the area through which it would pass is steep with narrow divides between creek channels. A heavy growth of scrub oak and other brush covers the area with scattered tracts of conifers and quaking aspen. The cost of acquisition and clearing of the canal right-of-way would be small. It would be necessary, however, to construct two small bridges across the canal to permit access to range lands above.

East Fork feeder canal.—This canal (capacity 30 second-feet) would divert water from East Fork of Big Creek at an elevation of about 9,860 feet and convey it 1.1 miles to a chute structure dropping into the Bonham Reservoir Basin. Storage water released from Atkinson Reservoir would enter the canal at an intake structure to be constructed at a point where the canal would cross a small natural drainage about 0.9 mile downstream from the diversion works on East Fork. Construction of the canal would be relatively simple consisting of the excavation of an earth section across moderate transverse slopes. The entire area to be traversed by the canal lies within the Grand Mesa National Forest, and it is covered by growths of fir and spruce interspersed with tracts of grassy mountain pasture.

Cottonwood feeder canal.—This unlined canal with a capacity of 15 second-feet would divert water from Cottonwood Creek a short distance below Cottonwood Reservoir No. 1 and convey it 2.1 miles to Big Meadows Reservoir. Along the course of the canal two small intake structures would be constructed at natural drainage crossings to pick up storage releases from Cottonwood Reservoirs Nos. 4 and 5. The area that would be traversed by the canal consists entirely of national forest lands. The vegetative cover is similar to that that would be encountered by the East Fork feeder canal.

South side canal.—This canal, which would be about 30 miles in length, would deliver irrigation water from Vega Reservoir to project lands. With minor exceptions it would consist of unlined earth section. From Vega Reservoir to Salt Creek the canal would have a capacity of 225 second-feet, and thereafter the capacity would be decreased at intervals to 40 second-feet at the termination near Mesa.

The first 9 miles of canal, from Vega Reservoir to Tea Creek, would present the most difficult problems of location. In this section the grade of the canal would be dropped about 800 feet in elevation by a system of chute structures. Such a drop, however, would permit



U.B.N., S.L.C.U.,-200-11-49

considerable flexibility in the selection of the most favorable location for the canal across the steep transverse slopes it would encounter. Two siphons would also be required in this section. They would be 1,050 feet and 1,425 feet in length and would be constructed at the crossing points of Park and Leon Creeks, respectively.

The canal from Tea Creek west would be constructed through relatively flat transverse slopes with adequate flume or siphon structures at stream crossings. One section of concrete bench flume, 260 feet long, and a closed conduit, 770 feet long, would be required between Spring and Coon Creeks where terrain features would make construction of earth section unfavorable. A system of 29 turn-out structures along the canal would deliver water to existing irrigation laterals of the project lands.

Most of the private lands along the canal route have been patented since 1888. Right-of-way, therefore, is reserved for canal construction. Clearance of right-of-way would involve the removal of a heavy growth of scrub oak, service berry, and other brush.

Other features—Pipeline and power facilities

Water for power, municipal, and domestic use would enter the pipeline system at the outlets of the Bonham and Big Meadows Reservoirs. Pipelines from these reservoirs would join at a point approximately 4½ miles northwest of Bonham Reservoir and about 2 miles north of Big Meadows Reservoir. From this point a single flow-line pipe would extend about 0.7 mile to penstock No. 1, through which the water would drop to power plant No. 1 located at Cottonwood Creek, about 3.5 miles southeast of Molina. Water released from the power plant would be collected in an afterbay reservoir and then conveyed by a flow-line pipe to penstock No. 2. This penstock would drop the water to power plant No. 2 located on the east bank of the Colorado River near Cameo. Water released from power plant No. 2 would be made available to the potential domestic and municipal water-distribution system, to be constructed by the water users through a flow-line pipe that would extend to the potential Grand Junction equalizing reservoir about 4 miles northeast of the city.

Pipeline—Bonham Reservoir to penstock No. 1.—All project pipelines above power plant No. 1, including the penstock, would be buried with a minimum cover of 30 inches of compacted backfill. For this analysis, it has been assumed welded steel pipe would be used for all pipelines and penstocks. Further study should be made prior to project construction, however, to determine the advisability of placing precast concrete pipe through sections with low-pressure heads. Over the 5¼-mile section from Bonham Reservoir to penstock No. 1 the pipe would be 30 inches in diameter and of welded steel construction, designed to carry 30 second-feet of flow. The soil in this area is free of corrosive agents, making wrapping of the pipe unnecessary. Pipe thickness, based on operating head, would vary from standard 7 gage to seven-sixteenths of an inch. The line would traverse national-forest lands throughout its length. Conifers and quaking aspen trees would have to be cleared.

Because Bonham Reservoir is slightly higher in elevation than Big Meadows Reservoir, a pressure-reducing valve would be installed in the Bonham line to prevent back flow into Big Meadows Reservoir.

Pipeline—Big Meadows Reservoir to Bonham line.—This section of pipeline would extend about 2 miles from the Big Meadows Reservoir

to join with the line from Bonham Reservoir. Throughout its length it would be standard 7 gage, welded steel pipe, 20 inches in diameter. The line would traverse only national-forest lands, and right-of-way preparation would require the clearing of conifers and quaking aspen trees.

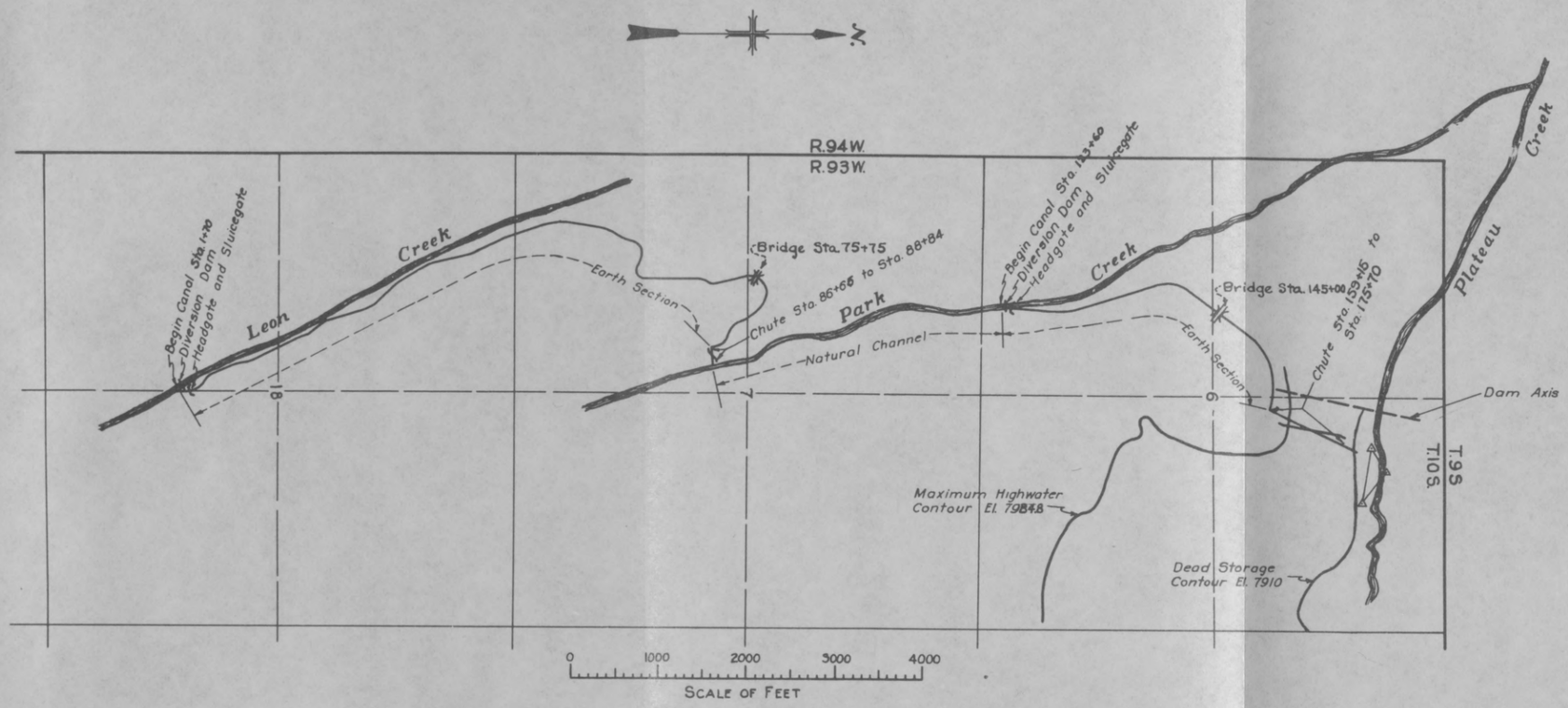
Pipeline—Power plant No. 1 to penstock No. 2.—This pipeline would have a capacity of 20 second-feet and would extend approximately 17 miles from an afterbay reservoir near power plant No. 1 to the head of penstock No. 2. It would consist of coated and wrapped welded steel pipe 30 inches in diameter with thickness varying from standard 7 gage to three-eighths inch except for a section approximately 4 miles long across the valley of Mesa Creek. This section, acting as an inverted siphon under greater head than the rest of the pipeline, would be 22 inches in diameter and would vary in thickness from one-fourth inch to three-eighths inch. It would be necessary to obtain an easement right-of-way through privately owned lands for much of the pipeline. The remaining lands through which the pipe would pass are public domain and would be withdrawn in order to permit construction. A heavy growth of scrub oak, service berry, and other brush along the route of pipeline would have to be cleared.

Penstock No. 1.—This power penstock would be approximately 9,750 feet in length and would drop water 2,600 feet from the Bonham line to power plant No. 1. Welded steel pipe varying from 30 inches to 23 inches in diameter and from seven-sixteenths inch to 1¼ inches in thickness would be required. About 75 percent of the line would traverse public lands, and the rest would be located on unimproved private grazing lands, over which an easement right-of-way would be required. Right-of-way clearance would consist mainly of the removal of scrub oak, service berry, and other brush.

Penstock No. 2.—This penstock would be approximately 4,300 feet in length and would have a maximum static pressure head of 1,860 feet or an effective head of about 1,770 feet when friction losses are deducted. The penstock would drop water from the top of a ridge down an exposed sandstone cliff. It would be tied to the cliff by reinforced concrete hangers and anchors. The sections above and below the cliff face would be coated, wrapped, and buried to a minimum depth of 30 inches. Welded steel pipe, varying from 30 to 24 inches in diameter, would be used for this structure. Pipe thickness would vary from one-fourth inch at the top of the penstock to 1 inch at the bottom. Little or no clearing of vegetation would be required. Right-of-way would be acquired by purchase of an easement through privately owned grazing lands.

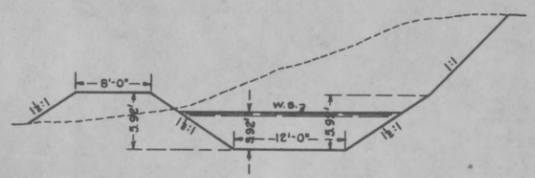
Power plant No. 1.—Both plants Nos. 1 and 2 would be powered by impulse turbines (Pelton waterwheels). This type of turbine would operate most efficiently with a small quantity of flow under high head as planned for the project. Water from both plants would be bypassed for municipal and domestic use during periods of shutdowns required for plant repair or maintenance.

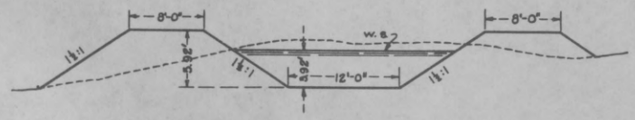
Power plant No. 1 would have an installed capacity of 5,000 kilowatts and would provide for the semipeaking of power by operating under a planned load factor of 70 percent. It would generate an average of about 3,500 kilowatts from an average flow of 20 second-feet of water under an effective head of approximately 2,590 feet. A maximum output of 5,000 kilowatts would be generated from 30



HYDRAULIC PROPERTIES

STA. TO STA.	SECTION	Q Cu.ft/Sec.	A Sq. Ft.	V Ft/Sec.	n	s	r
1+70 - 2+30	Headworks	200					
2+30 - 86+65	Earth	200	69.99	2.86	.0225	.0005	2.68
86+65 - 88+84	Chute	200					
88+84 - 123+60	Natural	200+					
123+60 - 124+10	Headworks	200					
124+10 - 159+15	Earth	200	69.99	2.86	.0225	.0005	2.68
159+15 - 175+70	Chute	200					





EARTH SECTIONS

LEGEND

Diversion Dam.
Headgate and Sluicegate.
Chute.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLLBRAN PROJECT

LEON-PARK FEEDER CANAL

DRAWN R.J.M. SUBMITTED
TRACED R.M.G. 4-14-44 RECOMMENDED
CHECKED R.J.M. 4-15-44 APPROVED

Rev. 4-4-44

GRAND JUNCTION, COLO. 482-P-68

second-feet of flow under an effective head of about 2,460 feet. Bonham Reservoir would be utilized as forebay storage in the operation of this plant. The generator and impulse turbine would be housed in a concrete building. Approximately 17 miles of transmission line would be constructed to deliver power to a switching station which would be located near power plant No. 2.

An afterbay storage reservoir would be constructed at the tailrace of power plant No. 1. It would be a reinforced concrete structure with a capacity of 10 acre-feet and would be used to facilitate delivery of a firm flow of 20 second-feet to the pipeline leading to power plant No. 2. There are no suitable natural storage sites between power plant No. 1 and penstock No. 2 that would provide adequate afterbay storage.

Power plant No. 2.—This plant would have an installed capacity of 2,400 kilowatts and would operate as a base-load plant. A flow of 20 second-feet would be delivered to the plant continually under an effective head of about 1,770 feet. The generator and impulse turbine would be housed in a concrete building. A single 7,400-kilowatt switching station would be constructed near power plant No. 2 to control the distribution of power generated by both of the project plants.

Service roads and rights-of-way.—Approximately 32 miles of unsurfaced service roads would be required to facilitate maintenance and construction of the features for power and domestic water supply.

Valley pipeline—Power plant No. 2 to equalizing reservoir.—This pipeline would be about 13 miles in length. It would consist of steel-lined concrete pipe or other material capable of withstanding the corrosive action of the valley soils. Right-of-way for the structure would be required through irrigated farm land.

COST ESTIMATES

Construction

Costs of constructing the major features of the project were estimated from unit prices prevailing at the time the studies were made. The estimates have been converted to July 1948 prices, which are essentially the same as October 1949 prices, by the application of proper indexes.

Costs for major engineering and overhead and construction camps are included in the estimated construction costs of the major project works. Other undistributed engineering and overhead is estimated at $353,000 (3 percent of construction costs exclusive of investigations and operation and maintenance during construction). Cost estimates of the valley pipeline below plant No. 2 were prepared by the R. J. Tipton & Associates, engineering firm of Denver, acting in the interests of the city of Grand Junction.

To derive maximum fishery benefits from the project, the Fish and Wildlife Service recommended construction of fish screens at project canal diversion works and at the pipeline intakes at Bonham and Big Meadows Reservoirs. Construction of such fish screens has been included in the project plan. The cost of constructing the screens is estimated at $3,000 at July 1948 prices.

The total estimated cost of the project works at July 1948 prices is summarized by features in the following table.

TABLE 26.—*Estimated construction costs*

Project feature	Estimated cost at July 1948 prices
Vega Dam including reservoir right-of-way and road relocation	$2,605,000
Leon-Park feeder canal	337,000
Bonham Dam and appurtenant works	1,787,000
East Fork feeder canal	27,000
Cottonwood feeder canal	63,000
Southside canal	1,864,000
Pipeline and penstocks above power plant No. 2	3,537,000
Power plants and appurtenant works	1,511,000
Service roads and rights-of-way for power and domestic features	23,000
Fish screens	3,000
Investigations and surveys [1]	145,000
Operating equipment and operation and maintenance during construction	45,000
Undistributed engineering and overhead	353,000
Subtotal	12,300,000
Valley pipeline [2]	1,116,000
Total	13,416,000

[1] Project investigations and surveys have been financed largely from nonreimbursable Colorado River development funds. About $28,000 has been spent from "General investigation" funds and will have to be repaid.

[2] Cost estimates prepared by R. J. Tipton & Associates of Denver, Colo.

Operation and maintenance

Annual operation and maintenance costs of new project works, including necessary replacements and overhead, have been estimated at $108,800. Such costs were estimated for a 60-year period (estimated repayment period) with replacement costs estimated on a sinking fund basis at 3 percent interest. In accordance with Bureau of Reclamation policy, power costs are based on current prices, while the remaining costs are based on average 1939–44 prices.

TABLE 27.—*Estimated annual operation, maintenance, and replacement costs*

Project feature	Annual power costs (July 1948 prices)		All other annual costs (1939–44 prices)		Total annual costs
	Operation and maintenance	Replacements	Operation and maintenance	Replacements	
Vega Reservoir (including Leon-Park feeder canal)	$1,400	$100	$4,100	$400	$6,000
Southside canal	2,100	100	17,200	200	19,600
Bonham Reservoir (including feeder canals)	3,800	300	900	100	5,100
Pipeline and penstocks above power plant No. 2	600	11,100	100	2,900	14,700
Service roads	100		100		200
Power plants and appurtenant works	47,900	12,500			60,400
Valley pipeline below power plant No. 2			100	2,700	2,800
Total	55,900	24,100	22,500	6,300	108,800

CHAPTER IV

IRRIGATION

PROJECT LANDS

General description

The project lands lie in extensive tracts near Mesa and Collbran and in somewhat smaller scattered tracts along Plateau Valley streams and on the terraces or alluvial fans south of Plateau Creek.

Physiographically, the area is a high plateau region, sculptured by streams into rugged form, with flat-topped divides and deep, steep-sided valleys. Irrigable lands occupy the stream valleys and a series of terraces or mesas separated by the deeply entrenched tributaries of Plateau Creek. Valley lands bordering the stream channels are generally less than one-half mile wide and are separated from the higher terraces by steep escarpments. The terraces or mesas, which lie from 50 to 100 feet above the streams, are outwash plains or ancient alluvial fans sloping gently toward Plateau Creek. Their upper limits end in the sharp slopes leading to the crest of Grand Mesa.

The soils have developed largely from alluvial deposits derived from the basaltic cap which covers Grand Mesa and from the varicolored shales and sandstones of the Mesa Verde, Wasatch, and Green River formations which border and underlie the area. The mantle of alluvial materials varies in thickness from a few feet to several hundred feet over the horizontal bedrock strata and consists of angular and rounded basalt boulders, cobbles or gravel, sand, silt, and clay.

More than 88 percent of the project land suitable for irrigation farming is now developed although the available water supply is insufficient for full crop production. The lands, where fully irrigated, have proved their ability to produce abundant crop yields over a long period of years.

Sagebrush and juniper predominate on the higher terraces and mesas, giving way to grasses in the valley floors. The stream channels are overgrown with willows and cottonwood trees.

Soils

The soils have developed under the controlling influence of a semi-arid, continental climate. Consequently they are low in organic content compared with soils formed under warmer and more humid conditions. Project soils have sufficient organic content and fertility, however, to make them highly productive with good irrigation. The soils generally are brown to dark brown in color and are characterized by a calcium carbonate accumulation relatively near the surface. The rainfall has been insufficient to leach the soil to any great depth.

On the basis of formation and topographic position, the soils of the area are divided into three distinct groups, including old alluvial fan and terrace soils, recent alluvial soils, and residual soils.

The old alluvial fan and terrace soils are the most extensive in the project and occupy the relatively less broad, gently sloping mesas or fans of outwash debris south of Plateau Creek and above the tributary stream valleys. They are brown to dark brown in color, gravelly loam to light clay loam in texture, and contain varying amounts of gravel or cobble throughout the profile. The typical soil is a brown silt loam extending to a depth of 5 feet or more and containing basaltic gravel or cobble in the subsoil. The size and quantity of the coarser materials increase toward the upper extremities of the fans and terraces with the soils becoming correspondingly less desirable for irrigation development. Both surface and subsoil drainage are good, and the soils are relatively free of harmful accumulations of soluble salts. They are inherently fertile and generally contain moderate amounts of lime which are somewhat concentrated in the subsoil and in the gravelly or stony substratum. These soils are well adapted for irrigation, although generally limited in cultivation by the presence of cobble or gravel in the plow zone or by shallowness over the substratum.

Small areas of shallow, stony soils unsuitable for irrigation are scattered throughout the larger tracts of deeper soils, particularly along the borders of the terraces. In the upper portion of Plateau Valley, approximately 7,000 feet above sea level, the soils are gravelly to sandy loams and are underlain to varying depths by sands and gravels. The porous, open nature of these soils is conducive to rapid surface and subsurface drainage, and they are relatively free of soluble salts. Their adaptability to diversified crop production with irrigation is limited by their degree of stoniness and to the low temperatures prevailing at that high altitude.

The recent alluvial soils are less extensive than the old terrace or mesa soils. They are fairly well distributed throughout the project area occurring on the narrow tracts of bottom lands and on the low terraces bordering the streams. These soils have been developed from the cobble, gravel, and fine-textured recent alluvial materials deposited by the present streams. These materials were in turn derived from the shale, sandstone, basalt, and older alluvial terrace sediments in the area. In general, they consist of very dark brown or nearly black silt loams, varying in depth from a few inches to a little more than a foot. They are underlain by river gravel and cobble. They are generally calcareous throughout and have a granular or single grain structure. Most of these recent alluvial soils are not suitable for irrigation agriculture and diversified crop production. In some areas, gravel and cobble occur on the surface or in the upper soil horizons in amounts sufficient to render cultivation difficult or impossible. Because of their low position the soils also are subject to poor drainage.

The recent alluvial soils adjacent to upper Plateau Creek, unlike those of the lower valley, are high in fertility and have good drainage. They consist of 18 to 40 inches of a nearly black silt loam high in organic content, underlain by a yellowish clay loam. They are suitable for irrigation and the production of all climatically adapted crops.

Residual soils occur only in a small portion of the project area. They consist of shallow (1 to 2 feet deep) sandy to clay loams developed from underlying shales and sandstones. They are distributed along

the outer borders of the mesas, on scattered narrow ridges, hills, and knolls, and on the escarpments between the terraces and bottom lands. As these soils are only in shallow layers over the parent rock and as their topographic conditions are unfavorable, they are generally low in productive capacity and are unsuitable for general crop farming under irrigation.

Topography

Most of the project lands are on the gently sloping alluvial fans or on mesas and are topographically suited for irrigation. The land surface is predominantly smooth, with a general slope of 3 to 5 percent, occasionally interrupted by narrow ridges, knolls, depressions, and small hills. In many cases where the topography is somewhat rolling, leveling cannot be satisfactorily accomplished without the exposure of gravel and cobble and a resultant loss of soil productivity.

The bottom lands and low terraces in the stream valleys are generally smooth, with few slopes in excess of 5 percent. The surface is dissected in places by old stream channels. Some tracts having an unfavorable relief are unsuitable for leveling because of the shallowness of the soil over cobble and stones. The colluvial slopes and alluvial fans, built up by smaller affluents and extending into the larger stream valleys, are fairly smooth but usually have slopes of more than 5 percent.

Other areas of unfavorable relief include the escarpments at the edges of the mesas, ridges, knolls, and rough hills throughout the project, and the drainage courses of the perennial and intermittent streams.

Drainage

The general slope, natural drainage channels, and permeable soils of the alluvial fans and terraces provide good surface and subsoil drainage which is expected to be adequate for full irrigation development.

A few small areas bordering the main drainage channels are restricted in drainage and suffer a high water table or swamp condition. These areas, however, are not sufficient in size and importance to warrant their reclamation by drainage.

In view of the excellent natural drainage conditions existing generally through the project area, a drainage problem is not expected under project conditions.

Salinity and alkalinity

The soils of the project are relatively free of harmful accumulations of soluble salts. In general they contain from 0.04 to 0.10 percent total soluble salts. They are moderately calcareous and are slightly to moderately alkaline (pH of 7.6 to 8.2). Salines in harmful quantities of 0.25 to 0.40 percent occur in a few small tracts in the bottom lands which are inadequately drained and are subject to seepage waters from adjacent salt-bearing shale formations. A few small tracts lying in the western part of the area, not more than 4 or 5 acres in all, are highly alkaline (pH of 8.5 to more than 9.0). These soils do not contain more than 0.77 percent total soluble salts.

Land classification

A detailed classification of Plateau Valley lands was made in 1942 and 1943 to determine the extent and character of arable lands and

the degree of their productivity and suitability for irrigation farming, based on productive capacity as established with respect to, and through consideration of, the factors of soils, topography, and drainage. The classification involved the determination and delineation of the arable lands, the separation of these lands into classes according to productive capacity under irrigation farming, and the segregation of those presently irrigated lands believed suitable only for the production of pasture crops.

The lands ranked as class 1 are highly productive, suitable in every respect for continuous profitable irrigation agriculture, and capable of producing all crops that are climatically adapted. Lands ranked as class 2 are suitable for irrigation development but are somewhat less adapted to irrigation farming than class 1 lands because of a deficiency in one or more of the factors considered. Pasture class lands are those not suitable for cultivation. When irrigated, however, they are useful for pasture and thus allow a balanced cropping plan without the production of needed pasture crops on class 1 and 2 lands.

Standards

The standards used in the land classification were established by the Bureau of Reclamation and are based on the correlation of land features in the project area with crop production on lands under irrigation. The standards used are summarized in the following table.

TABLE 28.—*Detailed land classification standards*

Land characteristics	Class 1—Arable	Class 2—Arable
Soils: Texture	Sandy loam to friable clay loam	Loamy sand to friable clay.
Depth: [1]		
To sand, gravel	18 to 24 inches plus good free working soil.	12 to 18 inches plus good free working soil.
To relatively impervious subsoil material.	48 inches plus	36 inches plus.
To penetrable lime zone	18 inches with 48 inches penetrable	14 inches with 36 inches penetrable.
Alkalinity	pH less than 8.8 unless soil is calcareous, low total salts and no evidence of black alkali.	pH 9 or less unless soil is calcareous, low total salts, and no evidence of black alkali.
Salinity	Total salts not to exceed 0.2 percent. May be slightly higher in open permeable soils with good drainage.	Total salts not to exceed 0.5 percent. May be slightly higher in open permeable soils with good drainage.
Rock and rocky soil	No solid or loose rock that will interfere with ordinary cultivation.	No rock in place. Easily removable loose rock limited to that generally cleared in similar irrigated areas.
Topography:		
Slopes	Smooth slopes up to 5 percent in general gradient; reasonably large-sized bodies sloping in same plane.	Smooth general slopes of 5 to 10 percent or rougher slopes less than 5 percent in general gradient.
Surface	Even enough to require only small amount of leveling and no heavy grading.	May require considerable leveling and moderate grading but in amounts generally found feasible in similar irrigated areas.
Drainage	Soil and topographic conditions such that no drainage is anticipated.	Soil and topographic conditions such that some drainage will probably be required, but artificial drainage practicable at reasonable cost.

[1] At minimum depths the texture must be fine sandy loam or heavier, with some soil mixed with the gravel or cobble. At greater depths it must be as heavy as sandy loam. Loamy sand underlain by coarse sand or gravel should be 24–30 inches deep, depending on the percentage of silt and clay, to qualify for class 2.

NOTES:

Pasture class—Limited arable—Includes all presently irrigated lands which do not meet the minimum requirements for class 2 because of excessive surface rock, shallow depth of soil over gravel or cobble, or steep topography (10 to 15 percent on smooth slopes or less than 10 percent on rougher slopes) that impedes cultivation.

Class 6—Nonarable—Includes lands which do not meet the minimum requirements of the pasture class lands and small areas of arable lands lying within larger bodies of nonarable lands.

Irrigable areas include all lands under the contemplated distribution system that meet the requirements for class 1 and 2 lands and that can be economically supplied irrigation water without the maintenance of checks in the canals to such high levels as to be detrimental to large areas of adjacent land. Scattered tracts of irrigable lands are located above the potential Southside canal. These lands are now served by existing distribution system and would be benefitted by project development through water exchange with lands below the canal. These scattered tracts, therefore, are included in the irrigable area of the project. Presently irrigated pasture class lands are also included in the irrigable area of the project because of their importance of the agricultural economy of the region. Irrigated pasture is essential to a livestock industry as practiced in the project area. Such lands are generally not adaptable to crop rotational practices. With proper seeding, irrigation, and periodic fertilization, however, they provide valuable animal feeds which otherwise would have to be grown on class 1 and 2 land.

Methods

The classification standards were carefully applied in the field to observed soil characteristics, topographic features, and drainage conditions. In keeping with detailed survey requirements, the area was traversed at a minimum of quarter-mile intervals for an examination of surface features. The nature of the underlying strata was observed in washes, road cuts, wells, other excavations, or from soil borings. Soil auger borings, extended where possible to a depth of 5 feet, were made for each uniform 40-acre tract or in smaller areas where necessary to determine separations between various land classes. Soil samples collected from the borings were analyzed quantitatively for total salts with an electrolytic bridge. Colorimetric determinations for soil reaction or pH were made, and the lime content estimated, by the observed degree of effervescence when treated with dilute hydrochloric acid.

Classified lands were delineated on two sets of aerial photographic prints of different scales (approximately 1 inch to 100 feet and 1 inch to 880 feet) covering separate portions of the project area. The photographic prints were then reviewed by land classification personnel, and various classes of land were outlined and designated. Location and logs of soil borings were also recorded on the prints. Distances and points used in bounding and locating the areas classified were determined in accordance with accepted standards by use of speedometer readings, pacing, stadia, and three-point location from control points. Accurate planimetric maps at a scale of 1 inch to 1,000 feet were then made from the photographic prints. This was accomplished by setting an extensive triangulation system of third order accuracy in the field from which adjustments in scale of the aerial photographs were made. A rectifying projector was used to transfer land boundary data from the photographic prints to the planimetric maps. Areas of land classified were determined by planimeter from the rectified maps. Prints were made of the rectified maps for permanent record.

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Results of Classification

Results of the detailed classification are summarized in the following table and are shown on drawing No. 482–P–2.

TABLE 29.—*Summary of classification—arable lands*

[Unit—acres]

Location	Class 1 and 2 land			Pasture lands	Total lands
	Class 1	Class 2	Total		
T. 10 S., R. 93 W.	35	1,064	1,099	8	1,107
T. 9 S., R. 93 W.	6	525	531	0	531
T. 10 S., R. 94 W.	57	1,431	1,488	358	1,846
T. 9 S., R. 94 W.	120	1,870	1,990	286	2,276
T. 9 S., R. 95 W.	17	1,355	1,372	417	1,789
T. 10 S., R. 95 W.	239	6,188	6,427	1,613	8,040
T. 10 S., R. 96 W.	558	3,604	4,162	877	5,039
T. 10 S., R. 97 W.	83	944	1,027	91	1,118
T. 11 S., R. 95 W.	0	93	93	40	133
T. 11 S., R. 96 W.	0	714	714	210	924
T. 11 S., R. 97 W.	0	68	68	15	83
Subtotal	1,115	17,856	18,971	3,915	22,886
Vega Reservoir Basin	41	879	920	0	920
Total	1,074	16,977	18,051	3,915	21,966

The arable area includes 21,966 acres. An allowance of 6 percent is made for rights-of-way for additional roads, ditches, and other nonproductive lands, making an irrigable area of 20,650 acres that would receive irrigation benefits under the potential project. This net irrigable acreage is summarized by stream service areas in the following table.

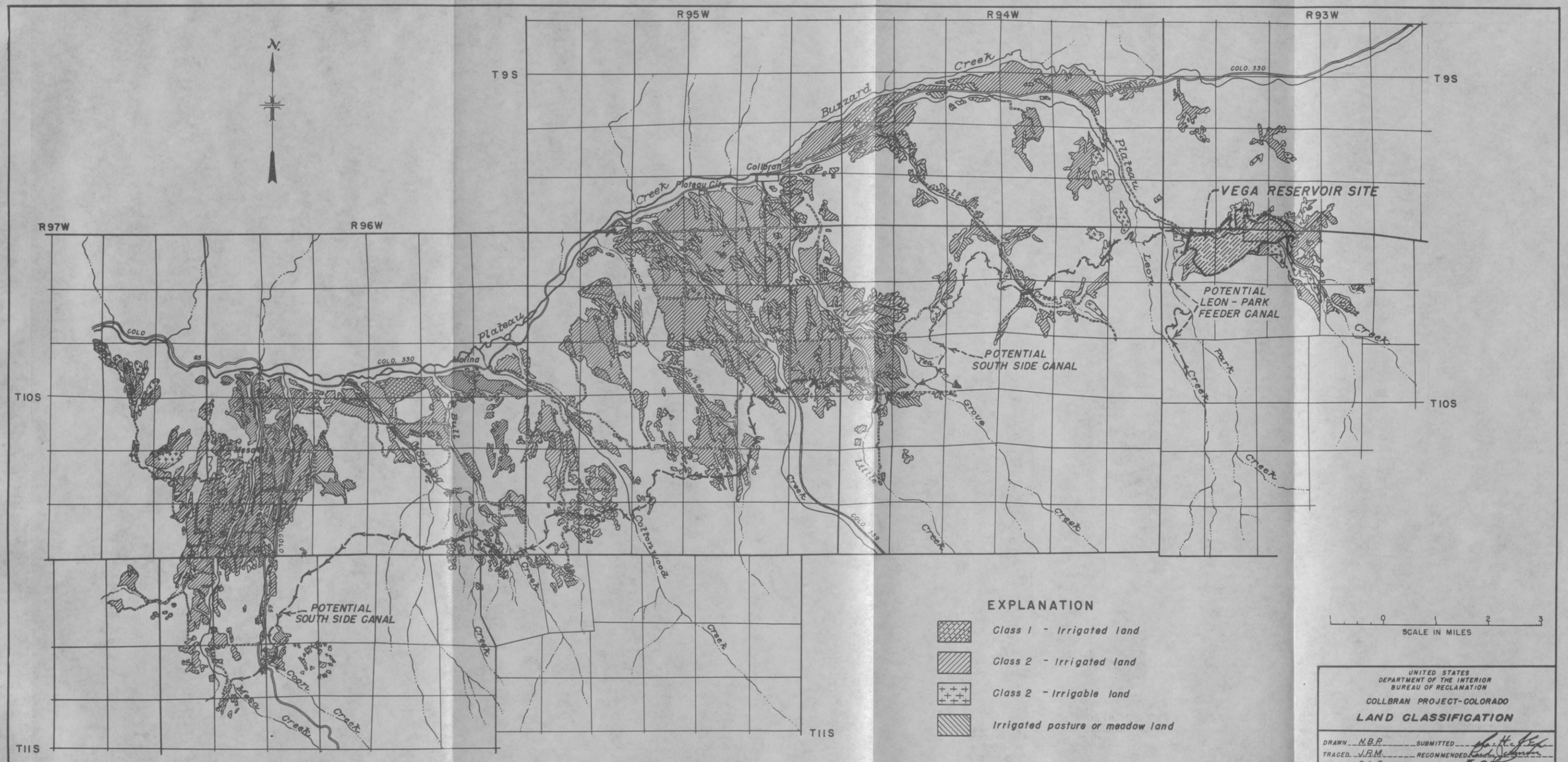
TABLE 30.—*Summary of project acreage in stream service areas* [1]

[Unit—acres]

Stream system	Class 1 and 2 land			Irrigated pasture	Grand total
	Nonirrigated	Irrigated	Total		
Plateau Creek above reservoir	459	216	675	8	683
Plateau Creek below reservoir	130	1,408	1,538	288	1,826
Salt Creek system	478	655	1,133	126	1,259
Big Creek system	463	5,221	5,684	1,600	7,284
Cottonwood Creek system	164	2,663	2,827	615	3,442
Bull Creek system	84	1,174	1,258	267	1,525
Mesa and Coon Creek system	532	3,323	3,855	776	4,631
Irrigable area	2,310	14,660	16,970	3,688	20,650

[1] 6 percent allowance for roads, ditches, and other nonproductive lands has been made in all acreages given.

Of the net project area, 16,970 acres or 82 percent is ranked as class 1 and 2. Of this total, about 6 percent is class 1, distributed in relatively small, scattered bodies throughout the project area. Class 2 lands, comprising 76 percent of the area, are evenly distributed through the project. Pasture class lands comprise 3,680 acres or 18 percent of the net project area.



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PRESENT AGRICULTURAL DEVELOPMENT

Type of development

Large areas of public domain and forest grazing land adjacent to the irrigated land in Plateau Valley provide an excellent setting for the livestock economy which has developed in the area. Nearly all irrigated lands, both cultivated and pasture, are operated to support the livestock industry. Feeder cattle are sold as the principal source of revenue.

Crops

The cropping system in Plateau Valley is fixed by climate, water supply, and topography. The production of livestock feeds predominates with more than 99 percent of the irrigated area devoted to alfalfa, pasture, and other feeds. The small remaining area produces fruits and vegetables for home consumption.

A Bureau of Reclamation survey conducted in 1941 and 1942 showed the crop yields of the area to be relatively low. These low yields are attributed largely to an inadequate late season water supply. Small grain yields are almost average since they obtain their growth during the early irrigation season and are not retarded by a shortage of late season water. Alfalfa is normally limited to two cuttings by the short growing season. Only a light yield is obtained from the second cutting because of inadequate irrigation water. Pastures suffer most from water shortages, receiving very little water after midsummer. Normally, however, those pastures receiving an adequate water supply do very well in the high elevation and relatively cool climate of the valley.

Table 31 shows the present crop distribution, yields, prices, and gross crop values per acre.

TABLE 31.—*Average crop yields, distribution, and values without project development*

Crop	Percent of area	Yield per acre	Unit price (1939–44 average)	Weighted gross value per acre
Alfalfa	50.1	2.1 tons	$11.00	$11.57
Pasture, tillable	20.9	4.5 animal units per month [1]	1.90	1.79
Pasture, nontillable	17.8	2.2 animal units per month [1]	1.90	.74
Barley	5.0	48.0 bushels	.65	1.56
Oats	2.3	52.0 bushels	.50	.60
Wheat	2.0	32.0 bushels	.90	.58
Corn silage	1.0	9.0 tons	5.50	.50
Miscellaneous	.9			[2] .22
Total	100.0			17.56

[1] Animal unit per month, equivalent to the amount of feed required per month by 1 beef cow, 1 horse, or 5 sheep.

[2] Miscellaneous crops estimated at average for the group.

Livestock

The Grand Mesa National Forest and public domain administered by the Bureau of Land Management adjacent to the project provide excellent range for cattle and sheep. Cattle are generally placed on the range during the summer and are fed on the home ranch during the winter. Some stock, however, are maintained on the farm the year round. Sheep are grazed on the mountain range in the summer

and on the desert lands of western Colorado and eastern Utah in the winter.

Table 32, prepared from records of the Mesa County assessor, Forest Service, and Bureau of Land Management, shows the estimated number of livestock owned by project ranchers in 1948.

TABLE 32.—*Number of livestock on project farms*

Class of livestock	Total number	Class of livestock	Total number
Beef cattle	10,500	Horses	600
Sheep	8,000	Hogs	350
Dairy cattle	900	Chickens	3,800

Cattle grazing permits.—Ninety-five project ranchers (40 percent of the project farm operators) hold grazing permits which allow them to graze an average of 105 head of cattle each on national forest lands near the project. At present, the permits allow 4 months of range use from June 16 to October 15. The average cost of grazing privileges for the period 1939 to 1944 was 19.3 cents per animal unit month. Sixty-nine ranchers have additional permits to graze an average of 83 head of cattle on lands under the supervision of the Bureau of Land Management. These permits are usually for a 45-day period extending from May 1 to June 15 at a cost of 5 cents per animal unit month.

Dairying.—Dairying predominates on the smaller farms of the area. At present 28 producers are annually selling on the Grand Junction market sweet cream and milk containing about 100,000 pounds of butterfat. Most dairymen in Plateau Valley, however, market sour cream through the Plateau Valley Creamery Association. This association has 125 active members who sold an average of 106,958 pounds of butterfat annually during the 12-year period 1935–46.

Sheep.—Sheep and lamb production is of minor importance in Plateau Valley. Only 17 ranchers hold permits to graze sheep on national forest lands and only 6 have permits for more than 500 head. The permits range from 50 to 1,492 head with an average of 453 head.

Markets

Livestock and livestock products are largely marketed east of the Continental Divide. Beef cattle are consigned to Denver and Kansas City as feeders. Sheep are consigned as feeder lambs to commission houses in Denver. Butterfat in the form of sour cream is marketed through the Plateau Valley Creamery Association, a cooperative marketing organization. Fat hogs are marketed in Grand Junction where any surplus above the needs of the local market is sold through the Mesa County Livestock Shipping Association on markets in Denver, Salt Lake City, and Los Angeles.

Farms and farmers

A survey conducted in Plateau Valley in 1941 and 1942 showed 238 farm units operating on the project at that time. Of this number 185 were owner-operated, 27 part owner-operated, and 26 tenant-operated. Twenty units were held by absentee owners.

As in many other irrigated sections of western Colorado, the average farm unit has been decreasing in size and now some units are too small for economic operation. The size and number of land ownerships, taken from the Mesa County assessor's records, are given in table 33.

TABLE 33.—*Size of land ownership units, Collbran project, 1946* [1]

Size of tracts (acres)	Number of tracts	Average area (acres)	Percent of total	
			Tracts	Area
20 and under	50	10.5	20	3
21 to 60	94	38.8	38	21
61 to 100	64	78.4	26	29
101 to 140	15	119.0	6	11
141 to 160	7	149.0	3	6
More than 160	17	308.5	7	30
Total	247	69.9	100	100

[1] Includes total acreage listed under 1 name or under name of husband and wife. Not necessarily operating farm units.

Many of the tracts of less than 20 acres are home sites or operational parts of larger farming units. Most of the tracts of more than 160 acres belong to estates which have never been settled. They are now operated as several units.

Land values have remained fairly static because of uncertainty of water supply. The average value of irrigated lands for the period 1939–44, based on assessed valuations, was $90 per acre for class A land, $50 per acre for class B land, $20 per acre for irrigated pasture, and $4 per acre for grazing land.

Few farm improvements have been made during the last decade. The present assessed valuation of all farm improvements averages $450 per farm, and the average investment in farm machinery is $282. These assessed values are approximately one-third of the real value at present prices.

Finances

Tax levies, including county, State, and local school district taxes for the period 1939-44, averaged 34.31 mills for project farms. Project farmers have been prompt in payment of taxes with only 1.4 percent listed as delinquent in 1945.

The Plateau Valley Farm Loan Association records show that there were 217 loans outstanding in 1941, representing a total indebtedness of $421,000. By 1946 this had been reduced to 127 loans, with an unpaid balance of $169,622, all in good order. The Farmers Home Administration listed 10 loans on project farms in 1942 and only 5 in 1946.

Irrigation development in the valley was accomplished through private initiative, and since the ditches were constructed many years ago there is no indebtedness for irrigation works. The present operation and maintenance cost is low, averaging around 30 cents per irrigated acre. Most of this cost represents labor furnished by the irrigators themselves.

General economic outlook

The area has been developed agriculturally to the limit of its present water supply. The only hope of the valley to increase its present livestock economy is to produce more farm-grown livestock feeds. An additional supply of irrigation water at a reasonable cost, therefore, could be profitably utilized to improve the economic status of the ranchers of the valley.

ANTICIPATED AGRICULTURAL ECONOMY

Type of development

The possibility of any great change in the basic economy of the project area is precluded by the climate and topography. With or without project development, livestock production will continue to predominate. By providing additional late season water, project development would make possible greater farm production of livestock feeds, thereby permitting livestock operations to expand. Without project development, the number of livestock would be limited by present crop production and range grazing.

Crops

The production of livestock feeds will continue to be of major importance in the future cropping program of the area with or without project development. With project development, which would add an average of about 15,900 acre-feet of water annually to the present irrigation supply, new lands would be devoted to the production of alfalfa and forage crops and presently irrigated lands would produce much better yields under about the same cropping program. Some increase in the area planted to corn silage and small grains would be probable. No attempt to grow intensive row crops is anticipated because of the short, cool growing season.

Average crop distribution, yields, and gross crop income per acre anticipated with project development are shown in table 34. Crop yields are based on the increase expected from an average of 0.8 acre-foot per acre of additional water annually. The anticipated yields are similar to yields obtained from lands in the area with a full water supply and from comparable lands outside of the project.

TABLE 34.—*Average crop yields, distribution, and values with project development*

Crop	Percent of area	Yield per acre	Unit price (1939–44 average)	Weighted gross value per acre
Alfalfa	45.5	2.5 tons	$11.00	$12.51
Pasture, tillable	21.4	8.0 animal units per month [1]	1.90	3.25
Pasture, nontillable	17.8	4.0 animal units per month [1]	1.90	1.35
Barley	6.0	50.0 bushels	.65	1.95
Oats	2.3	55.0 bushels	.50	.63
Wheat	1.0	35.0 bushels	.90	.32
Corn silage	4.5	10.0 tons	5.50	2.48
Miscellaneous	1.5			[2] .42
Total	100.0			22.91

[1] Animal units per month, equivalent to the amount of feed required per month by 1 beef cow, 1 horse, or 5 sheep.

[2] Miscellaneous crops estimated at average for the group.

Livestock

Table 35 shows the size, distribution, and number of grazing permits held by project ranchers in 1946.

TABLE 35.—*National forest grazing permits held by project ranchers*

Present size of permit (head)	Issued (1946)	
	Number of cattle [1]	Average permit (head)
50 and under	1,044	28
51 to 100	1,568	71
101 to 150	1,966	123
151 to 200	1,470	184
201 and over	3,910	356
Total	9,960	105

[1] Source: Forest Service Records, Grand Mesa National Forest, 1946.

Additional water from construction of the project would permit an increase of about 45 percent in the production of farm feeds. This increased feed could maintain approximately 3,400 head of beef cattle the year round in farm pastures and feed lots. The number of dairy cattle maintained is expected to increase and the quality of stock improve as more producers qualify to sell market milk. The number of hogs is expected to increase along with the number of dairy cattle in order that the additional skim milk might be utilized. Sheep production is expected to increase slightly. Poultry production would remain about as at present. Fewer horses will be used as mechanical propulsion becomes more prevalent.

Farm improvements

The 2,310 acres of new land to be developed under the project would require the most extensive land improvements, including removal of brush and rocks and a small amount of leveling. Improvements in farm ditches and laterals by establishment of proper alinement and grade would be required in other areas. It would also be desirable to improve farm buildings and sheds, construct and line trench silos, replace or improve many items of farm machinery and equipment, and recondition the farm home and domestic water system.

Farm settlement

Land settlement is not expected to present any special problems in connection with project development. The scattered tracts of new land would favorably be added to the smaller farm units. Only limited opportunity exists for new settlement. At the present time there are 17 individuals, estates, and partnerships, which hold title to irrigated acreage in excess of the 160-acre limit prescribed by reclamation law. Most of these would be reduced in the normal process of settlement of estates.

Development period

Benefits from the use of project water could be immediately realized on 89 percent of the 20,650 acres to be served by the project. The remaining 2,310 acres of new land is in small scattered tracts and would be developed in conjunction with lands already under cultivation.

Since this is primarily a supplementary water project involving little change in the type of farming and only small land development costs, a development period of not more than 3 years would be required before full benefits could be realized by the project lands.

IRRIGATION REPAYMENT

Analysis of repayment ability of water users

Two methods of determining payment capacity of the irrigated lands were used—the farm budget method and income-to-land method, both of which were based on earnings from irrigated farms of the project.

Farm budget method.—This method provides for the systematic outlining of the organization and operation of representative farms including, in detail, the anticipated income and expenditures for a normal year. From these data the net farm income is determined. Payment capacity is then derived by deducting the cost of living from the net farm income.

Income-to-land method.—This method is based on the premise that some of the farm receipts represent income to land and other fixed capital, whereas the remainder is income to labor and to operating management and capital. The accuracy of this method is dependent upon the exactness of determining the proper proportions of income and expense belonging to the land. The provisions of farm lease agreements commonly used in the area are taken as the basis for the division of income and expenses. The payment capacity is that amount remaining after expenses chargeable to land are deducted from the gross income to land.

Analysis of payment capacity by type of farming

Two types of farms, featuring dairy and range beef cattle, respectively, are representative of the project area. A 50-acre farm is typical of the dairy units and generally representative of the smaller farms. A 120-acre beef ranch is typical of the range livestock enterprises which provide the major source of income of the project area.

For simplicity all budgets were set up on the basis of the entire tillable areas being class 2 land since this class actually comprises 94 percent of the tillable area. Some irrigated pasture and private grazing lands are included in representative farms of the area and therefore such lands have been included in the budgets.

Farm budget analysis for dairy farms

Dairy farm without project development.—The farm organization and cropping system as set up in this budget for the 50-acre dairy farm is typical of dairy farms of the area. Estimated livestock numbers conform with actual numbers as shown by Mesa County assessor's records with proper adjustments made for expected labor and feed supply. The budget is based on an 8-year crop-rotation program consisting of 1 year of small grain production, 1 year of small grain and alfalfa or pasture production, and 6 years of alfalfa or pasture production. Land fertility would be easily maintained under such rotation because of the high percentage of the land seeded to alfalfa and pasture and the large amount of farm-produced fertilizer available.

The labor requirements are estimated to be 278 10-hour days well distributed throughout the year. A small amount of labor would be hired to help in harvesting of hay and threshing of grain. Since children on the farm would have an average age of less than 14, their labor would be of minor importance. Members of the farm family besides the operator would work only an estimated 43 days a year, this time being devoted to the care of chickens, washing of dairy utensils, and similar light tasks.

The net income of this farm is hardly sufficient for an adequate family living allowance and provides nothing for savings or debt retirement. The family living allowance may be temporarily increased by the use of some of the noncash farm expense set aside for depreciation and repair of farm machinery and improvements. Additional income may be received from off-farm work since there are periods throughout the year when the farm work does not require the full time of the operator. Table 36 on the following page is a summary of the income and expenses of a typical 50-acre dairy farm without project development.

Dairy farm with project development.—The farm budget set up for the typical 50-acre dairy farm is based on present crop yields and distribution adjusted for the changes anticipated with the additional 0.8 acre-foot of water per acre to be made available annually by the project. The budget is based on the maintenance of sufficient livestock to utilize the farm-produced feed, including pasture and private grazing land. A 7-year rotation program is anticipated, consisting of 1 year of corn or small grain production, 1 year of small grain and alfalfa or pasture production, and 5 years of alfalfa or pasture production. The nontillable pasture land is not suitable for cultivation but would be used as irrigated pasture. Labor requirements are estimated at 370 10-hour days annually. More man-hours would be required during spring, summer, and fall than during the winter. Hired labor (16 man-days) would be used in the harvesting of hay and grain crops.

TABLE 36.—*Summary of income and expenses on 50-acre dairy farm without project development*

Item	Percent of area	Acres or number	Production					Disposition (value)			Income to land [1]	
			Unit	Yield	Total	Price	Value	Farm	Home	Sales	Part	Value
Barley	9.0	4.5	Bu.	48	216	$0.65	$140	$66	---	$74	⅓	$47
Oats	4.0	2.0	Bu.	52	104	.50	52	22	---	30	⅓	17
Wheat	4.0	2.0	Bu.	32	64	.90	58	31	---	27	⅓	19
Alfalfa	52.0	26.0	Ton	2.1	54.6	11.00	601	454	---	147	½	300
Alfalfa pasture	[2]	(26.0)	AUM	1.0	26.0	1.90	49	49	---	---	---	---
Pasture:												
Tillable	12.8	6.4	AUM	4.5	28.8	1.90	55	55	---	---	½	28
Nontillable	14.0	7.0	AUM	2.2	15.4	1.90	29	29	---	---	½	15
Corn ensilage	2.0	1.0	Ton	9.0	9.0	5.50	50	50	---	---	⅓	16
Straw	[2]	(8.5)	Ton	1.0	8.5	4.00	34	34	---	---	---	---
Garden	.8	.4	Dol.	---	---	---	60	---	$60	---	---	---
Farmstead	1.4	.7										
Total, irrigable	100.0	50.0										
Grazing, nonirrigable	---	40.0	AUM	.2	8.0	1.90	15	15	---	---	½	8
Livestock												
	Product	*No.*										
Dairy cows (10)	B. F.	10	Lbs.	215	2,150	.36	774	66	33	675	---	---
	Culls	2	Cwt.	10.0	20	6.33	127	---	---	127	---	---
Calves	Veals	7	Cwt.	1.4	9.8	11.82	116	---	17	99	---	---
Heifers (calves)	Repl.	2	---	---	---	---	---	---	---	---	---	---
Heifers (yearlings)	Repl.	2	---	---	---	---	---	---	---	---	---	---
Laying hens (25)	Eggs	25	Doz.	11.0	275	.25	69	---	26	43	---	---
	Culls	20	Lbs.	6.5	130	.15	20	---	20	---	---	---
	Poultry [3]	30	Lbs.	4.0	120	.20	24	---	24	---	---	---
Market hogs	Pork	9	Cwt.	2.0	18	10.68	192	---	21	171	---	---
Other livestock (sow, 1; horses, 3; pullets, 25).												
Total	---	---	---	---	---	---	2,465	871	201	1,393	---	450

CURRENT FARM EXPENSES

Interest cost, at 3 percent (L–125)	$184
Taxes, at 34.31 mills (L–72)	95
Hired labor, 8 days, at $3.50	28
Custom work	38
Crop expense:	
Seed (L–15)	16
Sack and twine	6
Livestock expense:	
Purchased feed	
Stock replacement	
Range fees	18
Veterinary, service fees, etc.	
Grinding feed	56
Auto (farm share)	6
Machinery: Depreciation, repair, and insurance, at 8.5 percent	63
Improvements: Depreciation, repair, and insurance, at 5.5 percent (L–132)	73
Miscellaneous farm expense, at 2 percent	132
	15
Total, farm expense (L–344)	730

See footnotes at end of table, p. 117.

TABLE 36.—*Summary of income and expenses on 50-acre dairy farm without project development*—Continued

FINANCIAL SUMMARY

	Farm budget	Income to land
Receipts	$1,393	$450
Farm privileges	351	
Total	1,744	450
Farm expenses	730	344
Net farm income	1,014	106
Family living allowance	999	
Payment capacity per farm	15	[4] 165
Payment capacity per acre	.30	3.30
Irrigation operation and maintenance	.30	.30
Available for debt retirement		3.00

INVESTMENT

Land [1]	$2,684
Dwelling [1]	900
Other improvements [1]	586
Machinery and equipment	730
Livestock	1,000
Feed and supplies	235
Total	6,135

COST OF LIVING

Cash family	$648
Farm products	261
Farm dwelling	90
Total	999

FARM WORK

	Days
Crops	92
Livestock	161
Miscellaneous	25
Total	278
Work by—	
Operator	227
Family	43
Hired	8
Total	278

[1] Indicates a check method of income to land.
[2] Duplicated acreage.
[3] Includes cockerels and cull pullets.
[4] Includes 3-percent interest on operating capital as income attributable to water.

It is assumed that butterfat would continue to be sold principally as sour cream for butter manufacture. Dairymen who sell their butterfat in the form of market milk, however, would have a much higher payment capacity than shown by the budget. Should the present trend toward market milk production continue, the payment capacity of the average dairyman of the valley would be substantially increased.

The annual net income on a representative dairy farm under anticipated project conditions would be sufficient to provide the family with a living allowance of $1,400, to pay operation and maintenance charges of irrigation facilities, and to allow $2.90 per irrigated acre for debt retirement or savings. The anticipated conditions are summarized in table 37 on the following page.

Farm budget analysis for beef cattle ranches

Beef cattle ranch without project development.—A typical 120-acre livestock ranch was set up as the basis for this study. The number of livestock on such a ranch was determined from records of the Mesa County assessor and the Forest Service. The budget was based on a 9-year crop rotation program, consisting of 1 year of corn production, 1 year of small grain and alfalfa or pasture production, and 8 years of alfalfa or pasture production. Because of the rolling nature of much of the land, alfalfa is frequently left in more than 8 years or until native grasses replace the alfalfa. Pasture lands are seldom cultivated under present conditions.

Only about 10 percent of the beef stock would remain on the home ranch the year round, the remainder grazing on public domain and forest lands during the spring and summer. The range beef operations as presented in the following budgets, both with and without project development, are based on a 75 percent calf crop, 3 percent death loss, and 13 percent yearly replacement of breeding stock. Cattle are sold as long yearlings. The labor requirements on this farm are estimated at 355 10-hour workdays annually. Of this amount, 267 days are accomplished by the operator, 49 days by members of the farm family, and 19 days by hired help.

TABLE 37.—*Summary of income and expenses on 50-acre dairy farm with project development*

Item	Percent of area	Acres or number	Production					Disposition (value)			Income to land [1]	
			Unit	Yield	Total	Price	Value	Farm	Home	Sales	Part	Value
Barley	11.0	5.5	Bu.	50	275	$0.65	$179	$131	---	$48	⅓	$60
Oats	4.0	2.0	Bu.	55	110	.50	55	42	---	13	⅓	18
Wheat	4.0	2.0	Bu.	35	70	.90	63	63	---	-----	⅓	21
Alfalfa	48.0	24.0	Ton	2.5	60	11.00	660	568	---	92	½	330
Alfalfa pasture	[2]	(24.0)	AUM	1.5	36	1.90	68	68	---	-----	---	-----
Pasture:												
Tillable	10.6	5.3	AUM	8.0	42	1.90	80	80	---	-----	½	40
Nontillable	14.0	7.0	AUM	4.0	28	1.90	53	53	---	-----	½	26
Corn ensilage	6.0	3.0	Ton	10.0	30	5.50	165	165	---	-----	⅓	55
Straw	[2]	(9.5)	Ton	1.0	9.5	4.00	38	38	---	-----	---	-----
Garden	1.0	.5	Dol.	-----	-----	-----	75	-----	$75	-----	---	-----
Farmstead	1.4	.7										
Total irrigable	100.0	50.0										
Grazing, nonirrigable	-----	40.0	AUM	.2	8.0	1.90	15	15	---	-----	½	8
Livestock	*Product*	*No.*										
Dairy cows (14)	B. F.	14	Lb.	240	3,360	.36	1,210	86	34	1,090	---	-----
	Culls	3	Cwt.	10	30	6.33	190	-----	---	190	---	-----
Calves	Veal	9	Cwt.	1.4	12.6	11.82	149	-----	17	132	---	-----
Heifers (yearling)	Repl.	3										
Heifers (calves)	Repl.	3										
Laying hens (50)	Eggs	50	Doz.	11.0	550	.25	138	-----	25	113	---	-----
	Culls	40	Lbs.	6.5	260	.15	39	-----	19	20	---	-----
	Poultry [3]	60	Lbs.	4.0	240	.20	48	-----	24	24	---	-----
Market hogs	Pork	18	Cwt.	2.0	36	10.68	384	-----	21	363	---	-----
Other livestock (sows, 2; horses, 3; pullets, 50).												
Total	-----	-----	-----	-----	-----	-----	3,609	1,309	215	2,085	---	558

See Footnotes at end of table, p. 119.

TABLE 37.—*Summary of income and expenses on 50-acre dairy farm with project development*—Continued

CURRENT FARM EXPENSES

Interest cost, at 3 percent (L–142)	$214
Taxes, at 34.31 mills (L–81)	111
Hired labor, 16 days, at $3.50	56
Custom work	44
Crop expense:	
Seed (L–16)	19
Sack and twine	6
Livestock expense:	
Purchased feed	
Stock replacement	18
Range fees	
Veterinary, service fees, etc.	77
Grinding feed	12
Auto (farm share)	63
Machinery: Depreciation and repairs, at 8.5 percent	73
Improvements: Depreciation, repair and insurance, at 5.5 percent (L–156)	156
Miscellaneous farm expense, at 2 percent	16
Total farm expense (L–395)	865

FINANCIAL SUMMARY

	Farm budget	Income to land
Receipts	$2,085	$558
Farm privileges	375	
Total	2,460	558
Farm expenses	865	395
Net farm income	1,595	163
Family living allowance	1,400	
Payment capacity per farm	195	[4] 235
Payment capacity per acre	3.90	4.70
Irrigation operation and maintenance	1.00	1.00
Available for debt retirement	2.90	3.70

INVESTMENT

Land [1]	$2,942
Dwelling [1]	960
Other improvements [1]	818
Machinery and equipment	730
Livestock	1,365
Feed and supplies	292
Total	7,107

COST OF LIVING

Cash family	$1,025
Farm products	275
Farm dwelling	100
Total	1,400

FARM WORK

	Days
Crops	111
Livestock	225
Miscellaneous	34
Total	370
Work by—	
Operator	292
Family	62
Hired	16
Total	370

[1] Indicates check method of income to land.
[2] Duplicated acreage.
[3] Includes cockerels and cull pullets.
[4] Includes 3-percent interest on operating capital as income attributable to water.

The annual net income of this farm is sufficient to provide the farm family with a living allowance of $1,330 to pay operation and maintenance charges and to provide $0.99 per irrigable acre for debt retire-

ment or savings. Table 38 presents a summary of the income and expenses of a typical 120-acre beef ranch without project development.

Beef ranch with project development.—The farm budget for this 120-acre livestock ranch is based on present crop yields and distribution adjusted for changes expected with the additional irrigation water to be made available by project development. It is estimated sufficient livestock would be maintained on this farm to utilize all farm-produced feeds, including pasture and private grazing land, as well as all additional feed available from grazing permits on forest areas and public domain. The cropping system is built around a 9-year rotation program, consisting of 1 year of small grain or corn production, 1 year of small grain and alfalfa or pasture production, and 7 years of alfalfa and pasture production. The annual labor requirement for this ranch is estimated at 391 10-hour days of work. Labor requirements would be intensified during spring and summer when the work load is heavy. A slack period would occur during the winter months. As shown in table 39, the annual net farm income would be sufficient to provide the farm family with a living allowance of $1,550, pay operation and maintenance charges, and allow $2.11 per irrigable acre for debt retirement or savings.

TABLE 38.—*Summary of income and expenses on 120-acre beef-cattle ranch without project development*

Item	Percent of area	Acres or number	Production					Disposition (value)			Income to land [1]	
			Unit	Yield	Total	Price	Value	Farm	Home	Sales	Part	Value
Barley	5.0	6.0	Bu.	48	288	0.65	187	93	---	94	⅓	62
Oats	1.7	2.0	Bu.	52	104	.50	52	41	---	11	⅓	17
Wheat	1.7	2.0	Bu.	32	64	.90	58	34	---	24	⅓	19
Alfalfa	57.4	69.0	Ton	2.1	144.9	11.00	1,594	1,594	---	-----	½	796
Alfalfa, pasture	[2]	(69.0)	AUM	1.0	69.0	1.90	131	131	---	-----	---	-----
Pasture:												
Tillable	11.7	14.0	AUM	4.5	63.0	1.90	120	120	---	-----	½	60
Nontillable	17.5	21.0	AUM	2.2	46.2	1.90	88	88	---	-----	½	44
Straw	[2]	(10.0)	Ton	1.0	10.0	4.00	40	40	---	-----	---	-----
Corn ensilage	1.7	2.0	Ton	9.0	18.0	5.50	99	99	---	-----	⅓	33
Garden	.3	.4	Dol.	-----	-----	-----	60	-----	60	-----	---	-----
Farmstead	[3] 3.0	6.6										
Total, irrigable	100.0	120.0										
Grazing, nonirrigable	-----	372.0	AUM	.2	74.4	1.90	141	141	---	-----	½	70
Range permits	-----	-----	AUM	-----	[4] 355	1.90	674	674	---	-----	---	-----
Livestock												
	Product	*No.*										
Dairy cows (2)	B. F.	2	Lbs.	180	360	.36	130	30	33	67	---	-----
Calves (baby beef)	Beef	2	Cwt.	3	6	11.82	71	-----	71	-----	---	-----
Beef cows (53)	Calves	53	No.	.75	40							
	Culls	5	Cwt.	10	50	6.33	316	-----	---	316	---	-----
Steers and heifers	Beef	32	Cwt.	7	224	9.81	2,197	-----	---	2,197	---	-----
Laying hens (25)	Eggs	25	Doz.	11.0	275	.25	69	-----	26	43	---	-----
	Culls	20	Lbs.	6.5	130	.15	20	-----	20	-----	---	-----
	Poultry [5]	30	Lbs.	4.0	120	.20	24	-----	24	-----	---	-----
Other livestock (bulls, 2; horses, 6; calves, 39; heifers, 7).												
Total	-----	-----	-----	-----	-----	-----	6,071	3,085	234	2,752	---	1,101

See footnotes at end of table, p 121.

TABLE 38.—*Summary of income and expenses on 120-acre beef-cattle ranch without project development*—Continued

CURRENT FARM EXPENSES

Interest cost, at 3 percent (L–291)	$481
Taxes, at 34.31 mills (L–167)	265
Hired labor, 19 days, at $3.50	66
Custom work	45
Crop expense:	
Seed (L–18)	20
Sack and twine	6
Livestock expense:	
Purchased feed	110
Stock replacement	44
Range fees	58
Veterinary, service fees, etc	80
Grinding feed	9
Auto (farm share)	108
Machinery: Depreciation and repair, at 8.5 percent	136
Improvements: Depreciation, repair, and insurance, at 5.5 percent (L–210)	210
Miscellaneous farm expense, at 2 percent	43
Total farm expense (L–686)	1,681

FINANCIAL SUMMARY

	Farm budget	Income to land
Receipts	$2,752	$1,101
Farm privileges	414	
Total	3,166	1,101
Farm expenses	1,681	686
Net farm income	1,485	415
Family living allowance	1,330	
Payment capacity per farm	155	[6] 605
Payment capacity per acre	1.29	5.04
Irrigation operation and maintenance	.30	.30
Available for debt retirement	.99	4.74

INVESTMENT

Land [1]	$7,316
Dwelling [1]	1,200
Other improvements [1]	1,197
Machinery and equipment	1,182
Livestock	4,650
Feed and supplies	500
Total	16,045

COST OF LIVING

Cash family	$916
Farm products	294
Farm dwelling	120
Total	1,330

FARM WORK

	Days
Crops	169
Livestock	136
Miscellaneous	30
Total	335
Work by—	
Operator	267
Family	49
Hired	19
Total	335

[1] Indicates check method of income to land.
[2] Duplicated acreage.
[3] Includes 3 acres nonirrigable grazing land.
[4] Includes 260 animal-unit-months on forest lands and 95 animal-unit-months on Bureau of Land Management lands.
[5] Includes cockerels and cull pullets.
[6] Includes 3 percent interest on operating capital.

TABLE 39.—*Summary of income and expenses on 120-acre beef cattle ranch with project development*

Item	Percent of area	Acres or number	Production					Disposition (value)			Income to land [1]	
			Unit	Yield	Total	Price	Value	Farm	Home	Sales	Part	Value
Barley	8.3	10.0	Bu.	50	500	0.65	325	117	---	208	⅓	108
Oats	2.5	3.0	Bu.	55	165	.50	82	42	---	40	⅓	27
Wheat	2.5	3.0	Bu.	35	105	.90	94	35	---	59	⅓	31
Alfalfa	54.2	65.0	Ton	2.5	162.5	11.00	1,788	1,788	---	---	½	894
Alfalfa pasture	[2]	(65.0)	AUM	1.5	97.5	1.90	185	185	---	---	---	---
Pasture:												
Tillable	7.5	9.0	AUM	8.0	72.0	1.90	137	137	---	---	½	68
Nontillable	17.5	21.0	AUM	4.0	84	1.90	160	160	---	---	½	80
Corn ensilage	4.1	4.9	Ton	10.0	49	5.50	270	270	---	---	⅓	90
Straw	[2]	(16.0)	Ton	1	16	4.00	64	64	---	---	---	---
Garden	.4	.5	Dol.	---	---	---	75	---	75	---	---	---
Farmstead	[3] 3.0	[3] 6.6	---	---	---	---	---	---	---	---	---	---
Total, irrigable	100.0	120.0	---	---	---	---	---	---	---	---	---	---
Grazing, nonirrigable	6	372.0	AUM	.2	74.4	1.90	141	141	---	---	½	70
Range permits	---	---	AUM	---	[4] 355	1.90	674	674	---	---	---	---
Livestock												
	Product	*No.*										
Dairy cows (2)	B. F.	2	Lbs.	180	360	.36	130	30	33	67	---	---
Calves (baby beef)	Beef	2	Cwt.	3	6	11.82	71	---	71	---	---	---
Beef cows (63)	Calves	63	No.	.75	47	---	---	---	---	---	---	---
	Culls	6	Cwt.	10	60	6.33	380	---	---	380	---	---
Steers and heifers	Beef	37	Cwt.	7	259	9.81	2,541	---	---	2,541	---	---
Laying hens (25)	Eggs	25	Doz.	11.0	275	.25	69	---	26	43	---	---
	Culls	20	Lbs.	6.5	130	.15	20	---	20	---	---	---
	Poultry [5]	30	Lbs.	4.0	120	.20	24	---	24	---	---	---
Other livestock (calves, 46; yearling heifers, 9; bulls, 3; cows, 63; horses, 6).												
Total	---	---	---	---	---	---	7,230	3,643	249	3,338	---	1,368

CURRENT FARM EXPENSES

Interest cost, at 3 percent (L–314)	$539
Taxes, at 34.31 mills (L–180)	298
Hired labor, 41 days, at $3.50	144
Custom work	74
Crop expense:	
Seed (L–27)	32
Sack and twine	12
Livestock expense:	
Purchased feed	---
Stock replacement	66
Range fees	58
Veterinary, service fees, etc.	91
Grinding feed	8
Auto (farm share)	108
Machinery: Depreciation and repair, at 8.5 percent	144
Improvements: Depreciation, repair, and insurance, at 5.5 percent (L–225)	225
Miscellaneous farm expense, at 2 percent	45
Total farm expense (L–746)	1,844

See footnotes at end of table, p. 123.

TABLE 39.—*Summary of income and expenses on 120-acre beef cattle ranch with project development*—Continued

FINANCIAL SUMMARY

	Farm budget	Income to land
Receipts	$3,338	$1,368
Farm privileges	429	
Total	3,767	1,368
Farm expenses	1,844	746
Net farm income	1,923	622
Family living allowance	1,550	
Payment capacity per farm	373	[6] 847
Payment capacity per acre	3.11	7.06
Irrigation operation and maintenance	1.00	1.00
Available for debt retirement	2.11	6.06

INVESTMENT

Land [1]	$7,910
Dwelling [1]	1,200
Other improvements [1]	1,365
Machinery and equipment	1,236
Livestock	5,620
Feed and supplies	657
Total	17,988

COST OF LIVING

Cash family	$1,121
Farm products	309
Farm dwelling	120
Total	1,550

FARM WORK

	Days
Crops	204
Livestock	152
Miscellaneous	35
Total	391
Work by—	
Operator	291
Family	59
Hired	41
Total	391

[1] Indicates check method of income to land.
[2] Duplicated acreage.
[3] Includes 3 acres nonirrigable grazing land.
[4] Includes 260 animal unit months forest land and 95 animal unit months on Bureau of Land Management land.
[5] Includes cockerels and cull pullets.
[6] Includes 3 percent interest on operating capital.

Payment capacity of project lands

The payment capacity of project farmers, as determined by the farm budget and the income to land methods, is summarized in table 40.

TABLE 40.—*Estimated annual payment capacity by type of farm with and without project development*

Type of farm	Payment capacity without project development		Payment capacity with project development		Increased payment capacity due to project development			
	Farm budget	Income to land	Farm budget	Income to land	Farm budget		Income to land	
	Per acre	*Per acre*	*Per acre*	*Per acre*	*Per acre*	*Per acre-foot* [1]	*Per acre*	*Per acre-foot* [1]
Dairy	$0.30	$3.30	$3.90	$4.70	$3.60	$4.50	$1.40	$1.75
Beef	1.29	5.04	3.11	7.06	1.82	2.28	2.02	2.52
Weighted average	.99	4.51	3.35	6.35	2.36	2.95	1.84	2.30

[1] Based on 0.8 acre-foot per acre increase in water supply.

Amortization capacity

The amount of money available for debt retirement (amortization capacity) is the difference between payment capacity with and without project development less the increase in operation and maintenance costs resulting from the project. Table 41 shows the estimated annual payment capacity and amortization capacity by type of farm as determined by the farm budget analysis method.

TABLE 41.—*Estimated annual payment capacity and amortization capacity of project lands*

Type of farm and condition	Payment capacity per acre	Amount available for operation and maintenance per acre	Amount available for amortization of capital costs per acre
With project development:			
Dairy	$3.90	$1.00	$2.90
Beef	3.11	1.00	2.11
Average	3.35	1.00	2.35
Without project development:			
Dairy	.30	.30	
Beef	1.29	.30	.99
Average	.99	.30	.69
Increase due to project:			
Dairy	3.60	[1] 1.70	[2] 2.90
Beef	1.82	[1] 1.70	[2] 1.12
Average	2.36	[1] 1.70	[2] 1.66

[1] Although the increased operation and maintenance cost per acre is shown to be $0.70 in this table, about $0.73 per acre would be available for project operation because of a reduction of approximately 10 percent in present operation and maintenance costs through construction of the potential project.
[2] Amortization capacity per project acre.

Recommended annual payment

Although an average of $1.66 per irrigated acre would be available theoretically to meet project construction costs, the actual amount would vary from farm to farm. Variations may also be expected as a result of limitations in estimating income and expenses over an extended period in the future. Thus a contingency factor of about 25 percent has been allowed, making $1.25 the desirable average annual payment per irrigated acre. This would amount to approximately $1.62 per acre-foot of additional irrigation water supplied by the project or a total of $25,800 annually for the average of 15,900 acre-feet of water provided. This amount, together with the allowance of about $0.73 per acre of project land for the operation and maintenance of new works, shows that the project farmers could pay a total of $41,000 annually toward project construction, operation, and maintenance.

CHAPTER V

POWER

PRESENT DEVELOPMENT

The power market area adjacent to the project is served by two principal power systems. The Public Service Co. of Colorado operates one system which extends along the Colorado River. This is the western section of what is known as the company's central system and is called the Grand Junction division. The transmission line in the Grand Junction division is operated at 66,000 volts and extends from the company's Shoshone hydroelectric plant near Glenwood Springs, Colo., to a steam-electric plant at Grand Junction. The portion of the system extending eastward to Denver from the Shoshone plant is operated at 100,000 volts.

The other main power system adjacent to the Collbran project is owned and operated by the Western Colorado Power Co., a subsidiary of the Utah Power & Light Co. This system is south of the project area, extending from the vicinity of Somerset, Colo., southward by way of Delta to Durango. The main transmission line is operated at 44,000 volts. The main plants of this company are steam-driven and are located in the coal-mine area near Somerset.

Several small REA-financed systems are interconnected with the two principal power systems. These cooperatives are the Gunnison County Rural Electric Association, with headquarters at Crested Butte; the Grand Valley Rural Lines, Inc., with headquarters at Grand Junction; the Delta-Montrose Rural Lines Association, with its main office at Delta, and the Holy Cross Electric Association, Inc., with its main office at Eagle.

The Gunnison County Rural Electric Association generates only a part of its system's requirements for power, supplementing its needs by purchases from the city of Gunnison. The Holy Cross Electric Association produces a small amount of energy at its plants near Gypsum and Eagle and purchases energy from the Public Service Co. of Colorado and the Mountain Utilities Corp., at Aspen. The Grand Valley Rural Power Lines, Inc., purchases its energy from the Public Service Co. of Colorado at Fruita, Grand Junction, and DeBeque. The Delta-Montrose Rural Power Lines Association purchases its energy from the Western Colorado Power Co. at Delta, Pea Green, Montrose, Cedaredge, and Hotchkiss. The Mountain Utilities Co. operates a small power system in the vicinity of Aspen and supplies its own requirements at that location.

The cities of Gunnison and Delta operate their own generating plants. The plant at Delta is entirely Diesel-powered. At Gunnison steam engines and a steam turbine are used as prime movers.

The total installed generating capacity within the market area adjacent to the project, as shown in table 42, is 35,768 kilowatts.

This includes the capacity of the Shoshone plant of the Public Service Co. of Colorado. The greater part of the energy generated at this plant, however, is utilized outside the market area. Drawing No. 482–4–13 shows the location of the power plants and principal transmission lines in the area.

TABLE 42.—*Installed power-generating capacity within the project market area*

Plants	Installed capacity (kilowatts)	Type of prime mover	Owner
Shoshone	14,400	Hydro	Public Service Co. of Colorado.
Grand Valley	3,000	do	Bureau of Reclamation (operated by Public Service Co. of Colorado).
Rifle	125	do	Public Service Co. of Colorado.
Glenwood Springs	200	do	Glenwood Light & Water Co.
Redlands	1,400	do	Redlands Water & Power Co.
Crested Butte	300	50-kilowatt hydro, 250-kilowatt fuel.	Gunnison County Rural Electric Association, Inc.
Grand Junction [1]	9,350	Steam	Public Service Co. of Colorado.
Oliver [2]	3,000	do	Western Colorado Power Co.
Montrose	300	do	Western Colorado Power Co.
Delta	1,958	Internal combustion	City of Delta.
Gunnison	1,175	Steam	City of Gunnison.
Aspen	560	Hydro	Mountain Utilities Corp.
Total	35,768		

[1] New 5,000-kilowatt unit recently installed.
[2] New 2,000-kilowatt unit recently installed.

The electric energy generated in 1946 by the several utilities within the project market area is shown in table 43.

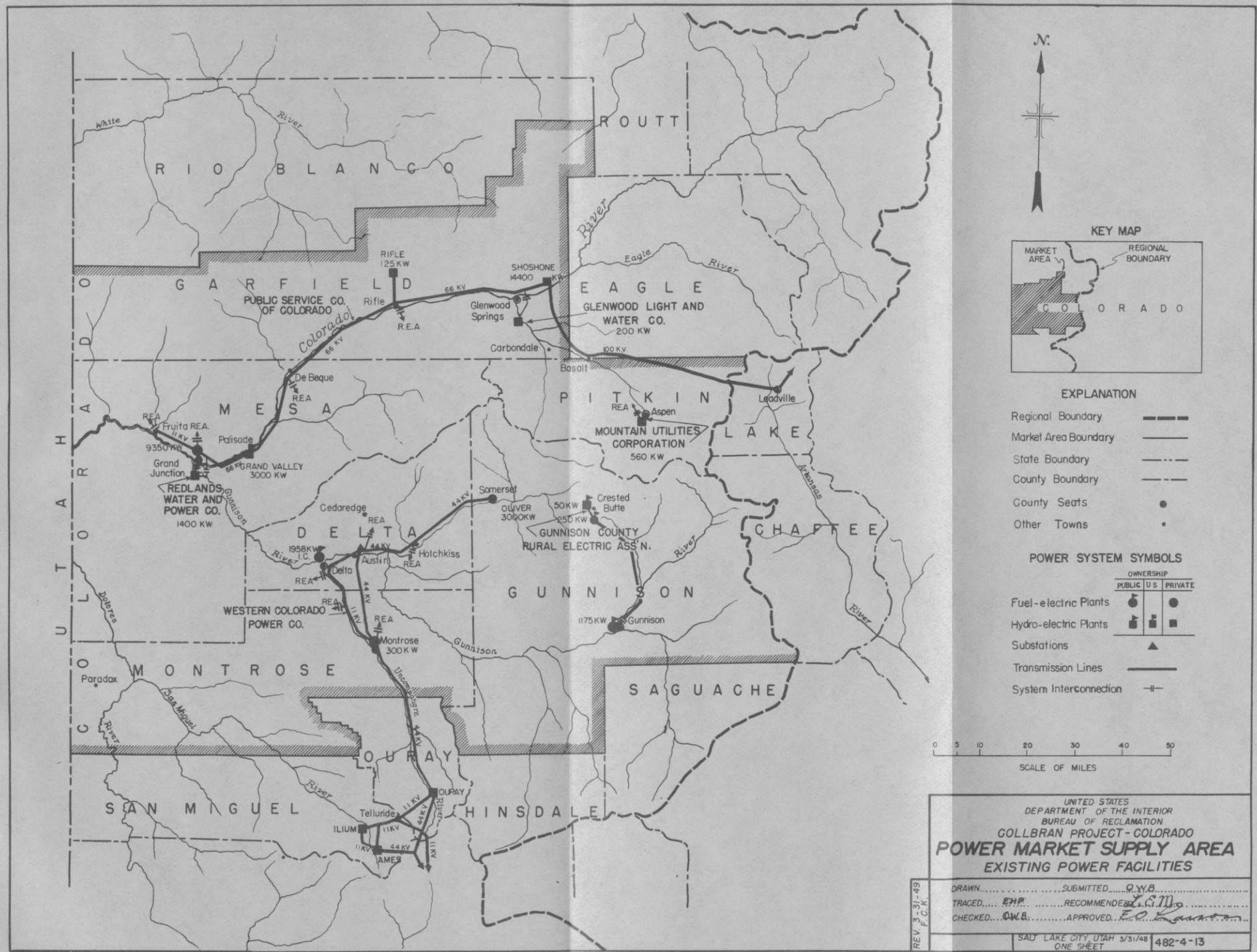
TABLE 43.—*Power generated in 1946 by plants in Collbran project power-market area*

Utility system	Power plant	Generated 1946 (1,000 kilowatt-hours)
Privately owned:		
Public Service Co. of Colorado	Shoshone	108,234
	Grand Valley	17,815
	Grand Junction	3,536
	Rifle	1,098
Western Colorado Power Co	Oliver	9,152
	Paonia [1]	117
	Montrose	41
Glenwood Light & Water Co	Glenwood Springs	[2] 1,600
Mountain Utilities Corp	Aspen	[2] 1,240
Publicly owned:		
Delta, city of	Delta	[2] 3,483
Gunnison, city of	Gunnison	[2] 2,700
Gunnison County Rural Electrification Association	Crested Butte	0
Redlands Water & Power Co	Redlands	7,798
Total		156,814

[1] Destroyed by fire in 1946.
[2] Estimated.

The total generation of 156,814,000 kilowatt-hours in 1946 exceeded the area's actual requirements in that year, which approximated 59,450,000 kilowatt-hours. The energy not required locally was sold out of the power market area.

Several municipalities are expected to be forced in the very near future to add to their generating capacity in order to meet the fast-growing demands for power within the immediate market area. The



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Public Service Co. of Colorado already has added 5,000 kilowatts of steam-generating capacity to its system. This indicates the fast-growing load in the Grand Junction division of this utility. Likewise, increasing loads in the eastern part of the company's system may soon require the entire output of the Shoshone plant.

POWER MARKET

Present power requirements

The power market area consists of three distinct sections insofar as the use of electrical energy is concerned. The Uncompahgre section, consisting of Delta County and the northeastern part of Montrose County, is essentially rural and agricultural. Consequently, the energy consumed is primarily for residential use. The section embracing Pitkin and Gunnison Counties contains a mining industry and, therefore, has a large demand for power for industrial purposes. The Grand Valley section, on the other hand, contains a number of municipalities and small towns with commercial and small industrial enterprises and shows a more diversified use of energy and a better balanced load than the other areas.

Table 44 shows the average annual use of electric energy for each of the three sections during the period 1919 to 1936. The average for the entire market area is also shown.

TABLE 44.—*Distribution of electric-energy sales for years 1919–36*

District	Average annual sales (1,000 kilowatt-hours)	Distribution of average annual sales in percentage of total		
		Industrial and commercial	Residential	Municipal
Uncompahgre (rural, agricultural)	2,117	51	41	8
Gunnison and Pitkin Counties (mining)	1,314	82	11	7
Grand Valley (diversified)	5,580	67	26	7
Entire market area	9,011	65	28	7

The electric-power load in the area has been increasing steadily since 1919 with an accelerated increase after 1934. The rapid increase is attributed to the extension of service to the rural communities, the wide use of electrical appliances, and the increased number of residents and business enterprises. Table 45 summarizes the electric-energy requirements in the area from 1919 to 1946, inclusive, showing the continuously increasing demand for power.

TABLE 45.—*Electric energy requirements*

Year	Project market area			State of Colorado		
	1,000 kilowatt-hours	Population	Per capita use (kilowatt-hours)	1,000 kilowatt-hours	Population	Per capita use (kilowatt-hours)
1919	7,680					
1920	8,610	65,402	132	397,246	939,629	423
1921	5,380					
1922	7,320					
1923	8,400					
1924	7,500					
1925	8,160					
1926	9,290					
1927	9,810					
1928	11,600					
1929	11,480					
1930	11,240	69,126	163	573,281	1,035,791	553
1931	13,200					
1932	12,000					
1933	11,230					
1934	16,080					
1935	16,250					
1936	18,960					
1937	24,065					
1938	28,007					
1939	31,462					
1940	37,697	84,267	450	791,967	1,123,296	705
1941	39,228					
1942	41,433					
1943	44,319					
1944	47,470	[1] 90,000	[1] 527	[1] 1,158,000	[1] 1,146,000	[1]10,082
1945	52,298					
1946	59,450					

[1] Estimated.

Future power market

Electrical energy requirements are expected to increase even more rapidly in the future than they have in the past. In the recent postwar years new industries have developed and established industries have expanded at a faster rate than ever before. This expansion is related closely to the current stimulation of mineral development in the region.

New industries with promise of early development include the production of synthetic fuels from oil-bearing shale in the vicinity of Rifle and increased production of coking coal from the newly developed deposits in the area east of Delta and Hotchkiss. The spiraling demand for oil in the face of diminishing known natural reserves portends early production of synthetic fuel from oil shale or coal. Exploration for new petroleum deposits is going forward on an unprecedented scale. The resulting discoveries, however, will only temporarily and partially meet the oil demands. Meanwhile the Bureau of Mines is conducting extensive experiments on the recovery of oil from oil shale and coal. An oil shale pilot plant is being operated at Rifle, Colo. The expansion of steel industries in Utah and California indicates that the Delta and Hotchkiss coking coal deposits soon will be developed. The mining of lead, zinc, silver, and gold within the power market area has increased during the last 2 or 3 years. The national program for stockpiling of strategic metals is accelerating development of the nearby mineral resources. The Atomic Energy Commission and the Geological Survey have recently set up offices in Grand Junction for the purpose of purchasing and milling uranium ores and furthering exploration. With future developments in the field of atomic energy or in case of war emergency, vast amounts of electric energy would be required for the processing and refining of the carno-

tite ore which is found in the area south and west of Grand Junction.

Drawing No. 482–P–92 shows past power requirements and future requirements estimated for the area through the year 1956. The curve is based on the findings of a power market survey made in January 1947. It is in substantial agreement with the findings of a more recent study made by the Federal Power Commission, entitled "Power Market Survey, Colorado River, Upper Basin," dated February 1948. The estimates of future energy requirements are believed conservative in view of the prospects for future developments of mineral resources, future irrigation of new lands, and the establishment of new industries.

Table 46 shows the area's energy requirements, load factors, and peak demands estimated for the years 1951, 1956, and 1960.

TABLE 46.—*Estimated future power load of area*

Item	1951	1956	1960
Energy requirements ---- 1,000 kilowatt-hours	85,600	117,100	144,000
Load factor ---- percent	50	53	55
Peak demand ---- kilowatts	19,500	25,200	29,900

All of the market area is not immediately available to project power, and the building of a transmission system large enough to supply the principal load centers would be costly. All of the output of the project power plants, however, could be absorbed by existing utilities in the immediate vicinity of the plants.

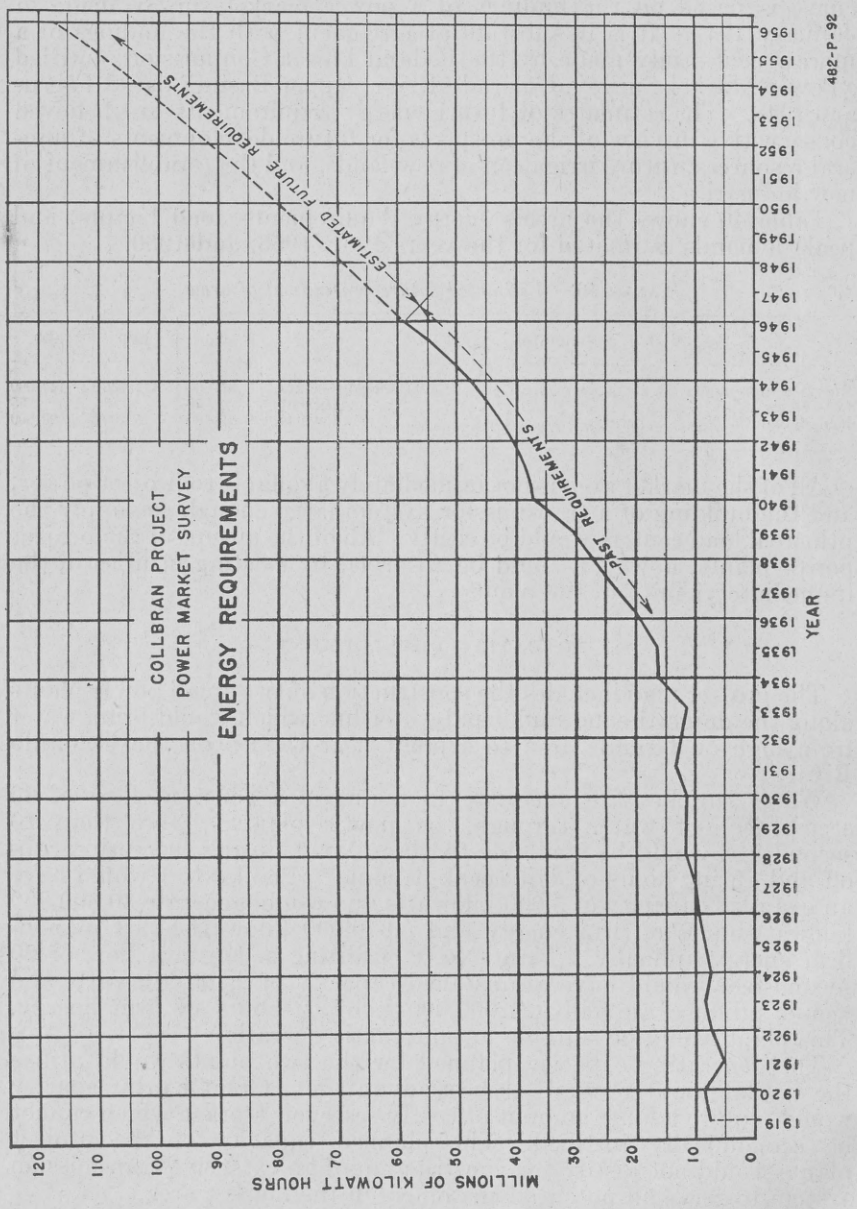
POTENTIAL DEVELOPMENT

The project plan includes the construction of two small power plants along the domestic and municipal water line which would bring water from high on Grand Mesa to a point near Cameo on the Colorado River.

Water supplies are adequate to maintain a constant flow of 20 second-feet of water through the power plants. More than 20 second-feet would be available to plant No. 1 during the spring runoff and during hours of daily peak demand. Plant No. 1 would have an installed capacity of 5,000 kilowatts and would generate 30,600,000 kilowatt-hours of firm energy and 6,670,000 kilowatt-hours of nonfirm energy annually. Plant No. 2, utilizing a constant flow of 20 second-feet, would have an installed capacity of 2,400 kilowatts and would produce annually 21,000,000 kilowatt-hours of firm energy. This plant would be suitable for automatic operation.

The generating capacity planned for the two plants would utilize the available water supply to best advantage. Greater firm capacity would require a large amount of costly reservoir storage which cannot be economically justified. The planned capacity of the project plants would not justify the construction of an extensive transmission system to serve all potential customers in the market area.

A transmission line would be provided to transmit power from plant No. 1 to plant No. 2 and from plant No. 2 to a point of delivery near Cameo, Colo. Additional transmission facilities may be needed to make deliveries at other points to potential customers. If additional transmission costs were incurred in making such deliveries, the cost would be reflected in the power rates charged.


ENERGY REQUIREMENTS
COLLBRAN PROJECT
POWER MARKET SURVEY
PAST REQUIREMENTS
ESTIMATED FUTURE REQUIREMENTS
MILLIONS OF KILOWATT HOURS
YEAR
482-P-92

CHAPTER VI

MUNICIPAL AND DOMESTIC WATER

PRESENT DEVELOPMENT

General

Only the three principal communities in Grand Valley, Grand Junction, Palisade, and Fruita, have improved municipal and domestic water-supply systems. In these places the quality of the water is excellent, but the quantity is inadequate for anticipated future needs. Domestic water for rural areas is either hauled from one of the three communities and stored in cisterns or taken direct from irrigation ditches or from the few wells in the valley. From the standpoint of sanitation the rural supply is deficient in both quantity and quality. As increased use is made of water, the stream flow is becoming harder and more polluted.

Water from the artesian wells is of excellent quality and has become popular with rural users. Most of the well owners have developed water-hauling businesses or sell water to commercial haulers. As a result the artesian flow is fully used and in some cases pumps are operated to increase output. Because of the low permeability of the sandstone supplying these wells, there has been a marked loss in artesian head during the last few years. Should the present rate of development be continued, it is probable that artesian flow will cease in the near future.

Grand Junction water supply system

Grand Junction now obtains its domestic water from Kannah Creek, a tributary of the Gunnison River. The water is diverted from the creek above all principal diversions for irrigation and is carried through a pipeline 20 miles to a treatment plant located 1 mile south of the city. The present collection system, pipeline, and treatment facilities have a capacity of about 8,000,000 gallons a day. The city has two natural flow water rights in Kannah Creek totaling approximately 11.7 second-feet (7,600,000 gallons a day). A combined reservoir capacity on the Kannah Creek watershed of 1,500 acre-feet is owned by the city and is used to furnish seasonal control and provide hold-over storage to supplement the natural flow rights. The water rights and supply system are considered by city officials to be adequate for present needs even during periods of drought but inadequate to support a further increase in population.

Grand Junction's present population of 18,500 is being served by a distribution system through 4,000 outlets. About 3,300 outlets are used for domestic purposes within the corporate city limits, 550 are used for commercial and industrial use in the city, and 150 are used for domestic and stock-watering purposes in areas adjacent to the city.

Palisade water supply system

Palisade receives its water from springs on the headwaters of Rapid Creek, a tributary of the Colorado River, about 6 miles southeast of

the town. The water is piped to a small treatment plant, located 1 mile east of the town. The system delivers about 1,000,000 gallons a day to Palisade and vicinity through 500 individual outlets. About 350 outlets are within the corporate limits of the town and are used for municipal, domestic, and industrial purposes. The remaining outlets supply domestic and stock water to the area surrounding the town.

Fruita water-supply system

Domestic and municipal water is supplied the town of Fruita by a collection pipeline system heading on Pinion Mesa and extending some 25 miles north through the Colorado National Monument to a small reservoir and treatment plant located approximately 2 miles south of the town. The water is diverted from the headwaters of East Creek, a tributary of the Gunnison River; the headwaters of Hay Press Creek, a tributary of the Dolores River; and several small springs. Three small reservoirs with a total of less than 80 acre-feet of storage capacity provide operational flexibility. The present system is capable of providing the town of Fruita and environs with a maximum of 500,000 gallons a day. Water is distributed to approximately 500 outlets, about 425 of which are within the corporate limits of the town. The remaining 75 are in the farming area bordering the town.

ANTICIPATED NEEDS

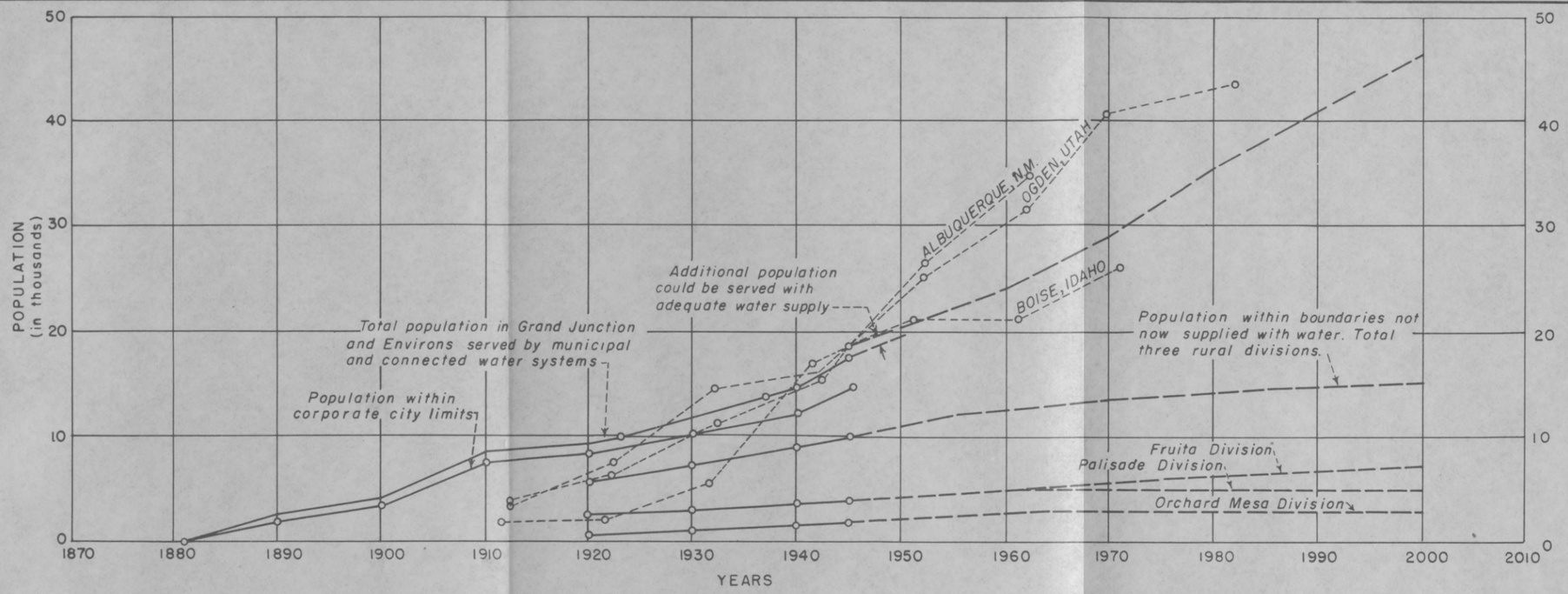
Population trend

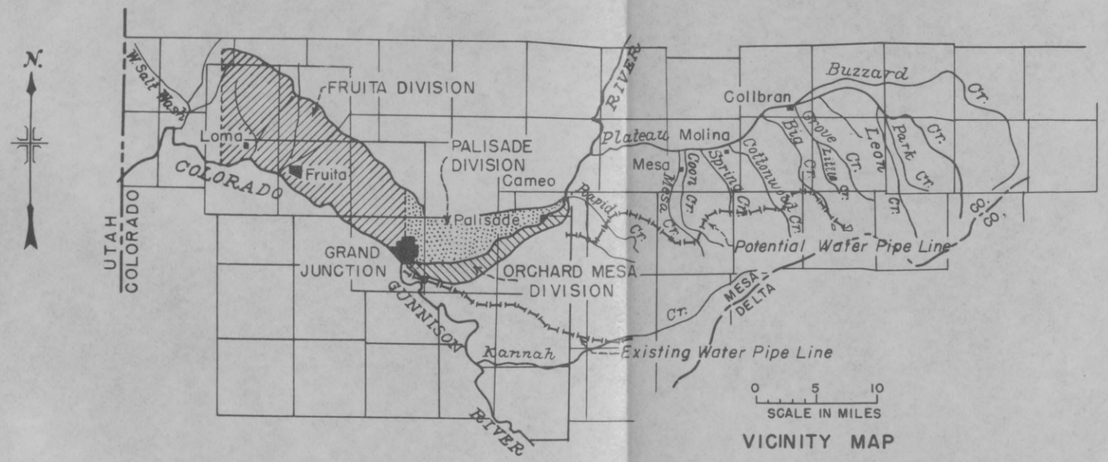
The Grand Junction, Palisade, and Fruita water systems serve approximately 23,500 people or 62 percent of the population of Grand Valley. The Palisade system is adequate for present needs and some future municipal needs. The Grand Junction and Fruita systems provide only enough water for present needs. Future growth will require the development of additional water supplies.

In order to determine future water requirements, a study of population trends was made for Grand Valley using data compiled by the engineering firm of R. J. Tipton & Associates, Inc., Denver, Colo. The results of this study are indicated graphically on drawing No. 482–P–32. The population of Grand Junction is expected to reach 20,500 by 1950 and to increase at a slightly accelerated rate to about 47,000 by the year 2000. The total population within Grand Valley, including Grand Junction, is expected to be 62,000 by the turn of the century. These estimates are based on a normal rate of municipal and rural expansion. Should large industrial development take place in the area, a much faster population growth would result.

Anticipated use of project municipal and domestic water

For purposes of analysis Grand Valley has been considered in four separate parts or divisions with respect to municipal and domestic water supply. The four divisions, as shown by the vicinity map on drawing No. 482–P–32, consist of the city of Grand Junction, the Fruita Division including the town of Fruita and the western portion of the valley, the Palisade division including the town of Palisade and the upper part of the valley north of the Colorado River, and the Orchard Mesa division embracing the eastern part of Grand Valley south of the river.





VICINITY MAP

NOTES

Populations shown for years 1890, 1900, 1910, 1920, 1930 and 1940 are those reported in U.S. Census, or calculated therefrom by difference or proportion.

Population in 1945 for City of Grand Junction calculated from water, electrical and telephone service connections.

Population of suburban area for 1945, 1940, and 1937 from city records of connections and number of consumers.

Population in 1923 for suburban area from Burns - Mc Donnell report on Improvements to City Water Works.

Rural population by divisions (see Vicinity Map) derived by proportion from ratio of persons that could be served with water to total rural farm population plus rural non-farm communities without water supplies as reported in 1940 census.

Other cities transposed along time scale to populations corresponding to that of Grand Junction in 1945 for comparative purposes.

NOTE:

Drawing based on data taken from Drawing No. 705-B by R.J. TIPTON AND ASSOCIATES INC., ENGINEERS.

REVISED: 3-16-49

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLLBRAN PROJECT-COLORADO

MUNICIPAL AND RURAL POPULATION

DRAWN J.R.M. SUBMITTED
TRACED J.R.M. RECOMMENDED
CHECKED R.L.B. APPROVED

GRAND JUNCTION, COLO. 1-17-49

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Although the present water supply of Palisade is adequate for some future municipal growth, it is inadequate to provide service to adjacent rural areas. A portion of the rural area embraced by each of these divisions was considered, therefore, in determining future domestic water requirements of the project. Domestic water systems would be extended only to the rural areas with fairly heavy concentrations of population which would not require excessively long supply lines. The rate of rural growth will determine the rate at which the water systems are extended. It is estimated that by the year 2000, 15 percent of the population of the Fruita division and 30 percent of the Palisade division would be served domestic water from the project.

The Orchard Mesa division is now without piped domestic water. It is made up of small communities rapidly becoming residential districts suburban to the city of Grand Junction. Residents of this area are pressing the city to extend water mains for their use. At least 50 percent of the people of this district are expected to be served domestic water from the project. The remaining population is so scattered that distribution would not be economically justified.

The project water supply and the present water supply of Grand Junction are believed adequate to meet the city's needs for domestic, municipal, and industrial purposes until after the year 2000.

WATER REQUIREMENTS

Use of municipal water

Grand Junction's future requirements for domestic and municipal water were estimated on the basis of past use. The present system can supply 430 gallons per capita daily, including nominal system losses, for the 18,500 people served. This is considered adequate to meet present peak demands of the city for domestic, industrial, and commercial uses. The maximum capacity of the system is fully utilized only during July and August. Less than 200 gallons per capita daily are required in the winter months. The yearly average is 300 gallons a day for each resident. Over-all annual use in the city amounts to approximately one-third acre-foot of water per capita.

The per capita use of water is expected to remain about the same over an extended period in the future. Requirements for maximum daily use, including treatment and distribution losses, are estimated at 420 gallons per capita. A small amount of water would be saved with the treatment of a larger volume of water, and the per capita use of domestic water would probably decrease as the city became more densely populated. Table 47 shows the present pattern of water use by the Grand Junction system and the estimated future demand. Quantities shown in the table include treatment and distribution system losses.

TABLE 47.—*Estimated requirements of Grand Junction for domestic and municipal water*

Month	Past pattern of use by Grand Junction [1]	Estimated future pattern of use	Estimated future requirement per capita	
			Gallons per day	Acre-feet per month
	Percent	*Percent*		
January	5.5	5.7	200	0.019
February	5.2	5.1	200	.017
March	5.8	5.7	200	.019
April	8.1	7.8	280	.026
May	10.9	10.8	380	.036
June	11.4	11.1	400	.037
July	12.0	12.0	420	.040
August	[2] 10.8	12.0	420	.040
September	11.2	10.8	390	.036
October	7.7	7.8	270	.026
November	5.7	5.5	200	.018
December	5.7	5.7	200	.019
Total	100.0	100.0	[3] 297	.333

[1] Based on the average use of water for domestic, municipal, and industrial purposes by the city of Grand Junction during the period 1942 to 1945, inclusive.
[2] Limited by available water supply.
[3] Average.

Service requirements

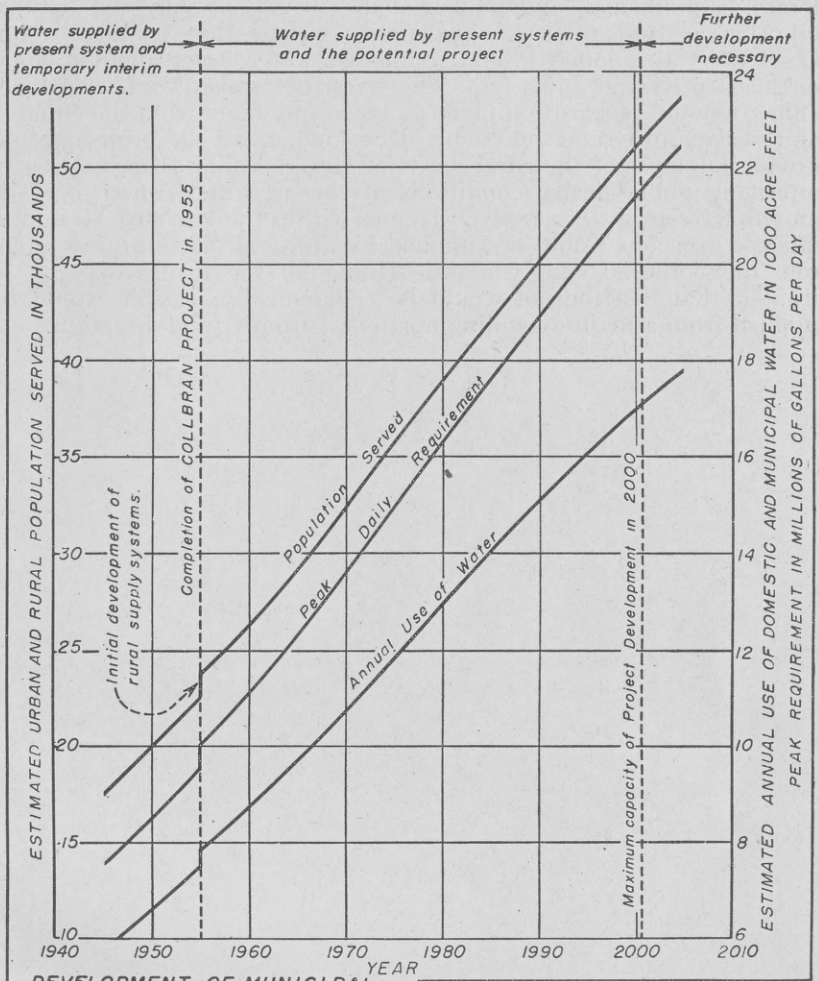
The municipal water supply system of Grand Junction is at present taxed to the limit of its capacity. There is no reserve to meet the growing needs that even next year may create a serious water shortage. The city must act at once, therefore, to provide more water. Temporary emergency measures may be necessary until a permanent long-range development can be made. If water should be available from the Collbran project by 1953, the interim emergency development would be small, amounting to an estimated additional capacity of 1 million gallons daily. The city is now investigating means of providing additional water for immediate needs. The purchase of water rights on the Kannah Creek watershed and the pumping of water from the Colorado River are being considered. Domestic water would not be made available to rural areas until larger developments were undertaken.

It is estimated that the potential Collbran project would adequately serve increased municipal and domestic water needs in Grand Junction and adjacent rural areas of Grand Valley for a period of 50 years. It could supply the maximum needs for a population of about 31,000. Drawing No. 482–P–29 shows the estimated service of domestic and municipal water by the project system. Estimates of future population include all rural and urban districts serviceable by the potential project. Water requirements are shown both by peak daily demand and total annual use. Although the drawing shows conditions based on project construction by 1955, the same general conditions would apply for any like period of similar population trends.

SPECIAL WATER TREATMENT

Because the watershed area from which domestic and municipal water would be piped is free of soluble salts and has a heavy vegeta-

tive cover, the project water is soft [1] and free from silt. It is of excellent quality and would require no special treatment other than filtration and chlorination. The reservoirs used for storage control



above the collection system, however, are subject to accumulation of algae, and they would require treatment to prevent undesirable effects of such growth.

[1] The total hardness of project waters has been estimated at less than 75 parts per million by the R. J. Tipton & Associates engineering firm of Denver, Colo.

POTENTIAL DEVELOPMENT

Project plan

As discussed in chapter I under Plan of Development, water for domestic, municipal, and industrial use would be delivered for distribution at the potential equalizing reservoir that would be constructed by the domestic and municipal water users about 4 miles northeast of Grand Junction. The water users also would construct a filtration and purification plant and a supply main from the equalizing reservoir to Grand Junction. Development of the project would provide for most of the rural needs of Grand Valley thereby greatly improving public-health conditions of the area and conserving the limited artesian water supply. Homes within the Orchard Mesa and Palisade divisions would be supplied by a lateral distribution system from the potential supply main. Homes of the Fruita division so situated that distribution would be economically feasible would be supplied from a main extending northwest from Grand Junction.

CHAPTER VII

OTHER PROJECT USES

FISH AND WILDLIFE CONSERVATION

Requirements for fish and wildlife protection

Findings of the Fish and Wildlife Service in its study of the potential project are discussed in a report dated March 1948, which is included in full as part of these substantiating materials. The Service recommended certain provisions, discussed below, for the full protection of existing resources and for the most beneficial use of potential developments.

1. When Vega Reservoir has been filled to maximum capacity, excess flow of Leon Creek should be bypassed down the natural creek channel rather than spilled from the reservoir into Plateau Creek. This would add to the fishery values of the 5-second-foot-minimum bypass as planned to satisfy downstream water rights.

2. The reservoirs of the Big Creek and Cottonwood Creek systems should be so operated that water from the enlarged natural lakes would be drawn first. On the remaining reservoirs, the rates of draw-down should be in proportion to the reservoir's maximum capacities so that the largest possible minimum pools could be maintained in all cases.

3. Reservoir releases should be made by gradual opening and closing of gates to prevent sudden changes in water surface elevation. Gradual reservoir releases also would bring about slow changes in stream runoff below the dam, thus preventing downstream wash-outs.

4. Big Creek is considered by the Fish and Wildlife Service to have a greater fishery value than Cottonwood Creek. It was therefore recommended that the maximum possible diversion be made from the natural flow of Cottonwood Creek in order that a larger flow might be maintained in Big Creek.

5. To prevent fish losses in canals and turbines, fish barriers and screens would be required at canal and pipeline intakes. A drop or fish barrier would be required in the chute leading from the Leon Park feeder canal into Vega Reservoir to prevent detrimental upstream migration of fish during the spawning season. Bar-type fish screens would be needed at the pipeline intakes on Bonham and Big Meadows Reservoirs, and rotary-type fish screens would be needed at feeder canal headings.

Contemplated measures for fish and wildlife protection

The provisions recommended by the Fish and Wildlife Service would have no adverse effect on other phases of the project and have been incorporated in the plan of development.

The diversion structure for the Leon-Park feeder canal has been so designed that the stream flow could be diverted or bypassed as desired. Therefore, water that would normally be spilled from Vega Reservoir

or released to lower Plateau Creek users could be allowed to flow down the channel of Leon Creek.

Under the development plan the collection pipeline system would first utilize storage from the more remote reservoirs, including the enlarged natural lakes. The larger reservoirs of the Big Creek system would provide final control of diversions. Water could be released from the reservoirs at rates approximately proportional to reservoir capacity without a decrease in project efficiency. Gradual changes in rates of reservoir releases could also be made.

The capacities of the pipeline collection system (Bonham intake, 30 second-feet, and Big Meadows intake, 15 second-feet) would permit considerable flexibility of operation in the diversion of natural flow. With the maximum divertible flow of Cottonwood Creek supplied to the pipeline, larger flows in Big Creek below Bonham could be maintained to keep the stream's high fishery values. Such operation would not change the amount of water required from Plateau Valley for replacement of water diverted. It would merely require larger replacements for Cottonwood Creek lands with correspondingly smaller replacements for Big Creek lands. Table 48 shows the average Big Creek flows recommended by the Fish and Wildlife Service and the flow that can be maintained by the project without detrimental effects to other uses. The table is based on water-supply records for the period 1920–45, inclusive.

Fish screens and barriers would be constructed as part of the project. Their estimated cost has been included in the total construction costs of the project.

TABLE 48.—*Estimated average flow of Big Creek below Bonham Reservoir with project operation*

[Unit: second-feet]

Month	Recommended average flow	Average flow without exchange	Additional flow available through exchange	Total flow under modified plan of operation
1	2	3	4	5
October	8.0	3.5	4.5	8.0
November	3.5	3.5		3.5
December	3.5	3.5		3.5
January	3.5	3.5		3.5
February	3.5	3.5		3.5
March	3.5	3.5		3.5
April	3.5	3.5		3.5
May	18.0	13.0	5.0	18.0
June	20.0	44.0		44.0
July	16.0	12.0	4.0	16.0
August	10.0	5.0	5.0	10.0
September	10.0	5.0	5.0	10.0

Column 2: Average flow recommended by Fish and Wildlife Service.
Column 3: Average flow under the plan adopted for project water operation studies.
Column 4: Additional flow that would be made available through exchange of Cottonwood Creek water for Vega Reservoir storage which otherwise would have been utilized for replacement to Big Creek lands.
Column 5: Average flow of Big Creek below Bonham Reservoir under the modified plan of operation. Such operation would not be adverse to other water uses of the project.

Effect of project on fish and wildlife resources

Development of the project, and particularly the enlargement of the Bonham Reservoir, would improve reservoir fishery conditions in the area. The project, however, would lower the values of stream fishing, the most significant stream losses being expected on Leon,

Plateau, Cottonwood, and Big Creeks. Its over-all effect on fishing conditions is expected by the Fish and Wildlife Service to result in a net annual benefit of $9,600.

Inundation of 240 acres of range land by Vega Reservoir would result in a loss in the value of big game (elk and deer), while the value of the waterfowl habitat would be increased by the construction of Vega Reservoir, enlargement of Bonham Reservoir, and maintenance of more uniform water surfaces on other reservoirs. The exchange of Cottonwood Creek water to augment flows of Big Creek would maintain the value of fur animals. The development would not affect upland game. The over-all effect of the project on wildlife habitats is expected by the Fish and Wildlife Service to result in a net annual loss in value of $300. With the suggested modified plan of development, therefore, the effect of the project on both fish and wildlife would result in a net annual benefit of $9,300.

RECREATION

The degree to which recreation could be developed on the watersheds from which a domestic supply is to be obtained would be governed by limitations imposed by the domestic water users and various agencies in the interests of public health and management. This report, therefore, fully considers the recreational potentialities of the project but does not include the construction of recreational facilities in the project plan nor the cost of such facilities in the estimated cost of project construction. For a full appraisal of all advantages which might result from project development, however, the benefits and costs which would accrue from full development of recreation have been considered in the analysis of project benefits and costs discussed in chapter VIII. Recreational facilities could be provided at any time after project construction without materially altering any project feature.

Need for development

A report of the National Park Service dated December 1947, summarizing its investigations of the recreational aspects of the Collbran project, is included in full as part of these substantiating materials. This report refers to a report by the Fish and Wildlife Service compiled in November 1946 which has since been revised in accordance with the present project plan. The revisions made, however, would have no material effect on the National Park Service's appraisal of recreational values. It is the revised Fish and Wildlife Service Report that is discussed in the preceding section and that is included with these substantiating materials.

The National Park Service Report points out that the number of visitors to Grand Mesa is continuously increasing, with the resultant need for additional recreational development in the area. Areas where good recreational facilities exist, particularly in the southwestern portion of the mesa, are so overused that much of their desirability is lost. Other areas, however, particularly in the mesa's northeastern portion where the project features would be constructed, have good recreational possibilities but are unused as no facilities are available. Development of recreational facilities at the Vega site is desirable to

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lengthen the area's recreational period as the higher reaches of Grand Mesa cannot be reached by car during the early and late seasons.

Potential recreational development

The National Park Service has recommended development of recreational facilities for only Bonham and Vega Reservoirs, the two major storage features of the project. Other storage features of the project would have good fishery value, but their relative inaccessibility would make extensive recreational development undesirable.

Vega Reservoir.—The National Park Service recommends that only limited recreational facilities be established at this reservoir as it would achieve only local significance for recreation. The facilities would consist of a public campground and provisions for the landing and launching of small boats. Pit toilets would be adequate for the moderate anticipated use, and potable water facilities would be desirable if found economically feasible. The most attractive sites for the development of recreational facilities lie along the south side of the potential reservoir in timber groves. Such sites would be accessible by a road planned for construction around the reservoir to provide access to existing farmsteads. Short spurs and parking areas would have to be constructed at the camping grounds.

Bonham Reservoir.—Recreational use of Bonham Reservoir should be much broader than that of Vega Reservoir. The reservoir would help to relieve overcrowded conditions at other recreational points on Grand Mesa. Careful planning must be made to the end of meeting immediate recreational needs with sufficient flexibility to provide for larger requirements of the future. On this basis the National Park Service recommends the following developments for this reservoir:

1. Picnic and camping areas planned for suitable expansion with proved need.
2. Pier and boat-launching arrangements.
3. Lodge with overnight accommodations, including overnight and housekeeping cabins and boat rental facilities. This would be a concession development.
4. One organized or group camp.
5. Utilities: Potable water; sewage disposal; power distribution (if and when available).
6. Access roads and parking areas.
7. Employees' residences and utility area. (These items would be contingent upon the needs of the administrative agency. Should, as seems probable, the Forest Service be the administrative agency, there would probably be no need for such items at Bonham Reservoir. Other such facilities on Grand Mesa would be ample.)

Unless there is a need for very extensive development of facilities in the future, the east side of the reservoir would provide the best sites for camping areas. That side of the reservoir is paralleled by the main road from Collbran, and good accesses to the camping area would be provided by the construction of short spurs and parking areas.

Estimated cost and returns of development

The cost of constructing the recommended recreational facilities has been estimated by the National Park Service at $13,300 for Vega Reservoir and $166,000 for Bonham. One half the cost at Bonham,

or $83,000, would be borne by the concessioner and repaid from resort income including the rental of cabins and boats. The total construction costs amortized over a 30-year period (estimated life of major facilities) at 3 percent interest would amount to about $700 annually at Vega Reservoir and $8,400 annually at Bonham Reservoir. Annual operation and maintenance costs of recreational facilities are estimated at $400 for Vega and $3,500 for Bonham. It is expected that replacement costs during the amortization period, amounting to an estimated $3,400 for Vega and $33,000 for Bonham, would be paid from concessioner receipts.

The gross postproject recreational value of the project would be $33,600 annually as estimated by the Park Service. Of this total, $1,100 would be attributed to increased recreational use of Vega Reservoir and $32,500 to Bonham. These annual values are exclusive of fishery benefits. Tables 49 and 50 summarize the estimated recreational costs and returns of the project.

TABLE 49.—*Construction costs of recreational facilities*

Area	Development cost		Total cost	Annual cost (30 years at 3 percent)
	Nonrepayable	Repayable		
Vega Reservoir	$13,300		$13,300	$700
Bonham Reservoir	83,000	[1] $83,000	166,000	8,400
Total	96,300	83,000	179,300	9,100

[1] Repayable from concessioner receipts.

TABLE 50.—*Summary of annual costs and values of recreational facilities*

Area	Annual cost	Annual operation and maintenance	Total annual cost	Annual value [1]	Net annual value
Vega Reservoir	$700	$400	$1,100	$1,100	
Bonham Reservoir	8,400	3,500	11,900	32,500	$20,600
Total	9,100	3,900	13,000	33,600	20,600

[1] Exclusive of fishery value.

Evaluation of benefits

Both Bonham and Vega Reservoirs are easily reached by automobile and would open fine recreational areas to public use. Improved facilities of Bonham Reservoir would not be in competition with other areas on Grand Mesa but would increase recreational values of the entire area through a more uniform use. The local population would receive greatest advantage from Vega Reservoir during the early and late seasons of the year. Both reservoirs would have greater fishing appeal. Boating would be possible on both reservoirs, and because of its lower elevation Vega Reservoir would afford swimming. Bonham Reservoir would provide excellent opportunity not only for fishing and boating but also for picnicking, camping, hiking, horseback riding, and other forms of recreation associated with high mountain areas.

The net annual monetary benefit that would result from full recreational development of the project features is estimated by the National

Park Service to be $15,600. This entire benefit would be attributable to the development of Bonham Reservoir facilities. Although the recreational value of Vega Reservoir would be enhanced by about $1,100 annually, the Park Service believes the benefits would be offset by the attendant costs of construction, operation, and maintenance.

FLOOD CONTROL

The protected nature of the Plateau Creek drainage area minimizes the possibility of extreme floods. The lower watersheds of main Plateau Creek and Buzzard Creek are subject to minor flash floods from cloudburst storms. These storms occur during the late summer after the heavy spring runoff of other tributaries has receded. There is, however, no record of any significant flood damage having occurred in Plateau Valley in the past.

Construction of Vega Reservoir and enlargement of Bonham Reservoir would provide almost complete control of Plateau and Big Creeks, thus reducing heavy stream runoff during the spring of the year. Normal operation of these reservoirs for irrigation would also tend to lessen the effects of summer storms. It is apparent, therefore, that some minor flood-control benefit would result from the project. As there is no serious flood hazard in the area, however, flood protection furnished by the project would be negligible and would have no significant monetary value.

SEDIMENT CONTROL

The high altitude of the watershed of Plateau Creek and its tributaries and the heavy vegetation with which the watershed is covered result in clear water runoff. Therefore the project could have no measurable effect on silt and debris control.

DRAINAGE

No drainage problem exists on the arable lands of the project area as the soil characteristics and topography provide good natural drainage. No drainage problems are expected to develop under project operation.

The present practice of overirrigation in the spring of the year has resulted in the saturation of some low lands along the Plateau Creek channel below the irrigable lands of the project. With more uniform application of water on higher lands under project operation, it is possible that this condition would be alleviated to some extent. Such benefit would be small, however, and its monetary value would be insignificant. The saturated areas occur in small scattered tracts of questionable soil quality. Drainage would, therefore, not be economically justified.

STREAM POLLUTION ABATEMENT

Stream pollution abatement would not present any problem in project development as the project streams originate on a high, unpolluted watershed.

NAVIGATION

None of the project streams is navigable.

CHAPTER VIII

FINANCIAL ANALYSIS

National benefits and costs resulting from project development are analyzed as annual equivalent values. It is essential, therefore, that a common period be established to provide a basis for computations. For the benefit-cost analysis of this report, the useful life of the project, estimated as 100 years, was selected as the common time basis. Considering the very low silt content of the project streams, at and above the elevations of the potential storage features and canals, the useful life of the earth structures, including Vega and Bonham Dams, Southside canal, feeder canals, and ditches, has been estimated to be 150 years with proper maintenance. Because most of the project works are earth structures, the project would be expected to remain in operation as long as these structures were useful. Because of uncertain conditions over such an extended period, however, the over-all life of the project was conservatively estimated as 100 years.

Many of the project works, such as pipelines, power facilities, bridges, headgates, and canal turn-outs, would require periodic replacements for efficient operation during the life of the project. The cost of such replacements has been considered in the annual equivalent costs which are discussed later in this chapter. An interest rate of 2.5 percent has been considered in studies of Federal funds expended and revenues received. It is considered that such funds would have an equivalent value if used for other purposes.

BENEFITS

Direct irrigation benefits

The direct irrigation benefits that would be realized from project development consist of the increase in income from agricultural products and services that would result from the improved water supply. Therefore, the increased earnings of the land and water, labor, invested capital, and management involved in production constitute a measure of the net direct national benefits from irrigation. Such increased earnings are readily susceptible of monetary evaluation from an analysis of the agricultural economy without project development as compared with that expected after the project has been constructed. An analysis of this nature was discussed in chapter IV. The tabulation on the following page presents a summary of the factors involved and the net annual national direct benefit to irrigation that would result from project development.

Increases in annual income:	
Receipts from sale of produce	$189, 500
Farm privileges	10, 800
Total income from farm	200, 300
Increases in annual expenses:	
Interest costs	16, 300
Hired labor	18, 500
Other expenses [1]	21, 400
Total	56, 200
Annual direct benefits:	
Direct benefits to project farmers	144, 100
Direct benefits to others (interest costs+hired labor)	34, 700
Total direct benefits	178, 800

[1] Other expenses include such operational costs as seed, fertilizer, supplemental feeds, range fees, stock replacements, veterinary fees, etc.

Direct power benefits

National direct power benefits would consist of the increase in usable energy delivered for sale as a result of project development. The monetary value of these benefits is measured by the gross revenues expected from the sale of the power produced. These estimated gross power revenues are shown in the following tabulation:

Annual revenues from power:	
Sale of firm energy (51,600,000 kilowatt-hours, at 5.6 mills)	$288, 960
Sale of nonfirm energy (6,670,000 kilowatt-hours, at 3 mills)	20, 000
Annual direct power benefits	308, 960

Domestic and municipal water supply benefits

The benefits from the use of water for drinking and other domestic, commercial, and municipal purposes are measured by the cost of the cheapest alternative source of new equivalent water. Since a water supply is indispensable to any community, a separate justification of the cost of such an alternative development is not necessary.

The Collbran project would provide water of excellent quality for domestic and municipal use in Grand Valley. The water users would provide an equalizing reservoir and facilities for ultimate distribution. Since any other development to supply the valley municipal water would require construction of essentially these same facilities by local interest, the alternative cost to be considered would be that of supplying water equivalent in quality and quantity to project water. From rough studies made by the Bureau of Reclamation and detailed investigations conducted by R. J. Tipton & Associates, engineering firm for the city of Grand Junction, it was determined that drawing of water from the Colorado River would be the cheapest alternative means of supplying such water. The Colorado River water, however, would require extensive treatment for the removal of water hardness (soluble salts) before it would be equal in quality to the project water. The cost of chemicals for such treatment has been estimated at $50 per million gallons of water. The use of Colorado River water would also require the construction of extensive treatment facilities, a supply line, and pumping facilities. The minimum annual cost of pumping would be about $13 per million gallons of water.

The use of water for domestic and municipal purposes is expected to increase with the population at a more or less uniform rate during the first 50 years of project operation. At the end of that period it is anticipated that a population of approximately 31,000 would be receiving a full, usable supply of 3,350 million gallons annually. An average annual supply of about 2,000 million gallons would be provided during the period. During the second 50-year period a full supply of 3,350 million gallons of water is expected to be used each year. Therefore, over the 100-year expected life of the project an average of approximately 2,670 million gallons would be supplied annually. This average supply would cost approximately $203,500 annually for water treatment, pumping, and amortization of capital costs of required structures over 100 years at 2.5 percent interest. This cost is the monetary measure of the average annual benefit resulting from the project municipal water supply.

Fish and wildlife conservation benefits

The Fish and Wildlife Service has appraised the annual values of fish and wildlife resources of the area at $18,600 under present conditions and at $27,900 with project development. The net annual gain in value of $9,300 expected to result from the project is taken by the Service as the measure of the benefit to fish and wildlife.

Recreational benefits

The National Park Service estimates a net annual increase in recreational value of $15,600 would result from project development, and this increase is taken by the Service as a measure of the project's benefit to recreation. Realization of the entire benefit, however, is contingent upon the provision of adequate recreational facilities, the cost of which is further discussed in this chapter under the section on benefit-cost ratio.

Indirect irrigation benefits

Besides the direct tangible benefits already discussed, the project would bring significant and valuable national benefits as a result of its stimulating effect on business and industry involved in the processing of farm goods. Such national benefits would be of an indirect nature but are measurable in monetary value.

Indirect benefits from irrigation of project lands would result from the processing of additional agricultural products and from increased local sales of goods and services. Processing benefits would include the increased value of merchandising, industrial processing, and wholesale and retail trade involved in the conversion of agricultural produce into consumer goods. The benefits realized from local sales of goods and services would consist of the increased expenditures made by local inhabitants for transportation, consumer goods, and public and professional services. The estimated annual values of these indirect irrigation benefits are shown in the following tabulation.

Indirect benefit:	*Annual value*
Processing and merchandising of increased agricultural products	$115, 600
Increased local sales of goods and services	45, 000
Total	160, 600

Indirect power benefits

Indirect power benefits would result from the distribution and final utilization of power generated by the project. The value of such benefits is determined through consideration of three separate elements discussed below.

Benefit B–1.—The saving in production cost to utilities purchasing power from the Bureau for resale and assumed to be passed on to the consumer;

Benefit B–2.—A proportionate share in the retailing utilities benefits arising from resale of Bureau power to ultimate consumer at higher rates;

Benefit B–3.—A proportionate share in the increased value of the goods and services produced by final utilization of Bureau power.

From estimated production costs and studies of past use of electrical energy in the potential power market area, these annual indirect benefits have been evaluated as follows:

Benefit B–1	$74, 590
Benefit B–2	155, 920
Benefit B–3	21, 230
Annual indirect benefit	251, 740

Intangible benefits

In addition to the measurable benefits that would be realized from the project, real and very valuable contributions of an intangible nature would be made to the public welfare and national security. Although these benefits are not susceptible of monetary evaluation, they are important to national morale and economy. Through an enlarged agricultural industry, resulting from improved irrigation, more and better farm homes could be furnished, economic opportunities would be enhanced, more labor would be employed, and incomes would be stabilized. Increased generation of electric energy would also provide greater employment opportunities by making possible greater industrial development. The morale of the local population would be raised by an increased standard of living which would be provided from the use of electrical appliances. Project power would help meet the great need for energy for local processing or uranium ores that would arise in case of national emergency. An improved domestic and municipal water supply would provide for community and industrial development. Rural residents, who must now use ditch water for domestic purposes, would enjoy piped culinary water. Intangible benefits would also be far reaching in scope.

BENEFIT-COST RATIO

Annual equivalent costs

Project construction costs.—To determine the ratio of benefits to costs, the costs were considered on the same basis as the benefits previously discussed. Annual equivalent values were established for the costs by amortization of the initial cost of project development over a 100-year period at 2.5 percent interest. Proper allowance was made for interest costs during project construction and salvage values of structures which would be useful after the 100-year period of

analysis. The annual equivalent costs of project development thus determined, including the cost of full recreational development, were found to be approximately $364,700.[1]

Operation, maintenance, and replacement costs.—The costs of operation, maintenance, and replacement of project works were also considered over a 100-year period of project operation. Such costs, with the exception of those chargeable to the generation of power, were based on average prices for the period 1939–44, which are believed indicative of average prices for such items over an extended period in the future. The costs chargeable to power were based on current prices in accordance with present Bureau policy.

Computed on the bases discussed above, the total operation, maintenance, and replacement costs of project works, including those chargeable to recreation, were estimated at $118,100. Replacements were computed on a sinking-fund basis at 2.5-percent interest over 100 years.

Indirect costs.—In addition to the costs already discussed, the project would involve increased private capital costs. Such costs would include the increased annual capital investment in equipment, labor, operation, and maintenance, and larger-scale business. The indirect cost thus incurred has been considered as a negative benefit in the computation of national benefits and, therefore, it need not be separately evaluated at this time.

Summary of costs.—The total annual equivalent costs of project development are summarized as follows:

Project construction	$364, 700
Operation, maintenance, and replacements	118, 100
Total annual costs	482, 800

Summary of benefits

Tangible benefits.—The annual direct and indirect tangible benefits are summarized in table 51.

TABLE 51.—*Summary of annual tangible benefits*

Project use	Annual benefit		
	Direct	Indirect	Total
Irrigation	$178, 800	$160, 600	$339, 400
Power	308, 960	251, 740	560, 700
Domestic and municipal water supply	203, 500		203, 500
Fish and wildlife	9, 300		9, 300
Recreation	15, 600		15, 600
Total	716, 160	412, 340	1, 128, 500

Ratio of project benefits to costs

To illustrate the degree of desirability of developing the project, the estimated national annual benefits ($1,128,500) are compared with annual equivalent costs ($482,800). This comparison results in a ratio of benefits to costs of 2.34 to 1. Thus each dollar expended would result in a national benefit of approximately $2.34.

[1] Capital cost of full recreational development recommended by National Park Service would be $179,300,

PROJECT COSTS AND COST ALLOCATIONS

Project costs

Considered in project repayment are the total construction costs estimated at current prices and annual expenditures that would be required for efficient operation and maintenance of project works over the repayment period. Beginning with the completion of project construction, a period of 60 years would be required for full retirement of the capital investment. Annual operation and maintenance costs would consist of the average expenditures required for overhead, operation, and upkeep of works each year to obtain proper efficiency. Included in the annual operation and maintenance costs would be an allowance for needed replacements of works which would normally be expected to fail during the repayment period. Such replacement costs have been based on the estimated useful lives of the individual project works and were computed as an average annual sinking-fund deposit that would be required over the 60-year period at 3 percent interest. The annual operation, maintenance, and replacement costs, with the exception of those charged to power, are based on average prices of the 1939–44 period. Annual power costs are based on current prices in accordance with Bureau of Reclamation policy. It is expected that the prices which prevailed during that period would reflect those over an extended period in the future.

The total cost of project construction at current prices would be $13,299,000, exclusive of nonreimbursable expenditures from Colorado River development funds for investigations and surveys. An annual expenditure of $108,800 would be required to maintain full efficiency of the project during the 60-year repayment period. Costs of recreational development are not included in present repayment estimates, since the development of recreational facilities would not require any modification of the project plan and would be contingent on later findings of desirability by other agencies. Recreational facilities could be constructed at any time in the future after the start of project operation.

Cost allocations

Allocation of construction costs.—The most suitable basis for allocating project construction costs was found to be an average of the results of the priority-of-use and alternative-justifiable-expenditure methods. With the costs allocated on this basis, all project uses would share in the economy of multiple-purpose development. No one purpose would be charged more than the capitalized value of its tangible benefits and each purpose would realize a saving over the cost of its respective cheapest alternative development.

Table 52 presents a summary of project cost allocations as computed by the priority-of-use method averaged with the alternative-justifiable-expenditure method. Subject to approval by the Secretary of the Interior, a nonreimbursable allocation of $257,000 has been made to the conservation of fish and wildlife. This allocation is based on the value that would be realized with the annual benefits from fish and wildlife conservation capitalized at 3 percent interest over a 60-year project repayment period.

TABLE 52.—*Allocation of construction costs*

Project purpose	Allocation of capital costs		
	Priority-of-use method	Alternative-cost method	Average
Irrigation	$4,026,000	$3,948,000	$3,987,000
Power	6,281,000	6,345,000	6,313,000
Municipal and domestic uses	2,735,000	2,749,000	2,742,000
Fish and wildlife	257,000	257,000	257,000
Total	13,299,000	13,299,000	13,299,000

Allocation of operation and maintenance costs.—The annual costs of project operation and maintenance, including replacements, have been allocated among the project uses by the priority-of-use method. Table 53 shows the allocations made. Operation and maintenance costs of fish and wildlife structures would be negligible and have been provided for in the annual costs of Bonham and Vega Reservoirs.

TABLE 53.—*Allocation of annual costs for project operation, maintenance, and replacement of works*

Item	Allocation of annual costs			Total [1]
	Power	Irrigation	Municipal and domestic water	
Project operation and maintenance	$55,900	$20,500	$2,000	$78,500
Replacement of works	24,100	500	5,800	30,300
Annual cost	80,000	21,000	7,800	108,800

[1] All annual costs are based on average prices for the period 1939–44 with the exception of power costs which are based on July 1948 prices.

PROJECT REPAYMENT

The allocation to fish and wildlife is considered nonreimbursable. Costs allocated to irrigation, power, and municipal water would be repaid. These costs would be paid from power and municipal water revenues over a 60-year period and from irrigation payments over a 50-year period.

Domestic and municipal water supply repayment

Users of domestic and municipal water could be charged at an annual rate of $78,880 in addition to operation, maintenance, and replacement costs. This would be adequate to retire the capital investment over a period of 60 years at 2-percent interest. A total of $1,991,001 in interest would be returned to the United States Treasury during the 60 years of repayment.

Power repayment

To repay the capital investment allocated to power with 3-percent interest over the 60-year repayment period and provide for annual costs of operation, maintenance, and replacements, it would be necessary to sell power at a rate of 5.6 mills per kilowatt-hour for firm energy and 3 mills for nonfirm energy. The total annual revenue from power generated by the project would be $308,960. This would fully repay all power costs and provide a surplus of $139,016 of power revenue at the end of the sixtieth year. The interest component,

amounting to $7,285,584 in 60 years, would pay $2,987,000 toward the irrigation allocation and still provide the United States Treasury $4,298,584 for other purposes. If firm power were sold for 6 mills a kilowatt-hour for the first 6 years of project operation and 5.5 mills thereafter, retirement of costs allocated to power could be accomplished in 60 years. If all firm power were sold at 5.5 mills, however, 64 years would be required for repayment.

Irrigation repayment

It was shown in chapter IV that revenues from irrigation would provide a total of $41,000 annually for debt retirement and for operation, maintenance, and replacements. On the basis of operation, maintenance, and replacements costing about $0.73 an acre, it was shown that $15,200 annually would be required for these purposes and $25,800 would be available for debt retirement. Detailed studies, however, indicate that annual costs allocable to irrigation would amount to about $1.01 an acre, or a total of $21,000, leaving $20,000 for payment of capital costs. A 3-year development period would be desirable after the first delivery of project water for irrigation and before irrigators were charged capital costs in order that they could fully prepare and improve the lands for operation under the project. After the development period, however, the irrigators would make annual payments of $20,000 for 50 years, amortizing $1,000,000 of the irrigation capital allocation. Payment of the remaining $2,987,000 would require 41-percent of the interest component on the power allocation. Irrigators would pay their allocation of operation, maintenance, and replacement costs throughout the 60-year period required for total project repayment.

Fish and wildlife nonreimbursable cost

The net annual gain in fish and wildlife resources of the project area would amount to $9,300. An annual value of this amount, capitalized at 3 percent interest over a 60-year period, would constitute a total of $257,000 in nonreimbursable construction costs.

Pay-out schedule

The repayment schedule on the following page has been prepared from an analysis of annual project revenues and disbursements for the recommended 60-year repayment period.

REPAYMENT ORGANIZATION

A water-conservancy district, which is authorized by Colorado statutes, would be the most desirable contracting entity for the project. Such a district may include not only lands to be irrigated by a project but municipalities, industries, utilities, and others which would be directly or indirectly benefited by the project. Such districts have a limited power to tax property within their boundaries for general district purposes as well as the authority to contract for the delivery and sale or lease of water for irrigation, municipal, and industrial use. Such a district would also have centralized control of the project water supply, the operation and maintenance of the project, and all other business affairs of the project. Colorado law also permits the organization of water users' associations, mutual irrigation companies, and irrigation districts, but the powers of such entities are too restricted for the project.

Table 54
PROJECT PAYOUT SCHEDULE

Project year	Irrigation: Revenue	Irrigation: Annual costs	Irrigation: Repayment of capital	Power: Revenue	Power: Annual costs	Power: Interest on investment: Total	Power: Interest on investment: Irrig. subsidy	Power: Interest on investment: Fed. repayment	Power: Repayment of capital	Domestic and municipal use: Revenue	Domestic and municipal use: Annual costs	Domestic and municipal use: Interest on investment	Domestic and municipal use: Repayment of capital	Balance outstanding: Irrigation	Balance outstanding: Power	Balance outstanding: Domestic and municipal use	Balance outstanding: Project total	Earned surplus	Project year
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0														$3,987,000	$6,313,000	$2,742,000	$13,042,000		0
1	$21,000	$21,000		$308,960	$80,000	$189,390		$189,390	$39,570	$86,680	$7,800	$54,840	$24,040	3,987,000	6,273,430	2,717,960	12,978,390		1
2	21,000					188,203		188,203	40,757			54,359	24,521	3,987,000	6,232,673	2,693,439	12,913,112		2
3	21,000					186,980		186,980	41,980			53,869	25,011	3,987,000	6,190,693	2,668,428	12,846,121		3
4	41,000		$20,000			185,721	$61,000	124,721	43,239			53,369	25,511	3,906,000	6,147,454	2,642,917	12,696,371		4
5	184,424					184,424		123,424	44,536			52,858	26,022	3,825,000	6,102,918	2,616,895	12,544,813		5
6						183,088		122,088	45,872			52,338	26,542	3,744,000	6,057,046	2,590,353	12,391,399		6
7						181,711		120,711	47,249			51,807	27,073	3,663,000	6,009,797	2,563,280	12,236,077		7
8						180,294		119,294	48,666			51,266	27,614	3,582,000	5,961,131	2,535,666	12,078,797		8
9						178,834		117,834	50,126			50,713	28,167	3,501,000	5,911,005	2,507,499	11,919,504		9
10						177,330		116,330	51,630			50,150	28,730	3,420,000	5,859,375	2,478,769	11,758,144		10
11						175,781		114,781	53,179			49,575	29,305	3,339,000	5,806,196	2,449,464	11,594,660		11
12						174,186		113,186	54,774			48,989	29,891	3,258,000	5,751,422	2,419,573	11,428,995		12
13						172,543		111,543	56,417			48,391	30,489	3,177,000	5,695,005	2,389,084	11,261,089		13
14						170,850		109,850	58,110			47,782	31,098	3,096,000	5,636,895	2,357,986	11,090,881		14
15						169,107		108,107	59,853			47,160	31,720	3,015,000	5,577,042	2,326,266	10,918,308		15
16						167,311		106,311	61,649			46,525	32,355	2,934,000	5,515,393	2,293,911	10,743,304		16
17						165,462		104,462	63,498			45,878	33,002	2,853,000	5,451,895	2,260,909	10,565,804		17
18						163,557		102,557	65,403			45,218	33,662	2,772,000	5,386,492	2,227,247	10,385,739		18
19						161,595		100,595	67,365			44,545	34,335	2,691,000	5,319,127	2,192,912	10,203,039		19
20						159,574		98,574	69,386			43,858	35,022	2,610,000	5,249,741	2,157,890	10,017,631		20
21						157,492		96,492	71,468			43,158	35,722	2,529,000	5,178,273	2,122,168	9,829,441		21
22						155,348		94,348	73,612			42,443	36,437	2,448,000	5,104,661	2,085,731	9,638,392		22
23						153,140		92,140	75,820			41,715	37,165	2,367,000	5,028,841	2,048,566	9,444,407		23
24						150,865		89,865	78,095			40,971	37,909	2,286,000	4,950,746	2,010,657	9,247,403		24
25						148,522		87,522	80,438			40,213	38,667	2,205,000	4,870,308	1,971,990	9,047,298		25
26						146,109		85,109	82,851			39,440	39,440	2,124,000	4,787,457	1,932,550	8,844,007		26
27						143,624		82,624	85,336			38,651	40,229	2,043,000	4,702,121	1,892,321	8,637,442		27
28						141,064		80,064	87,896			37,846	41,034	1,962,000	4,614,225	1,851,287	8,427,512		28
29						138,427		77,427	90,533			37,026	41,854	1,881,000	4,523,692	1,809,433	8,214,125		29
30						135,711		74,711	93,249			36,189	42,691	1,800,000	4,430,443	1,766,742	7,997,185		30
31						132,913		71,913	96,047			35,335	43,545	1,719,000	4,334,396	1,723,197	7,776,593		31
32						130,032		69,032	98,928			34,464	44,416	1,638,000	4,235,468	1,678,781	7,552,249		32
33						127,064		66,064	101,896			33,576	45,304	1,557,000	4,133,572	1,633,477	7,324,049		33
34						124,007		63,007	104,953			32,670	46,210	1,476,000	4,028,619	1,587,267	7,091,886		34
35						120,859		59,859	108,101			31,745	47,135	1,395,000	3,920,518	1,540,132	6,855,650		35
36						117,616		56,616	111,344			30,803	48,077	1,314,000	3,809,174	1,492,055	6,615,229		36
37						114,275		53,275	114,685			29,841	49,039	1,233,000	3,694,489	1,443,016	6,370,505		37
38						110,835		49,835	118,125			28,860	50,020	1,152,000	3,576,364	1,392,996	6,121,360		38
39						107,291		46,291	121,669			27,860	51,020	1,071,000	3,454,695	1,341,976	5,867,671		39
40						103,641		42,641	125,319			26,840	52,040	990,000	3,329,376	1,289,936	5,609,312		40
41						99,881		38,881	129,079			25,799	53,081	909,000	3,200,297	1,236,855	5,346,152		41
42						96,009		35,009	132,951			24,737	54,143	828,000	3,067,346	1,182,712	5,078,058		42
43						92,020		31,020	136,940			23,654	55,226	747,000	2,930,406	1,127,486	4,804,892		43
44						87,912		26,912	141,048			22,550	56,330	666,000	2,789,358	1,071,156	4,526,514		44
45						83,681		22,681	145,279			21,423	57,457	585,000	2,644,079	1,013,699	4,242,778		45
46						79,322		18,322	149,638			20,274	58,606	504,000	2,494,441	955,093	3,953,534		46
47						74,833		13,833	154,127			19,102	59,778	423,000	2,340,314	895,315	3,658,629		47
48						70,209		9,209	158,751			17,906	60,974	342,000	2,181,563	834,341	3,357,904		48
49						65,447	61,000	4,447	163,513			16,687	62,193	261,000	2,018,050	772,148	3,051,198		49
50						60,542	60,542		168,418			15,443	63,437	180,458	1,849,632	708,711	2,738,801		50
51						55,489	55,489		173,471			14,174	64,706	104,969	1,676,161	644,005	2,425,135		51
52						50,285	50,285		178,675			12,880	66,000	34,684	1,497,486	578,005	2,110,175		52
53	41,000		20,000			44,925	14,684	30,241	183,035			11,560	67,320	0	1,313,451	510,685	1,824,136		53
54	21,000					39,404		39,404	189,556			10,214	68,666		1,123,895	441,019	1,565,914		54
55						33,717		33,717	195,243			8,840	70,040		928,652	371,979	1,300,631		55
56						27,860		27,860	201,100			7,440	71,440		727,552	300,539	1,028,091		56
57						21,827		21,827	207,133			6,011	72,869		520,419	227,670	748,089		57
58						15,613		15,613	213,347			4,553	74,327		307,072	153,343	460,415		58
59						9,212		9,212	219,748	86,680		3,067	75,813		87,324	77,530	164,854		59
60	21,000	21,000		308,960	80,000	2,620		2,620	87,324	86,881	7,800	1,551	77,530		0	0	0	$139,016	60
Total	$2,260,000	$1,260,000	$1,000,000	$18,537,600	$4,800,000	$7,285,584	$2,987,000	$4,298,584	$6,313,000	$5,201,001	$468,000	$1,991,001	$2,742,000					$139,016	

Columns 3, 6, and 12 - Annual costs provide for operation, maintenance, and replacement of project works.
Column 7 - Total interest on power investment at end of year, computed at 3 percent.
Column 8 - Interest on power investment needed to aid in the repayment of irrigation charges.
Column 9 - Interest on power investment in excess of that required for aid in irrigation repayment.
Column 13 - Interest on municipal and domestic water supply investment at end of year, computed at 2 percent.
Column 19 - Earned surplus from power revenues.

Cost and Repayment Allocation

Total estimated project cost $13,299,000

Allocation of Costs
- Reimbursable costs:
  - Irrigation $3,987,000
  - Power 6,313,000
  - Municipal and domestic water supply . 2,742,000
- Total $13,042,000
- Nonreimbursable costs:
  - Fish and wildlife . . . . . $ 257,000
- Total project cost $13,299,000

Repayment of Reimbursable Costs
- From irrigation water users . . . . . $ 1,000,000
- From power revenues:
  - For electric plant investment 6,313,000
  - For irrigation plant investment 2,987,000
- From municipal and domestic water users 2,742,000
- Total $13,042,000

Summary of Project Payout

Total estimated project reimbursable cost $13,042,000
Earned surplus 139,016
Interest:
- On electric plant investment* 4,298,584
- On municipal and domestic water plant investment . 1,991,001
- Total $19,470,601

Net revenues:**
- From irrigation water users . . . . . $1,000,000.
- From sale of project power 13,737,600
- From municipal and domestic water users 4,733,001
- Total $19,470,601

*The total interest component from net power revenues would be $7,285,584. Of this amount, $2,987,000 would be required to aid in the repayment of irrigation plant costs.

**Net revenues consist of total project revenues less annual costs for operation, maintenance, and replacement of project works.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
WASHINGTON, D. C.

A PRELIMINARY EVALUATION REPORT ON FISH AND WILDLIFE RESOURCES IN RELATION TO THE PROPOSED

COLLBRAN PROJECT

PLATEAU CREEK
COLORADO RIVER BASIN, COLO.

Sponsored by: United States Bureau of Reclamation, Department of the Interior.
Source of Engineering Data: Area Office, United States Bureau of Reclamation, Grand Junction, Colo.
Situated in: Mesa County, Colo.
Original Report Dated: December 1946.
Revised Report Dated: March 1948.
Field Work and Report by: River Basin Studies Staff, Fish and Wildlife Service, Region II.

A PRELIMINARY EVALUATION REPORT ON FISH AND WILDLIFE RESOURCES IN RELATION TO THE PROPOSED COLLBRAN PROJECT, PLATEAU CREEK-COLORADO RIVER BASIN, COLO.

INTRODUCTION

1. *Purpose.*—The purposes of this report are to review the plan of the regional director, region 4, Bureau of Reclamation, covering the potential Collbran project, Plateau Creek, Colo.; to evaluate the plan from the standpoint of its effect on fish and wildlife resources in the area; and to outline preliminary recommendations which should be incorporated in the plan of development in order to protect and enhance the existing value of these resources.

2. *Authority.*—Pursuant to the provisions of Public Law 732, Seventy-ninth Congress, second session, the regional director, region 4, Bureau of Reclamation, during a conference on June 13, 1947, requested that a previous Fish and Wildlife Service report covering the Collbran project, dated December 1946, be reviewed and revised as required for correlation with modified project plans. This revised report summarizes the views and opinions of both the Fish and Wildlife Service and the Colorado Game and Fish Department.

3. *Status of project.*—The regional director, region 4, Bureau of Reclamation, is completing his report on the feasibility of the Collbran project. It is expected that his report will be completed and forwarded to the Secretary of the Interior in the near future.

DESCRIPTION OF BASIN AND PROJECT AREA

4. *General.*—The Collbran project is planned to supply supplemental late season irrigation water for lands in Plateau Valley, supplemental municipal water for the city of Grand Junction and Grand Valley, and hydroelectric power. Water for the municipal supply and for the production of power would be collected from streams on the north slope of the Grand Mesa and conveyed by pipeline to a point near the town of Cameo. Power would be produced from the high pressure head developed by the pipeline's steep drop down the slopes of Grand Mesa. The water diverted by the pipeline, which is presently used for irrigation in Plateau Valley, would be replaced by water from Plateau Creek which would be stored in Vega Reservoir to be constructed on the creek. Not only would this storage replace the diverted water, but it would also provide adequate supplemental water to all irrigable lands in an area south of Plateau Creek, extending from about 8 miles east of Collbran to about 3 miles west of Mesa. The irrigation water would be distributed by a canal traversing the north slope of Grand Mesa from the reservoir to Mesa Creek.

5. *Topography.*—Grand Mesa and Battlement Mesa are two large flat-topped mountains, the summits of which are roughly 11,000 feet

in elevation. Between these mesas, Plateau Creek has cut a deep canyon, running westward, which has its confluence with the Colorado River at elevation 4,780 feet mean sea level. The stream that would be tapped for the project and those that would receive supplemental irrigation water, flow down the north slope of Grand Mesa and into Plateau Creek. Between these small streams are several broad, gently sloping terraces that are extensively farmed.

6. *Geology.*—The two mesas are formed by a plain of Tertiary Basalt. The deeply eroded hillsides reveal successive layers of Green River and Wasatch shales and sandstones (Eocene); Mesa Verde sandstone, Mancos shale and Dakota sandstone (Upper Cretaceous); and Morrison sandstone and shale (Lower Cretaceous). Granite of the Precambrian Age underlies these formations.

7. *Soils.*—Soils in that part of the project area above elevation 10,000 feet are of the Helmer-Santa-Benewah series. This series is a light brown to brown podzol developed on coniferous forest land.

8. Underwood-Babb soils are found between elevations 7,000 to 10,000 feet. This series varies greatly in color, texture, stoniness, and depth, though it is generally shallow. On north slopes this soil grades into the preceding type.

9. Below 7,000 feet in the project area, the McCammon-Deschutes soil type exists. These are gray-brown to dark brown shallow soils with considerable amounts of gravel and stones.

10. *Climate.*—Climatic conditions differ considerably over the mountains with their high rainfall and low temperatures and the lower areas with little rainfall and mild temperatures. Table 1 gives the contrast between upper, middle, and lower project areas.

TABLE I.—*Climatic data*

Area	Rainfall (inches)	Average July temperature; (degree)	Average January temperature (degree)	Maximum (degree)	Minimum (degree)	Length of growing season (days)
Upper (Grand Mesa)	18	60	16			60
Middle (Collbran)	15.9	69	22	100	−36	129
Lower (Palisade)	10.3	78	25	100	−23	180

11. *Hydrology.*—Streams in the area are typical mountain streams in their upper reaches. They flow through V-walled canyons with banks well covered with brush and trees. Stream bottoms vary in composition from silt to large gravel, with some streams flowing through areas of boulders. Little silt is present until the streams descend through the farming areas and irrigation return flow joins in. Plateau Creek below Collbran has a heavy load of silt, and the stream bottom is sandy.

12. *Vegetation.*—Vegetation is divided into three classifications within the project area. Above about elevation 9,000 feet, a forest-type vegetation is predominant, with Engelmann spruce the principal species and an understory of box-myrtle, blueberry, shrubby cinquefoil, and bearberry. Between elevations of 7,000 and 9,000 feet, a mountain-shrub type of vegetation prevails which consists largely of aspen and Gambel oak, interspersed with willow, rose, skunkberry,

serviceberry, and big sagebrush. Grasses include bluegrass and sheep fescue. Below elevation 7,000 feet the vegetation gives way to a piñon-juniper type with big sagebrush, rabbit brush, saltbrush, and such grasses as muhly, cheat grass, and blue grama.

13. *Engineering features of the project.*—The Collbran project would consist of two distinct, though complementary units; one a series of small reservoirs feeding a pipeline leading to two power plants, the other an irrigation reservoir and canal.

14. *Pipeline and power plants.*—Storage facilities for the Grand Junction pipeline would be provided by five existing storage reservoirs on the headwaters of Big Creek, and six existing storage reservoirs on the headwaters of Cottonwood Creek. These reservoirs lie along the north flank of Grand Mesa Mountain at altitudes of 9,500 to 9,900 feet, mean sea level. Pertinent data, descriptions, and proposed plans covering existing reservoirs which would be integrated with the Grand Junction pipeline are set forth in table 2.

15. The Grand Junction pipeline would have one branch originating at Bonham Reservoir on Big Creek and another at Big Meadows Reservoir on Cottonwood Creek. Water released from reservoirs on the Big Creek drainage would be collected at the Bonham Reservoir, and water released from the reservoirs on the Cottonwood Creek drainage would be collected at Big Meadows Reservoir. The branch pipelines would unite into a 30 second-foot capacity line about 3 miles above the proposed power plant No. 1 on Cottonwood Creek. This power plant at elevation 7,700 feet mean sea level will be located immediately above the proposed Southside canal where water from the afterbay may (1) be diverted into the potential Southside canal to supplement irrigation water from Vega Reservoir; (2) be added to Cottonwood Creek flows; (3) or reenter the 20 second-foot capacity Grand Junction pipeline, which would flank the Grand Mesa and conduct the water to power plant No. 2 located near Cameo, at elevation 5,000 feet mean sea level.

16. Water passing through power plant No. 2 would be distributed for domestic use to Grand Valley and Grand Junction, Colo., through an existing distribution system.

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TABLE 2.—*Pertinent data, descriptions, and proposed plans for Grand Junction pipeline storage reservoirs*

Name	Existing conditions			Proposed conditions		
	Active storage capacity	Maximum area (acres)	Present description	Active storage capacity	Maximum area (acres)	Proposed engineering changes
BIG CREEK SYSTEM						
Bonham Reservoir	1,070	80	Storage reservoir on Big Creek.	6,300	215	To be enlarged. Will be main storage facility for Grand Junction pipeline.
Silver Lake	165	13	Natural lake with storage above original water surface.	165	13	None; storage will be utilized similar to present conditions.
Forty Acre Lake	330	26	do	330	26	Do.
Big Creek Reservoir No. 1	550	95	Storage reservoir on Big Creek, flows into Bonham Reservoir.	550	95	Do.
Atkinson Reservoir	1,800	110	Storage reservoir on tributary to Big Creek.	1,800	110	Do.
COTTONWOOD CREEK SYSTEM						
Neversweat Lake	320	35	Natural lake with storage above original water surface.	320	35	Do.
Unnamed Lake	0	2.3	Small marsh near Neversweat Lake.	0	2.3	Water from Neversweat Lake would run through Unnamed Lake and into Cottonwood Reservoir No. 5.
Cottonwood Lake No. 5	320	42	Natural lake with storage above original water surface.	320	42	None; storage will be utilized similar to present conditions.
Little Meadows Reservoir.	120	13	Storage reservoir on tributary to Cottonwood Creek.	120	13	Do.
Big Meadows Reservoir	220	43	Storage reservoir immediately below Little Meadows Reservoir.	220	43	Do.
Cottonwood Lake No. 1	--------	115	Storage reservoir on tributary to Cottonwood Creek.	--------	115	Storage to be used during dry periods on a direct-trade basis with replacement from Southside canal.

17. *Reservoir and canals.*—It is proposed to construct the Vega Dam on Plateau Creek near the town of Collbran for the purpose of furnishing irrigation water to replace that diverted to the Grand Junction pipeline and to supplement present supplies. Vega Dam would be a rolled-earth-fill type structure with a riprapped upstream face, varying in slope from 3:1 to 5:1, and rock fill downstream face with slope from 2½:1 to 4:1. The dam would rise 142 feet above the stream bed and would be 1,710 feet long, with crest elevation 7,991 feet, mean sea level. Pertinent engineering data are shown in table 3.

TABLE 3.—*Pertinent data, Vega Reservoir*

Water at	Elevation in feet, mean sea level	Capacity acre-feet	Area acres	Shore line, miles
Maximum pool	7,985	34,500	945	7.9
Top of live storage	7,980	30,000	865	8.1
Spillway crest	7,980	30,000	865	8.1
Average annual maximum pool	7,979	29,000	850	8.0
Average annual minimum pool	7,935	5,500	290	4.9
Dead storage	7,910	1,000	20	3.5

18. The outlet would be a high-pressure valve at elevation 7,910 feet, mean sea level, located in the south end of the dam, and discharges would flow into a stilling basin before entering Southside canal, where a gate would provide for releases back into Plateau Creek.

19. Southside canal would extend from the stilling basin of Vega Reservoir, westward along the north slope of Grand Mesa, for a distance of 25 miles, and end at Mesa Creek about 7 miles above the mouth of the stream.

20. Southside canal would furnish irrigation water to about 2,300 acres of new lands and a late-season supplemental water supply for about 18,600 acres of land now under irrigation. The canal, with a capacity at its head of 225 second-feet and progressively decreasing to a capacity of 40 second-feet at its junction with Mesa Creek, would run along the hillside above most of the irrigated land across Leon, Grove, Little, Big, Cottonwood, Bull, and Spring Creeks by siphons, discharging water down the streams for supplemental irrigation. There would be an intake from Cottonwood Creek into Southside canal to enable the canal to pick up water from this stream.

21. The flows of Park Creek and Leon Creek would be diverted by canal and chute into Vega Reservoir. At present these streams enter Plateau Creek about three-quarters and one and one-half miles below the dam site, respectively.

EFFECT OF THE PROJECT ON FISHERY VALUES

22. *Preproject resources.*—Fishery values within the project area are fairly high. Rainbow trout are the most abundant species and are present in almost all waters. Eastern brook trout and native trout occur in the headwater areas of both streams and lakes. Bonham, Atkinson, and Big Creek No. 1 Reservoirs are accessible by road and receive heavy utilization. The remaining reservoirs on Big and Cottonwood Creeks are easily accessible by trail and receive moderately heavy utilization. Streams within the project area receive moderate usage, except for Leon and Upper Plateau Creeks which are heavy utilized.

23. Bonham, Atkinson, and Big Creek No. 1 Reservoirs furnish only fair fishing generally, since they are drawn down to such an extent that some winter kill occurs about once every 3 or 4 years. Big Meadows and Little Meadows Reservoirs are drained completely most years and no fishery exists. Silver, Forty Acre, Neversweat, Cottonwood No. 5, and Cottonwood No. 1 Lakes are all natural lakes with a dike constructed across the outlet to store water above the

normal lake level, and fishing in these bodies of water is usually good. Unnamed Lake, a small marsh 3 to 5 feet deep, has no present fishery.

24. In general, the streams within the project area are not large, and fishing is best along the upper or headwater reaches. Leon and Big Creeks are considered good trout fishing, while the upper reaches of Park, Cottonwood, Bull, and Mesa Creeks all support fair fishing. The lower reaches of these same streams are heavily utilized for irrigation during the summer months, and fishery values are low or nonexistent. Plateau Creek is a good trout stream within the Vega Reservoir site, poor within the canyon immediately below the Vega Dam site, but quite good again below the confluence of Leon Creek. Below the town of Collbran, Plateau Creek has almost no fishery value since large quantities of water are diverted for irrigation purposes, and tributary Buzzard Creek contains large amounts of silt.

25. The 49½ miles of streams to be affected by the project are valued at $10,000 annually, and the 11 project reservoirs, with a minimum surface area of about 182 acres, are valued at $6,100 annually, indicating a total annual preproject fishery value of $16,100.

26. Esthetic values attached to these streams and the surrounding area are considerable. Many hundreds of tourists visit the Grand Mesa National Forest during the summer, and it is a popular winter sports area.

27. *Postproject resources.*—The effects of the Collbran project upon fishery resources within the project area would be many and varied.

28. In the case of reservoirs taken over by the project, the general effect would be an improvement over preproject conditions. Average minimum storage amounts would be significantly increased, and period of low content would be of shorter duration than at present. Big Meadows Reservoir, Little Meadows Reservoir, and Unnamed Lake should produce fish under postproject conditions where no fishing exists at present. The enlargement of Bonham Reservoir should materially increase the fishery of that body of water. Silver Lake, Forty Acre Lake, Cottonwood Lake No. 5 and Cottonwood Reservoir No. 1 would be unaffected.

29. Vega Reservoir would have an average annual fluctuation of 44 feet, and would vary in size between 290 acres at average minimum pool and 850 acres at average maximum pool. Maximum depths would be 85 and 129 feet, respectively. The lake would flood relatively flat, rich land; and the shore line would be sloping but not steep. Conditions within the reservoir should be average for the production of trout, and fishing pressure should be moderate.

30. The over-all effect of the project on stream fishing in the area would be to lower existing values. A few short reaches of streams would be dewatered as indicated in table 4, below, but values represented in those sections are not high. The most significant stream losses would result from the flooding of Plateau Creek within the reservoir site, and the reduction in flow below dams or diversion structures on Leon, Plateau, Cottonwood, and Big Creeks.

31. Throughout the farming area and below Southside canal, all streams would receive supplemental water throughout the irrigation season. Maintenance of summer flows adequate to meet irrigation demands at the lower ends of these streams should increase fishery values. Plateau Creek below Collbran would probably not be significantly affected by this increased flow.

32. Annual postproject fishery values of the reservoirs and streams in the project area are estimated to be $17,900 and $6,900, respectively, indicating an annual postproject fishery value of $24,800. Preproject and postproject fishery values, by sections, are summarized in table 4.

EFFECTS OF THE PROJECT ON WILDLIFE VALUES

33. *Preproject resources.*—The preproject values of wildlife in the project area are discussed in the following paragraphs.

34. *Big game.*—Big game values in the project area are relatively high per unit of area. Mule deer are present throughout the project area, except on lands under cultivation, and are hunted extensively. The annual deer-kill reports of the State of Colorado indicate that about two buck deer are killed annually on land to be flooded by Vega Reservoir. Land which would be flooded by the enlargement of Bonham Reservoir supports deer during the summer months, and thus contributes to the yield in other areas.

TABLE 4.—*Annual fishery values*

Area	Preproject value	Effect of project	Postproject value
Stream sections:			
Plateau Creek in reservoir site	$500	Covered with water	----------
Plateau Creek, reservoir to mouth of Leon Creek	100	Dewatered at times	----------
Plateau Creek, mouth of Leon Creek to Collbran	3,100	Partially dewatered	$1,700
Leon Creek, diversion dam to mouth	1,900	do	1,200
Park Creek, diversion dam to mouth	100	Dewatered	----------
Big Creek, Bonham Reservoir to canal	1,900	Partially dewatered	600
Big Creek through farming area	500	Flow increased in summer	1,000
Cottonwood Creek, outlet of reservoir to canal crossing.	800	Slightly dewatered	600
Cottonwood Creek through farming area	----------	Flow increased in summer	500
Bull Creek through farming area	400	do	600
Mesa Creek through farming area	700	No effect	700
Reservoirs:			
Bonham	500	Enlarged and storage increased	3,000
Atkinson	500	Average minimum storage increased.	2,000
Big Creek No. 1	500	do	1,300
Silver Lake	500	No effect	500
Forty Acre	700	do	700
Neversweat	500	Will be low for short period only	600
Unnamed	----------	Will obtain good supply of fresh water.	500
Cottonwood No. 5	900	No effect	900
Little Meadows	----------	Average minimum pool maintained.	800
Big Meadows	----------	do	900
Cottonwood No. 1	2,000	No effect	2,000
Vega	----------	Created by project	4,700
Total	16,100	----------	24,800
Net gain	----------	----------	8,700

35. Combining the yield value for Vega Reservoir site and the range value for the Bonham Reservoir area, an annual value of $400 is obtained.

36. *Upland game.*—Upland game values are moderately high per unit of area, but exist almost entirely on the farmlands along Plateau Creek in the lower portion of the project area. Pheasants and Gambel quail are the species present on these areas. Irrigated lands on the benches adjacent to the valley do not support significant populations of either game bird.

37. The annual preproject value of upland game on the project area is estimated at $500.

38. *Fur animals.*—Fur animal values are moderately high within the project area. No data on actual take of furs are available; however, beaver and mink are known to be relatively abundant along streams within the project. Fur animals do not exist in significant numbers around those existing project reservoirs with fluctuating shore lines. An annual value of $1,500 is estimated for fur animals on the 49½ miles of streams within the project area.

39. *Waterfowl.*—Waterfowl values within the project area are low. Some few ducks utilize the Vega Reservoir site and the reservoirs on Big and Cottonwood Creeks for nesting grounds, and during the early part of the fall migration moderate numbers of ducks use the various reservoirs for resting and feeding. The annual value of project areas to waterfowl is evaluated at $100.

40. *Postproject resources.*—The postproject values of wildlife in the project area are discussed in the following paragraphs.

41. *Big game.*—Construction of Vega Reservoir and enlargement of Bonham Reservoir would eliminate 240 acres of big game range, valued at $400. No other change in habitat value is expected.

42. *Upland game.*—The addition of late season irrigation water and the irrigation of new land by the project would not significantly affect the existing upland game bird population. Most of the land to be irrigated is situated upon the benches above the valley and would not become pheasant habitat. Only about 100 acres of the 2,300 acres of new land to be irrigated would be located along Plateau Creek in the lower project area where pheasants could be produced. The yield of this new habitat would not be significant, and the postproject value of upland game is estimated to be the same as the preproject value, $500 annually.

43. *Fur animals.*—The effect of the project upon fur animal values would be a slight loss. Reaches of streams that would be dewatered and those to be flooded would result in total losses, while streams partially dewatered would result in small losses. Streams throughout the farming areas should have an increase in fur values due to the additional water in summer which they will receive from the South side canal. Postproject fur animal values are estimated to be $1,400 annually.

44. *Waterfowl.*—A small nesting area for waterfowl would be inundated by the Vega Reservoir, and the nesting value on the reservoir itself is expected to be poor due to fluctuating water levels. Nesting should be fairly good on the other project reservoirs which would have practically no fluctuation during summer months. Conditions suitable for waterfowl resting and feeding should exist on all bodies of water. The estimated annual value to waterfowl of the habitat to be provided in the project area amounts to about $200.

45. *Summary.*—Preproject and postproject wildlife values are summarized in table 5. As indicated, the project would result in a net annual loss to wildlife of $400.

TABLE 5.—*Annual wildlife values*

Type of game	Preproject value	Postproject value	Net loss or gain
Big game	$400		−$400
Upland game	500	$500	
Fur animals	1,500	1,400	−100
Waterfowl	100	200	100
Total	2,500	2,100	−400

MEANS OF MITIGATING LOSSES AND DERIVING MAXIMUM BENEFITS

46. Throughout the preparation of the sponsor's report for the project, the Fish and Wildlife Service has been consulted as to means of mitigating losses which would result from the project and measures for deriving maximum benefits. The results of this cooperation are reflected in the project plans of South side canal crossing streams by siphons rather than diversion dams which would block upstream fish migration. This cooperation also resulted in the development of a plan of operation which would provide for the annual utilization of stored waters in Silver, Forty Acre, Neversweat and Cottonwood No. 5 lakes before draw-downs would be made in Bonham, Atkinson, Big Creek No. 1, Little Meadows, and Big Meadows Reservoirs. This operational plan was developed because the former lakes have plentiful natural dead storage and winter kill of fish is not a problem, and such an operation would tend to maintain higher water levels during the winter in the latter reservoirs where winter kill is serious.

47. Under the present plan of operation, the flow of Leon Creek except for a minimum flow of 5 second-feet, would be diverted at the Leon Creek diversion dam into Vega Reservoir. Whenever Vega Reservoir is full, fish and wildlife would benefit more from an operation of the Leon Creek diversion which would allow the natural flow to continue down Leon Creek rather than be diverted into Vega Reservoir and allowed to spill into Plateau Creek where the additional flows provided would not increase the fishery values.

48. The proposed Grand Junction Pipe Line would divert water from both Big Creek and Cottonwood Creek. The former stream has the greater fish and wildlife value. Whenever an interchange of water is possible, the flows of Big Creek should be augmented to increase the value of the fishery habitat.

49. Construction of fish screens or barriers at canal and pipeline take-offs would be advantageous in assuring maximum benefits to the project by preventing fish losses in canals and turbines. Necessary structures would be: (*a*) a drop or fish barrier in the inlet canal to Vega Reservoir which would prevent trout from getting into the inlet canal and spawning where the eggs would be lost when diversion water might be cut off; (*b*) fish screens, probably of the bar type, at the pipeline intakes from Bonham Reservoir and from Big Meadows Reservoir, to keep fish out of the turbines; and (*c*) a fish screen probably of the rotary type, at the head of the feeder inlet from Cottonwood Creek to the South side canal to prevent fish being lost when flows of the South side canal would be cut off.

SUMMARY OF VALUES

50. Construction of the Collbran project would result in a net annual benefit to fish and wildlife of about $8,300. If the United States Fish and Wildlife Service recommendations concerning methods of operation and fish barriers are included in the plan of improvement, the Collbran project would result in a net annual benefit to fish and wildlife of $9,300. Estimates of annual values are summarized in table 6.

TABLE 6.—*Summary of annual fish and wildlife values*

	Preproject values	Under sponsor's plan		Under sponsor's plan including Fish and Wildlife Service recommendations	
		Postproject values	Net gain or loss	Postproject values	Net gain or loss
Fish	$16,100	$24,800	$8,700	$25,700	$9,600
Wildlife	2,500	2,100	—400	2,200	—300
Total	18,600	26,900	8,300	27,900	9,300

CONCLUSIONS AND RECOMMENDATIONS

51. Inasmuch as this report is based on the sponsor's plans for development of the Collbran project made prior to January 1948, the Fish and Wildlife Service should be advised of any changes in plans for structures or methods of operation so that a modified fish and wildlife report can be prepared.

52. The net effect of the project will be beneficial to fish and wildlife resources, if the project is built and operated as proposed by the sponsor. The net annual benefit is estimated to be $8,300. If certain modifications are made in the project, as outlined in the following recommendations, additional annual benefits of about $1,000 will result.

53. It is recommended that:

(*a*) Whenever Vega Reservoir is full, the normal flow of Leon Creek be bypassed at the Leon Creek diversion dam to flow down Leon Creek, rather than be diverted into Vega Reservoir and released down Plateau Creek. No minimum flows are recommended for Park Creek or Plateau Creek below Vega Dam. It is felt that this water would be more valuable flowing down Leon Creek to supplement the 5.0 second-foot minimum flow provided for by the sponsor.

(*b*) Operation of the reservoir systems draw first upon storage contained in converted natural lakes, and then concurrently upon storage from the other reservoirs as outlined in paragraph 46, above. Draw-downs should be prorated among the reservoirs on the basis of maximum storage capacity so as to leave as large a minimum pool as possible in each reservoir.

(*c*) Cottonwood Creek water be traded with Big Creek water as outlined in paragraph 48, above, until the flow of Big Creek would be that described in table 7 on following:

TABLE 7.—*Recommended flow below Bonham Reservoir*

Month of water year	Recommended flow in second-feet	Month of water year	Recommended flow in second-feet
October	8.0	April	3.5
November	3.5	May	18.0
December	3.5	June	[1] 20.0
January	3.5	July	16.0
February	3.5	August	10.0
March	3.5	September	10.0

[1] This is recommended flow. Spills from Bonham Reservoir would add to this during June of most years.

Since Big Creek is a more valuable stream than Cottonwood Creek, the recommendation would increase the annual benefit accruing to the project.

(*d*) Fish screens be constructed at the entrance to the diversion from Cottonwood Creek into southside canal, and at the pipeline intakes at Bonham and Big Meadows Reservoirs.

(*e*) A drop or other barrier to the passage of fish be constructed a short distance above high-water level in the chute carrying water into Vega Reservoir.

(*f*) The entire project area be open to free use by the public except such portions as may be reserved by the sponsoring agency for the purpose of safety, efficient operation, or protection of public property.

(*g*) Releases from the reservoir and diversion dams be accomplished by gradual opening and closing of gates to forestall rapid changes in reservoir pool levels and sudden changes in outflow below the dams.

(*h*) In planning for full use of the reservoir areas, the sponsor make provisions for access adequate for the needs of anglers and hunters.

(*i*) No part of the reservoir area be leased for the exclusive benefit of any corporation, individual, or group of individuals for any purpose which will prevent or interfere with use of that area for recreational, hunting, or sport fishing purposes by the general public.

(*j*) Responsibility for management of fish and wildlife resources inherent to the project area remains with the State of Colorado.

K. C. KARTCHNER.

RECONNAISSANCE REPORT
RECREATIONAL USE AND DEVELOPMENT

COLLBRAN PROJECT
VEGA AND BONHAM RESERVOIRS

UPPER COLORADO RIVER BASIN
COLORADO

PREPARED BY
REGION THREE, NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

For
REGION 4, BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR

December 1947

LANDS DIVISION: Milton J. McColm, Regional Chief of Lands
Report by: Richard D. Sias, Park Planner

RECREATIONAL USE AND DEVELOPMENT, COLLBRAN PROJECT, COLORADO, VEGA AND BONHAM RESERVOIRS

INTRODUCTION

Authority

In accordance with departmental policies regarding interagency cooperation in the river basin study program, and as covered by an agreement between region 3, National Park Service, and region 4, Bureau of Reclamation, for the 1947 fiscal year, the National Park Service was requested by letter of January 21, 1947, to prepare a report on the recreational use and development of the Collbran project for the Bureau of Reclamation. Subsequently, arrangements for the report and pertinent data on the project were included in a letter of October 27, 1947, addressed to region 3, National Park Service, from region 4, Bureau of Reclamation. Preparation of the report, including necessary field reconnaissance, is also in accordance with an agreement between the two offices covering 1948 fiscal year cooperation, currently being arranged.

Purpose

The purpose of this report is to appraise and analyze recreational opportunities that will be created by the Collbran project, sponsored by the Bureau of Reclamation. These values will be related primarily to the two water-impoundment reservoirs, the Vega and Bonham, which will be the source of water for the operation of the project as a whole. It is also necessary for the purposes of this report to consider recreational needs in the area which can reasonably be served by the reservoirs, the amount of use that is likely to be made of them, and developments deemed warranted to encourage and accommodate such use. In order to assure appropriate coordination with the economic phases of project development as far as possible, the National Park Service has been requested to estimate the cost of recreational developments which are recommended, and to appraise broadly, in monetary terms, such factors in connection with recreational benefits which will accrue to the project as it is believed can be reasonably expressed in such economic terms. Certain benefits, as to public health and social welfare, while often very real, are yet considered to be intangible, primarily because of difficulties involved in attempting to attach sound monetary evaluations to such phases of recreational benefits.

The Vega Reservoir was mentioned in the National Park Service section of the report on The Colorado River issued by the Department of the Interior, March 1946 (Project Planning Report No. 34–8–2), and broad preliminary estimates of development costs and annual monetary benefits were provided. These appraisals were predicated upon a preliminary reconnaissance made by representatives of the National Park Service.

Further reconnaissance of the site and also that of the Bonham Reservoir site was made on November 12, 1947, by Mr. R. D. Sias,

representing the National Park Service, and Mr. Black, from the Grand Junction area planning office, representing the Bureau of Reclamation.

Following the field survey, representatives of the Bureau of Reclamation in the Grand Junction office were interviewed regarding the project and its proposed operation. At this time, too, there was an opportunity to discuss matters pertaining to recreational use of the Grand Mesa National Forest with representatives of the United States Forest Service, notably Mr. Williams of the Forest Supervisor's office. Valuable information regarding such use, including estimates of annual use, was cooperatively provided by that office, which has a direct interest in the development of the Bonham Reservoir that lies wholly within the Grand Mesa National Forest.

SUMMARY

Findings, conclusions, and recommendations

As a result of a field reconnaissance of the Vega and Bonham Reservoir sites and analysis of project data and plans of operation supplied by the sponsor, the National Park Service finds that the Collbran project will result in a considerable increase in recreational values.

It is found that the value of the Vega Reservoir for recreation would be nominal and almost entirely local. It is concluded that it would be valuable primarily for fishing and that the annual cost of the nominal development recommended would be about equal to the value of incidental recreational use, other than fishery values. The advantage of this reservoir would consist in earlier use in the spring and somewhat later use in the fall, than is likely to be the case for the Bonham Reservoir at a considerably higher elevation.

It is found that the Bonham Reservoir, enlarged and operated as presently planned by the sponsor, would be greatly improved for recreation, especially if adequately developed, operated, and maintained to accommodate and encourage the potential increase in recreational use. In the absence of additional developments, it is believed that only nominal increased use with commensurate increases in economic values would accrue to the reservoir.

It is estimated that without developments, the increase in value would be some $3,000 annually, and that with adequate developments the increase in value could be $15,600, not including fishery values appraised by the Fish and Wildlife Service and allowing for annual costs of $11,900.

It is believed that the Bonham Reservoir would be chiefly significant as part of the Grand Mesa area which is widely recognized for its high recreational value. It is not believed that the appeal of the area, as a whole, will be greatly enhanced by improvements to the Bonham Reservoir. However, it is believed that considerable, if intangible, benefits to the Grand Mesa area can occur as a result of desirable dispersion of recreational use which will, in the long run, reduce undesirable tendencies for overconcentration of development.

The responsibility of the United States Forest Service in connection with recreational development and use of the Bonham Reservoir is recognized, the National Park Service enjoys full confidence in the ability of that Service to adequately appraise the disadvantages of developments at the Bonham Reservoir which would be in competi-

tion with existing developments on the Grand Mesa, and the advantages of dispersing National Forest Service use in the larger interest.

It is found that no National Park Service area or State park will be affected by the Collbran project.

It is believed that archeological sites of value are unlikely to occur at elevations involved in the Collbran project. The National Park Service has not yet determined to what extent areas of historic interest or importance may occur.

It is recommended that:

1. Clearing for both reservoirs, but especially for the Bonham Reservoir, be done in such a manner as to assure public safety by removal of stumps and other underwater hazards and to retain the natural aspect of shore line as far as possible.

2. Only nominal recreational facilities directly associated with reservoir use be considered for the Vega Reservoir.

3. Developments be considered for the Bonham Reservoir that are commensurate with its importance in the general Grand Mesa area as administered by the United States Forest Service.

GENERAL DESCRIPTION OF THE AREA

Location

The Collbran project is located in easterly Mesa County in the Plateau Creek Valley which separates the Grand Mesa (to the south) and Battlement Mesa (on the north). The latter is interposed between the Plateau Creek Valley and the main Colorado River. The general location is west-central Colorado, on the westerly approaches to the Rocky Mountains.

Glenwood Springs, about 95 miles by road, and Grand Junction, some 44 miles by road (from the small town of Collbran), are the most important towns in this part of the State.

The general area is accessible from United States Highways 6 and 24 at the confluence of Plateau Creek and the Colorado River (about 20 miles east of Grand Junction) via State Highways 65 and 330. From Collbran, a minor State road (339) and a mountain road offer access to the Bonham Reservoir about 12 miles from Collbran. This road continues across the Grand Mesa National Forest joining State 65 on the Mesa at the Grand Mesa lakes area. The mountain road from Collbran follows reasonable grades, but is treacherous during and following precipitation. Improvement and adequate maintenance will be required to assure all-weather use of the road. State 65 across the Mesa is improved, and there are plans for surfacing much if not all of it, which will make the general Grand Mesa area accessible from Delta to the south, which town is on U S 50 (important east-west highway between Pueblo and Grand Junction), and is also served by U S 550 leading north from Durango through Montrose.

The Vega Reservoir site is about 10 miles up the Plateau Creek valley from Collbran. After leaving State Highway 330, 6 miles or so above Collbran, the basin is reached over a country road similar to the one passing the Bonham site. While grades are less, the road needs similar improvement and maintenance for satisfactory all-weather use.

The Vega site is on the main Plateau Creek stream, the Bonham being on a tributary leading from the northern slopes of the Grand

Mesa—the so-called Big Creek fork. The upper watershed for the whole project lies within the Grand Mesa National Forest.

Purpose of the project and reservoirs

Data provided by the sponsor (October 27, 1947) indicate that the Collbran project would serve multiple purposes. It is stated that "it is designed to supply supplemental irrigation water to 20,650 acres of land in the Plateau Valley; to provide water for domestic use by Grand Junction City and surrounding area; and to generate hydroelectric power." The generation of power would not occur at the reservoir dams, but would be "made possible by utilizing the excess head of a pipeline to be constructed for the diversion of domestic water from Plateau Valley to a point near Palisade." Two generating stations would be established at different points on this pipeline. Water now used in the valley for irrigation which will be thus diverted will be replaced by storage allocations in the Vega Reservoir.

The Vega Reservoir, located in the Plateau Creek meadows, would have a total capacity of 30,000 acre-feet (at surface elevation 7,980), of which 1,000 acre-feet would be dead storage for silt control and the protection of fish life, and 29,000 acre-feet would be active storage for irrigation, domestic, and power water use. The usable 29,000 acre-foot storage would be allocated 15,500 acre-feet for irrigation, and 13,500 for power and domestic use.

The reservoir would be filled by storing the winter and spring flows of Plateau Creek, supplemented by diversions from nearby Leon and Park Creeks.

In reservoir operation, it is planned to release irrigation water during the summer period, July through September, but power-domestic water would be used only in part (9,000 acre-feet) for yearly operation, leaving a reserve of 4,500 acre-feet as insurance for meeting power requirements during drought years, such as occurred in 1934. Thus, during years of normal runoff, the minimum pool occurring generally in the late fall and winter months would be not less than 5,500 acre-feet, forming a 280-acre reservoir.

Analysis of the table of contents of the Vega Reservoir prepared by the sponsor by months for the period of study, 1933–45, shows that only during the months of September 1934, April 1935, and in October 1935 would recourse to this reserve have reduced the storage below 5,500 acre-feet, and that only in October 1934 would the minimum 1,000 acre-feet capacity have been reached with an 86-acre surface at approximate elevation 7,910. The average minimum for the study period, occurring in October, would have been 10,700 acre-feet with approximately 430 acres of surface at elevation 7,950 (or a little less). Correspondingly, the average maximum, occurring in June, would have been 26,200 acre-feet, representing about 525-acre lake at elevation 7,976. This indicates an average annual recreational use-season fluctuation of around 26 feet, against a potential over-all fluctuation between maximum and minimum pools of about 70 feet.

The schedule of planned, total content of the Vega Reservoir by months, during the period of study, 1933–45, is given in table I. The area capacity table showing the relation between surface elevation, surface acreage, and acre-foot capacity is provided in table II.

The above project development is to be supplemented by enlargement and development of the small existing Bonham Reservoir on the

Big Creek fork of Plateau Creek, located near the upper reaches of the Grand Mesa within the Grand Mesa National Forest. The present reservoir, privately developed for irrigation storage, will be enlarged from 1,070 acre-feet to 6,300 acre-feet. Additional storage will be provided near the headwaters of nearby Cottonwood Creek. Irrigation water formerly provided by these drainages will be replaced by irrigation allocation in the Vega Reservoir.

TABLE I.—*Planned total content of Vega Reservoir by months during the period of study, 1933-45*

[Total reservoir capacity: 30,000 acre-feet. Unit: 1,000 acre-feet]

Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1933	15.6	16.1	16.6	17.1	18.0	18.7	25.2	30.0	25.6	19.7	12.4	8.5
1934	9.0	9.4	9.8	10.5	11.4	15.6	17.3	9.3	7.8	6.4	4.9	1.0
1935	1.5	2.1	2.7	3.2	3.8	3.8	7.5	23.3	20.9	14.7	8.7	4.8
1936	5.6	6.3	7.1	7.7	8.5	13.5	27.9	23.7	13.0	10.7	9.2	5.3
1937	5.9	6.4	6.9	7.3	7.8	8.8	24.9	29.9	23.7	18.2	12.3	8.4
1938	9.3	10.1	10.8	11.5	12.5	16.9	30.0	30.0	30.0	26.2	21.8	17.8
1939	18.9	19.9	20.8	21.7	23.0	25.7	30.0	25.9	15.8	11.6	10.1	6.2
1940	6.7	7.1	7.5	8.0	8.8	11.9	24.4	17.9	10.8	9.3	7.8	3.9
1941	4.7	5.5	6.3	7.0	7.8	7.8	28.1	30.0	28.1	24.4	20.9	16.9
1942	18.8	20.2	21.4	22.4	23.5	27.6	30.0	30.0	28.4	25.6	21.3	17.3
1943	18.0	18.5	19.0	19.6	20.9	25.8	30.0	30.0	21.9	20.1	15.3	11.3
1944	12.6	13.4	14.0	14.6	15.4	15.2	28.8	30.0	30.0	27.3	22.6	18.6
1945	19.5	20.4	21.1	21.7	22.5	22.6	30.0	30.0	29.4	26.5	23.2	19.2
Average	11.2	12.0	12.6	13.3	14.1	16.5	25.7	26.2	22.0	18.5	14.7	10.7

TABLE II.—*Vega Reservoir area-capacity table*

Elevation in feet above sea level	Area in acres	Accumulated capacity in acre-feet	Elevation in feet above sea level	Area in acres	Accumulated capacity in acre-feet
7,850	0	0	7,935	281.9	5,402.8
7,855	.35	.9	7,940	337.9	6,952.3
7,860	.40	2.8	7,945	387.7	8,766.3
7,865	1.00	6.3	7,950	438.3	10,831.3
7,870	1.90	13.5	7,955	492.9	13,159.3
7,875	3.95	28.1	7,960	555.7	15,780.8
7,880	6.50	54.3	7,965	623.1	18,727.8
7,885	11.75	99.9	7,970	718.0	22,080.5
7,890	16.60	170.8	7,975	783.7	25,834.6
7,895	25.00	274.8	7,980	862.2	29,950.9
7,900	37.25	430.4	7,985	942.0	34,462.9
7,905	50.8	650.6	7,990	1,012.3	39,348.6
7,910	85.7	991.8	7,995	1,070.0	44,554.4
7,915	116.5	1,497.3	8,000	1,124.1	50,039.6
7,920	152.4	2,169.6			
7,925	191.6	3,029.6	Total	1,124.1	50,039.6
7,930	237.9	4,103.3			

Water stored in the Bonham Reservoir would be reserved for use during winter months for power and domestic use. Filled during spring months, the reservoir would be held at capacity during the summer until early winter. The full capacity of the reservoir would only be used in years of extreme drought, such as 1934, according to the sponsor. On this basis, in average water-years, the reservoir would not be drawn below 3,465 acre-feet, being 55 percent of total capacity and forming a 160-acre lake at elevation 9,817. Even in extreme years, it appears a minimum winter pool of 1,070 acre-feet, with 80 surface acres at elevation 9,797, will be maintained. It is believed that this will represent a marked improvement over the

existing situation, involving such nearly complete exhaustion that fish are eliminated on an average of 1 year out of 3 according to local reports.

The significance of the plan of operation is clearly illustrated in table III, furnished by the sponsor, which gives the planned total content of Bonham Reservoir by months during the period of study, 1921–44. From this schedule it is at once apparent that minimum pools occur during winter and early spring months of February, March, and April, and that maximum pools occur consistently during June, July, August, and September. The fluctuation between these pools would normally be 15 feet—none of which would, however, occur in the summer recreation-use period, during which season it is proposed to maintain the pool at full capacity. For recreational use, the plan of operation represents a favorable situation which is rarely possible with water impoundment projects.

TABLE III.—*Planned total content of Bonham Reservoir by months during the period of study 1921–44*

[Total reservoir capacity: 6,300 acre-feet. Unit: 1,000 acre-feet]

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Year 1921	6.1	5.8	5.3	4.8	4.2	3.6	3.5	6.3	6.3	6.3	6.3	6.3
Year 1922	6.3	6.0	5.7	5.3	4.8	4.3	4.2	6.3	6.3	6.3	6.2	6.0
Year 1923	5.9	5.4	4.9	4.4	3.8	3.3	3.2	6.0	6.3	6.3	6.3	6.3
Year 1924	6.3	6.0	5.6	5.1	4.6	4.1	4.0	6.3	6.3	6.3	6.0	5.9
Year 1925	5.7	5.3	4.8	4.3	3.8	3.3	3.7	6.2	6.3	6.3	6.3	6.3
Year 1926	6.3	6.2	5.8	5.4	4.8	4.4	4.9	6.3	6.3	6.3	6.3	6.1
Year 1927	6.1	5.7	5.3	4.8	4.2	3.7	3.8	6.3	6.3	6.3	6.3	6.3
Year 1928	6.3	6.1	5.8	5.3	4.8	4.3	4.5	6.3	6.3	6.3	6.3	6.3
Year 1929	6.3	6.3	6.1	5.7	5.2	4.8	5.6	6.3	6.3	6.3	6.3	6.3
Year 1930	6.3	6.3	6.0	5.6	5.1	4.6	5.2	6.3	6.3	6.3	6.3	6.3
Year 1931	6.3	6.1	5.7	5.2	4.7	4.2	4.0	6.3	6.3	6.2	6.0	5.9
Year 1932	5.8	5.4	4.9	4.4	3.8	3.4	3.6	6.3	6.3	6.3	6.3	6.2
Year 1933	6.1	5.7	5.2	4.7	4.1	3.6	3.4	5.4	6.3	6.3	6.3	6.2
Year 1934	6.1	5.6	5.2	4.7	4.1	3.6	3.7	4.9	4.7	4.3	3.9	3.6
Year 1935	3.3	2.7	2.1	1.6	.9	.4	.1	1.4	4.0	4.5	4.5	4.3
Year 1936	4.0	3.5	3.0	2.5	1.9	1.4	1.5	4.4	5.6	5.7	5.7	5.5
Year 1937	5.2	4.7	4.1	3.5	2.8	2.3	1.8	5.0	6.3	6.3	6.2	6.1
Year 1938	5.9	5.4	4.8	4.3	3.7	3.2	3.5	6.3	6.3	6.3	6.3	6.3
Year 1939	6.2	5.9	5.3	4.8	4.2	3.7	3.7	6.3	6.3	6.2	6.0	5.8
Year 1940	5.6	5.0	4.4	3.8	3.3	2.7	2.6	5.3	5.8	5.6	5.4	5.3
Year 1941	5.2	4.7	4.2	3.7	3.1	2.6	2.2	5.9	6.3	6.3	6.3	6.3
Year 1942	6.3	6.1	5.7	5.2	4.7	4.2	4.4	6.3	6.3	6.3	6.3	6.1
Year 1943	5.9	5.4	4.8	4.2	3.6	3.1	3.2	5.3	6.3	6.3	6.3	6.2
Year 1944	6.1	5.6	5.1	4.5	3.9	3.4	3.0	5.8	6.3	6.3	6.3	6.0
Average	5.8	5.5	5.0	4.5	3.9	3.4	3.5	5.7	6.1	6.1	6.0	5.9

Physical characteristics

Plateau Creek traverses a deep valley between Grand Mesa and Battlement Mesa, both of which are included in the Grand Mesa National Forest. The bordering mesas run above 10,000 feet in elevation, while the elevation at the confluence of Plateau Creek and the Colorado is around 4,800. In the section of the valley around Collbran, the bottom valley is flanked by broad, gentle mesas or terraces elevated appreciably above the river. These terraces, as well as some bottom land, are extensively farmed. Above these terraces, the great massive of Grand Mesa rises abruptly.

The flanking mesas are remains of tertiary basalt, underlain with shales and various sandstones in successive layers which are discernible at elevations which have been exposed by erosion. The Grand Mesa has been described as "the world's largest flat-topped moun-

tain"—an isolated fragment of the Roan Plateau north of the Colorado River. The glaciated, lake-dotted surface is 900 square miles in extent.

Vegetation varies consistently with elevations involved. At higher levels are extensive forests, consisting mostly of Engelman spruce, often combined with quaking aspen. It is this type of cover which occurs notably around the Bonham Reservoir site. Undergrowth shrubbery includes box myrtle, bearberry, blueberry, and similar species generally associated with such forest covers at this elevation. At lower elevations, ranging down to about 7,000 feet, shrubby vegetation is predominant, with bluegrass and fescue among other herbaceous covering. Shrubby growth includes big sagebrush, rose, willow, etc. It is this type of vegetation which prevails around the Vega Reservoir site, especially on the north side which is bordered by comparatively low rolling hills to form the meadowlike reservoir basin which lies between them and the abrupt slopes of the northern edge of Grand Mesa on the south side. Some groves of aspens occur in the small valleys of these hills, which are quite bleak in appearance compared to the impressive, much steeper slopes on the south side, which are partially covered with the lower forest zone of spruce with extensive areas given over to aspen.

The scenery is interesting, but by no means spectacular for Colorado. The low rolling hills on the north side and the steep mesa slopes on the south side of the Vega site have been mentioned. The general aspect of the topography is gently rolling with little suggestion of the rugged, rocky tors, crags, and peaks which occur elsewhere in the Rockies.

The scenery around the Bonham site is more consistent, being generally framed by the slightly higher, rolling, domelike formations that occur on the Grand Mesa itself. The area is delightfully forested, an effect pleasantly relieved by forest glades and openings in which occur individual trees and small boskets.

Fed by clear mountain streams which arise on the Grand Mesa, the water in both reservoirs should be clear and sparkling and singularly free from silt or minerals in solution.

Climate

The climate varies consistently with differences in elevation. Average rainfall on the Grand Mesa is reported to be 18 inches annually, while in the valley near Collbran it is given as 15.9 inches. At the Vega site, rainfall is probably somewhere between these amounts. The climatic variation is likewise notable in the different length of seasons, with an average frost-free period of 129 days and a growing season of 156 days around Collbran, and with a growing season of only 60 days on the Grand Mesa. At Collbran, temperatures range from 100° maximum to 36° below zero. The average summer (July) temperature is 60° on the mesa and 69° at Collbran, January averages being 16° and 22°, respectively.

Generally, summer days are bright and warm, but rarely if ever oppressively so at these altitudes, and nights are comparatively cool and refreshing.

Historical and archeological investigations

National Park Service archeologists are of the opinion that it is extremely unlikely that archeological sites of importance occur in this

part of Colorado at elevations involved in the Collbran project. The possibility that minor historic interests may occur has not yet been investigated.

Present recreational evaluation

According to a report prepared by the United States Fish and Wildlife Service, November 1946, the fishery values within the project area are moderate per mile of stream, and Collbran was indicated as the lower end of trout water on Plateau Creek. Fishing pressure on these streams is considered moderate because of opportunities offered by the Grand Mesa lakes.

Aside from limited fishing value, it does not appear that the broad fertile farm valley, which is the site of the proposed Vega Reservoir, has much if any appeal for other recreational uses.

The small existing Bonham Reservoir presents a very different picture. In the above Fish and Wildlife Service report, it is noted that this reservoir, which is drawn down annually to as little as 11 acres, has a present fishery value of $530. However, this reservoir is on the Grand Mesa itself rather than being related to it, as in the case of the Vega Reservoir. On this basis, it is a part of a justly renowned recreational area which includes many small natural lakes, some of which are noteworthy for fishing. In some cases, these lakes are reported to have been increased in capacity by artificial barriers which involve unnatural summer fluctuations. However, it is reported that some of these lakes on the northern slopes will be stabilized during the summer and larger minimum pools maintained for secondary holding basins operated in connection with the Collbran project. The Fish and Wildlife Service indicates such operation will improve fishery values. Very few of these lakes will be accessible by more than trails.

The United States Forest Service broadly estimates that 5,000 man-days a year involve the Bonham Reservoir for recreational activities, but this is only a small part of the estimated use of the Grand Mesa area which is believed to exceed 90,000 man-days annually, including travel through the area as well as active recreational use.

Some provision has been made by the United States Forest Service to accommodate recreational use of the Bonham Reservoir. This consists mainly in a public campground. There are also several private cabins on leased sites. Forest Service representatives reported that these cabins were, in their opinion, generally substandard, inadequately maintained, and that they were interested in eliminating this type of land utilization in favor of larger public interests, at least in the Bonham Reservoir area.

Types of recreation for which reservoirs are suited

Both reservoirs should have appeal for fishing. One advantage vested in the Vega Reservoir in this respect will be somewhat earlier accessibility in the spring and later use in the fall due to its lower elevation, and what should be easier access at such times, provided seasonal road maintenance is adequate.

Some boating, limited very largely if not entirely to fishing, would be feasible and probably desired on both reservoirs. Boats would be small, provided at most with outboard motors, if any.

Limited picnicking, mostly relating to fishing, could be desirable at the Vega site, and, conceivably, some camping although Grand Mesa appeal for this important phase of recreation is so far superior to

opportunities which are likely to be found around the Vega Reservoir that it is unlikely to assume much importance.

The Vega Reservoir could be used for swimming, but the elevation is such that this type of recreation, too, is unlikely to exert a great deal of appeal.

The Bonham Reservoir, if operated according to present plans, should exert appeal not only for fishing but to a high degree for picnicking, camping, hiking, horseback riding, and other forms of recreation associated with high, cool, well-forested mountain country graced with scattered ponds, lakes, and meadows. There are also considerable winter sport activities on related areas of the Grand Mesa.

FACTORS INFLUENCING RECREATIONAL DEVELOPMENT

The region which could be served by recreational features of the Collbran project (primarily those associated with the Bonham Reservoir) would comprise essentially that generally associated with the over-all Grand Mesa area, of which it would form a part. This area of influence is definitely regional in scope, the Grand Mesa being nationally noted for its high recreational value in Colorado, a State similarly noted.

The area which could be influenced by the Vega Reservoir unit of the project will almost certainly be very local by comparison.

The population of Mesa County was given as 33,800 in the 1940 census, and that of Delta County, which includes important sections of Grand Mesa, was 16,470; the combined population of these two counties being 50,000. Community developments naturally occur in the more accessible valleys in this rugged country. The population of Grand Junction was 12,500 in 1940, and it is highly probable that well over half the population of the country is concentrated in this fertile section of the Colorado River.

There is no indication that this population is insensible to existing nearby recreational values—indeed, quite the contrary. Undoubtedly, this population contributes heavily to daytime use of the Grand Mesa country and, to some extent, to more extensive use. However, the very heavy use of this fine area, which approaches if it does not surpass 100,000 man-days a year, can only result from very extensive visitation by people from more distant parts of the State and from other States as well. It is significant that this use is largely concentrated in the southwest portion of the Grand Mesa National Forest.

The chief economic resources of this section of the State appear to be livestock, agriculture, including irrigated fruit orchards and small crops, and forestry. Income derived from the extensive tourist and recreation trade also contributes significantly to economic stability.

The Vega Reservoir, except for early and late season use, will be definitely in competition with the general Grand Mesa area. This is a relation which emphasizes the impression that it will be purely local in its limited recreational value. The value of this reservoir for fishing has been appraised by the Fish and Wildlife Service in their report at $4,700.

The Bonham Reservoir will not, on the other hand, be in competition with the Grand Mesa area; it will, in fact be part of it. Its chief significance in this respect will be the opportunity to enlarge

existing recreational opportunities on Grand Mesa and to reduce increasing tendencies of overuse; a matter about which United States Forest Service representatives expressed some concern.

It seems unlikely, except in circumstances of very unusual recreational development, that the Bonham Reservoir could of itself appreciably increase the already great recreational appeal exercised by the Grand Mesa area. In other words, while use of the Bonham area should considerably increase, predicated on the sponsor's plan of operation and appropriate developments, it is believed unlikely that use of the Grand Mesa as a whole will be appreciably affected thereby.

It would be the general area then, rather than the Bonham Reservoir itself, which could be affected by the development of major reservoirs being considered near Grand Junction, such as the one on the Gunnison at or near Whitewater, and possibly on the Colorado itself (the Dewey site) in eastern Utah, and extending somewhat into Colorado. It is believed, however, that, if developed, such reservoirs would be so entirely different in character and so much lower in altitude they would complement rather than compete with the Grand Mesa area as a whole. To the extent competition was involved, it could, in the long run, be beneficial by tending to reduce dangers of overdevelopment and overuse which could be highly detrimental to the Grand Mesa.

In considering factors influencing recreational development, it is interesting to note that a recreational survey report on the Colorado River Basin (shortly to be published) states as follows: "Of all portions of the Colorado River Basin, the Grand and San Juan divisions have the least need for artificial lakes. However, with the great number of tourists attracted to the region, additional water bodies that do not interfere with or eliminate existing recreational resources should be of considerable benefit."

ESTIMATE OF RECREATIONAL NEED AND USE

The extensive use now made of the Grand Mesa area for day use, week end, vacation, and tourist use as well as for organized group and other camping and summer home sites is irrefutable evidence of recreational needs and use which can be and are being provided for in this fine area. When United States Forest Service representatives were interviewed regarding this use, estimates for 1947 visitors were not available. However, the records for 1946 were enlightening, and included the following:

	Man-days
Camp use (forest)	21, 000
Picnic use	12, 000
Organized group areas	3, 500
Hotels and resorts	5, 500
Winter sports	1, 200
Summer home guests	4, 100
Total	47, 300

It was estimated that approximately an equal number of people traveled through the area, representing a total of over 90,000 man-days of recreational use of the Grand Mesa area. The 1946 travel year was a very heavy one for National Park Service areas (all categories). But travel to these areas in 1947 shows an increase of 17

percent while for recreational areas, such as Lake Mead, Lake Texoma, etc., the increase was 23 percent. It seems logical to assume a comparable increase for travel to and through the Grand Mesa. Even on the basis of the more conservative percentage, this would represent a use of this area exceeding 100,000 man-days.

Recreational use of Grand Mesa is accommodated by both public and private developments, including Forest Service camp and picnic grounds and lodge developments with overnight cabins in private lands (and possibly some on forest land, under permit from the Forest Service). There are also private cabins on leased Forest Service sites, and camping facilities include provision for group or organized camping.

The most important of these developments are reported to occur in relation to State Highway 65 at or near the junction with the mountain road from Collbran via the Bonham Reservoir which is 7 or 8 miles by road from this section of the national forest.

RECOMMENDED RECREATIONAL DEVELOPMENT

Vega Reservoir

In view of the appraised local significance of the Vega Reservoir, it is believed that only nominal facilities directly associated with recreational use of the reservoir should be considered. These would include arrangements for launching and landing small boats, and related picnic area. Only a slight modification of the usual picnic area could adopt it, in part at least, to such limited camping as may occasionally be desired. Suitable pit toilets, properly maintained, should be adequate to meet the needs of anticipated use.

If feasible economically, it would be desirable to make provision for potable water.

The most attractive sites for such a development appear to be on the south side of the reservoir, which the sponsor has advised it will be necessary to serve with a road in any event, for access to existing farms or ranches. It would be preferable, if possible, to select a site related to this road to minimize road construction. In this case, under otherwise favorable conditions, only a minor spur road should be required, supplemented with necessary parking areas, boat trailer turn-around, etc.

Bonham Reservoir

There are interesting possibilities for recreational developments which could accommodate and encourage public recreational use of the Bonham Reservoir. This reservoir may prove to be a comparatively popular unit on the Grand Mesa. Developments will require consideration of existing developments on Grand Mesa and a careful analysis of elements of both competition with such developments and desirable distribution of use that would, in the long run, benefit the Grand Mesa area as a whole by reducing tendencies for overconcentration of use and development in some places and underdevelopment in other places of equal, sometimes superior, recreational value.

The trend of recreational use on Grand Mesa appears to be such that it is believed that eventually consideration of the advantages of dispersion of use will justify considerable development at the Bonham Reservoir.

On this basis, but not necessarily in the immediate future, it is recommended that the following developments be considered for this reservoir:

Picnic and camping areas planned for suitable expansion with proved need.
Boat launching arrangements.
Pier.
Lodge with overnight accommodations, including overnight and housekeeping cabins and boat rental facilities. This would be a concession development.
One organized or group camp.
Employees' residences.[1]
Utility area.[1]
Utilities: Potable water; sewage disposal; power distribution (if and when available).
Access roads and parking areas.

Except as especially suitable sites for development occur on the west side of the reservoir or ultimate pressure of use encourages developments there, access to areas in the east side, which is paralleled by the main access road, should not involve much difficulty or cost, either of construction or maintenance.

Trail systems which may serve this reservoir area would be in the national forest, and, to the extent developed, would probably be directly involved in normal national forest operations or developed, in part at least, in connection with the general recreational program for Grand Mesa as promulgated by the United States Forest Service.

LAND ACQUISITION

The Bonham Reservoir is entirely surrounded by national forest. It does not appear that the situation here is complicated by private "inholdings." The allocation of lands around the reservoir for recreational (and other) uses will be made by the United States Forest Service. It is appropriate to assume that such allocations will be wisely made and based on adequate land utilization studies conducted by that agency in connection with uses relating to both the reservoir and the national forest.

The Vega Reservoir site is all privately owned according to the sponsor, and will have to be acquired. It is quite possible that the nominal developments recommended for this reservoir can be satisfactorily accommodated on land acquired for project development and operation. Only at such time as a suitable site for recreational development can be determined on the ground and tentative severance lines established will it be possible to comment constructively on desirable boundaries that would satisfactorily meet the requirements indicated. It is recommended, however, that the sponsor accord careful consideration to these matters in severance line studies, so far as compatible with regulations and policies governing reservoir land acquisitions.

[1] These items would be contingent upon the needs of the administrative agency. If, as seems probable (see below), this is the U. S. Forest Service, it is possible that National Forest Service operation and administration facilities on Grand Mesa would make these unnecessary at the Bonham Reservoir, in whole or in part.

ESTIMATED COST OF DEVELOPMENT

The following cost estimates, prepared in the absence of either general or detailed plans, must be accepted as broad in scope and subject to later revision as more complete information regarding sites and details of facilities, based on further study and planning, become available. It is, however, believed that the costs indicated, predicated on 1947 indices, are sufficient to permit development of facilities commensurate with estimated needs as indicated in this report.

Vega Reservoir

It is estimated that developments for the Vega Reservoir should be provided for a cost of $14,400, which, amortized at 3 percent over a 30-year period, would represent an annual cost (in round figures) of $700. Allowing $400 for operation and maintenance, the total annual cost for this reservoir would be $1,100.

It is broadly estimated that $4,500 should be allowed for replacements during the amortization period indicated.

Initial development costs have been estimated higher than was indicated in the National Park Service section of the 1946 Colorado River Report (previously referred to) because of higher prevailing costs of construction and because it is now believed to be essential to make some allowance for road work, which may be required, and suitable provision for plans, surveys, and supervision of construction.

The nominal allowance for annual maintenance is predicated upon recommended administration of the area, as discussed later in this report.

Bonham Reservoir

It is estimated that the development costs for the Bonham Reservoir would be $176,000, half of which would be repayable through rents and concessioner charges in the event concessional facilities are Government provided. Amortized at 3 percent over a 30-year period, the annual cost would be $8,400.

Predicated on the recommended (and probable) administration, operation, and maintenance of the area by the United States Forest Service, it is broadly estimated that annual operation and maintenance costs would be $3,500, making total annual costs $11,900.

It is broadly estimated that $35,000 should be allowed for replacements occasioned by wear and/or obsolescence during the amortization period.

As in the case of such development items as the custodian's residence and utility area, an effort has been made in estimating operation and maintenance costs to recognize the existing well-organized administration of the National Forest, including personnel and equipment. Obviously, the United States Forest Service, already broadly experienced in such national forest uses, is in a stronger position to estimate more accurately what additional provision, if any, would be required to satisfactorily operate and maintain the Bonham Reservoir as one unit in an extensive forest area with its attending recreational uses, or a reasonable allocation of present personnel and equipment to assure satisfactory results.

An analysis of estimated costs is provided in the appendix of this report.

ESTIMATED MONETARY BENEFITS

Vega Reservoir

It is broadly estimated that incidental recreational use of this reservoir, aside from fishing, will result in economic values of $1,100 for recreational and related benefits.

Bonham Reservoir

It is estimated that general recreational and related values deriving from use of this reservoir would be $32,500 annually, exclusive of fishing values.

On the estimated man-day use basis, and recognizing the present absence of overnight accommodations with attending per diem benefits, it is believed that this represents a gain of some $27,500 over preproject recreational values. The net annual value would be $20,600 for this reservoir (when allowance is made for $11,900 annual costs) involving a gain of $15,600 over preproject values.

It must be emphasized that such benefits are predicated upon the full development and utilization of the recreational resources inherent in this reservoir in its relation to the Grand Mesa area.

Without developments and facilities to accommodate the estimated increased use, it is believed that any increase in present use would be material, but far less than with the development indicated. It is very roughly estimated that without such developments, increased use could be valued at possibly $3,000 over a preproject evaluation, especially since per diem benefits would be negligible in the absence of suitable overnight accommodations.

As previously noted, it is unlikely that this reservoir would materially increase the already great appeal of the Grand Mesa. From this point of view, the above benefits would not be net benefits to the general area. Benefits accruing to Grand Mesa, through desirable dispersion of use, could be very great in the long run, but such over-all benefits are believed to be too intangible to justify an attempt to express them in monetary terms.

An analysis of benefits is included in the appendix of this report. Development costs, annual values, and benefits are summarized in table IV.

RECOMMENDED AGENCY FOR ADMINISTRATION, OPERATION, AND MAINTENANCE

Vega Reservoir

The Vega Reservoir could be, at most, a matter of county recreational interest. In view of the size of the county, total population and its distribution, and the wealth of recreational opportunities naturally occurring in the region, it is doubtful if the county authorities could be much interested in assuming responsibilities in connection with the administration, operation, and maintenance of recreational facilities at the reservoir. As noted in the report, only nominal developments are considered justified for this reservoir, and they are not of an order which could justify elaborate administration arrangements.

TABLE IV.—*Summary of costs and values*

Area	Development cost		Total cost	Annual cost	Annual maintenance and operation	Total annual cost	Annual value [1]	Net annual value
	Non-repay	Repay						
Vega Reservoir	$13,300	-------	$13,300	$700	$400	$1,100	$1,100	-------
Bonham Reservoir	83,000	$83,000	166,000	8,400	3,500	11,900	32,500	$20,600
Collbran project	96,300	83,000	179,300	9,100	3,900	13,000	33,600	20,600

[1] Exclusive of fishery values.

ESTIMATED REPLACEMENT COSTS DURING AMORTIZATION PERIOD

Vega	$3,400
Bonham	33,000

Summary of benefits

Bonham Reservoir:	
With development:	
Preproject value	$5,000
Net postproject value	20,600
Net benefit	15,600
Without development:	
Postproject value	8,000
Net benefit	3,000

Annual costs and values for the Vega Reservoir should practically balance with recreational facilities. Without added facilities, it is believed that incidental recreational use of the reservoir (in addition to values appraised by the Fish and Wildlife Service) would be too negligible to justify expression in monetary terms.

It is recommended that the county be encouraged to participate to the extent of incidental maintenance of the very limited road which is likely to be necessary for access.

It is believed that it should be feasible for project operation personnel assigned to the reservoir to exercise satisfactory supervision of such maintenance as would be required, which could be done by part-time labor employed for the purpose. It is possible (and it would be desirable) if such labor could be secured in the neighborhood, or Collbran, and provision made to include such privately owned equipment (as pickup or truck) as the circumstances warrant. It should be possible to arrange such service on a use-season contract basis.

Bonham Reservoir

The administration, operation, and maintenance of this fine area should present no problem. The area lies entirely within the Grand Mesa National Forest. These responsibilities fall naturally into the sphere of operations of the United States Forest Service, which is extensively experienced in such matters. When interviewed, representatives of that Service expressed very definite interest in the preparation of a land utilization plan for the Bonham Reservoir area for all suitable uses including recreation. This is held to be an altogether appropriate approach to the problem. The National Park Service entertains great confidence in the ability of the United States Forest Service to make appropriate and well-considered allocations of land use with due regard to the Grand Mesa area as a whole, with which that Service is thoroughly familiar, and to properly balance disadvantages of possible competition with existing developments

with advantages of dispersing usage in the major interest of the whole area.

Further study and planning

Further study will be required to determine the area best suited to the limited developments recommended for the Vega Reservoir, and, ultimately even the nominal facilities which may prove warranted will require surveys and detailed planning commensurate with their importance.

As noted above, a land utilization plan for the Bonham Reservoir will require a considerable measure of study on the part of the United States Forest Service based on their intimate knowledge of the Grand Mesa and on experience and data which greatly transcend those which are presently available to the National Park Service.

Additional studies of these reservoirs will entail due consideration of any changes in plans of operation advanced by the sponsoring agency.

APPENDIX

TO

NATIONAL PARK SERVICE REPORT

Estimated cost of recreational developments, Vega Reservoir

	Cost	Annual cost
Roads and parking areas	$6,000	
Launching ramp	1,000	
Boat landing	1,200	
Picnic-camp area	1,000	
Pit toilets (2)	600	
Potable water (if feasible)	700	
Subtotal	10,500	
Contingencies, 10 percent	1,050	
Subtotal	11,550	
Plans, surveys, supervision of construction, 15 percent	1,732	
Total development cost	13,282	
Cost ($13,300) amortized 30 years at 3 percent ($678)		$700
Annual maintenance:		
Part-time labor and materials		400
Total annual cost		1,100

Replacement costs

In the absence of both structural plans and reliable data on future cost trends, it is broadly estimated that $3,400 should be allowed for replacements due to wear and tear and also obsolescence during the indicated amortization period.

Estimated cost of recreational developments, Bonham Reservoir

	Cost	Annual cost
A. Nonrepayment items:		
Roads, access and parking areas	$8,000	
Boat-launching ramp	1,500	
Pier	2,500	
Picnic area	3,000	
Camping area	3,000	
Organized camp	8,000	
Utilities, water, sewerage system, power	20,000	
Public toilets (2)	9,000	
Pit toilets	1,800	
Utility area	3,500	
Subtotal	60,300	
Contingencies, 10 percent	6,030	
Subtotal	66,330	
Plans, surveys, supervision of construction, 25 percent	16,582	
Total nonrepayment development cost	82,912	
Cost (rounded $83,000) amortized 30 years at 3 percent ($4,233)		$4,200
B. Repayment items:		
Lodge and appurtenances	60,000	
Custodian's residence	8,500	
Subtotal	68,500	
Contingencies, 10 percent	6,850	
Subtotal	75,350	
Plans, surveys, supervision of construction, 10 percent	7,535	
Total repayment cost	82,885	
Cost (rounded $83,000) amortized 30 years at 3 percent		4,200
(These items, to the extent constructed with Federal funds, would be repaid through rent, concessioner charges, etc.)		
C. Administration, operation, and maintenance:		
Salary, ranger-manager (part time)	1,800	
Salary, labor (part time)	1,200	
Equipment (prorated)	300	
Materials, supplies, etc	200	
Total annual operation and maintenance	3,500	3,500
Total annual costs		11,900

D. Replacement costs

In the absence of both structural plans and reliable data on future cost trends, it is broadly estimated that $33,000 should be allowed for replacements due to wear and tear and also obsolescence during the indicated amortization period.

ESTIMATED BENEFITS OF VEGA RESERVOIR

Predicated on the appraised local importance of the Vega Reservoir, it is estimated that its chief value for recreation would be for fishing. The United States Fish and Wildlife Service has indicated a postproject fishery value of $4,700 for this reservoir. The National Park Service believes that only a very nominal allowance should be made for incidental recreational use of the reservoir aside from fishing, and would assign an additional $1,100 as representing a reasonable monetary evaluation of incidental use with attending recreational and related benefits.

Bonham Reservoir

Estimated 10,000 visitors:		
Local use	2,000	
Tourist and other uses	8,000	
Travel value: [1] 2,000×110 at 1½ cents per mile	$3,300	
Tourist and related travel: [2] 8,000×20 at 1½ cents per mile	2,400	
Total travel value		$5,700
Per diem value: [3] 2,000×3 at $3.50 per day		21,000
Recreational value:		
10,000 visitors at 25 cents	$2,500	
2,000 visitors 2 extra days at 25 cents	1,000	
Total recreational value		3,500
General value:		
20 percent of $5,700 travel value	$1,140	
20 percent of $21,000 per diem value	4,200	
Total general value		5,340
Total general recreational and related values		35,540
Less postproject fishery value		−3,060
Net value (rounded, $32,500)		32,480

[1] Local zone estimated average round trip: 110 miles.
[2] Estimated mileage allocable to use of reservoir: 20 miles.
[3] It is estimated that 20 percent of the visitors will spend an average of 3 days in the area.

The Fish and Wildlife Service has attached a postproject fishery value of $3,060 to this reservoir. Since these values are obviously directly involved in general recreational and related values, full allowance must be made for them to avoid confusing duplication of evaluations appraised by the two Services. On this basis, the net National Park Service appraisal of recreational and related values for the Bonham Reservoir is $32,500.

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