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STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

Northern District

THOMES-NEWVILLE AND GLENN RESERVOIR PLANS

ENGINEERING FEASIBILITY

NOVEMBER 1980

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November 1980

View to the southeast over Newville Reservoir area, with Black Butte Reservoir at upper left. Newville Dam site is the low opening in the right third of the prominent Rocky Ridge, where trees fan out into the valley. A diversion canal from Thomes Creek would enter the valley through the same gap that the road now travels, in the right of the photograph.

FOREWORD

In 1978, the Department's Bulletin 76, "Delta Water Facilities", included a Glenn Reservoir offstream storage plan in the program to meet future needs of the State Water Project. Since then, additional investigations of the Glenn Reservoir Plan have been carried out by the Northern District under the State Water Project Future Supply Program. During these studies, a smaller version of the Glenn Reservoir Plan was considered. Called the Thomes-Newville Plan, it could be developed either as a separate facility or be treated as the first stage of a later full-scale Glenn Reservoir Plan.

This report assesses the physical and operational feasibility of the two plans. Environmental studies are underway and have been taken into account in the formulation and design work; they will be continued and reported fully in a subsequent phase of the investigation. The present objective is to provide a sound basis for judging the potential of the plans and to guide future work.

The report concludes that both the Thomes-Newville and Glenn Reservoir Plans are feasible from an engineering viewpoint, although many details remain to be worked out. The Thomes-Newville Plan would better meet expected future water demands and has been tentatively scheduled for construction in the mid-1990s (subject to its satisfying the necessary environmental and economic criteria). To meet that schedule, investigation of the Plan continues and will culminate in a plan formulation and draft environmental impact report in June 1983.

Albert J. Dolcini, Chief
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State of California
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DEPARTMENT OF WATER RESOURCES

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TABLE OF CONTENTS

FIGURES

Figure No.		Page

TABLES

Table No.

APPENDIXES

PLATES

CHAPTER 1. SUMMARY

This report discusses the physical and operational feasibility of two potential plans for developing additional water supplies for the State Water Project. Current water supply and demand projections indicate that the smaller of these, the Thomes-Newville Plan, could be needed in the mid-1990s. Subsequent studies will concentrate on the Thomes-Newville Plan as a viable development in its own right. Larger developments of the scale of the Glenn Reservoir Plan will not be needed until after the turn of the century. Further study of Glenn Reservoir will be deferred, but may be resumed within the next few years as part of the analysis of alternatives in the upcoming feasibility evaluation of enlarged Shasta Reservoir.

The Thomes-Newville and Glenn Reservoir Plans would be located on the west side of the Sacramento Valley in Tehama and Glenn Counties, as shown in Figure 1-1. Glenn Reservoir would be formed by Newville and Rancheria Dams in the Stony Creek drainage area upstream from the existing Black Butte Reservoir. The Thomes-Newville Plan would include only the northern compartment of Glenn Reservoir, with facilities to divert from Thomes Creek and the main stem of Stony Creek.

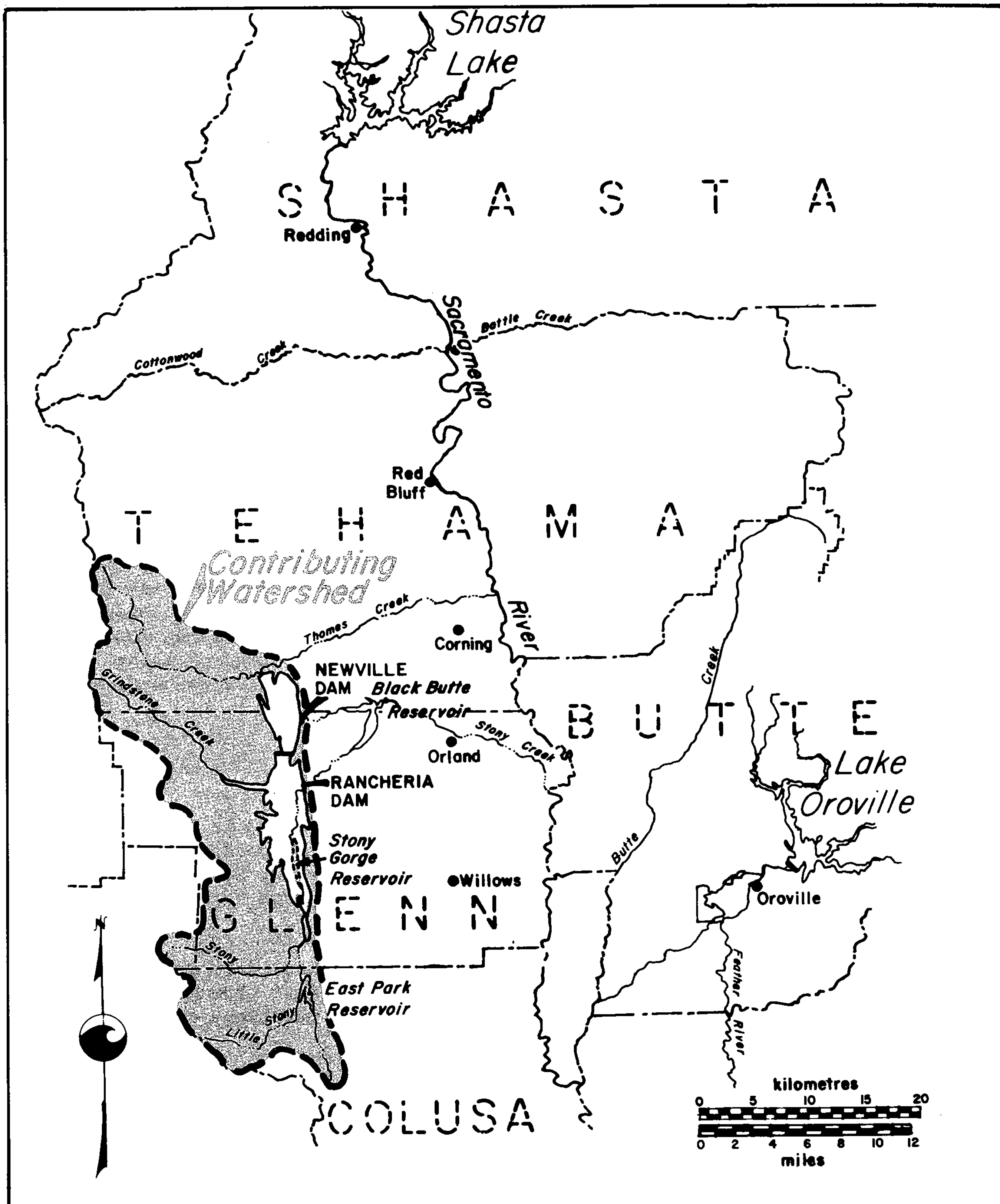
Most of the major features of these plans have been studied in considerable detail over the past 20 to 25 years and a substantial body of data has been developed to support assessment of their engineering feasibility. Appendix F summarizes the history of water development in the Thomes and Stony Creek Basins and outlines past planning studies that have led to the current plans.

Thomes-Newville Plan

The centerpiece of the Thomes-Newville Plan would be the reservoir created by Newville Dam on the North Fork of Stony Creek. The North Fork has a limited drainage area and little surplus water; most of the water supply for Newville Reservoir would be diverted from adjacent streams, as shown in Figure 1-2.

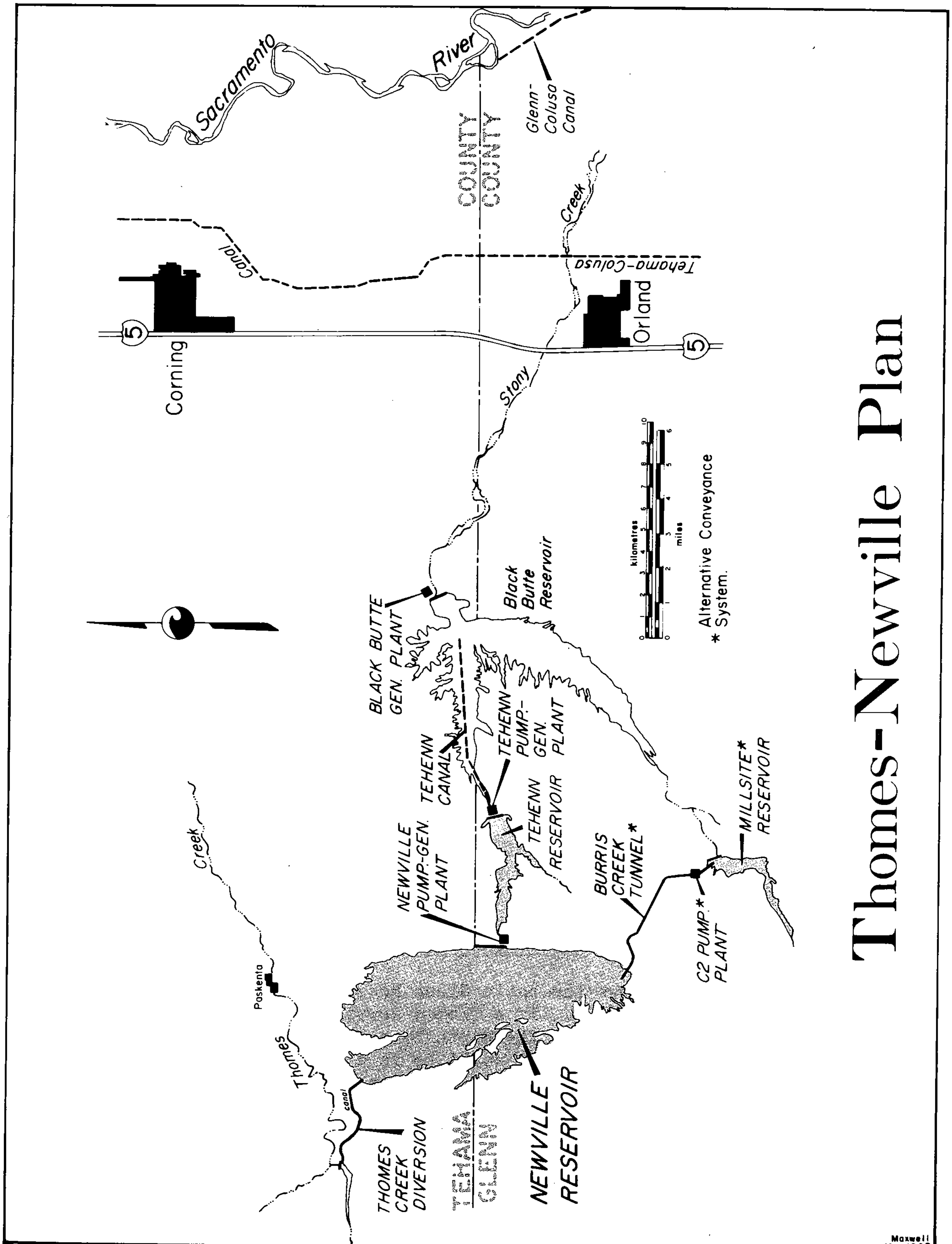
Surplus water from Thomes Creek would be conveyed by gravity flow from a low diversion dam. The diversion canal would pass through a saddle on the drainage divide and discharge directly to the northwest corner of Newville Reservoir.

Diversion of surplus flows from the main stem of Stony Creek would be more complex. Two alternative methods of making this diversion have been investigated; both are shown in Figure 1-2, but only one would actually be built. The northern conveyance alternative would involve pumping from the existing Black Butte Reservoir to a Tehenn Reservoir on the North Fork of Stony Creek. Tehenn Reservoir would back water to the toe of Newville Dam, where a second plant would make the final pump lift into Newville Reservoir.



Location Map

Figure 1-2



Thomes-Newville Plan

Reversible pump-turbine units would be included at both the Tehenn and Newville Plants so that electrical energy could be generated whenever reservoir releases were being made.

The alternative Stony Creek diversion route would employ a Millsite Reservoir to capture surplus water before it reached Black Butte Reservoir. From Millsite Reservoir, a pumping plant would lift the diverted flows to the south end of Newville Reservoir via a penstock, tunnel, and channel system. Reservoir releases would be discharged through a separate generating plant at Newville Dam to the natural channel of the North Fork of Stony Creek. Tehenn Reservoir would not be built under this option.

With either of the alternative diversion routes, Newville Reservoir releases would be discharged to lower Stony Creek via Black Butte Reservoir. Additional energy could be recovered if a generating plant were built below Black Butte Dam, but that plant would not be essential to operation of the plan. Releases would flow down Stony Creek and be diverted, under an exchange agreement, to either the Glenn-Colusa Irrigation District Canal or the Tehama-Colusa Canal of the Central Valley Project. Little water from Newville Reservoir would reach the Sacramento River under planned operating conditions.

The Thomes-Newville Plan would have relatively few detrimental impacts on the local environment. The reservoir would inundate an area used primarily for cattle grazing. The land is in fairly large holdings and supports about 20 different ranching operations that depend on native range. Only about 70 permanent residents would be displaced. No irrigated areas have been identified within the prospective reservoir area. Newville Reservoir and the Thomes Creek diversion facilities would affect a wintering area used by migratory deer; at present, this appears to be the most serious potential impact on wildlife. Studies of environmental impacts of the Thomes-Newville Plan are underway and will be receiving increased emphasis in subsequent phases of investigation. A plan formulation and draft environmental impact report are scheduled for completion in June 1983.

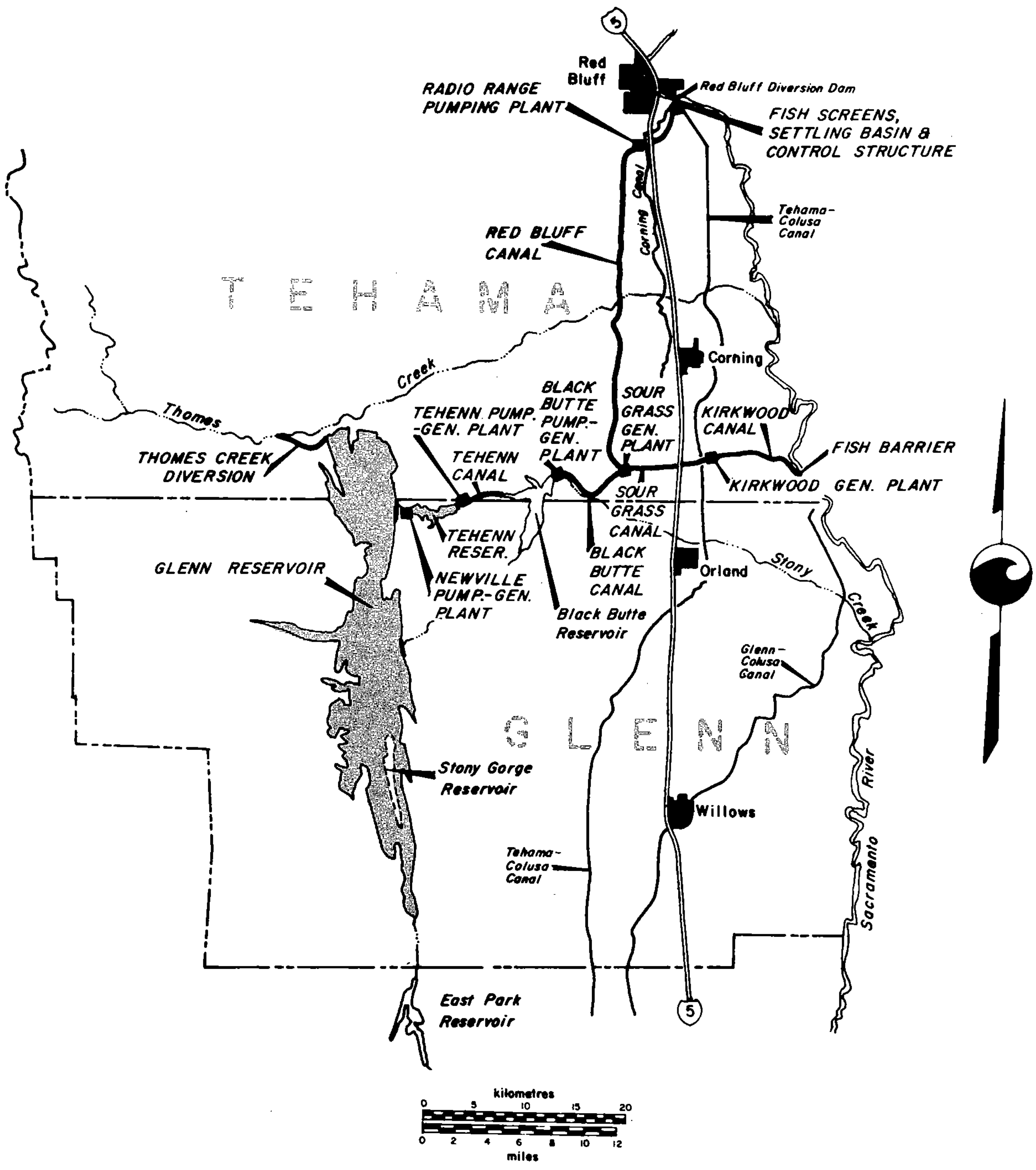
As stated earlier, the Thomes-Newville Plan would constitute a viable water supply development in its own right, but it could be designed for later enlargement as a part of a full-scale Glenn Reservoir Plan. The enlargement options are described in a subsequent section of this chapter.

Glenn Reservoir Plan

Figure 1-3 shows the basic Glenn Reservoir Plan that would be built in a single stage (i.e., if a Thomes-Newville Plan were not built previously). Newville Dam, on the North Fork of Stony Creek, would be some 30 m (100 ft) higher than it would be in a Thomes-Newville Plan. Rancheria Dam would be constructed on the main stem of Stony Creek and the two reservoir compartments would merge to form Glenn Reservoir.

Surplus runoff from Stony and Thomes Creeks would be insufficient to justify construction of such a large reservoir. About 70 percent of the

Figure I-3



Glenn Reservoir Plan

Maxwell
April 1980

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necessary water supply would be derived by pumping surplus winter and spring flows from the Sacramento River. As shown, the water would be diverted from the river at the existing Red Bluff Diversion Dam via an extensive conveyance system. Two pumping plants and about 46 km (29 mi) of canals would be required to deliver Sacramento River water to Black Butte Reservoir. From there, facilities similar to those described for the Thomes-Newville Plan would connect to the Newville compartment via Tehenn Reservoir; two more pumping lifts would be needed in this reach. The total static pumping lift from the Sacramento River to Glenn Reservoir would be approximately 230 m (750 ft).

Releases from Glenn Reservoir would ordinarily be made at Newville Dam so that energy could be recovered through use of reversible pump-turbine units. (During infrequent extreme reservoir drawdowns, the reservoir compartments would separate and the lower portion of Rancheria Reservoir would have to be withdrawn at Rancheria Dam.) An additional power drop would be taken at Black Butte Dam, where the releases would enter the Black Butte Canal. At the east end of the Black Butte Canal, the releases would enter a separate canal system that would deliver them either to the Sacramento River or for exchange with the Tehama-Colusa or Glenn-Colusa Canal. Power would be recovered at two additional plants along this canal system.

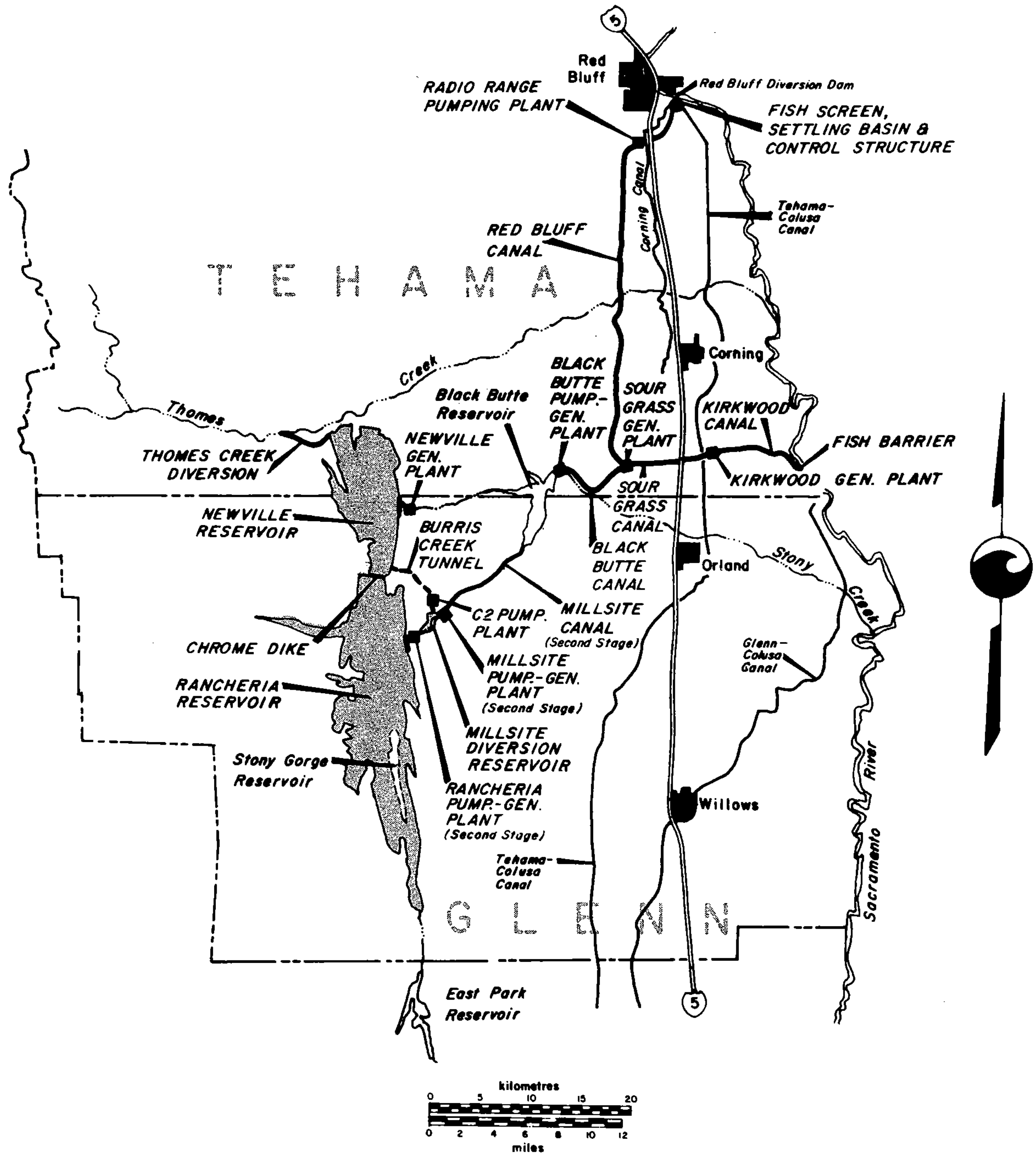
Alternative (Staged) Glenn Reservoir Plan

As noted, the Glenn Reservoir Plan shown by Figure 1-3 would be constructed as a single-stage development. However, current water demand-water supply projections indicate that the full yield of a development of that size would not be needed until well after the turn of the century. Even then, demands would not be increasing at a rate to use the Glenn Reservoir yield as rapidly as it would develop. In short, single-stage development of a full-scale Glenn Reservoir Plan would produce too much water all at once. For this reason, it is unlikely that the plan shown by Figure 1-3 would be built.

On the other hand, a Thomes-Newville Plan would fit well into an orderly sequence of smaller developments staged to fit the expected demand buildup. Then, if a larger increment of additional yield were needed at some later date, the initial facilities could be incorporated into a Glenn Reservoir Plan. This would result in a somewhat different final plan configuration, as shown by Figure 1-4.

In the staged plan, the initial Thomes-Newville Plan would incorporate the Millsite diversion alternative to capture Stony Creek water. Then, in the second stage, the diversion from Black Butte Reservoir would follow the main stem of Stony Creek, through the Millsite Reservoir that would have been built in the first stage. The main inlet and outlet to Glenn Reservoir would thus be at Rancheria Dam (rather than at Newville Dam as it would be in the single-stage plan). All the conveyance facilities north and east of Black Butte Dam would be the same for either the staged or single-stage plans.

Figure 1-4



Alternative (staged) Glenn Reservoir Plan

Maxwell
April 1980

There are two major options for the reservoir in a staged Glenn Reservoir Plan. The first option investigated was to raise Newville Dam in the second stage to create a conventional Glenn Reservoir. The conveyance facilities between Millsite and Newville Reservoirs would have to be abandoned or modified substantially, as they would reach the enlarged reservoir at the wrong elevation. The Newville generating facilities would be retained, for occasional use during extreme drawdown.

Studies of raising Newville Dam in a staged plan indicate that the total eventual dam cost would be only a few percent more than with single-stage construction. However, there would be a substantial shift in cost to the first stage compared to a similar dam that did not provide for later enlargement. This would add significantly to the cost of water from the Thomes-Newville Plan.

The second option for staged construction of a Glenn Reservoir Plan was developed to avoid unfavorable impacts on the cost of the Thomes-Newville Plan. In this option, all of the first stage features would be left intact at their original sizes. A Rancheria compartment would be constructed to a higher level than the Newville compartment, using a dike to separate the two. Sacramento River water would be pumped through Black Butte Reservoir to Millsite Reservoir as with the other option; from Millsite Reservoir, it could be pumped to both compartments of Glenn Reservoir using the Millsite-Newville diversion facilities constructed in the first stage and the second-stage pumping facilities at Rancheria Dam.

Operation of this "split-level" Glenn Reservoir would be more complex than for the more conventional plan, but it appears to have significant potential because it would not require a commitment at the time of construction of the Thomes-Newville Plan.

General Findings

The major findings of the current investigation of engineering feasibility are:

- All of the features of the Thomes-Newville and Glenn Reservoir Plans are physically feasible and could be designed and constructed with conventional techniques. There are no active faults at the sites of any of the proposed structures. Construction materials are available, although additional exploration and testing is needed to evaluate their qualities and quantities.

- The Thomes-Newville and Glenn Reservoir Plans are operationally feasible; they could produce substantial quantities of new yield under the terms described in Chapters 2 and 6.

- A wide variety of Thomes-Newville and Glenn Reservoir Plans could be formulated to meet different objectives under varying conditions. However, the water supply and topographic conditions are best suited to a large carry-over storage reservoir that would be operated to favor production of dry period yield.

- Formulations of specific Thomes-Newville and Glenn Reservoir Plans to meet the needs of the State Water Project depend on many factors, such as: (1) what other storage and conveyance facilities are proposed for development; (2) the sequence of future development; (3) future demand buildup rates; (4) the value of new yield; (5) the value of energy; and (6) discount rates and formulation criteria. None of these factors is completely defined at present, so it would be unwise to select a single plan at this early stage of planning.

- Seismic design of Newville and Rancheria Dams would be controlled by a "maximum credible earthquake" of Magnitude 6.5 on the Stony Creek Fault west of the reservoir. The fault lies 5.6 km (3.5 mi) from Newville Dam site and 7.0 km (4.3 mi) from Rancheria Dam site. The resulting accelerations at the dams would be of manageable proportions and should not require any extraordinary design measures.

- The sizes of outlet facilities and spillways at Newville and Rancheria Dams would be dictated by criteria for emergency reservoir evacuation. These criteria can have a very substantial impact on costs.

- Preliminary designs and cost estimates for Newville and Rancheria Dams have been based on use of substantial quantities of impervious embankment materials from potential borrow areas east of the damsites. Future studies should devote additional attention to possible use of the less-abundant materials from within the future reservoir areas. (Use of materials from the reservoir would reduce project impacts on the local area, but could interfere with filling the reservoir during the final stages of construction.)

Thomes-Newville Plan Findings

More specific study findings relating only to the Thomes-Newville Plan are:

- With the formulation criteria described in Chapter 2, the optimum size range of Newville Reservoir in a Thomes-Newville Plan would be from about 1 700 000 to 2 300 000 dam^3 (1,400,000 to 1,900,000 ac-ft), depending on the operating mode and the value of yield.

- Materials are available nearby for construction of the various features of the Thomes-Newville Plan, but more work is needed to evaluate their quality and quantity. Local sandstone and conglomerate appear to be weaker and less durable than the usual quarried rock for use in dams; the dam could be designed to accommodate the properties of the rock material, but it would probably prove more economical to use stream gravels from Stony and Grindstone Creeks.

- Known quantities of sand and gravel in the vicinity are insufficient to construct the major structural zones of both Newville and Rancheria Dams. One of the dams would have to include a substantial zone of quarried rock. If it were less costly than rock, the gravel should be used in the Thomes-Newville Plan (even though the gravel borrow areas are much closer to Rancheria Dam site).

- Provisions for later enlargement would add substantially (about $80,000,000 in 1980 dollars) to the first cost of the reservoir in a Thomes-Newville Plan. (This covers only the cost of the dam and saddle dams; other added costs would be encountered for spillway and outlet facilities.)

- The water supply available with the Thomes-Newville Plan would justify development of only about half of the storage potential of the Newville Reservoir site. Diversion of Sacramento River water via the Tehama-Colusa Canal could conceivably be used to permit fuller development of the Newville Reservoir storage potential. The Water and Power Resources Service is currently examining a similar development using Sites Reservoir in Colusa County for offstream storage of Tehama-Colusa Canal water; if that plan were rejected, consideration should be given to linking the Tehama-Colusa Canal to Newville Reservoir.

- The optimum capacity of the Thomes Creek diversion facilities is relatively insensitive to the project operating mode or the value of new yield. A capacity of about 283 m^3/s (10,000 ft^3/s) was derived from application of the formulation criteria used in this study.

- Thomes Creek carries a heavy sediment load. The storage capacity at prospective diversion reservoirs on Thomes Creek would be too small to assimilate the incoming sediment, so the diversion facilities would have to be designed to pass most of the suspended sediment on through to Newville Reservoir. Newville Reservoir would have capacity to store all the Thomes Creek sediment for several thousand years. (The extraordinary sediment associated with extreme floods would be carried on down Thomes Creek.)

- Plan formulation studies have been based on diverting only those Thomes Creek flows in excess of 1.4 m^3/s (50 ft^3/s) in the winter or 2.3 m^3/s (82 ft^3/s) in the summer. Studies are underway to evaluate Thomes Creek flows needed to satisfy irrigation rights, maintain ground water levels, and meet instream flow requirements. If these studies indicate substantially greater streamflows are necessary to meet these requirements, plan formulation would be affected.

- In a Thomes-Newville Plan that provides for eventual enlargement of Newville Reservoir, the least costly diversion from Thomes Creek would use an open canal only. An alternative plan using a tunnel and canal in combination would be about $10,000,000 (21 percent) more costly; it should be considered only if absolutely essential to minimize interference with deer migration corridors.

- In a Thomes-Newville Plan not designed for later enlargement of Newville Reservoir, the most economical diversion from Thomes Creek would be downstream from the site used in the plan providing for enlargement. Only cursory studies have been conducted of this alternative.

- The original plan of building a Paskenta Dam on Thomes Creek (instead of a Thomes-Newville diversion) should be considered if wildlife studies show it to be acceptable. A Paskenta Reservoir would have some operational advantages, would avoid sediment problems, and could provide water for local use.

- The optimum size of the Stony Creek diversion facilities would be in the range of 57 to 113 m^3/s (2,000 to 4,000 ft^3/s), depending on the mode of operation of the Thomes-Newville Plan and the value assigned to new yield.

- The Tehenn route for diverting Stony Creek water to Newville Reservoir would be superior to the Millsite route from the standpoint of operation because of the regulating effect of Black Butte Reservoir. However, it would be somewhat more costly because of the difficulty of pumping from the fluctuating reservoir.

- The Millsite route for diverting Stony Creek water to Newville Reservoir would have a somewhat lower first cost than the Tehenn route. However, it would be less effective at capturing surplus water, would generate less hydroelectric energy and would require careful design to overcome potential sediment problems in Millsite Reservoir.

- If the Thomes-Newville Plan were to be built with the idea of eventual incorporation into a Glenn Reservoir Plan, the Millsite diversion route should be favored because of its superior compatibility with the expansion.

- If the Thomes-Newville Plan were to be built without provision for later construction of a Glenn Reservoir Plan, the diversion from Stony Creek could follow either the Tehenn or Millsite routes. Additional studies would be required to choose the better route.

- More Stony Creek water could be captured if the Thomes-Newville Plan were operated conjunctively with the Orland Project. This would require arrangements to indemnify the Orland Unit Water Users Association against any loss of yield. Studies of coordinated operation will be undertaken in the next phase of investigation.

- Under average hydrologic conditions, the initial filling of Newville Reservoir would require 6 to 7 years after the completion of construction. (This is based on storage of surplus Thomes and North Fork Stony Creek water for 2 years prior to completion and allows for a gradual buildup of new yield releases during the initial filling period.)

- The Thomes-Newville Plan would eventually produce a small net energy surplus (long-term average on the order of 30 gWh per year). At this rate, about 8 to 10 years of normal operation would be required to offset the net energy deficit incurred during the initial filling period.

- Long-term average net energy generation of the Thomes-Newville Plan would be less than indicated in the previous finding if: (a) Thomes Creek water exceeding local needs but subject to downstream prior rights could not be diverted through Newville Reservoir for generation; or (b) the Millsite diversion alternative were employed rather than the Tehenn route. Neither of these possibilities has yet been evaluated.

- Energy production of the Thomes-Newville Plan could be increased by an average of 25 to 30 gWh per year by addition of a generating plant at Black Butte Dam. (Part of this energy production would be available with the existing Black Butte Reservoir; this potential is being evaluated by the Corps of Engineers.)

- Because the Thomes-Newville Plan would eventually produce a small net surplus of electrical energy, the sizing of the features is not very sensitive to energy values.

- The Thomes-Newville Plan could be operated to provide modest downstream benefits by reducing flooding from Thomes Creek. This would require joint use of some Newville Reservoir storage, a refinement that will be incorporated into upcoming investigations. Preliminary flood benefits calculated by the Corps of Engineers indicate that it would not be economically justifiable to increase the size of Newville Reservoir or the Thomes diversion solely to provide additional flood control.

- If Newville Reservoir were to be operated to control Thomes Creek flooding, spillway facilities should be provided to discharge back to Thomes Creek; evacuation of Thomes Creek floodwaters via Stony Creek would complicate the operation of Black Butte Reservoir and aggravate channel and bank erosion problems.

- New yield from the Thomes-Newville Plan should not be directly discharged to the Sacramento River because of potential adverse impacts on river temperature and water quality. Water could most easily be released to Stony Creek and delivered to the Glenn-Colusa Irrigation District in exchange for equivalent reductions in the district's river diversions. This delivery would require no new facilities, as the district dams Stony Creek at its main canal crossing. However, preliminary studies indicate that channel losses from Stony Creek would be excessive between Black Butte Dam and the Glenn-Colusa Irrigation District Canal crossing. Therefore, an alternative exchange with the Tehama-Colusa Canal appears preferable.

- A pumping plant and an 11-km (7-mi) pipeline would be needed to deliver a firm water supply from Newville Reservoir to Thomes Creek. These facilities would be costly and it is doubtful that they would be justified by conventional economic analysis based on supply of supplemental irrigation water to the Thomes Creek area.

Glenn Reservoir Plan Findings

The principal study findings relating to the Glenn Reservoir Plan are:

- Surplus water supplies available from local runoff and the Sacramento River are sufficient to support development of up to about 12 000 000 dam^3 (10,000,000 ac-ft) of storage in a Glenn Reservoir. Even larger reservoirs would be hydrologically feasible, but only if operated to favor meeting peak (dry period) water demands (at the expense of lowered average yield).

- The maximum capacity of a conventional Glenn Reservoir (Rancheria and Newville compartments at the same level) would be controlled by Rocky Ridge, the east rim of the Newville compartment. The maximum elevation of the Newville compartment would depend primarily on cost considerations and has not been precisely defined. However, the maximum elevation is probably within the range of 304 to 312 m (1,000 to 1,025 ft); for discussion purposes, the Glenn Reservoir storage limit is assumed to be that of approximately the middle of this range, 11 000 000 dam^3 (9,000,000 ac-ft).

- Storage of more than about 11 000 000 dam^3 (9,000,000 ac-ft) could be achieved at Glenn Reservoir only by building a Chrome Dike between the two compartments and raising the southern portion above the northern portion. For example, with Newville Reservoir at elevation 305 m (1,000 ft) and Rancheria Reservoir 15 m (50 ft) higher, the total storage would be 12 820 000 dam^3 (10,390,000 ac-ft).

- Providing for later expansion of Newville Reservoir in a Thomes-Newville Plan would add substantially to the initial cost. A "split-level" Glenn Reservoir Plan could avoid this drawback by adding a higher Rancheria Reservoir (and Chrome Dike) to the lower Newville Reservoir, which would be left at its original size. The maximum storage potential with this approach would be about the same as with a conventional single-level plan, 11 000 000 dam^3 (9,000,000 ac-ft).

- The types and sizes of outlet and spillway facilities required at Newville and Rancheria Dams vary considerably with the choice of plan and staging assumptions. Multiple-level outlets would be needed for control of the quality and temperature of releases. Outlets (and probably generation facilities) should be included at both dams, even though one set would be needed only during infrequent extreme drawdowns.

- The optimum capacity of Sacramento River--Glenn Reservoir pumping facilities would range from about 280 m^3/s (10,000 ft^3/s) to about 420 m^3/s (15,000 ft^3/s). The smaller sizes would result from formulations based on relatively low values of yield; the larger sizes would be associated with formulations approaching maximum development of Glenn Reservoir storage potential.

- The current formulation studies for Glenn Reservoir Plans were based on the assumption that the Cottonwood Creek Project would have prior claim on surplus flows in the upper Sacramento River Basin. If other new projects (either upstream or downstream) were assumed to have priority over the Glenn Plan, the optimum sizes of Glenn Reservoir and the river diversion facilities would be somewhat smaller, but studies have not been made to evaluate these effects.

- The Water and Power Resources Service is currently appraising the West Sacramento Canal Unit, which would compete directly with the Glenn Reservoir Plan for surplus Sacramento River flows at Red Bluff. Under the area-of-origin provisions of the California Water Code, the West Sacramento Canal Unit would have first priority on the surplus water. This would have a major impact on the formulation of the Glenn Reservoir Plan and would necessitate a total reanalysis.

- The amount of Sacramento River water that could be pumped to Glenn Reservoir could be increased by coordinated operation with existing Shasta Reservoir. This possibility has not been explored in any detail.

- If Shasta Reservoir were enlarged, the water supply available for diversion to Glenn Reservoir would be reduced. This would have a significant impact on formulation of the Glenn Reservoir Plan but would not necessarily render it infeasible. A substantial amount of surplus water originates in the 6 500-km^2 (2,500 mi^2) drainage area between Keswick Dam and Red Bluff. The Glenn Reservoir Plan has not been evaluated with an enlarged Shasta Reservoir.

- Diversion of Sacramento River water at Red Bluff would involve potential conflicts with the existing Tehama-Colusa and Corning Canal headworks. There is limited space remaining adjacent to Lake Red Bluff for the large facilities that would be needed to handle sediment, debris, and fish screening problems for a diversion to Glenn Reservoir. Further design studies of this aspect are essential if the Glenn Reservoir Plan is investigated further.

- Three canal routes were investigated for diversion of Sacramento River water from Lake Red Bluff to Black Butte Reservoir. The most attractive route would have one pumping lift near Red Bluff, feeding a canal that would reach Black Butte Dam at the elevation of the existing downstream pool. A second pumping plant near the dam would lift water to a stabilized Black Butte Reservoir.

- The least costly facilities for diversion of Sacramento River water to Black Butte Reservoir would pump from the river near the mouth of Burch Creek, about 55 river km (34 river mi) south of Red Bluff. The total pumping lift would be increased by about 30 m (100 ft) with this plan, but it deserves additional consideration when more is learned about future energy values.

- Earlier versions of the Glenn Reservoir Plan have included small regulating reservoirs along the diversion canals between the Sacramento River and Black Butte Reservoir. Such reservoirs should be omitted from the plan if possible, as they would provide settling areas for sediment diverted from the river. (It would be preferable to keep sediment in suspension until the water reached Black Butte Reservoir.)

- If Glenn Reservoir were to be built in a single stage, the diversion of Sacramento River water upstream from Black Butte Reservoir should follow the Tehenn route to Newville Dam. Black Butte Reservoir would be stabilized and the Tehenn diversion route would be simpler and less costly than the alternative Millsite route.

- If Glenn Reservoir were to be built as an expansion of an earlier Thomes-Newville Plan, the diversion of Sacramento River water upstream from Black Butte Reservoir should follow the Millsite diversion route to Rancheria Dam. (Millsite Reservoir would have been built as a feature of the original Thomes-Newville Plan.)

- Any large Glenn Reservoir Plan should include separate conveyance facilities to deliver releases back to the Sacramento River. For maximum operational flexibility, these facilities should provide for water exchanges with the Tehama-Colusa and Glenn-Colusa Canals (but these provisions have not been included in plans to date). Glenn Reservoir releases should not be conveyed down Stony Creek because of potential losses and detrimental erosion and ground water impacts.

- Under average hydrologic conditions, Glenn Reservoir would fill in about 7 years after completion of construction. (This is based on storage of surplus local inflow plus diversions from Thomes Creek for 2 years prior to completion and allows for a gradual buildup of new yield releases during the initial filling period.)

- The Glenn Reservoir Plan would eventually be a net producer of electrical energy, but some 40 to 70 years of normal operation would be required to offset the energy deficit incurred during initial filling. Earlier studies formulated smaller Glenn Reservoir Plans that would have shorter energy payback periods, but the criteria used in the current studies led to larger reservoirs and larger pumping capacities.

- Current formulation studies for Glenn Reservoir Plans were based on relatively low energy values. If higher values were adopted, the optimum reservoir sizes and pumping capacities would be smaller, but sensitivity studies have not been made to determine the actual changes.

- Although project formulation studies were based on continuous pumping and baseload generation, the Glenn Reservoir Plan would include significant opportunity for offpeak pumping and peaking power generation. Using Black Butte Reservoir for reregulation, pumping and generating could be shifted as desired whenever the facilities were operating at partial capacity.

Most Promising Plan

As the findings indicate, there are many possible alternative approaches to formulating the Thomes-Newville and Glenn Reservoir Plans. Final selection of an optimum formulation for these features can be made only as part of the development of a total plan for the entire State Water Project system. As other elements of this total plan have not been fully defined, it is impossible to identify an optimum configuration for the Thomes-Newville or Glenn Reservoir Plans at this time.

Nevertheless, recent studies have narrowed the scope of viable alternatives and it is now possible to focus on a "most promising" plan to serve as the basis for subsequent investigations. This would include initial construction of a Thomes-Newville Plan that did not provide for later enlargement, with the idea that any future expansion would use the "split-level" Glenn Reservoir concept. The Thomes-Newville Plan would include as large a reservoir as could be justified with the available water supply; this would result in a water surface elevation of around 274 m (900 ft) and a gross storage capacity of about 2 270 000 dam^3 (1,840,000 ac-ft). The Millsite alternative would be selected for diversion of around 100 m^3/s (3,500 ft^3/s) from Stony Creek, since that alternative would be more compatible with a possible future Glenn Reservoir. A 283-m^3/s (10,000-ft^3/s) Thomes Creek diversion would be placed as low on the creek as possible, since it would not have to accommodate raising of Newville Reservoir. Construction of a major bypass canal to carry releases around lower Stony Creek would be avoided if possible, as similar (but larger) facilities would be required with any later Glenn Reservoir development.

With the foregoing approach, planning studies in the near future could concentrate almost entirely on the Thomes-Newville Plan without foreclosing eventual options for development of a large Glenn Reservoir. The exception would be the necessity to explore thoroughly the operational aspects of the "split-level" Glenn Reservoir at an early date to make certain that it would be practicable. (The concept was developed only recently and detailed operation studies have not been performed.)

Future Studies

Feasibility studies and environmental impact analyses of the Thomes-Newville Plan are already programmed for the 1980-83 period. The current investigation has identified several areas that should be accorded special empahsis during the next phase of study. These are:

- Hydrology (Relationship to other features of the State Water Project system, thorough analysis of pumping from Millsite Reservoir, possible coordinated operation with the Orland Project)
- Construction Materials (Physical properties of quarried rock, quantity and quality of sand and gravel, potential impervious, transition, and random borrow materials within Newville Reservoir area)
- Seismicity (Stony Creek Fault, effects on designs and costs of major structures)
- Foundation Geology (Newville Dam, Millsite diversion facilities, Thomes Creek diversion facilities, Newville spillway and outlet works, saddle dam)
- Sediment (Effects on design and operation of diversion structures on Thomes and Stony Creeks, potential of reducing sediment loads through watershed management)
- Millsite Dam (Maximum size, compatibility with Grindstone Indian Rancheria)
- Thomes Creek Instream Flows (For fish and wildlife, local irrigation, maintenance of ground water levels)
- Stony Creek Channel Losses and Bank Erosion (Impact of yield releases, effects on adjacent ground water, possible need for bypass canal)
- Energy (Availability, value, effect on plan formulation, generating facilities below Black Butte Dam)
- Designs and Costs (More refined cost estimates, spillway and diversion hydrology, emergency reservoir evacuation criteria)
- Major Project Formulation Changes (Possibilities of substituting Paskenta Dam for Thomes Creek diversion facilities and of adding a diversion from the Tehama-Colusa Canal)

CHAPTER 2. THOMES-NEWVILLE PLAN-- FORMULATION AND ANALYSIS

Newville Reservoir would occupy a large natural basin in the Coast Range foothills along the western side of the Sacramento Valley, about 32 km (20 mi) west of the town of Orland and about 10 km (6 mi) upstream from the existing Black Butte Reservoir. Natural inflow, from the North Fork of Stony Creek and other small streams, is insufficient to justify development of more than a small fraction of the storage potential of the Newville Reservoir site. Under the Thomes-Newville Plan, surplus water from Thomes and Stony Creeks would be diverted to Newville Reservoir so that a greater portion of its storage potential could be developed.

This chapter addresses the economic formulation and operational feasibility of the Thomes-Newville Plan. The optimum sizes of the individual features depend on the mode of operation (peaking or base load water supply). Three example formulations are presented to illustrate this dependency. These formulations are based on preliminary cost estimates that are being revised by continuing geologic and design studies, so they are subject to change as planning progresses; however, major revisions are unlikely.

Planning Framework

The three example formulations are based on the following planning criteria:

1. The hydrologic base study was the Division of Planning computer run dated January 20, 1978, entitled "1977 Augmentation Study with Year 2000 Supply and Ultimate Level CVP/SWP Demands. Cottonwood, Glenn and Southern California Ground Water Basins Not Operational. No Dry-Year Deficiencies Imposed". The period of analysis was 1922 through 1971 (50 years). This study is based upon the Four-Agency Fish Agreement Delta Water Quality Standards and determines the total SWP/CVP water surplus or need for each month of the study period.

2. The Thomes-Newville Plan was formulated for a range of alternative modes of operation, as expressed by a factor (K) that represents the ratio of average annual yield over the 1922-71 study period to the average annual yield during the May 1928 through October 1934 critically dry period. As an extreme example, a plan formulated for a K of 0.13 would release water during the critical period only and a large storage reservoir would be justified, as it would be drawn down very infrequently with adequate time to refill. Conversely, a plan formulated for a K of 1.0 would release an essentially constant amount of water each year regardless of statewide water conditions; in this case, less reservoir capacity could be justified. Example formulations for K factors of 0.70, 0.47,

and 0.30 are presented in this chapter to illustrate the effect of operating mode on sizing and operation. The analyses were keyed to the SWP/CVP demands from the base study, which averaged 1 827 000 dam^3 (1,481,000 ac-ft) annually over the 50-year study period and 3 868 000 dam^3 (3,136,000 ac-ft) per year during the critical period (K = 0.47).

3. All formulations were based on a refill period of 10 years, which is calculated as the average time the reservoir would take to fill from minimum pool if it were to continue to meet the full average demands imposed upon it. The refill period is equal to the ratio of conservation storage to the net average annual available water supply in excess of operational releases and evaporation losses. A 10-year refill period is not rigid, but it does lead to reasonable plan formulations that develop a majority of the available water supply while still leaving a margin of surplus runoff to refill the reservoir after severe drawdown. Most existing major surface water storage facilities in Northern and Central California have refill periods of 2 to 4 years. These projects have developed the relatively inexpensive water, avoiding the more costly increments. Today, the higher value of water justifies larger projects and, consequently, longer refill periods.

4. Formulation studies were based entirely on construction of the Thomes-Newville Plan as an independent development, without provision for later enlargement or incorporation into a Glenn Reservoir Plan. The diversion alternative involving pumping from Black Butte Reservoir via Tehenn Reservoir was used throughout the formulation process. (The Millsite diversion alternative was not developed until after the formulation studies were completed.)

5. Preliminary costs used in this formulation study represent 1978 price levels, without allowances for escalation during the construction period. (More recent cost estimates are presented in Chapters 3 through 5, but they were not available in time for this preliminary formulation analysis.) Annual operation, maintenance, and replacement costs were based on a percentage of the first costs of each particular feature.

6. Energy generated was valued at 30 mills/kWh and energy consumed at 40 mills. The Thomes-Newville Plan would be a small net energy producer, so plan formulation is not very sensitive to the energy prices used. Off-peak pumping was not considered at this time.

7. A rational procedure (explained later in this chapter) was developed to determine energy needs and yield buildup during the initial filling period. A market was assumed to exist for all new yield as soon as available.

8. The Corps of Engineers examined potential flood control benefits associated with diversions from Thomes Creek to Newville Reservoir. The Corps' figures indicated that flood control benefits would probably not justify enlarging the diversion or the reservoir

solely to provide additional flood control. However, there would be modest flood control benefits along Thomes Creek and the Sacramento River if the project were operated with some joint use flood reservation. This possibility will be explored further in the next round of study, but it was not evaluated in the current formulation process.

9. All project costs were assumed to be allocated to SWP water supply. The three example formulations were based on maximizing net benefits with a $243/dam³ ($300/ac-ft) dry period yield value, based on a 50-year repayment period and a 6-percent interest rate. Under this traditional sizing procedure, the project is increased in size until the unit cost of the last increment of dry period yield is equal to the selected yield value. When this point is reached, the average unit cost of yield is much lower than the limiting value. This approach is intended to make maximum use of each water development site, without including any economically unjustifiable size increments. The $243/dam³ ($300/ac-ft) value for dry period yield was selected for illustrative purposes as representative of the upper range of costs for surface water storage facilities presently being considered under the SWP Future Supply Program.

North Fork Stony Creek Hydrology

North Fork Stony Creek drains an area of 163 km² (63 mi²) above Tehenn Dam site. Elevations within the basin vary between about 150 and 1 500 m (500 and 5,000 ft). Precipitation averages about 640 mm (25 in) per year. North Fork Stony Creek runoff has been regulated by the Corps of Engineers' Black Butte Reservoir since 1963. Newville Reservoir would inundate a significant portion (30 to 35 percent) of the North Fork Stony Creek drainage basin, but natural runoff would provide a relatively small portion of the water supply for the Thomes-Newville Plan.

The U. S. Geological Survey (USGS) operated a streamflow gaging station near Tehenn Dam site from June 1963 through September 1973. The runoff averaged 37 000 dam³ (30,000 ac-ft) per year during this period. To extend the runoff record to cover the 1922-71 hydrologic base period, North Fork Stony Creek flows were correlated with the runoff of Thomes Creek at Paskenta. The runoff was determined to be about 11.6 percent of the Thomes Creek gage for the overlapping record. Based on the recorded data of 1964-71 and the correlated data for 1922-63, the 50-year average annual runoff at Tehenn Dam site was calculated as 28 000 dam³ (23,000 ac-ft). An average of about 11 000 dam³ (9,000 ac-ft) per year of the runoff was determined to be nonstorable water (that which would have contributed to prior water rights or environmental needs within or downstream from the basin). Nonstorable water was indirectly determined from the hydrologic base study developed by the Division of Planning. Table 2-1 tabulates the estimated monthly inflow and storable water at Tehenn Dam site for the 50-year (1922-71) hydrologic base period.

Tehenn Reservoir would not be constructed under the alternative involving pumping from a Millsite Reservoir on Stony Creek. In this case, the runoff of the lower 21-km² (8-mi²) of North Fork Stony Creek drainage

TABLE 2-1A

THOMES-NEWVILLE PLAN — 1 of 2

NORTH FORK STONY CREEK — Units in 1 000 dam^3

Total Flow @ Tehema Dam Site
Potentially Storable

Source of Total Flow: 1922-63, 11.6% of Thomes Creek @ Paskenta. 1964-71, USGS.

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	0	2	4	4	2	9	6	1	0	0	0	28
	0	0	0	0	4	0	0	0	0	0	0	0	4
1923	0	1	4	4	2	2	5	1	1	0	0	0	20
	0	0	4	4	2	0	0	0	0	0	0	0	10
1924	0	0	0	0	2	0	0	0	0	0	0	0	2
	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	1	4	3	14	5	7	6	1	0	0	0	41
	0	0	0	0	14	0	0	0	0	0	0	0	14
1926	0	0	1	1	9	4	4	1	0	0	0	0	20
	0	0	0	0	9	0	0	0	0	0	0	0	9
1927	0	3	6	5	14	9	7	4	1	0	0	0	49
	0	0	2	5	14	9	0	0	0	0	0	0	30
1928	0	4	2	4	7	11	6	3	1	0	0	0	38
	0	0	0	4	7	11	6	0	0	0	0	0	28
1929	0	0	1	1	1	2	1	1	0	0	0	0	7
	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	5	2	5	4	3	1	0	0	0	0	20
	0	0	0	0	0	4	0	0	0	0	0	0	4
1931	0	0	0	2	1	3	1	0	0	0	0	0	7
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	1	2	3	5	3	2	1	0	0	0	17
	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	2	4	3	1	0	0	0	10
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	1	2	3	3	1	1	0	0	0	0	11
	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	1	1	2	4	3	7	4	0	0	0	0	22
	0	0	0	0	0	0	7	0	0	0	0	0	7
1936	0	0	0	8	9	4	4	1	1	0	0	0	27
	0	0	0	8	9	0	0	0	0	0	0	0	17
1937	0	0	0	0	1	4	6	4	1	0	0	0	16
	0	0	0	0	0	2	0	0	0	0	0	0	2
1938	0	6	10	2	6	14	12	10	3	0	0	0	63
	0	0	10	2	6	14	12	0	0	0	0	0	44
1939	0	0	1	1	2	3	1	1	0	0	0	0	9
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	1	7	14	10	5	2	0	0	0	0	39
	0	0	0	7	14	10	0	0	0	0	0	0	31
1941	0	0	7	7	13	14	10	7	3	1	0	0	62
	0	0	7	7	13	14	10	7	0	0	0	0	58
1942	0	0	9	7	9	4	5	5	2	0	0	0	41
	0	0	9	7	9	0	5	0	0	0	0	0	30
1943	0	1	4	9	5	5	2	1	0	0	0	0	27
	0	1	4	9	5	0	0	0	0	0	0	0	19
1944	0	0	0	1	1	2	3	3	1	0	0	0	11
	0	0	0	0	1	0	0	0	0	0	0	0	1
1945	0	1	2	1	5	1	4	3	1	0	0	0	18
	0	0	1	0	5	0	0	0	0	0	0	0	6
1946	0	2	10	5	1	4	4	2	0	0	0	0	28
	0	0	10	5	0	0	0	0	0	0	0	0	15

TABLE 2-1A

NORTH FORK STONY CREEK

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	0	1	1	0	2	4	1	0	0	0	0	0	9
	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	1	0	0	5	1	2	6	4	1	0	0	0	20
	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	1	0	1	5	6	3	1	0	0	0	17
	0	0	0	0	0	5	0	0	0	0	0	0	5
1950	0	0	0	2	3	5	5	2	0	0	0	0	17
	0	0	0	2	3	0	0	0	0	0	0	0	5
1951	1	2	5	6	8	3	3	2	0	0	0	0	30
	0	0	5	6	8	0	0	0	0	0	0	0	19
1952	0	1	6	4	10	7	10	6	2	0	0	0	46
	0	0	6	4	10	7	10	0	0	0	0	0	37
1953	0	0	2	15	4	3	5	4	2	0	0	0	35
	0	0	2	15	0	0	0	0	0	0	0	0	17
1954	0	1	2	6	7	8	7	3	1	0	0	0	35
	0	0	0	6	7	8	7	0	0	0	0	0	28
1955	0	1	2	1	2	1	3	4	0	0	0	0	14
	0	0	2	1	0	0	0	0	0	0	0	0	3
1956	0	1	17	14	7	6	8	6	3	0	0	0	62
	0	0	17	14	7	0	0	0	0	0	0	0	38
1957	0	0	0	0	6	5	3	4	1	0	0	0	19
	0	0	0	0	6	5	0	0	0	0	0	0	11
1958	2	2	4	8	23	6	10	6	3	0	0	0	64
	0	0	0	8	23	6	10	6	0	0	0	0	53
1959	0	0	0	5	2	4	3	1	0	0	0	0	15
	0	0	0	5	2	0	0	0	0	0	0	0	7
1960	0	0	0	0	9	7	3	2	1	0	0	0	22
	0	0	0	0	9	7	0	0	0	0	0	0	16
1961	0	0	2	1	5	4	4	3	1	0	0	0	20
	0	0	0	0	5	4	0	0	0	0	0	0	9
1962	0	0	1	1	2	3	7	1	0	0	0	0	15
	0	0	0	0	2	3	0	0	0	0	0	0	5
1963	2	1	4	3	10	2	9	5	1	0	0	0	37
	0	0	0	0	10	2	9	0	0	0	0	0	21
1964	0	1	0	1	0	0	0	0	0	0	0	0	2
	0	0	0	1	0	0	0	0	0	0	0	0	1
1965	0	4	12	17	2	1	11	1	0	0	0	0	48
	0	0	12	17	2	0	11	0	0	0	0	0	42
1966	0	6	1	7	8	3	1	0	0	0	0	0	26
	0	0	0	7	8	0	0	0	0	0	0	0	15
1967	0	1	7	17	4	3	10	2	4	0	0	0	48
	0	0	7	17	4	0	10	2	4	0	0	0	44
1968	0	0	0	9	10	2	0	0	0	0	0	0	21
	0	0	0	9	10	0	0	0	0	0	0	0	19
1969	0	0	7	22	26	9	3	1	0	0	0	0	68
	0	0	0	22	26	9	0	0	0	0	0	0	57
1970	0	0	4	28	6	6	2	0	0	0	0	0	46
	0	0	4	28	6	0	0	0	0	0	0	0	38
1971	0	5	8	10	1	4	2	0	0	0	0	0	30
	0	0	8	10	1	4	0	0	0	0	0	0	23
TOTAL	6	47	158	262	294	223	236	132	40	1	0	0	1399
	0	1	110	230	261	124	97	15	4	0	0	0	842
AVERAGE	0	1	3	5	6	4	5	3	1	0	0	0	28
	0	0	2	5	5	3	2	0	0	0	0	0	17

TABLE 2-1B

THOMES-NEWVILLE PLAN

NORTH FORK STONY CREEK

Units in 1,000 ac-ft

Total Flow @ Tehenn Dam Site
Potentially Storable

Source of Total Flow: 1922-63, 11.6% of Thomes Creek @ Paskenta. 1964-71, USGS.

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	0	2	3	3	2	7	5	1	0	0	0	23
	0	0	0	0	3	0	0	0	0	0	0	0	3
1923	0	1	3	3	2	1	4	1	1	0	0	0	16
	0	0	3	3	2	0	0	0	0	0	0	0	8
1924	0	0	0	0	2	0	0	0	0	0	0	0	2
	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	1	3	2	11	4	6	5	1	0	0	0	33
	0	0	0	0	11	0	0	0	0	0	0	0	11
1926	0	0	1	1	7	3	3	1	0	0	0	0	16
	0	0	0	0	7	0	0	0	0	0	0	0	7
1927	0	3	5	4	11	7	6	3	1	0	0	0	40
	0	0	2	4	11	7	0	0	0	0	0	0	24
1928	0	3	2	3	6	9	5	2	1	0	0	0	31
	0	0	0	3	6	9	5	0	0	0	0	0	23
1929	0	0	1	1	1	1	1	1	0	0	0	0	6
	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	4	2	4	3	2	1	0	0	0	0	16
	0	0	0	0	0	3	0	0	0	0	0	0	3
1931	0	0	0	2	1	2	1	0	0	0	0	0	6
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	1	2	2	4	2	2	1	0	0	0	14
	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	2	3	2	1	0	0	0	8
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	1	2	2	2	1	1	0	0	0	0	9
	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	1	1	2	3	2	6	3	0	0	0	0	18
	0	0	0	0	0	0	6	0	0	0	0	0	6
1936	0	0	0	7	7	3	3	1	1	0	0	0	22
	0	0	0	7	7	0	0	0	0	0	0	0	14
1937	0	0	0	0	1	3	5	3	1	0	0	0	13
	0	0	0	0	0	2	0	0	0	0	0	0	2
1938	0	5	8	2	5	11	10	8	2	0	0	0	51
	0	0	8	2	5	11	10	0	0	0	0	0	36
1939	0	0	1	1	1	2	1	1	0	0	0	0	7
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	1	6	11	8	4	2	0	0	0	0	32
	0	0	0	6	11	8	0	0	0	0	0	0	25
1941	0	0	6	6	10	11	8	6	2	1	0	0	50
	0	0	6	6	10	11	8	6	0	0	0	0	47
1942	0	0	7	6	7	3	4	4	2	0	0	0	33
	0	0	7	6	7	0	4	0	0	0	0	0	24
1943	0	1	3	7	4	4	2	1	0	0	0	0	22
	0	1	3	7	4	0	0	0	0	0	0	0	15
1944	0	0	0	1	1	2	2	2	1	0	0	0	9
	0	0	0	0	1	0	0	0	0	0	0	0	1
1945	0	1	2	1	4	1	3	2	1	0	0	0	15
	0	0	1	0	4	0	0	0	0	0	0	0	5
1946	0	2	8	4	1	3	3	2	0	0	0	0	23
	0	0	8	4	0	0	0	0	0	0	0	0	12

TABLE 2-1B

NORTH FORK STONY CREEK

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	0	1	1	0	2	3	1	0	0	0	0	0	8
	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	1	0	0	4	1	1	5	3	1	0	0	0	16
	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	1	0	1	4	5	2	1	0	0	0	14
	0	0	0	0	0	4	0	0	0	0	0	0	4
1950	0	0	0	2	2	4	4	2	0	0	0	0	14
	0	0	0	2	2	0	0	0	0	0	0	0	4
1951	1	2	4	5	6	2	2	2	0	0	0	0	24
	0	0	4	5	6	0	0	0	0	0	0	0	15
1952	0	1	5	3	8	6	8	5	1	0	0	0	37
	0	0	5	3	8	6	8	0	0	0	0	0	30
1953	0	0	2	12	3	2	4	3	2	0	0	0	28
	0	0	2	12	0	0	0	0	0	0	0	0	14
1954	0	1	1	5	6	6	6	2	1	0	0	0	28
	0	0	0	5	6	6	6	0	0	0	0	0	23
1955	0	1	2	1	1	1	2	3	0	0	0	0	11
	0	0	2	1	0	0	0	0	0	0	0	0	3
1956	0	1	14	11	6	5	6	5	2	0	0	0	50
	0	0	14	11	6	0	0	0	0	0	0	0	31
1957	0	0	0	0	5	4	2	3	1	0	0	0	15
	0	0	0	0	5	4	0	0	0	0	0	0	9
1958	2	2	3	6	19	5	8	5	2	0	0	0	52
	0	0	0	6	19	5	8	5	0	0	0	0	43
1959	0	0	0	4	2	3	2	1	0	0	0	0	12
	0	0	0	4	2	0	0	0	0	0	0	0	6
1960	0	0	0	0	7	6	2	2	1	0	0	0	18
	0	0	0	0	7	6	0	0	0	0	0	0	13
1961	0	0	2	1	4	3	3	2	1	0	0	0	16
	0	0	0	0	4	3	0	0	0	0	0	0	7
1962	0	0	1	1	2	2	5	1	0	0	0	0	12
	0	0	0	0	2	2	0	0	0	0	0	0	4
1963	2	1	3	2	8	2	7	4	1	0	0	0	30
	0	0	0	0	8	2	7	0	0	0	0	0	17
1964	0	1	0	1	0	0	0	0	0	0	0	0	2 ← min
	0	0	0	1	0	0	0	0	0	0	0	0	1
1965	0	3	10	14	1	1	9	1	0	0	0	0	39
	0	0	10	14	1	0	9	0	0	0	0	0	34
1966	0	5	1	6	6	2	1	0	0	0	0	0	21
	0	0	0	6	6	0	0	0	0	0	0	0	12
1967	0	1	6	14	3	2	8	2	3	0	0	0	39
	0	0	6	14	3	0	8	2	3	0	0	0	36
1968	0	0	0	7	8	2	0	0	0	0	0	0	17
	0	0	0	7	8	0	0	0	0	0	0	0	15
1969	0	0	6	18	21	7	2	1	0	0	0	0	55 ← max 55,000 af
	0	0	0	18	21	7	0	0	0	0	0	0	46
1970	0	0	3	23	5	5	1	0	0	0	0	0	37
	0	0	3	23	5	0	0	0	0	0	0	0	31
1971	0	4	7	8	1	3	1	0	0	0	0	0	24
	0	0	7	8	1	3	0	0	0	0	0	0	19
TOTAL	6	42	132	216	235	174	186	108	34	1	0	0	1134
	0	1	91	188	209	99	79	13	3	0	0	0	683
AVERAGE	0	1	3	4	5	3	4	2	1	0	0	0	23
	0	0	2	4	4	2	2	0	0	0	0	0	14

would not be available for the Thomes-Newville Plan. Studies have not been made to reflect this change, but the effect on total water supply available for the plan would be minor.

Thomes Creek Hydrology

The Thomes Creek drainage basin is located north and west of the proposed Newville Reservoir. Thomes Creek drains an area of 502 km^2 (194 mi^2) above the stream gage at the town of Paskenta. Elevations within the basin vary between about 230 and 2 300 m (750 and 7,500 ft). Precipitation averages about 1 000 mm (40 in) per year. There are no major storage or diversion structures within the basin. The Paskenta Community Services District has an appropriative water right for up to 360 dam^3 (290 ac-ft) per year from Thomes Creek and currently diverts about 60 dam^3 (50 ac-ft) annually via an infiltration gallery located just upstream from the town of Paskenta. Crane Mills, a lumber company, also diverts about 60 dam^3 per year near Paskenta. Several irrigation diversions, using small pumps or gravity ditches, operate downstream from Paskenta during the spring and summer. Under the Thomes-Newville Plan, surplus Thomes Creek water would be diverted via a gravity-flow canal into Newville Reservoir. A low concrete diversion dam would be located on Thomes Creek approximately 8 km (5 mi) upstream from the town of Paskenta.

The USGS has operated a streamflow gaging station on Thomes Creek at Paskenta since January 1921. Average annual runoff during the 50-year (1922-71) hydrologic base period was 249 000 dam^3 (202,000 ac-ft); of this, 75 000 dam^3 (61,000 ac-ft) was determined to be nonstorable water (44 percent for Thomes Creek instream needs and 56 percent for needs downstream from its mouth). Table 2-2 tabulates the monthly flow and potentially storable amounts for the 50-year hydrologic base period.

Using the area-precipitation method, it was estimated that the point of diversion would collect 97 percent of the flow at the Paskenta gage. A daily flow analysis, examining the entire 50-year period day by day, was performed to determine the portion of Thomes Creek flows at the diversion point that could be diverted with various diversion capacities. A minimum of 1.4 m^3/s (50 ft^3/s) during winter months to 2.3 m^3/s (82 ft^3/s) during summer months was assumed to remain in Thomes Creek whenever water was being diverted to Newville Reservoir. Figure 2-1 summarizes the daily flow analysis. The divertible flow values shown include Thomes Creek water that is surplus to local needs, but which must be released to satisfy prior rights downstream from the mouth of Thomes Creek. (This approach assumes that the water for downstream prior rights would be routed through Newville Reservoir for hydroelectric energy generation.) The storable flow values of Figure 2-1 represent Thomes Creek water that is surplus to both local and downstream prior rights.

The minimum Thomes Creek flow requirements are working assumptions and not the result of rigorous analysis; studies are currently underway to better define the Thomes Creek flows needed to meet local irrigation demands, recharge ground water basins, and maintain environmental and other instream values.

TABLE 2-2A

THOMES-NEWVILLE PLAN — **1 of 2**

THOMES CREEK — **Units in 1 000 dam^3**

Total Flow @ Paskenta / Potentially Storable — **Source of Total Flow: USGS**

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	1	23	31	30	25	72	49	6	1	0	0	238
	0	0	20	22	26	21	0	0	0	0	0	0	89
1923	1	6	36	35	19	12	43	14	8	1	0	0	175
	0	2	32	31	15	0	14	0	0	0	0	0	94
1924	1	1	3	5	22	4	4	1	0	0	0	0	41
	0	0	0	0	19	0	0	0	0	0	0	0	19
1925	4	15	27	23	112	40	62	53	10	4	1	1	352
	0	0	0	0	109	0	58	0	0	0	0	0	167
1926	2	4	9	11	75	28	37	9	3	0	0	0	178
	0	0	0	0	72	0	33	0	0	0	0	0	105
1927	0	27	49	39	116	73	62	36	11	3	1	0	417
	0	23	0	36	112	68	59	31	0	0	0	0	329
1928	0	32	17	37	60	95	49	17	8	2	0	0	317
	0	0	0	33	57	91	46	0	0	0	0	0	227
1929	0	0	12	10	12	10	10	11	3	0	0	0	68
	0	0	0	0	9	0	0	0	0	0	0	0	9
1930	0	0	44	20	37	37	25	9	3	0	0	0	175
	0	0	0	16	0	33	0	0	0	0	0	0	49
1931	0	1	1	16	12	21	9	4	1	0	0	0	65
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	1	3	11	19	16	41	21	21	6	1	0	0	140
	0	0	0	15	12	0	0	0	0	0	0	0	27
1933	0	0	1	2	4	23	35	26	15	1	0	0	107
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	1	11	20	19	22	11	6	1	0	0	0	91
	0	0	0	16	0	0	0	0	0	0	0	0	16
1935	1	11	9	19	27	23	68	27	5	1	0	0	191
	0	0	0	15	0	20	64	0	0	0	0	0	99
1936	0	1	3	75	73	37	28	12	6	1	0	0	236
	0	0	0	71	69	33	0	0	0	0	0	0	173
1937	0	0	0	1	6	31	53	36	9	1	0	0	137
	0	0	0	0	2	27	31	0	0	0	0	0	60
1938	1	51	80	20	48	118	110	89	25	4	1	1	548
	0	47	76	16	44	115	106	84	5	0	0	0	493
1939	1	3	11	6	7	27	14	7	3	0	0	0	79
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	12	62	120	84	47	18	5	1	0	0	349
	0	0	0	58	116	80	43	0	0	0	0	0	297
1941	1	4	60	65	105	116	88	63	23	6	1	1	533
	0	0	56	61	101	112	84	58	0	0	0	0	472
1942	1	4	72	69	75	28	46	39	17	4	1	0	356
	0	0	68	65	72	25	42	35	11	0	0	0	318
1943	0	11	35	73	41	43	26	13	5	1	0	0	248
	0	0	31	69	37	40	22	0	0	0	0	0	199
1944	0	1	3	6	10	21	16	17	6	1	0	0	81
	0	0	0	0	6	17	0	0	0	0	0	0	23
1945	0	10	20	11	42	14	29	17	6	1	0	0	150
	0	0	16	0	38	10	0	0	0	0	0	0	64
1946	1	16	81	46	14	27	34	20	5	1	0	0	245
	0	0	78	42	10	23	0	0	0	0	0	0	153

TABLE 2-2A

THOMES CREEK

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	0	6	9	2	22	33	15	5	4	0	0	0	96
	0	0	0	0	18	30	0	0	0	0	0	0	48
1948	7	4	3	39	7	10	49	37	15	3	0	1	175
	0	0	0	0	0	0	46	32	0	0	0	0	78
1949	1	5	10	4	10	46	58	23	6	1	0	0	164
	0	0	0	0	0	42	0	0	0	0	0	0	42
1950	0	1	1	20	25	47	42	19	5	0	0	0	160
	0	0	0	16	21	43	0	0	0	0	0	0	80
1951	15	22	47	53	68	22	21	20	5	1	0	0	274
	0	18	43	49	64	19	0	15	0	0	0	0	208
1952	1	8	51	33	84	59	90	51	14	4	1	0	396
	0	0	47	30	80	56	86	46	7	0	0	0	352
1953	0	1	24	123	36	26	43	31	19	5	1	1	310
	0	0	20	120	32	22	39	26	0	0	0	0	259
1954	1	9	10	51	69	59	64	20	7	1	1	0	292
	0	0	0	47	65	56	60	0	0	0	0	0	228
1955	1	11	20	14	11	12	16	27	5	1	0	0	118
	0	0	16	10	0	0	0	0	0	0	0	0	26
1956	0	6	153	121	66	49	64	54	17	4	1	0	535
	0	0	149	117	62	46	56	49	0	0	0	0	479
1957	2	2	3	5	47	46	25	32	9	1	0	1	173
	0	0	0	0	43	42	0	27	0	0	0	0	112
1958	22	20	36	63	202	56	83	58	17	5	1	1	564
	18	0	32	59	199	52	79	53	11	0	0	0	503
1959	0	2	3	39	22	36	23	10	3	0	0	1	139
	0	0	0	36	18	32	0	0	0	0	0	0	86
1960	0	0	1	5	78	63	21	17	8	1	0	0	194
	0	0	0	0	74	59	0	0	0	0	0	0	133
1961	0	4	21	16	46	30	27	18	7	1	0	0	170
	0	0	0	0	42	26	0	0	0	0	0	0	68
1962	0	2	10	6	27	26	51	15	5	1	0	0	143
	0	0	0	0	24	22	0	0	0	0	0	0	46
1963	23	9	32	25	84	26	79	44	9	2	1	0	334
	20	0	28	0	80	22	75	40	0	0	0	0	265
1964	1	23	7	16	17	10	11	8	3	0	0	0	96
	0	20	0	12	0	0	0	0	0	0	0	0	32
1965	0	11	218	93	42	25	69	33	9	2	1	0	503
	0	0	215	89	38	0	65	28	0	0	0	0	435
1966	0	15	8	43	20	52	59	20	4	1	0	0	222
	0	11	0	40	16	48	0	0	0	0	0	0	115
1967	0	21	54	64	42	31	27	69	27	4	1	0	340
	0	0	51	61	38	27	23	64	21	0	0	0	285
1968	1	3	10	63	86	33	21	11	4	1	1	0	234
	0	0	0	59	82	30	0	0	0	0	0	0	171
1969	0	5	19	127	54	82	138	91	17	4	1	0	538
	0	0	15	123	51	78	134	86	11	0	0	0	498
1970	1	2	67	220	36	37	12	11	4	1	1	0	392
	0	0	63	216	32	33	0	0	0	0	0	0	344
1971	2	21	53	102	41	69	44	32	11	3	1	0	378
	0	17	49	99	37	66	41	27	0	0	0	0	336
TOTAL	93	416	1500	2068	2344	1985	2151	1370	424	82	17	8	12458
	38	138	1105	1749	2042	1566	1306	701	66	0	0	0	8711
AVERAGE	2	8	30	41	47	40	43	28	8	2	0	0	249
	1	3	22	35	41	31	26	14	1	0	0	0	174

TABLE 2-2B

THOMES-NEWVILLE PLAN

THOMES CREEK

Units in 1,000 ac-ft

Total Flow @ Paskenta
Potentially Storable

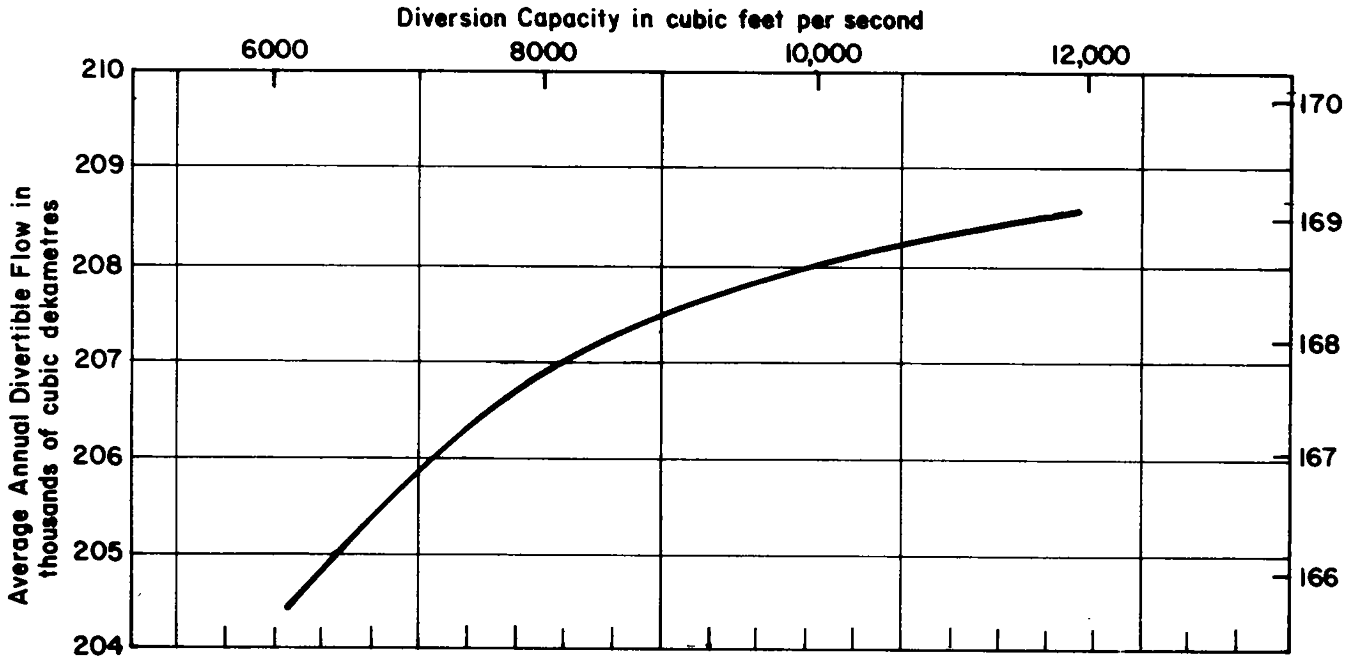
Source of Total Flow: USGS

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	0	1	19	25	24	20	58	40	5	1	0	0	193
	0	-0	16	18	21	17	0	0	0	0	0	0	72
1923	1	5	29	28	15	10	35	11	6	1	0	0	141
	0	2	26	25	12	0	11	0	0	0	0	0	76
1924	1	1	2	4	18	3	3	1	0	0	0	0	33
	0	0	0	0	15	0	0	0	0	0	0	0	15
1925	3	12	22	19	91	32	50	43	8	3	1	1	285
	0	0	0	0	88	0	47	0	0	0	0	0	135
1926	2	3	7	9	61	23	30	7	2	0	0	0	144
	0	0	0	0	58	0	27	0	0	0	0	0	85
1927	0	22	40	32	94	59	50	29	9	2	1	0	338
	0	19	0	29	91	55	48	25	0	0	0	0	267
1928	0	26	14	30	49	77	40	14	6	1	0	0	257
	0	0	0	27	46	74	37	0	0	0	0	0	184
1929	0	0	10	8	10	8	8	9	2	0	0	0	55
	0	0	0	0	7	0	0	0	0	0	0	0	7
1930	0	0	36	16	30	30	20	7	2	0	0	0	141
	0	0	0	13	0	27	0	0	0	0	0	0	40
1931	0	1	1	13	10	17	7	3	1	0	0	0	53
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	1	2	9	15	13	33	17	17	5	1	0	0	113
	0	0	0	12	10	0	0	0	0	0	0	0	22
1933	0	0	1	2	3	19	28	21	12	1	0	0	87
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	1	9	16	15	18	9	5	1	0	0	0	74
	0	0	0	13	0	0	0	0	0	0	0	0	13
1935	1	9	7	15	22	19	55	22	4	1	0	0	155
	0	0	0	12	0	16	52	0	0	0	0	0	80
1936	0	1	2	60	59	30	23	10	5	1	0	0	191
	0	0	0	57	56	27	0	0	0	0	0	0	140
1937	0	0	0	1	5	25	43	29	7	1	0	0	111
	0	0	0	0	2	22	25	0	0	0	0	0	49
1938	1	41	65	16	39	96	89	72	20	3	1	1	444
	0	38	62	13	36	93	86	68	4	0	0	0	400
1939	1	2	9	5	6	22	11	6	2	0	0	0	64
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	10	50	97	68	38	15	4	1	0	0	283
	0	0	0	47	94	65	35	0	0	0	0	0	241
1941	1	3	48	53	85	94	71	51	19	5	1	1	432
	0	0	45	50	82	91	68	47	0	0	0	0	383
1942	1	3	58	56	61	23	37	32	14	3	1	0	289
	0	0	55	53	58	20	34	28	9	0	0	0	257
1943	0	9	28	59	33	35	21	11	4	1	0	0	201
	0	0	25	56	30	32	18	0	0	0	0	0	161
1944	0	1	2	5	8	17	13	14	5	1	0	0	66
	0	0	0	0	5	14	0	0	0	0	0	0	19
1945	0	8	16	9	34	11	24	14	5	1	0	0	122
	0	0	13	0	31	8	0	0	0	0	0	0	52
1946	1	13	66	37	11	22	28	16	4	1	0	0	199
	0	0	63	34	8	19	0	0	0	0	0	0	124

TABLE 2-2B

THOMAS CREEK

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	0	5	7	2	18	27	12	4	3	0	0	0	78
	0	0	0	0	15	24	0	0	0	0	0	0	39
1948	6	3	2	32	6	8	40	30	12	2	0	1	142
	0	0	0	0	0	0	37	26	0	0	0	0	63
1949	1	4	8	3	8	37	47	19	5	1	0	0	133
	0	0	0	0	0	34	0	0	0	0	0	0	34
1950	0	1	1	16	20	38	34	16	4	0	0	0	130
	0	0	0	13	17	35	0	0	0	0	0	0	65
1951	12	18	38	43	55	18	17	16	4	1	0	0	222
	0	15	35	40	52	15	0	12	0	0	0	0	169
1952	1	7	41	27	68	48	73	41	11	3	1	0	321
	0	0	38	24	65	45	70	37	6	0	0	0	285
1953	0	1	19	100	29	21	35	25	15	4	1	1	251
	0	0	16	97	26	18	32	21	0	0	0	0	210
1954	1	7	8	41	56	48	52	16	6	1	1	0	237
	0	0	0	38	53	45	49	0	0	0	0	0	185
1955	1	9	16	11	9	10	13	22	4	1	0	0	96
	0	0	13	8	0	0	0	0	0	0	0	0	21
1956	0	5	124	98	53	40	52	44	14	3	1	0	434
	0	0	121	95	50	37	45	40	0	0	0	0	388
1957	2	2	2	4	38	37	20	26	7	1	0	1	140
	0	0	0	0	35	34	0	22	0	0	0	0	91
1958	18	16	29	51	164	45	67	47	14	4	1	1	457
	15	0	26	48	161	42	64	43	9	0	0	0	408
1959	0	2	2	32	18	29	19	8	2	0	0	1	113
	0	0	0	29	15	26	0	0	0	0	0	0	70
1960	0	0	1	4	63	51	17	14	6	1	0	0	157
	0	0	0	0	60	48	0	0	0	0	0	0	108
1961	0	3	17	13	37	24	22	15	6	1	0	0	138
	0	0	0	0	34	21	0	0	0	0	0	0	55
1962	0	2	8	5	22	21	41	12	4	1	0	0	116
	0	0	0	0	19	18	0	0	0	0	0	0	37
1963	19	7	26	20	68	21	64	36	7	2	1	0	271
	16	0	23	0	65	18	61	32	0	0	0	0	215
1964	1	19	6	13	14	8	9	6	2	0	0	0	78
	0	16	0	10	0	0	0	0	0	0	0	0	26
1965	0	9	177	75	34	20	56	27	7	2	1	0	408
	0	0	174	72	31	0	53	23	0	0	0	0	353
1966	0	12	7	35	16	42	48	16	3	1	0	0	180
	0	9	0	32	13	39	0	0	0	0	0	0	93
1967	0	17	44	52	34	25	22	56	22	3	1	0	276
	0	-0	41	49	31	22	19	52	17	0	0	0	231
1968	1	2	8	51	70	27	17	9	3	1	1	0	190
	0	0	0	48	67	24	0	0	0	0	0	0	139
1969	0	4	15	103	44	66	112	74	14	3	1	0	436
	0	0	12	100	41	63	109	70	9	0	0	0	404
1970	1	2	54	178	29	30	10	9	3	1	1	0	318
	0	0	51	175	26	27	0	0	0	0	0	0	279
1971	1	17	43	83	33	56	36	26	9	2	1	0	307
	0	14	40	80	30	53	33	22	0	0	0	0	272
TOTAL	79	338	1213	1675	1899	1608	1743	1113	339	68	17	8	10100
	31	113	895	1417	1656	1268	1060	568	54	0	0	0	7062
AVERAGE	2	7	24	34	38	32	35	22	7	1	0	0	202
	1	2	18	28	33	25	21	12	1	0	0	0	141

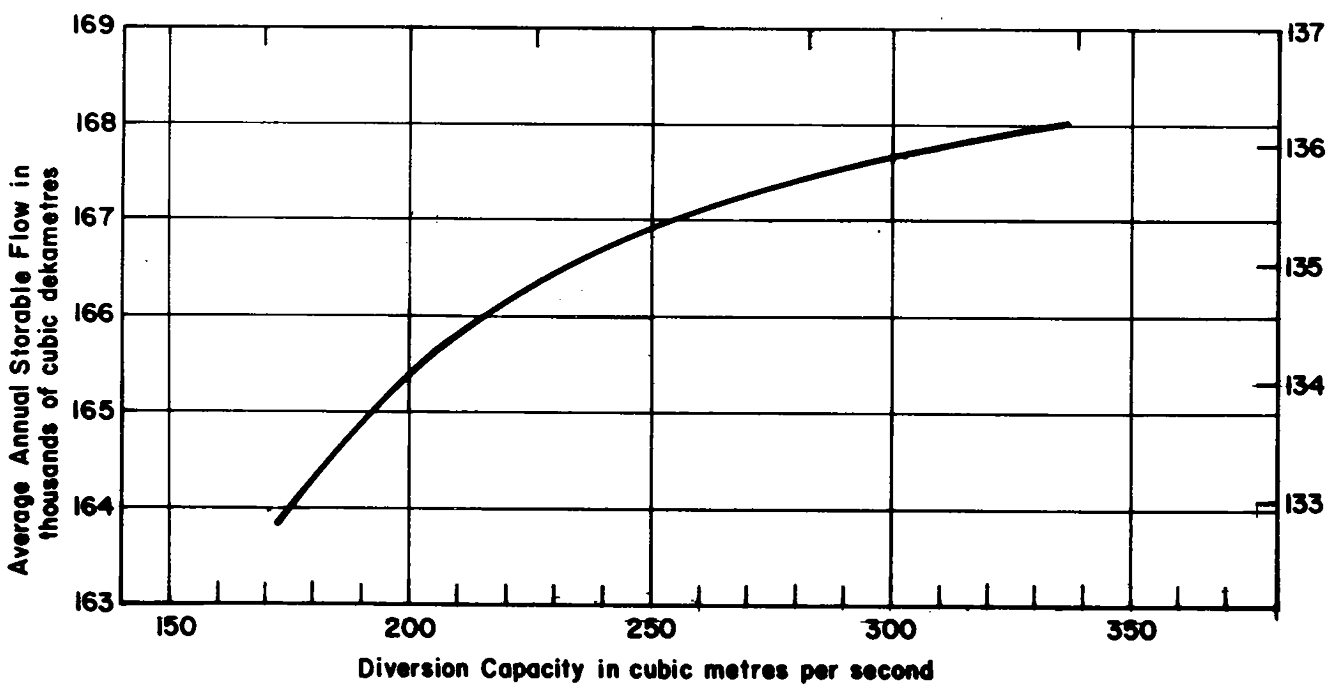


Thomes-Newville Plan

Thomes Creek Diversion Capacity

VS

Storable and Divertible Flow



Stony Creek Hydrology

The Stony Creek drainage basin lies south and west of the proposed Newville Reservoir. The stream drains an area of 1 920 km^2 (741 mi^2) (including North Fork Stony Creek) above Black Butte Dam. Elevations within the basin vary from about 120 to 1 920 m (400 to 6,300 ft). Precipitation averages about 890 mm (35 in) per year. Three major surface water storage facilities have been developed within this basin. East Park Dam and Reservoir (storage began in January 1911) and Stony Gorge Dam and Reservoir (storage began in November 1928) were constructed by the U. S. Reclamation Service and the Bureau of Reclamation as principal features of the Orland Project. Combined, the two projects have a storage capacity of about 125 000 dam^3 (101,000 ac-ft). Since the completion of Stony Gorge Dam and Reservoir, annual water deliveries to the Orland Project service area have averaged about 123 000 dam^3 (100,000 ac-ft). The 197 000-dam^3 (160,000-ac-ft) Black Butte Reservoir (storage began in October 1963) was constructed by the Corps of Engineers primarily for flood control, although the project does provide additional CVP water supply.

The USGS, Bureau of Reclamation, and Department of Water Resources have operated eleven streamflow-gaging stations in the Stony Creek Basin at various times, as listed in the following tabulation:

Station Name	Period of Record	Drainage Area km^2	Drainage Area mi^2
Stony Creek near Hamilton City	Jan. 1941-Sept. 1973	2 000	772
Stony Creek at Black Butte Dam Site	Jan. 1953-Sept. 1962	1 920	741
Stony Creek below Black Butte Dam	Oct. 1962-Present	1 920	741
Stony Creek near Orland	Jan. 1920-Sept. 1934	1 650	636
Stony Creek near Fruto	Feb. 1901-Sept. 1912	1 560	601
	Oct. 1960-Sept. 1978	1 550	597
Stony Creek near Elk Creek	May 1919-Sept. 1934	780	301
Stony Creek above Stony Gorge Dam	Oct. 1933-Sept. 1941	689	266
Stony Creek near Stonyford	Apr. 1913-Dec. 1914	251	97
	Dec. 1918-Dec. 1920	251	97
	Oct. 1921-Sept. 1934	251	97
Little Stony Creek near Lodoga	Jan. 1908-Sept. 1934	256	99
Little Stony Creek above East Park Reservoir	Sept. 1966-Present	119	46
Grindstone Creek near Elk Creek	Nov. 1935-Sept. 1937	404	156
	Oct. 1939-Apr. 1940	404	156
	Oct. 1965-Sept. 1972	404	156

Operation records are also available for East Park, Stony Gorge, and Black Butte Reservoirs.

For the formulation of the Thomes-Newville Plan, the Corps of Engineers' "R-1" operation study of Black Butte Reservoir was used to determine the amount of water potentially pumpable to Newville Reservoir. The Corps performed the operation study to determine the yield capability of Black Butte Reservoir (in conjunction with East Park and Stony Gorge Reservoirs) under conditions of ultimate development of the Orland Project.

The study set an annual target delivery to the Orland Project of 134 000 dam^3 (109,000 ac-ft) and an additional 60 000 dam^3 (49,000 ac-ft) of new yield from Black Butte Reservoir. Analysis of the Corps' study in conjunction with the SWP/CVP base study showed that an annual average of about 259 000 dam^3 (210,000 ac-ft) of surplus water would be available in Black Butte Reservoir for potential diversion to Newville Reservoir. This available surplus figure is derived as follows:

Black Butte Reservoir	1922-71 Average Annual Flow dam^3	(ac-ft)
Total inflow	479 000	388,000
Less evaporation	- 9 000	- 7,000
Total release	470 000	381,000
Less release for Orland Project and CVP	-186 000	-151,000
Flood control releases	284 000	230,000
Less portion contributing to downstream prior rights	- 7 000	- 6,000
Remainder	277 000	224,000
Less portion storable on North Fork Stony Creek	-18 000	-14,000
Remainder: potentially pumpable from Black Butte to Newville Reservoir	259 000	210,000

Table 2-3 shows the monthly distribution of Black Butte Reservoir inflow and potential pumpable amounts. Both sets of values have been adjusted to reflect storage of North Fork Stony Creek water by Newville Reservoir. Occasionally, pumpable amounts are greater than the inflow due to reservoir drawdown necessary to meet flood control operation criteria.

A daily flow analysis was performed to determine pumpable Black Butte Reservoir inflow for a range of pumping capacities. Monthly inflow was distributed on a daily basis in proportion to the Thomes Creek flow recorded at the Paskenta gage. This procedure was checked for accuracy by performing a similar analysis for the overlapping record of Thomes Creek and the record of Stony Creek at Black Butte Dam site (1955-62). Pumpable amounts for pumping capacities of 142 and 283 m^3/s (5,000 and 10,000 ft^3/s) checked to within 1 percent. Figure 2-2 summarizes pumpable flow based on the daily flow analysis.

An alternative Stony Creek diversion plan would involve pumping from a small Millsite Reservoir, about 8 km (5 mi) upstream from Black Butte Reservoir. As previously noted, that plan would not have access to runoff from the 21-km^2 (8-mi^2) drainage area between Newville and Tehenn Dams on the North Fork of Stony Creek. In addition, the alternative plan would not be able to capture surplus runoff from the 171-km^2 (66-mi^2) portion of Black Butte Reservoir drainage area that lies downstream from Tehenn and Millsite Dam sites. The combined effect of these changes would be an 8-percent reduction in the total Stony and Thomes Creek drainage areas tributary to the Thomes-Newville Plan facilities. The percentage change in total water supply would be less because the omitted tributary area includes only lower, less productive watersheds. However, selection of the Millsite diversion alternative would have an impact on formulation of the remainder of the features in the plan. Studies of that impact will be undertaken in the next phase of planning.

TABLE 2-3A

THOMES-NEWVILLE PLAN 1 of 2

BLACK BUTTE RESERVOIR Units in 1 000 dam^3

Total Inflow Minus North Fork Stony Creek
Potentially Storable

Source of Total Inflow: USCE R-1 Operation Study

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	14	1	4	1	80	16	47	43	12	0	0	0	218
	0	0	0	0	23	0	0	0	0	0	0	0	23
1923	22	11	59	53	26	7	15	12	3	0	25	24	257
	0	0	55	25	0	0	0	0	0	0	0	0	80
1924	6	1	1	3	7	1	0	3	14	15	12	4	67
	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	1	1	8	15	199	25	68	96	17	0	0	0	430
	0	0	0	0	190	0	0	0	0	0	0	0	190
1926	21	4	4	27	168	15	70	11	0	0	20	24	364
	0	0	0	0	191	0	0	0	0	0	0	0	191
1927	9	17	81	65	313	86	31	30	8	0	0	6	646
	0	0	0	53	348	20	0	0	0	0	0	0	421
1928	15	5	26	57	105	81	71	18	1	0	0	0	377
	0	0	0	31	82	52	14	0	0	0	0	0	179
1929	22	2	4	8	34	5	5	4	1	9	26	14	134
	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	7	1	5	15	53	52	28	14	1	0	7	25	208
	0	0	0	0	0	1	0	0	0	0	0	0	1
1931	14	2	0	9	5	9	1	1	16	26	22	12	117
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	6	10	6	26	17	21	11	15	4	0	34	25	175
	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	14	1	1	5	5	17	11	10	6	28	26	19	143
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	7	1	11	19	19	12	4	3	2	28	32	21	159
	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	5	9	6	37	35	42	91	27	3	1	0	2	258
	0	0	0	0	0	0	7	0	0	0	0	0	7
1936	23	4	4	109	154	22	30	14	7	1	33	25	426
	0	0	0	73	174	0	0	0	0	0	0	0	247
1937	14	2	1	1	27	44	41	20	4	0	10	25	189
	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	13	18	167	70	222	204	88	46	19	2	0	0	849
	0	0	150	70	241	152	0	0	0	0	0	0	613
1939	25	5	9	7	11	7	2	1	0	0	20	19	106
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	9	1	2	84	239	88	59	14	3	0	0	17	516
	0	0	0	58	268	0	0	0	0	0	0	0	326
1941	13	6	210	343	397	324	281	79	31	9	9	6	1708
	0	0	198	360	397	260	186	5	0	0	0	0	1406
1942	32	5	115	226	297	39	133	59	30	10	5	4	955
	0	0	163	260	279	0	41	0	0	0	0	0	743
1943	32	12	56	225	74	42	39	26	14	9	7	7	543
	0	5	71	268	52	0	0	0	0	0	0	0	396
1944	31	2	3	6	43	27	37	35	11	6	6	10	217
	0	0	0	0	43	0	0	0	0	0	0	0	43
1945	25	6	35	35	95	17	25	21	8	5	6	8	286
	0	0	0	0	76	0	0	0	0	0	0	0	76
1946	29	19	226	95	31	20	21	15	7	5	6	23	497
	0	0	232	78	0	0	0	0	0	0	0	0	310

BLACK BUTTE RESERVOIR

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	14	2	1	6	46	41	28	8	5	4	12	25	192
	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	12	1	0	15	15	7	73	53	27	8	7	5	223
	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	30	5	6	10	20	189	65	33	9	5	6	6	384
	0	0	0	0	0	217	0	0	0	0	0	0	217
1950	30	4	2	41	86	36	43	23	9	5	6	11	296
	0	0	0	3	113	0	0	0	0	0	0	0	116
1951	31	36	145	125	110	28	26	14	7	5	7	20	554
	0	0	154	129	78	0	0	0	0	0	0	0	361
1952	17	14	131	192	189	109	97	52	26	10	8	6	851
	0	0	107	223	157	31	47	0	0	0	0	0	565
1953	31	6	169	276	62	15	42	44	27	10	9	7	698
	11	0	263	276	0	0	0	0	0	0	0	0	550
1954	31	8	17	117	125	56	94	27	11	6	10	6	508
	0	0	0	116	148	9	37	0	0	0	0	0	310
1955	31	15	52	37	25	9	10	26	8	6	8	20	247
	0	0	85	3	0	0	0	0	0	0	0	0	88
1956	13	0	241	279	214	63	56	51	16	7	6	5	951
	0	0	220	300	172	0	0	0	0	0	0	0	692
1957	29	5	2	20	89	74	11	17	4	21	36	25	333
	0	0	0	0	124	62	0	0	0	0	0	0	186
1958	12	8	22	134	569	199	130	75	19	4	0	22	1194
	0	0	0	126	614	134	31	5	0	0	0	0	910
1959	4	4	5	64	121	47	8	1	0	32	36	25	347
	0	0	0	84	155	0	0	0	0	0	0	0	239
1960	1	0	1	4	103	74	5	5	1	10	36	25	263
	0	0	0	0	70	10	0	0	0	0	0	0	80
1961	15	1	16	23	66	47	10	5	1	0	22	25	229
	0	0	0	0	37	0	0	0	0	0	0	0	37
1962	15	1	6	2	104	90	15	14	2	0	31	25	305
	0	0	0	0	54	59	0	0	0	0	0	0	113
1963	12	1	20	26	197	72	137	47	10	0	0	22	544
	0	0	0	0	185	31	82	0	0	0	0	0	298
1964	2	25	10	36	23	13	5	2	0	14	36	25	191
	0	0	0	23	0	0	0	0	0	0	0	0	23
1965	12	10	267	242	59	33	91	33	8	0	0	20	775
	0	0	264	238	1	0	36	0	0	0	0	0	539
1966	0	31	24	136	73	52	13	16	0	0	20	25	390
	0	0	0	117	82	0	0	0	0	0	0	0	199
1967	15	10	70	207	79	63	42	70	41	1	0	15	613
	0	0	33	223	51	0	5	1	3	0	0	0	316
1968	0	8	19	93	165	56	7	5	1	23	36	25	438
	0	0	0	136	179	0	0	0	0	0	0	0	315
1969	8	3	23	252	234	149	65	54	14	0	0	0	802
	0	0	0	284	234	56	0	0	0	0	0	0	574
1970	1	20	91	474	103	74	9	6	1	0	22	25	826
	0	0	83	527	62	0	0	0	0	0	0	0	672
1971	15	19	96	155	47	104	32	23	9	1	0	0	501
	0	0	106	124	0	69	0	0	0	0	0	0	299
TOTAL	790	384	2480	4506	5580	2923	2323	1321	472	326	660	735	22500
	11	5	2184	4208	4880	1163	486	11	3	0	0	0	12951
AVERAGE	16	8	50	90	112	58	46	26	9	7	13	15	450
	0	0	44	84	98	23	10	0	0	0	0	0	259

TABLE 2-3B

THOMES-NEWVILLE PLAN — 1 of 2

BLACK BUTTE RESERVOIR — Units in 1,000 ac-ft

Total Inflow Minus North Fork Stony Creek
Potentially Storable

Source of Total Inflow: USCE R-1 Operation Study

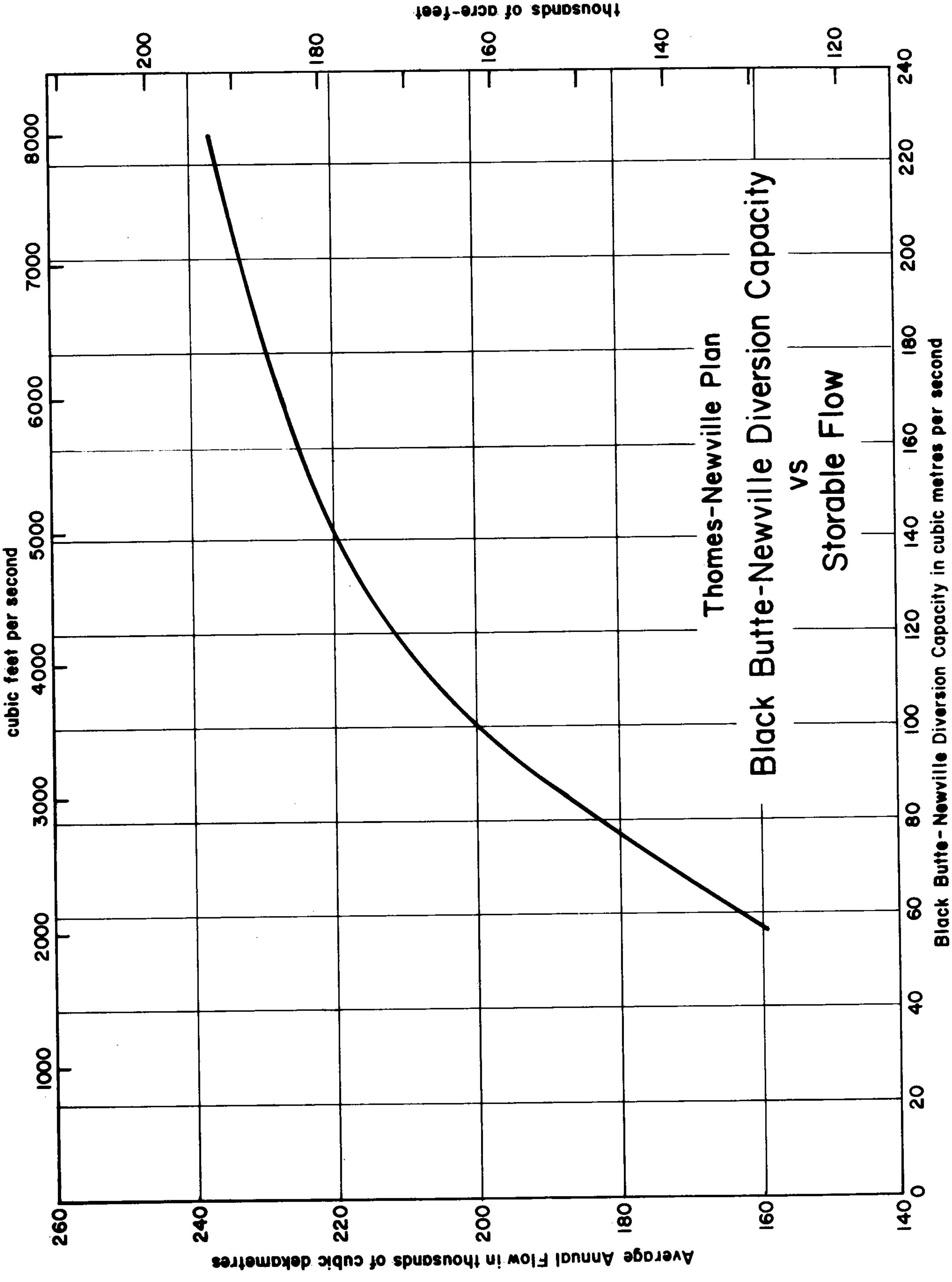
WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	11	1	3	1	65	13	38	35	10	0	0	0	177
	0	0	0	0	19	0	0	0	0	0	0	0	19
1923	18	9	48	43	21	6	12	10	2	0	20	19	208
	0	0	45	20	0	0	0	0	0	0	0	0	65
1924	5	1	1	2	6	1	0	2	11	12	10	3	54
	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	1	1	7	12	161	20	55	78	14	0	0	0	349
	0	0	0	0	154	0	0	0	0	0	0	0	154
1926	17	3	3	22	136	12	57	9	0	0	16	20	295
	0	0	0	0	155	0	0	0	0	0	0	0	155
1927	7	14	66	53	254	70	25	24	6	0	0	5	524
	0	0	0	43	282	16	0	0	0	0	0	0	341
1928	12	4	21	46	85	66	58	15	1	0	0	0	306
	0	0	0	25	67	42	11	0	0	0	0	0	145
1929	18	2	3	7	28	4	4	3	1	7	21	11	109
	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	6	1	4	12	43	42	23	11	1	0	6	20	169
	0	0	0	0	0	1	0	0	0	0	0	0	1
1931	11	2	0	7	4	7	1	1	13	21	18	10	95
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	5	8	5	21	14	17	9	12	3	0	28	20	142
	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	11	1	1	4	4	14	9	8	5	23	21	15	116
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	6	1	9	15	15	10	3	2	2	23	26	17	129
	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	4	7	5	30	28	34	74	22	2	1	0	2	209
	0	0	0	0	0	0	6	0	0	0	0	0	6
1936	19	3	3	88	125	18	24	11	6	1	27	20	345
	0	0	0	59	141	0	0	0	0	0	0	0	200
1937	11	2	1	1	22	36	33	16	3	0	8	20	153
	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	11	15	135	57	180	165	71	37	15	2	0	0	688
	0	0	122	57	195	123	0	0	0	0	0	0	497
1939	20	4	7	6	9	6	2	1	0	0	16	15	86
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	7	1	2	68	194	71	48	11	2	0	0	14	418
	0	0	0	47	217	0	0	0	0	0	0	0	264
1941	11	5	170	278	322	263	228	64	25	7	7	5	1385
	0	0	160	292	322	211	151	4	0	0	0	0	1140
1942	26	4	93	183	241	32	108	48	24	8	4	3	774
	0	0	132	211	226	0	33	0	0	0	0	0	602
1943	26	10	45	182	60	34	32	21	11	7	6	6	440
	0	4	58	217	42	0	0	0	0	0	0	0	321
1944	25	2	2	5	35	22	30	28	9	5	5	8	176
	0	0	0	0	35	0	0	0	0	0	0	0	35
1945	20	5	28	28	77	14	20	17	7	4	5	7	232
	0	0	0	0	62	0	0	0	0	0	0	0	62
1946	24	15	183	77	25	16	17	12	6	4	5	19	403
	0	0	188	63	0	0	0	0	0	0	0	0	251

TABLE 2-3B

BLACK BUTTE RESERVOIR

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	11	2	1	5	37	33	23	7	4	3	10	20	156
	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	10	1	0	12	12	6	59	43	22	6	6	4	181
	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	24	4	5	8	16	153	53	27	7	4	5	5	311
	0	0	0	0	0	176	0	0	0	0	0	0	176
1950	24	3	2	33	70	29	35	19	7	4	5	9	240
	0	0	0	2	92	0	0	0	0	0	0	0	94
1951	25	29	118	101	89	23	21	11	6	4	6	16	449
	0	0	125	105	63	0	0	0	0	0	0	0	293
1952	14	11	106	156	153	88	79	42	21	8	7	5	690
	0	0	87	181	127	25	38	0	0	0	0	0	458
1953	25	5	137	224	50	12	34	36	22	8	7	6	566
	9	0	213	224	0	0	0	0	0	0	0	0	446
1954	25	7	14	95	101	45	76	22	9	5	8	5	412
	0	0	0	94	120	7	30	0	0	0	0	0	251
1955	25	12	42	30	20	7	8	21	7	5	7	16	200
	0	0	69	2	0	0	0	0	0	0	0	0	71
1956	11	0	195	226	174	51	45	41	13	6	5	4	771
	0	0	178	243	140	0	0	0	0	0	0	0	561
1957	24	4	2	16	72	60	9	14	3	17	29	20	270
	0	0	0	0	101	50	0	0	0	0	0	0	151
1958	10	7	18	109	461	161	105	61	15	3	0	18	968
	0	0	0	102	498	109	25	4	0	0	0	0	738
1959	3	3	4	52	98	38	7	1	0	26	29	20	281
	0	0	0	68	126	0	0	0	0	0	0	0	194
1960	1	0	1	3	84	60	4	4	1	8	29	20	213
	0	0	0	0	57	8	0	0	0	0	0	0	65
1961	12	1	13	19	54	38	8	4	1	0	18	20	186
	0	0	0	0	30	0	0	0	0	0	0	0	30
1962	12	1	5	2	84	73	12	11	2	0	25	20	247
	0	0	0	0	44	48	0	0	0	0	0	0	92
1963	10	1	16	21	160	58	111	38	8	0	0	18	441
	0	0	0	0	150	25	66	0	0	0	0	0	241
1964	2	20	8	29	19	11	4	2	0	11	29	20	155
	0	0	0	19	0	0	0	0	0	0	0	0	19
1965	10	8	216	196	48	27	74	27	6	0	0	16	628
	0	0	214	193	1	0	29	0	0	0	0	0	437
1966	0	25	20	110	59	42	11	13	0	0	16	20	316
	0	0	0	95	66	0	0	0	0	0	0	0	161
1967	12	8	57	168	64	51	34	57	33	1	0	12	497
	0	0	27	181	41	0	4	1	2	0	0	0	256
1968	0	7	15	75	134	45	6	4	1	19	29	20	355
	0	0	0	110	145	0	0	0	0	0	0	0	255
1969	6	2	19	204	190	121	53	44	11	0	0	0	650
	0	0	0	230	190	45	0	0	0	0	0	0	465
1970	1	16	74	384	84	60	7	5	1	0	18	20	670
	0	0	67	428	50	0	0	0	0	0	0	0	545
1971	12	15	78	126	38	84	26	19	7	1	0	0	406
	0	0	86	100	0	56	0	0	0	0	0	0	242
TOTAL	641	313	2011	3652	4525	2369	1885	1071	380	264	537	593	18241
	9	4	1771	3411	3958	942	393	9	2	0	0	0	10499
AVERAGE	13	6	40	73	91	47	38	21	8	5	11	12	365
	0	0	36	68	79	19	8	0	0	0	0	0	210

Figure 2-2



Thomes-Newville Plan
Black Butte-Newville Diversion Capacity
vs
Storable Flow
cubic feet per second
1000
2000
3000
4000
5000
6000
7000
8000
thousands of acre-feet
200
180
160
140
120
Black Butte-Newville Diversion Capacity in cubic metres per second
0
20
40
60
80
100
120
140
160
180
200
220
240
Average Annual Flow in thousands of cubic dekametres
260
240
220
200
180
160
140

Evaporeservation

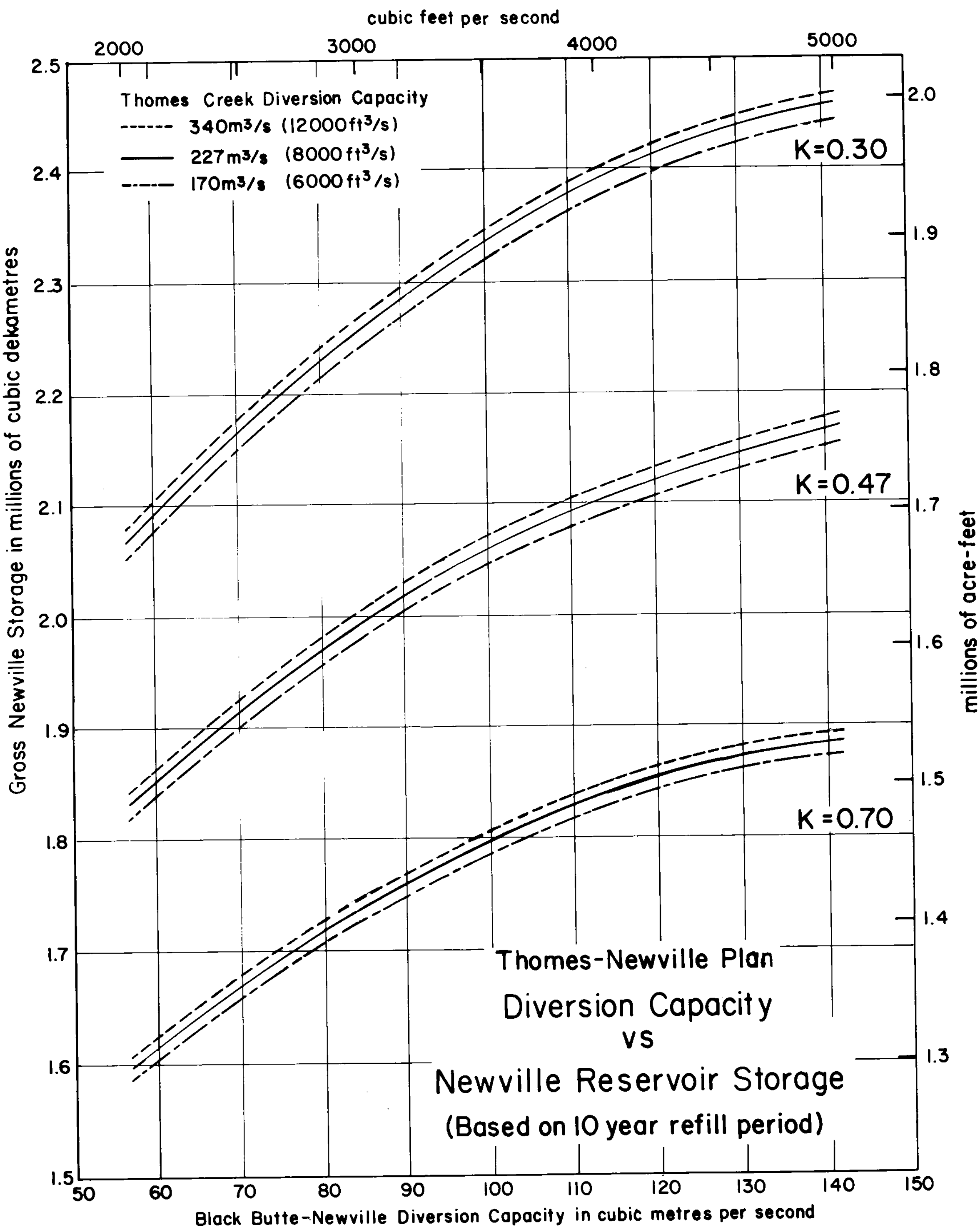
Evaporation from Newville Reservoir is estimated to average about 1 400 mm (55 in) per year. But, at the same time, the reservoir would prevent consumptive use of rainfall by native vegetation and dry-farmed crops within the area of inundation; this would increase the usable water supply from precipitation in the reservoir area by about 380 mm (15 in) per year. For use in the operation studies, these two partially offsetting effects were combined under the coined term "evaporeservation", as shown in the following tabulation:

Month	Lake Evaporation		Native Vegetation Depletion		Evaporeservation	
	mm	(in)	mm	(in)	mm	(in)
October	100	4.1	30	1.3	70	2.8
November	50	1.9	60	2.3	-10	-0.4
December	30	1.3	70	2.9	-40	-1.6
January	30	1.4	50	2.0	-20	-0.6
February	50	1.8	40	1.5	10	0.3
March	80	3.1	50	1.9	30	1.2
April	110	4.4	40	1.5	70	2.9
May	160	6.2	20	0.8	140	5.4
June	210	8.3	10	0.4	200	7.9
July	230	9.0	0	0	230	9.0
August	190	7.5	0	0.1	190	7.4
September	160	6.3	10	0.3	150	6.0
Total	1 400	55.3	380	15.0	1 020	40.3

Plan Formulation

The first step in the formulation process was to define the relationships between storage, Thomes Creek diversion capacity, Black Butte-Newville conveyance capacity, yield and operating mode (K factor). For any particular diversion capacity and K factor, one additional parameter is needed to define unique values for storage and yield. As previously noted, a 10-year refill period, defined as the average amount of time required to fill the reservoir from minimum pool while still meeting the full average demands imposed upon it, was used as the additional formulating tool for this analysis. Formulations based on the 10-year refill criterion were found to allow the reservoir to fill in the spring of 1928 (except for K values of about 1.0 or more), while still regulating a majority of the water supply. A computer operation program was developed to determine the diversion capacity-storage-K relationship, based on the 10-year refill criterion. Figure 2-3 presents the results of this analysis. The figure shows clearly that storage is primarily dependent on the operating mode (K factor) and the capacity of the diversion facilities to capture surplus Stony Creek water; within the range of sizes considered, the Thomes Creek diversion capacity has little impact on the size of Newville Reservoir. All plans considered would capture the maximum amount of potentially storable flow during the critical period (May 1928 through October 1934) and would be at a minimum Newville Reservoir storage of 62 000 dam^3 (50,000 ac-ft) at the

Figure 2-3



cubic feet per second
2000
3000
4000
5000
Thomes Creek Diversion Capacity
------ 340m³/s (12000ft³/s)
227m³/s (8000ft³/s)
170m³/s (6000ft³/s)
K=0.30
K=0.47
K=0.70
Gross Newville Storage in millions of cubic dekametres
millions of acre-feet
Black Butte-Newville Diversion Capacity in cubic metres per second
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
50
60
70
80
90
100
110
120
130
140
150
Thomes-Newville Plan
Diversion Capacity
vs
Newville Reservoir Storage
(Based on 10 year refill period)

end of the critical period. Therefore, critical period yield would be a function of storage only (within the range of sizes covered by Figure 2-3). Figure 2-4 presents the storage-critical period yield relationship. This is the new yield that could be developed by the Thomes-Newville Plan during a repetition of the most severe historic hydrologic sequence under expected year 2000 conditions. Long-term average annual yield for any particular formulation can be determined by multiplying the annual critical period yield from Figure 2-4 by the selected K factor.

The initial formulation studies examined the possibility of dedicating a portion of the new yield from Newville Reservoir to augmenting flows for instream needs along Thomes Creek, according to the following schedule estimated by the Division of Planning:

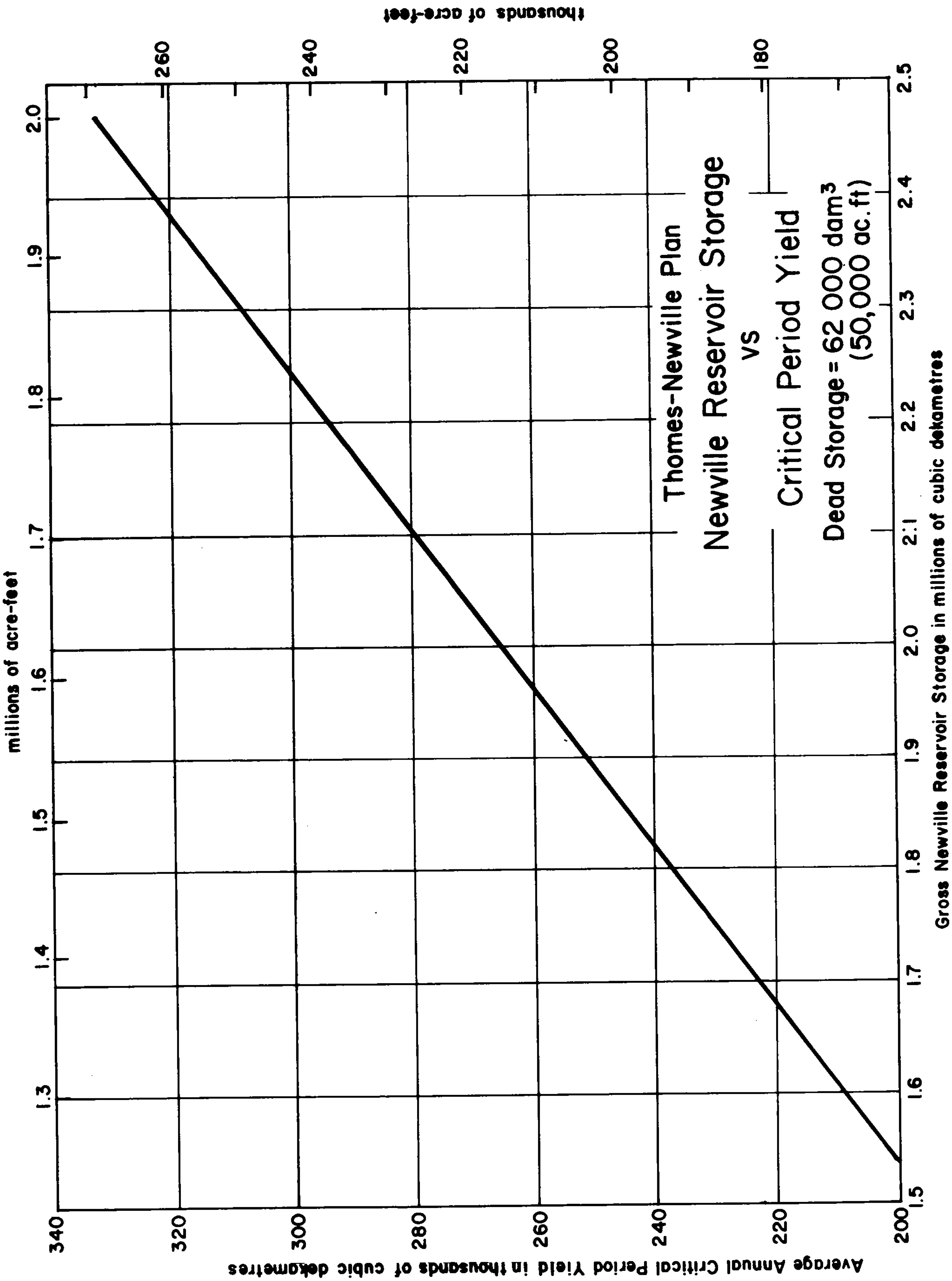
	Minimum Flow of Thomes Creek at Paskenta			
Period	m^3/s	(ft^3/s)	dam^3	(ac-ft)
October-April	1.4	50	25 900	21,000
May	1.8	65	4 900	4,000
June-August	2.3	82	18 500	15,000
September	1.4	50	3 700	3,000
			53 000	43,000

Under this option, if the full indicated minimum flow was not available at the Thomes Creek diversion dam, the remainder would be delivered from Newville Reservoir. Operation studies show that these augmentation releases to Thomes Creek would average about 20 000 dam^3/yr (16,000 ac-ft/yr) during the 50-year base period and 27 000 dam^3/yr (22,000 ac-ft/yr) during the critical period. Later, cost studies showed that augmentation flow release facilities (which would require pumping) would be very expensive and of doubtful economic justification. For these formulation studies, releases to Thomes Creek were assumed equal in value to releases made to the State Water Project. No final decision has been made concerning the Thomes Creek augmentation facilities, but the State Water Project yield figures are based on the assumption that there would be no allocation of new yield to the Thomes Creek Basin.

Since Newville Reservoir would not regulate a significant portion of Stony Creek runoff, Black Butte Reservoir flood control operations would have to be continued. Facilities for pumping from Black Butte Reservoir would have to be operable at pool elevations as low as 130 m (430 ft), as the flood control operations practically empty the reservoir during many months with potentially pumpable flows. Black Butte Reservoir storage at this pool level is about 31 000 dam^3 (25,000 ac-ft).

All releases from Newville Reservoir would pass through Black Butte Reservoir to lower Stony Creek. The least costly option would be to allow the water to flow down Stony Creek to the Glenn-Colusa Irrigation District Canal. (The District builds a temporary gravel dam on lower Stony Creek each irrigation season, where their main canal crosses the creek.)

Figure 2-4


Thomes-Newville Plan
Newville Reservoir Storage
vs
Critical Period Yield
Dead Storage = 62 000 dam³
(50,000 ac.ft)
millions of acre-feet
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
thousands of acre-feet
180
200
220
240
260
Gross Newville Reservoir Storage in millions of cubic dekametres
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
Average Annual Critical Period Yield in thousands of cubic dekametres
200
220
240
260
280
300
320
340

Under an exchange agreement, the District could accept water from the Thomes-Newville Plan in lieu of pumping a like amount of water from the river*. This would avoid any possible adverse impacts on Sacramento River temperature or water quality; it would also enhance lower Stony Creek and keep it flowing even during extreme dry periods. On the other hand, a significant portion of the new yield might be lost to percolation in the 34 km (21 mi) of Stony Creek channel between Black Butte Reservoir and the Glenn-Colusa Irrigation District Canal. Bank erosion and impacts on adjacent ground water levels would also have to be considered.

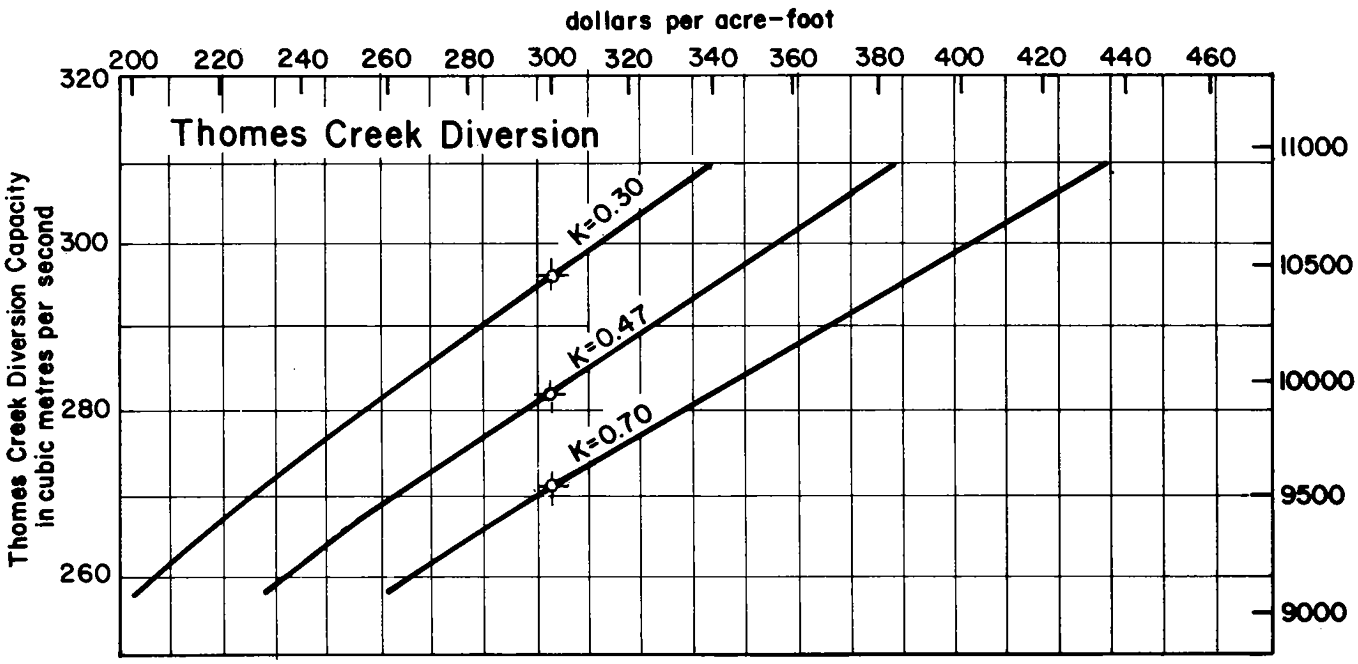
Studies of the potential channel losses in lower Stony Creek are presently underway. It appears that the major losses may occur in the downstream portion, east of Interstate Highway 5. If this should be the case, an exchange with the Tehama-Colusa Canal of the Central Valley Project would be an attractive possibility, even though a diversion dam and possibly a low pumping lift would be required. The Tehama-Colusa Canal crosses Stony Creek 16 stream km (10 stream mi) above the Glenn-Colusa Canal.

If channel loss or other problems could not be resolved, a separate conveyance canal would have to be constructed from Black Butte Dam. An earlier cost estimate showed that a bypass canal all the way back to the river would cost about $40 million. A much shorter canal could be used to connect to the Tehama-Colusa Canal; in fact, such a canal is included in the original Tehama-Colusa Canal authorization.

Example Formulations

Three example plans were formulated to illustrate the effect of the various modes of operation on storage capacity and the sizes of other facilities. The example formulations correspond to K factors (State Water Project release patterns) of 0.70, 0.47, and 0.30. (Including yield released from storage to Thomes Creek, the effective K values would be 0.71, 0.49, and 0.33.) The plans represent the results of maximizing net water supply benefits with an incremental value of critical period yield of $243/dam^3 ($300/ac-ft). While this exercise was based on preliminary cost estimates, the results (shown on Figures 2-5 and 2-6) serve to illustrate the general relationships between the optimum sizes of the major features and the value of critical period yield. For example, Figure 2-5 shows that the optimum size of the Thomes Creek diversion facilities is relatively insensitive to the value of yield or the choice of operating mode, while the optimum size of the Black Butte-Newville conveyance facilities varies substantially and is primarily influenced by the yield value. Figure 2-6 shows that the optimum size of Newville Reservoir is most affected by the operating mode and is influenced to a lesser degree by the value of yield. The formulation analyses will be refined by future studies.

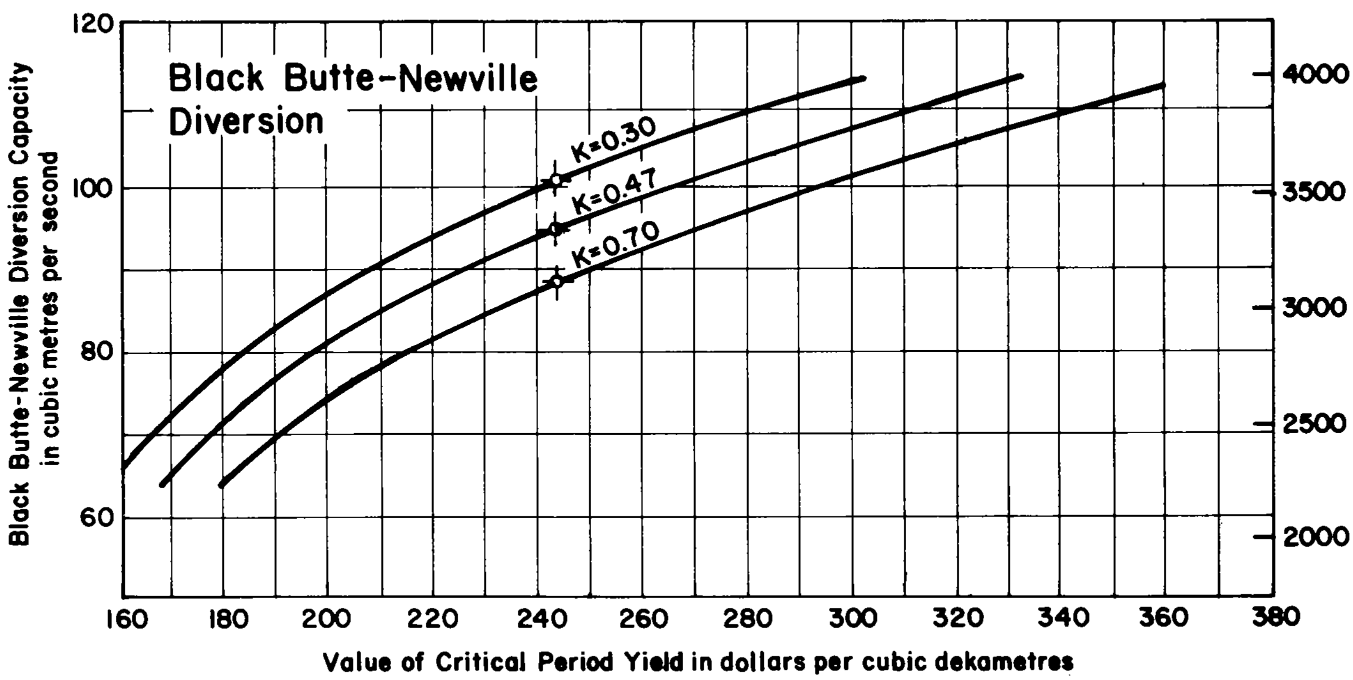
*The Glenn-Colusa Irrigation District delivers on the order of 1 000 000 dam^3 (800,000 ac-ft) annually, which is three to four times the maximum yield of the Thomes-Newville Plan.

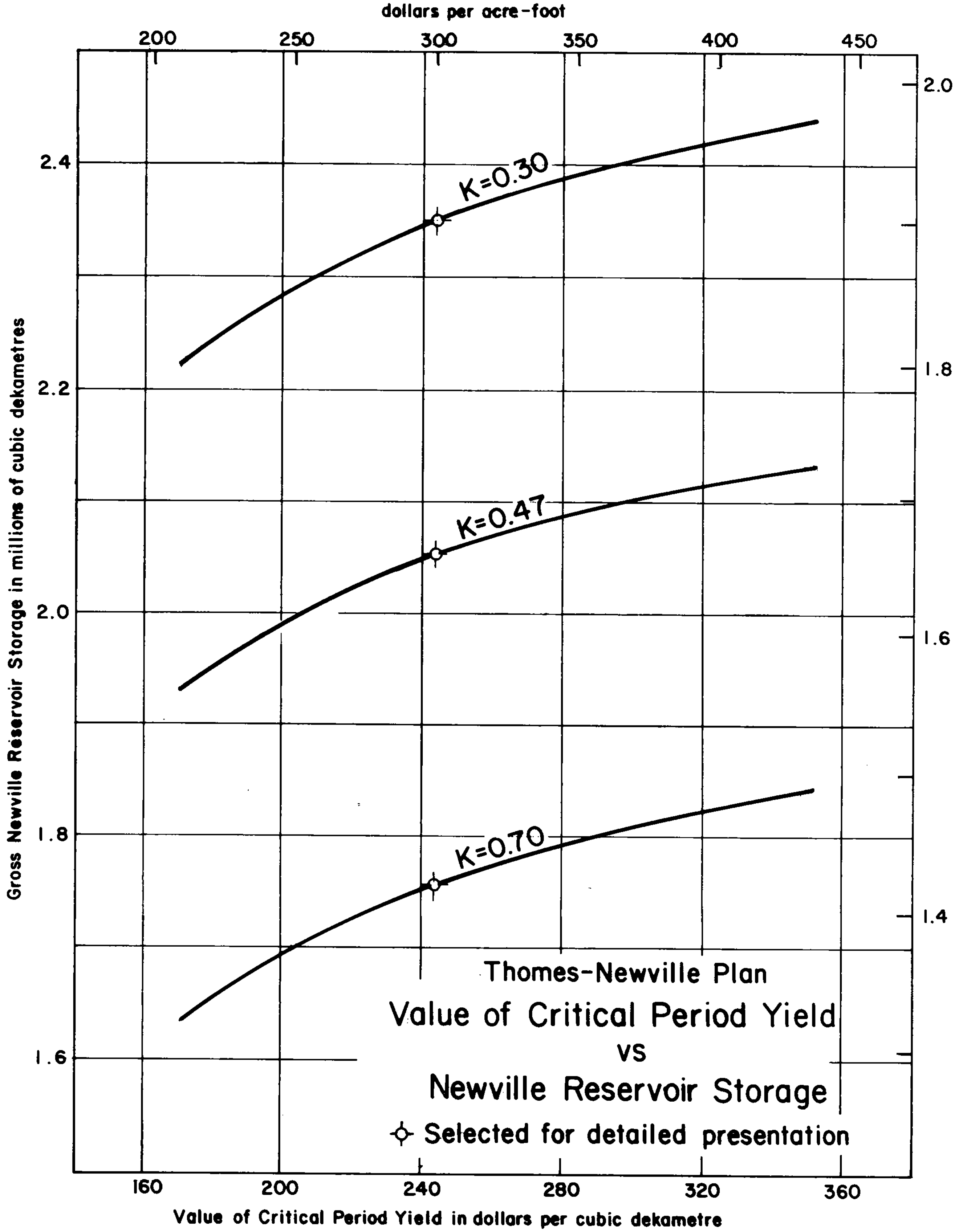


Thomes-Newville Plan

Value of Critical Period Yield
vs
Diversion Capacities

⌖ Selected for detailed presentation




dollars per acre-foot
200
250
300
350
400
450
2.0
1.8
1.6
1.4
millions of acre-feet
2.4
2.2
2.0
1.8
1.6
Gross Newville Reservoir Storage in millions of cubic dekametres
K=0.30
K=0.47
K=0.70
Thomes-Newville Plan
Value of Critical Period Yield
vs
Newville Reservoir Storage
Selected for detailed presentation
160
200
240
280
320
360
Value of Critical Period Yield in dollars per cubic dekametre

Information on the three example formulations is summarized by the following figures and tables:

- Table 2-4 summarizes pertinent data for each of the example formulations.

- Tables 2-5 through 2-7 (and the accompanying explanation of the column headings) summarize the long-term average operation. As previously described, these summaries are derived from studies in which part of the project yield would be released to Thomes Creek. If subsequent studies do not support the need or justification for such releases, the water shown under the "RTL" column would instead be released down Stony Creek and added to the "RBB", "SWP", and "PST" columns. Thomes Creek floodflows of up to 110 000 dam^3 (90,000 ac-ft) per month were assumed to be routed through Newville Reservoir for power generation. This corresponds to an assumed maximum generating capacity of 42 m^3/s (1,500 ft^3/s) at the Newville and Tehenn Pumping-Generating Plants. Later studies may refine the floodflow routing quantity. A generating capacity of only 28 m^3/s (1,000 ft^3/s) was used for the preliminary cost estimates presented in Chapter 5.

- Figures 2-7 through 2-9 are graphical presentations of the annual Newville Reservoir operating range and yield under the varying operational modes of the three example formulations. For the plan formulated for a K of 0.70, Figure 2-7 shows that annual reservoir drawdown would be moderately large. Conversely, the plan formulated for a K of 0.30 (Figure 2-9) would make large releases only during extreme dry periods, with minimal reservoir drawdown in normal years.

- Table 2-8 illustrates the procedure that was used to evaluate project yield buildup and nominal energy requirements during the initial filling period. Thomes Creek diversion facilities would be completed early, allowing for the storage of Thomes Creek and North Fork Stony Creek water two years prior to completion of the remainder of the facilities and commencement of State Water Project releases. The filling analysis is based upon average water supply conditions. The actual initial filling period could vary considerably, depending on hydrologic conditions.

Energy

The Thomes-Newville Plan would incorporate reversible pump-turbines that could operate either to pump surplus Stony Creek water to Newville Reservoir or to generate hydroelectric power when water was being released. The pumping-generating facilities would be tied into the Pacific Gas and Electric Company grid through 230 kV transmission lines to the Glenn Substation, about 3 km (2 mi) north of Orland.

TABLE 2-4A

THOMES-NEWVILLE PLAN EXAMPLE FORMULATIONS
Metric Units

	K = 0.70	K = 0.47	K = 0.30
Capacities, cubic dekametres			
Joint use flood reservation	*0	*0	*0
Conservation storage	1 692 000	1 988 000	2 287 000
Inactive storage	62 000	62 000	62 000
Gross Storage	1 754 000	2 050 000	2 349 000
Elevation, metres			
Dam crest	271	276	282
Top of conservation pool	265	270	276
Minimum pool	209	209	209
Streambed	183	183	183
Dam height, metres	88	93	99
Areas, hectares			
Reservoir at gross storage	4 980	5 380	5 710
Reservoir at minimum pool	890	890	890
Gross land purchased	7 200	7 700	8 220
Black Butte-Newville conveyance system			
Capacity, cubic metres per second	88	95	102
Maximum static pump lift, metres	134	139	144
Average pumped, cubic dekametres per year	97 000	84 000	68 000
Thomes Creek diversion system			
Capacity, cubic metres per second	269	283	297
Average diverted, cubic dekametres per year	202 000	202 000	202 000
Average stored, cubic dekametres per year	99 000	89 000	81 000
Average initial fill period, years	6	7	7
Energy, long-term averages, gWh per year			
Used for pumping	39	35	29
Generated	67	66	63
Net generation	28	31	34
New yield, cubic dekametres per year**			
Average (1922-71)	163 000	134 000	105 000
Dry period (1928-34)	231 000	273 000	315 000
50-year average annual equivalent dry period	208 000	242 000	274 000

*Flood control was not included in this preliminary study, but it will be considered in all future studies.

**Includes releases to State Water Project and to Thomes Creek.

TABLE 2-4B

THOMES-NEWVILLE PLAN EXAMPLE FORMULATIONS
English Units

	K = 0.70	K = 0.47	K = 0.30
Capacities, acre-feet			
Joint use flood reservation	*0	*0	*0
Conservation storage	1,372,000	1,612,000	1,854,000
Inactive storage	50,000	50,000	50,000
Gross Storage	1,422,000	1,662,000	1,904,000
Elevations, feet			
Dam crest	888	907	925
Top of conservation pool	868	887	905
Minimum pool	685	685	685
Streambed	600	600	600
Dam height, feet	288	307	325
Areas, acres			
Reservoir at gross storage	12,300	13,300	14,100
Reservoir at minimum pool	2,200	2,200	2,200
Gross land purchased	17,800	19,200	20,300
Black Butte-Newville conveyance system			
Capacity, cfs	3,100	3,350	3,600
Maximum static pump lift, feet	438	457	475
Average pumped, acre-feet per year	79,000	68,000	55,000
Thomes Creek diversion system			
Capacity, cfs	9,500	10,000	10,500
Average diverted, acre-feet per year	164,000	164,000	164,000
Average stored, acre-feet per year	80,000	72,000	66,000
Average initial fill period, years	6	7	7
Energy, long-term averages, gWh per year			
Used for pumping	39	35	29
Generated	67	66	63
Net generation	28	31	34
New yield, acre-feet per year**			
Average (1922-71)	132,000	109,000	85,000
Dry period (1928-34)	187,000	221,000	255,000
50-year average annual equivalent dry period	169,000	196,000	222,000

*Flood control was not included in this preliminary study, but it will be considered in all future studies.

**Includes releases to State Water Project and to Thomes Creek.

THOMES-NEWVILLE PLAN
EXPLANATION OF COLUMNS OF 50-YEAR OPERATION SUMMARY

MTH - Month of water year.

STG - End-of-month storage in Newville Reservoir.

ELV - Beginning-of-month elevation of Newville Reservoir.

EVP - Evaporeservation at Newville Reservoir.

HTH - Historic Thomes Creek flow at Paskenta.

DTH - Potentially divertable Thomes Creek flow for the specified diversion capacity.

NFS - Historic North Fork Stony Creek flow at Newville Dam site.

ADD - Portion of DTH and NFS that is nonstorable due to prior downstream rights.

RTL - Release from storage for Thomes Creek local demand.

PTH - Thomes Creek flow at Paskenta under project conditions.

HST - Historic Black Butte Reservoir release based on USCE R-1 operation study; includes flows to Sacramento River and local demand.

PBB - Potentially pumpable Black Butte spills for the specified pumping capacity.

BBP - Portion of PBB actually pumped to Newville Reservoir.

PST - Black Butte Reservoir release under project conditions.

SWP - Release to State Water Project from Newville Reservoir.

FLD - Flood release; a maximum of 111 000 dam^3 (90,000 ac-ft) per month would be routed through Newville Reservoir; the remainder would remain in Thomes Creek.

RBB - Release from Newville Reservoir to Black Butte Reservoir.

ENG - Net energy produced or consumed; values are for power drops through Newville and Tehenn Pumping-Generating Plants only.

TABLE 2-5A

THOMES-NEWVILLE PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.70
Metric Units (thousand dam^3, except as indicated)

Gross Storage = 1 754 000 dam^3
Critical Period Yield = 231 000 dam^3/yr*

Thomes Creek Diversion Capacity = 269 m^3/s
Black Butte-Newville Pumping Capacity = 88 m^3/s

MTH	STG	ELV (m)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
50-year totals																	
			2268	12458	10391	1399	2584	1000	3340	23480	9535	4850	31848	7127	3779	13217	1423
50-year averages																	
Oct	1274	253	2	2	1	0	0	3	4	14	0	0	17	4	0	4	1
Nov	1275	253	0	8	5	1	4	1	4	1	0	0	6	0	0	5	1
Dec	1324	253	-1	30	25	3	5	0	6	48	31	25	30	0	0	6	-9
Jan	1378	254	-1	41	37	5	4	0	7	90	62	28	76	0	13	14	-8
Feb	1435	255	0	47	42	6	3	0	7	105	66	33	94	0	20	21	-7
Mar	1458	257	1	40	34	4	6	0	5	30	22	10	43	0	17	23	3
Apr	1467	257	4	43	38	5	16	0	5	26	10	1	57	1	16	32	8
May	1460	258	6	28	22	3	11	0	5	26	0	0	49	5	9	23	6
Jun	1422	258	9	8	4	1	3	1	6	33	0	0	65	30	0	32	8
Jul	1351	257	10	2	0	0	0	5	6	41	0	0	97	56	0	57	14
Aug	1291	255	9	0	0	0	0	6	6	33	0	0	79	46	0	46	11
Sep	1280	253	6	0	0	0	0	4	4	23	0	0	23	1	0	1	0
Tot	1368	255	45	249	208	28	52	20	67	470	191	97	636	143	75	264	28

Pumping Energy = -39 gWh/yr

Generating Energy = 67 gWh/yr

Critical period (May 1928-October 1934) averages (thousand dam^3/yr)

982	240	39	101	73	11	69	27	56	175	0	0	447	204	0	273	62

*Includes releases to the State Water Project (SWP) and releases to Thomes Creek (RTL)

TABLE 2-5B

THOMES-NEWVILLE PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.70
English Units (thousand ac-ft, except as indicated)

Gross Storage = 1,422,000 ac-ft
Critical Period Yield = 187,000 ac-ft/yr*

Thomes Creek Diversion Capacity = 9,500 ft^3/s
Black Butte-Newville Pumping Capacity = 3,100 ft^3/s

MTH	STG	ELV (ft)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
50-year totals																	
			1839	10100	8424	1134	2095	811	2708	19035	7730	3932	25819	5778	3064	10715	1423
50-year averages																	
Oct	1033	830	2	2	1	0	0	2	3	11	0	0	14	3	0	3	1
Nov	1034	829	0	7	4	1	3	1	3	1	0	0	5	0	0	4	1
Dec	1073	830	-1	24	20	3	4	0	5	39	25	20	24	0	0	5	-9
Jan	1117	833	-1	34	30	4	3	0	6	73	50	23	62	0	11	11	-8
Feb	1163	838	0	38	33	5	3	0	6	85	54	27	75	0	16	17	-7
Mar	1182	843	1	32	28	3	5	0	4	24	18	8	35	0	14	19	3
Apr	1189	844	3	35	31	4	13	0	4	21	8	1	46	1	13	26	8
May	1184	845	5	22	18	2	9	0	4	21	0	0	40	4	7	19	6
Jun	1153	845	7	7	3	1	2	1	5	27	0	0	53	24	0	26	8
Jul	1095	842	8	1	0	0	0	4	5	33	0	0	79	46	0	46	14
Aug	1047	836	7	0	0	0	0	5	5	27	0	0	64	37	0	37	11
Sep	1038	831	6	0	0	0	0	3	3	19	0	0	19	1	0	1	0
Tot	1109	837	37	202	168	23	42	16	54	381	155	79	516	116	61	214	28

Pumping Energy = -39 gWh/yr

Generating Energy = 67 gWh/yr

Critical period (May 1928-October 1934) averages (thousand ac-ft/yr)

	STG	ELV	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG
	796	789	32	82	59	9	56	22	45	142	0	0	362	165	0	221	62

*Includes releases to the State Water Project (SWP) and releases to Thomes Creek (RTL)

TABLE 2-6A

THOMES-NEWVILLE PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.47
Metric Units (thousand dam^3, except as indicated)

Gross Storage = 2 050 000 dam^3
Critical Period Yield = 273 000 dam^3/yr*

Thomes Creek Diversion Capacity = 283 m^3/s
Black Butte-Newville Pumping Capacity = 95 m^3/s

MTH	STG	ELV (m)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
50-year totals																	
			2477	12458	10398	1399	2584	1000	3351	23480	9841	4196	31612	5736	4300	12329	1537
50-year averages																	
Oct	1586	260	4	2	1	0	0	3	4	14	0	0	17	4	0	4	1
Nov	1589	260	0	8	5	1	4	1	4	1	0	0	6	0	0	5	1
Dec	1636	260	-1	30	25	3	5	0	6	48	32	23	30	0	0	6	-9
Jan	1678	261	-1	41	37	5	4	0	9	90	64	21	88	0	17	18	-4
Feb	1731	262	0	47	42	6	3	0	7	105	69	31	97	0	21	21	-6
Mar	1752	263	1	40	34	4	6	0	5	30	22	9	46	0	21	26	3
Apr	1755	263	4	43	38	5	16	0	5	26	10	0	60	1	17	35	9
May	1748	264	6	28	22	3	11	0	5	26	0	0	51	5	10	25	7
Jun	1715	263	10	8	4	1	3	1	6	33	0	0	60	25	0	27	8
Jul	1654	262	11	2	0	0	0	5	6	41	0	0	85	44	0	44	12
Aug	1605	261	9	0	0	0	0	6	6	33	0	0	68	35	0	35	9
Sep	1594	260	7	0	0	0	0	4	4	23	0	0	24	1	0	1	0
Tot	1670	262	50	249	208	28	52	20	67	470	197	84	632	115	86	247	31

Pumping Energy = -35 gWh/yr

Generating Energy = 66 gWh/yr

Critical period (May 1928-October 1934) averages (thousand dam^3/yr)

MTH	STG	ELV (m)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
	1147	244	43	101	73	11	69	27	56	175	0	0	488	245	0	315	74

*Includes releases to the State Water Project (SWP) and releases to Thomes Creek (RTL)

TABLE 2-6B

THOMES-NEWVILLE PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.47
English Units (thousand ac-ft, except as indicated)

Gross Storage = 1,662,000 ac-ft
Critical Period Yield = 221,000 ac-ft/yr*

Thomes Creek Diversion Capacity = 10,000 ft^3/s
Black Butte-Newville Pumping Capacity = 3,350 ft^3/s

MTH	STG	ELV (ft)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
50-year totals																	
			2008	10100	8430	1134	2095	811	2717	19035	7978	3402	25628	4650	3486	9995	1537
50-year averages																	
Oct	1286	852	3	2	1	0	0	2	3	11	0	0	14	3	0	3	1
Nov	1288	852	0	7	4	1	3	1	3	1	0	0	5	0	0	4	1
Dec	1326	852	-1	24	20	3	4	0	5	39	26	19	24	0	0	5	-9
Jan	1360	855	-1	34	30	4	3	0	7	73	52	17	71	0	14	15	-4
Feb	1403	858	0	38	34	5	3	0	6	85	56	25	79	0	17	17	-6
Mar	1420	862	1	32	28	3	5	0	4	24	18	7	37	0	17	21	3
Apr	1423	864	3	35	31	4	13	0	4	21	8	0	49	1	14	28	9
May	1417	865	5	22	18	2	9	0	4	21	0	0	41	4	8	20	7
Jun	1390	864	8	7	3	1	2	1	5	27	0	0	49	20	0	22	8
Jul	1341	861	9	1	0	0	0	4	5	33	0	0	69	36	0	36	12
Aug	1301	857	7	0	0	0	0	5	5	27	0	0	55	28	0	28	9
Sep	1292	853	6	0	0	0	0	3	3	19	0	0	20	1	0	1	0
Tot	1354	858	40	202	169	23	42	16	54	381	160	68	513	93	70	200	31

Pumping Energy = -35 gWh/yr

Generating Energy = 66 gWh/yr

Critical period (May 1928-October 1934) averages (thousand ac-ft/yr)

MTH	STG	ELV (ft)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
	930	802	35	82	59	9	56	22	45	142	0	0	396	199	0	255	74

*Includes releases to the State Water Project (SWP) and releases to Thomes Creek (RTL)

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TABLE 2-7A

THOMES-NEWVILLE PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.30
Metric Units (thousand dam^3, except as indicated)

Gross Storage = 2 349 000 dam^3
Critical Period Yield = 315 000 dam^3/yr*

Thomes Creek Diversion Capacity = 297 m^3/s
Black Butte-Newville Pumping Capacity = 102 m^3/s

MTH	STG	ELV (m)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
50-year totals																	
			2651	12458	10407	1399	2584	1000	3344	23480	10068	3382	31426	4281	4755	11328	1693
50-year averages																	
Oct	1893	266	4	2	1	0	0	3	4	14	0	0	16	4	0	4	1
Nov	1895	265	0	8	5	1	4	1	4	1	0	0	6	0	0	5	1
Dec	1937	265	-2	30	25	3	5	0	6	48	33	17	36	0	0	6	-6
Jan	1970	266	-1	41	37	5	4	0	9	90	66	16	96	0	22	21	0
Feb	2016	267	0	47	42	6	3	0	7	105	70	25	105	0	24	24	-4
Mar	2034	268	1	40	34	4	6	0	5	30	22	10	48	0	21	27	4
Apr	2037	269	4	43	38	5	16	0	5	26	10	0	62	1	19	36	10
May	2029	269	7	28	22	3	11	0	5	26	0	0	51	5	9	25	7
Jun	2000	269	11	8	4	1	3	1	6	33	0	0	56	19	0	21	6
Jul	1951	268	12	2	0	0	0	5	6	41	0	0	72	31	0	32	9
Aug	1912	267	10	0	0	0	0	6	6	33	0	0	58	25	0	25	6
Sep	1901	266	7	0	0	0	0	4	4	23	0	0	23	1	0	1	0
Tot	1965	267	53	249	208	28	52	20	67	470	201	68	629	86	95	227	34

Pumping Energy = -29 gWh/yr

Generating Energy = 63 gWh/yr

Critical period (May 1928-October 1934) averages (thousand dam^3/yr)

	STG	ELV	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG
	1314	248	46	101	73	11	69	27	56	175	0	0	530	287	0	356	86

*Includes releases to the State Water Project (SWP) and releases to Thomes Creek (RTL)

TABLE 2-7B

THOMES-NEWVILLE PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.30
English Units (thousand ac-ft, except as indicated)

Gross Storage = 1,904,000 ac-ft
Critical Period Yield = 255,000 ac-ft/yr*

Thomes Creek Diversion Capacity = 10,500 ft^3/s
Black Butte-Newville Pumping Capacity = 3,600 ft^3/s

MTH	STG	ELV (ft)	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG (gWh)
50-year totals																	
			2149	10100	8437	1134	2095	811	2711	19035	8162	2742	25477	3471	3855	9184	1693
50-year averages																	
Oct	1535	872	3	2	1	0	0	2	3	11	0	0	13	3	0	3	1
Nov	1536	871	0	7	4	1	3	1	3	1	0	0	5	0	0	4	1
Dec	1570	871	-2	24	20	3	4	0	5	39	27	14	29	0	0	5	-6
Jan	1597	874	-1	34	30	4	3	0	7	73	53	13	78	0	18	17	0
Feb	1634	877	0	38	34	5	3	0	6	85	57	20	85	0	20	20	-4
Mar	1649	880	1	32	28	3	5	0	4	24	18	8	39	0	17	22	4
Apr	1651	881	3	35	31	4	13	0	4	21	8	0	50	1	15	29	10
May	1645	882	6	22	18	2	9	0	4	21	0	0	41	4	7	20	7
Jun	1621	881	9	7	3	1	2	1	5	27	0	0	45	15	0	17	6
Jul	1582	879	10	1	0	0	0	4	5	33	0	0	58	25	0	26	9
Aug	1550	876	8	0	0	0	0	5	5	27	0	0	47	20	0	20	6
Sep	1541	873	6	0	0	0	0	3	3	19	0	0	20	1	0	1	0
Tot	1593	876	43	202	169	23	42	16	54	381	163	55	510	69	77	184	34

Pumping Energy = -29 gWh/yr

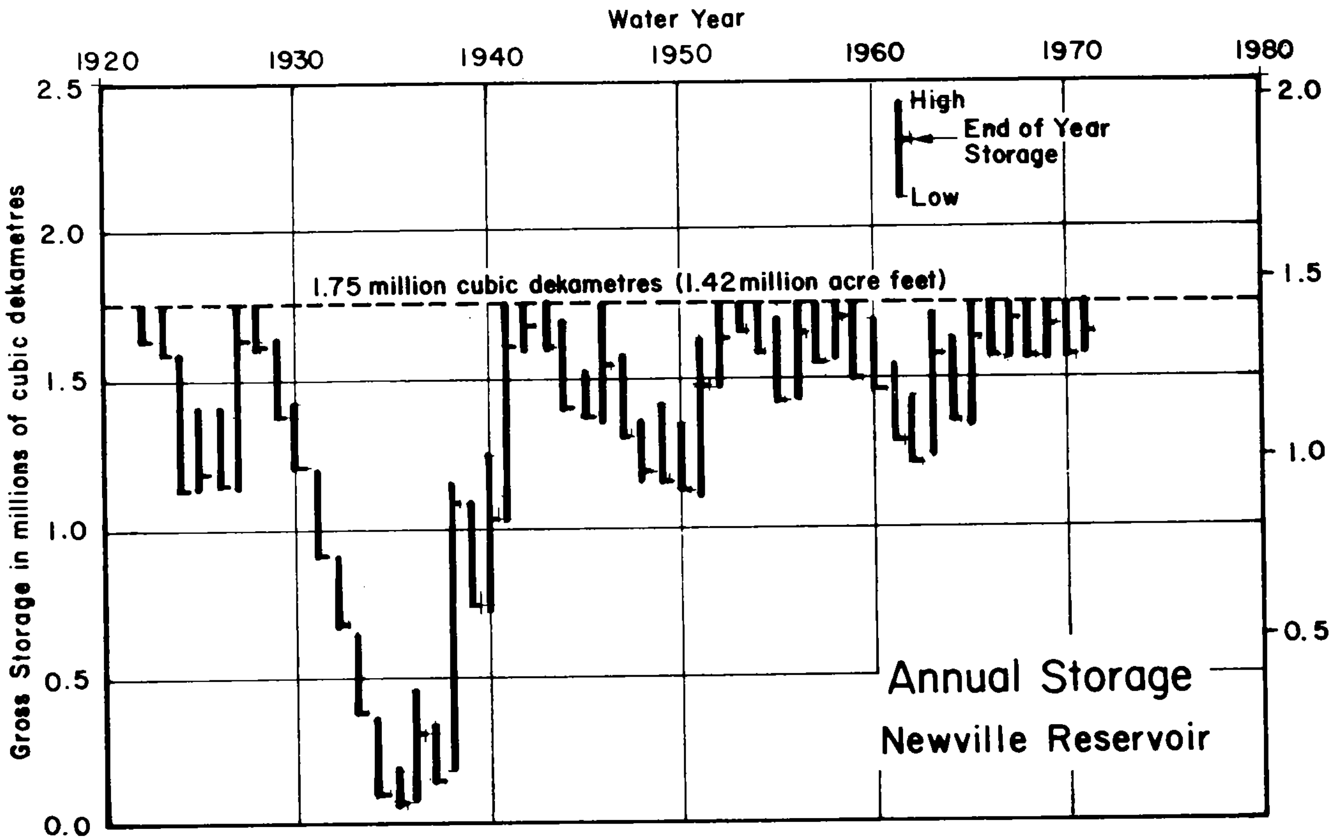
Generating Energy = 63 gWh/yr

Critical period (May 1928-October 1934) averages (thousand ac-ft/yr)

STG	ELV	EVP	HTH	DTH	NFS	ADD	RTL	PTH	HST	PBB	BBP	PST	SWP	FLD	RBB	ENG
1065	814	37	82	59	9	56	22	45	142	0	0	430	233	0	289	86

*Includes releases to the State Water Project (SWP) and releases to Thomes Creek (RTL)

Figure 2-7



Thomes-Newville Plan
K=0.70

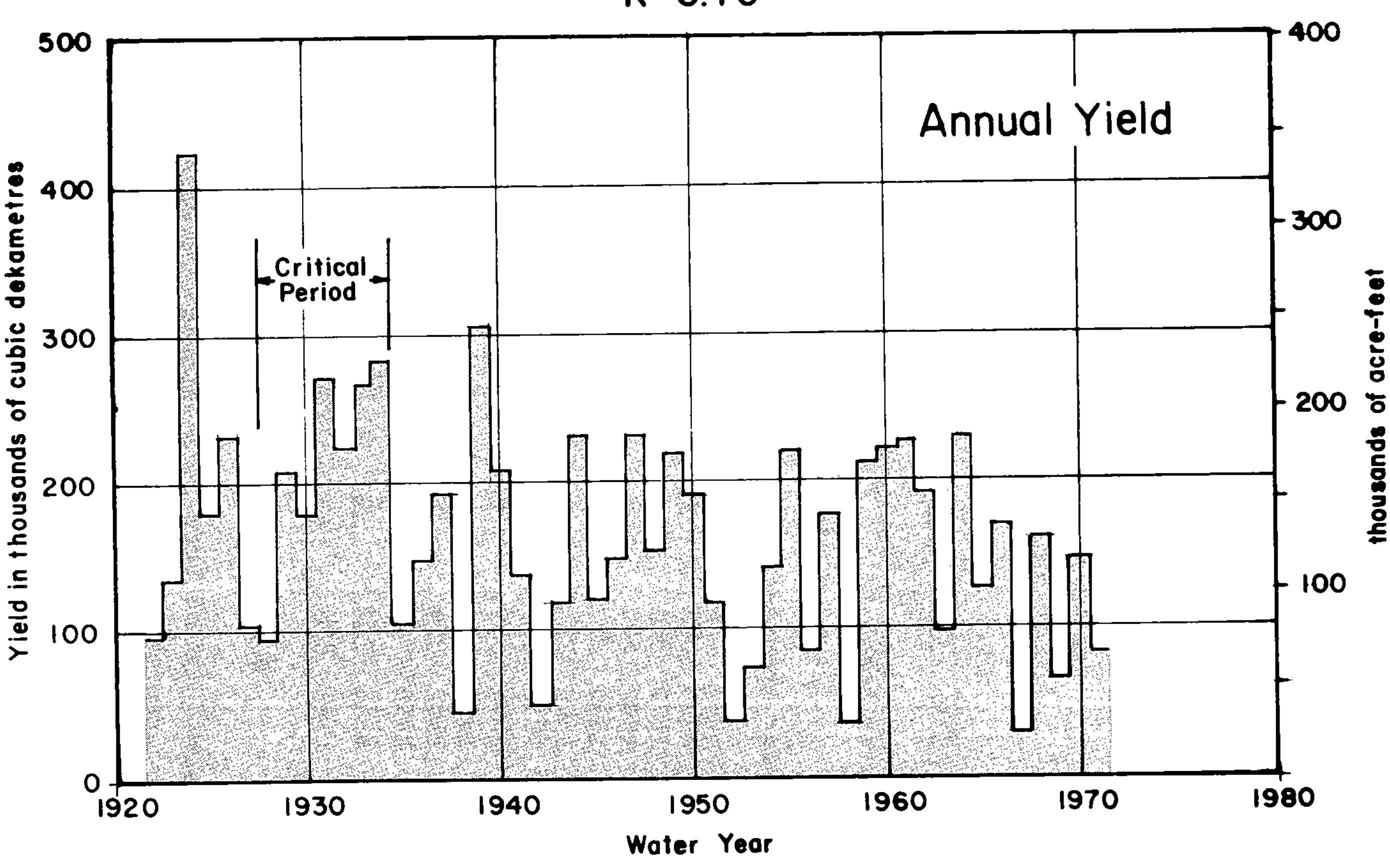


Figure 2-8

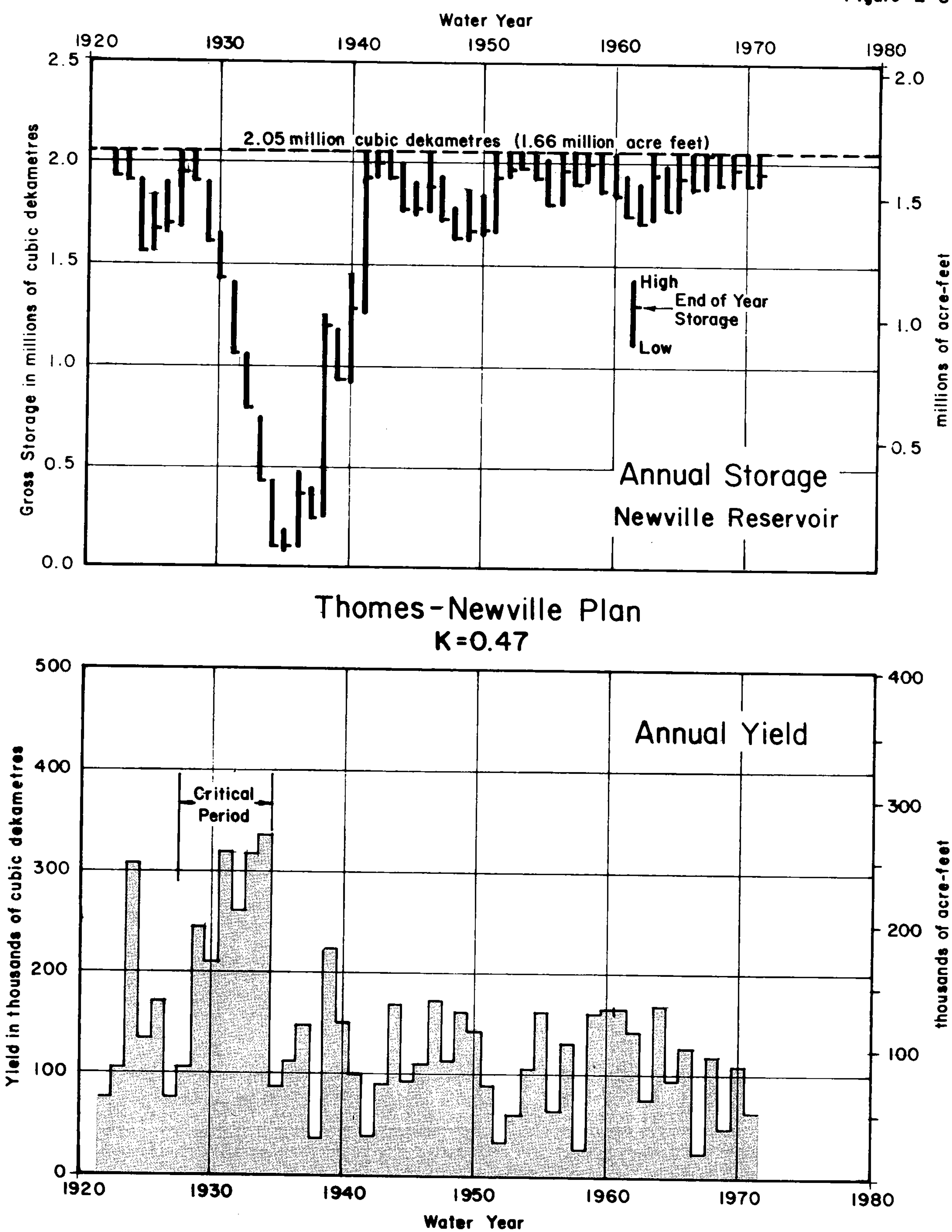
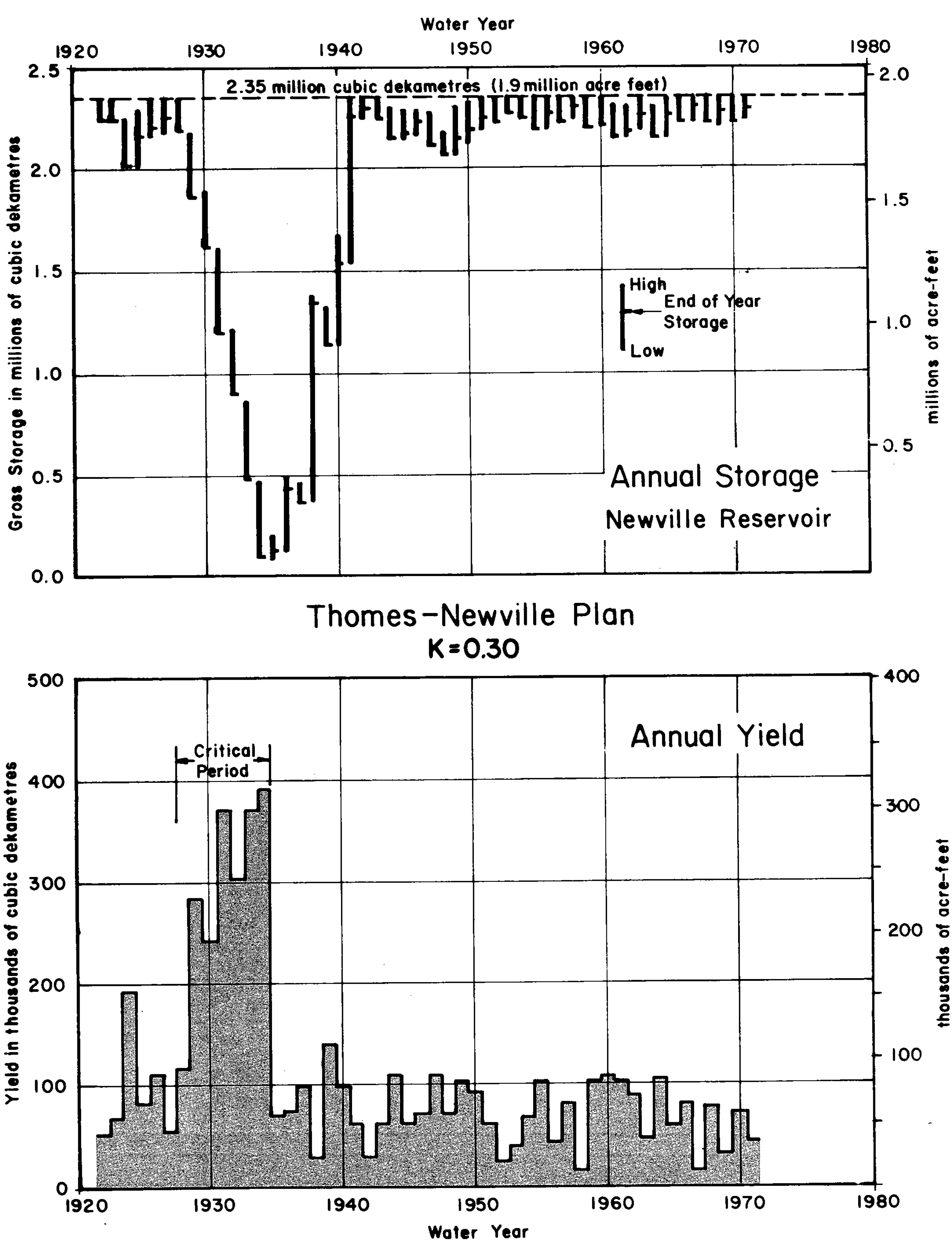

Water Year
1920
1930
1940
1950
1960
1970
1980
2.5
2.0
1.5
1.0
0.5
0.0
Gross Storage in millions of cubic dekametres
millions of acre-feet
2.05 million cubic dekametres (1.66 million acre feet)
High
End of Year
Storage
Low
Annual Storage
Newville Reservoir
Thomes-Newville Plan
K=0.47
500
400
300
200
100
0
Yield in thousands of cubic dekametres
thousands of acre-feet
Annual Yield
Critical
Period
Water Year

Figure 2-9



Water Year
1920
1930
1940
1950
1960
1970
1980
2.35 million cubic dekametres (1.9 million acre feet)
Gross Storage in millions of cubic dekametres
millions of acre-feet
High
End of Year Storage
Low
Annual Storage
Newville Reservoir
Thomes-Newville Plan
K=0.30
Annual Yield
Critical Period
Yield in thousands of cubic dekametres
thousands of acre-feet
Water Year

TABLE 2-8A

FILLING ANALYSES FOR THOMES-NEWVILLE PLAN EXAMPLE FORMULATIONS

Metric Units (Thousand dam^3, except as indicated)

SWP K = 0.70

Newville Res. Gross Storage = 1 754 000 dam^3
Dry Period Yield = 231 000 dam^3/yr

Thomes Cr. Diversion Capacity = 269 m^3/s
Black Butte-Newville Pump. Cap. = 88 m^3/s

Year After Completion	Thomes & Local Storable Inflow	Pumped From Black Butte	Newville Spring Storage	Evapo- reser- vation	Average Yield Release	Dry Period Yield Potential	Energy (gWh) Consumed	Energy (gWh) Generated*
-1	184	0	184	17	0	0	0	0
0	184	0	351	22	0	0	0	0
1	184	191	704	32	58	83	70	24
2	184	191	989	38	85	122	74	33
3	184	191	1 241	44	111	158	77	40
4	184	191	1 461	48	132	189	81	48
5	184	191	1 656	51	152	217	83	54
6	184	117	1 754	53	162	231	52	58
Totals	1 472	1 072		305	700	1 000	437	257

SWP K = 0.47

Newville Res. Gross Storage = 2 050 000 dam^3
Dry Period Yield = 273 000 dam^3/yr

Thomes Cr. Diversion Capacity = 283 m^3/s
Black Butte Pumping Capacity = 95 m^3/s

Year After Completion	Thomes & Local Storable Inflow	Pumped From Black Butte	Newville Spring Storage	Evapo- reser- vation	Average Yield Release	Dry Period Yield Potential	Energy (gWh) Consumed	Energy (gWh) Generated*
-1	184	0	184	17	0	0	0	0
0	184	0	351	22	0	0	0	0
1	184	197	710	32	41	83	72	20
2	184	197	1 018	39	62	127	76	27
3	184	197	1 298	46	81	167	81	33
4	184	197	1 552	49	99	202	85	39
5	184	197	1 785	53	115	236	88	45
6	184	197	1 998	56	130	265	91	51
7	184	54	2 050	57	133	273	26	53
Totals	1 656	1 236		371	661	1 353	519	268

SWP K = 0.30

Newville Res. Gross Storage = 2 349 000 dam^3
Dry Period Yield = 315 000 dam^3/yr

Thomes Cr. Diversion Capacity = 297 m^3/s
Black Butte Pumping Capacity = 102 m^3/s

Year After Completion	Thomes & Local Storable Inflow	Pumped From Black Butte	Newville Spring Storage	Evapo- reser- vation	Average Yield Release	Dry Period Yield Potential	Energy (gWh) Consumed	Energy (gWh) Generated*
-1	185	0	185	17	0	0	0	0
0	185	0	353	22	0	0	0	0
1	185	201	717	32	27	84	74	18
2	185	201	1 044	39	43	130	79	22
3	185	201	1 348	46	57	173	83	27
4	185	201	1 631	51	70	213	87	33
5	185	201	1 896	54	83	250	91	37
6	185	201	2 145	58	94	285	95	43
7	185	171	2 349	59	104	315	84	47
Totals	1 665	1 377		378	478	1 450	593	227

*Includes generation from release of 52 000 dam^3/yr non-storable water.

TABLE 2-8B

FILLING ANALYSES FOR THOMES-NEWVILLE PLAN EXAMPLE FORMULATIONS

English Units (Thousand ac-ft, except as indicated)

SWP K = 0.70

Newville Res. Gross Storage = 1,422,000 ac-ft
Dry Period Yield = 187,000 ac-ft/yr

Thomes Cr. Diversion Capacity = 9,500 ft^3/s
Black Butte-Newville Pump. Cap. = 3,100 ft^3/s

Year After Completion	Thomes & Local Storable Inflow	Pumped From Black Butte	Newville Spring Storage	Evapo-reser-vation	Average Yield Release	Dry Period Yield Potential	Energy (gWh) Consumed	Energy (gWh) Generated*
-1	149	0	149	14	0	0	0	0
0	149	0	284	18	0	0	0	0
1	149	155	570	26	47	67	70	24
2	149	155	801	31	69	99	74	33
3	149	155	1,005	36	90	128	77	40
4	149	155	1,183	39	107	153	81	48
5	149	155	1,341	41	123	176	83	54
6	149	96	1,422	43	131	187	52	58
Totals	1,192	871		248	567	810	437	257

SWP K = 0.47

Newville Res. Gross Storage = 1,662,000 ac-ft
Dry Period Yield = 221,000 ac-ft/yr

Thomes Cr. Diversion Capacity = 10,000 ft^3/s
Black Butte Pumping Capacity = 3,350 ft^3/s

Year After Completion	Thomes & Local Storable Inflow	Pumped From Black Butte	Newville Spring Storage	Evapo-reser-vation	Average Yield Release	Dry Period Yield Potential	Energy (gWh) Consumed	Energy (gWh) Generated*
-1	149	0	149	14	0	0	0	0
0	149	0	284	18	0	0	0	0
1	149	160	575	26	33	67	72	20
2	149	160	825	32	50	103	76	27
3	149	160	1,052	37	66	135	81	33
4	149	160	1,258	40	80	164	85	39
5	149	160	1,447	43	93	191	88	45
6	149	160	1,620	45	105	215	91	51
7	149	43	1,662	46	108	221	26	53
Totals	1,341	1,003		301	535	1,096	519	268

SWP K = 0.30

Newville Res. Gross Storage = 1,904,000 ac-ft
Dry Period Yield = 255,000 ac-ft/yr

Thomes Cr. Diversion Capacity = 10,500 ft^3/s
Black Butte Pumping Capacity = 3,600 ft^3/s

Year After Completion	Thomes & Local Storable Inflow	Pumped From Black Butte	Newville Spring Storage	Evapo-reser-vation	Average Yield Release	Dry Period Yield Potential	Energy (gWh) Consumed	Energy (gWh) Generated*
-1	150	0	150	14	0	0	0	0
0	150	0	286	18	0	0	0	0
1	150	163	581	26	22	68	74	18
2	150	163	846	32	35	105	79	22
3	150	163	1,092	37	46	140	83	27
4	150	163	1,322	41	57	173	87	33
5	150	163	1,537	44	67	203	91	37
6	150	163	1,739	47	76	231	95	43
7	150	138	1,904	48	84	255	84	47
Totals	1,350	1,116		307	387	1,175	593	227

*Includes generation from release of 42,000 ac-ft/yr non-storable water.

Previous studies of offstream storage facilities in the Sacramento Valley area were based on the assumption that pumping would be on an offpeak basis, to take advantage of favorable prices for offpeak energy. Since these studies were conducted (the early 1970s), the outlook for low-cost offpeak energy has dimmed considerably. Current formulation studies were based on continuous pumping, which eliminates the need to oversize pumping facilities. However, by using Black Butte Reservoir for daily reregulation, most of the energy generation of the Thomes-Newville Plan could be on a peaking basis. The unit value of peaking energy generated would tend to be greater than the unit value of the continuous energy used for pumping, but this difference was not taken into account in these preliminary formulation studies. The unit energy values used in the formulation studies (40 mills/ kWh for pumping energy and 30 mills /kWh for energy generated) were selected on the assumption that Thomes-Newville Plan energy operations would be integrated with the remainder of the State Water Project pumping and generating facilities. More study is needed of energy values for use in economic formulation studies, but the sizing of the major Thomes-Newville Plan facilities would not be greatly influenced by energy values (because the plan would eventually produce a modest net energy surplus).

During the initial 6-to-7-year filling period of Newville Reservoir, the Thomes-Newville Plan would be a net consumer of energy. This net consumption would vary with hydrologic conditions, reservoir storage, and the selected operating mode. From Table 2-8, the average annual net energy consumption during filling would be in the range of 30 to 52 gWh for the alternative involving pumping from Black Butte Reservoir. (Maximum pumping load would be about 160 MW.) Energy analyses of the Millsite diversion alternative have not been completed, but net energy consumption during initial filling would be somewhat less than for the Black Butte Reservoir diversion route.

After initial filling of Newville Reservoir, the Thomes-Newville Plan would become a long-term average net energy producer. For the plan involving pumping from Black Butte Reservoir, the net average energy production would range from 28 to 34 gWh per year. Maximum generating capacity would be about 28 MW at the Newville plant and 15 MW at the Tehenn plant. With the Millsite diversion alternative, there would be no Tehenn plant and net energy production would be approximately 40 to 60 percent smaller. Either plan would require on the order of 8 to 10 years of normal operation to repay the energy deficit accumulated during the initial filling period.

A generating plant at the toe of Black Butte Dam could provide an additional average annual power generation of about 25 to 30 gWh if the facilities of the Thomes-Newville Plan were constructed. Since a Black Butte generating plant would not be necessary for the operation of the Thomes-Newville Plan, it was not included in the current formulation; additional studies will be made of this possibility in the future.

Conclusions and Recommendations

The formulation studies reported in this chapter demonstrate that the Thomes-Newville Plan is operationally feasible and could provide a significant increment of additional yield for the State Water Project. Illustrative sizing studies show that the optimum sizes of major features vary over a moderately wide range with the assumed mode of operation and, to a lesser degree, with the value of critical period yield.

With the criteria used in this exercise, the Thomes-Newville Plan would not fully develop the storage potential of Newville Reservoir. The largest reservoir, resulting from an operating mode that would favor dry period yield production at the expense of average yield (K = 0.3), would be 2 349 000 dam^3 (1,904,000 ac-ft). Topographically, Newville Reservoir could have a maximum capacity of at least 4 200 000 dam^3 (3,400,000 ac-ft). The potential storage capacity in the upper portion of Newville Reservoir would be relatively inexpensive on an incremental basis and it would be desirable to develop it if possible. The plan shown would make nearly full use of the surplus flows of Stony and Thomes Creeks, so a larger Newville Reservoir could be justified only by addition of another source of water supply. The most readily apparent such source is Sacramento River water delivered via the Tehama-Colusa Canal. This possibility would be in direct conflict with the potential West Sacramento Canal Unit of the Central Valley Project, which would transport surplus Sacramento River water through the Tehama-Colusa Canal for offstream storage in a Sites Reservoir. The Water and Power Resources Service is currently making a feasibility study of the West Sacramento Canal Unit; if that study indicates the plan is infeasible, consideration should be given to using the Tehama-Colusa Canal to permit fuller development of Newville Reservoir in the Thomes-Newville Plan.

The Thomes-Newville formulation analyses conducted to date have not led to selection of a definite single plan. A number of additional studies are recommended for the continuing investigations to improve the accuracy of planning data, explore alternative configurations, and focus on a single formulation for presentation in a full feasibility report. The recommended studies include:

1. Revise the basic appraisals of water supply available for storage by the Thomes-Newville Plan to account for the most recent Delta water quality standards and for operation of the Cottonwood Creek Project.

2. Revise water supply estimates and plan formulation studies to examine the alternative plan of diverting surplus Stony Creek water from a Millsite Reservoir.

3. Incorporate updated and improved construction cost estimates into plan formulation studies.

4. Evaluate flows needed for fish and wildlife, local irrigation, and maintenance of ground water levels along lower Thomes and Stony Creeks.

5. Evaluate potential channel loss, erosion, or ground water problems that might be associated with using Stony Creek to convey releases from the Thomes-Newville Plan.

6. Explore arrangements under which Thomes-Newville Plan yield would be delivered to the Glenn-Colusa Irrigation District or to the Tehenn-Colusa Canal in exchange for a like reduction in their diversions from the Sacramento River. (This would minimize impacts on river water quality.)

7. Reexamine the potential for incorporating flood control as a project purpose and modify the plan formulation as appropriate. (This would require flood evacuation releases to be discharged to Thomes Creek.)

8. Examine possibilities for conjunctive operation with the Orland Project's Stony Gorge and East Park Reservoirs. (Storage space in those reservoirs could be operated to regulate surplus Stony Creek flows and increase the amount of water that could be pumped to Newville Reservoir; if such operation were occasionally detrimental to Orland Project water supply, the loss would have to be offset by releases from Newville Reservoir to the Orland Unit Water Users Association.)

9. Investigate the feasibility and economic justification of adding a power plant at Black Butte Dam as a feature of the Thomes-Newville Plan.

10. Continue analyses of the total SWP/CVP system (and potential future additional facilities) to better define the role that the Thomes-Newville Plan would be expected to fulfill.

CHAPTER 3. THOMES-NEWVILLE PLAN--NEWVILLE RESERVOIR

Newville Dam would be located on the North Fork of Stony Creek, about 29 km (18 mi) west of Orland and 10 km (6 mi) upstream from Black Butte Reservoir. The damsite lies near the northern boundary of Glenn County, but about half of the bowl-shaped reservoir would extend north into Tehama County.

This chapter describes the basis of the preliminary designs and cost estimates that have been prepared for Newville Reservoir as an element of a Thomes-Newville Plan. Along with the supporting geology appendixes, this chapter summarizes the evidence that leads to the conclusion that an earth and rock dam and appurtenant facilities are physically feasible.

The maximum storage capacity of a Newville Reservoir is controlled by the topography of Rocky Ridge, which forms the east rim of the prospective reservoir area. A reservoir elevation of 305 m (1,000 ft) is now generally considered to be practicable, but the extreme upper limit would be a function of the cost that could be justified for increments of storage. As Chapter 2 shows, the size of Newville Reservoir in a Thomes-Newville Plan would be limited by the available water supply and would not approach the site potential; the three example plan formulations led to Newville Reservoir conservation pool elevations of only 265 to 276 m (868 to 905 ft). The representative Newville Reservoir elevation of 274 m (900 ft) selected for discussion in this chapter does not correspond exactly to any of the example formulations because the design and cost estimating work had to be conducted at the same time as the formulation studies.

Previous Studies

Appendix F summarizes the general history of planning for Newville Reservoir and other features covered by this report. Newville Dam site was first examined by the U. S. Geological Survey (USGS) sometime between 1901 and 1903. The USGS noted that the natural runoff was quite limited and briefly considered the possibility of diverting Thomes Creek water to Newville Reservoir; the current Thomes-Newville Plan is a direct descendant of this early USGS idea.

Newville Reservoir was again examined during the California Water Plan studies in 1947-57. The resulting framework plan, presented in the Department's Bulletin 3, suggested a 1 170 000-dam^3 (950,000 ac-ft) Newville Reservoir that would be supported by gravity diversion of surplus flows from a Paskenta Reservoir on Thomes Creek and a 61-km (38-mi) gravity diversion canal from upper Stony and Grindstone Creeks. This proposal is the closest ancestor of the current Thomes-Newville Plan, since it would develop surplus runoff from the same sources.

The first intensive investigations of Newville Reservoir were conducted by the Department in the 1958-63 period as a part of the North Coastal

Area Investigation. These studies indicated the damsite was suitable for the reservoir elevation of about 305 m (1,000 ft) that was then being considered, but noted that more study of Rocky Ridge should be performed if the reservoir were to be higher than elevation 290 m (950 ft). Based on these studies, the Department's Bulletin 136 presented a plan for early construction of a Newville Reservoir at elevation 258 m (845 ft) with a diversion from Paskenta Reservoir on Thomes Creek; the bulletin envisioned later integration of the Paskenta-Newville facilities into a full-fledged Glenn Reservoir development for reregulation of water imported from the north coastal area.

The Bureau of Reclamation conducted much more detailed studies of The Paskenta-Newville Plan in 1965-71. The Bureau also concluded that conditions were suitable for construction of a large Newville Reservoir. The Bureau's 1971 status report outlined a plan including a Newville Reservoir at elevation 297 m (975 ft), forming a 3 683 000-dam^3 (2,986,000-ac-ft) reservoir. (The reservoir size was limited by hydrologic considerations, not geology.) The feasibility design drawings presented in the Bureau's report showed both Newville Dam and Chrome Dike as rolled earthfill structures.

While the Bureau's studies were in progress, the Department was conducting its own studies of the possible integration of a Newville Reservoir with an upper Eel River development. The Department's design criteria led to a Newville Dam section that incorporated substantial zones of quarried rock upstream of the central rolled earth core. Preliminary designs and cost estimates for reservoir elevations up to 305 m (1,000 ft) were prepared, but Newville Reservoir was eventually dropped from the Eel River plans in favor of the more favorably located Rancheria Reservoir.

In the early 1970s the Department made additional planning studies of Newville Reservoir as a component of a Glenn Reservoir that would be used for storage of surplus water pumped from the Sacramento River. The 1975 report on these studies presented a 301-m (987-ft) Newville Reservoir elevation as "near the maximum size feasible due to topographic and geologic limitations" of Rocky Ridge. No new geologic studies were conducted during this planning phase.

Additional field investigations of Rocky Ridge were undertaken in 1979 as a part of the current planning effort. These additional geologic studies, summarized in Appendix C, addressed lingering concerns about the structural integrity and leakage potential of Rocky Ridge; it is now felt that the suitability of the ridge for a reservoir elevation of up to at least 305 m (1,000 ft) has been adequately established.

Background Data

The following sections describe the supporting information accumulated over the many years of study of Newville Dam and Reservoir.

Topographic Mapping

The Department mapped the Newville Dam site area in 1959 at a scale of 1:2400 with a 1.5-m (5-ft) contour interval and in 1960 completed a

1:4800 map of the entire reservoir area with a contour interval of 6.1 m (20 ft). The 1960 mapping extended only up to the 335-m (1,100-ft) contour, but the original photographs are still available and have recently been used to extend the mapping along Rocky Ridge to the ridge crest. The reservoir map has been placed on 16 standard-sized sheets (at the original scale).

Newville Reservoir and the adjacent areas are also covered by the following U. S. Geological Survey quadrangle maps:

Map Name	Scale	Contour Interval m	Contour Interval (ft)	Date
Paskenta*	1:62,500	15.2	50	1952
Flournoy	1:62,500	15.2	50	1958
Elk Creek	1:62,500	15.2	50	1957
Newville	1:24,000	12.2	40	1967
Sehorn Creek	1:24,000	6.1	20	1967
Chrome	1:24,000	12.2	40	1968

*Out of print

Reservoir Area - Capacity Data

The 1960 reservoir mapping was reduced to 1:12,000 scale and used to determine the area and capacity data illustrated in Table 3-1 and Figure 3-1. A Chrome Dike was assumed as the southern limit of the reservoir for sizes above the natural saddle elevation of 283 m (930 ft). (While the data in Table 3-1 violate the normal limits for number of significant figures, the English values are taken from the 1960 calculation sheets and are reproduced here to preserve them in their original form for future reference.)

Seismicity

Preliminary planning designs prepared in the 1960s for Newville Dam and appurtenant structures were based on generalized seismic design criteria that reflected the moderate seismic hazard potential of the northern Sacramento Valley. A comprehensive review of existing information on seismic conditions was undertaken in 1977, as outlined in the Deparment's July 1978 report, "West Sacramento Valley Fault and Seismicity Study--Glenn Complex, Colusa Reservoir, Berryessa Enlargement". This review led to a contract with Earth Sciences Associates of Palo Alto in 1979.

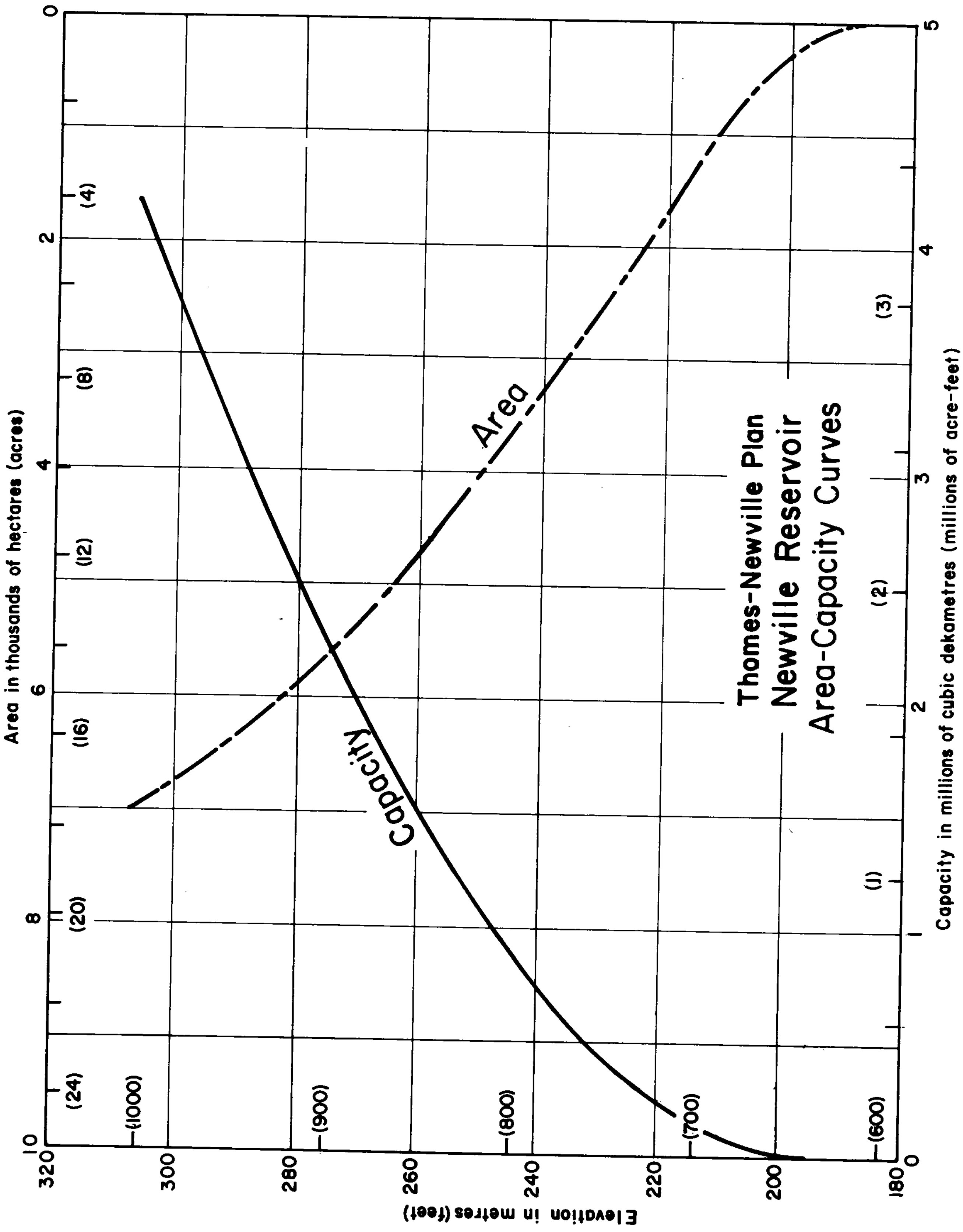
Earth Sciences Associates was asked to determine if any fault or seismic hazards exist that would make the Glenn Reservoir Project infeasible. Their January 1980 report, "Seismic and Fault Activity Study--Proposed Glenn Reservoir Complex", concludes that:

- All faults near the sites of principal engineering structures are pre-Quaternary in age (over 1 million years) and surface offsets need not be considered in project feasibility studies.

TABLE 3-1

NEWVILLE RESERVOIR AREA-CAPACITY DATA

Elevation		Area		Capacity	
m	(ft)	ha	(ac)	dam^3	(ac-ft)
182.9	600	0	0	0	0
189.0	620	7	18	220	180
195.1	640	107	264	3 700	3,000
201.2	660	348	860	17 570	14,240
207.3	680	762	1,882	51 390	41,660
213.4	700	1 215	3,003	111 640	90,510
219.5	720	1 706	4,215	200 680	162,690
225.6	740	2 203	5,444	319 820	259,280
231.7	760	2 708	6,691	469 510	380,630
237.7	780	3 177	7,851	648 880	526,050
243.8	800	3 594	8,880	855 260	693,360
249.9	820	4 036	9,972	1 087 800	881,880
256.0	840	4 439	10,970	1 346 120	1,091,300
262.1	860	4 866	12,025	1 629 760	1,321,250
268.2	880	5 278	13,042	1 938 960	1,571,920
274.3	900	5 625	13,900	2 271 290	1,841,340
280.4	920	5 993	14,808	2 625 410	2,128,420
286.5	940	6 281	15,520	2 999 500	2,431,700
292.6	960	6 521	16,114	3 389 710	2,748,040
298.7	980	6 763	16,711	3 794 600	3 076 290
304.8	1,000	6 978	17,242	4 213 410	3,415,820


Thomes-Newville Plan
Newville Reservoir
Area-Capacity Curves
Area
Capacity
Area in thousands of hectares (acres)
0
2
4
6
8
10
(4)
(8)
(12)
(16)
(20)
(24)
Capacity in millions of cubic dekametres (millions of acre-feet)
0
1
2
3
4
5
(1)
(2)
(3)
Elevation in metres (feet)
180
200
220
240
260
280
300
320
(600)
(700)
(800)
(900)
(1000)

- Major uplift on the Stony Creek fault, which lies about 5.6 km (3.5 mi) southwest of Newville Dam site, last occurred more than 250,000 years ago, with minor renewed movement between 30,000 and 130,000 years ago.

- The Stony Creek fault is the critical structure in terms of design criteria and has been assigned a maximum credible earthquake magnitude of 6.5, for either a natural or reservoir-induced seismic event. However, the probability of occurrence of such an event is very low.

- Based upon historical seismicity, earthquakes up to between magnitude 4 and 5 can be expected anywhere in the Glenn Reservoir region.

A detailed synopsis of seismicity and related basic data is presented in Appendix A, "Regional Geology, Fault, and Seismic Considerations".

The Department completed installation of an eight-station sensitive seismograph network in the Glenn Reservoir area in May 1980. Data from that network, continuously transmitted to recording devices in Sacramento, will be used to refine analyses of seismic conditions and to locate precisely areas of minor seismic activity in the vicinity of proposed facilities. The seismic network will be maintained permanently unless studies of the Thomes-Newville or Glenn Plans are terminated.

Foundation Geology and Construction Materials

Appendix B, "Newville Dam Site Geology", Appendix C, "Rocky Ridge Geology", and Appendix D, "Construction Materials", summarize the past geology and materials investigations pertinent to Newville Reservoir. The Department's first detailed geologic studies, conducted between 1958 and 1961, involved only surface mapping at the damsite. Based on these studies, it was concluded that damsite foundation conditions were suitable. The principal concern at that time was for the structural integrity and watertightness of Rocky Ridge; geologic maps were prepared for the entire ridge and eight exploratory holes were drilled and water-tested at various saddles. These studies concluded that Rocky Ridge would safely contain a moderate-sized Newville Reservoir, but additional studies were recommended for reservoirs above elevation 290 m (950 ft).

Some rather thorough exploration for construction materials was also carried out during this period; about 30 auger holes were drilled to explore potential impervious embankment materials in the vicinity of Newville Dam site. Another 21 auger holes were drilled in and near the Chrome Dike foundation area to confirm its suitability. All of the foregoing 1958-61 geology and materials studies are summarized in "Bulletin 136, North Coastal Area Investigation, Appendix E, Engineering Geology, Volume I", August 1965.

The Bureau of Reclamation undertook a feasibility-level investigation of Newville Reservoir in 1965. The principal geology work for this program was carried out in 1966; it included detailed geologic mapping of the damsite, drilling and water testing of 10 exploratory holes in the foundation area, and additional exploration and testing of potential construction materials. The Bureau's studies are reported in their June 1967 report, "Paskenta-Newville Unit, Engineering Geology for Feasibility Estimates, Lower Trinity River Division, North Coast Project, California". The Bureau report presents an enormous amount of data, including summaries of the previous State work. While it avoids formal conclusions, the Bureau geology report suggests no concern about the suitability of the site for a large reservoir.

Current geology and construction materials work has concentrated on two areas: investigating the suitability of Rocky Ridge as a rim of the reservoir, and searching for a source of quarried rock in quantities and quality sufficient to make up a substantial part of the dam embankment as a free-draining rockfill. The Rocky Ridge work, which is most pertinent to a large Newville Reservoir, is covered by Chapter 7 and Appendix C. Exploration and testing of potential quarry rock sources is still in progress. Several potential quarry sites have been identified and some drilling and laboratory testing have been completed on sandstone and conglomerate deposits from Rocky Ridge north of Newville Dam site. Results to date indicate that the soft rock from these deposits would probably produce an embankment that would be semi-pervious and not as strong as usually contemplated for rockfill. Additional drilling is being carried out to assess the Rocky Ridge materials more thoroughly. Eventually, a small test embankment may be constructed to help determine the physical properties of materials from this source under construction conditions of blasting, handling, and compaction.

Hydrology

Newville Dam would command a drainage area of only 142 km^2 (55 mi^2). The USGS operated a stream gage from 1963 to 1973 at a downstream site with a drainage area of 164 km^2 (63.4 mi^2). Mean annual runoff of North Fork Stony Creek at that gage for the 1922-71 period was calculated as 28 000 dam^3 (23,000 ac-ft). Based on the correlated flows for the 50-year period, the largest annual flow was 69 200 dam^3 (56,100 ac-ft) in 1968-69 and the largest monthly flow was 28 600 dam^3 (23,200 ac-ft) in January 1970. Peak flow during the 10 years of record was 354 m^3/s (12,500 ft^3/s) on January 5, 1965, but the flow subsided rapidly, as the mean discharge for that day was only 91 m^3/s (3,210 ft^3/s).

In previous studies, the Newville spillway was sized to handle local inflow plus floodflows diverted from Thomes Creek via either Paskenta Reservoir or via a very large diversion canal. The current Thomes-Newville Plan would be capable of diverting only around 283 m^3/s (10,000 ft^3/s) from Thomes Creek to Newville Reservoir and local flood inflow to Newville Reservoir would be relatively small in relation to the reservoir size. Consequently, spillway sizing would be controlled by emergency drawdown criteria rather than conventional probable maximum flood criteria. The selected spillway could handle any conceivable flood entering Newville Reservoir; therefore, detailed design flood and routing studies were not made.

Sediment

Reservoir sedimentation from the small natural drainage area of Newville Reservoir would be insignificant in comparison to the reservoir storage. There are no known measurements of North Fork Stony Creek sediment loads, but the USGS has made estimates for other portions of the Stony Creek Basin in its Water Supply Paper 1798-J, "Sediment Transport in the Western Tributaries of the Sacramento River, California", 1972. A mean annual suspended load of 122 t/km^2 (347 ton/mi^2) was estimated for the area between East Park and Stony Gorge Reservoirs. A similar or lower sediment production rate could be expected to prevail in the Newville Reservoir drainage area. If so, natural sediment deposition in Newville Reservoir would average no more than about 20 dam^3 (16 ac-ft) per year.

Newville Reservoir sediment inflows from Thomes Creek would be more significant, but still of little importance in view of the large reservoir storage. The suspended sediment load of Thomes Creek at Paskenta, which is discussed more thoroughly in Chapter 4, averages about 390 dam^3 (320 ac-ft) per year. About 80 percent of the flow of Thomes Creek would be diverted to Newville Reservoir, and an analysis based on daily flow records indicated the average annual sediment diversion would be on the order of 310 dam^3 (260 ac-ft). This is approximately 16 times the natural sediment load entering Newville Reservoir, but less than 2 percent of the gross storage capacity would be filled in 100 years of operation.

Newville Dam

The basic Thomes-Newville Plan covered by this chapter would involve one-stage construction of a medium-sized Newville Dam. No provision would be included for later enlargement; this possible variation is treated in Chapter 7. The discussion in this chapter centers on a representative Newville Reservoir at elevation 274 m (900 ft), which requires a dam height of 98 m (320 ft) above original ground level. The three example formulations shown in Chapter 2 require dam heights of 88 to 99 m (288 to 325 ft). Future planning studies will eventually focus in on a definite size of Newville Reservoir as its role in the State Water Project system is more clearly defined.

Axis Location

Newville Dam would fill a low gap in the narrow, north-south trending Rocky Ridge. The axis location is dictated by abutment topography and the need to avoid excessive spillover on the downstream side of the ridge. There are no alternative sites for a dam of the height under consideration.

Selection of Dam Section

All past studies of Newville Dam have been based on earthfill or earth-rockfill structures. Foundation conditions appear suitable for a concrete dam, however, and a brief cursory appraisal of a concrete gravity dam section was made during the current study. That appraisal indicated that the combined costs of the dam, spillway and outlet works would be about 20 percent greater with a concrete dam, so the current preliminary studies continued with the embankment-type section. As economic and energy conditions change in the future, another look at the concrete dam alternative may be justified.

The principal materials available for construction of an embankment-type Newville Dam are described in Appendix D. These include:

- Tehama Formation soils, available in virtually limitless quantities 5 to 10 km (3 to 6 mi) east of the damsite. These clayey, gravelly soils have been tested extensively and are considered quite suitable for use in impervious zones of the dam.

- Terrace and slopewash deposits from within Newville Reservoir area and downstream from the damsite along North Fork Stony Creek. These deposits are generally shallow and discontinuous, but adequate quantities for the medium-sized Newville Dam have been explored and tested (to a limited degree).

- Stream gravels from various sources. Only about 1 100 000 m^3 (1,500,000 yd^3) of gravel have been identified within Newville Reservoir area. Another 1 400 000 m^3 (1,800,000 yd^3) of stream gravels are present along North Fork Stony and Burris Creeks about 11 km (7 mi) east of Newville Dam site. The principal deposits in the area lie 11 to 20 km (7 to 12 mi) south and southeast of the damsite along Stony and Grindstone Creeks; these total at least 26 000 000 m^3 (34,000,000 yd^3).

- Quarried sandstone and conglomerate from the higher portions of Rocky Ridge. The potential borrow sites nearest the damsite are of limited extent and contain considerable percentages of weathered rock. The most promising nearby area (QA-9) lies about 5 km (3 mi) north of the damsite; it is estimated to be capable of providing up to 16 000 000 m^3 (21,000,000 yd^3) of fresh material above elevation 311 m (1,020 ft). Other potential borrow sources for rock material are available at greater distances from the damsite, as outlined in Appendix D.

For preliminary design and cost estimating purposes, the Tehama Formation soils, stream gravels, and sandstone and conglomerate from Rocky Ridge were selected as the main structural elements of the dam. The Tehama Formation soils were chosen instead of the closer slopewash and terrace deposits because of their abundance and apparent better suitability for dam construction. The terrace and slopewash materials would present obvious environmental and cost advantages and must be more thoroughly investigated in future studies; meanwhile, the preliminary costs are based on the more conservative choice of impervious materials. Likewise, the sand and gravel were assumed to come from the larger and better explored, but more distant, Stony and Grindstone Creek deposits; future study may permit some savings through use of stream gravel deposits from within the reservoir. (However, these limited deposits could supply only a portion of the sand and gravel needed for the dam.)

Preliminary tests of the sandstone and conglomerate from area QA-9 on Rocky Ridge have indicated that their strength and durability would require more conservative embankment slopes than are customary in high rock-fill dams. More exploration and testing will be carried out on the QA-9 area during the 1980 and 1981 field seasons. In the meantime, the quality of the QA-9 material was reflected by selecting a relatively flat upstream dam slope and by building an allowance into the cost estimate for processing all of the borrow material from QA-9. With this processing allowance, the preliminary cost estimate shows that the unit price of processed gravel from the more distant Stony and Grindstone Creek areas would be slightly lower than that of the processed material from QA-9. So, future studies must also consider use of stream gravels in the main shell zones of Newville Dam.

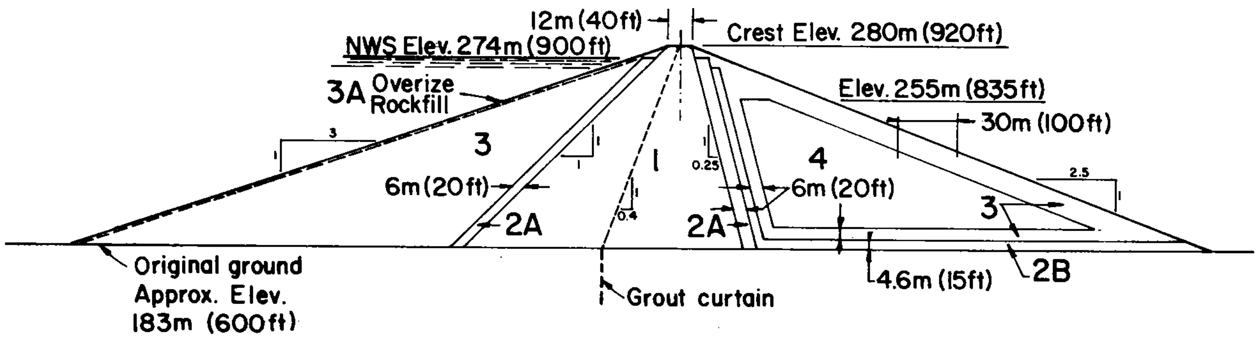
Figure 3-2 shows the dam section selected for preliminary planning and cost analyses. It is a conventional earth-rock section, with a wide central impervious core to make maximum use of the less expensive Tehama Formation soils. The upstream shell would be constructed of compacted sandstone and conglomerate, which would be processed to remove fines. The downstream shell would be similar, except it would incorporate a zone of random fill in the less critical interior; the random fill would be constructed of waste from the quarry rock processing operation and selected material from the various required excavations. Chimney and blanket drains would be included in the downstream portion of the dam to assure positive control of any seepage through the core or foundation.

The 12-m- (40-ft-) wide dam crest was set 6 m (20 ft) above reservoir normal pool elevation. With the limited drainage area and the selection of a gated spillway (described later in this chapter), the reservoir would rise above normal pool level by only a small amount even during the probable maximum flood. Consequently, the residual freeboard would be larger than normal, but a conservative choice was felt justified at this stage of planning in view of seismic and wave considerations.

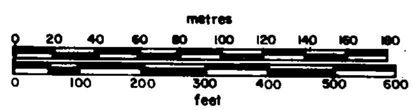
The embankment section shown in Figure 3-2 was checked for stability under the usual range of static and seismic loading conditions. The static analysis was based on the Modified Bishop Method, using both effective and total strength criteria; the steady seepage, partial pool, and maximum drawdown conditions were examined to determine the minimum safety factors for both upstream and downstream dam slopes. The resulting safety factors met the Department's usual criteria for large dams under all static loading conditions. The following design properties for the various embankment materials were used in the stability anlayses:

	Unit Weight				Shear Strength			
	Saturated		Moist		Total		Effective	
Zone	kg/m^3	lb/ft^3	kg/m^3	lb/ft^3	ϕ'	Cohesion	ϕ	Cohesion
1 Impervious	2 290	143	2 210	138	15°	*	30	0
2A Transition, 2B Drain	2 320	145	2 160	135	38°	0	38	0
3 3A Shell	2 260	141	2 050	128	35°	0	35	0
4 Random	--	--	2 320	145	35°	0	35	0
Foundation	2 080	130	--	--	50°	0	--	-

*2 400 kg/m^2 (0.25 ton/ft^2)



Zone	Embankment Material	Zone	Embankment Material
1	Tehama Formation	3,3A	Compacted processed rockfill
2A,2B	Transition and drain zones of processed sands and gravels.	4	Random zone.



Thomes-Newville Plan

Newville Dam

(maximum section)

The design properties for Zone 1 are based on laboratory tests conducted primarily in the 1960s. Those for Zones 2A and 2B are assumed values typical of compacted sand and gravel. The Rocky Ridge material in Zones 3 and 3A was considered to behave as semi-pervious, dirty, non-plastic gravel with about 70 percent of the material larger than 6 mm (0.25 in) and a maximum particle size of about 300 mm (12 in); recent triaxial tests on very small samples built up of crushed core showed the shear strength of 35°. Design properties for Zone 4 and the foundation material are based on comparison with tests of similar materials.

Next, seismic stability of the embankment was considered, using the procedures developed by Makdisi and Seed*. The seismic design would be controlled by the maximum credible earthquake on the Stony Creek Fault, which would have a magnitude of 6.5, located about 5.6 km (3.5 mi) from Newville Dam. A maximum ground acceleration of 0.55 g was used for the seismic analysis (based on attenuation curves presented by Schnabel and Seed), and the cyclic shear strength of the embankment and foundation materials was assumed to be 90 percent of the total stress strengths used for the static analysis. With these inputs, the permanent embankment deformation resulting from the design earthquake was indicated to be about 0.8 m (2.6 ft), which would be acceptable in a dam of the size under consideration. So, although much additional testing and design work remains to be done prior to construction, the dam section shown on Figure 3-2 is considered to constitute a reasonable basis for feasibility judgments and cost estimates. Several measures are provided to improve the embankment's ability to withstand earthquakes: (1) conservative outer slopes; (2) a wide impervious zone of clayey soil; (3) wide transition and drain zones; and (4) a generous freeboard allowance.

The total embankment volumes for Newville Dam would be:

Zone	Source	Volume m^3	Volume (yd^3)
1 Impervious	Tehama Formation	2 990 000	3,910,000
2A Transition, 2B Drain	Processed sand and gravel	1 220 000	1,600,000
3, 3A Shell	Processed QA-9 material	6 340 000	8,290,000
4 Random	QA-9, required excavations	1 280 000	1,680,000
		11 830 000	15,480,000

The indicated volume of the shell and random material represents only about one-fourth of the known quantity of sand and gravel deposits within reasonable haul distance of Newville Dam site. Thus, processed gravel is a viable potential alternative to the use of QA-9 material in the shells of this size of Newville Dam.

*Makdisi, F. I., and H. B. Seed. Simplified Procedure for Estimating Dam and Embankment Earthquake Induced Deformations. Journal of Geotechnical Engineering Division, American Society of Civil Engineers. July 1978.

Figure 3-3 shows a plan view of the layout of the dam and appurtenant structures. The outlet works and pumping plant shown would match the plan involving pumping from Black Butte Reservoir via Tehenn Reservoir; a slightly different layout would be used with the Millsite diversion alternative. The spillway and outlet works design are discussed later in this chapter.

Foundation Treatment

Appendix B describes foundation conditions at Newville Dam site and summarizes the results of geologic investigations conducted to date. Briefly, the central portion of the dam is underlain by north-south trending sandstone and conglomerate beds that dip steeply to the east (downstream). Most of the dam would be founded on these resistant, massive units. The sandstone and conglomerate are flanked by less resistant mudstone that is generally interbedded with fine-grained sandstone. The mudstone slakes into small particles when exposed, but is moderately strong and hard when fresh.

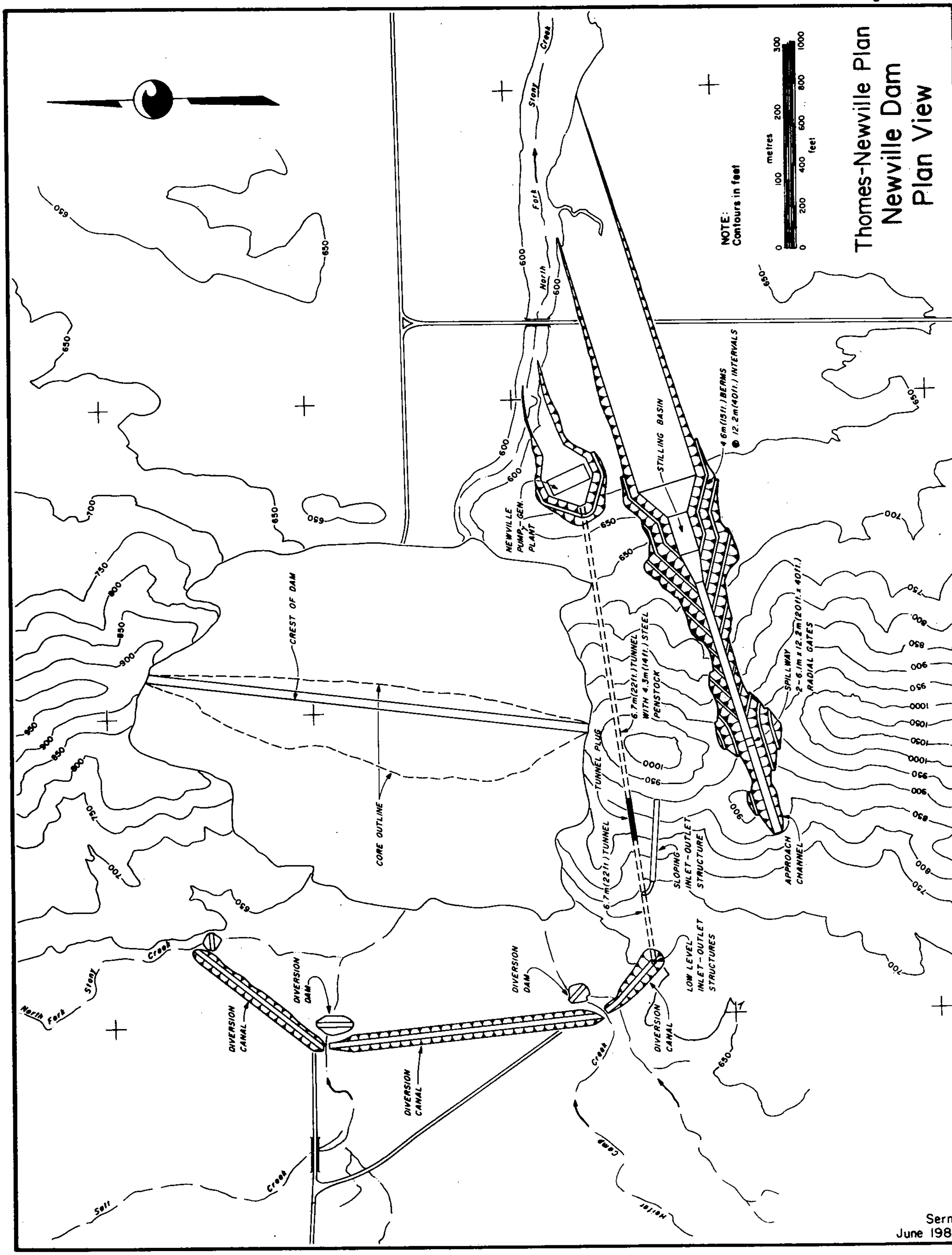
Several parallel faults pass through the damsite in a northeasterly direction. The most recent movement on these faults was at least 3,300,000 years ago. The Department's consultants concluded that offsets on these faults need not be considered in the design of the dam.

Exploration drilling, trenching, and geologic mapping indicate that the rock on both abutments is intensely weathered to a depth of 3 to 7 m (10 to 20 ft) and that fresh rock is found at depths of 9 to 20 m (30 to 65 ft). Soil depth is generally less than 1 m (3 ft). Alluvium deposits in the channel average 1.5 m (5 ft) deep and an additional 9 m (30 ft) of weathered rock overlie fresh rock. Average depths of stripping required under the outer shells of the dam are estimated in Appendix B as 5 m (15 ft) on the right abutment, 9 m (30 ft) in the channel area, and 3 m (10 ft) on the left abutment. Under the impervious core, the average stripping depth would be about 9 m (30 ft) on the abutments and 12 m (40 ft) in the channel. Additional excavation would be required in weathered areas along the faults and in lenses of poorly cemented conglomerate. (The preliminary design and cost estimate are based on earlier geologic appraisals, which recommended somewhat less stripping.)

Water pressure tests conducted on drill holes indicate that the rock underlying Newville Dam site is essentially impervious, but some local fractures along the faults could contribute to leakage if not treated. The preliminary design and cost estimate allow for a grout curtain beneath the dam to control leakage. Quantity estimates were based on a single line of holes on 3-m (10-ft) centers with depths varying from 28 to 56 m (93 to 185 ft). Grout take is expected to be low except for a few intervals of open-jointed rock. Additional appraisal of grouting requirements will be carried out during advanced planning and final design phases.

A minor potential construction problem could be encountered with air slaking of fresh mudstone exposed foundation stripping. It was judged that this could be avoided by trimming to final grade immediately before embankment placement.

Figure 3-3


Thomes-Newville Plan
Newville Dam
Plan View
NOTE:
Contours in feet
metres
feet
STILLING BASIN
4.6m(15ft.) BERMS
@ 12.2m(40ft.) INTERVALS
NEWVILLE
PUMP-GEN.
PLANT
CREST OF DAM
CORE OUTLINE
TUNNEL PLUG
6.7m(22ft.) TUNNEL
WITH 4.3m(14ft.) STEEL
PENSTOCK
SPILLWAY
2-6.1m x 12.2m(20ft. x 40ft.)
RADIAL GATES
APPROACH
CHANNEL
SLOPING
INLET-OUTLET
STRUCTURE
6.7m(22ft.) TUNNEL
LOW LEVEL
INLET-OUTLET
STRUCTURES
DIVERSION
DAM
DIVERSION
CANAL
North Fork Stony Creek
Salt Creek
Camp Creek
Heifer
Serna
June 1980

Outlet Works

For economical design, outlet facilities should be arranged to convey the pumped water back into Newville Reservoir, as well as the releases from the reservoir. The maximum release to meet water supply operational requirements would be about 42 m^3/s (1,500 ft^3/s). For the alternative involving pumping from Tehenn Reservoir, the maximum pumping rate would be approximately 85 m^3/s (3,000 ft^3/s). The outlet works must also function in conjunction with the spillway to provide adequate capacity for emergency drawdown of the reservoir in response to some threat to the safety of the dam. For Newville Reservoir, the emergency drawdown requirements would control the sizing of both the outlet works and the spillway.

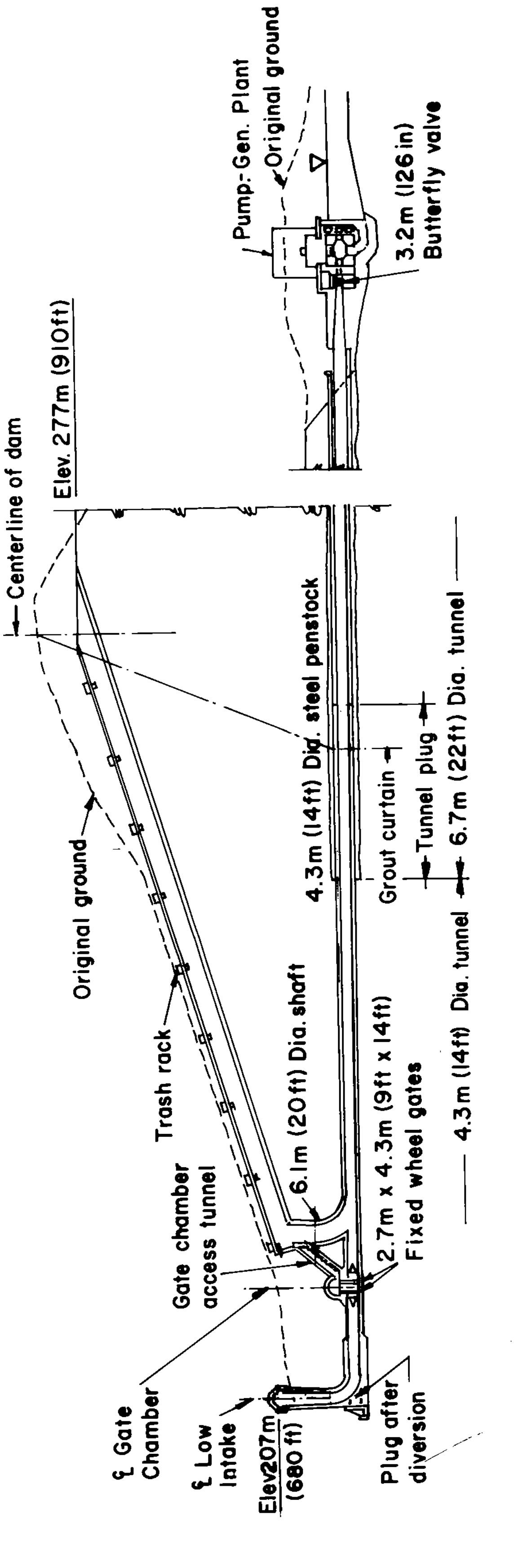
An emergency drawdown criterion is not rigidly prescribed, but is selected on a judgment basis for each individual dam and reservoir. For Newville Reservoir, the Division of Design and Construction selected a combination of spillway and outlet facilities that would be capable of evacuating one-third of the contents of a full reservoir within approximately 16 days. This translates to reducing the reservoir level from elevation 274 m (900 ft) to elevation 259 m (850 ft). The 16-day drawdown criterion could be met by a variety of combinations of spillway and outlet facilities. But, the spillway would ordinarily be capable of evacuating only the uppermost reservoir levels and substantial low-level outlet capacity would still be needed to evacuate the lower two-thirds of the reservoir.

Another major factor controlling the design of the Newville outlet works is the need for a facility to allow selection of the reservoir level from which withdrawals would be made. This would permit manipulation of the temperature and turbidity of releases to eliminate or minimize any detrimental impacts on Black Butte Reservoir fisheries or recreation. The tentative criterion established for preliminary planning calls for intakes spaced at 7.6-m (25-ft) vertical intervals between minimum and normal pool levels. The system should permit withdrawals from any level or any combination of levels.

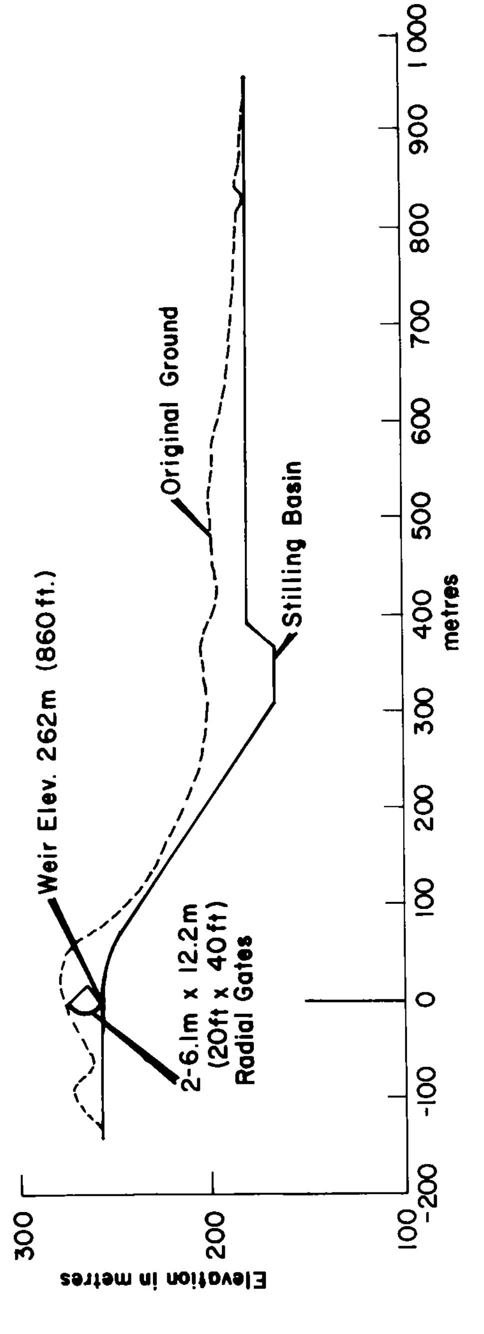
The preliminary outlet works layout shown on Figures 3-3 and 3-4 was developed to meet the foregoing criteria. It would involve a 580-m (1,900-ft) tunnel through the right abutment of the dam. The upstream portion of the tunnel would be 4.3 m (14 ft) in diameter and the downstream portion 6.7 m (22 ft). As Appendix B notes, tunneling conditions through either abutment are expected to be favorable and no unusual problems are foreseen (provided the final tunnel alignment was selected to avoid faults or cross them at nearly right angles). The right abutment location was selected because the tunnel would be shorter than it would with a left abutment alignment.

The sloping intake shown on Figure 3-4 was tentatively selected for cost estimating purposes at this stage of study; future studies will consider a combination of a sloping and a vertical intake tower. The sloping concrete intake conduit would have nine evenly spaced levels of inlets. At each inlet level, two separate 1 800-mm (72-in) hydraulically operated butterfly valves would control the admission of water. The low-level intake shown on the figure would be used only for emergency evacuation or extreme drawdown to minimum pool level.

Figure 3-4



Newville Outlet Works Profile



Newville Spillway Profile

Maxwell
May 1980

Future studies will refine the plans for the Newville outlet facilities and investigate alternative arrangements. But, these preliminary layouts have revealed that the outlet would present no unusual design or construction problems.

Spillway

The preceding discussion of outlet facilities described the emergency drawdown criteria that would control the sizing of the Newville spillway. A conventional gated overpour spillway with concrete-lined chute and stilling basin was selected during the preliminary design phase. Geologic studies indicate that the spillway could be located at nearly any topographically suitable site along Rocky Ridge; a right abutment location was selected for the current study. Figure 3-3 shows the general layout and Figure 3-4 includes a profile of the spillway.

The deep gates were selected to let the spillway help meet the emergency reservoir evacuation criteria. Peak discharge under emergency conditions would be about 930 m^3/s (33,000 ft^3/s). Under normal operating conditions, spillway discharge would rarely, if ever, exceed 280 m^3/s (10,000 ft^3/s). So, the stilling basin could be designed for a smaller flow, with the expectation that considerable damage would be sustained in the rare event of an emergency necessitating extraordinary reservoir releases.

Additional exploratory drilling will be performed to evaluate spillway foundation conditions prior to final design; this will permit adjustment of the alignment to best avoid faults or other troublesome areas. Once the alignment is chosen, design and construction of the Newville spillway should be routine.

Diversion During Construction

With its limited drainage area, North Fork Stony Creek would present minimal problems during construction of Newville Dam. The creek could be diverted through the outlet works tunnel by low cofferdams and shallow connecting cuts, as shown on Figure 3-3. With the cofferdam crests at elevation 191 m (625 ft), approximately 170 m^3/s (6,000 ft^3/s) could be handled through the outlet tunnel without flooding the worksite. This would be more than adequate for any flows likely to occur during the late spring and summer of the first full season of embankment construction. During the remainder of the construction period, the partially completed embankment would be high enough that any incoming flood could be passed through the outlet tunnel.

Saddle Dam

For the size of Newville Reservoir covered by this chapter, only one saddle dam would be required. It would be located at Burrows Gap (Saddle L), 4.7 km (2.9 mi) south of the main dam. The lowest elevation in

Saddle L is about 259 m (850 ft), so a saddle dam about 21 m (70 ft) high would be needed to match the crest elevation of Newville Dam. The next lowest saddle in Rocky Ridge is Saddle B, 3.4 km (2.1 mi) north of Newville Dam; its elevation is about 290 m (950 ft), far higher than the reservoir under consideration here.

Foundation conditions at Saddle L are similar to those at the main damsite. As at Newville Dam site, a northeast-trending fault passes through Saddle L, but it is not considered active. Topography at the saddle is suitable for construction of an embankment-type dam and the preliminary cost estimate was based on an earth-rockfill dam section patterned after that used for Newville Dam. Total embankment volume of the saddle dam would be only about 430 000 m^3 (560,000 yd^3). No unusual problems are anticipated in the design or construction of the dam at Saddle L.

Road Relocations

There are about 13 km (8 mi) of public roads within the prospective Newville Reservoir. The Paskenta-Round Valley route, a paved two-lane county road, passes through the north end of the reservoir for a distance of about 3 km (2 mi), and another county road crosses northwestward through the reservoir site from the damsite to connect with the Paskenta-Round Valley Road. The Glenn County portion of the road within the reservoir is about 3 km (2 mi) long and is paved; the 7 km (4 mi) portion within Tehama County is unpaved.

Both of these roads would be relocated and upgraded to current county paved road standards. The Paskenta-Round Valley Road would be realigned around the north end of the reservoir and the other road would pass along the east side of Rocky Ridge to link Newville Dam site to the town of Paskenta. The total length of new road construction would be about 16 km (10 mi).

Construction Schedule

The main construction contracts for Newville Dam could easily be completed within a 4½-year period. The first 15 to 18 months would be devoted to driving and lining the outlet tunnel, relocating roads, opening borrow and quarry areas, constructing haul roads, stripping the damsite abutments, and grouting.

Cofferdams and stream diversion excavations would be completed in the spring of the second full year to channel the stream through the outlet tunnel. Foundation excavation and grouting would be completed in the channel and full-scale embankment placement would begin. Construction of the intake facilities and reservoir clearing would begin during the summer of the second year and be completed within about 12 months.

Embankment placement would continue throughout the third full year, which would also be used for construction of the saddle dam. Spillway construction would begin early in the third year so that rock from the spillway excavation could be placed directly into the random fill zone of the main dam. By July of the third year, streamflow would drop to negligible levels and the outlet tunnel would be plugged; the outlet conduits and valves would be installed within the following few months. Upon plugging the outlet tunnel, reservoir storage could begin, including storage of flows diverted from Thomes Creek (to the extent that filling would not interfere with active borrow areas or haul roads within the reservoir). Even with the partially completed embankment, reservoir storage would be great enough to absorb any conceivable inflow during the remainder of the construction period.

Embankment placement and spillway construction would be completed during the summer of the fourth full year. All remaining minor work would be wrapped up and the reservoir would be fully operational by the end of the year. If average hydrologic conditions occurred during the third and fourth winters, approximately 350 000 dam^3 (280,000 ac-ft) of water could be in storage in the spring of the fifth year (see Table 2-8); this would correspond to a reservoir elevation of about 227 m (745 ft), or about half of the ultimate reservoir depth.

Cost Estimates

Preliminary cost estimates for Newville Dam and Reservoir are summarized in Table 3-2. These cost estimates are based on cost levels prevailing in the spring of 1980 and do not include any allowances for cost escalation during the 4½-year construction period. As noted throughout this chapter, design and cost studies are continuing; the data in Table 3-2 are presented only to illustrate the general magnitude of expected costs.

TABLE 3-2

THOMES-NEWVILLE PLAN
NEWVILLE RESERVOIR-PRELIMINARY COST ESTIMATES
(Price Basis - Spring 1980)

Reservoir Normal Pool Elevation: 274 m (900 ft)
Dam Crest Elevation: 280 m (920 ft)
Dam Height Above Streambed: 98 m (320 ft)
Reservoir Storage Capacity: 2 271 000 dam^3 (1,841,000 ac-ft)

	Estimated Costs			
Item	Contract	Contingencies	Engineering	Total
Reservoir, Relocations	$ 13,940,000	$ 1,390,000	$ 3,530,000	$ 18,860,000
Newville Dam	86,690,000	8,670,000	21,930,000	117,290,000
Outlet Works	23,530,000	2,350,000	5,950,000	31,830,000
Spillway	9,550,000	960,000	2,420,000	12,930,000
Saddle Dam	6,290,000	630,000	1,590,000	8,510,000
Subtotals	$140,000,000	$14,000,000	$35,420,000	$189,420,000
Land Acquisition				9,000,000
Total				$198,420,000

Conclusions and Recommendations

Geology and preliminary design studies summarized in this chapter and the related appendixes have revealed no substantial obstacles to design and construction of a safe and economical dam at the Newville site. Foundation conditions have been investigated thoroughly (for a planning-level study) and found satisfactory. Seismic design criteria will be stringent, but well within the bounds of established engineering precedent. Adequate volumes of construction materials have been identified, although additional investigation will be required to define their properties and determine how they could best be combined in the dam. Spillway and outlet structures would be of conventional design and their design and construction should present no exceptional problems. The limited natural streamflow and the mild climate at the site would be very favorable for efficient construction operations. Concerns about the watertightness and structural integrity of Rocky Ridge have been laid to rest, particularly for the relatively low reservoir that would be included in a Thomes-Newville Plan.

As usual, the preliminary studies have revealed a number of areas to which continuing study should be directed during subsequent planning. These include:

1. Continue exploration and testing of sandstone and conglomerate from QA-9 and stream gravels as construction materials.

2. Examine the potential use of materials from within the reservoir for the impervious core of the dam.

3. Refine dam design studies and compare alternative dam sections using material from QA-9 and stream gravels in the main structural zones.

4. Continue seismicity studies, including operation of the seismic monitoring network and additional geologic studies related to the Stony Creek fault. Incorporate the findings of these studies into the design criteria.

5. Continue refining geologic studies in the damsite area, including drilling, trenching, geophysical exploration, and field and laboratory testing. Explore foundation areas to define optimum alignments for the outlet tunnel and spillway.

6. Develop spillway design flood hydrographs and perform routing studies. Reconsider dam freeboard requirements.

7. Reexamine criteria for emergency reservoir drawdown and compare alternative relative proportions of spillway and outlet capacities.

8. Investigate alternative designs for the multiple-level intake facilities; coordinate this work with continuing analyses of reservoir water quality.

9. Improve and upgrade cost estimates and construction schedules as design studies progress.

CHAPTER 4. THOMES-NEWVILLE PLAN-- THOMES CREEK DIVERSION FACILITIES

Except for Cottonwood Creek, Thomes Creek is the largest remaining uncontrolled Sacramento River tributary on the west side of the valley. As it approaches the valley floor, Thomes Creek passes within 0.6 km (0.4 mi) of a low saddle separating its drainage area from the Newville Reservoir drainage area. At that point, Thomes Creek is about 37 m (120 ft) below the saddle, which is near elevation 302 m (990 ft). The facilities covered by this chapter would divert water from Thomes Creek through the saddle to Newville Reservoir.

Preliminary designs and cost estimates have been prepared for a Thomes Creek diversion system that could serve a Newville Reservoir with a normal water surface elevation anywhere in the range of 274 to 300 m (900 to 984 ft). These designs were prepared on the assumption that the smaller Newville Reservoir would be enlarged in a later stage as part of a Glenn Reservoir development (see Chapter 7). For a Thomes-Newville Plan not intended for later expansion, the Thomes Creek diversion facilities should be rearranged to match. These revisions will be examined in subsequent planning studies; meanwhile, this report features the design that would accommodate either a medium-sized or a large Newville Reservoir.

This chapter is based on information presented in the December 1979 memorandum report, "Reconnaissance Study and Cost Estimates for Thomes Creek Diversion Facilities". That report examined three possible diversion capacities: 85, 184, and 283 m^3/s (3,000, 6,500, and 10,000 ft^3/s). Following the formulation studies described in Chapter 2, this chapter focuses entirely on the largest of these capacities.

Previous Studies

The possibility of diverting Thomes Creek water to Newville Reservoir was briefly mentioned in a 1903 report by the U. S. Geological Survey (USGS) but was first given serious study during the California Water Plan investigations in the early 1950s. The California Water Plan envisioned construction of Paskenta Dam on Thomes Creek, about 4 km (2.5 mi) northeast of the Thomes-Newville saddle. This same basic plan continued in vogue through the Bureau of Reclamation's Paskenta-Newville Unit investigation of 1965-71. The Paskenta Reservoir elevations included in the various plans ranged from 290 to 307 m (950 to 1,006 ft). The corresponding Paskenta Dam heights would be 55 to 71 m (180 to 233 ft). With the smaller dams, the saddle would have to be cut lower to allow water to spill into Newville Reservoir.

Depending on its size, Paskenta Reservoir would inundate about 400 to 800 ha (1,000 to 2,000 ac) of land at the base of the Coast Range. By 1970, Department of Fish and Game studies revealed that much of this area along Thomes Creek was critical wintering habitat for migratory deer.

7—81626

Prospects for compensating for the loss of this key habitat were considered unpromising, so the Department of Water Resources attempted to alter the physical plan to minimize its impact. Initially, the goal was to duplicate the accomplishments of the Paskenta Reservoir Plan, which included diversion of large floodflows from Thomes Creek for storage in Newville Reservoir. So, the first alternative plans laid out in the early 1970s included low diversion dams on Thomes Creek and very large unlined channels to connect to Newville Reservoir. Capacities of up to 1 900 m^3/s (67,000 ft^3/s) were considered for the Thomes-Newville channel.

As studies progressed, attention shifted to smaller diversion capacities. Water supply calculations showed that very little more water could be diverted as the channel capacity increased above a modest size. Also, although the larger channels could allow operation to provide flood control on Thomes Creek and downstream, preliminary studies raised doubts about the economic justification for such enlargement. Finally, potential difficulties with sediment and interference with deer migration would be reduced with smaller diversion capacity.

Background Data

Considerable background information was developed on the Paskenta Reservoir Plan over some 25 years of study. Much of this information is applicable to the revised diversion scheme, but some new data had to be gathered. The following sections summarize the current status of background data on the Thomes Creek diversion facilities.

Topographic Mapping

The Department's 1960 Glenn Reservoir map covers the Paskenta Reservoir area at a 1:4800 scale and contour interval of 6.1 m (20 ft). The Thomes diversion area was remapped in 1979, using the original 1960 photography. Two versions of the 1979 map were completed, one compiled at 1:5000 with 5-m contours and one at 1:4800 with 10-ft contours.

The Thomes diversion area is also covered by the USGS Newville quadrangle at 1:24,000 and the USGS Paskenta quadrangle at 1:62,500.

Geology and Construction Materials

In the 1960s, the Bureau of Reclamation made some rather thorough studies of geologic conditions at Paskenta Dam site, including considerable foundation drilling, but that work is only of indirect value in appraising geologic conditions at the Thomes diversion site. The only geologic studies directed specifically toward the Thomes Creek diversion facilities were performed in 1978 and 1979 as a part of the current planning program. Department geologists evaluated the site geology on the basis of surface examination, supplemented by limited seismic refraction studies to help evaluate excavation conditions in the vicinity of the Thomes-Newville saddle. Two possible diversion damsites were examined on Thomes Creek and tunneling conditions were appraised for plans that would use tunnels in place of all or part of the diversion canal.

The 1978-79 geologic studies were summarized in three memoranda, which are appended to the more formal report, "Reconnaissance Study and Cost Estimates for Thomes Creek Diversion Facilities", December 1979. In general, the entire Thomes diversion area is underlain by rocks of the Stony Creek Formation, consisting of thinly bedded, friable mudstones with occasional thin layers of sandstone. No particular problems were noted with either diversion damsite or along any of the canal or tunnel routes; however, the mudstone is subject to air slaking and erosion, which must be taken into account in design.

Bureau of Reclamation studies outlined construction materials for Paskenta Dam, including impervious, gravel, and rock sources. The Department's design studies recommend a concrete diversion structure on Thomes Creek, so the main item of current interest is aggregates. The Bureau's 1967 geology report for the Paskenta-Newville Unit identified about 900 000 m^3 (1,180,000 yd^3) of sand and gravel deposits along the channel of Thomes Creek within 6 km (3.7 mi) of the diversion damsite. The gravels are hard, fresh, and poorly graded, with many large cobbles and boulders up to 1.2 m (4 ft) in diameter; with proper processing, they would yield satisfactory concrete aggregates. The available quantities of these nearby Thomes Creek aggregates appear more than adequate for all of the concrete in the Thomes diversion facilities.

Hydrology

The U. S. Geological Survey has recorded the flow of Thomes Creek at the town of Paskenta since January 1921. Mean annual runoff at that gage for the 1922-71 base period is 249 000 dam^3 (202,000 ac-ft). The drainage area at the Paskenta gage is 502 km^2 (194 mi^2) and the diversion structure site selected for the current study would control a drainage area of 427 km^2 (165 mi^2). The water supply calculations described in Chapter 2 assumed that Slate Creek (just downstream from the diversion structure) and Bennett Creek (tributary to the diversion canal) would be included; in that case, the total drainage area controlled would be 461 km^2 (178 mi^2).

The largest peak Thomes Creek flow recorded at the Paskenta gage was 1 070 m^3/s (37,800 ft^3/s) on December 22, 1964. The largest monthly flow was 220 000 dam^3 (178,000 ac-ft) in January 1970. Summer flow typically drops below 1.4 m^3/s (50 ft^3/s) in early July and gradually falls to less than 0.3 m^3/s (10 ft^3/s) by early fall. There are periods of no surface flow at the gage in drier years.

In its October 1964 office report, "Project Hydrology", the Department presented a probable maximum flood hydrograph for the 487-km^2 (188-mi^2) drainage area above Paskenta Dam site. This hydrograph showed a peak flow of 2 350 m^3/s (83,000 ft^3/s) and a 3-day volume of about 300 000 dam^3 (240,000 ac-ft). Later, following the record 1964 flood, the Bureau of Reclamation developed a spillway design flood for its studies of Paskenta Reservoir; it had a peak of 2 750 m^3/s (97,000 ft^3/s) and a 3-day volume of 250 000 dam^3 (200,000 ac-ft). The Department's figures were used for preliminary design of the diversion dam on Thomes Creek. The probable maximum flood should be recalculated during the next phase of planning, using the most recent techniques and criteria. The peak flow is of most importance, as the small diversion reservoir would have little moderating effect and its spillway would have to handle essentially the peak inflow.

Sediment

The sediment load borne by Thomes Creek is one of the highest known in the Central Valley (in terms of load per unit of drainage area). Consequently, sediment data are of extreme importance in the planning and design of facilities to divert water from Thomes Creek.

The USGS maintained daily records of suspended sediment transport at the Paskenta gage from October 1962 through September 1973. In 1972, the USGS published Water Supply Paper 1798 J, "Sediment Transport in the Western Tributaries of the Sacramento River, California". Based on sediment records for 1962-68, Water Supply Paper 1798 J estimated mean annual suspended sediment transport at Paskenta as 590 000 t (650,000 tons), or 1 170 t/km^2 (3,350 ton/mi^2).

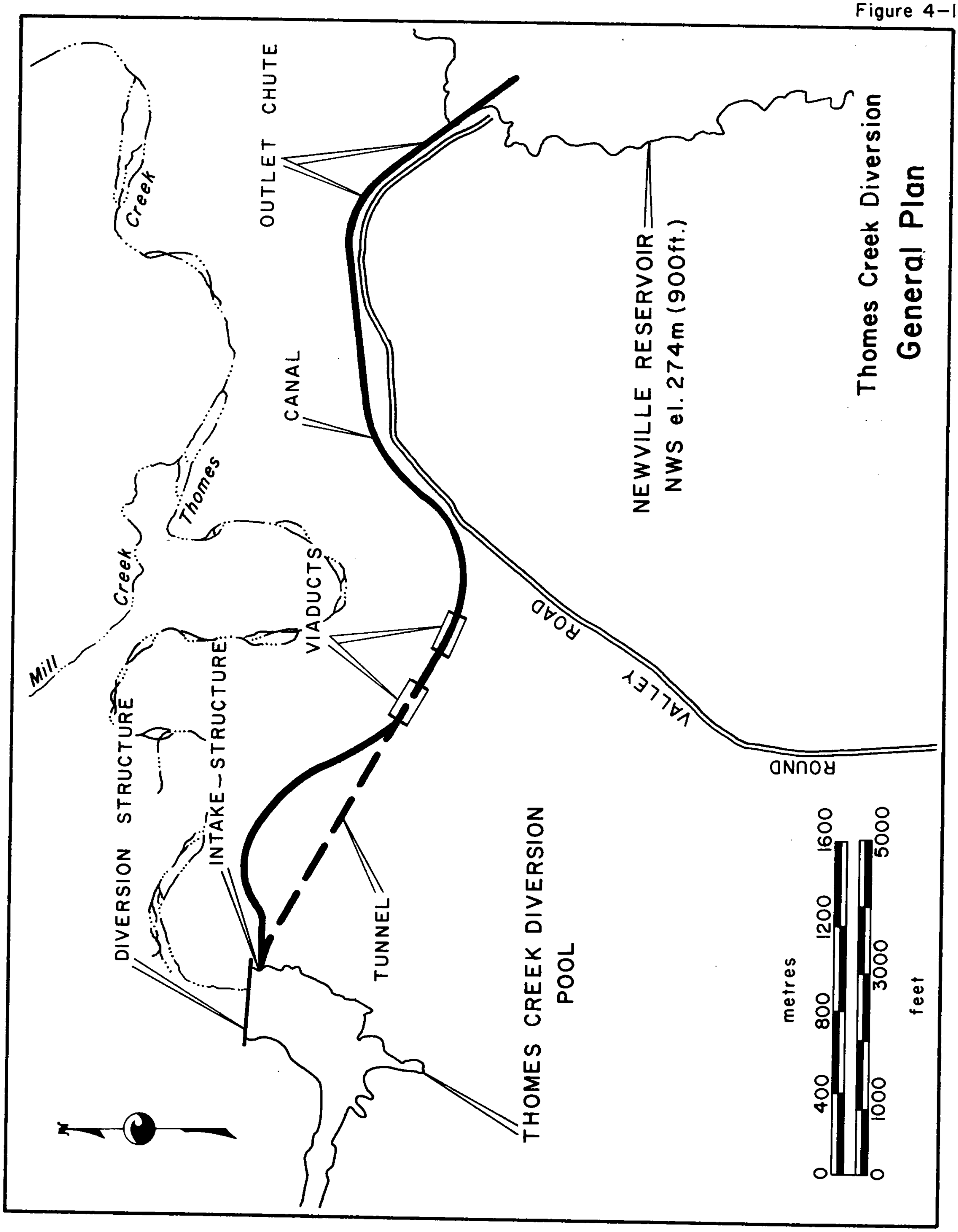
The Department's Staff Sedimentation Engineer reviewed the data and the USGS report in 1979 and concluded that the sediment estimates should be adjusted to reflect a more average base period and to account for the undue influence of the 1964-65 flood period on the original calculations. After these revisions, the long-term average suspended sediment load of Thomes Creek at Paskenta is now estimated as 460 000 t (510,000 tons). Bedload is estimated to average 6 percent of the total load, or 29 000 t (32,000 tons) annually. After deposition in a reservoir, the average annual suspended load would occupy a volume of 390 dam^3 (320 ac-ft) and the bedload would total about 19 dam^3 (15 ac-ft). The actual sediment movement in a given year would vary greatly, as sediment transport capability increases exponentially with flow. For example, the total suspended sediment load recorded at Paskenta in 1964-65 was 9 800 000 t (10,800,000 tons), or more than 20 times the annual average. And, almost half (47 percent) of that total 1964-65 load passed the station on a single day.

The size distribution of suspended sediment at Paskenta is 44 percent sand, 35 percent silt, and 21 percent clay (which is considered representative of the diversion site). The Department recently made limited studies of the composition of bed material at the diversion site. These showed 26 percent sand and finer particles, 40 percent gravel, and 34 percent cobbles and boulders up to 460 mm (18 in) in diameter. Larger boulders, up to 1.2 m (4 ft) in diameter, were observed in the channel deposits.

Thomes Creek Diversion Structure

Figure 4-1 shows a preliminary layout of the Thomes Creek diversion facilities. As noted, this layout was made when the planning emphasis was on later expansion of Newville Reservoir to a water surface elevation of about 300 m (984 ft). The location of the diversion structure was selected to provide enough head to reach the larger size of Newville Reservoir and to facilitate the handling of sediment. Should the diversion system not have to accommodate later expansion of Newville Reservoir, the diversion structure could be moved downstream and the conveyance facilities could be shortened considerably. This variation will be examined in the next phase of planning studies.

Figure 4-1



Thomes Creek Diversion
General Plan
OUTLET CHUTE
CANAL
VIADUCTS
NEWVILLE RESERVOIR
NWS el. 274m (900ft.)
ROUND VALLEY ROAD
Thomes Creek
Mill Creek
DIVERSION STRUCTURE
INTAKE-STRUCTURE
TUNNEL
THOMES CREEK DIVERSION POOL
metres
0 400 800 1200 1600
feet
0 1000 3000 5000

The diversion structure on Thomes Creek would have to control the diversion of water to Newville Reservoir, accommodate or pass large sediment inflows, provide for downstream releases during diversion periods, and be capable of passing extreme floods. A gated, concrete gravity dam was selected as best to serve these functions.

Sediment considerations play a major role in the layout and design of the Thomes Creek diversion structure. Annual bedload deposition in the diversion pool would average about 19 dam^3 (15 ac-ft), but would range from almost none up to 270 dam^3 (220 ac-ft). A portion of the suspended load would also deposit in the diversion pool; if half of the sand portion of the suspended load were deposited, the average annual storage loss would be about 86 dam^3 (70 ac-ft). The total infilling rate, including both bedload and suspended sediment, would average about 105 dam^3 (85 ac-ft) per year.

Figure 4-2 shows reservoir area and capacity data for the diversion pool site illustrated on Figure 4-1. It shows that a very large reservoir would be required to detain all of the incoming sediment over the life of the project. Since the original objective was to avoid flooding deer habitat, the diversion structure obviously would have to be designed to pass most sediment on downstream, or to divert it to Newville Reservoir. To allow the major portion of the coarser sediments to pass through the diversion structure, the gate sills would be placed relatively low, about 8 m (25 ft) above original streambed level. At that level, only about 220 dam^3 (180 ac-ft) of storage would initially be available below the gate sill elevation; sediment would fill that space within a few years of operation. From that time on, coarser sediments would be flushed on downstream through the gates during periods of floodflows in excess of the diversion capacity. During periods with lower flows, sediment would be temporarily stored in the upper portion of the diversion pool until the next major flood. If an excessive amount of such material should accumulate, physical removal might be necessary. Because of the limited storage capacity in the diversion pool, the trap efficiency would be low and most of the suspended sediment load, particularly the finer portion, would flow on through to Newville Reservoir or Thomes Creek.

The layout of the diversion structure is shown on Figure 4-3 and a profile and sections are depicted on Figure 4-4. The normal pool elevation would depend on whether a canal or a combination of tunnel and canal were selected for the conveyance facilities. The illustrated pool elevation of 315 m (1,035 ft) matches the canal plan; for the plan with both tunnel and canal, the pool would be about 4 m (15 ft) higher. Each of the two radial gates would be 6.1 m (20 ft) wide and 15.2 m (50 ft) high; together, they could pass up to 1 160 m^3/s (41,000 ft^3/s) at normal pool level. Larger floodflows would pass both through the gates and over the 152-m (500-ft) overpour section on the left abutment.

The diversion structure would be a conventional concrete gravity dam, founded on Stony Creek Formation mudstone. Grouting of the foundation area would be required. A concrete apron would be included to prevent erosion below the gate and overpour sections. No unusual design or construction

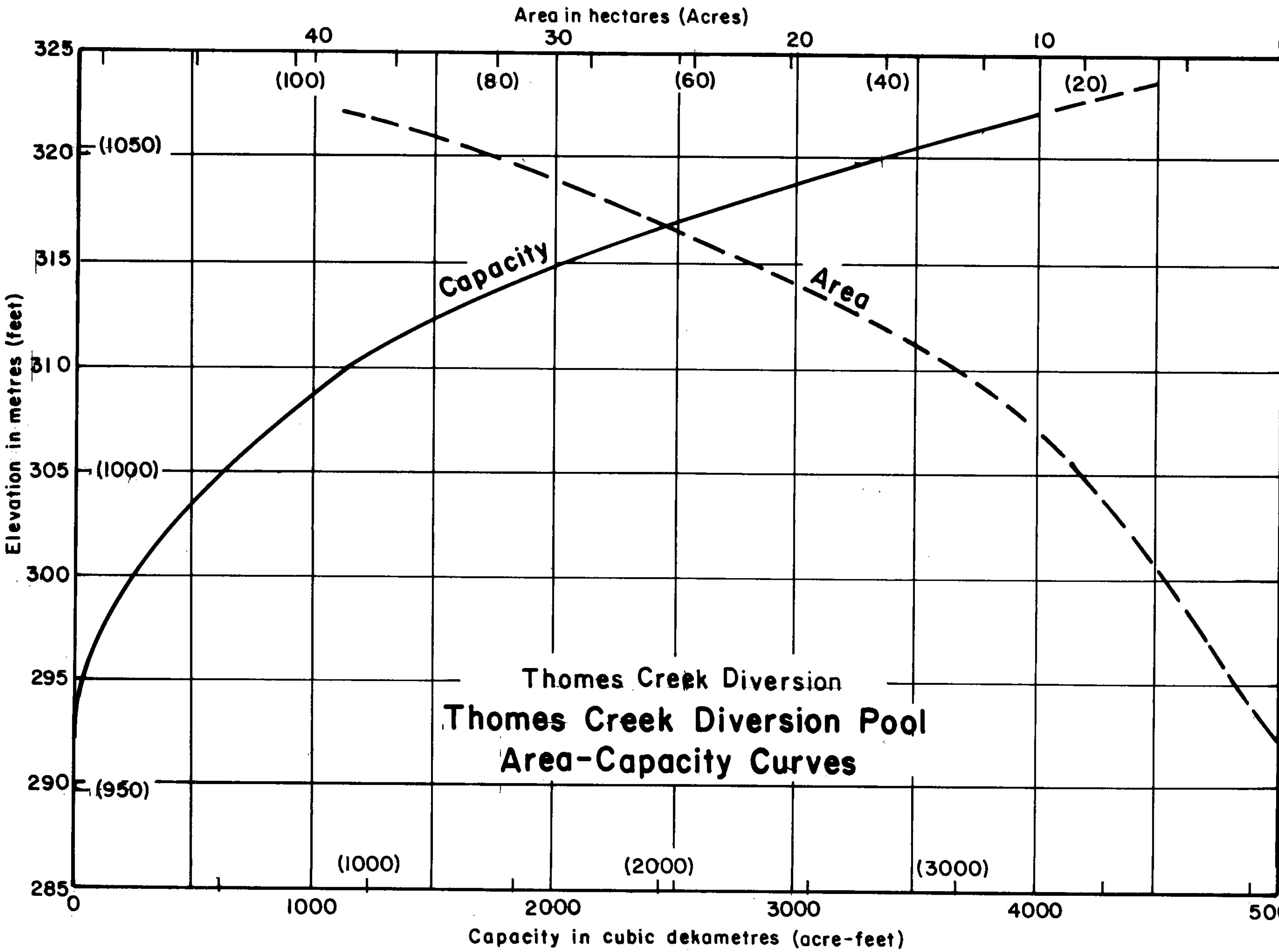
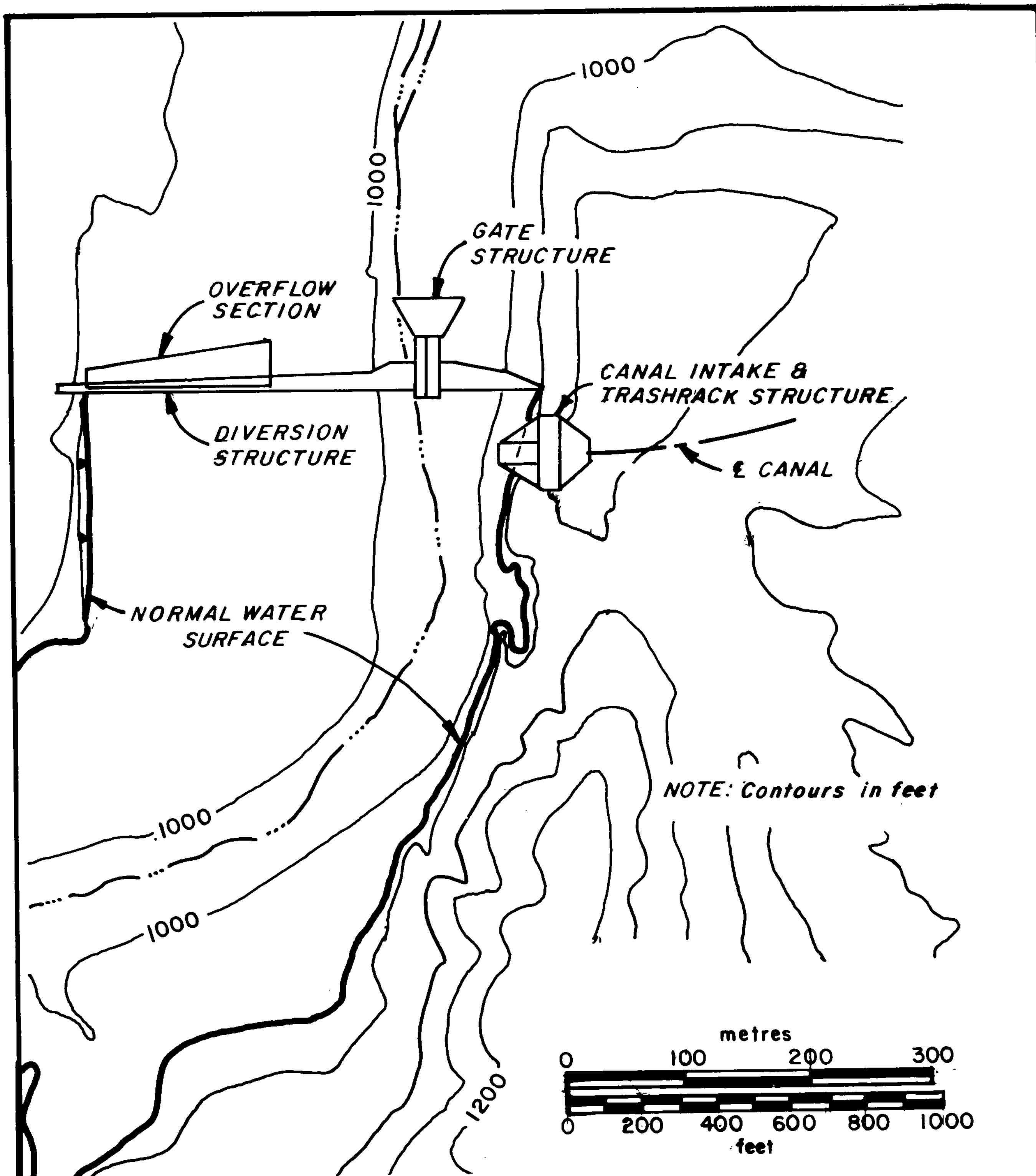

Area in hectares (Acres)
40
30
20
10
0
(100)
(80)
(60)
(40)
(20)
325
320
315
310
305
300
295
290
285
(1050)
(1000)
(950)
Elevation in metres (feet)
Capacity
Area
Thomes Creek Diversion
Thomes Creek Diversion Pool
Area-Capacity Curves
(1000)
(2000)
(3000)
0
1000
2000
3000
4000
5000
Capacity in cubic dekametres (acre-feet)

Figure 4-2

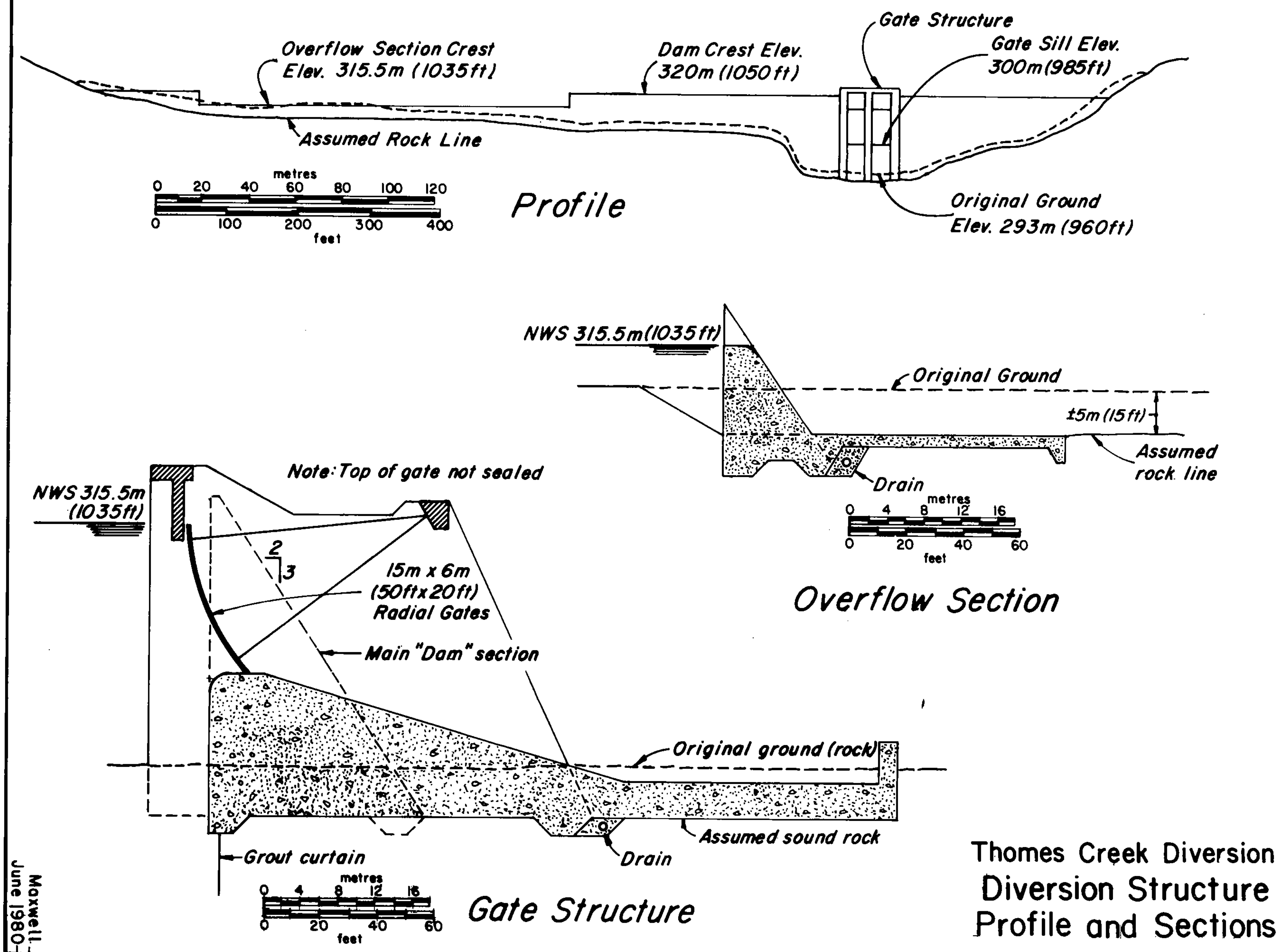
Figure 4-3



Thomes Creek Diversion

Diversion Structure Plan

Figure 4-4



Thomes Creek Diversion
Diversion Structure
Profile and Sections

problems are foreseen, but special care would be required to provide an adequate safety factor against sliding on the relatively weak foundation rock.

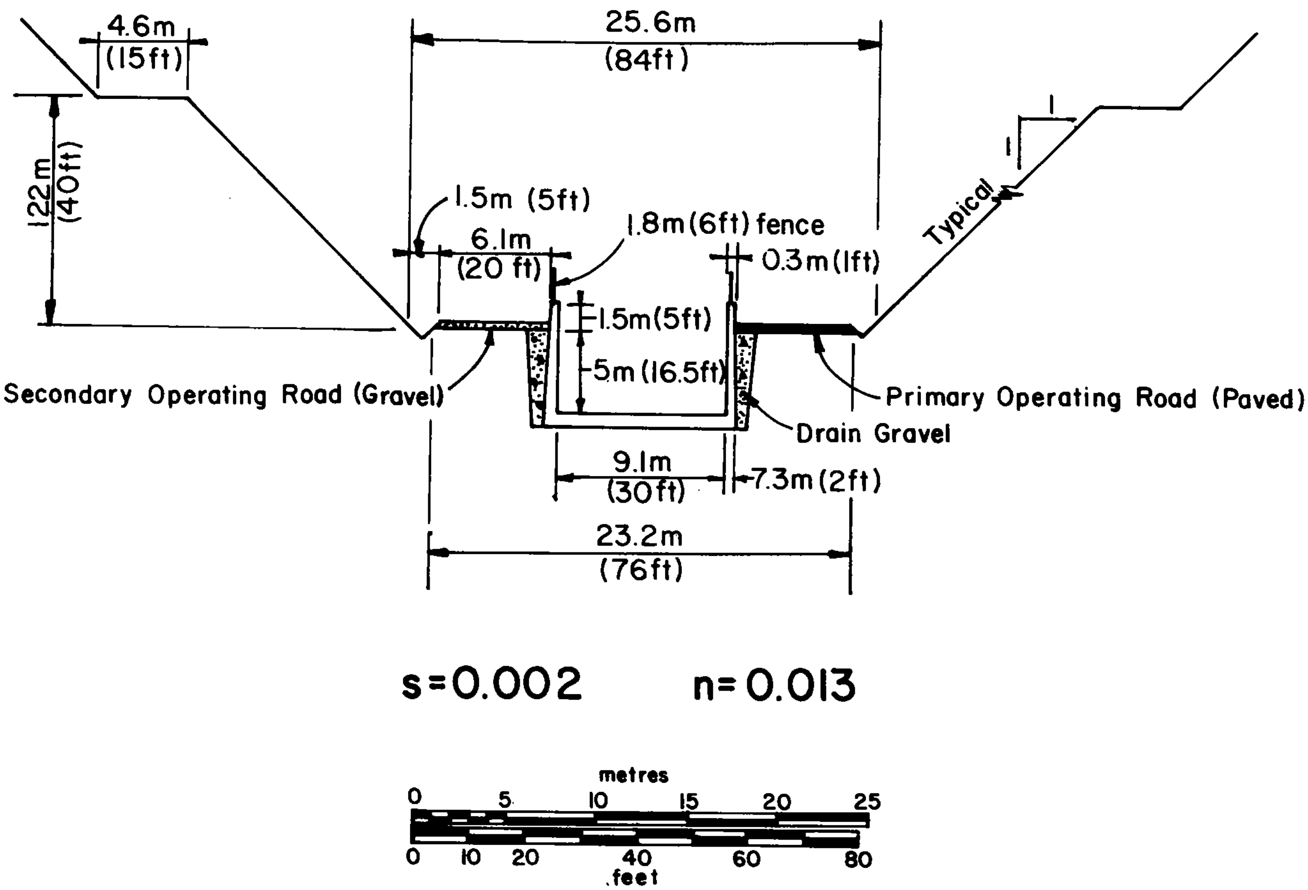
The crest of the diversion structure would be at elevation 320 m (1,050 ft), about 27 m (90 ft) above streambed level. During the winter, the radial gates would generally remain closed so that most of the Thomes Creek inflow would be diverted to Newville Reservoir. The water surface in the diversion pool would fluctuate between elevation 308 and 319 m (1,010 and 1,045 ft), depending on the incoming flow. Stream releases to Thomes Creek would be made via a small outlet conduit through the diversion structure. When it was not desired to divert to Newville Reservoir, the gates would be fully opened and the diversion pool level would drop to about elevation 300 m (985 ft). The gates would also be opened during floods to release excess water and to help flush accumulated sediment from the diversion pool.

Conveyance Facilities

Three alternative arrangements were investigated for conveying water from the Thomes Creek diversion structure to Newville Reservoir. One, a direct tunnel, was clearly too expensive and was dropped from further consideration. Alignments of two other schemes are shown on Figure 4-1. The canal plan would be the less costly for a diversion capacity of more than about 142 m^3/s (5,000 ft^3/s). The tunnel-canal combination would be about $10 million more costly for the selected capacity of 283 m^3/s (10,000 ft^3/s), but it would have the advantage of being less disruptive of deer migration. If wildlife studies indicate that the additional $10 million would be a justified expenditure, the tunnel-canal plan could be adopted. For the present, the canal plan is assumed to be the more viable and is featured in the remainder of this chapter.

Early designs of the Thomes Creek diversion facilities were based on wide unlined canals. These were attractive because, with suitable side slopes, deer could cross them freely at any but very high flow levels. As more was learned about Thomes Creek sediment loads, it has become apparent that flow velocities would have to be maintained at rather high levels in the canal to keep sediment in suspension throughout the diversion facilities. Since high velocities would cause severe erosion of the mudstone, a concrete-lined canal section would be necessary. A rectangular canal section was eventually selected as most economical, considering the combined costs of excavation, lining, and deer crossings.

Figure 4-5 shows the preliminary canal design. The high walls and fences would keep deer out of the canal. The design includes provision for deer crossings at 800-m (0.5-mi) intervals; each crossing would be formed by bridging the canal with a soil-covered concrete slab about 60 m (200 ft) in length. In the preliminary design, the canal would cross over Bennett Creek and an unnamed smaller creek in a viaduct section; these structures would provide additional opportunities for deer to pass. More definite plans for deer crossings will be developed when more is learned about their migration routes.



Thomes Creek Diversion

Typical Canal Section

The inlet structure to the canal would be located near the diversion structure, as shown on Figure 4-3. The concrete inlet structure would incorporate a trashrack to exclude rocks or debris larger than 127 mm (5 in) from the canal. Provision would be included for placing stoplogs in the inlet structure to isolate the canal for maintenance or repairs, but there would be no gates or control devices for normal operation. Instead, the flow through the diversion canal would be limited by use of the diversion structure gates. The canal invert at the inlet structure would be about 8 m (25 ft) higher than the sill of the radial gates of the diversion structure, which should prevent bedload being drawn into the diversion.

Total length of the canal would be 4 000 m (13,100 ft). With a slope of 0.002, its invert would drop from elevation 308 m (1,010 ft) at the inlet structure to elevation 300 m (984 ft) at its terminus. At maximum capacity, the flow depth would be 5 m (16.5 ft) and the velocity 6 m/s (20 ft/s). The canal would be constructed so that the water would generally be below the natural ground level. The maximum depth of cut would be about 27 m (90 ft). The total excavation quantity would be about 1 700 000 m^3 (2,220,000 yd^3). Most of the excavation would be in mudstone; the top 3 to 4 m (10 to 12 ft) could probably be ripped, but deeper cuts might require drilling and blasting.

At the downstream end of the diversion canal, a steep concrete-lined chute would lead to Newville Reservoir. The chute would be 650 m (2,150 ft) long, with a total vertical drop of about 26 m (84 ft). Preliminary designs for this chute were premised on raising Newville Dam within a few years, thus rendering the chute no longer necessary. Additional design studies would be needed if the chute were to be considered a permanent feature of the Thomes-Newville Plan; in that case, a stilling basin or some other form of energy dissipator would probably be needed.

Construction Schedule

The Thomes Creek diversion facilities could be constructed over a period of about 2½ years. Work would commence in the spring of the first year with excavation of the diversion structure foundation and the canal prism. Concrete placement would begin on the inlet structure and the higher portions of the diversion structure that fall. No special provisions would be required for stream care and diversion during construction, as Thomes Creek would be allowed to flow through the uncompleted section of the structure during the winter and spring.

As soon as Thomes Creek flows would recede to manageable levels in the second summer, foundation excavation would be completed and concrete placement would begin in the central portion of the diversion structure. The diversion structure would be completed (except for installing the gates) by late fall. Lining of the canal would begin during the second summer and continue on through the following winter.

The third year would be devoted to finishing the canal lining, placing the radial gates in the diversion structure, completing the outlet chute, and constructing roads and other appurtenances. The facilities would be ready to divert Thomes Creek flows during the winter of the third year.

Cost Estimates

Table 4-1 summarizes cost estimates for the Thomes Creek diversion facilities, based on prices prevailing in late fall of 1979. As with other cost estimates in this report, the figures in Table 4-1 do not include any allowances for cost escalation during the construction period. Also, the costs shown do not include land acquisition or relocation of the county road that parallels the canal route; both of these items are included in costs presented in the preceding chapter for Newville Reservoir.

TABLE 4-1

THOMES-NEWVILLE PLAN
THOMES CREEK DIVERSION FACILITIES--
PRELIMINARY COST ESTIMATES
(Price Basis--Fall 1979)

	Estimated Costs for Diversion Capacity of 283 m^3/s (10,000 ft^3/s)			
Item	Contract	Contingencies	Engineering	Total
Diversion Structure	$ 7,940,000	$1,190,000	$2,100,000	$11,230,000
Intake Structure	1,150,000	170,000	300,000	1,620,000
Canal and Roads	21,740,000	3,260,000	5,750,000	30,750,000
Outlet Chute	1,860,000	280,000	490,000	2,630,000
Totals	$32,690,000	$4,900,000	$8,640,000	$46,230,000

Preliminary cost estimates were also prepared for an alternative layout that would substitute 1 220 m (4,000 ft) of 7.3-m- (24-ft-) diameter tunnel for a 1 430-m (4,700-ft) portion of the canal. The total estimated cost of this alternative is $56 million, about 21 percent greater than the basic canal plan for the 283-m^3/s (10,000-ft^3/s) design capacity.

Conclusions and Recommendations

Although the preliminary studies have been based on relatively limited field data, there are no particular areas of doubt about the physical feasibility of the Thomes Creek diversion facilities. The proposed facilities would be of conventional design and there are no known geologic or foundation problems of abnormal proportions. The heavy sediment load of Thomes Creek presents a special challenge, but it is considered that potential sediment problems could be solved by proper design and operation.

Recommendations for additional study during the advanced planning phase include:

1. Perform hydrologic studies to determine the probable maximum flood on Thomes Creek.

2. Resume collection of suspended and bedload sediment data at the Thomes Creek at Paskenta gaging station.

3. Examine an alternative plan that would divert from farther downstream on Thomes Creek and pass through the Thomes/Newville saddle at a lower elevation (either via deep cut or tunnel).

4. If the upstream diversion site is retained, examine the possibilities of channeling Slate Creek into the diversion pool.

5. Investigate the economics of diverting water from Bennett Creek to the diversion canal rather than crossing over it.

6. Perform more detailed geologic analysis and exploration on the most promising alternatives (including drilling at the sites of major structures).

7. Consider the need for an energy dissipator on the chute that would drop into Newville Reservoir.

8. Appraise the possibilities for reducing the sediment load of Thomes Creek through watershed management.

9. When more information becomes available on deer migration patterns, reexamine the criteria for deer crossings and the economic justification of the combination canal/tunnel plan.

10. Keep the possibility of Paskenta Dam alive; if the deer problem could be overcome, it might be the best plan.

CHAPTER 5. THOMES-NEWVILLE PLAN-- STONY CREEK DIVERSION FACILITIES

Almost half of the new water supply developed by the Thomes-Newville Plan would be derived from the main stem of Stony Creek. This chapter reports on two alternative plans for facilities to convey surplus flows from Stony Creek to Newville Reservoir.

The first plan, which was studied most, would involve pumping from Black Butte Reservoir to a Tehenn Reservoir on North Fork Stony Creek. Tehenn Reservoir would back water to a pumping-generating plant at the toe of Newville Dam. The total pumping lift would range from about 64 to 143 m (211 to 470 ft), depending on the levels of Black Butte and Newville Reservoirs.

The second plan was developed only recently, but appears to have significant advantages over the original plan. It would call for construction of a small Millsite Reservoir on Stony Creek, 8 km (5 mi) upstream from Black Butte Reservoir. From Millsite Reservoir, pumps would lift water to the south end of Newville Reservoir. The total pumping lift would be constant at about 99 m (325 ft).

Based on preliminary formulation studies, a nominal pumping capacity of 85 m^3/s (3,000 ft^3/s) was selected for the initial design and cost studies. This is slightly smaller than the pumping capacities selected for the example formulations in Chapter 2, but the difference does not affect judgments of engineering feasibility.

Previous Studies

In 1957, the Department presented a plan similar to the current one in Bulletin 3, "The California Water Plan". That plan suggested gravity diversions from Thomes, Stony, and Grindstone Creeks to a 1 170 000-dam^3 (950,000-ac-ft) Newville Reservoir. Thomes Creek would have been diverted via a Paskenta Reservoir and Stony and Grindstone Creeks would have been conveyed through a 61-km (38-mi) canal from above Stony Gorge Reservoir to the saddle at Chrome. The canal capacity would have been 24 m^3/s (840 ft^3/s).

There were no further studies of diversion from Stony Creek to Newville Reservoir until late 1978. For several years prior to that time, the planning emphasis had been directed at a Glenn Reservoir that would be supplied with water pumped from the Sacramento River via Black Butte Reservoir. For the connection between Black Butte and Newville Reservoirs, initial studies suggested a deep cut and a single pump lift; however, later work indicated that a Tehenn Reservoir and two pump lifts would be more practical.

In late 1978, attention was redirected to the Bulletin 3 concept of a Newville Reservoir storing water from both Thomes and Stony Creeks.

Since design studies had already been completed for Tehenn Dam and the associated pumping-generating facilities, it was natural to adopt the same scheme to the smaller plan. An alternative plan, involving pumping from Millsite Reservoir, was developed in early 1980 as a way to avoid the complication of pumping from a widely fluctuating Black Butte Reservoir.

Millsite Reservoir was first identified by the U. S. Geological Survey between 1900 and 1903, as part of an overall appraisal of potential storage sites in the Stony Creek area. The U. S. Reclamation Service explored the site in detail in 1923, and would have proceeded to construction except for an unfavorable vote of local water users. The 1930 State Water Plan included a 142 000-dam^3 (115,000-ac-ft) Millsite Reservoir, to be formed by a dam 41 m (135 ft) high. A much larger Millsite Reservoir was considered in the late 1950s under the Department's North Coastal Area Investigation; the site was eventually discarded in favor of the Rancheria site, which is better suited for a high dam. The current proposal would involve a smaller Millsite Dam than any previously considered.

Background Data

The current level of supporting data for the Stony Creek diversion facilities is not as high as for the other features of the Thomes-Newville Plan. Newville Reservoir and the Thomes Creek diversion facilities have been studied over a period of many years, while planning emphasis has shifted only recently to diverting Stony Creek to Newville Reservoir. The following sections outline the background data that are presently available and describe additional studies planned for the next phase of investigation.

Topographic Mapping

The Department's 1960 Glenn Reservoir map covers part of the area of the Stony Creek diversion facilities at a 1:4,800 scale and a contour interval of 6.1 m (20 ft). The original mapping extends eastward to Millsite Dam site and thus includes most of the area of the Millsite diversion route. This mapping is being expanded, using the original models, to provide complete coverage of the Millsite diversion route.

On the North Fork of Stony Creek, the 1:4,800 mapping extends only a short distance downstream from Newville Dam, so it provides little useful coverage of the Tehenn diversion route. The entire route is being mapped to provide a sound basis for geology, construction materials, design, and environmental studies.

Both alternative diversion routes are covered by the USGS Paskenta and Flournoy quadrangle maps at a scale of 1:62,500 and by the Newville and Sehorn quadrangles at 1:24,000. The Sehorn Creek map, with a contour interval of 6.1 m (20 ft), was used as the basis of planning for the facilities on the Tehenn diversion route.

Reservoir Area-Capacity Data

Area and capacity data for the two small reservoirs were determined during the current studies, as shown in Table 5-1.

TABLE 5-1

TEHENN AND MILLSITE RESERVOIRS
AREA-CAPACITY DATA

Reservoir	Elevation m	Elevation (ft)	Area ha	Area (ac)	Capacity dam^3	Capacity (ac-ft)
Tehenn	157.9	518	0	0	0	0
	158.5	520	1	3	2	2
	164.6	540	45	112	1 421	1,152
	170.7	560	113	280	6 256	5,072
	176.8	580	200	494	15 804	12,812
	182.9	600	300	741	31 037	25,162
	189.0	620	420	1,038	52 981	42,952
Millsite	165.5	543	0	0	0	0
	170.7	560	23	56	587	476
	176.8	580	134	330	5 348	4,336
	182.9	600	221	547	16 166	13,106
	189.0	620	373	922	34 286	27,796

The Tehenn Reservoir data (plotted on Figure 5-2) were determined from the 1:24,000 mapping, based on a damsite location in the West ½ of Section 5, Township 22 North, Range 5 West. The Millsite Reservoir data are based on the 1960 1:4,800 map, with the dam located in the Southeast ¼ of Section 1, Township 21 North, Range 6 West. The U. S. Reclamation Service mapped Millsite Reservoir in 1923 at a scale of 1:6,000 with 3-m (10-ft) contour interval; the capacity data that the Service prepared from that map show about 17 800 dam^3 (14,400 ac-ft) at elevation 182.9 m (600 ft).

Geology and Construction Materials

Geologic studies of the Tehenn diversion route have been of limited extent. A surface appraisal of excavation conditions along the North Fork Stony Creek between Black Butte Reservoir and Tehenn Dam site was completed in early 1978. This appraisal was supplemented by seismic refraction surveys conducted in the fall of 1978. These studies were reported in two brief internal memoranda; no formal geology report was prepared. The geologic reconnaissance and the seismic surveys showed that the North Fork Stony Creek channel is generally underlain by 3 to 5 m (10 to 15 ft) of Tehama Formation soils and alluvium that could be excavated by ordinary means. Below that, mudstone and sandstone of the Great Valley Sequence would be encountered. An upper weathered zone of the Great Valley Sequence might be rippable, but unweathered rock would probably require drilling and blasting. At the time these studies were made, the emphasis was on a Glenn Reservoir Plan that would allow Black Butte Reservoir to be stabilized at near its spillway elevation of 144.5 m (474 ft). With the Thomes-Newville Plan, however, Black Butte Reservoir would have to continue to operate to meet its flood control and water supply obligations. In that case, the channel of North Fork Stony Creek would have to be excavated about 13 m (44 ft) deeper than with the Glenn Reservoir Plan and much more hard rock would be encountered.

A surface geologic reconnaissance study was also made of the site of Tehenn Dam and its associated pumping-generating plant in early 1978. The entire site is underlain by the Great Valley Sequence. Although surrounding areas of the sequence include sandstone and conglomerate, the rocks in the vicinity of the Tehenn site are almost entirely mudstone. The mudstone is impervious and competent, but it is soft and subject to air slaking. Tehama Formation soils overlie the Great Valley Sequence on both abutments, with the contact approximately at the proposed dam crest elevation. Required foundation stripping depths for an embankment-type dam were estimated to range from 3 to 8 m (10 to 25 ft). Additional geologic studies and drilling would be needed to confirm these reconnaissance findings.

Foundation conditions for the pumping-generating plant at Newville Dam are covered by the damsite geology studies. The selected site is underlain by a sandstone unit that appears free of faults. Subsurface exploration of the plant foundation area is being carried out during the 1980 field season.

Except for Millsite Dam, only cursory studies of geologic conditions have been completed for facilities of the Millsite diversion route. The U. S. Reclamation Service explored the Millsite Dam area in 1923 with 3 test pits and 19 diamond drill holes. The site was reappraised by the Department in the early 1960s, as reported in Bulletin 136, "North Coastal Area Investigation, Appendix E, Engineering Geology, Volume I", 1965. Foundation conditions at Millsite Dam site are similar to those at Rancheria Dam site, except that there is a greater proportion of conglomerate. Stripping requirements would be similar to those estimated for Rancheria Dam (see Appendix E of this report). The 1965 report concluded that the site is suitable for an embankment-type dam up to 130 m (425 ft) high. Since Millsite Dam would be less than 24 m (80 ft) high under the current plan, there is little doubt that the site is adequate.

The other major features of the Millsite diversion alternative are a pumping plant, penstocks, a 2 800-m (9,200-ft) tunnel, three small dams, and two excavated channels. Cursory appraisals have been made of geologic conditions for these facilities, based on general knowledge of the area. This is normal procedure in planning studies; the cursory appraisals are used in preparing preliminary cost estimates. Then, if the plan appears promising, more thorough geology and design studies are made. Current studies of the Millsite diversion route represent the first step in this process and additional work will follow.

Cursory geologic appraisal revealed no particular problems for siting or construction of the various Millsite diversion route facilities, and no faults have been identified in the area. Foundation conditions along the route are similar to those for other features in the area; mudstone predominates, but sandstone and conglomerate are interbedded in varying quantities.

Relatively small quantities of construction materials would be required for the facilities on either of the alternative Stony Creek diversion routes. Appendix D summarizes investigations of construction materials for the major features of the Glenn Reservoir Plan; the same sources would be available for the Stony Creek diversion facilities. Tehenn Dam would be an embankment-type structure, built primarily with Tehama Formation soils that are abundant nearby. Millsite Dam and most of the other structures required for either route would be constructed of concrete, using either commercial aggregate sources or local stream deposits.

Hydrology

Chapter 2 summarizes available hydrologic data that would be applicable to design and construction of the features along the Tehenn diversion route. The USGS operated a stream gaging station (North Fork Stony Creek near Newville) just upstream from Tehenn Dam site from June 1963 through September 1973. Average annual runoff is estimated as 28 000 dam^3 (23,000 ac-ft) and the peak flow of record was 354 m^3/s (12,500 ft^3/s) in January 1965. No spillway design flood calculations have been prepared for Tehenn Reservoir; its spillway sizing would be controlled by the maximum outflow from Newville Reservoir for emergency drawdown.

Hydrologic information pertinent to the design of Millsite Dam is presented in Chapters 6 and 8, which cover Rancheria Dam. Gaging station records for Stony Creek near Fruto are available from January 1901 through October 1912 and October 1960 through September 1978. The gaging station, located close to Rancheria Dam site, measures runoff from a drainage area of 1 550 km^2 (597 mi^2). The drainage area at Millsite Dam site is 2.5 percent greater, at 1 590 km^2 (612 mi^2). Average annual runoff at the gaging station for the 1922-71 period is estimated as 411 000 dam^3 (333,000 ac-ft). The largest flow recorded during the 29 years of record was 1 130 m^3/s (40,200 ft^3/s) on December 23, 1964. In 1969, the Corps of Engineers prepared a spillway design (probable maximum) flood hydrograph for Rancheria Reservoir, showing a peak inflow of 5 270 m^3/s (186,000 ft^3/s); the same Corps study estimated the standard project flood peak as 2 550 m^3/s (90,000 ft^3/s). The Water and Power Resources Service is currently reappraising spillway safety at Stony Gorge; the Service has reportedly developed a design flood of 3 680 m^3/s (130,000 ft^3/s) for the 780-km^3 (301 mi^3) drainage area. Since the drainage area at Millsite Dam is over twice as large, some additional consideration of its spillway design flood is obviously needed before further design studies are conducted.

Sediment

With Newville Reservoir just upstream, sediment deposition in Tehenn Reservoir would be negligible. The USGS estimated the mean annual suspended sediment load for the area between East Park and Stony Gorge Reservoirs as 120 t/km^2 (340 ton/mi^2). If the same rate prevailed in the 21 km^2 (8 mi^2) drainage area between Newville and Tehenn Dams, the annual sediment deposition in Tehenn Reservoir would average only about 3 dam^3 (2 ac-ft).

Sediment would be of much greater concern with a Millsite Reservoir. The USGS monitored suspended sediment in Stony Creek at Black Butte Dam site from 1957 through 1962 and collected periodic samples of suspended sediment between 1967 and 1972 at the gaging station on Grindstone Creek near Elk Creek. Surveys of sediment accumulation in East Park and Stony Gorge Reservoirs were reported in the 1969 USGS Water Supply Paper 1798-F, "Sedimentation in Upper Stony Creek Basin, Eastern Flank of the Coast Ranges of Northern California". Based on the available data, the following estimates of suspended sediment load were presented in Water Supply Paper 1798-J, "Sediment Transport in the Western Tributaries of the Sacramento River, California" (1972):

	Area*		Estimated Mean Annual Suspended Sediment Transport			
Reservoir Basin	km^2	(mi^2)	t	(tons)	t/km^2	(tons/mi^2)
East Park	254	98	42 000	46,000	165	469
East Park to Stony Gorge	526	203	63 000	69,000	120	340
Stony Gorge to Black Butte	1 140	440	404 000	445,000	354	1,010

*The original report used slightly different drainage areas for the first two basins; the latest USGS drainage areas are shown here and the unit sediment yields were recomputed to match.

The Department's Staff Sedimentation Engineer estimated the average annual suspended sediment load at Millsite Dam site as 367 000 t (405,000 tons), by assuming that the unit sediment yield of the 329-km^2 (127-mi^2) area between Millsite and Black Butte Dam sites is the same as that of the area between East Park and Stony Gorge Dams. This estimate also included a minor allowance for suspended sediment passing through Stony Gorge Reservoir. Bedload at Millsite Dam site would be about 2 percent of the suspended load, or about 7 000 t (8,000 tons) annually.

If all of the sediment load were deposited in Millsite Reservoir, it would occupy a volume of about 420 dam^3 (340 ac-ft) per year. However, the trap efficiency of the small Millsite Reservoir would be rather low. The Staff Sedimentation Engineer calculated that most of the incoming sediment would be flushed through the reservoir; even after 100 years of operation, sediment deposits at the dam should not extend above the spillway gate crest elevation of 177 m (580 ft). However, some deposition would be expected at the upstream end of the reservoir and this could cause backwater effects above the normal pool level.

Stony Creek sediment production was not of particular concern while the planning emphasis was on the huge Rancheria Reservoir. Now, as a small Millsite Reservoir appears likely to become a viable part of the Thomes-Newville Plan, sediment has assumed much greater importance. Accordingly, the Department has taken steps to have the USGS resume stream gaging of Stony Creek in the general area of Millsite Dam site and to have both suspended and bedload sediment monitored at the gage.

Tehenn Diversion Route

Figure 5-1 illustrates the principal features of the plan to divert Stony Creek water from Black Butte Reservoir to Newville Reservoir via the Tehenn route. The Tehenn Canal would be excavated along North Fork Stony Creek from Black Butte Reservoir to the Tehenn Pumping-Generating Plant. The plant would lift surplus water from Black Butte Reservoir to Tehenn Reservoir. At the upper end of Tehenn Reservoir, the Newville Pumping-Generating Plant would make the final lift to Newville Reservoir. Releases from Newville Reservoir would pass through the same facilities on the way back to Black Butte Reservoir. Some of the units at the two plants would be reversible, to generate power whenever releases were being made.

Tehenn Canal

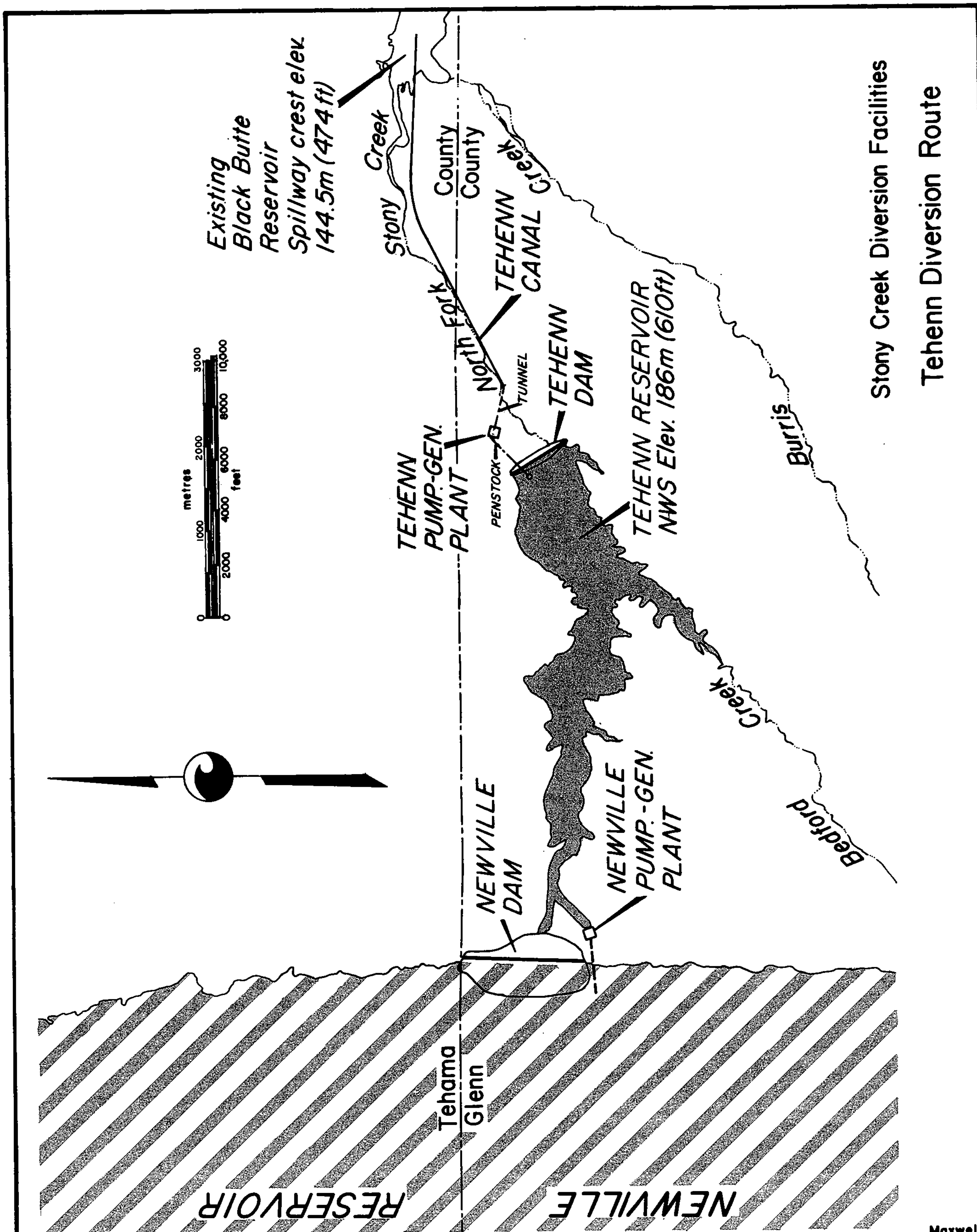
The Tehenn Canal would simply be an unlined excavation, generally following the natural channel of North Fork Stony Creek. To allow pumping when Black Butte Reservoir was drawn down to low levels for flood control, the canal would have to extend far into the existing reservoir area. Hydrology studies determined that pumping would be necessary down to a Black Butte Reservoir elevation of 131 m (430 ft); to meet this requirement, an invert elevation of 125 m (410 ft) was selected for the Tehenn Canal. The resulting canal would be 8 km (5 mi) long. Maximum depth of cut would be 37 m (120 ft).

The bottom width of the Tehenn Canal would vary with the design flow capacity; for the 85-m^3/s (3,000-ft^3/s) size considered in this study, the bottom width would be 10 m (34 ft). The total volume of excavation would be 8 400 000 m^3 (11,000,000 yd^3). Approximately 22 percent of this would be common excavation; about 76.6 percent was assumed to require drilling and blasting, and 1.4 percent would be dredged.

The water level in the Tehenn Canal would fluctuate with the storage in Black Butte Reservoir. In its 17 years of operation, the reservoir has never risen above its spillway crest elevation of 144.5 m (474 ft), but under extreme flood conditions, it could reach the maximum pool level of 155.4 m (510 ft).

Construction of the Tehenn Canal would be routine, provided that Black Butte Reservoir could be drawn down to facilitate completion of the portion normally inundated. Excavation should proceed in an upstream direction, keeping a definite gradient toward the reservoir to allow drainage of the work site. The first stage of excavation would stay above the summer water level of Black Butte Reservoir. Once streamflow dropped to negligible levels (normally by July), excavation could proceed to final grade along all but the eastern portion of the canal. Finally, in late fall, Black Butte Reservoir would be drawn down to permit completion of the excavation. If the pool could not be lowered, the excavation could be made by leaving a plug in the entrance to the canal in Black Butte Reservoir, completing the remainder of the excavation, removing most of the plug with a dragline, and finally dredging the canal entrance.

Figure 5-1



Stony Creek Diversion Facilities

Tehenn Diversion Route

Tehenn Reservoir

Tehenn Reservoir would be the key conveyance link between Black Butte and Newville Reservoirs. Pumping facilities at Tehenn Dam would pump from Black Butte Reservoir to Tehenn Reservoir, which would back water up to the second pumping plant, at the toe of Newville Dam.

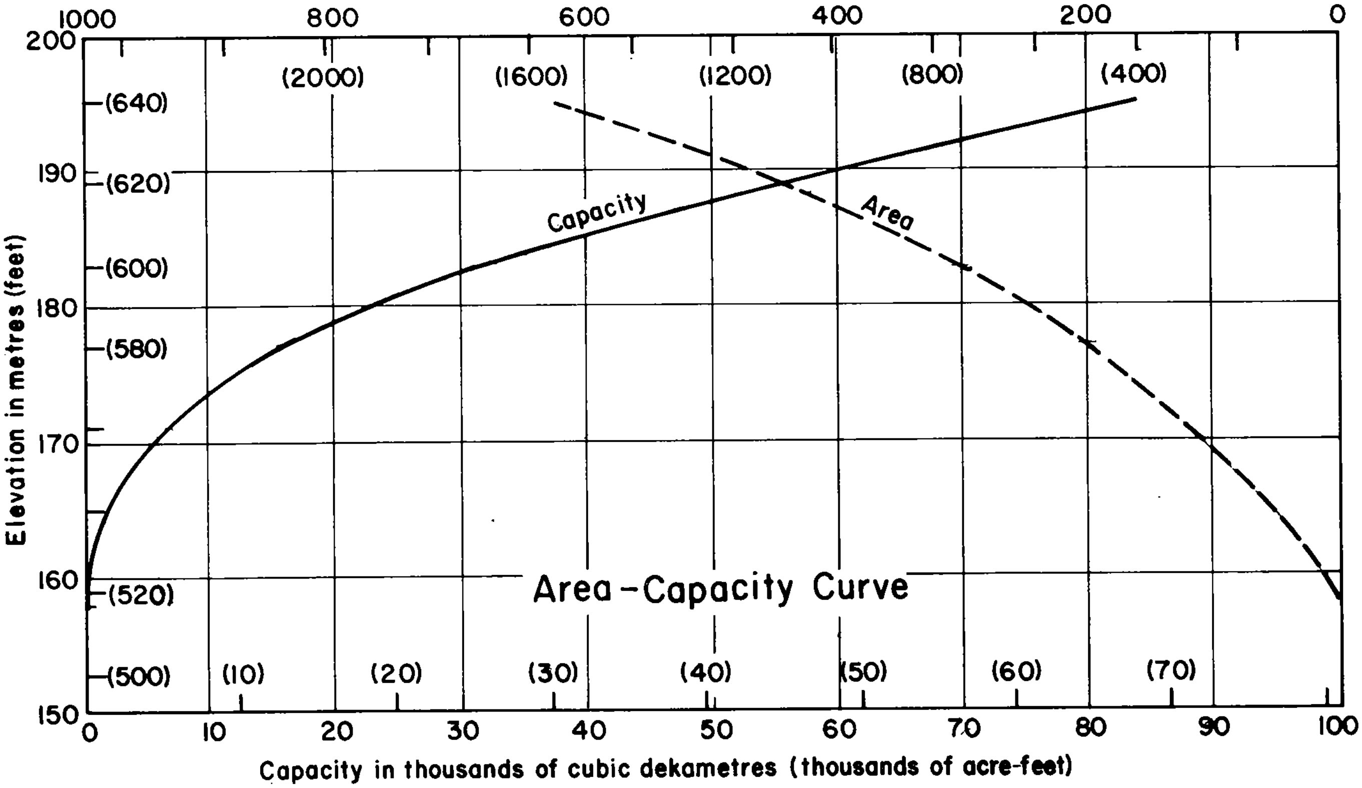
Selection of the optimum site for Tehenn Dam would require a careful balancing of dam costs with the cost of Tehenn Canal excavation. As the dam was moved downstream, it would become higher, wider, and more costly, but the Tehenn Canal would become shorter and less costly. The preliminary selection of Tehenn Dam site was based on judgment rather than a rigorous analysis of costs. The selected site is the farthest downstream location that would allow a reasonably compact dam; below the selected site, the canyon widens significantly.

In September 1979, a reconnaissance planning appraisal was made of a Tehenn Dam located about 3.2 km (2 mi) farther downstream. This would eliminate nearly 90 percent of the cost of Tehenn Canal, but the savings would be slightly exceeded by the increased cost of Tehenn Dam and Reservoir. However, to make a thorough comparison, it was necessary to analyze the entire Thomes-Newville Plan. First, the added storage in Tehenn Reservoir would permit a reduction in the size of Newville Reservoir. But, the larger surface area of Tehenn Reservoir would increase total evaporation and thus decrease new yield. When all factors were taken into account, the downstream site was found to be slightly inferior from both economic and geologic standpoints, so it was concluded that the original site was a reasonable choice. However, it would be prudent to examine an intermediate site before a final selection was made for construction.

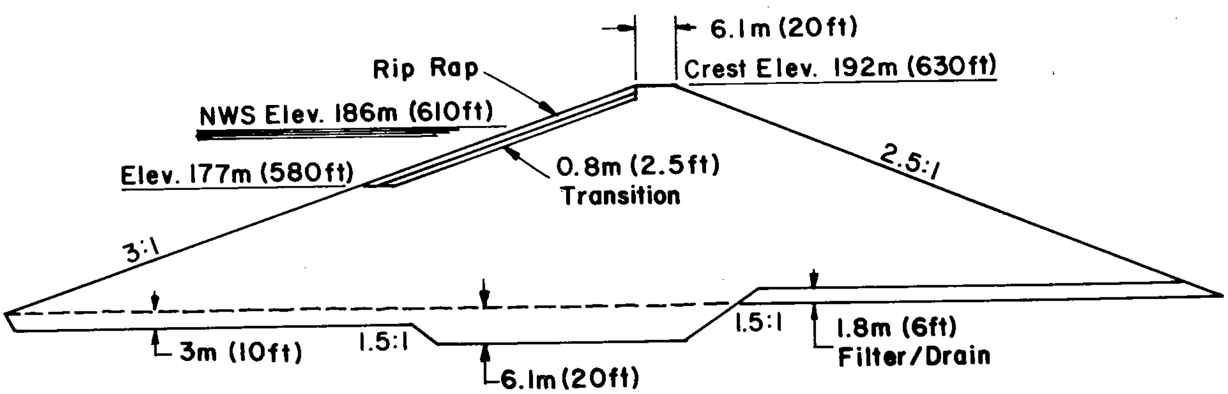
A normal pool level of 185.9 m (610 ft) was selected for Tehenn Reservoir. This would back water to the Newville Pumping-Generating Plant without requiring significant excavation. The resulting gross storage capacity of Tehenn Reservoir would be 40 100 dam^3 (32,500 ac-ft).

Figure 5-2 shows the area-capacity relationship for Tehenn Reservoir and the selected dam section. The dam would be a homogeneous earthfill structure, rising 34 m (112 ft) above original streambed level. Crest length would be 760 m (2,500 ft). The total volume of embankment would be about 2 000 000 m^3 (2,600,000 yd^3). The main zone of the dam would be constructed of compacted Tehama Formation soils available nearby on either abutment. Sands and gravels for the drain and filter would be obtained from excavation of the lower reach of the Tehenn Canal. No stability calculations were performed for this preliminary study; dam slopes were selected by judgment, after comparison with other dams.

The spillway for Tehenn Reservoir would be a concrete-lined, ungated, chute-type on the left abutment. The chute would be about 400 m (1,300 ft) long and would terminate in a concrete stilling basin. Preliminary cost estimates are based on a spillway crest length of 76 m (250 ft); this could pass the peak emergency drawdown release from Newville Reservoir of about 1 420 m^3/s (50,000 ft^3/s) with a head of 4.6 m (15 ft). With its crest elevation set 6.1 m (20 ft) above spillway level, the dam would have 1.5 m (5 ft) of residual freeboard.



Stony Creek Diversion Facilities
Tehenn Dam and Reservoir



Typical Dam Section

Maxwell
June 1980

The outlet works for Tehenn Dam would be a cut-and-cover steel-lined concrete conduit under the left abutment. The conduit would be 4.9 m (16 ft) in diameter and 150 m (500 ft) long; it would convey both water pumped and water released via the Tehenn Pumping-Generating Plant. A vertical tower would house trashracks and gates, but multi-level intake capability would not be required. Facilities to bypass the pumping-generating plant would provide for stream releases or emergency reservoir evacuation.

Tehenn Pumping-Generating Plant

The design and construction of this plant would be somewhat unusual because it would have to operate with Black Butte Reservoir at any elevation between 131 and 144 m (430 and 474 ft). In addition, the plant would have to be able to withstand a reservoir pool level as high as 155 m (510 ft) for short periods during rare flood conditions. Under ordinary conditions, Tehenn Reservoir would be maintained at its spillway crest elevation of 186 m (610 ft). Consequently, the normal static pumping head at the Tehenn plant would range from 42 to 55 m (136 to 180 ft).

Preliminary geology exploration indicates that an underground plant would not be feasible in this area. Studies were made to build the plant aboveground at the toe of the dam, but this location would require having the plant deep under water to meet requirements for pump submergence. This scheme would result in extreme building costs and difficult engineering problems.

The recommended plant would be located 600 m (2,000 ft) downstream from the toe of Tehenn Dam in an excavated bowl on the north side of the stream. The bowl would be about 120 feet deep, with 1.75:1 slopes and 4.6 m (15 ft) wide benches spaced every 12 m (40 ft) vertically. About 1 030 000 m^3 (1,350,000 yd^3) of excavation would be required. The plant would be connected to the Tehenn Reservoir outlet by a 4.9-m (16-ft)-diameter welded steel penstock and to Tehenn Canal by a 5.3-m (17.5-ft)-diameter concrete-lined tunnel. The tunnel would be provided with a coaster gate at the entrance and other facilities to permit dewatering. The plant itself would be of conventional design of the indoor type with an in-line arrangement of units. Three bays would house one reversible pump-turbine unit and two pump units. The entire structure would be 24 m (80 ft) wide and 61 m (200 ft) long. The pump-turbine would generate 13 MW when the maximum design release of 28 m^3/s (1,000 ft^3/s) was being made. When pumping the design flow of 85 m^3/s (3,000 ft^3/s), the plan would draw 54 MW.

Newville Pumping-Generating Plant

The final pumping lift from Tehenn Reservoir to Newville Reservoir would be handled by a plant at the toe of Newville Dam. The water level in Tehenn Reservoir would be constant at elevation 186 m (610 ft), while Newville Reservoir would fluctuate between elevation 209 to 274 m (685 to 900 ft). Static pumping lift would vary from an extreme low of 23 m to as much as 88 m (75 to 290 ft). This is a very wide range of pumping heads, but operation studies show that, once Newville Reservoir was initially filled, less than 2 percent of the total pumpage would be at heads less than 34 m (110 ft) and only about 7 percent would be at heads less than 43 m (140 ft). In fact, during about 77 percent of the total pumping, the static head would be above 67 m (220 ft).

As with the Tehenn plant, part of the units at the Newville Plant would be reversible pump-turbines so that power could be generated with reservoir releases. The large fluctuation in head is unfavorable for power generation, but approximately 90 percent of the releases would be made when the static head was above 58 m (190 ft).

The Newville Pumping-Generating Plant would be a conventional indoor facility with an in-line arrangement of units. Two pumps, one pump-turbine, and a service bay would be provided. The entire structure would be 24 m (80 ft) wide and 61 m (200 ft) long. Installed generating capacity would be about 20 MW and up to about 90 MW would be consumed when pumping at the design rate of 85 m^3/s (3,000 ft^3/s).

Millsite Diversion Route

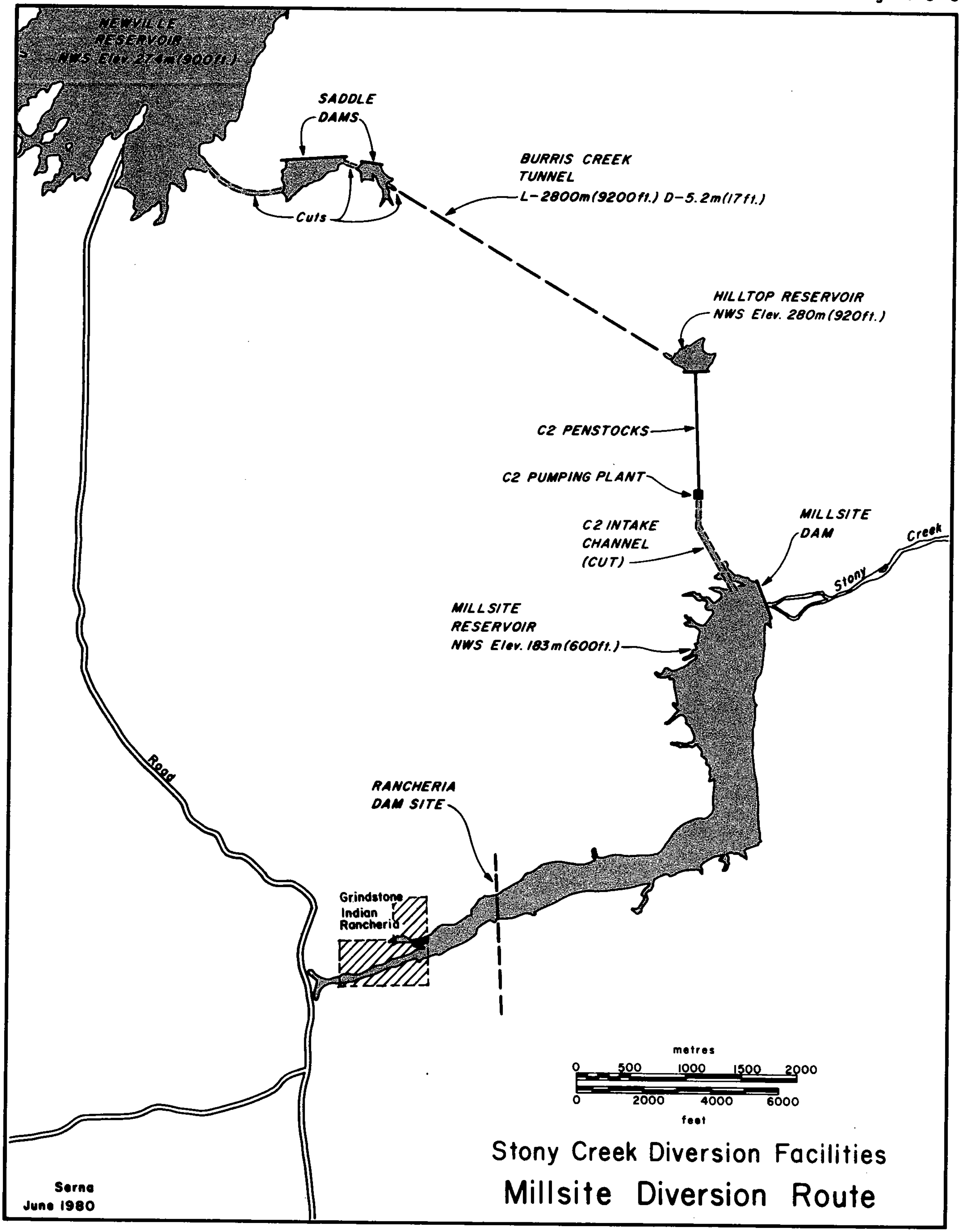
The principal features of this alternative plan are shown on Figures 5-3 and 5-4. Millsite Reservoir would intercept the majority of surplus Stony Creek runoff upstream from Black Butte Reservoir. The C2 Pumping Plant would lift the surplus water to the small Hilltop Reservoir. via the Burris Creek Tunnel and a series of small cuts and saddle dams.

One of the advantages of the Millsite route is that all of the pumping would be at a constant head. Hilltop Reservoir would be about 6 m (20 ft) above the normal pool level of Newville Reservoir during maximum operation of the diversion system. For the illustrative size of Newville Reservoir featured in Chapter 3, Hilltop Reservoir would be at elevation 280 m (920 ft) and the static pumping lift from Millsite Reservoir would always be near 97 m (320 ft). The total static pumping lift on the Tehenn diversion route would range from 64 to 143 m (211 to 470 ft), but the average would be about 125 m (410 ft). Thus, total energy consumption should be lower with the Millsite diversion route than with the alternative Tehenn route. However, energy generation would also be lower with the Millsite route because Tehenn Dam and its associated generating facilities would not be included in the plan. The next phase of planning studies will include a thorough analysis of the energy balance for the Millsite route.

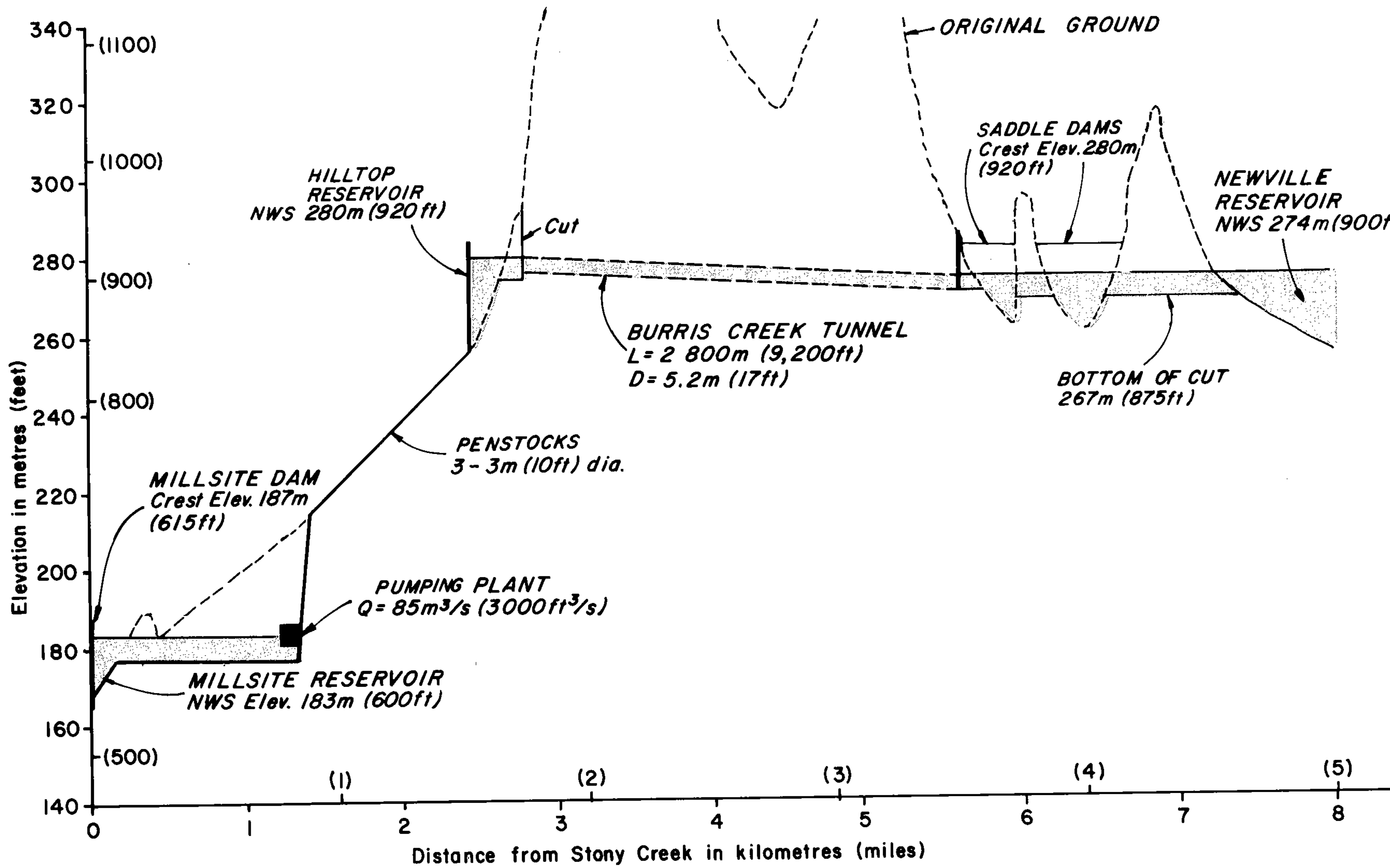
Millsite Reservoir

With this alternative, surplus flows of Stony Creek would be intercepted at a Millsite Reservoir, which would form a pumping pool for the C2 Pumping Plant. The size of Millsite Dam is a particularly knotty problem with this plan. On the one hand, a large Millsite Reservoir would be desirable to cope with the heavy sediment loads of the creek. On the other hand, the size of Millsite Reservoir should be limited to avoid inundation of a significant area of the Grindstone Indian Rancheria. The 100-acre rancheria is bisected by Stony Creek. Most of the buildings and

Figure 5-3



Stony Creek Diversion Facilities
Millsite Diversion Route



Stony Creek Diversion Facilities
Millsite Diversion Route
Profile

Figure 5-4

Maxwell
June 1980

other developments are situated high on the terrace on the north side of the creek, above elevation 189 m (620 ft). For the initial reconnaissance appraisal of Millsite Dam, a normal pool level of 183 m (600 ft) was selected. The resulting lake would stay well within the creek banks at that elevation, but a small portion of the Stony Creek floodplain would be inundated within the Grindstone Indian Rancheria. The affected area is currently subject to occasional inundation from floodflows.

Because of the heavy sediment loads and the need to pass extreme floodflows without a major rise in the reservoir level, a concrete dam with a gated spillway was selected for preliminary studies of Millsite Dam. The dam would include a wide central overpour spillway section, with 8 radial gates, each 12.2 m wide and 7.6 m high (40 ft wide and 25 ft high). Flanking the gated spillway section, overpour sections totalling 107 m (350 ft) in width would have a crest elevation of 183 m (600 ft). A separate overpour spillway (at the same elevation) would be cut around the right end of the dam; its concrete weir crest would be 183 m (600 ft) long. With a nominal spillway design flood of 4 250 m^3/s (150,000 ft^3/s), the maximum reservoir elevation would be about 184 m (604 ft) with all gates open. In an emergency situation with all gates closed, the spillway design flood would cause the reservoir to rise to elevation 187 m (613 ft).

At the normal pool level of 183 m (600 ft), Millsite Reservoir would have an initial capacity of 16 200 dam^3 (13,100 ac-ft). As outlined previously in this chapter, with the gated spillway crest set 6 m (20 ft) below normal pool level, most of the Stony Creek sediment load would be flushed on through the reservoir during high flows. Also, a portion of the bedload material could be trapped upstream on Grindstone and Stony Creeks if existing deposits of sand and gravel there were removed to provide construction materials for Newville Dam or other features. Approximately 15 000 000 m^3 (20,000,000 yd^3) of sands and gravels have been identified along Stony and Grindstone Creeks upstream from Millsite Dam site. This total volume of sand and gravel is nearly equal to the original storage capacity of Millsite Reservoir, so removal of a substantial portion of those deposits could significantly reduce the sediment load reaching Millsite Reservoir.

Millsite Dam would be a conventional concrete structure. Its crest length would be about 370 m (1,200 ft) and its maximum height above original streambed would be 22 m (72 ft). Foundation stripping, based on 1965 estimates, would range from 3 m (10 ft) beneath the left abutment terrace to 6 m (21 ft) in the channel. The total volume of concrete in the dam would be about 80 000 m^3 (105,000 yd^3). No unusual problems are anticipated in design or construction. Handling of streamflow during construction could be facilitated by coordinated operation of Stony Gorge and Black Butte Reservoirs; if necessary, summer or fall flows through the construction area could be reduced to minimum levels for a month or more.

The preliminary design for Millsite Dam did not provide for an outlet works because of the anticipated sediment deposition in the lower levels of the reservoir. In normal winter and spring operation, one or more of the spillway gates would be manipulated to maintain the pool level near elevation 183 m (600 ft). Occasionally, during flood periods, the gates would be opened wide to assist in flushing accumulated sediment from the reservoir. In the summer and fall, the reservoir would not be used for diversion and it could be either left full or lowered, depending on local preferences. This would be decided in consultation with the Grindstone Indian Rancheria Tribal Council and other affected interests.

C2 Pumping Plant

As Figure 5-4 shows, the C2* Pumping Plant would be located about 900 m (3,000 ft) north of Millsite Reservoir. It would pump surplus Stony Creek water for storage in Newville Reservoir. The total static pumping lift would be 97 m (320 ft).

Sizing studies have not been conducted yet for the C2 Pumping Plant. For comparative purposes, a pumping capacity of 84 m^3/s (3,000 ft^3/s) was selected for the initial design and cost studies. The pumping plant would be a conventional indoor facility, with three 31-MW (42,000-hp) pump units of equal size. Its main floor level would be 18 to 24 m (60 to 80 ft) below original ground level. The intake channel would have a 9-m (30-ft) bottom width, at elevation 175 m (575 ft). About 1 500 000 m^3 (1,900,000 yd^3) of excavation would be required for the intake channel and pumping plant bowl.

Water would be conveyed from the pumping plant to Hilltop Reservoir via three 3 050-mm (120-in) steel or pre-stressed concrete pipe penstocks. Each penstock would be about 1 190 m (3,900 ft) long. The penstocks would terminate at a siphon outlet structure.

Hilltop Reservoir

Hilltop Reservoir would serve as a conveyance link between the C2 Pumping Plant and the Burris Creek Tunnel. The reservoir would be formed by an embankment-type dam near the headwaters of a small unnamed tributary of Stony Creek. The dam would rise about 30 m (100 ft) above original ground. It would have a crest elevation of 287 m (940 ft) and a crest length of about 230 m (750 ft). Pending completion of additional topographic mapping, only cursory designs and cost estimates have been prepared for Hilltop Dam. Total embankment volume was estimated as 560 000 m^3 (730,000 yd^3). No specific design has yet been made for Hilltop Dam, but it would be similar to the Tehenn Dam design (compacted impervious soils from the Tehama Formation, with internal gravel drains).

Although Hilltop Reservoir would have minimal storage capacity and a natural drainage area of only about 33 ha (82 ac), it would be a major structure. The preliminary design and cost estimate included provisions for an overpour spillway and a small outlet works that could be used to empty the reservoir in an emergency.

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*Named after the ranch on which it would be located.

Burris Creek Tunnel

The Burris Creek Tunnel would be the main feature of the Millsite diversion route. It would carry Stony Creek water from Hilltop Reservoir to an extension of Newville Reservoir. For the illustrative capacity of 84 m^3/s (3,000 ft^3/s), the tunnel would be a concrete-lined circular section 5.2 m (17 ft) in diameter. Total tunnel length would be 2 800 m (9,200 ft). The tunnel invert would slope from elevation 274 m (900 ft) at the upstream end to 268 m (880 ft) at the downstream portal.

The Burris Creek Tunnel would be relatively shallow, with a maximum depth of cover of only about 128 m (420 ft). Geologic appraisals of the tunnel route have been limited but no particular problem areas have been identified. The tunnel would pass through mudstone with interbedded sandstone and conglomerate crossing the alignment at near right angles. No major faults have been identified in the tunnel area and gas or underground water is not expected to be present in detrimental quantities.

The preliminary cost estimate for the Burris Creek Tunnel was based on a conservative appraisal of similar tunnels built elsewhere. The estimate was based on conventional full-face excavation, with generous allowances for steel supports. The tunnel could be driven from either one or two headings. A total of about 91 000 m^3 (119,000 yd^3) of material would be excavated from the tunnel; some of the tunnel spoil might be salvaged for use in the nearby saddle dams or Hilltop Dam, but most would be wasted close to the portals.

Saddle Dams and Channels

Water from the Burris Creek Tunnel would discharge into the upper watershed of Bedford Creek, which enters the North Fork of Stony Creek downstream from Newville Dam site. Two saddle dams and two excavated channels would be used to connect this area to Newville Reservoir. The saddle dam crests would be at the same elevation as the crest of Newville Dam and the connecting channels' invert elevation would be about 14 m (45 ft) lower. In effect, these facilities would create an extension of Newville Reservoir into the upper portion of the adjacent watershed.

The saddle dams would have a combined crest length of 1 070 m (3,500 ft) and maximum heights of 15 to 18 m (50 to 60 ft) above original ground level. Their design would be similar to that of Hilltop Dam. About 1 300 000 m^3 (1,700,000 yd^3) of embankment would be required for the two saddle dams.

The two connecting channels would have a combined length of about 1 280 m (4,200 ft). The preliminary cost estimate was based on a bottom width of 30 m (100 ft), but more detailed study may show that a narrower channel would suffice; the drainage area tributary to the reservoir extension is very small and it is not likely that the 30-m (100-ft) channel would be needed to carry floodflows. The total volume of excavation for the two channels would be about 1 500 000 m^3 (2,000,000 yd^3); almost all of this would be for the westernmost channel.

Newville Generating Plant

The Tehenn diversion route facilities would include reversible pump-turbines at Newville Dam. The Millsite diversion facilities would not include any generating capability, so a Newville Generating Plant should be added to permit direct comparison of the two routes. Consequently, a preliminary cost estimate was prepared for a Newville Generating Plant, sized for a generating release of 28 m^3/s (1,000 ft^3/s). This results in an installed generating capacity of about 20 MW, the same as at the Newville Pumping-Generating Plant that would be included in the Tehenn diversion alternative.

Cost Estimates

Table 5-2 summarizes preliminary cost estimates for the two alternative diversion routes to bring Stony Creek water to Newville Reservoir. As indicated, the cost estimates reflect price levels prevailing in the spring of 1980. The costs do not include any provision for price escalation during the construction period (which would be about 3 years long). Costs of land acquisition are not included in these estimates, but they would be relatively minor in comparison to the construction costs.

Conclusions and Recommendations

Based on studies conducted thus far, both the Tehenn and Millsite diversion schemes appear to be physically feasible. None of the proposed facilities would be of unusual size or complexity and foundation conditions appear suitable for the relatively conventional structures that would be involved.

Only two aspects of these plans are not routine. First, the wide range of Black Butte Reservoir levels would affect the layout and design of Tehenn Pumping-Generating Plant, and, second, the anticipated sediment load of Stony Creek would require special consideration in the design of Millsite Dam. Both of these potential problems could be overcome with proper design. The preliminary designs and cost estimates prepared for the current study have made provision for the special measures and costs needed to deal with these problem areas.

Table 5-2 indicates that the Millsite diversion alternative would be slightly less costly than the Tehenn alternative. However, a full comparison of the two routes would have to consider energy consumption, energy generation, operation and maintenance costs, evaporation losses, and intangible factors such as compatibility with a possible later expansion as part of a Glenn Reservoir Plan. While both alternatives should be considered as possibilities, it is recommended that the emphasis be placed on the Millsite route for the immediate future. It shows considerable promise from the standpoints of simplicity, first cost, and compatibility with possible future expansions.

TABLE 5-2

THOMES-NEWVILLE PLAN
STONY CREEK DIVERSION FACILITIES
PRELIMINARY COST ESTIMATES
(Price Basis--Spring 1980)

Pumping Capacity:	85 m^3/s (3,000 ft^3/s)
Generating Capacity:	28 m^3/s (1,000 ft^3/s)
Tehenn Reservoir:	Elevation 186 m (610 ft)
Millsite Reservoir:	Elevation 183 m (600 ft)

Item	Estimated Costs			
	Contract	Contingencies	Engineering	Total
Tehenn Diversion Route				
Tehenn Canal	$ 39,350,000	$ 3,940,000	$ 9,950,000	$ 53,240,000
Tehenn Reservoir	29,010,000	2,900,000	7,340,000	39,250,000
Tehenn Pumping-Generating Plant	42,470,000	6,110,000	11,620,000	60,200,000
Newville Pumping-Generating Plant	43,480,000	6,260,000	12,350,000	62,090,000
Totals	$154,310,000	$19,210,000	$41,260,000	$214,780,000
Millsite Diversion Route				
Millsite Reservoir	$ 15,850,000	$ 2,380,000	$ 4,190,000	$ 22,420,000
C2 Pumping Facilities*	57,890,000	8,060,000	15,790,000	81,740,000
Hilltop Reservoir	4,970,000	750,000	1,310,000	7,030,000
Burris Creek Tunnel	27,490,000	4,120,000	7,270,000	38,880,000
Saddle Dams	10,780,000	1,620,000	2,850,000	15,250,000
Channels	5,800,000	870,000	1,530,000	8,200,000
Newville Generating Plant	19,670,000	2,950,000	5,740,000	28,360,000
Totals	$142,450,000	$20,750,000	$38,680,000	$201,880,000

*Includes intake channel and penstocks.

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The following steps are recommended for the advanced planning phase of this investigation:

1. Resume stream gaging on Stony Creek near Millsite Dam site and initiate monitoring of suspended and bedload sediment at that station.

2. Reanalyze Stony Creek flood hydrographs for design of Millsite Dam.

3. Extend detailed topographic mapping to cover the entire Millsite diversion route (already underway).

4. Determine the maximum size of Millsite Dam that could be built without detrimental impact on the Grindstone Indian Rancheria.

5. Perform more detailed geologic studies for all features of the Millsite and Tehenn diversion routes.

6. Prepare additional designs and cost estimates for a range of diversion capacities and make economic sizing studies specifically for a Millsite diversion. (Present sizing studies used costs for a Tehenn diversion plan.)

Other recommendations related to diverting from Millsite Reservoir are presented in Chapter 2, which covers plan formulation. These relate to hydrology and operation studies and to analysis of possible coordination with upstream reservoirs.

CHAPTER 6. GLENN RESERVOIR PLAN-- FORMULATION AND ANALYSIS

Before the recent shift of emphasis to the Thomes-Newville Plan, considerable attention was devoted to a Glenn Reservoir Plan. Glenn Reservoir would be a combination of Newville Reservoir on the North Fork of Stony Creek and Rancheria Reservoir, which would be formed by a dam on the main stem of Stony Creek. The two reservoirs would merge at water surface elevations greater than 283 m (930 ft). Glenn Reservoir would have enormous storage potential; at elevation 305 m (1,000 ft), it would hold 10 460 000 dam^3 (8,480,000 ac-ft) of water. This would exceed the combined capacity of the two largest reservoirs in California (Shasta and Oroville).

The natural runoff reaching Glenn Reservoir would justify development of only a small fraction of its storage potential. As with Newville Reservoir in the Thomes-Newville Plan, water would have to be brought from other basins to support a large-scale Glenn Reservoir development. As Appendix F describes, Glenn Reservoir was first conceived as a feature of various plans to import water from the north coastal area. More recently, it has been tied to diversion of surplus flow from the Sacramento River. This is the plan that this chapter addresses.

Glenn Reservoir could be constructed either all at once or in stages. If the Thomes-Newville Plan were constructed first, it could later be enlarged and integrated into a Glenn Reservoir Plan, provided that the initial design made allowance for the later expansion. As Chapter 7 shows, this provision for later expansion would add subtantially to the initial construction cost of the Thomes-Newville Plan. The added initial expense could be avoided if the second stage did not entail raising Newville Reservoir. This could be accomplished by building a dike at Chrome between the two reservoir compartments and allowing Rancheria Reservoir to be substantially higher than Newville Reservoir. Such an approach would forego a portion of the Glenn Reservoir storage potential, but it has promise because it would not require an early commitment to the eventual development of the larger plan.

The formulation studies described in this chapter are based on the presumption that the Glenn Reservoir Plan would be constructed as a single unit. Similar studies could be conducted for staged construction, but the results should not differ greatly as long as it was assumed that Newville Reservoir would be enlarged in the second stage. However, a complete economic analysis might show that enlargement of Newville Reservoir would not be economically justifiable, and any second stage should involve only a high Rancheria Reservoir with a Chrome Dike. If so, additional formulation studies would be needed to define optimum sizes of the various features of this plan variation.

Planning Framework

Formulation criteria used for analysis of the Glenn Reservoir Plan are identical to those outlined in Chapter 2 for the Thomes-Newville Plan, with the following exceptions.

1. The Cottonwood Creek Project was assumed to be constructed prior to the Glenn Reservoir Plan. The impact of that project on Sacramento River flows was evaluated from a December 4, 1979 Department of Water Resources operation study entitled "Proposed Cottonwood Creek Project with August 1978 D-1485 Criteria--Water Supply Based on DWR 10/76 Water Action Plan Depletion--Total Project Storage Capacity Reduced to 1.6 MAF--100-year Flood Protection and 200-100-1,000 cfs Fish Flow Requirements".

2. Since Glenn Reservoir would intercept most of the inflow to Black Butte Reservoir, the Black Butte Reservoir flood reservation of up to 185 000 dam^3 (150,000 ac-ft) was assumed to be transferred to Glenn Reservoir. No additional flood control benefits would accrue from this change, but it would allow Black Butte Reservoir to be stabilized under normal conditions at elevation 144 m (474 ft), with a storage of 197 000 dam^3 (160,000 ac-ft). As with the Thomes-Newville Plan formulation, the Glenn Reservoir formulation did not include a specific flood control storage allocation for Thomes Creek runoff at this time; later studies may indicate justification for some joint-use flood reservation for this purpose.

3. Example project formulations were based on maximizing net benefits with a unit value of dry period yield of $162/$dam^3$ ($200/ac-ft). A higher value of $243/$dam^3$ ($300/ac-ft) was used for the Thomes-Newville Plan formulation. Use of this higher value for the Glenn Reservoir Plan would lead to reservoir sizes that exceed the topographic limits of the Newville Reservoir compartment. Developments of that scale would require raising the Rancheria Reservoir compartment far above the Newville compartment; this would transform the plan into a different one and necessitate an entirely new set of cost estimates, formulation studies, and appraisals of physical feasibility. For this analysis, prudence dictated a choice of criteria that limited reservoir sizes to those that have been investigated and proven feasible.

4. Following the sizing studies presented in Chapter 2, the capacity of the Thomes Creek diversion facilities was fixed at 269 to 297 m^3/s (9,500 to 10,500 ft^3/s), depending on the selected operating mode.

The remainder of the formulation criteria are described in detail in Chapter 2. Three different operating modes were examined, as reflected by the ratio (K) of average annual new yield over the 1922-71 study period to average annual new yield during the critical dry period between May 1928 and October 1934. Formulation analyses were conducted for K values of 0.30, 0.47, and 0.70. All formulations were based on a refill period* of 10 years.

*The refill period is calculated as the average period required for the reservoir to refill from minimum pool while continuing to meet the long-term average demands that would be imposed on it.

Costs used in the formulation reflected spring 1978 price levels, without allowances for escalation during the construction period. Energy generated was valued at 30 mills/kWh and energy consumed was assumed to cost 40 mills/kWh.

Thomes Creek Hydrology

Surplus flows of Thomes Creek would be diverted to the Newville compartment of Glenn Reservoir, using the same facilities that would be included in a Thomes-Newville Plan. Chapter 2 discusses the hydrology of Thomes Creek in detail; the same discussion is applicable to the Glenn Reservoir Plan.

Stony Creek Hydrology

Stony Creek drains an area of 1 920 km^2 (741 mi^2) above Black Butte Dam and 1 690 km^2 (654 mi^2) of that area would be intercepted by Newville and Rancheria Dam. The Glenn Reservoir Plan would include facilities to pump water from Black Butte Reservoir, so all of the runoff above Black Butte Dam would be subject to capture.

Chapter 2 summarized calculations of surplus flows in Black Butte Reservoir for use in the Thomes-Newville Plan formulation studies. The resulting flows are not applicable to the Glenn Reservoir Plan because: (1) Glenn Reservoir would inundate Stony Gorge Reservoir, so the effects of storage and evaporation in Stony Gorge should be removed; (2) Black Butte Reservoir evaporation would be increased, so present evaporation should be added back into the water supply and the evaporation under project conditions should be calculated separately; and (3) a minimum flow release, assumed as 1.4 m^3/s (50 ft^3/s), should be guaranteed for Stony Creek below Black Butte Dam. ↳ 36,500 a-f yr.

Computations of monthly Stony Creek basin inflow available for storage in Glenn Reservoir were based on depletion area studies prepared by the Division of Planning. For the 50-year study period, the resulting averages are as shown in the tabulation on the following page.

Calculations of water supply for the Thomes-Newville Plan were derived from the Corps of Engineers' R-1 operation study for Black Butte Reservoir. If that study were adopted as the base for the Glenn Reservoir water supply, the potentially storable Stony Creek flow would average about 276 000 dam^3 (224,000 ac-ft) per year. This 10 percent difference is not of great significance to plan formulation, but studies are currently underway to reconcile the results of the two methods of calculation.

Table 6-1 presents monthly total Stony Creek inflow and potentially storable flows, derived as shown by the following tabulation. Negative potentially storable amounts indicate months when releases would be made from Glenn Reservoir storage to meet prior rights or instream maintenance downstream of Black Butte Dam.

	1922-71 Average Annual Flow	
	dam^3	(ac-ft)
Flow at Rancheria and Newville Dam sites	439 000	356,000
Correction for net effect of Stony Gorge Reservoir	+ 5 000	+ 4,000
Adjusted Glenn Reservoir inflow	444 000	360,000
Accretions between Glenn and Black Butte Reservoirs	+12 000	+10,000
Minor adjustments to eliminate calculated negative flows	+ 1 000	+ 1,000
Total adjusted flow at Black Butte Dam site	457 000	371,000
Less release for Orland Project and Central Valley Project	-186 000	-151,000
Less portion contributing to downstream prior rights	- 7 000	- 6,000
Surplus inflow above Black Butte Dam site	264 000	214,000
Less additional releases for Stony Creek stream maintenance	-14 000	-11,000
Remainder: potentially storable Stony Creek water	250 000	203,000

Sacramento River Hydrology

The Sacramento River basin drains an area of about 23 300 km^2 (9,000 mi^2) above the Red Bluff Diversion Dam. Elevations within this basin vary between a low at the City of Red Bluff of 79 m (260 ft) to a high at Mt. Shasta of 4 300 m (14,000 ft). The crest elevation of the surrounding mountain ranges averages about 2 000 m (6,500 ft). Average annual precipitation varies substantially within the basin from a low of 250 mm (10 in) in the high elevation plateau lands of northeastern California to 2 300 mm (90 in) within the McCloud River Basin. Annual precipitation for the entire basin upstream of Red Bluff averages about 1 140 mm (45 in).

Several major surface water storage facilities affect flows of the upper Sacramento River. Shasta Reservoir, located about 16 km (10 mi) north of the City of Redding at the confluence of the Pit and upper Sacramento Rivers, began operation in December 1943 as the key unit of the federal

TABLE 6-1A

GLENN RESERVOIR PLAN

STONY CREEK

Units in 1 000 dam^3

Source of Data: Division of Planning

Total Glenn Reservoir Inflow
Potentially Storable

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	3	1	11	12	84	41	58	48	14	1	0	0	273
	-11	-2	7	9	80	37	43	22	-21	-41	-34	-25	64
1923	1	13	59	54	27	15	38	13	4	0	0	6	230
	-12	9	56	51	23	11	23	-14	-31	-42	-35	-18	21
1924	9	1	2	4	14	4	1	0	5	21	17	0	78
	3	-2	-1	0	10	0	-4	-10	-9	6	5	-4	-6
1925	0	9	21	21	212	47	84	99	19	2	1	2	517
	-4	5	17	17	208	43	69	56	-16	-39	-33	-22	301
1926	2	3	4	27	148	52	89	12	1	0	0	1	339
	-11	-1	0	-18	144	48	74	-14	-33	-42	-35	-23	89
1927	12	29	96	68	316	90	67	31	9	0	0	1	719
	4	26	43	64	312	86	52	5	-26	-42	-35	-23	466
1928	1	8	27	57	109	119	75	17	1	0	0	1	415
	-12	4	23	53	105	114	60	-9	-33	-42	-33	-23	207
1929	2	4	7	7	33	10	14	9	4	0	0	16	106
	-11	0	4	4	30	6	2	-11	-22	-31	-26	2	-53
1930	6	0	25	27	56	84	31	14	2	1	0	1	247
	-1	-4	21	23	25	80	16	-12	-32	-41	-35	-23	17
1931	1	3	0	17	15	20	6	2	1	19	23	11	118
	-12	-1	-4	14	11	16	-4	-14	-21	-7	1	-1	-22
1932	0	1	37	39	16	36	14	26	6	1	0	16	192
	-6	-2	33	36	12	32	-1	0	-28	-41	-35	-9	-9
1933	15	1	4	9	6	28	21	15	11	1	27	21	159
	1	-2	0	5	2	25	9	-6	-15	-29	1	2	-7
1934	0	0	19	31	26	25	23	6	1	37	0	1	169
	-7	-4	15	27	22	21	10	-17	-29	2	-32	-20	-12
1935	2	11	6	48	31	41	90	74	22	1	1	0	327
	-3	7	2	44	-31	37	75	48	-12	-41	-33	-24	69
1936	1	2	4	100	178	55	47	15	10	2	0	19	433
	-12	-1	0	96	174	52	32	-11	-25	-39	-35	-6	225
1937	16	1	1	3	59	84	69	32	6	3	1	1	276
	2	-1	-2	-1	55	80	54	6	-28	-40	-33	-24	68
1938	0	49	164	64	265	306	124	94	32	5	1	3	1107
	-14	46	160	60	261	302	109	68	-2	-37	-33	-22	898
1939	1	2	9	11	14	25	10	4	0	1	0	1	78
	-12	-1	5	7	8	21	-3	-17	-27	-32	-27	-17	-95
1940	6	0	6	127	280	143	77	24	5	1	1	1	671
	-2	-4	3	123	276	139	62	-2	-30	-41	-33	-23	468
1941	1	4	160	313	323	284	224	94	28	3	0	3	1437
	-12	-1	157	310	319	280	210	68	-6	-39	-35	-22	1229
1942	1	4	111	193	241	58	139	64	15	1	1	1	829
	-34	-5	107	189	237	54	125	38	-20	-41	-33	-10	607
1943	1	11	49	201	63	82	33	26	6	3	1	1	477
	-35	2	46	197	59	78	18	0	-28	-39	-33	-23	242
1944	3	1	2	11	41	63	35	39	7	3	1	3	209
	-11	-2	-1	7	37	59	19	13	-27	-39	-33	-22	0
1945	1	10	30	31	95	33	37	15	4	1	1	2	260
	-12	6	26	9	91	29	22	-11	-31	-41	-33	-22	33
1946	1	19	184	90	27	26	22	7	3	3	1	2	385
	-12	15	180	86	23	22	7	-19	-32	-39	-33	-22	176

TABLE 6-1A

STONY CREEK

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	1	7	10	4	46	63	22	0	3	2	2	0	160
	-12	4	6	0	42	59	7	-26	-32	-39	-32	-25	-48
1948	1	3	0	26	11	19	95	48	20	1	0	2	226
	-12	-1	-3	22	7	15	80	22	-15	-41	-35	-22	17
1949	1	0	7	6	27	164	69	27	4	1	3	3	312
	-12	-3	4	2	21	160	54	1	-31	-41	-32	-22	101
1950	1	1	1	39	73	48	43	26	8	1	0	1	242
	-12	-2	-2	34	69	44	28	0	-27	-41	-35	-23	33
1951	5	38	120	124	116	57	25	41	6	2	0	1	535
	-9	34	116	121	112	53	10	15	-28	-39	-35	-23	327
1952	1	4	121	180	172	111	90	70	17	1	0	0	767
	-12	0	117	176	168	107	75	44	-17	-41	-34	-24	559
1953	1	2	126	289	47	52	54	53	17	3	0	0	644
	-12	-1	117	285	43	48	39	27	-17	-39	-35	-25	430
1954	0	2	9	120	101	79	90	27	7	4	0	1	440
	-13	-1	5	116	97	75	75	1	-27	-38	-35	-23	232
1955	10	23	52	28	16	15	25	27	4	5	0	1	206
	-4	20	43	25	11	11	10	1	-31	-37	-35	-23	-9
1956	1	3	236	243	174	81	54	52	17	6	3	1	871
	-12	-1	232	239	170	77	39	26	-17	-36	-32	-23	662
1957	2	1	2	20	94	79	28	36	9	0	0	25	296
	-11	-2	-1	14	69	75	13	10	-26	-42	-35	0	64
1958	27	17	40	142	592	205	168	83	23	6	1	0	1304
	14	13	36	138	588	201	153	57	-11	-36	-33	-25	1095
1959	2	4	5	68	120	51	22	7	1	0	28	26	334
	-11	0	1	64	116	47	7	-18	-33	-41	-6	1	127
1960	0	0	4	12	135	83	23	20	5	0	0	22	304
	-4	-4	0	9	131	79	9	-6	-30	-42	-35	-2	105
1961	16	7	41	31	71	50	30	20	4	0	0	0	270
	2	4	37	27	68	47	15	-6	-31	-42	-34	-25	62
1962	16	5	20	6	121	94	50	19	5	1	0	2	339
	2	1	16	2	117	90	36	-7	-29	-41	-34	-22	131
1963	26	6	42	42	207	74	176	52	12	4	0	0	641
	12	2	38	38	204	70	162	26	-22	-38	-34	-25	433
1964	2	27	11	36	21	13	9	5	0	0	14	25	163
	-11	23	7	32	-6	10	-6	-21	-34	-42	-21	0	-69
1965	11	25	298	239	60	31	130	25	0	0	0	0	819
	-1	21	295	236	57	27	115	-1	-35	-42	-35	-25	612
1966	0	42	26	142	80	54	42	16	1	0	0	0	403
	-13	38	-12	138	76	51	27	-10	-33	-42	-35	-25	160
1967	10	24	97	224	83	67	81	70	43	0	0	0	699
	-4	20	94	221	79	63	67	44	9	-42	-35	-25	491
1968	1	5	19	101	175	58	17	11	5	0	20	26	438
	-12	1	-3	97	171	54	2	-15	-29	-42	-14	1	211
1969	7	8	57	278	260	160	100	58	16	0	0	0	944
	0	4	53	274	257	157	85	32	-19	-42	-35	-25	741
1970	4	4	96	502	111	81	21	14	4	1	0	12	850
	-10	0	93	498	107	78	6	-12	-31	-41	-35	-12	641
1971	16	38	125	165	48	109	59	28	12	5	3	1	609
	2	35	121	162	44	105	44	2	-22	-37	-32	-23	401
TOTAL	248	483	2603	4632	5640	3669	2951	1615	459	153	151	263	22867
	-391	292	2307	4382	5311	3475	2231	343	-1202	-1861	-1513	-889	12485
AVERAGE	5	10	52	93	113	73	59	32	9	3	3	5	457
	-8	6	46	88	106	69	45	7	-24	-37	-30	-18	250

TABLE 6-1B

GLENN RESERVOIR PLAN

STONY CREEK

Units in 1,000 ac-ft

Total Glenn Reservoir Inflow / Potentially Storable

Source of Data: Division of Planning

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	2	1	9	10	68	33	47	39	11	1	0	0	221
	-9	-2	6	7	65	30	35	18	-17	-33	-28	-20	52
1923	1	10	48	44	22	12	31	10	3	0	0	5	186
	-10	7	45	41	19	9	19	-11	-25	-34	-28	-15	17
1924	7	1	2	3	11	3	1	0	4	17	14	0	63
	2	-2	-1	0	8	0	-3	-8	-7	5	4	-3	-5
1925	0	7	17	17	172	38	68	80	15	2	1	2	419
	-3	4	14	14	169	35	56	45	-13	-32	-27	-18	244
1926	2	2	3	22	120	42	72	10	1	0	0	1	275
	-9	-1	0	-15	117	39	60	-11	-27	-34	-28	-19	72
1927	10	24	78	55	256	73	54	25	7	0	0	1	583
	3	21	35	52	253	70	42	4	-21	-34	-28	-19	378
1928	1	6	22	46	88	96	61	14	1	0	0	1	336
	-10	3	19	43	85	93	49	-7	-27	-34	-27	-19	168
1929	2	3	6	6	27	8	11	7	3	0	0	13	86
	-9	0	3	3	24	5	2	-9	-18	-25	-21	2	-43
1930	5	0	20	22	45	68	25	11	2	1	0	1	200
	-1	-3	17	19	20	65	13	-10	-26	-33	-28	-19	14
1931	1	2	0	14	12	16	5	2	1	15	19	9	96
	-10	-1	-3	11	9	13	-3	-11	-17	-6	1	-1	-18
1932	0	1	30	32	13	29	11	21	5	1	0	13	156
	-5	-2	27	29	10	26	-1	0	-23	-33	-28	-7	-7
1933	12	1	3	7	5	23	17	12	9	1	22	17	129
	1	-2	0	4	2	20	7	-5	-12	-24	1	2	-6
1934	0	0	15	25	21	20	19	5	1	30	0	1	137
	-6	-3	12	22	18	17	8	-14	-24	2	-26	-16	-10
1935	1	9	5	39	25	33	73	60	18	1	1	0	265
	-3	6	2	36	-25	30	61	39	-10	-33	-27	-20	56
1936	1	2	3	81	144	45	38	12	8	2	0	15	351
	-10	-1	0	78	141	42	26	-9	-20	-32	-28	-5	182
1937	13	1	1	2	48	68	56	26	5	2	1	1	224
	2	-2	-2	-1	45	65	44	5	-23	-32	-27	-19	55
1938	0	40	133	52	215	248	100	76	26	4	1	2	897
	-11	37	130	49	212	245	88	55	-2	-30	-27	-18	728
1939	1	2	7	9	11	20	8	3	0	1	0	1	63
	-10	-1	4	6	7	17	-2	-14	-22	-26	-22	-14	-77
1940	5	0	5	103	227	116	62	19	4	1	1	1	544
	-2	-3	2	100	224	113	50	-2	-24	-33	-27	-19	379
1941	1	3	130	254	262	230	182	76	23	2	0	2	1165
	-10	0	127	251	259	227	170	55	-5	-32	-28	-18	996
1942	1	3	90	156	195	47	113	52	12	1	1	1	672
	-28	-4	87	153	192	44	101	31	-16	-33	-27	-8	492
1943	1	9	40	163	51	66	27	21	5	2	1	1	387
	-28	2	37	160	48	63	15	0	-23	-32	-27	-19	196
1944	2	1	2	9	33	51	28	32	6	2	1	2	169
	-9	-2	-1	6	30	48	16	11	-22	-32	-27	-18	0
1945	1	8	24	25	77	27	30	12	3	1	1	2	211
	-10	5	21	7	74	24	18	-9	-25	-33	-27	-18	27
1946	1	15	149	73	22	21	18	6	2	2	1	2	312
	-10	12	146	70	19	18	6	-15	-26	-32	-27	-18	143

TABLE 6-1B

STONY CREEK

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	1	6	8	3	37	51	18	0	2	2	2	0	130
	-10	3	5	0	34	48	6	-21	-26	-32	-26	-20	-39
1948	1	2	0	21	9	15	77	39	16	1	0	2	183
	-10	-1	-3	18	6	12	65	18	-12	-33	-28	-18	14
1949	1	0	6	5	22	133	56	22	3	1	2	2	253
	-10	-3	3	2	17	130	44	1	-25	-33	-26	-18	82
1950	1	1	1	31	59	39	35	21	6	1	0	1	196
	-10	-2	-2	28	56	36	23	0	-22	-33	-28	-19	27
1951	4	31	97	101	94	46	20	33	5	2	0	1	434
	-7	28	94	98	91	43	8	12	-23	-32	-28	-19	265
1952	1	3	98	146	139	90	73	57	14	1	0	0	622
	-10	0	95	143	136	87	61	36	-14	-33	-28	-20	453
1953	1	2	102	234	38	42	44	43	14	2	0	0	522
	-10	-1	95	231	35	39	32	22	-14	-32	-28	-20	349
1954	0	2	7	97	82	64	73	22	6	3	0	1	357
	-11	-1	4	94	79	61	61	1	-22	-31	-28	-19	188
1955	8	19	42	23	13	12	20	22	3	4	0	1	167
	-3	16	35	20	9	9	8	1	-25	-30	-28	-19	-7
1956	1	2	191	197	141	66	44	42	14	5	2	1	706
	-10	-1	188	194	138	63	32	21	-14	-29	-26	-19	537
1957	2	1	2	16	76	64	23	29	7	0	0	20	240
	-9	-2	-1	11	56	61	11	8	-21	-34	-28	0	52
1958	22	14	32	115	480	166	136	67	19	5	1	0	1057
	11	11	29	112	477	163	124	46	-9	-29	-27	-20	888
1959	2	3	4	55	97	41	18	6	1	0	23	21	271
	-9	0	1	52	94	38	6	-15	-27	-33	-5	1	103
1960	0	0	3	10	109	67	19	16	4	0	0	18	246
	-3	-3	0	7	106	64	7	-5	-24	-34	-28	-2	85
1961	13	6	33	25	58	41	24	16	3	0	0	0	219
	2	3	30	22	55	38	12	-5	-25	-34	-28	-20	50
1962	13	4	16	5	98	76	41	15	4	1	0	2	275
	2	1	13	2	95	73	29	-6	-24	-33	-28	-18	106
1963	21	5	34	34	168	60	143	42	10	3	0	0	520
	10	2	31	31	165	57	131	21	-18	-31	-28	-20	351
1964	2	22	9	29	17	11	7	4	0	0	11	20	132
	-9	19	6	26	-5	8	-5	-17	-28	-34	-17	0	-56
1965	9	20	242	194	49	25	105	20	0	0	0	0	664
	-1	17	239	191	46	22	93	-1	-28	-34	-28	-20	496
1966	0	34	21	115	65	44	34	13	1	0	0	0	327
	-11	31	-10	112	62	41	22	-8	-27	-34	-28	-20	130
1967	8	19	79	182	67	54	66	57	35	0	0	0	567
	-3	16	76	179	64	51	54	36	7	-34	-28	-20	398
1968	1	4	15	82	142	47	14	9	4	0	16	21	355
	-10	1	-3	79	139	44	2	-12	-24	-34	-12	1	171
1969	6	6	46	225	211	130	81	47	13	0	0	0	765
	0	3	43	222	208	127	69	26	-15	-34	-28	-20	601
1970	3	3	78	407	90	66	17	11	3	1	0	10	689
	-8	0	75	404	87	63	5	-10	-25	-33	-28	-10	520
1971	13	31	101	134	39	88	48	23	10	4	2	1	494
	2	28	98	131	36	85	36	2	-18	-30	-26	-19	325
TOTAL	205	391	2109	3755	4570	2971	2393	1307	372	125	124	216	18538
	-322	233	1868	3554	4311	2821	1813	279	-978	-1498	-1235	-724	10122
AVERAGE	4	8	42	75	92	59	48	26	7	3	3	4	371
	-6	5	37	71	86	56	36	6	-20	-30	-24	-14	203

Central Valley Project (CVP). This multi-purpose 5 610 000-dam^3 (4,550,000-ac-ft) reservoir provides flood protection, water supply, navigation, hydroelectric power, recreation, fishery, and water quality benefits. Keswick Dam and Reservoir was constructed below Shasta Dam to serve as an afterbay and to provide additional hydroelectric power. Trinity Dam and Clair Engle Lake and Lewiston Reservoir were constructed by the Bureau of Reclamation to divert Trinity River water to the Sacramento River Basin for power generation and additional CVP water supply. Trinity River water is transferred from Lewiston Reservoir via a 17.4-km (10.8 mi) tunnel to the Judge Francis Carr Power Plant, which discharges to Whiskeytown Reservoir on Clear Creek. From Whiskeytown Reservoir, water is diverted through the Spring Creek Power Plant to Keswick Reservoir for release to the Sacramento River. Since diversions began in April 1963, interbasin transfers to Whiskeytown Reservoir have averaged 1 540 000 dam^3 (1,250,000 ac-ft) per year.

In 1970, Congress authorized the Corps of Engineers to construct the Cottonwood Creek Project on Cottonwood Creek, which enters the Sacramento River about 48 km (30 mi) upstream of Red Bluff. The Corps' present plan calls for the construction of Dutch Gulch Reservoir on Cottonwood Creek and Tehama Reservoir on the South Fork of Cottonwood Creek. Combined, the two reservoirs would have a total storage of about 1 970 000 dam^3 (1,600,000 ac-ft), with up to 456 000 dam^3 (370,000 ac-ft) reserved for flood control. The Department of Water Resources expects to purchase conservation storage space in the Cottonwood Project Reservoirs, under terms of the Water Supply Act of 1958. That storage space would be operated to provide municipal and industrial yield for the State Water Project. Preliminary studies indicate that new yield from the Cottonwood Creek Project would have averaged 250 000 dam^3 (204,000 ac-ft) per year during the historic May 1928 through October 1934 critically dry period and 221 000 dam^3 (179,000 ac-ft) per year over the 1922-71 base period. This Cottonwood Creek Project operation was incorporated into the hydrologic base study that indirectly determined the total and potentially storable Sacramento River flows for the Glenn Reservoir Plan.

The Bureau constructed the Red Bluff Diversion Dam in the mid-1960s to serve as a diversion pool for the Tehama-Colusa and Corning Canals. The Glenn Reservoir Plan would also divert at Red Bluff Diversion Dam. Table 6-2 tabulates the total monthly Sacramento River flow above the Red Bluff Diversion Dam and potentially storable amounts for the 50-year hydrologic base period. The total monthly flow values represent the projected flow above the Red Bluff Diversion Dam during a repetition of the 1922-71 historic hydrologic sequence under expected year 2000 conditions. The potentially storable amounts represent water above the Red Bluff Diversion Dam that would be surplus to all environmental needs and prior rights within the Sacramento River Basin and the Sacramento-San Joaquin Delta.

Analysis of Table 6-2 shows that 93 percent of potentially storable flows at Red Bluff occur during the December through April period. Over the 50-year (600-month) study period, only 174 months showed storable surplus water at Red Bluff. Daily flow analyses of those 174 months were conducted to determine how much of the surplus water could have been diverted with diversions of various capacities. In the daily flow analyses, mandatory

TABLE 6-2A

GLENN RESERVOIR PLAN

SACRAMENTO RIVER

Units in 1 000 dam^3

Total Flow Above Red Bluff Diversion Dam
Potentially Storable

Source of Data: Division of Planning 2000 Level Operation Study

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	521	509	466	339	635	412	460	649	918	1061	855	538	7363
	0	0	85	0	362	101	0	0	0	0	0	0	548
1923	374	609	665	490	295	303	461	795	1088	1129	1066	392	7667
	0	122	362	186	21	0	0	0	0	0	0	0	691
1924	352	354	344	316	365	439	558	403	583	897	678	412	5701
	0	0	0	0	81	0	0	0	0	0	0	0	81
1925	365	416	363	371	1370	406	945	759	1383	1946	1388	493	10205
	0	0	0	0	1043	0	422	0	0	0	0	0	1465
1926	383	423	601	423	874	380	422	729	886	1416	1125	517	8179
	0	0	0	0	601	0	0	0	0	0	0	0	601
1927	358	468	696	634	2469	702	1284	1067	1063	1349	1035	497	11622
	0	27	0	321	2195	391	956	252	0	0	0	0	4142
1928	391	495	518	432	731	2089	860	783	995	1346	1341	516	10497
	0	0	0	49	448	1779	433	0	0	0	0	0	2709
1929	392	416	353	298	475	306	546	831	841	1272	1008	542	7280
	0	0	0	0	117	0	0	0	0	0	0	0	117
1930	421	553	435	458	486	585	499	731	792	1114	1050	481	7605
	0	0	0	154	0	274	0	0	0	0	0	0	428
1931	375	342	524	423	319	564	738	383	602	987	881	388	6526
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	337	343	635	413	292	286	511	510	760	887	813	392	6179
	0	0	0	89	8	0	0	0	0	0	0	0	97
1933	323	675	377	417	303	684	527	632	709	928	748	397	6720
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	332	466	423	470	411	312	403	455	618	974	806	386	6056
	0	0	0	69	0	0	0	0	0	0	0	0	69
1935	342	503	310	710	382	528	767	616	1241	1611	1014	739	8763
	0	0	0	5	0	195	439	0	0	0	0	0	639
1936	485	376	367	893	677	340	447	802	1177	1568	1109	496	8737
	0	0	0	472	394	0	0	0	0	0	0	0	866
1937	396	358	533	350	646	771	358	706	1093	1368	995	540	8114
	0	0	0	0	373	460	0	0	0	0	0	0	833
1938	374	765	1472	577	3027	3498	1116	792	786	951	872	630	14860
	0	210	1168	274	2753	3187	788	380	0	0	0	0	8760
1939	760	598	419	312	302	417	750	643	838	1182	1000	453	7674
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	366	478	641	866	2941	2281	565	625	1088	1530	1029	481	12891
	0	0	0	350	1840	1970	237	0	0	0	0	0	4397
1941	355	394	1519	3055	2833	2103	1797	1337	929	1156	1357	402	17237
	0	0	1215	2752	2560	1792	1469	877	0	0	0	0	10665
1942	720	594	2002	2228	3157	348	1132	1335	889	1110	1029	524	15068
	0	0	1699	1924	2883	27	802	740	6	0	0	0	8081
1943	707	655	638	1802	851	1484	875	883	1143	1329	1031	550	11948
	0	0	180	1499	577	1173	547	0	0	0	0	0	3976
1944	527	592	645	320	380	333	553	697	898	1327	1026	529	7827
	0	0	0	0	96	22	0	0	0	0	0	0	118
1945	390	465	421	364	622	444	406	667	856	1248	988	539	7410
	0	0	0	0	348	133	0	0	0	0	0	0	481
1946	372	443	2410	1028	299	315	659	794	1199	1586	1048	479	10632
	0	0	2107	724	25	0	0	0	0	0	0	0	2856
1947	399	371	332	344	344	392	501	665	1134	1315	1025	503	7325
	0	0	0	0	46	75	0	0	0	0	0	0	121

TABLE 6-2A

SACRAMENTO RIVER

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1948	384	371	448	543	486	694	705	944	776	1288	1052	482	8173
	0	0	0	0	0	0	377	532	0	0	0	0	909
1949	370	466	377	349	354	1550	522	707	891	1224	918	491	8219
	0	0	0	0	0	1240	0	0	0	0	0	0	1240
1950	418	355	539	489	549	385	519	811	899	1185	894	491	7534
	0	0	0	31	275	20	0	0	0	0	0	0	326
1951	403	1064	1638	1155	1632	540	693	974	892	1139	1002	416	11548
	0	624	1335	851	1296	221	0	347	0	0	0	0	4674
1952	347	607	2035	1402	1871	1500	1731	1140	815	889	1141	664	14142
	0	0	1732	1097	1587	1189	1320	476	70	0	0	0	7471
1953	692	555	1454	3455	342	646	915	1258	1003	1087	945	574	12926
	181	0	1032	3152	68	336	37	464	0	0	0	0	5270
1954	709	789	373	1597	1998	1415	1284	920	1161	1346	986	509	13087
	0	0	0	455	1725	1104	956	0	0	0	0	0	4240
1955	382	476	785	412	290	313	569	838	1254	1361	951	477	8108
	0	0	407	109	0	0	0	0	0	0	0	0	516
1956	387	443	2657	3920	2292	650	617	1343	757	989	982	626	15663
	0	0	2353	3617	2008	339	0	639	0	0	0	0	8956
1957	794	586	284	322	1152	1113	569	1270	918	1111	1060	419	9598
	0	0	0	0	799	802	0	408	0	0	0	0	2009
1958	802	829	1002	1639	6000	2525	1653	941	1011	961	1100	768	19231
	38	0	308	1262	5726	2214	1325	344	370	0	0	0	11587
1959	770	590	349	1215	1549	347	728	696	965	1311	1158	421	10099
	0	0	0	733	1275	0	0	0	0	0	0	0	2008
1960	421	382	791	358	611	978	719	714	1296	1488	1185	487	9430
	0	0	0	0	327	667	0	0	0	0	0	0	994
1961	428	432	522	356	724	748	639	780	1104	1510	1175	474	8892
	0	0	0	0	450	157	0	0	0	0	0	0	607
1962	429	404	533	363	2011	518	624	1031	1236	1238	898	474	9759
	0	0	0	0	1737	207	0	0	0	0	0	0	1944
1963	526	483	955	369	1161	807	3020	865	962	1259	1029	455	11891
	44	0	389	0	887	496	2691	189	0	0	0	0	4696
1964	389	1013	334	582	279	385	1201	734	995	1254	1044	442	8652
	0	239	0	267	0	0	0	0	0	0	0	0	506
1965	390	496	1586	2383	364	320	1794	882	979	1132	951	428	11705
	0	0	1089	2081	90	0	1465	139	0	0	0	0	4864
1966	434	1020	449	870	730	1242	845	762	924	1239	1140	476	10131
	0	252	0	471	435	513	0	0	0	0	0	0	1671
1967	419	504	1409	1467	817	1627	1362	1537	974	856	1079	677	12728
	0	0	1105	1106	543	1316	1034	902	353	0	0	0	6359
1968	702	561	382	587	2285	696	480	687	1090	1399	921	521	10311
	0	0	0	50	2001	385	0	0	0	0	0	0	2436
1969	375	396	999	2908	2584	909	1367	1240	775	860	1078	725	14216
	0	0	654	2071	1891	598	971	471	123	0	0	0	6779
1970	782	595	1782	5938	1660	613	471	597	1009	1193	1142	489	16271
	60	0	1479	5283	1387	302	0	0	0	0	0	0	8511
1971	550	855	2028	1860	502	2098	640	1314	931	1016	991	676	13461
	0	60	1675	1557	228	1778	9	592	0	0	0	0	5899
TOTAL	23420	26935	41821	52873	57730	43341	41805	42273	48127	60921	51137	25478	515861
	325	1534	20374	33059	41506	25463	16277	7751	923	0	0	0	147212
AVERAGE	468	539	836	1057	1154	867	836	846	963	1218	1023	510	10317
	7	31	407	661	830	509	326	155	18	0	0	0	2944

TABLE 6-2B

GLENN RESERVOIR PLAN

SACRAMENTO RIVER

Units in 1,000 ac-ft

Total Flow Above Red Bluff Diversion Dam
Potentially Storable

Source of Data: Division of Planning 2000 Level Operation Study

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1922	422	413	378	275	515	334	373	526	744	860	693	436	5969
	0	0	69	0	293	82	0	0	0	0	0	0	444
1923	303	494	539	397	239	246	374	645	882	915	864	318	6216
	0	99	293	151	17	0	0	0	0	0	0	0	560
1924	285	287	279	256	296	356	452	327	473	727	550	334	4622
	0	0	0	0	66	0	0	0	0	0	0	0	66
1925	296	337	294	301	1111	329	766	615	1121	1578	1125	400	8273
	0	0	0	0	846	0	342	0	0	0	0	0	1188
1926	311	343	487	343	709	308	342	591	718	1148	912	419	6631
	0	0	0	0	487	0	0	0	0	0	0	0	487
1927	290	379	564	514	2002	569	1041	865	862	1094	839	403	9422
	0	22	0	260	1780	317	775	204	0	0	0	0	3358
1928	317	401	420	350	593	1694	697	635	807	1091	1087	418	8510
	0	0	0	40	363	1442	351	0	0	0	0	0	2196
1929	318	337	286	242	385	248	443	674	682	1031	817	439	5902
	0	0	0	0	95	0	0	0	0	0	0	0	95
1930	341	448	353	371	394	474	405	593	642	903	851	390	6165
	0	0	0	125	0	222	0	0	0	0	0	0	347
1931	304	277	425	343	259	457	598	311	488	800	714	315	5291
	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	273	278	515	335	237	232	414	413	616	719	659	318	5009
	0	0	0	72	7	0	0	0	0	0	0	0	79
1933	262	547	306	338	246	555	427	512	575	752	606	322	5448
	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	269	378	343	381	333	253	327	369	501	790	653	313	4910
	0	0	0	56	0	0	0	0	0	0	0	0	56
1935	277	408	251	576	310	428	622	499	1006	1306	822	599	7104
	0	0	0	4	0	158	356	0	0	0	0	0	518
1936	393	305	298	724	549	276	362	650	954	1271	899	402	7083
	0	0	0	383	319	0	0	0	0	0	0	0	702
1937	321	290	432	284	524	625	290	572	886	1109	807	438	6578
	0	0	0	0	302	373	0	0	0	0	0	0	675
1938	303	620	1193	468	2454	2836	905	642	637	771	707	511	12047
	0	170	947	222	2232	2584	639	308	0	0	0	0	7102
1939	616	485	340	253	245	338	608	521	679	958	811	367	6221
	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	297	388	520	702	2384	1849	458	507	882	1240	834	390	10451
	0	0	0	284	1492	1597	192	0	0	0	0	0	3565
1941	288	319	1231	2477	2297	1705	1457	1084	753	937	1100	326	13974
	0	0	985	2231	2075	1453	1191	711	0	0	0	0	8646
1942	584	482	1623	1806	2559	282	918	1082	721	900	834	425	12216
	0	0	1377	1560	2337	22	650	600	5	0	0	0	6551
1943	573	531	517	1461	690	1203	709	716	927	1077	836	446	9686
	0	0	146	1215	468	951	443	0	0	0	0	0	3223
1944	427	480	523	259	308	270	448	565	728	1076	832	429	6345
	0	0	0	0	78	18	0	0	0	0	0	0	96
1945	316	377	341	295	504	360	329	541	694	1012	801	437	6007
	0	0	0	0	282	108	0	0	0	0	0	0	390
1946	302	359	1954	833	242	255	534	644	972	1286	850	388	8619
	0	0	1708	587	20	0	0	0	0	0	0	0	2315

TABLE 6-2B

SACRAMENTO RIVER

WATER YEAR	OCT	NOV	DEC	JAN	FEB	AMR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1947	323	301	269	279	279	318	406	539	919	1066	831	408	5938
	0	0	0	0	37	61	0	0	0	0	0	0	98
1948	311	301	363	440	394	563	572	765	629	1044	853	391	6626
	0	0	0	0	0	0	306	431	0	0	0	0	737
1949	300	378	306	283	287	1257	423	573	722	992	744	398	6663
	0	0	0	0	0	1005	0	0	0	0	0	0	1005
1950	339	288	437	396	445	312	421	657	729	961	725	398	6108
	0	0	0	25	223	16	0	0	0	0	0	0	264
1951	327	863	1328	936	1323	438	562	790	723	923	812	337	9362
	0	506	1082	690	1051	179	0	281	0	0	0	0	3789
1952	281	492	1650	1137	1517	1216	1403	924	661	721	925	538	11465
	0	0	1404	889	1287	964	1070	386	57	0	0	0	6057
1953	561	450	1179	2801	277	524	742	1020	813	881	766	465	10479
	147	0	837	2555	55	272	30	376	0	0	0	0	4272
1954	575	640	302	1295	1620	1147	1041	746	941	1091	799	413	10610
	0	0	0	369	1398	895	775	0	0	0	0	0	3437
1955	310	386	636	334	235	254	461	679	1017	1103	771	387	6573
	0	0	330	88	0	0	0	0	0	0	0	0	418
1956	314	359	2154	3178	1858	527	500	1089	614	802	796	507	12698
	0	0	1908	2932	1628	275	0	518	0	0	0	0	7261
1957	644	475	230	261	934	902	461	1030	744	901	859	340	7781
	0	0	0	0	648	650	0	331	0	0	0	0	1629
1958	650	672	812	1329	4864	2047	1340	763	820	779	892	623	15591
	31	0	250	1023	4642	1795	1074	279	300	0	0	0	9394
1959	624	478	284	985	1256	281	590	564	782	1063	939	341	8187
	0	0	0	594	1034	0	0	0	0	0	0	0	1628
1960	341	310	641	290	495	793	583	579	1051	1206	961	395	7645
	0	0	0	0	265	541	0	0	0	0	0	0	806
1961	347	350	423	289	587	606	518	632	895	1225	953	384	7209
	0	0	0	0	365	127	0	0	0	0	0	0	492
1962	348	328	432	294	1630	420	506	836	1002	1004	728	384	7912
	0	0	0	0	1408	168	0	0	0	0	0	0	1576
1963	427	392	774	299	941	654	2448	701	780	1021	834	369	9640
	36	0	315	0	719	402	2182	153	0	0	0	0	3807
1964	315	821	271	472	226	312	974	595	807	1017	846	358	7014
	0	194	0	216	0	0	0	0	0	0	0	0	410
1965	316	402	1286	1932	295	259	1454	715	794	918	771	347	9489
	0	0	883	1686	73	0	1188	113	0	0	0	0	3943
1966	352	827	364	705	592	1007	685	618	749	1004	924	386	8213
	0	204	0	382	353	416	0	0	0	0	0	0	1355
1967	340	409	1142	1189	662	1319	1104	1246	790	694	875	549	10319
	0	0	896	897	440	1067	838	731	286	0	0	0	5155
1968	569	455	310	476	1852	564	389	557	884	1134	747	422	8359
	0	0	0	41	1622	312	0	0	0	0	0	0	1975
1969	304	321	810	2358	2095	737	1108	1005	628	697	874	588	11525
	0	0	530	1679	1533	485	787	382	100	0	0	0	5496
1970	634	482	1445	4814	1346	497	382	484	818	967	926	396	13191
	49	0	1199	4283	1124	245	0	0	0	0	0	0	6900
1971	446	693	1644	1508	407	1701	519	1065	755	824	803	548	10913
	0	49	1358	1262	185	1441	7	480	0	0	0	0	4782
TOTAL	18986	21836	33904	42864	46802	35137	33891	34271	39017	49389	41457	20655	418209
	263	1244	16517	26801	33649	20643	13196	6284	748	0	0	0	119345
AVERAGE	380	437	678	857	936	703	678	685	780	988	829	413	8364
	5	25	330	536	673	413	264	126	15	0	0	0	2387

releases from Whiskeytown, Cottonwood, and Shasta Reservoirs for power, fish and wildlife conservation, and navigation (derived from monthly operation studies) were assumed uniform over the month. On the other hand, the monthly values for flood control were distributed among the days of each surplus month on the basis of inspection of historic flow patterns and flood control operating criteria. Daily unregulated tributary flow was based on recorded data.

The daily flow analyses determined the amount of water that could have been pumped in each of the 174 months with pumping capacities of 142 to 396 m^3/s (5,000 to 14,000 ft^3/s), at even intervals of 28 m^3/s (1,000 ft^3/s). The following tabulation lists the minimum flows allowed to remain in the Sacramento River above the Red Bluff Diversion Dam for fish, navigation, and Tehama-Colusa and Corning Canal diversions.

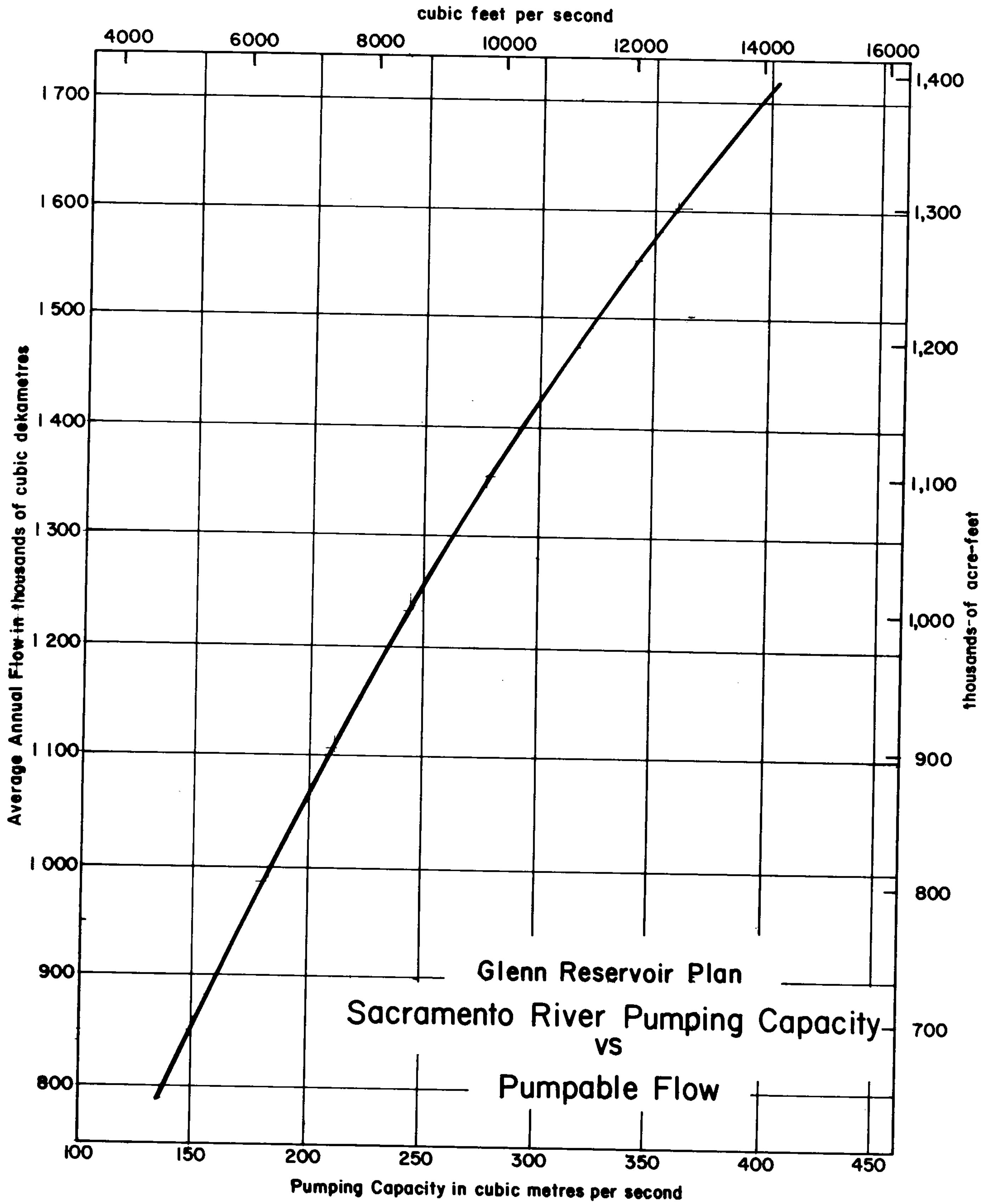
	Minimum Flow	
Month	m^3/s	ft^3/s
October	180	6,360
November	170	6,000
December	113	4,000
January	113	4,000
February	113	4,000
March	116	4,100
April	127	4,470
May	154	5,430
June	166	5,850
July	No surplus	
August	water during	
September	these months.	

During the irrigation season, these minimum flows seldom control because greater releases are usually required to satisfy downstream prior rights.

Figure 6-1 summarizes the average annual pumpable amounts of surplus Sacramento River water over the 50-year study period; it shows that even the largest pumping capacity considered could capture only about 58 percent of the potentially storable flow. (Much of the surplus water at Red Bluff occurs during flood periods and unrealistically large pumping capacity would be necessary to capture a large percentage of it.)

Evaporeservation

As stated in Chapter 2, evaporeservation is a term selected to represent the combined effects of reservoir evaporation and the net increase in water supply attributable to a new reservoir's inundation of vegetation that would have otherwise consumed a part of the rainfall. (These effects are distinct from one another, but they are traditionally combined for ease of calculation in reservoir operation studies.) The values used for the Thomes-Newville Plan studies were also used for the Glenn Reservoir Plan. Evaporation is estimated to average about 1 400 mm (55 in) annually and the increased runoff due to suppression of consumptive use would be about


cubic feet per second
4000
6000
8000
10000
12000
14000
16000
1 700
1 600
1 500
1 400
1 300
1 200
1 100
1 000
900
800
Average Annual Flow in thousands of cubic dekametres
1,400
1,300
1,200
1,100
1,000
900
800
700
thousands of acre-feet
100
150
200
250
300
350
400
450
Pumping Capacity in cubic metres per second
Glenn Reservoir Plan
Sacramento River Pumping Capacity
VS
Pumpable Flow

380 mm (15 in). The combined effect, the evaporeservation, would thus be a net loss from the reservoir surface of about 1 020 mm (40 in) annually; a tabulation of the monthly distribution of evaporeservation is presented in Chapter 2

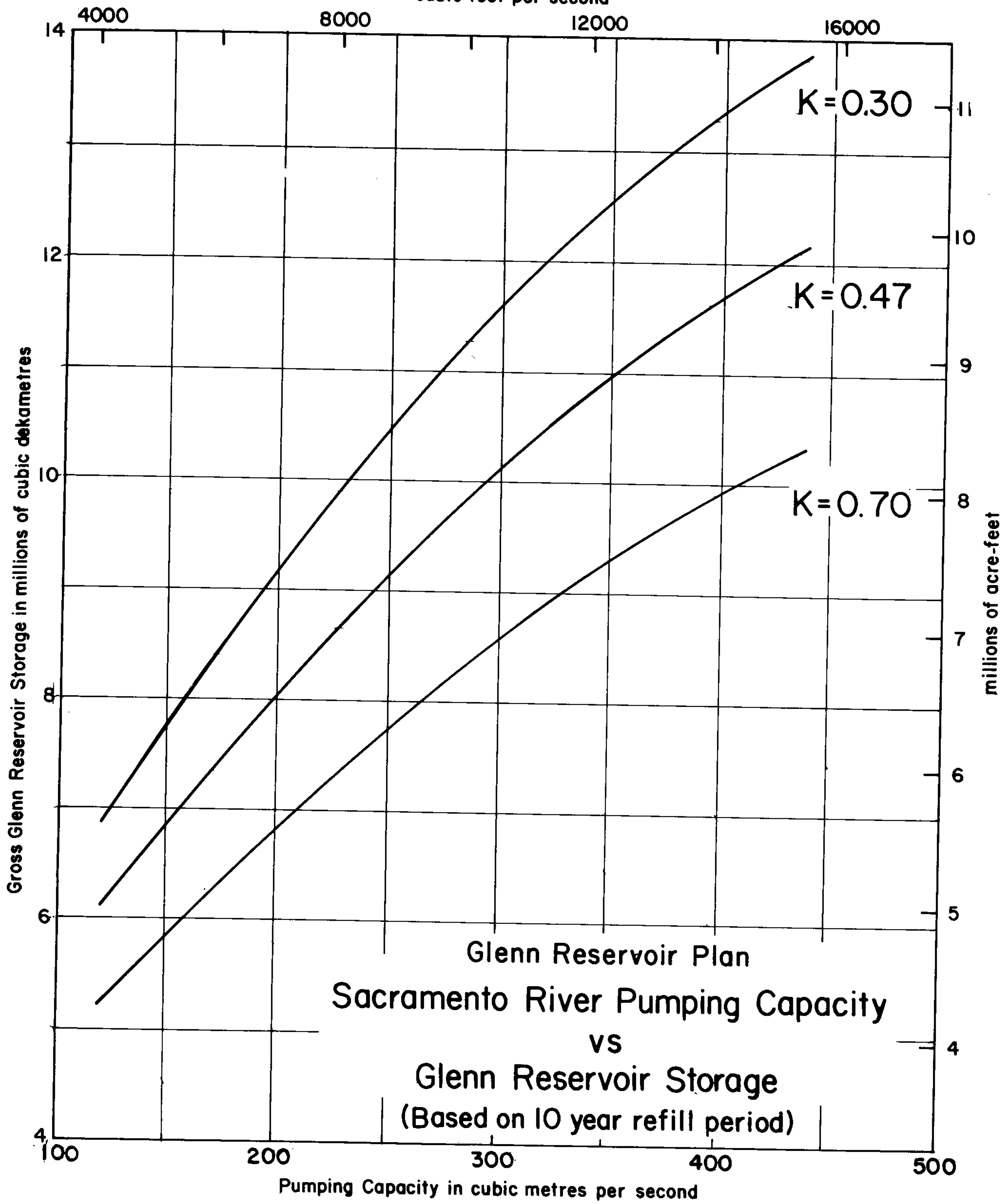
Plan Formulation

Formulation studies of the Glenn Reservoir Plan followed the same general procedures used for the Thomes-Newville Plan. The process was actually somewhat simpler, because the capacity of the Thomes Creek diversion facilities was fixed at the size determined for the Thomes-Newville Plan. The study began by defining the relationship between reservoir storage and river diversion capacity for various operating modes (as expressed by the K factor). For any given K factor and diversion capacity, only one reservoir size will meet the 10-year refill period criterion. This analysis was repeated for a range of diversion capacities and K factors to define the curves shown on Figure 6-2. The storages shown include allowance for 247 000 dam^3 (200,000 ac-ft) of inactive storage. Figure 6-2 shows that the available water supply would justify construction of a very large reservoir (provided the Sacramento River diversion capacity could be enlarged accordingly).

The next step in the formulation process was to define the relationship between reservoir storage and the average annual new yield that could be developed during a repetition of the 1928-34 hydrologic sequence under expected year 2000 conditions. For the Glenn Reservoir Plan, this critical period yield would be primarily a function of storage, but it would also be slightly influenced by the capacity of Sacramento River diversion facilities. (Surplus Sacramento River water would have been available during 6 months of the 1928-34 critical period and the amount of it that could be captured would vary with the size of the diversion facilities.) Figure 6-3 presents the relationship between storage, diversion capacity, and critical period yield. All of the reservoir sizes covered by Figure 6-3 would have filled in the spring of 1928 for the range of K factors under study and the yields shown are those that would result from drawing the reservoir to minimum pool level by the fall of 1934. Critical period yields also include 28 000 dam^3 (23,000 ac-ft) per year that would be derived from emptying Black Butte Reservoir at the end of the critical period. Long-term average annual yield for any particular formulation can be determined by multiplying the annual critical period yield from Figure 6-3 by the selected K factor.

Example Formulations

For a given operating mode, the optimum sizes of Glenn Reservoir and the Sacramento River diversion facilities are determined by the value assigned to critical period yield. (Each increment of size produces an increment of additional yield, but the unit cost of each yield increment is greater than for the preceding increment.) Traditional sizing criteria require a project to be enlarged until the unit cost of the last increment of yield is just equal to the unit value of yield.



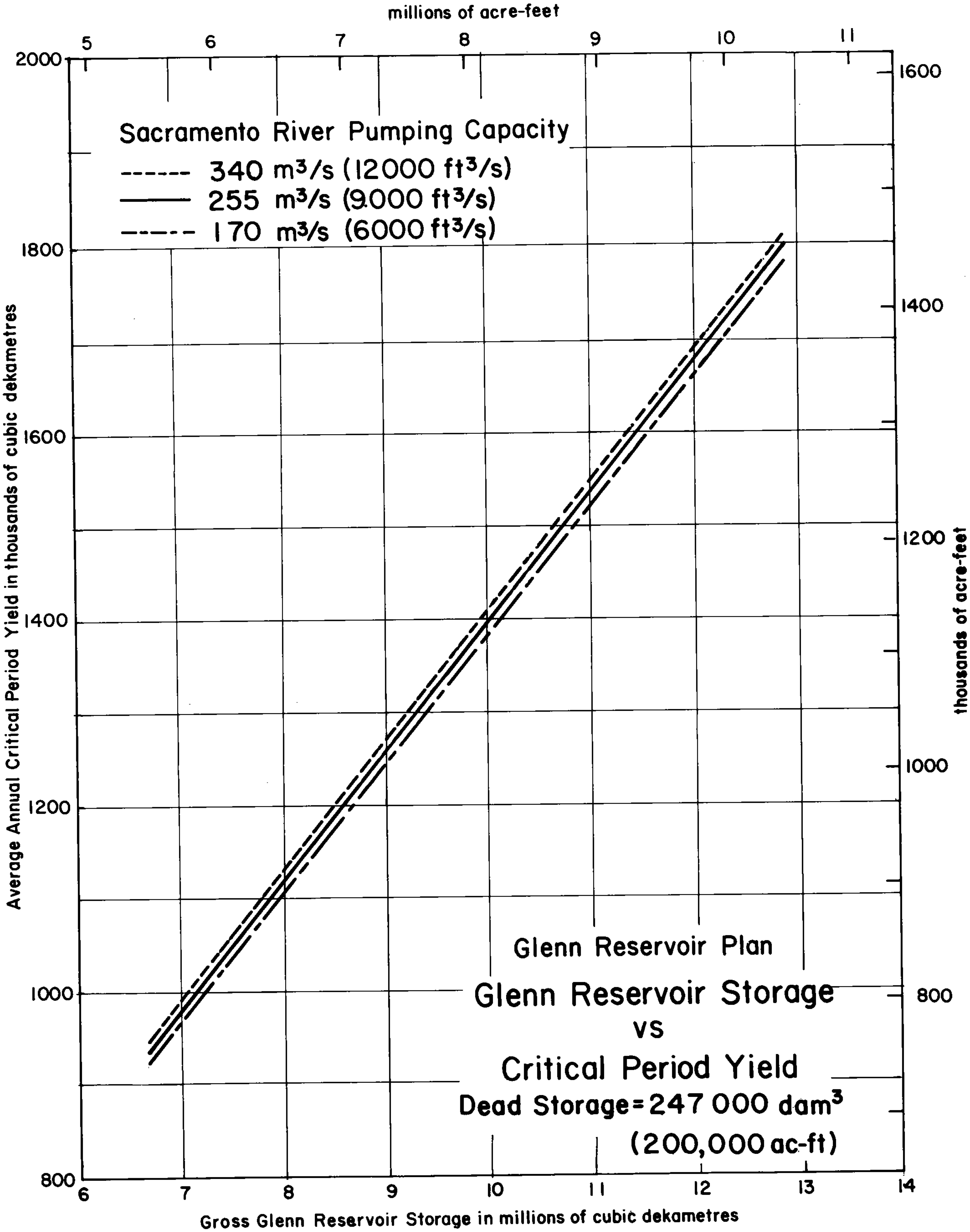
Glenn Reservoir Plan

Sacramento River Pumping Capacity

vs

Glenn Reservoir Storage

(Based on 10 year refill period)


millions of acre-feet
5
6
7
8
9
10
11
2000
1800
1600
1400
1200
1000
800
1600
1400
1200
1000
800
Sacramento River Pumping Capacity
------ 340 m3/s (12000 ft3/s)
—— 255 m3/s (9.000 ft3/s)
--·-- 170 m3/s (6000 ft3/s)
Average Annual Critical Period Yield in thousands of cubic dekametres
thousands of acre-feet
Glenn Reservoir Plan
Glenn Reservoir Storage
vs
Critical Period Yield
Dead Storage = 247 000 dam3
(200,000 ac-ft)
6
7
8
9
10
11
12
13
14
Gross Glenn Reservoir Storage in millions of cubic dekametres

The relationship between unit value of yield and the size of the Glenn Reservoir Plan facilities is summarized on Figures 6-4 and 6-5. These figures are based on preliminary cost estimates (at spring 1978 price levels) for a Glenn Reservoir Plan constructed as a single unit; similar relationships could be developed for a Glenn Reservoir Plan constructed as an expansion of a Thomes-Newville Plan, but such studies have not yet been conducted.

Figure 6-4 shows how the optimum size of Sacramento River pumping facilities varies with the unit value of critical period yield. Similarly, Figure 6-5 shows the realtionship between yield value and optimum Glenn Reservoir storage capacity. (The storage and pumping capacities on these two figures are interrelated as shown by Figure 6-2.) To permit inspection of the full spectrum of sizing possibilities, cost curves were extrapolated so that Figure 6-5 covers reservoir sizes that are considerably larger than the sizes for which detailed cost estimates have been prepared. The upper limit of size for a conventional Glenn Reservoir would be controlled by topographic and geologic conditions along Rocky Ridge, the east rim of the Newville Reservoir compartment. This upper limit has not been precisely defined, although a reservoir elevation of 305 m (1,000 ft) is considered feasible. At that elevation, the gross storage of Glenn Reservoir would be about 10 460 000 dam^3 (8,480,000 ac-ft). The reservoir could be made somewhat larger, but costs would soon begin to increase rapidly as more and larger saddle dams became necessary. For the time being, the larger reservoir sizes shown on Figure 6-5 should be considered only as theoretical possibilities.

Two example plans (for K values of 0.47 and 0.70) were selected for detailed presentation. As indicated on Figures 6-4 and 6-5, these example formulations correspond to the optimum sizes for a unit value of critical period yield of about \$162/dam^3 (\$200/ac-ft). An example formulation is not presented for the K value of 0.3 because the indicated reservoir size would exceed the likely limit of physical feasibility. Detailed studies of the two example formulations are summarized by the following figures and tables:

- Table 6-3 presents pertinent data for each of the example formulations.

- Tables 6-4 and 6-5 (and accompanying explanation of the column headings) summarize long-term average operations.

- Figures 6-6 and 6-7 are graphical presentations of the annual Glenn Reservoir operating range and yield under the two operational modes.

- Table 6-6 illustrates the procedure used to evaluate nominal energy requirements and project yield during the initial filling period. The table is based on average water supply conditions and the assumption that Thomes and Stony Creek water would be stored two years prior to completion of the Sacramento River pumping facilities and the commencement of new yield releases.

Figure 6-4

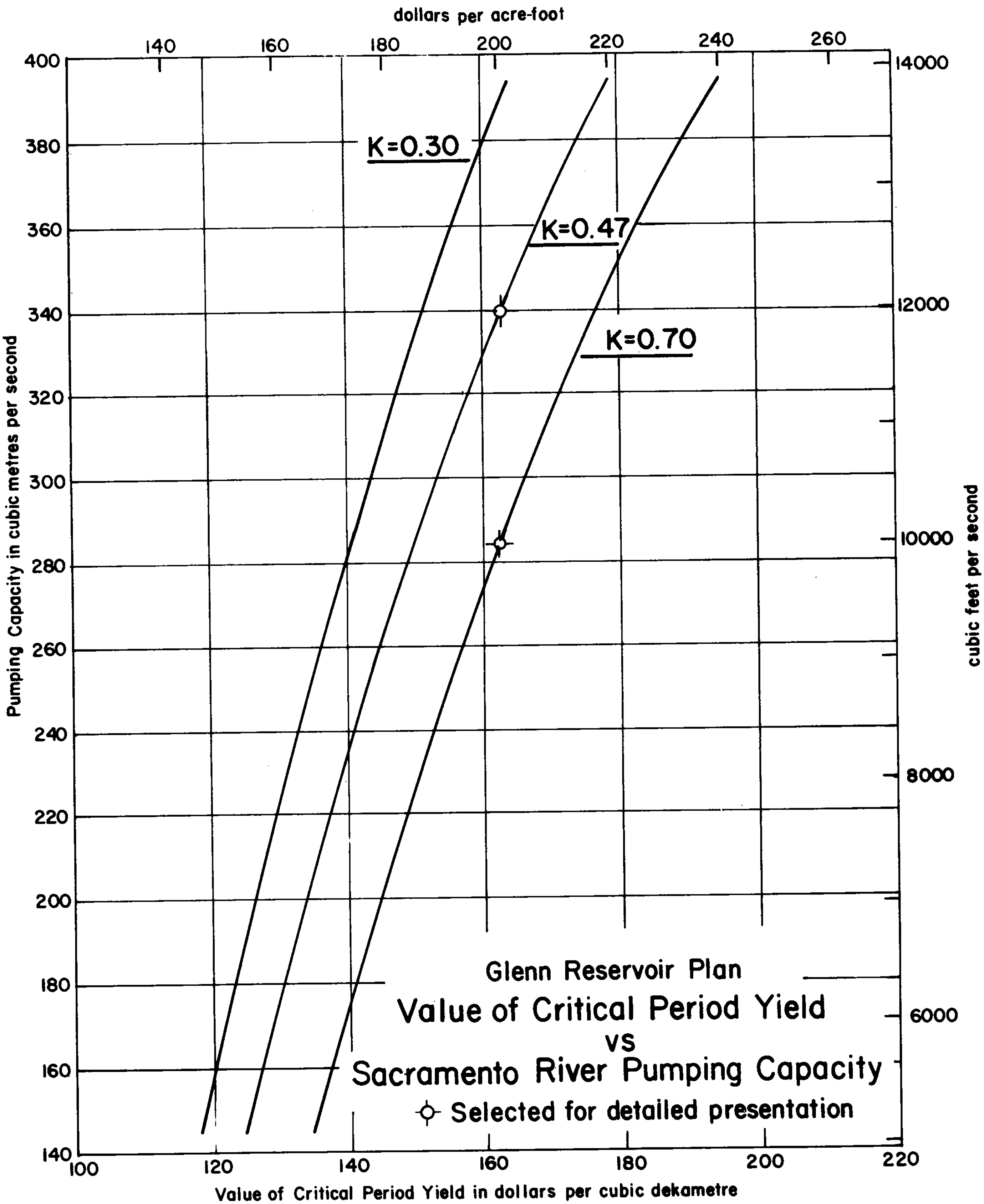

dollars per acre-foot
140
160
180
200
220
240
260
400
380
360
340
320
300
280
260
240
220
200
180
160
140
Pumping Capacity in cubic metres per second
14000
12000
10000
8000
6000
cubic feet per second
K=0.30
K=0.47
K=0.70
100
120
140
160
180
200
220
Value of Critical Period Yield in dollars per cubic dekametre
Glenn Reservoir Plan
Value of Critical Period Yield
vs
Sacramento River Pumping Capacity
Selected for detailed presentation

Figure 6-5

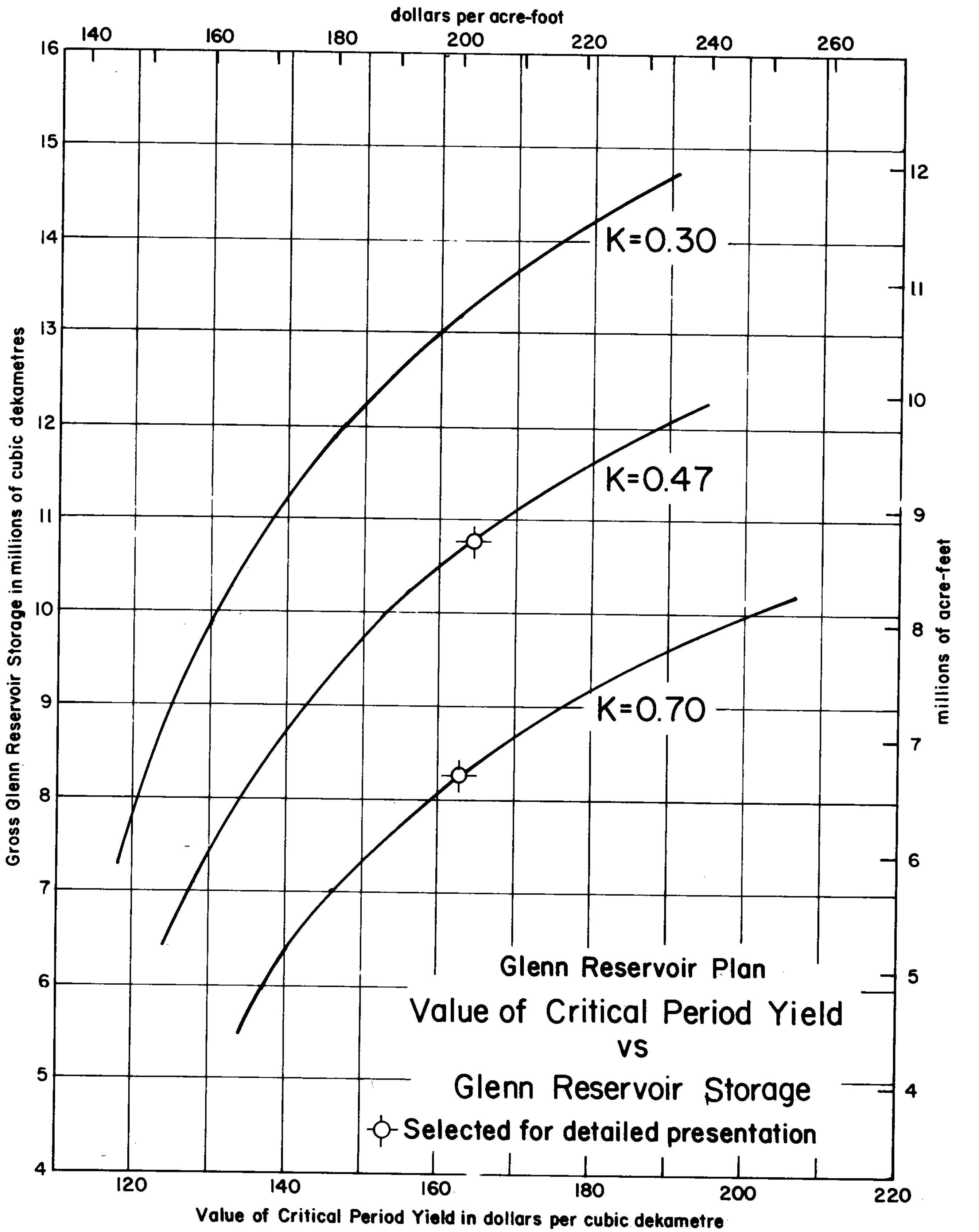

dollars per acre-foot
140
160
180
200
220
240
260
16
15
14
13
12
11
10
9
8
7
6
5
4
Gross Glenn Reservoir Storage in millions of cubic dekametres
12
11
10
9
8
7
6
5
4
millions of acre-feet
K=0.30
K=0.47
K=0.70
Glenn Reservoir Plan
Value of Critical Period Yield
VS
Glenn Reservoir Storage
Selected for detailed presentation
120
140
160
180
200
220
Value of Critical Period Yield in dollars per cubic dekametre

TABLE 6-3A

GLENN RESERVOIR PLAN
EXAMPLE FORMULATIONS
Metric Units

	K = 0.70	K = 0.47
Capacities, cubic dekametres		
Joint use flood reservation	185 000*	185 000*
Conservation storage	7 835 000	10 317 000
Inactive storage	247 000	247 000
Gross Storage	8 267 000	10 749 000
Elevations, metres		
Dam crest	300	312
Top of joint use flood reservation	294	306
Top of conservation pool	293	305
Minimum pool	215	215
Streambed (Newville/Rancheria)	183/180	183/180
Dam height, metres (Newville/Rancheria)	117/120	129/132
Areas, hectares		
Reservoir at gross storage	18 900	21 600
Reservoir at minimum pool	2 230	2 230
Gross land purchased	29 700	33 900
Red Bluff-Newville conveyance system		
Canal length, kilometres	51	51
Capacity, cubic metres per second	283	340
Maximum static pump lift, metres	217	229
Average pumped, cubic dekametres per year	692 000	641 000
Thomes Creek diversion system		
Capacity, cubic metres per second	269	283
Average diverted, cubic dekametres per year	208 000	208 000
Average stored, cubic dekametres per year	111 000	105 000
Average intitial fill period, years	7	7
Energy, long-term averages, gWh per year		
Used for pumping	467	460
Generated	545	538
Net generation	78	78
New SWP/CVP yield, cubic dekametres per year		
Average (1922-71)	797 000	698 000
Dry period (1928-34)**	1 139 000	1 494 000
50-year average annual equivalent dry period	1 015 000	1 296 000

*Existing Black Butte Reservoir flood reservation
**Includes 28 000 cubic dekametres per year from Black Butte Reservoir

TABLE 6-3B

GLENN RESERVOIR PLAN
EXAMPLE FORMULATIONS
English Units

	K = 0.70	K = 0.47
Capacities, acre-feet		
Joint use flood reservation	150,000*	150,000*
Conservation storage	6,352,000	8,364,000
Inactive storage	200,000	200,000
Gross Storage	6,702,000	8,714,000
Elevations, feet		
Dam crest	984	1,024
Top of joint use flood reservation	964	1,004
Top of conservation pool	961	1,002
Minimum pool	705	705
Streambed (Newville/Rancheria)	600/590	600/590
Dam height, feet (Newville/Rancheria)	384/394	424/434
Areas, acres		
Reservoir at gross storage	46,700	53,400
Reservoir at minimum pool	5,500	5,500
Gross land purchased	73,300	83,800
Red Bluff-Newville conveyance system		
Canal length, miles	32	32
Capacity, cubic feet per second	10,000	12,000
Maximum static pump lift, feet	711	751
Average pumped, acre-feet per year	561,000	520,000
Thomes Creek diversion system		
Capacity, cubic feet per second	9,500	10,000
Average diverted, acre-feet per year	168,000	169,000
Average stored, acre-feet per year	90,000	85,000
Average initial fill period, years	7	7
Energy, long-term averages, gWh per year		
Used for pumping	467	460
Generated	545	538
Net generation	78	78
New SWP/CVP yield, acre-feet per year		
Average (1922-71)	646,000	566,000
Dry period (1928-34)**	923,000	1,211,000
50-year average annual equivalent dry period	823,000	1,051,000

*Existing Black Butte Reservoir flood reservation
**Includes 23,000 acre-feet per year from Black Butte Reservoir

GLENN RESERVOIR PLAN
EXPLANATION OF COLUMNS OF
50-YEAR OPERATION SUMMARY

MTH - Month of water year.

STG - End-of-month storage in Glenn Reservoir.

ELV - Beginning-of-month elevations of Glenn Reservoir.

EVP - Evaporeservation of Glenn and Black Butte Reservoirs.

DTH - Potentially divertable Thomes Creek flow for the specified diversion capacity.

STN - Impaired Stony Creek inflow to Glenn Reservoir, with the effects of Stony Gorge Reservoir removed.

PRB - Potentially pumpable Sacramento River flow above Red Bluff Diversion Dam for the specified pumping capacity.

RBP - Portion of PRB actually pumped to Glenn Reservoir.

STD - Historic yield to Orland Project and CVP from Stony Creek based on USCE R-1 operation study.

ADD - Portion of DTH and STN that had historically contributed to prior water rights within the Sacramento River basin.

FLD - Flood control release from Glenn Reservoir.

SWP - Release to State Water Project from Glenn Reservoir.

TRL - Total Glenn Reservoir release; TRL = STD + ADD + FLD + SWP.

HTH - Historic Thomes Creek flow at Paskenta.

PTH - Thomes Creek flow at Paskenta under project conditions.

HST - Historic Black Butte Reservoir release based on R-1 operation study; includes flows to Sacramento River and local demand.

PST - Stony Creek flow below Black Butte Reservoir under project conditions. If monthly TRL is greater than 370 000 dam^3 (300,000 ac-ft), the remainder would be released to Stony Creek.

ENG - Net energy produced or consumed at Glenn Reservoir Plan Facilities.

TABLE 6-4A

GLENN RESERVOIR PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.70

Metric Units (thousand dam^3, except as indicated)

Gross Storage = 8 267 000 dam^3
Critical Period Yield = 1 139 000 dam^3/yr*

Thomes Creek Diversion Capacity = 269 m^3/s
Sacramento River Pumping Capacity = 283 m^3/s

MTH	STG	ELV (m)	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG (gWh)
50-year totals																	
	6126	279	9087	10391	22867	68379	34611	10000	2409	6987	39859	59255	12458	2067	23480	13041	3901
50-year averages																	
Oct	5656	276	11	1	5	6	6	12	1	0	21	34	2	1	14	12	10
Nov	5689	276	-1	5	10	26	26	4	4	0	2	10	8	3	1	4	-13
Dec	5901	276	-7	25	52	167	143	4	6	4	0	14	30	5	48	4	-92
Jan	6123	277	-2	37	93	264	139	4	5	41	0	49	41	5	90	11	-70
Feb	6375	279	1	42	113	313	165	4	5	59	0	68	47	5	105	12	-77
Mar	6559	281	6	34	73	250	107	4	5	17	0	26	40	5	30	4	-60
Apr	6656	283	13	38	59	184	67	15	11	16	10	52	43	5	26	15	-20
May	6658	283	25	22	32	139	35	25	9	2	26	62	28	6	26	25	1
Jun	6439	283	37	4	9	19	4	33	2	0	163	199	8	5	33	42	89
Jul	6043	282	41	0	3	0	0	39	0	0	318	358	2	1	41	75	166
Aug	5727	279	33	0	3	0	0	33	0	0	253	286	0	0	33	33	136
Sep	5680	276	24	0	5	0	0	23	0	0	4	27	0	0	23	23	8
Total	6126	279	181	208	457	1368	692	200	48	139	797	1185	249	41	470	260	78

Pumping Energy = -467 gWh/yr

Generating Energy = 545 gWh/yr

Critical period (May 1928-October 1934) averages (thousand dam^3/yr)

MTH	STG	ELV (m)	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG (gWh)
	4601	263	162	73	152	96	96	183	62	0	1139	1384	101	28	175	179	554

*Includes 28 000 dam^3/yr from Black Butte Reservoir

TABLE 6-4B

GLENN RESERVOIR PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.70
English Units (thousand ac-ft, except as indicated)

Gross Storage = 6,702,000 ac-ft
Critical Period Yield = 923,000 ac-ft/yr*

Thomes Creek Diversion Capacity = 9,500 ft^3/s
Sacramento River Pumping Capacity = 10,000 ft^3/s

MTH	STG	ELV (ft)	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG (gWh)
50-year totals																	
	4966	916	7367	8424	18538	55435	28059	8107	1953	5664	32314	48038	10100	1676	19035	10572	3901
50-year averages																	
Oct	4585	905	9	1	4	5	5	10	1	0	17	28	2	1	11	10	10
Nov	4612	904	-1	4	8	21	21	3	3	0	2	8	7	3	1	3	-13
Dec	4784	905	-6	20	42	135	116	3	5	3	0	11	24	4	39	3	-92
Jan	4964	910	-2	30	75	214	113	3	4	33	0	40	34	4	73	9	-70
Feb	5168	916	1	33	92	254	134	3	4	48	0	55	38	4	85	10	-77
Mar	5317	922	5	28	59	203	87	3	4	14	0	21	32	4	24	3	-60
Apr	5396	927	11	31	48	149	54	12	9	13	8	43	35	4	21	12	-20
May	5398	929	20	18	26	113	28	20	7	2	21	50	22	5	21	20	1
Jun	5220	929	30	3	7	15	3	27	2	0	132	161	7	4	27	34	89
Jul	4899	924	33	0	3	0	0	32	0	0	258	290	1	1	33	61	166
Aug	4643	915	27	0	3	0	0	27	0	0	205	232	0	0	27	27	136
Sep	4605	906	20	0	4	0	0	19	0	0	3	22	0	0	19	19	8
Total	4966	916	147	168	371	1109	561	162	39	113	646	961	202	34	381	211	78

Pumping Energy = -467 gWh/yr   Generating Energy = 545 gWh/yr

Critical period (May 1928-October 1934) averages (thousand ac-ft/yr)

	STG	ELV	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG
	3730	863	131	59	123	78	78	148	50	0	923	1122	82	23	142	145	554

*Includes 23,000 ac-ft/yr from Black Butte Reservoir

TABLE 6-5A

GLENN RESERVOIR PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.47
Metric Units (thousand dam^3, except as indicated)

Gross Storage = 10 749 000 dam^3
Critical Period Yield = 1 494 000 dam^3/yr*

Thomes Creek Diversion Capacity = 283 m^3/s
Sacramento River Pumping Capacity = 340 m^3/s

MTH	STG	ELV (m)	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG (gWh)
50-year totals																	
	8528	293	10598	10398	22867	77387	32093	10000	2409	7851	34907	55167	12458	2060	23480	11890	3901
50-year averages																	
Oct	8086	290	14	1	5	6	6	12	1	0	21	35	2	1	14	12	10
Nov	8121	290	-1	5	10	27	27	4	4	0	2	10	8	3	1	4	-15
Dec	8342	290	-9	25	52	191	151	4	6	4	0	14	30	5	48	4	-104
Jan	8512	291	-2	37	93	297	99	4	5	52	0	61	41	5	90	11	-38
Feb	8766	292	1	42	113	359	171	4	5	64	0	73	47	5	105	12	-86
Mar	8944	294	7	34	73	291	106	4	5	20	0	28	40	5	30	4	-59
Apr	9023	295	16	38	59	210	49	15	11	16	11	54	43	5	26	15	-8
May	9011	296	28	22	32	148	28	25	9	1	30	64	28	6	26	25	7
Jun	8803	296	43	4	9	19	4	33	2	0	147	181	8	5	33	43	84
Jul	8447	294	47	0	3	0	0	39	0	0	271	311	2	1	41	52	155
Aug	8166	292	38	0	3	0	0	33	0	0	212	245	0	0	33	33	123
Sep	8114	290	30	0	5	0	0	23	0	0	4	27	0	0	23	23	9
Total	8528	293	212	208	457	1548	641	200	48	157	698	1103	249	41	470	238	78

Pumping Energy = -460 gWh/yr

Generating Energy = 538 gWh/yr

Critical period (May 1928-October 1934) averages (thousand dam^3/yr)

STG	ELV	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG
5990	272	184	73	152	99	99	183	62	0	1494	1738	101	28	175	321	719

*Includes 28 000 dam^3/yr from Black Butte Reservoir

TABLE 6-5B

GLENN RESERVOIR PLAN
50-YEAR (1922-71) OPERATION SUMMARY

SWP K = 0.47

English Units (thousand ac-ft, except as indicated)

Gross Storage = 8,714,000 ac-ft
Critical Period Yield = 1,211,000 ac-ft/yr*

Thomes Creek Diversion Capacity 10,000 ft^3/s
Sacramento River Pumping Capacity = 12,000 ft^3/s

MTH	STG	ELV (ft)	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG (gWh)
50-year totals																	
	6914	960	8592	8430	18538	62738	26018	8107	1953	6365	28299	44724	10100	1670	19035	9639	3901
50-year averages																	
Oct	6555	952	11	1	4	5	5	10	1	0	17	28	2	1	11	10	10
Nov	6584	950	-1	4	8	22	22	3	3	0	2	8	7	2	1	3	-15
Dec	6763	951	-7	20	42	155	122	3	5	3	0	11	24	4	39	3	-104
Jan	6901	955	-2	30	75	241	80	3	4	42	0	49	34	4	73	9	-38
Feb	7107	959	1	34	92	291	139	3	4	52	0	59	38	4	85	10	-86
Mar	7251	964	6	28	59	236	86	3	4	16	0	23	32	4	24	3	-59
Apr	7314	969	13	31	48	170	40	12	9	13	9	44	35	4	21	12	- 8
May	7305	971	23	18	26	120	23	20	7	1	24	52	22	5	21	20	7
Jun	7137	970	35	3	7	15	3	27	2	0	119	147	7	4	27	35	84
Jul	6848	966	38	0	3	0	0	32	0	0	220	252	1	1	33	42	155
Aug	6620	959	31	0	3	0	0	27	0	0	172	199	0	0	27	27	123
Sep	6578	953	24	0	4	0	0	19	0	0	3	22	0	0	19	19	9
Total	6914	960	172	169	371	1255	520	162	39	127	566	894	202	33	381	193	78

Pumping Energy = -460 gWh/yr

Generating Energy = 538 gWh/yr

Critical period (May 1928-October 1934) averages (thousand ac-ft/yr)

	STG	ELV	EVP	DTH	STN	PRB	RBP	STD	ADD	FLD	SWP	TRL	HTH	PTH	HST	PST	ENG
	4856	892	149	59	123	80	80	148	50	0	1211	1409	82	23	142	260	719

*Includes 23,000 ac-ft/yr from Black Butte Reservoir

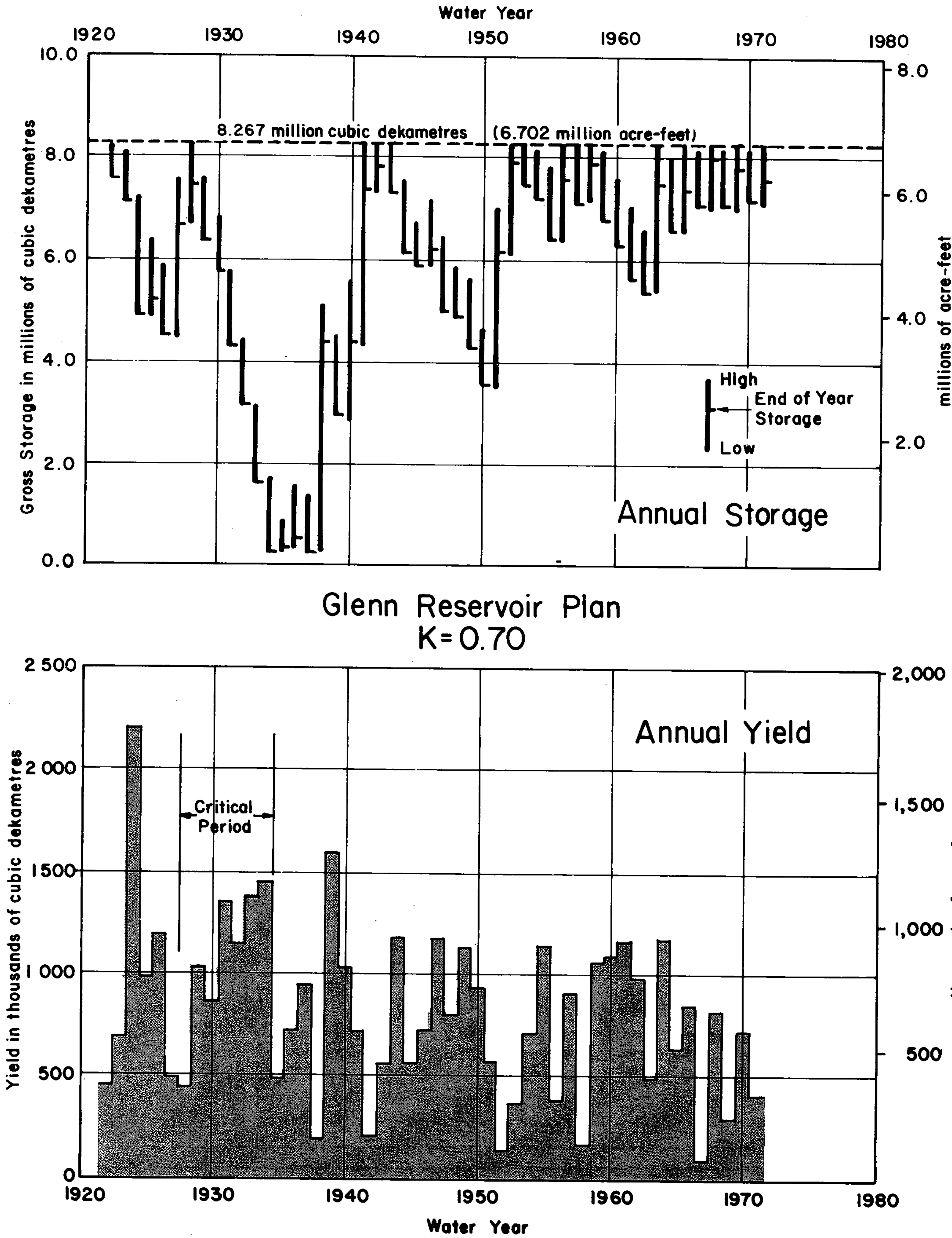
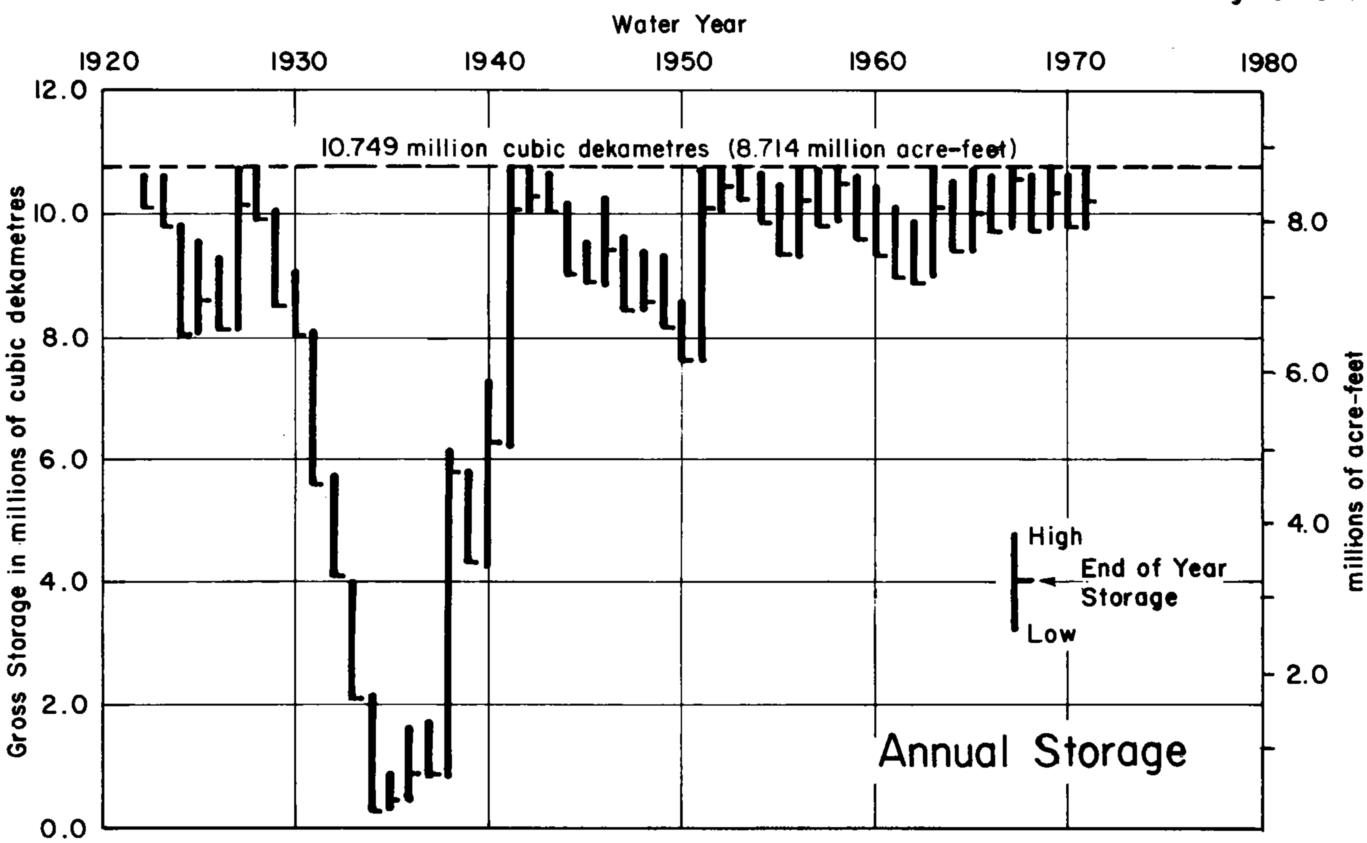

Water Year
1920
1930
1940
1950
1960
1970
1980
10.0
8.0
6.0
4.0
2.0
0.0
Gross Storage in millions of cubic dekametres
millions of acre-feet
8.267 million cubic dekametres (6.702 million acre-feet)
High
End of Year Storage
Low
Annual Storage
Glenn Reservoir Plan
K=0.70
2 500
2 000
1 500
1 000
500
0
2,000
1,500
1,000
Yield in thousands of cubic dekametres
thousands of acre-feet
Annual Yield
Critical Period

Figure 6-7



Glenn Reservoir Plan
K=0.47

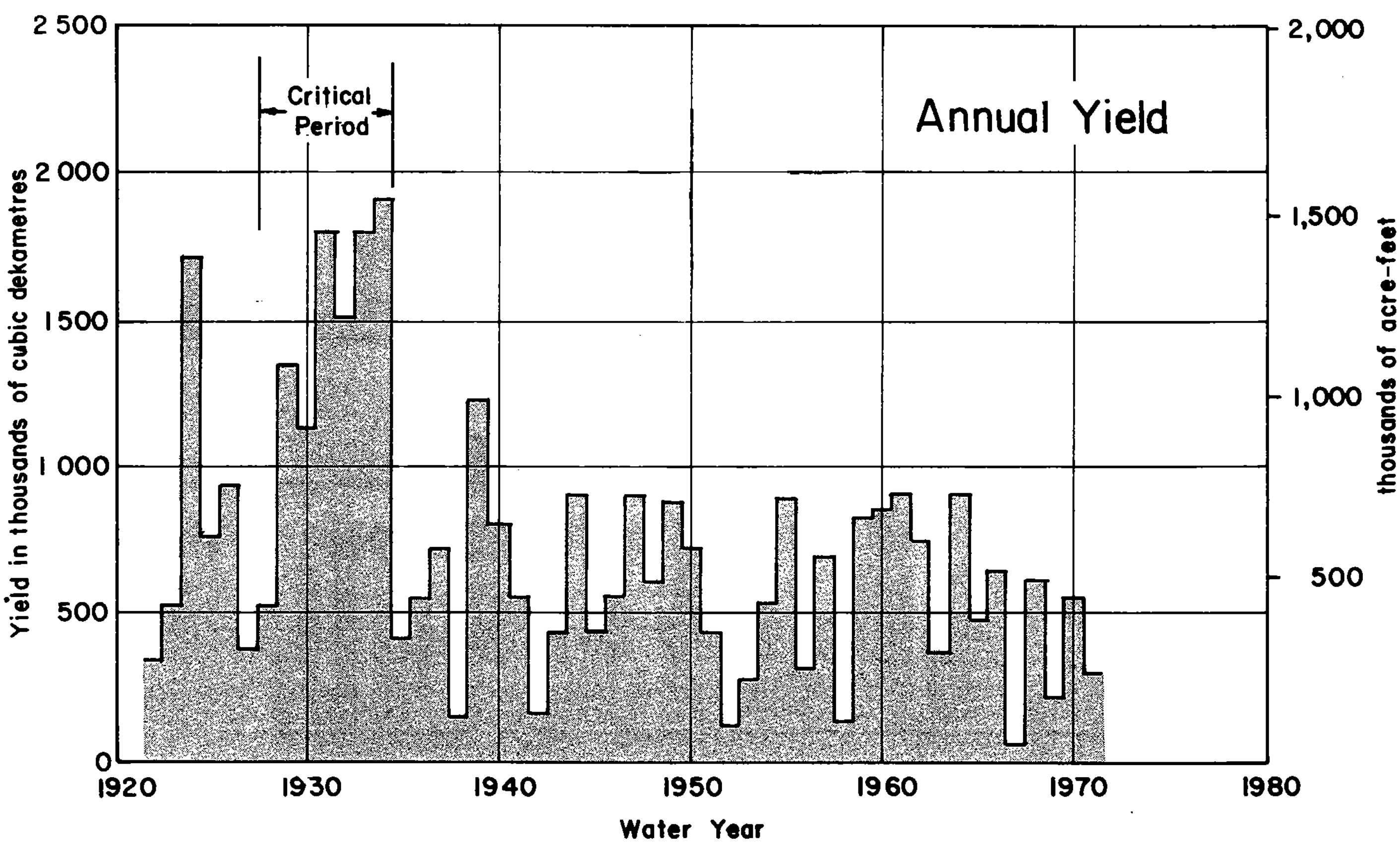


TABLE 6-6A

FILLING ANALYSES FOR GLENN RESERVOIR PLAN EXAMPLE FORMULATIONS
Metric Units

(thousands of dam^3, except as indicated)

SWP K = 0.70

Glenn Res. Gross Storage = 8 267 000 dam^3
Dry Period Yield = 1 139 000 dam^3/yr

Thomes Cr. Diversion Capacity 269 m^3/s
Sacramento R. Pumping Capacity = 283 m^3/s

Year After Completion	Thomes & Stony Storable Inflow	Pumped from Sacto. River	Glenn Spring Storage	Evapo-reser-vation	Average Yield Releases	Dry Period Yield Potential	Energy (gWh) Consumed	Generated*
-1	417	0	417	51	0	0	0	0
0	417	0	783	69	0	0	0	0
1	417	1 368	2 499	120	243	347	822	177
2	417	1 368	3 921	148	381	544	882	255
3	417	1 368	5 177	169	503	718	925	329
4	417	1 368	6 290	185	611	873	958	395
5	417	1 368	7 279	200	707	1 010	985	456
6	417	1 368	8 157	211	792	1 132	1 009	512
7	417	634	8 205**	211	797	1 139	468	516
Total	3 753	8 842		1 364	4 034	5 763	6 049	2 640

SWP K = 0.47

Glenn Res. Gross Storage = 10 749 000 dam^3
Dry Period Yield = 1 494 000 dam^3/yr

Thomes Cr. Diversion Capacity = 283 m^3/s
Sacramento R. Pumping Capacity = 340 m^3/s

Year After Completion	Thomes & Stony Storable Inflow	Pumped from Sacto. River	Glenn Spring Storage	Evapo-reser-vation	Average Yield Releases	Dry Period Yield Potential	Energy (gWh) Consumed	Generated*
-1	417	0	417	51	0	0	0	0
0	417	0	783	68	0	0	0	0
1	417	1 548	2 680	125	176	375	941	148
2	417	1 548	4 344	155	285	607	1 015	213
3	417	1 548	5 869	179	386	820	1 072	278
4	417	1 548	7 269	197	477	1 016	1 115	337
5	417	1 548	8 560	216	562	1 196	1 152	393
6	417	1 548	9 747	229	640	1 362	1 183	447
7	417	1 394	10 689**	239	702	1 494	1 087	490
Total	3 753	10 682		1 459	3 228	6 870	7 565	2 306

*Includes 48 000 dam^3/yr power generation of nonstorable water and 200 000 dam^3/yr of releases to Orland Project

**Maximum allowable first of May storage due to flood reservation

TABLE 6-6B

FILLING ANALYSES FOR GLENN RESERVOIR PLAN EXAMPLE FORMULATIONS
English Units
(thousands of ac-ft, except as indicated)

SWP K = 0.70

Glenn Res. Gross Storage = 6,702,000 ac-ft
Dry Period Yield = 923,000 ac-ft/yr

Thomes Cr. Diversion Capacity = 9,500 ft^3/s
Sacramento R. Pumping Capacity = 10,000 ft^3/s

Year After Completion	Thomes & Stony Storable Inflow	Pumped from Sacto. River	Glenn Spring Storage	Evapo-reser-vation	Average Yield Releases	Dry Period Yield Potential	Energy (gWh)	
							Consumed	Generated*
-1	338	0	338	41	0	0	0	0
0	338	0	635	56	0	0	0	0
1	338	1,109	2,026	97	197	281	822	177
2	338	1,109	3,179	120	309	441	882	255
3	338	1,109	4,197	137	408	582	925	329
4	338	1,109	5,099	150	495	708	958	395
5	338	1,109	5,901	162	573	819	985	456
6	338	1,109	6,613	171	642	918	1,009	512
7	338	514	6,652**	171	646	923	468	516
Total	3,042	7,168		1,105	3,270	4,672	6,049	2,640

SWP K = 0.47

Glenn Res. Gross Storage = 8,714,000 ac-ft
Dry Period Yield = 1,211,000 ac-ft/yr

Thomes Cr. Diversion Capacity = 10,000 ft^3/s
Sacramento R. Pumping Capacity = 12,000 ft^3/s

Year After Completion	Thomes & Stony Storable Inflow	Pumped from Sacto. River	Glenn Spring Storage	Evapo-reser-vation	Average Yield Releases	Dry Period Yield Potential	Energy Consumed (gWh)	Energy Generated* (gWh)
-1	338	0	338	41	0	0	0	0
0	338	0	635	55	0	0	0	0
1	338	1,255	2,173	101	143	304	941	148
2	338	1,255	3,522	126	231	492	1,015	213
3	338	1,255	4,758	145	313	665	1,072	278
4	338	1,255	5,893	160	387	824	1,115	337
5	338	1,255	6,939	175	456	970	1,152	393
6	338	1,255	7,901	186	519	1,104	1,183	447
7	338	1,130	8,664**	194	569	1,211	1,087	490
Total	3,042	8,660		1,183	2,618	5,570	7,565	2,306

*Includes 39,000 ac-ft/yr power generation of nonstorable water and 162,000 ac-ft/yr of releases to Orland Project.
**Maximum allowable first of May storage due to flood reservation.

Energy

The Glenn Reservoir Plan would include four pumping installations to lift surplus Sacramento River water to the reservoir. The maximum total static pumping head for the two example plans would range from 217 to 229 m (711 to 751 ft). All reservoir releases (except for a minor amount of flood spills) would pass through a series of five hydroelectric power plants on the way to the Sacramento River. Because releases would reach the river far downstream from the point of diversion, the total generating head would exceed the total pumping head by about 27 m (90 ft).

Due to natural inflow and the water diverted from Thomes Creek, long-term average reservoir releases would exceed Sacramento River diversions by about 71 percent. Consequently, the Glenn Reservoir Plan would eventually be a net energy producer. However, a heavy energy deficit would be incurred during initial filling of the reservoir. Based on average hydrologic conditions, the initial filling period would last about 7 years. Average energy consumption and production for the two example formulations would be:

	Average Energy (gWh/yr)	
	K = 0.70	K = 0.47
Initial filling period		
Consumption	864	1 081
Generation	377	329
Net consumption	487	752
Long-term average operation		
Consumption	467	460
Generation	545	538
Net generation	78	78

The cumulative net energy deficit during the 7-year initial filling period of these examples would range from 3 400 to 5 300 gWh*. With the relatively small net generation under long-term average operating conditions, some 44 to 68 years would be required to offset the energy used during initial filling.

The total installed pumping load for the four plants of a Glenn Reservoir Plan would range from about 750 to 1 000 MW, depending on the plan formulation selected. (The larger capacities would be associated with the larger reservoirs and diversion capacities that would result from formulation to meet a peaking demand schedule as opposed to a more uniform demand schedule.) Combined generating capacity would be in the vicinity of 280 MW, assuming generating facilities were designed for a release of 142 m^3/s (5,000 ft^3/s).

*To place these figures into perspective, the total State Water Project net energy demand in the year 2000 is predicted as about 8 000 gWh per year.

The formulation studies described in this chapter were based on unit values of 40 mills/kWh for energy consumed and 30 mills/kWh for energy produced. These values were derived on the assumption that Glenn Reservoir energy operations would be integrated with those of the other State Water Project pumping and generating facilities. Alternatively, the Glenn Reservoir Plan formulation could be based on energy values that reflected marginal costs of production; this could have a significant impact on the optimum sizes of the various features. A thorough analysis of expected future energy costs is clearly needed as a key element of any future planning studies of this plan.

Plan formulation studies were based on continuous pumping and baseload power generation. Black Butte Reservoir would provide a degree of flexibility in the Glenn Reservoir system in that it could be operated to reregulate diversions or releases over short periods. Whenever the diversion or release facilities were not operating at full capacity, pumping could be shifted toward offpeak hours and generation could be shifted toward peak hours. This would apply only to the facilities between Black Butte and Glenn Reservoirs, but most of the head would be in that reach. Analysis of such incidental power or load management opportunities is beyond the scope of current preliminary planning studies, but they should be appraised eventually.

Conclusions and Recommendations

The Glenn Reservoir Plan could be constructed either as a single-stage development or as an expansion of a Thomes-Newville Plan. The formulation studies covered by this chapter treat only the single-stage construction option. They demonstrate that projected supplies of surplus Sacramento River water would be sufficient to justify construction of a very large Glenn Reservoir, together with pumping capacities on the order of 280 to 420 m^3/s (10,000 to 15,000 ft^3/s). The development would eventually be a small net energy producer, but a substantial energy investment would be required during the early years while the reservoir was first being filled.

Traditional sizing studies, based on the outlined formulation criteria, show that a single-stage Glenn Reservoir should be built to or near the topographic limit of the Newville Reservoir compartment. This limit has not been precisely defined, but it is probably somewhere in the range of elevation 305 m to 312 m (1,000 to 1,025 ft). The corresponding gross Glenn Reservoir storage would range from about 10 500 000 to 12 000 000 dam^3 (8,500,000 to 9,800,000 ac-ft). A Glenn Reservoir near the upper limit of this range could be justified only if its operating mode would favor production of dry period yield at the expense of average yield (the lower K values).

Although the basic hydrologic feasibility of Glenn Reservoir has been established, much additional work would be required to investigate plan variations and to determine the optimum plan. In particular, more analysis would be needed if the Glenn Reservoir Plan were proposed as an expansion of a Thomes-Newville Plan. This work should emphasize the "split-level" Glenn Reservoir Plan, whereby a Chrome Dike would be constructed so that Rancheria Reservoir could be maintained at a higher level. Specific studies would include:

1. Continue to reappraise water supply calculations to reflect the most recent Delta water quality standards and updated estimates of future depletions.

2. Reconcile differences in Stony Creek water supply calculations.

3. Perform detailed reservoir operation studies and energy analyses of a split-level Glenn Reservoir.

4. Incorporate updated and improved construction cost estimates into plan formulation studies.

5. Repeat plan formulation studies for staged construction sequences.

6. Evaluate flows needed for prior rights and environmental needs on lower Stony Creek.

7. Investigate the need and economic justification for flow augmentation releases to Thomes Creek.

8. Examine flood control aspects of the plan, considering both Stony and Thomes Creeks and downstream areas along the Sacramento River.

9. Investigate expected future energy values and reappraise the plan formulation accordingly; test sensitivity of the plan formulation and economics to energy values.

10. Explore possibilities for incidental electrical load management that could be accomplished without oversizing pumping or generating facilities.

11. Continue analyses of the total SWP/CVP system and other potential additional facilities; because of its size, the Glenn Reservoir Plan would have to be tailored to match remaining system needs and its formulation would depend heavily on what came before it.

CHAPTER 7. GLENN RESERVOIR PLAN-- NEWVILLE COMPARTMENT

Glenn Reservoir would be formed by Newville and Rancheria Dams, whose reservoir sites are separated by a saddle near the small community of Chrome. The Chrome saddle lies at elevation 283 m (930 ft) and at any higher pool level the reservoirs would merge.

The project formulation studies covered in Chapter 6 are based on building Glenn Reservoir in a single stage, with Newville and Rancheria Dams constructed at the same time. In that case, the Glenn Reservoir spillway would logically be placed near Rancheria Dam, on the larger of the two dammed streams. And, as Chapter 9 concludes, the main pumping-generating facilities between Black Butte and Glenn Reservoirs would best follow the Tehenn Reservoir route, to Newville Dam.

On the other hand, Glenn Reservoir could be built as an expansion of an earlier-constructed Thomes-Newville Plan. This would entail raising Newville Dam by as much as 30 m (100 ft). If possible, the Newville spillway would be modified to serve the combined reservoir and to aid in meeting emergency drawdown criteria; if not, it would be replaced with a new spillway near Rancheria Dam. The main pumping-generating facilities would be located at Rancheria Dam, but the generating plant at Newville Dam would be retained for use during periods when the reservoir would drop below the saddle level.

In a variation on the Glenn Reservoir theme, an earlier-constructed Thomes Newville Plan could be incorporated into a larger development without raising Newville Reservoir. By building a dike near Chrome, Rancheria Reservoir could be constructed to a higher level than Newville Reservoir. The total storage in the separate Newville and Rancheria Reservoirs could thus be made equal to that of a single-level Glenn Reservoir. Under this "split-level" type of plan, there would be no physical modification of the initial Newville Reservoir facilities.

This chapter addresses the physical feasibility of the Newville compartment of a conventional single-level Glenn Reservoir (as outlined in the first two of the preceding three descriptions). Preliminary designs and costs were prepared in 1980 for two-stage construction of a Newville Dam and Reservoir as follows:

	Stage I	Stage II
Dam crest elevation, m (ft)	280 (920)	306 (1,004)
Dam height above streambed, m (ft)	98 (320)	123 (404)
Normal pool elevation, m (ft)	274 (900)	300 (984)
Reservoir storage, dam^3	2,271,000	3,877,000
" " (ac-ft)	(1,841,000)	(3,143,000)

The second stage size was based on early formulation studies that have been superseded by those described in Chapter 6; current studies indicate that the second stage dam could be about 6 m (20 ft) higher than the size for which the estimates were prepared. To allow direct cost comparisons, the Northern District prepared cost estimates for construction in one stage of a dam with a crest elevation of 306 m (1,004 ft).

Previous Studies

The concept of building Newville Dam to one size and enlarging it later was not considered prior to the current investigation. Earlier studies of single-stage development of Newville Reservoir are described in Chapter 3 and Appendix F.

Background Data

Chapter 3 summarizes supporting information on topographic mapping, reservoir capacity, seismicity, geology, construction materials, hydrology, and sedimentation for the medium-sized Newville Reservoir that would be included in a Thomes-Newville Plan. All of that information is applicable to the larger Newville facilities of a Glenn Reservoir Plan.

The principal items of concern with the larger reservoir are (1) the structural integrity and leakage potential of Rocky Ridge, which would form the east reservoir rim, and (2) the availability and suitability of construction materials for the dam embankment. Appendixes C and D describe the detailed studies that have been conducted of these aspects. The Rocky Ridge questions have been resolved by investigations that led to the conclusion that the suitability of the ridge has been adequately established for a reservoir elevation up to 305 m (1,000 ft). Investigations of construction materials are continuing, with emphasis on sandstone and conglomerate from borrow area QA-9 on Rocky Ridge and on stream gravels from Stony and Grindstone Creeks. As Chapter 3 describes, the QA-9 material is relatively weak in comparison to the quarried rock usually associated with high rockfill dams. However, it appears that a satisfactory design could be developed to accommodate use of QA-9 material in the dam's shell zones.

Newville Dam

This section covers either one-stage or two-stage construction of a high Newville Dam as a part of a Glenn Reservoir Plan. Single-stage construction would be used only if Glenn Reservoir were developed all at once, an approach that is no longer receiving serious consideration. Construction in two stages would come about if the Thomes-Newville Plan were developed first and later incorporated into a full-scale Glenn Reservoir Plan.

Appendix B summarizes the geologic studies that have been conducted at Newville Dam site over the past two decades. It concludes that the foundation is suitable for an embankment-type dam at least 128 m (420 ft) high. (The actual upper limit of dam height would be controlled by topographic and cost considerations rather than foundation suitability.)

One-Stage Construction

The main purpose of examining one-stage construction is to evaluate the added cost of building in two stages. Many designs and cost estimates have been prepared over the past two decades for one-stage construction of a large Newville Dam, but none of these fully reflect current price levels, design criteria, or data on construction materials. Consequently, a brief appraisal of a one-stage Newville Dam was prepared just prior to completion of this report. That appraisal was based on a higher version of the dam section shown on Figure 3-2 for the Thomes-Newville Plan. The main structural elements of the dam would be a wide central impervious core of Tehama Formation soils and shells of compacted sandstone and conglomerate from borrow area QA-9 on Rocky Ridge about 5 km (3 mi) north of the damsite. Internal drain and transition zones would be constructed of processed sand and gravel from borrow areas along Stony and lower Grindstone Creeks. The downstream shell would incorporate a large random fill zone made up of waste from required excavations and borrow area QA-9.

Stability calculations were not made specifically for the higher dam, but the studies made for the lower version support the judgment that no more than minor design modifications would be required to meet static and seismic stability criteria. The internal stresses associated with the higher dam could result in lower design strengths for the sandstone and conglomerate in the shell zones; this could necessitate some flattening of the outer dam slopes but more testing would be required to evaluate any such effects.

Chapter 3 discusses the possible substitution of stream gravels for the QA-9 material in the outer shells of Newville Dam, but this option would not apply to a one-stage Newville Dam that was being built at the same time as Rancheria Dam. Appendix D shows that some 28 000 000 m^3 (37,000,000 yd^3) of sand and gravel have been identified within reasonable haul distance of the Glenn Reservoir Dams. That quantity would be sufficient for the drains and transition zones of the two major dams, as well as for an upstream shell zone of one of them. As the sand and gravel deposits are much closer to Rancheria Dam, it is logical that they be used there rather than in Newville Dam (if the dams were being built simultaneously).

The total embankment volumes for the one-stage Newville Dam with crest elevation of 306 m (1,004 ft) would be as follows:

			Volume	
	Zone	Source	m^3	(yd^3)
1	Impervious	Tehama Formation	5 700 000	7,460,000
2A	Transition	Processed sand and gravel	1 940 000	2 540,000
2B	Drain	Processed sand and gravel		
3, 3A	Shell	Processed QA-9 material	16 350 000	21,390,000
4	Random	QA-9, required excavations	1 930 000	2,530,000
			25 920 000	33,920,000

As the tabulation shows, the selected Newville Dam section would require a relatively small share of the total volumes of sand and gravel known to be available in the Glenn Reservoir vicinity.

Two-Stage Construction

Chapter 3 describes the Newville Dam that would be constructed as part of an independent Thomes-Newville Plan. If the dam was to be enlarged later, a substantially different dam would be constructed initially. This section summarizes the design that would be used for the two-stage plan.

In the example chosen to appraise the staged construction sequence, Newville Dam would initially be built with a crest elevation of 280 m (920 ft). The second stage would entail raising the dam by 26 m (84 ft). Figure 7-1 shows the dam section selected; it is designed to permit the enlargement to be carried out without interfering with the operation of the reservoir. A plan view of the staged development is shown on Figure 7-2.

The two-stage dam section is similar to the section selected for one-stage construction. The volumes of the various material in the two stages would be:

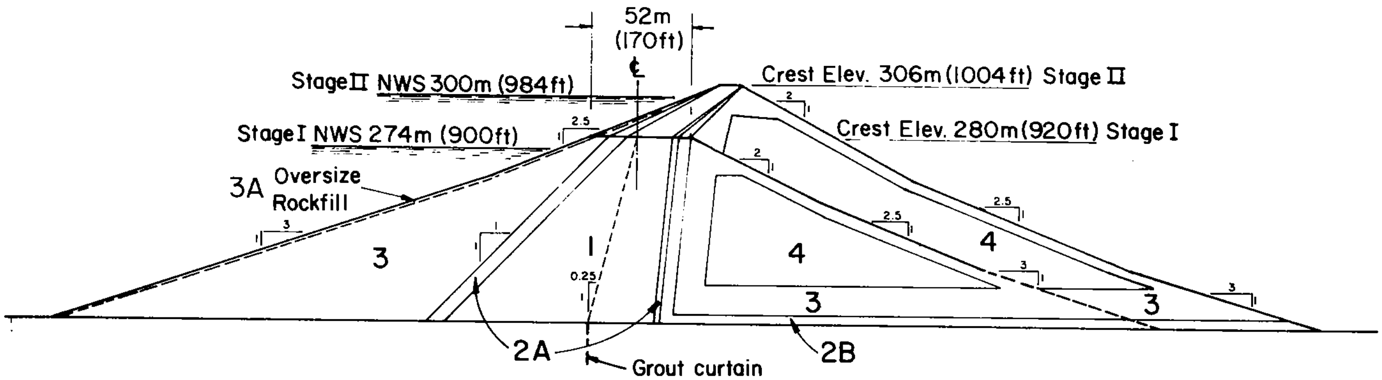
		Stage 1		Stage 2	
	Zone	m^3	(yd^3)	m^3	(yd^3)
1	Impervious	3 760 000	4,920,000	570 000	750,000
2A 2B	Transition Drain	2 080 000	2,720,000	2 210 000	2,890,000
3, 3A	Shell	10 160 000	13,290,000	4 330 000	5,660,000
4	Random	1 900 000	2,480,000	2 100 000	2,750,000
		17 900 000	23,410,000	9 210 000	12,050,000

The total embankment volume would be about the same with either the one-stage or the two-stage plans. Somewhat more sand and gravel would be needed with the staged plan, but the total would not be large compared to the quantity available.

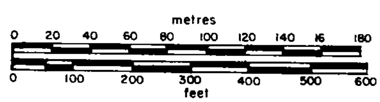
Stability analyses were not performed for the two-stage dam section, but Chapter 3 describes the static and seismic stability studies of a similar Newville Dam section. Those studies provide a reasonable basis of support for the two-stage dam section; some design revisions may prove necessary, but they should not have a major impact on feasibility or cost.

Outlet Works

The design of the Newville Dam outlet facilities for a Glenn Reservoir Plan would depend on the construction sequence. With the one-stage plan, Sacramento River water would be pumped to Glenn Reservoir via the Tehenn diversion route and the Newville facilities would be large enough to serve as the main inlet and outlet for Glenn Reservoir. With the



Zone	Embankment Material	Zone	Embankment Material
1	Tehama Formation	3,3A	Compacted processed rockfill
2A,2B	Transition and drain zones of processed sands and gravels.	4	Random zone.



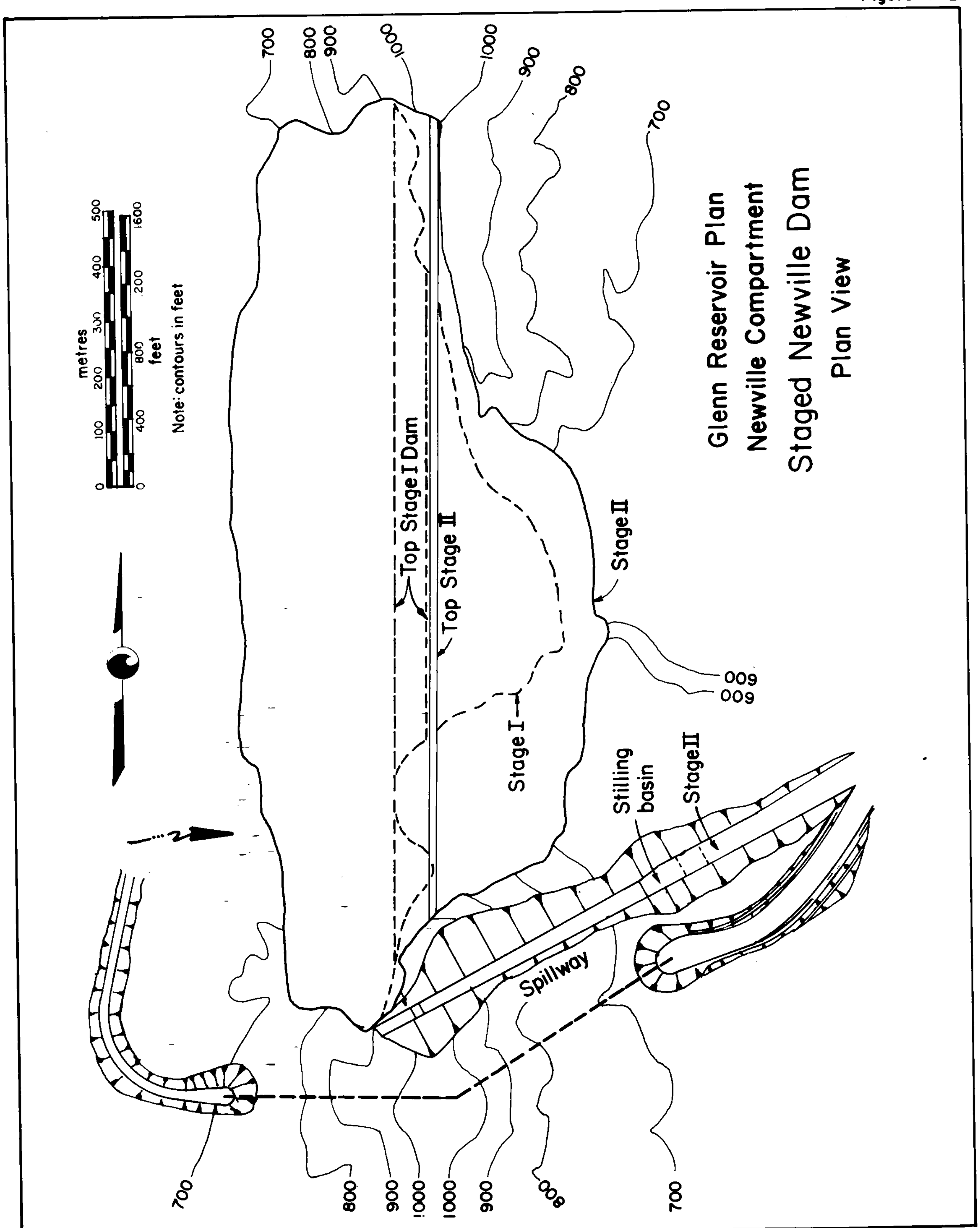
Glenn Reservoir Plan

Newville Compartment

Staged Newville Dam

(maximum section)

Figure 7-2


Glenn Reservoir Plan
Newville Compartment
Staged Newville Dam
Plan View
metres
feet
Note: contours in feet
Top Stage I Dam
Top Stage II
Stage I
Stage II
Stilling basin
Spillway
700
800
900
1000

two-stage plan, the main inlet and outlet facilities would be at Rancheria Dam and the facilities at Newville Dam would need only to be adequate for the first-stage development.

One-Stage Construction

Preliminary designs and cost estimates were made in 1978 for outlet facilities to be used with the one-stage plan. These considered a range of possible pumping capacities between Tehenn and Newville Reservoirs. For a 283-m^3/s (10,000-ft^3/s) pumping capacity, four tunnels would be constructed through the right abutment, using an alignment similar to that shown on Figure 7-2. The upstream portions of the tunnels would be 4.9 m (16 ft) in diameter and the downstream portions would be enlarged to 7.3 m (24 ft). One of the tunnels would be used for diversion during construction. Steel penstocks would eventually be installed in the downstream portions of the tunnels to connect to the pumping-generating plant at the toe of Newville Dam. Two tunnels would be used for pumping only; at their upstream ends, only a low-level outlet structure would be required. The other tunnels would serve the reversible pump-turbine units; they would be equipped with both low-level intake/outlet structures and multi-level intake/outlet towers. Tandem fixed wheel gates would be provided on all four tunnels for emergency use.

More recent design studies of the outlet works for a smaller Newville Dam have led to somewhat different design concepts and it is likely that the layout described would be revised considerably if new studies were begun today. However, it constitutes a reasonable basis for assessing physical feasibility and the general range of costs involved. Appendix B describes tunneling conditions in either abutment as favorable, with no unusual problems expected if the tunnel alignments were chosen carefully with respect to faulted areas. Four tunnels would fit in the right abutment, but there would be only limited flexibility in their alignments; consequently, some more difficult tunneling conditions should be anticipated.

Emergency evacuation of Glenn Reservoir would be accomplished with the spillway and the outlet facilities at the two dams. The one-stage plan should include large bypasses on all of the outlet conduits to help meet emergency drawdown criteria.

Two-Stage Construction

If Glenn Reservoir were to be developed as an expansion of an earlier Thomes-Newville Plan, the diversion between Black Butte and Glenn Reservoirs should follow the main stem of Stony Creek (via Millsite Dam). This decision is based largely on consideration of the costs of Newville Dam outlet facilities that would be required with the alternative diversion through Tehenn Reservoir on the North Fork of Stony Creek. If the Tehenn diversion route were to be used, many of the second-stage outlet facilities would have to be included in the initial Thomes-Newville Plan. This would increase the cost of the Thomes-Newville Plan by more than $60,000,000 for facilities that would sit idle for perhaps 20 years until the second stage was constructed (if ever).

Under the selected plan, the outlet works for the first stage Newville Dam would be essentially identical to that shown on Figures 3-3 and 3-4 for the basic Thomes-Newville Plan. The outlet would include both a low-level intake and a sloping multi-level intake on the right abutment of the dam. The outlet facilities would be integrated with the diversion tunnel, which would be 4.3 m (14 ft) in diameter in the upstream portion and 6.7 m (22 ft) in the downstream portion. These facilities would be used to convey releases of only up to about 28 m^3/s (1,000 ft^3/s) to the Newville Generating Plant, but they would be sized to help meet emergency reservoir evacuation criteria rather than for the ordinary reservoir releases.

When Newville Dam was raised in the second stage, the sloping intake facility could be extended up the right abutment to the new reservoir pool level. This would allow the Newville Generating Plant to remain in full service at any reservoir level. However, there would be no reason to make releases through the Newville Plant unless Glenn Reservoir dropped below the level of the Chrome saddle. (All releases through the main outlet facilities at Rancheria Dam would also pass through the generating facilities at Millsite Dam; some 38 m (126 ft) of potential power head would be foregone if the releases were made at Newville Dam.) Consequently, there would be no justification to extend the sloping intake under this particular plan; only the control and access facilities would have to be raised.

Spillway

If Glenn Reservoir were constructed in one stage, the spillway would be located near Rancheria Dam and there would be no spillway in the Newville compartment. With the two-stage plan as it is currently envisioned, the first-stage spillway would be similar to that shown on Figure 3-5 for the Thomes-Newville Plan. (A gated spillway would be necessary to meet emergency reservoir evacuation criteria.) In the second stage, the spillway would be raised, or if this proved too costly, an entirely new spillway could be constructed (probably at Rancheria Dam). None of the preliminary designs and cost estimates prepared to date has covered the possibility of raising a gated spillway. The cost summary at the end of this chapter includes only the costs of a first-stage spillway at Newville Dam.

Rocky Ridge and Saddle Dams

Rocky Ridge is a relatively narrow ridge that would form the east rim of Newville Reservoir for a distance of about 16 km (10 mi). It ranges up to elevation 402 m (1,320 ft) at the highest peak. The lowest elevation along the ridge line is 183 m (600 ft) in the channel of the North Fork of Stony Creek at Newville Dam site. The principal saddles around the Newville Reservoir rim are (see Plate C-1, Appendix C):

Saddle	Saddle Elevation m	(ft)	Distance North or South of Newville Dam	
L	259	850	4.7 km S	(2.9 mi S)
E*	282	926	0.5 km S	(0.3 mi S)
B	290	950	3.4 km N	(2.1 mi N)
H	295	967	4.0 km S	(2.5 mi S)
G	295	969	3.1 km S	(1.9 mi S)
M**	296	972	7.4 km N	(4.6 mi N)
D	300	984	0.8 km N	(0.5 mi N)
A	305	1,002	4.0 km N	(2.5 mi N)
K	307	1,006	4.3 km S	(2.7 mi S)
F	308	1,010	1.3 km S	(0.8 mi S)
C	309	1,014	2.7 km N	(1.7 mi N)
J	309	1,014	4.2 km S	(2.6 mi S)
---	311	1,021	2.7 km S	(1.7 mi S)
---	312	1,023	6.4 km S	(4.0 mi S)

*Spillway site for first stage; becomes part of main dam in second stage.
**Saddle M is along the north rim of the reservoir, not on Rocky Ridge.

With the relatively high pool levels that would be used with the Glenn Reservoir Plan, there was once considerable concern about the structural integrity and leakage potential of Rocky Ridge and the attendant problems associated with constructing dams in the saddles. In response, substantial geologic exploration was performed and consultants were retained to advise the Department on appraising conditions along the ridge. The first such efforts were carried out in 1960 and additional work was done in 1978-79. Both of these programs are summarized in Appendix C, "Rocky Ridge Geology" and reported in detail in various office reports listed in the bibliography in Appendix G. The studies conducted to date have led to the conclusion that the ridge is quite competent and generally impermeable. The foundations of the saddle dams should be treated with conventional cement grouting; upstream blankets or other special measures to control leakage do not appear necessary. The grouting program would be exploratory, with provisions for additional grouting where permeable zones were encountered.

Only one saddle dam would actually be required with the first stage of Newville Reservoir. This would be at Saddle L (Burrows Gap), where an embankment-type dam would be constructed using a staged section similar to that shown on Figure 7-1. In the first stage of construction, the Saddle L dam would extend 21 m (70 ft) above the present saddle level and contain 630 000 m^3 (830,000 yd^3) of materials. In the second stage, the dam would be raised by 26 m (84 ft), which would require placement of an additional 960 000 m^3 (1,250,000 yd^3) of embankment.

For the second-stage reservoir size illustrated in this chapter, another six saddle dams would be necessary. To match the crest elevation of Newville Dam, these six dams would range from 1 to 16 m (2 to 54 ft) in height above the original saddle levels. The present saddle dam cost estimates are based on an embankment-type dam section similar to that outlined in Chapter 3 for the Newville Dam of a Thomes-Newville Plan. With that design, four of the saddle dams would extend below the normal pool level of the first stage of Newville Reservoir. It was assumed that the first-stage reservoir could not be drawn down to facilitate construction of the second stage, so the lower portions of the four saddle dams would have to be included in the initial construction. The first-stage work on these second-stage saddle dams would require placement of 760 000 m^3 (990,000 yd^3) of embankment at a total cost of about $11,500,000. This is more costly than anticipated and future studies should definitely examine concrete gravity saddle dams, particularly for the two-stage plan. The concrete dams might be more attractive even if they cost more, because they would not have to be constructed until actually needed.

In the second stage of Newville Reservoir, the four partial saddle dams that were built in the first stage would be raised and two additional saddle dams constructed. The total volume of embankment required for this stage would be about 820 000 m^3 (1,070,000 yd^3), bringing the total volume for the six lesser saddle dams to 1 580 000 m^3 (2,060,000 yd^3); the combined volume of these six saddle dams would be almost exactly the same as that of the major saddle dam at Saddle L.

In the one-stage plan, the dam at Saddle L and the six minor saddle dams would be similar to those of the two-stage plan, except for the provisions for staging. No recent designs have been made for the one-stage saddle dams, but their total embankment volumes would be almost identical to those of the two-stage plan.

Cost Estimates

Table 7-1 summarizes preliminary cost estimates for both one-stage and two-stage construction of Newville Reservoir. As with all other costs shown in this report, no allowances are included for price escalation during the construction period. All costs represent prices prevailing in the spring of 1980.

The costs shown for the one-stage plan are not the product of specific detailed estimates prepared by the Division of Design and Construction; they were assembled by the Northern District to permit a general assessment of the comparative costs of one-stage and two-stage construction, using the following procedures:

1. The costs of reservoir, relocations, saddle dams, and land acquisition are the sums of those for the two parts of the two-stage plan.

2. The dam cost was developed via an itemized estimate using the dam section of Figure 3-2 and the unit prices calculated by the Division of Design and Construction for the two-stage plan.

3. The outlet works costs were taken directly from the Division of Design and Construction's 1978 cost studies, with 20 percent added to account for price escalation to the current 1980 price base.

TABLE 7-1

GLENN RESERVOIR PLAN
NEWVILLE RESERVOIR-PRELIMINARY COST ESTIMATES
(Price Basis - Spring 1980)

	Stage I of Two-Stage Plan	One-Stage Plan or Stage II of Two-Stage Plan
Reservoir Normal Pool Elevation	274 m (900 ft)	300 m (984 ft)
Dam Crest Elevation	280 m (920 ft)	306 m (1,004 ft)
Dam Height Above Streambed	98 m (320 ft)	123 m (404 ft)
Reservoir Storage	2 271 000 dam^3 (1,841,000 ac-ft)	3 877 000 dam^3 (3,143,000 ac-ft)

Item	Estimated Costs			
	Contract	Contingencies	Engineering	Total
ONE-STAGE PLAN				
Reservoir, Relocations	$ 14,420,000	$ 1,440,000	$ 3,650,000	$ 19,510,000
Newville Dam	200,700,000	20,070,000	50,760,000	271,530,000
Outlet Works[a/]	78,500,000	7,850,000	19,860,000	106,210,000
Spillway[b/]	---	---	---	---
Saddle Dams	29,250,000	2,930,000	7,400,000	39,580,000
Subtotals	$322,870,000	$32,290,000	$81,670,000	$436,830,000
Land Acquisition				9,000,000
Total				$445,830,000
TWO-STAGE PLAN, STAGE I				
Reservoir, Relocations	$ 12,340,000	$ 1,230,000	$ 3,120,000	$ 16,690,000
Newville Dam	137,750,000	13,780,000	34,850,000	186,380,000
Outlet Works[c/]	23,530,000	2,350,000	5,950,000	31,830,000
Spillway	14,760,000	1,480,000	3,730,000	19,970,000
Saddle Dams	14,790,000	1,480,000	3,740,000	20,010,000
Subtotals	$203,170,000	$20,320,000	$51,390,000	$274,880,000
Land Acquisition				9,000,000
Total				$283,880,000
TWO-STAGE PLAN, STAGE II				
Reservoir	$ 2,080,000	210,000	$ 530,000	$ 2,820,000
Newville Dam	68,050,000	6,800,000	17,220,000	92,070,000
Outlet Works[d/]	5,880,000	590,000	1,490,000	7,960,000
Spillway[e/]	---	---	---	---
Saddle Dams	14,460,000	1,450,000	3,660,000	19,570,000
Subtotals	$90,470,000	$9,050,000	$22,900,000	$122,420,000
Land Acquisition				1,800,000
Total				$124,220,000

a/ For 283 m^3/s (10,000 ft^3/s) pumping capacity or 142 m^3/s (5,000 ft^3/s) generating capacity between Newville and Tehenn Reservoirs.

b/ With the one-stage plan, the Glenn Reservoir spillway would be at Rancheria Dam. See Chapter 8.

c/ For release of up to 28 m^3/s (1,000 ft^3/s) through the Newville Generating Plant.

d/ Only nominal changes would be necessitated by reservoir enlargement; the main Glenn Reservoir inlet and outlet would be at Rancheria Dam. No estimate is available; cost shown was taken as 25% of Stage I cost.

e/ No cost shown on assumption that new spillway would be built at Rancheria Dam; future studies should consider raising Stage I spillway.

The costs shown for the two-stage plan are based on the presumption that Stony Creek water would be diverted via the Millsite route in the first stage and that the main inlet and outlet facilities for Glenn Reservoir would be located at Rancheria Dam in the second stage. All of the recent design and cost estimating work for the staged plan was based on diversion of Stony Creek water via Tehenn Reservoir, so no specific estimate was available for an outlet works that would be compatible with the Millsite diversion alternative. The outlet cost shown for the first stage of the two-stage plan was taken directly from the estimate for the Thomes-Newville Plan reported in Chapter 3; the facilities would be similar because their design is controlled by emergency reservoir evacuation criteria rather than water supply operations.

The sums of the costs of the one-stage and two-stage plans are not directly comparable because of the influence of the different assumptions about spillways and outlet capacities. The most significant comparison is the cost of Newville Dam itself; Table 7-1 shows that the eventual dam cost would be about the same whether it was constructed in one stage or two. But, comparison with the costs in Chapter 3 shows that the provisions for expansion would add almost 60 percent to the cost of the initial stage of the dam structure ($186,380,000 vs. $117,290,000). Another significant difference is the initial cost of saddle dams ($20,010,000 vs. $8,510,000). These added costs to provide for possible later expansion would have considerable impact on the cost of water from a first stage Thomes-Newville Plan.

Conclusions and Recommendations

The design and cost studies completed to date and the geology and seismic studies summarized in Appendixes A through D indicate that a large Newville Reservoir is physically feasible. It could be constructed either in one or two stages. In a two-stage plan, the provisions for expansion would add more than $80,000,000 to the cost of the first stage.

Earlier concerns about the structural integrity and leakage potential of Rocky Ridge have been adequately resolved for the planning level. The ridge was found to be highly competent and stable. A reservoir level of 305 m (1,000 ft) does not appear to present any particular problem, although care would be required in the design and construction of several saddle dams. There is no well-defined limit to the maximum height of Newville Reservoir, but the needs for saddle dams begin to increase rapidly above the 305-m (1,000-ft) level. Economic and design considerations would probably limit Newville Reservoir to a maximum elevation somewhere in the range of 305 to 312 m (1,000 to 1,025 ft); however, studies to precisely define this upper limit have not been conducted.

If additional studies of the Glenn Reservoir Plan were to be conducted, the principal emphasis on Newville Reservoir should focus on design and construction materials issues. Specific recommendations are presented in Chapter 3 for the smaller Newville Reservoir that would be included in a Thomes-Newville Plan; these recommendations are also applicable to the larger reservoir covered by this chapter.

CHAPTER 8. GLENN RESERVOIR PLAN--
RANCHERIA COMPARTMENT

Rancheria Reservoir would be formed by a dam on Stony Creek about 13 km (8 mi) south of Newville Dam site. The natural saddle between the Rancheria and Newville Reservoir areas lies at about elevation 283 m (930 ft); at any higher water surface level, the two reservoirs would merge to form Glenn Reservoir. This chapter discusses the physical feasibility of the Rancheria portion of the full Glenn Reservoir development.

As discussed in Chapters 6 and 7, a Glenn Reservoir Plan could be formulated in a variety of ways and it could be developed either independently or as an expansion of a Thomes-Newville Plan. However, the feasibility of the Rancheria Reservoir compartment is relatively independent of the overall plan configuration and a representative reservoir size corresponding to a normal water surface elevation of 305 m (1,000 ft) was selected for presentation in this chapter. This reservoir size corresponds closely to the larger of the example project formulations described in Chapter 6.

Previous Studies

The general history of Rancheria Reservoir studies is documented in Appendix F. The damsite was first investigated in detail in 1958-59 under the Department's North Coastal Area Investigation, as part of a search for large storage reservoirs to reregulate water imported from the Eel, Trinity, and Klamath Rivers. Some fairly extensive exploration of potential construction materials was carried out in the early 1960's, but dam foundation exploration was limited to nine shallow auger holes. Based on those auger holes and surficial geologic mapping, it was tentatively concluded that the Rancheria site is free from active faults and otherwise suitable for construction of a high dam. The preliminary Rancheria Dam design used as a basis for the 1964 report, "Bulletin 136, North Coastal Area Investigation", assumed a nearly homogeneous rolled earth dam section constructed of Tehama Formation soils (with thin internal drainage zones and quarried rock slope protection).

A second major planning effort on Rancheria Dam took place in the 1964-72 period as a part of the Department's Middle Fork Eel River Development Advance Planning Program. The original preliminary dam design was revised in 1965 to reflect more conservative design criteria; this led to substitution of a large upstream zone of free-draining gravels for the rolled earth upstream section that had been selected for the earlier design. Then, in 1967, the damsite geology was remapped in greater detail and the foundation was explored by resistivity surveys, refraction seismic surveys, and 11 core drill holes with a total combined depth of 512 m (1,680 ft). At the same time, additional exploration and testing was carried out on nearby construction materials (stream gravels and potential impervious borrow materials within the reservoir area). The 1967 studies reaffirmed the earlier conclusion that Rancheria Dam site appeared suitable for a high earthfill dam.

In the early 1970s, the Department shifted attention from a Rancheria Reservoir that would be integrated with an Eel River development to one that could be used for offstream storage of surplus water pumped from the Sacramento River. As the 1967 exploration and testing programs did not necessitate any substantial modification of the 1965 preliminary designs, the planning studies continued to use the 1965 designs and cost estimates (with appropriate adjustments for changing price levels). Updated preliminary designs and cost estimates were prepared in 1978 as part of the current studies, but the basic dam section is still quite similar to the 1965 earth-gravel design.

Background Data

Over more than 20 years of investigation, a substantial amount of data has been gathered that relates to the physical feasibility of a Rancheria Reservoir. The following sections outline this information.

Topographic Mapping

In 1960, the Department mapped the entire reservoir and damsite areas at a scale of 1:4800 with a contour interval of 6.1 m (20 ft). The original maps are quite large and cumbersome but they have been reduced to 1:12,000 scale. The Rancheria Reservoir and surrounding areas are also covered by the following USGS quadrangle maps:

Map Name	Scale	Contour Interval m	Contour Interval (ft)	Date
Elk Creek	1:62,500	15.2	50	1957
Fruto	1:62,500	15.2	50	1958
Stonyford	1:62,500	15.2	50	1951
Lodoga	1:62,500	24.4	80	1960
Chrome	1:24,000	12.2	40	1968
Julian Rocks	1:24,000	12.2	40	1968
Elk Creek	1:24,000	12.2	40	1968
Fruto	1:24,000	12.2	40	1968
Stonyford	1:24,000	12.2	40	1968

Reservoir Area-Capacity Data

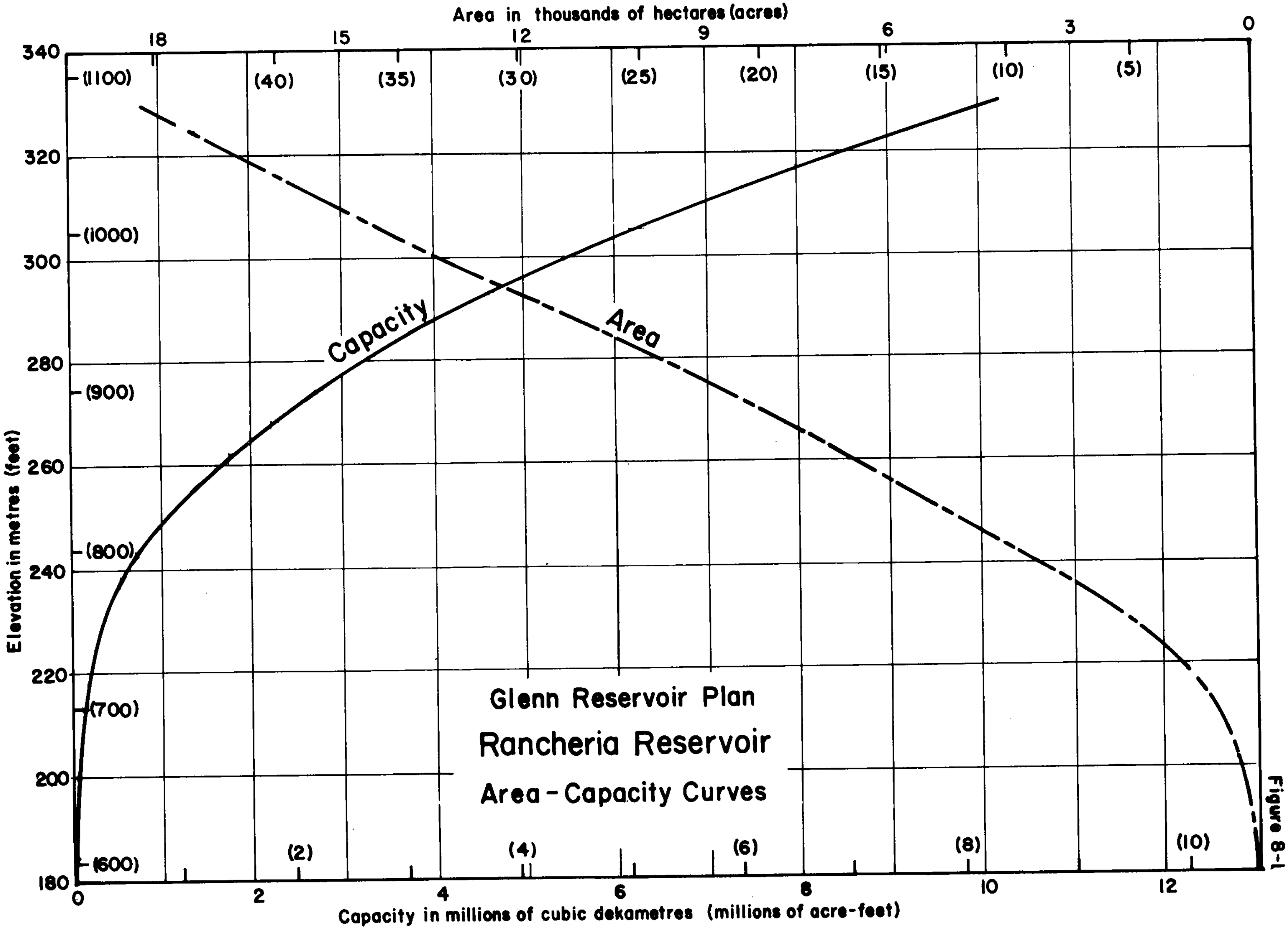
The 1:12,000 scale reductions of the 1960 Department mapping were used to determine the Rancheria Reservoir area and capacity data shown in Table 8-1 and Figure 8-1. For reservoir elevations above 283 m (930 ft), the northern limit of Rancheria Reservoir was assumed to be the natural saddle near the small settlement of Chrome.

TABLE 8-1

RANCHERIA RESERVOIR AREA-CAPACITY DATA

Elevation		Area		Capacity	
Metres	Feet	Hectares	Acres	Cubic Dekametres	Acre-Feet
176.8	580	0	0	0	0
182.9	600	17	42	520	420
189.0	620	75	185	3 320	2,690
195.1	640	211	522	12 040	9,760
201.2	660	363	897	29 540	23,950
207.3	680	531	1,312	56 790	46,040
213.4	700	787	1,944	96 950	78,600
219.5	720	1 182	2,921	156 960	127,250
225.6	740	1 706	4,215	244 990	198,610
231.7	760	2 419	5,977	370 700	300,530
237.7	780	3 275	8,093	544 260	441,230
243.8	800	4 248	10,496	773 550	627,120
249.9	820	5 159	12,747	1 060 250	859,550
256.0	840	5 983	14,785	1 399 860	1,134,870
262.1	860	6 884	17,011	1 792 070	1,452,830
268.2	880	7 761	19,177	2 238 440	1,814,710
274.3	900	8 678	21,444	2 739 500	2,220,920
280.4	920	9 790	24,190	3 302 400	2,677,260
286.5	940	10 918	26,979	3 933 570	3,188,950
292.6	960	12 109	29,921	4 635 430	3,757,950
298.7	980	13 184	32,577	5 406 340	4,382,930
304.8	1,000	14 335	35,421	6 245 100	5,062,910
317.0	1,040*	16 200	40,100	8 100 000	6,570,000
329.2	1,080*	18 300	45,100	10 210 000	8,280,000
341.4	1,120*	20 500	50,700	12 570 000	10,190,000

*Although the 1960 reservoir map extends to elevation 335.3 m (1,100 ft), the detailed planimetry to determine areas and capacities did not extend above elevation 304.8 m (1,000 ft). These three higher elevations were determined from advance copies of 1:24,000 USGS quadrangle maps during a rough appraisal of larger reservoirs in 1967. These higher Rancheria Reservoir levels would exceed the topographic limits of the Newville Reservoir area and could be developed only by use of a high dike near Chrome to isolate Rancheria Reservoir from Newville Reservoir.


Area in thousands of hectares (acres)
18
15
12
9
6
3
0
(40)
(35)
(30)
(25)
(20)
(15)
(10)
(5)
Elevation in metres (feet)
340
320
300
280
260
240
220
200
180
(1100)
(1000)
(900)
(800)
(700)
(600)
Capacity
Area
Glenn Reservoir Plan
Rancheria Reservoir
Area - Capacity Curves
Capacity in millions of cubic dekametres (millions of acre-feet)
0
2
4
6
8
10
12
(2)
(4)
(6)
(8)
(10)
Figure 8-1

Seismicity

Preliminary planning designs prepared in the 1960s for Rancheria Dam and appurtenant structures were based on generalized seismic design criteria that reflected the moderate seismic hazard potential of the northern Sacramento Valley. A comprehensive review of existing information on seismic conditions was undertaken in 1977, as outlined in the Department's July 1978 report, "West Sacramento Valley Fault and Seismicity Study--Glenn Complex, Colusa Reservoir, Berryessa Enlargement". This review led to a contract with Earth Sciences Associates of Palo Alto in 1979.

Earth Sciences Associates was asked to determine if any fault or seismic hazards exist that would make the Glenn Reservoir Project infeasible. Their January 1980 report, "Seismic and Fault Activity Study--Proposed Glenn Reservoir Complex", concludes that:

- All faults near the sites of principal engineering structures are pre-Quaternary in age (over 1 million years) and surface offsets need not be considered in project feasibility studies.

- Major uplift on the Stony Creek fault, which lies about 7 km (4.3 mi) west of Rancheria Dam site, last occurred more than 250,000 years ago, with minor renewed movement between 30,000 and 130,000 years ago.

- The Stony Creek fault is the critical structure in terms of design criteria and has been assigned a maximum credible earthquake magnitude of 6.5, for either a natural or reservoir-induced seismic event. However, the probability of occurrence of such an event is very low.

- Based upon historical seismicity, earthquakes up to between magnitude 4 and 5 can be expected anywhere in the Glenn Reservoir region.

A detailed synopsis of seismicity and related basic data is presented in Appendix A, "Regional Geology, Fault, and Seismic Considerations".

The Department completed installation of an eight-station sensitive seismograph network in the Glenn Reservoir area in May 1980. Data from that network, continuously transmitted to recording devices in Sacramento, will be used to refine analyses of seismic conditions and to precisely locate areas of minor seismic activity in the vicinity of proposed facilities. The seismic network will be maintained permanently unless studies of the Thomes-Newville or Glenn Plans are terminated.

Foundation Geology and Construction Materials

Foundation geology and construction materials for Rancheria Dam and its associated structures have been investigated in two principal phases. In the first phase (1959-62), the damsite was concluded to be suitable on the basis of a reconnaissance-level appraisal and the principal emphasis was directed at quantitative evaluation of potential construction materials.

In the second phase (1967-68), the main emphasis was on subsurface exploration to confirm the suitability of the site; some additional exploration and testing of construction materials was also performed. Recent (1978-80) geology and materials investigations have concentrated on Newville Reservoir, but some of the findings apply to Rancheria Reservoir also.

During the overall several years of study of Rancheria Dam and Reservoir, a fairly extensive body of data and reports has been accumulated. Appendix D, "Construction Materials", and Appendix E, "Rancheria Dam Site Geology", summarize the previous studies and present complete reference lists of supporting documents. All studies to date indicate that Rancheria Dam site is suitable for construction of an embankment-type dam of the size under consideration. Abundant deposits of impervious embankment materials have been identified, but proven quantities of gravel or rockfill are marginal for a high dam; additional exploration and testing would be required to appraise the total available gravel and rock sources with a high degree of reliability.

Hydrology

The drainage area upstream from Rancheria Dam site encompasses 1 551 km^2 (599 mi^2), distributed as follows:

	km^2	(mi^2)	%
Little Stony Creek above East Park Dam	254	98	16
Between East Park and Stony Gorge Dams	526	203	34
Subtotal--above Stony Gorge Dam	780	301	50
Grindstone Creek near mouth	445	172	29
Other tributary areas	326	126	21
Total--above Rancheria Dam Site	1 551	599	100

A number of gaging stations have been operated in the Stony Creek basin at various locations and at various times over the past 70 years. Chapters 2 and 6 described the available flow records and the development of estimated monthly inflows to Rancheria Reservoir for the 50-year (1922-71) study period; these data were used for project formulation and reservoir operation studies.

Information on flood peaks and hydrographs is also needed, to establish criteria for sizing diversion facilities, spillway design, and construction scheduling. The "Stony Creek near Fruto" stream gage, located essentially at Rancheria Dam site, operated from January 1901 through October 1912 and from October 1960 through September 1978. The largest flood during that period of record occurred in December 1964. Comparisons with other flow records in the vicinity indicate that the 1964 flow peaks were likely the largest in this century. The recorded December 1964 flows were:

Date (Dec. 1964)	Daily Mean Flow m^3/s	(ft^3/s)
20	11	383
21	146	5,160
22	600	21,200
23	742	26,200
24	388	13,700
25	176	6,230
26	155	5,470
27	214	7,550
28	127	4,490
29	77	2,720

Peak flow: 1 130 m^3/s (40,200 ft^3/s, Dec. 23

Ten-day volume: 228 000 dam^3 (185,000 ac-ft)

The Corps of Engineers, Sacramento District, calculated a preliminary spillway design flood and a preliminary standard project flood in 1969 as part of a review of Rancheria Reservoir plans conducted for comparison with the Dos Rios Project. Data for those floods are presented in the Corps' office report, "Rancheria Reservoir, Stony Creek, California", July 1969. The Corps' spillway design (probable maximum) flood hydrograph shows a peak reservoir inflow of 5 270 m^3/s (186,000 ft^3/s) and a 5-day volume of 696 000 dam^3 (564,000 ac-ft). The standard project flood peak is estimated in the Corps' report as 2 550 m^3/s per second (90,000 ft^3/s) with a 3-day volume of 296 000 dam^3 (240,000 ac-ft).

The Water and Power Resources Service is currently reappraising the adequacy of the spillway at Stony Gorge Reservoir and has reportedly calculated a design flood with a peak of 3 680 m^3/s (130,000 ft^3/s). Since the drainage area tributary to Stony Gorge Dam is just half that to Rancheria Dam, it appears that the 1969 Corps data should be further analyzed before any detailed design studies are performed.

Sediment

The USGS estimated the mean annual sediment load of Stony Creek in its Water Supply Paper 1798-J, "Sediment Transport in the Western Tributaries of the Sacramento River, California". The USGS findings are summarized in Chapter 5 in reference to a Millsite Dam on Stony Creek. Chapter 5 concludes that the total average annual sediment load entering Millsite Reservoir would occupy a volume of about 420 dam^3 (340 ac-ft). Sediment inflow to Rancheria Reservoir would be greater, because it would inundate Stony Gorge Reservoir, which presently traps an annual average of about 60 dam^3 (50 ac-ft) of sediment. So, total sediment deposition in Rancheria would be on the order of 480 dam^3 (390 ac-ft); this is insignificant in comparison to the sizes of reservoir under consideration.

Rancheria Dam

The Department prepared preliminary designs and cost estimates in 1978 for three sizes of Rancheria Dam and appurtenant facilities:

Normal Pool Elevation		Dam Crest Elevation		Dam Height Above Streambed		Reservoir Storage	
m	(ft)	m	(ft)	m	(ft)	dam^3	(ac-ft)
289.6	950	295.7	970	116	380	4 275 000	3,466,000
304.8	1,000	310.9	1,020	131	430	6 245 000	5,063,000
320.0	1,050	326.1	1,070	146	480	8 606 000	6,977,000

The highest of these dams would be used only with a Chrome Dike that would isolate Rancheria Reservoir from Newville Reservoir (which could not be built to such a height because of topographic limitations). The smaller sizes would probably be merged with a comparable Newville Reservoir, so that a Chrome Dike would not be required. The middle-sized example is used as a basis for the remainder of this chapter, since it is relatively close to the sizes of the example project formulations described in Chapter 6.

Axis Location

For over 50 years, studies of potential reservoir storage on the middle reaches of Stony Creek focused on Millsite Dam site, 5 km (3 mi) downstream from Rancheria Dam site. In the late 1950s, attention shifted to very large reservoirs for storage of water from other basins and Rancheria Dam site was found to be topographically superior to the Millsite alternative. (Approximately 50 percent more dam embankment would be required at Millsite for an equivalent reservoir capacity.) Also, foundation conditions at Rancheria Dam site are slightly more favorable than those at Millsite because of a higher ratio of sandstone to mudstone.

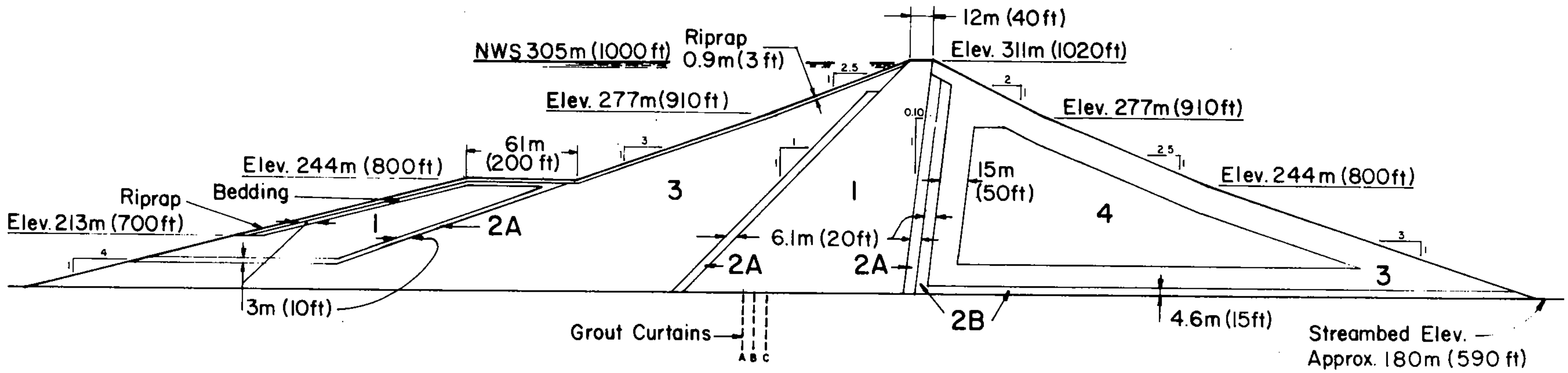
Rancheria Dam site is located where Stony Creek crosses a prominent north-south-trending ridge. Due to the narrowness of both abutments, there is little latitude in location of the dam.

Selection of Dam Section

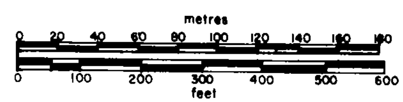
The topography and foundation at Rancheria Dam site are best suited for an embankment-type dam. Appendix D describes the various construction materials that have been identified for possible use in the dam. These are the same materials that were discussed in Chapter 3 for Newville Dam: (1) Tehama Formation soils lying east of the damsite; (2) terrace and slopewash deposits from within the reservoir area; (3) stream gravels, primarily from the channels of Grindstone and Stony Creeks; and (4) sandstone and conglomerate from nearby ridges.

The dam section shown on Figure 8-2 was used as a basis for the most recent cost estimates. The central impervious core would be constructed of Tehama Formation soils, the same material selected for the core of Newville

Figure 8-2



Zone	Embankment Material	Zone	Embankment Material
1	Tehama Formation	3	Rolled stream sand and gravel.
2A,2B	Transition and drain zones.	4	Random zone.



Glenn Reservoir Plan

Rancheria Dam

(maximum section)

Dam. The shell zones would be primarily sand and gravel, but the downstream shell would include a large random zone of Tehama Formation soils and selected spoil from required excavations. Transition and drain zones would be processed from stream channel deposits. The selection of the Tehama Formation soils instead of the potential impervious borrow material from within the reservoir was based on their abundance and proven suitability. The stream gravels were selected because of their proximity to the damsite and because of the uncertainty about the strength and durability of nearby quarried rock.

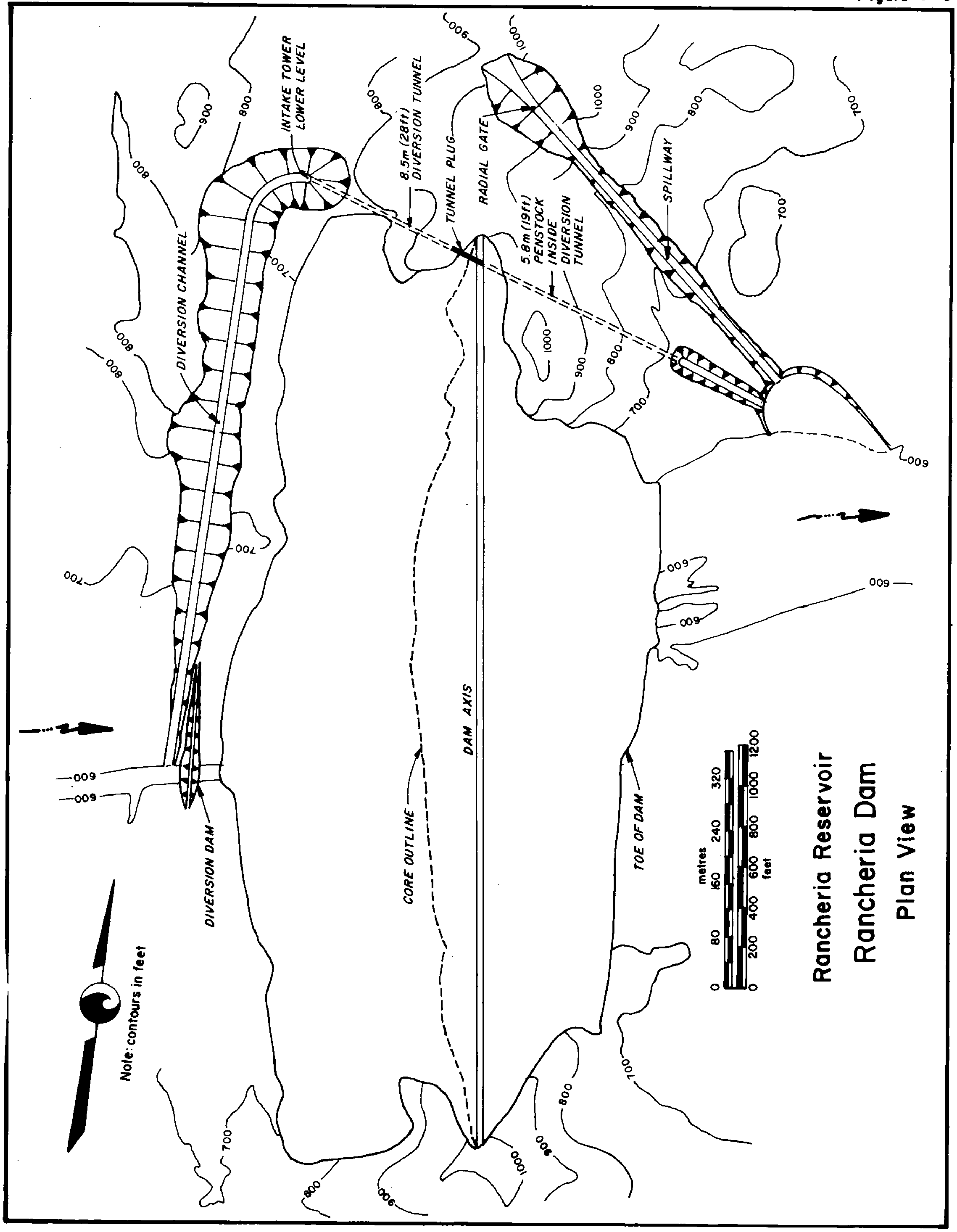
No stability calculations were performed specifically for the selected dam section, but limited analyses of a very similar section were conducted in 1966. These studies indicated that the section would meet both static and seismic stability criteria that were in effect at the time. Much more detailed stability analyses were recently completed for Newville Dam, as reported in Chapter 3; while the results are not directly applicable to the Rancheria Dam section, they do indicate that a similar section is adequate. So, while some minor adjustments might eventually be needed, the dam section on Figure 8-2 represents a reasonable basis for assessing the feasibility and cost of Rancheria Dam. Figure 8-3 shows a plan view of Rancheria Dam, using the selected section.

For a Rancheria Dam with a crest elevation of 311 m (1,020 ft), the volumes of the principal materials would be:

Zone	Source	Volume m^3	Volume (yd^3)
1 Impervious	Tehama Formation }	24 000 000	31,400,000
4 Random	Waste, Tehama Formation }		
2A Transition	Processed sand and gravel }	3 100 000	4,000,000
2B Drain	Processed sand and gravel }		
3 Shell	Sand and gravel	21 100 000	27,600,000
- Riprap, bedding	Quarried rock	660 000	860,000
		48 860 000	63,860,000

The volume of sand and gravel required for Zones 2A, 2B, and 3 would approach the total volume of 26 000 000 m^3 (34,000,000 yd^3) that has been identified along Stony and Grindstone Creeks. Under the current concept of development, Rancheria Dam would be constructed only along with a Newville Dam. The preliminary design of a high Newville Dam would require nearly 5 000 000 m^3 (6,500,000 yd^3) of sand and gravel, a major part of which would have to be obtained from the Stony and Grindstone Creek areas. Consequently, there appears to be a shortage of nearby sand and gravel deposits for the construction of large dams at both the Rancheria and Newville sites. This problem could be overcome by (a) redesign of Rancheria Dam to use less gravel, or (b) exploration to locate and prove out additional sand and gravel deposits. Ultimately, the Rancheria Dam section might have to be revised to substitute quarried sandstone and conglomerate for part of the gravel zones. The potential quarry areas near Rancheria Dam would produce material similar to that investigated for use in Newville Dam, so it is likely that a satisfactory design could be worked out.

Figure 8-3



Rancheria Reservoir
Rancheria Dam
Plan View
Note: contours in feet
INTAKE TOWER
LOWER LEVEL
8.5m (28ft)
DIVERSION TUNNEL
TUNNEL PLUG
RADIAL GATE
5.8m (19ft)
PENSTOCK
INSIDE
DIVERSION
TUNNEL
SPILLWAY
DIVERSION CHANNEL
DIVERSION DAM
CORE OUTLINE
DAM AXIS
TOE OF DAM
metres
0 80 160 240 320
0 200 400 600 800 1000 1200
feet

If a staged Newville Dam plan were adopted, it might prove advantageous to use sand and gravel in place of quarried rock in the shells of the first stage dam. (This would probably be based on costs and suitability of materials and uncertainty about the eventual construction of Rancheria Dam.) If so, about half of the identified quantity of Stony and Grindstone Creek materials would be used in the first stage of Newville Dam and a design incorporating a substantial amount of rock would almost certainly be necessary for Rancheria Dam.

Foundation Treatment

Appendix E summarizes the foundation exploration and geologic studies that have been conducted at Rancheria Dam site. Foundation conditions are similar to those at Newville Dam site. The central portion of the dam would be founded on interbedded sandstone and mudstone beds that strike parallel to the dam axis and dip steeply downstream. The remainder of the site is underlain by mudstone with a minor amount of interbedded sandstone. Shallow, irregular terrace deposits occur on the lower portions of both abutments. Alluvium fills the channel to an average depth of about 5 m (15 ft). There are no major faults in the foundation area or nearby. Average stripping requirements are estimated in Appendix E as 4 to 6 m (14 to 20 ft) under the various dam zones. Air slaking of fresh mudstone exposed during foundation stripping should be avoidable by trimming to final grade just prior to embankment placement. Water pressure testing on drill holes has shown the foundation to be generally tight and impervious; only light grouting would be required.

Outlet Works

After a wide range of alternatives was examined, it appears that Glenn Reservoir could be developed in three basically different ways. These would affect the sizing of inlet and outlet facilities at Rancheria Dam as follows:

1. If Glenn Reservoir were developed in a single stage, water diverted from the Sacramento River to Black Butte Reservoir would best be conveyed to Glenn Reservoir via Tehenn Reservoir on the North Fork of Stony Creek. In this case, the outlet facilities at Rancheria Dam would be sized to satisfy criteria for diversion during construction and emergency reservoir evacuation. Most reservoir releases would be made through the power-generating facilities at Newville Dam. However, some release capability would have to be retained at Rancheria Dam to provide access to the 3 500 000 dam^3 (2,840,000 ac-ft) of active storage that would remain in the Rancheria compartment should Glenn Reservoir drop below the 283-m (930-ft) Chrome saddle elevation. The required release capacity would be on the order of 50 m^3/s (1,800 ft^3/s). The Rancheria outlet would be used only infrequently and the need for multiple-level intake facilities has not been determined; if a multiple-level intake were required, it would have to function only between reservoir elevations of 215 to 283 m (705 to 930 ft).

2. If Glenn Reservoir were developed in conjunction with a two-stage plan for construction of Newville Reservoir, the main inlet and outlet facilities would be located at Rancheria Dam. They would have to handle pumping of around 280 m^3/s (10,000 ft^3/s) from Black Butte Reservoir and releases of about half that amount. Multiple-level intake facilities would have to be provided for the entire reservoir operating range between minimum and normal pool levels.

3. If a split-level Glenn Reservoir were developed (by combining a higher Rancheria Reservoir with an earlier-constructed Newville Reservoir using Chrome Dike), the intake and outlet facilities would be split between the two dams. The initial Thomes-Newville Plan would include about 85 m^3/s (3,000 ft^3/s) of pumping capacity between Millsite and Newville Reservoirs. In the ultimate development, this pumping capacity could be used to handle part of the water diverted from the Sacramento River. The remainder, around 200 m^3/s (7,000 ft^3/s), would be pumped to the Rancheria compartment. Releases would be made at both Rancheria and Newville Dams, in accordance with the volumes of water in storage in the respective reservoir compartments.

Designs and cost estimates have been prepared only for a plan similar to the first of the preceding options. That option now appears unlikely to be selected as an element of the State Water Project. Further work is obviously needed on the other options if the Glenn Reservoir Plan is considered in the future. However, the design that has been completed forms a reasonable basis for appraisal of physical feasibility cost.

The preliminary designs and cost estimates that have been completed include both a high-level and a low-level outlet works. The low-level system would be installed in the diversion tunnel, which would be located beneath the left abutment of the dam. A single low-level intake would be constructed on the upstream end of the 8.5-m- (28-ft-) diameter tunnel. Downstream from a tunnel plug near the dam axis, a 5.8-m (19-ft) penstock would be installed within the tunnel. At the downstream end of the tunnel, two 2 400-mm (96-in) fixed-cone valves would discharge to a stilling basin. (A power plant might eventually prove to be justified here, even though it would operate infrequently.) These facilities were sized to help meet reservoir evacuation needs; they could discharge about 340 m^3/s (12,000 ft^3/s) with the reservoir at elevation 305 m (1,000 ft).

The high-level outlet facilities were designed to draw water from within the upper 24 m (80 ft) of Rancheria Reservoir, using a multiple-level intake tower. These facilities would not be compatible with the single-stage Glenn Reservoir (because the multiple-level intake covers the wrong elevation range), but they could be modified to meet the proper criteria without any great change in cost. As designed, the high-level outlet would include an intake tower, a 4-m- (13-ft-) diameter tunnel through the upper left abutment, and the necessary associated control and access facilities. The high-level outlet would discharge up to about 250 m^3/s (9,000 ft^3/s) to the spillway chute.

Although studies of the Rancheria Dam outlet works have been quite limited, there is no indication that a feasible and economical plan could not be developed for any particular outlet criteria that may be selected. Tunneling conditions are satisfactory in either dam abutment and, although the outlet facilities would be large, they would be well within the range of established practice. It is anticipated that design would be fairly conventional and the construction routine.

Spillway

Under most of the various approaches to construction of Glenn Reservoir, a spillway would be included in the Rancheria compartment. The only exception would occur if the first-stage spillway at a two-stage Newville Reservoir could be modified to serve the entire Glenn Reservoir. The Rancheria spillway needs would vary with the configuration of the overall plan. Glenn Reservoir would be so large that much of an incoming flood could be temporarily stored, so the maximum outflow would be but a fraction of the peak inflow.

The most recent (1978) designs and cost estimates for a Rancheria Dam provided for an ungated, chute-type spillway on the left abutment. For these estimates, the spillway crest length was shown as 61 m (220 ft) and the peak discharge would have been about 820 m^3/s (29,000 ft^3/s) during the spillway design flood. At the peak design flow, the reservoir level would have risen to about 3.4 m (11 ft) above the spillway crest. This 1978 design was developed for inflow from the Rancheria Reservoir basin only, not the entire Glenn Reservoir drainage area. But, for the larger reservoir, the peak spillway discharge would not be much different, because the added volume of the Newville compartment would be able to absorb the runoff from the North Fork Stony Creek drainage area.

The 1978 design, with an ungated spillway, would not permit the spillway to be used to help evacuate the reservoir in an emergency. The preliminary designs for Newville Reservoir were based on an emergency drawdown criterion that called for releasing one-third of the reservoir volume within 16 days. With a full Glenn Reservoir, this criterion would require average releases of almost 3 400 m^3/s (120,000 ft^3/s), which would be rather impractical. For Glenn Reservoir, a more realistic criterion would be to allow 30 days for this drawdown, which would require an average discharge of about 1 300 m^3/s (47,000 ft^3/s) as the reservoir elevation dropped from 305 m (1,000 ft) to 287 m (940 ft). Approximately half of the required emergency drawdown release could be handled by the outlet facilities at Rancheria and Newville Dams, but the remainder would have to be passed through the spillway. To accomplish this, a gated spillway would be needed. Detailed designs have not been prepared for this particular case, but a cursory appraisal was made of a gated spillway (using a left abutment alignment similar to that of the 1978 design). With two gates, each 6.1 m (20 ft) wide and 15.2 m (50 ft) high, the spillway could discharge about 1 400 m^3/s (50,000 ft^3/s) with the reservoir at normal pool level; it would easily be able to handle the outflow resulting from the spillway design flood.

A left abutment spillway at Rancheria Dam would be founded primarily on mudstone. The spillway chute would be about 600 m (2,000 ft) long, terminating in a concrete stilling basin that would discharge directly to Stony Creek or Millsite Reservoir. Design and construction would be routine.

Diversion During Construction

A diversion tunnel alignment through the left abutment was selected; favorable tunneling conditions would be encountered in either abutment, but the left abutment alignment would be shorter. The tunnel would be 730 m (2,400 ft) long, with lengthy approach and discharge channel excavations as shown on Figure 8-3. The tunnel would be fully lined, using an 8.5-m (23-ft)-diameter circular section. This size was selected to handle the peak daily flow of record of 742 m^3/s (26,200 ft^3/s) with the reservoir pool at elevation 207 m (680 ft). This criterion was selected to minimize the risk of flooding borrow areas within the reservoir area. If future studies determine that the diversion facilities should be able to handle the standard project flood, both a larger tunnel and a higher cofferdam would be necessary.

Saddle Dam

One saddle dam would be required for the Rancheria compartment of Glenn Reservoir. The saddle is about 3 km (2 mi) north of the main damsite and has a low point elevation of 291 m (956 ft). Foundation conditions at the saddle are similar to those at the Newville compartment saddle dams along Rocky Ridge, but the terrain is not as steep. The Rancheria saddle dam section would be the same as proposed for Newville Reservoir, as shown on Figure 3-2. The total volume of embankment required would be only about 150 000 m^3 (200,000 yd^3).

The only other Rancheria Reservoir saddle lower than elevation 317 m (1,040 ft)* is located about 1.4 km (0.9 mi) north of the main dam; it has a low point elevation (as indicated by the Department's 1:4800 scale mapping) of 313 m (1,027 ft). Some slope protection might be necessary at this saddle, but it would be on a reservoir arm and thus would not be exposed to heavy wave action.

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*The USGS 1:62,500 "Elk Creek" quadrangle map shows another saddle at an elevation lower than 305 m (1,000 ft) about 2.3 km (1.4 mi) north of Rancheria Dam. The Department's 1:4800 map and the later 1:24,000 "Chrome" quadrangle show that the older map is in error and the true elevation of this saddle is over 341 m (1,120 ft).

Construction Schedule

A six-year construction schedule was laid out for Rancheria Dam. The first season would be devoted to borrow area and damsite stripping, construction of the diversion tunnel, haul roads, etc. Embankment placement could be started at any time on the higher portions of the channel section; full-scale placement would begin early in the second year. Cofferdams would be constructed as early as possible in the second year to divert Stony Creek through the completed tunnel. The remainder of the channel section would be stripped and embankment placement would proceed along the entire length of the dam. For safety against overtopping, the dam should be brought to above elevation 207 m (680 ft) by the start of the rainy season.

The third, fourth, and fifth construction seasons would be devoted to embankment placement and construction of appurtenant works, reservoir clearing, road relocations, etc. Final diversion tunnel closure and the initiation of storage in the reservoir could be accomplished long before the dam was complete, as the maximum annual runoff is less than the storage capacity at a pool level of 260 m (850 ft). However, that scheme would flood a portion of the gravel borrow areas and the haul roads for the riprap. It was assumed that final closure would be accomplished midway in the fourth construction season. Final closure of the diversion tunnel and completion of the outlet works could be greatly facilitated by the existing reservoirs on Stony Creek. In the spring of the fourth season, Stony Gorge and East Park Reservoirs could be drawn down and Black Butte Reservoir filled. Then, releases from the upstream reservoirs could be stopped while a bulkhead was installed to seal the Rancheria Dam diversion tunnel. The tunnel plug, penstock, control valves, and other features of the outlet works could be completed during the summer months. During this time, all downstream prior rights could be met by releases from Black Butte Reservoir.

Cost Estimates

Table 8-2 summarizes the estimated cost of Rancheria Dam and Reservoir. The basic cost estimates were prepared by the Divisions of Design and Construction and Land and Right-of-Way in 1978, referenced to spring 1978 price levels. Except as noted, the figures in Table 8-2 were derived by multiplying the 1978 costs by a factor of 1.20, to correct to spring 1980 price levels. The costs shown do not include any allowances for price escalation during the six-year construction period.

TABLE 8-2

GLENN RESERVOIR PLAN
RANCHERIA RESERVOIR-PRELIMINARY COST ESTIMATES
(Price Basis - Spring 1980)

Reservoir Normal Pool Elevation: 305 m (1,000 ft)
Dam Crest Elevation: 311 m (1,020 ft)
Dam Height Above Streambed: 131 m (430 ft)
Reservoir Storage Capacity: 6 245 000 dam^3 (5,063,000 ac-ft)

Item	Contract	Contingencies	Engineering	Total
Reservoir, Relocations	$ 34,470,000 a/	$ 3,450,000	$ 8,720,000	$ 46,640,000
Rancheria Dam	273,350,000	27,340,000	69,160,000	369,850,000
Outlet Works	38,300,000	3,830,000	9,690,000	51,820,000
Spillway b/	15,700,000	1,570,000	3,970,000	21,240,000
Saddle Dam	1,150,000	120,000	290,000	1,560,000
Subtotals	$362,970,000	$36,310,000	$91,830,000	$491,110,000
Land Acquisition				65,190,000
Total				$556,300,000

a/ Includes allowance of $10 million for highway bridge or causeway crossing at Chrome (which was not included in original estimates).

b/ Estimate for gated spillway, prepared by Northern District.

Conclusions

Based on past geology and design studies, it is concluded that the Rancheria site is suitable for construction of a high dam. The site is free of major faults and seismic conditions would be within the range of normal practice. Materials to build the dam have been located within reasonable haul distance. Most work to date has concentrated on reservoir elevations of 305 m (1,000 ft) or less, but there is no topographic or geologic reason to rule out a higher dam. The reservoir rim is higher than that of the Newville compartment and saddle dams would not become significant until the dam crest elevation approached about 335 m (1,100 ft).

Rancheria Dam and Reservoir could be integrated with the Newville compartment in a number of different ways, and the choice of the overall plan would have a substantial influence on the design of the Rancheria facilities. Studies have not been conducted for all of the plan variations. Any future design work on Rancheria Dam should begin by developing a comprehensive and compatible set of plans for diversion during construction, emergency reservoir evacuation, spillway, and outlet facilities. Past studies of these items have shown that feasible plans can be developed, but designs of the various features have not yet been matched to a single plan.

All recent design studies of Rancheria Dam have been based on the use of nearby sand and gravel deposits to make up a major portion of the dam embankment. The identified volumes of sand and gravel in Stony and Grindstone Creeks are not adequate for construction of both Rancheria and Newville Dams and more effort should be devoted to finding and appraising additional sources of sand and gravel.

If design studies of Rancheria Dam are resumed in the future, they should begin by revising the dam section to meet the latest seismic design criteria. Studies should also be conducted to evaluate the strength of the mudstone in the dam foundation. Unless substantial additional quantities of sand and gravel are identified, Rancheria Dam should be redesigned to substitute quarried rock for a portion of the sand and gravel in the shell zones.

CHAPTER 9. GLENN RESERVOIR PLAN-- CONVEYANCE FACILITIES

Conveyance facilities would account for a large share of the total cost of a Glenn Reservoir Plan. They may be grouped into four categories: (1) facilities to divert Sacramento River water to Black Butte Reservoir; (2) facilities to convey water in either direction between Black Butte and Glenn Reservoirs; (3) facilities to convey releases to the Sacramento River; and (4) facilities to divert surplus water from Thomes Creek to Glenn Reservoir. The Thomes Creek diversion facilities are treated in Chapter 4; this chapter covers the other three categories.

The Division of Design and Construction prepared preliminary designs and cost estimates in 1978 for Glenn Reservoir diversion facilities with capacities of 142, 283, and 566 m^3/s (5,000, 10,000, and 20,000 ft^3/s). Those studies are reported in an October 1979 memorandum report entitled "SWP Future Supply Program, Glenn Reservoir Complex Reconnaissance Study". For the example plan formulations described in Chapter 6, the optimum size of Sacramento River diversion would be in the range of 283 to 340 m^3/s (10,000 to 12,000 ft^3/s); this chapter focuses on the 283-m^3/s size as the most representative size for which designs and cost estimates are available. Facilities to deliver Glenn Reservoir releases to the Sacramento River are illustrated with a capacity of 142 m^3/s (5,000 ft^3/s).

Previous Studies

Over the past three decades, studies have been made of a number of conveyance systems along the west side of the upper Sacramento Valley. As a prelude to an overview of these past studies, note should be taken of the following key elevations:

Reservoir	Normal Pool or Spillway Crest Elevation	
	m	(ft)
Shasta	325	1,067
Keswick	179	587
Red Bluff Diversion	77	252
Black Butte	144	474
Glenn	305±	1,000±
Colusa	158±	520±

The earliest canal studies for the upper Sacramento Valley area led to construction of the federal Tehama-Colusa Canal, which diverts from Red Bluff Diversion Dam and follows a minimum gradient southward for over 160 km (100 mi). Construction of the Tehama-Colusa Canal began in the early 1960s and completion is nearing today.

In the late 1950s, the Department conceived the High-Level Westside Conveyance System. It would have generally followed the 305-m (1,000-ft) contour from the Middle Fork of Cottonwood Creek to Glenn Reservoir, by connecting 17 reservoirs with excavated channels. This plan was originally intended to convey water imported from the Trinity and Klamath Rivers, but the system was eventually extended to cover the possibility of capturing excess water directly from Shasta Reservoir.

In the mid-1960s, various versions of a Low-Level Westside Conveyance System were investigated. This system would have terminated at Colusa Reservoir; it mainly emphasized conveyance of imported water, but an extension to capture floodflows from Keswick Reservoir was also examined. None of these plans appeared very promising.

Studies of using Glenn Reservoir strictly for offstream storage of Sacramento River water began in 1970. The initial planning, based on offpeak pumping, settled on a gravity diversion from the Red Bluff Diversion Dam to a Kirkwood Forebay Reservoir on Sour Grass Creek. The 40-km (25-mi) canal from Red Bluff to Kirkwood Forebay would have run parallel to the Tehama-Colusa Canal. From Kirkwood Forebay, a 13-km (8-mi) cut would have led to an offpeak pumping plant near the toe of Black Butte Dam. From Black Butte Reservoir, another deep cut would have connected to a second offpeak pumping plant at Newville Dam. Releases would have followed the same route to Kirkwood Forebay for discharge to the Sacramento River via about 10 km (6 mi) of improved creek channels. Power would have been generated through use of reversible pump-turbine units at both of the pumping installations.

When the 1978 design and cost studies began, offpeak pumping no longer appeared to be economically attractive, thus obviating the need for forebay storage. Consequently, the pumping plants could be located wherever desired and a wide range of conveyance alignments became possible. Three representative alternative alignments were examined in detail: (1) a low-level alignment similar to the original plan, except that two pumping lifts would be employed to reach Black Butte Reservoir; (2) a mid-level route that would involve one pump lift near Red Bluff Diversion Dam and another at the toe of Black Butte Dam; and (3) a high-level route with two pump lifts near Red Bluff and gravity flow to Black Butte Reservoir. With the high-level route, a completely separate system would be needed to carry releases from Black Butte Reservoir to the Sacramento River; with the other routes, part of the conveyance facilities could be used for releases. Taking the costs of release facilities into account, the low- and mid-level routes were found to be about equal in cost, while the high-level route would be significantly more expensive. The mid-level route was selected because it would traverse a less-inhabited area than the low-level route. Also, with one pumping lift at either end, the canal alignment could be varied to best fit the terrain and to avoid local development.

A cursory examination was also made of a fourth alternative for diversion from the Sacramento River near the mouth of Burch Creek, about 55 river km (34 river mi) downstream from Red Bluff Diversion Dam. With this plan, the same facilities could be used for both diversions and releases, so the total length of conveyance canals would be less than for any of the plans diverting from Red Bluff. Also, surplus flows would occur for longer periods at the downstream diversion point, so less diversion capacity would be required to pump a given amount of water; the savings in capacity would be approximately 9 percent. The cursory studies showed significant savings in construction costs with the Burch Creek alternative route. The drawback, of course, is that the total pumping head would be increased by about 30 m (100 ft) in comparison to a plan that would divert from Red Bluff. With the relatively low energy value used in the current study, construction cost savings would outweigh the additional energy cost and the overall unit cost of water would be lower with the Burch Creek route. Higher energy values, however, would reduce or eliminate the apparent advantage of the Burch Creek route, but it appears sufficiently promising to warrant more detailed study in the future.

Background Data

Chapter 5 describes the information that has been developed to support the studies of the conveyance facilities between Black Butte and Glenn Reservoirs. The other conveyance facilities (from Red Bluff Diversion Dam to Black Butte Reservoir and from Black Butte Reservoir to the Sacramento River) have involved a wide range of alternatives over a considerable geographic area. Consequently, the background studies have been of limited extent in comparison to these carried out for other features of the Glenn Reservoir Plan.

Topographic Mapping

Preliminary layouts and cost estimates of the Red Bluff-Black Butte Reservoir-Sacramento River conveyance facilities were based on the following USGS quadrangle maps:

Map Name	Scale	Contour Interval m	Contour Interval (ft)	Date
Red Bluff East	1:24,000	3.0/1.5	10/5	1951*
Gerber	1:24,000	1.5	5	1950*
West of Gerber	1:24,000	3.0	10	1951*
Henleyville	1:24,000	3.0	10	1967
Black Butte Dam	1:24,000	6.1/3.0	20/10	1967
Kirkwood	1:24,000	1.5	5	1949*
Foster Island	1:24,000	1.5	5	1950*

*Photorevised 1969.

Geology

The major portion of the conveyance facilities between Red Bluff and Black Butte Reservoir would be founded on soils of either the Red Bluff or Tehama Formation. Both of these formations cover extensive areas of the northern Central Valley and their properties are well known. All excavation within these formations could be accomplished by common methods and overall conditions would be similar to those encountered on the nearby Tehama-Colusa