CHAPTER VI

DEVELOPABLE WATER

GENERAL:

This chapter summarizes the alternatives which were considered for developing each of the water sources described in the previous chapter. Included are projects suggested by previous studies as well as some developed during this study. No effort was made to prioritize the alternatives. Estimates have been made which indicate the magnitude of project costs at the end of the year 1981. However, care should be taken in evaluating one alternative against another as the costs do not include associated project costs for modifications to the distribution systems.

For some of the water sources, several alternatives are presented. Use of one of these alternatives may exclude the use of other alternatives. However, in some cases, a combination of alternatives may be chosen as the plan of development. This study does not evaluate environmental considerations. However, some of the project sites are environmentally sensitive. The known environmentally sensitive issues are mentioned in each case.

The water source development alternatives include dams, reservoirs, diversion structures, water treatment plants, pipelines and various combinations of the same. Alternatives are discussed for each of the canyons described in Chapter V. The selection of the alternative and the timing of development are left to the water agencies wishing to develop the source.

DAMS, RESERVOIRS AND DIVERSION STRUCTURES: A literature review indicated that all the major dam and reservoir sites within Salt Lake County have been previously located, considered, and in some cases have been studied extensively. Smaller dams with reservoir capacities from the low hundreds to several thousand acre-feet have generally not been considered in earlier studies. There are, however, numerous potential sites for such dams within the study area.

An attempt was made to locate and study, on a reconnaissance level, at least one damsite per canyon. In some cases, several damsites per canyon were identified and studied. However, a cursory examination of some canyons revealed no reasonable site for a dam and reservoir due to adverse topography.

The basic criterion used in selecting damsites for study was topography. Sites which would allow for a maximum storage volumes with minimal dam sizes were chosen for cost analysis and further study. Because of the reconnaissance level of this study, other criteria such as geology and availablility of borrow material were not considered unless developed in a previous study.

In general, capital costs for developing each damsite were estimated for three different reservoir capacities in order to provide a representative range of costs. The three capacities chosen were: (1) the mean annual yield; (2) the mean annual yield less the average constant base stream flow, referred to in this report as the "spring runoff volume"; and (3) an arbitrary capacity smaller than both (1) and (2). The resulting total capital cost for each of the three reservoir capacities mentioned was then amortized over 20 years at 10 percent interest, and combined with the estimated annual operation and maintenance cost (0.5 percent of the capital cost) to obtain an annual cost per acre-foot of storage capacity. These three annual unit costs were plotted versus reservoir capacity, and a curve graphically fitted to them. A unit annual cost for any reservoir capacity within this range could then be extracted from the graph.

The major items considered when estimating dam construction project costs are: borrow volumes and cost of placement, haul distances, spillway, outlet works, keyway, clearing area, road and utility relocations, land purchase requirements, accessibility, and environmental assessment costs.

Following the plotting of three unit storage costs for each reservoir site, calculations were made to determine the most probable dam and reservoir capacity that would actually be chosen by a water agency. To do this, certain assumptions were made. In general, three scenarios were assumed when sizing reservoirs and calculating the amount of water yielded from presently undeveloped streams. They are:

1. The reservoir is used as an equalizing facility. Reservoir storage is used such that the entire mean (50 pecent probability) annual stream yield is delivered in a typical annual community demand pattern as calculated from records of the Salt Lake County Water Conservancy District and the Salt Lake City Department of Public Utilities.
2. The reservoir is used as a peak supply facility. The stream flow occurring from November through June of a 50 percent probability year is completely stored, and then completely released during July through October in typical demand pattern.
3. No storage is provided. New water treatment facilities are sized to process most natural unregulated stream flows during an average runoff year.

For streams which supply existing treatment plants, the criteria were changed slightly, but are similar. This is because the plant (or conduit) capacity at present is known, and becomes a maximum treated water supply rate. The first two scenarios are:

1. The water treatment plant processes 100 percent of the stream flow within the plant capacity (during the winter and spring). When the plant capacity is reached (generally during the spring) all additional stream flow in excess of plant capacity is stored in the reservoir. Water is then withdrawn from the reservoir at a rate such that the plant is operated at capacity constantly through the summer for as long as the storage lasts.
2. The water treatment plant processes about 110 percent of the amount of water it processed during 1980, according to its 1980 pattern. During November through June, all stream flow in excess of the plant capacity is stored in the reservoir. Beginning in July the plant is operated at capacity, drawing upon storage from the reservoir, for as long as the storage lasts.

The third scenario is not applicable in the case of existing water treatment plants.

To provide enough storage for "dry" years, a one year "carry-over" storage volume is added to the planned reservoir capacity. This applies to both scenarios already described. This additional carry-over storage is calculated as the difference in volume between a 50 percent probability and a 90 percent probability annual stream yield. This essentially provides for additional storage to be saved during an average (50 percent probability) year so that the same average yield may be released from the reservoir during a subsequent dry (90 percent probability) year.

These results were then used to calculate the annual cost per acre-foot of water yielded, treated, and delivered to the canyon mouth. It should be noted that the annual cost per acre-foot of additional developed water from each source was calculated. The average unit cost of treatment and conveyance of all the water from each source will be much lower than the costs of developing additional water as estimated in this report.

Four of the canyons in the study area, as well as the Jordan River, have had previous studies prepared concerning potential damsites. Much of the data presented on a particular damsite for these water sources is a combination of the conclusions of more than one study, since often more than one report proposed similar projects. It should be noted that many of the previously proposed dams were recommended before many of the more stringent environmental or structural requirements of today were developed. These requirements may now make some of the formerly proposed dams undesirable. Some of these sites are very sensitive environmentally. The more pronounced environmentally sensitive issues are mentioned, but not evaluated in this report.

All of the project cost estimates shown herein from former studies have been updated to current 1981 costs using the Engineering News Record (ENR) construction cost index of 3210. The annual operation and maintenance cost was assumed to 0.5 percent of the total project cost in each case. The project cost was amortized over 20 years at 10 percent interest. This annual amortization was then combined with the annual operation and maintenance cost to produce an estimated total annual cost. Detailed computations are included in the supporting data provided to the three sponsoring agencies.

CONVENTIONAL WATER TREATMENT PLANTS AND PIPELINES: A conventional water treatment plant or a conveyance pipeline to a treatment plant was considered for nearly all of the water sources studied. In some instances the flows from two smaller canyons were combined as the source for a single treatment plant.

The plant sizes considered range from 70 gpm (0.10 mgd) up to the source's 50 percent probability peak monthly flow. For flows below one mgd, the treatment plants were considered to be a package complete treatment plant with many automatic control features. For plants with capacities of one mgd or greater both conventional treatment and direct filtration type plants were considered and a range of costs is shown. The cost curves used in this study for both the construction and the operation and maintenance costs were developed by the U.S. Environmental Protection Agency (EPA). These curves were compared to the inhouse cost-estimating curves of the participating consulting engineering firms and found to result in comparable total project costs. Because the EPA curves were presented by separated treatment units, rather than a total plant cost, they offered the flexibility in varying the treatment process for the different sources. The project costs were updated to an ENR construction cost index of 3210 and were amortized at 10 percent interest for a period of 20 years. The annual operation and maintenance costs were based on the following: a total labor cost of $12.50/hour, which included fringe benefits, a power cost of $0.05/kilowatt-hour and diesel fuel cost of $1.25/gallon. The amortized project costs and annual operation and maintenance costs were combined to compose the annual costs, which are shown in the graphs accompanying each section on the various water sources. Computations of the plant construction and operation costs are included in the calculation sheets which have been provided to the three sponsoring agencies.

DESALINATION PLANTS: Salt Lake County has an abundance of brackish water (total dissolved solids concentration of above 2000 mg/l but below 35,000 mg/l) and salt water (concentration above 35,000 mg/l). The processes for treating this water are discussed in the following paragraphs.

Reverse Osmosis: Osmosis is a natural phenomenon that can be observed when two solutions of different salt contents are separated by a selectively permeable membrane, and water diffuses through the membrane toward the higher salinity concentration resulting in unequal water levels. The membrane allows water to pass through but not the dissolved salts. Reverse osmosis is the process of using mechanical forces, viz. pressure difference, to reverse the natural process. The pressure applied must be greater than the natural osmotic pressure. The water flows through the membrane because of the imposed pressure gradient. For a constant applied pressure, there is a practical limit of recovery because of the increasing salt concentration in the waste water.

The salty water used in a reverse osmosis facility must be clean to prevent plugging the membrane. This may require filtering influent water prior to its entering the reverse osmosis unit. Additional pretreatment may be required to prevent calcium precipitation. This is accomplished by adjusting the pH by the addition of a mineral acid. Chlorine is often added to prevent microbial growth. After the pretreatment, the salt water is pressurized to about 500 to 800 psi to provide the driving force across the system and is fed into reverse osmosis cells (modules). Part of the water permeates the membrane and is collected as fresh water. The remainder (brine) is passed through a turbine for recovery of power before it is rejected.

The undesirable salt permeation rate through the membrane is proportional to the difference in concentration across the membrane. Therefore, high salinity feeds give poor product water quality. With current technology 90 percent of the water can be recovered in a single pass with a salinity of less than 500 mg/l if the raw water has a total dissolved solids concentration of 5000 mg/l or less. A smaller percent of recovery with the same product quality is possible with higher salinity concentration feeds. However, reverse osmosis is not recommended for treatment of waters with over 10,000 mg/l of total dissolved solids.[(43)]

Ion Exchange: The ion exchange process uses natural or synthetic resins as carriers to exchange undesirable ions for less harmful ions. Salts are composed of a positive ion of a base and a negative ion of an acid. In the ion exchange process, the positive ions are removed in the cation exchanger and are exchanged for hydrogen. In the anion exchanger, the negative ions of the acid are removed, which completes the two-step removal of the salt. Once the demineralizer ion exchangers are saturated, they have to be regenerated. Cation exchangers are regenerated by strong acids such as sulfuric acid, and anion exchangers by caustic soda. This process is very effective in removal of the salt but is not practical for water with total dissolved solids concentration of 5,000 mg/l or greater.[43] Because of the large quantity of regeneration chemicals required, it is generally believed that the ion exchange process cannot compete economically with other processes when the raw water feed salinity exceeds 1000 mg/l.[54]

Electrodialysis: This process uses plastic membranes which will not pass water but are selective for the passage of ions of a given charge. Two different membranes are used, one more selective to anions and the other more selective to cations. An electrodialysis cell consists of alternate cation and anion permeable membranes arranged in a stack with alternately charged electrodes on each side. The passage of electric current through the cell aids the diffusion of these ions. The cations migrate towards the cathode, and the anions to the anode. However, because of the membranes, the ions cannot pass through more than one cell toward the elctrodes. Thus, the feedstream becomes depleted of the salt ions while the adjacent stream is enriched. The plant produces a potable water stream and a salt-rich stream which is rejected.

The electric energy required for this process is proportional to the concentration of salts in the saline water. Therefore, the process is somewhat attractive for mildly brackish water, and is considered to be too costly for desalting water with over 4,000 mg/l of total dissolved solids.[43]

Distillation: When a saline solution is boiled, the dissolved salts, which are relatively non volatile, remain in solution as the water is vaporized. When the water vapor is then condensed on a cooler surface, the water that forms is pure. There are two basically different process techniques which are available to achieve this. The first is called the multiple effect technique. The evaporators are operated in series with each evaporator at slightly lower pressure than the previous one. Because the boiling point decreases as pressure decreases, it is possible to use the water vapor of the first evaporator as the heating medium in the second evaporation, and so on. The second technique is called flash evaporation. In this technique the water is heated under sufficiently high pressure to prevent boiling. Sudden evaporation or "flashing" occurs as soon as the pressure is released. By releasing the pressure in small steps, a high degree of internal heat recovery is achieved.

All distillation processes are tied to the two principles explained above. The multiplicity of processes is due to the ingenuity of inventors and designers in attempting to reduce costs by improving the efficiency of heat recovery and in the type of heat transfer material used. The chief problems experienced in distillation plants are scaling and corrosion. To prevent scaling, the maximum dissolved solids concentration in the reject brine must be kept below 70,000 mg/l.[54]

Solar distillation to date has not proven to be commercially feasible. This is due to the low energy transfer rates obtainable when compared to current industrial rates.[43]

CITY CREEK CANYON:

DAMSITES: City Creek Canyon has been the subject of several studies since the Salt Lake Valley was settled. Of the various studies made to evaluate potential damsites in City Creek Canyon, only one of the reports presented extensive information. In 1980 the State Division of Water Resources conducted a preliminary investigation on the possibility of a reservoir midway up City Creek Canyon.(3) The purpose of the dam would be to store spring runoff which exceeds the capacity of the water treatment plant and release it later in the summer for treatment. The proposed project would be located about four miles northeast of the State Capitol, 2000 feet upstream from the existing treatment plant. This is shown on the map in Figure VI-1 as site A.

There are an estimated 2600 acre-feet of water annually that could be stored in this proposed reservoir.(3) Besides use as a storage reservoir, there would be limited ability of the dam to store some of the peak flows during high water periods which would reduce the flood hazard for areas below the canyon mouth. There have occasionally been periods when the spring runoff exceeded the capacity of the storm drain pipeline in Memory Grove Park.

Because of a preference for a dam above the end of the road in City Creek Canyon, five sites were initially investigated in that area. Upon inspection by the Utah Division of Water Resources geologist, these sites were rejected in favor of the site previously mentioned. The site recommended by the Division of Water Resources was chosen, not for any special topographic reasons, but because of geologic, access, borrow area location, and land ownership conditions.

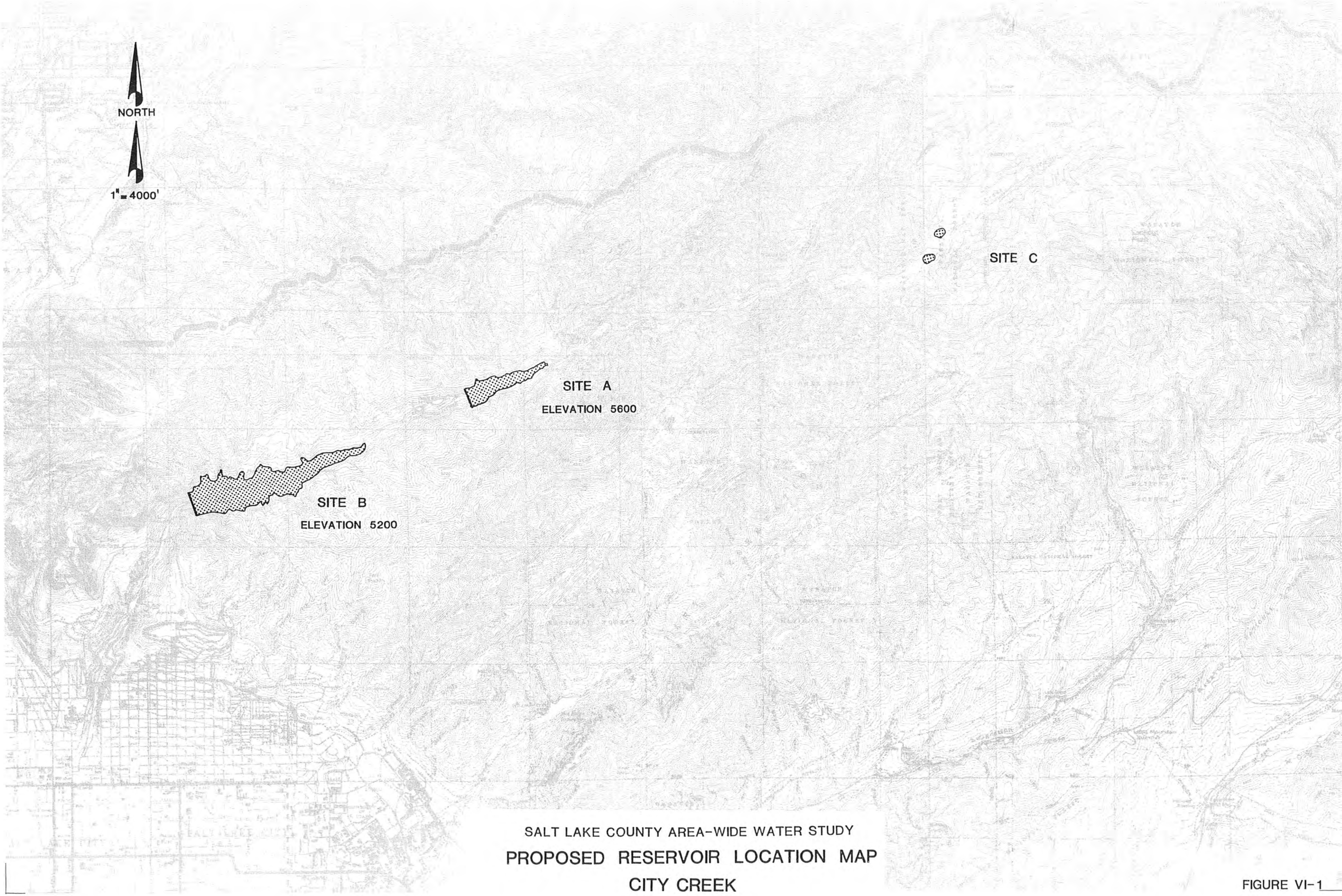
The proposed dam would be 123 feet high with a crest length of 700 feet and would require about 500,000 cubic yards of embankment for construction. The reservoir capacity is estimated at 1000 acre-feet, with 700 acre-feet of that storage usable as a water supply. The estimated cost of this project is $3.84 million. The equivalent annual cost would be $451,000, thus yielding a storage cost per acre-foot of $644 for municipal water yield.

Three other sites were considered in previous studies. One of these sites is a proposed 20,000 acre-foot reservoir, shown in Figure VI-1 as site B.[8] The dam would be 300 feet high and contain six million cubic yards of earth-rockfill embankment. The purpose of the reservoir would be for water supply and flood control.

A second damsite was investigated by the Corps of Engineers strictly as a flood control project.[73] The proposed earth-fill dam would be 117 feet high and located immediately above Bonneville Boulevard where the streambed elevation is 4694 feet. The crest width would be 20 feet and its length would be 800 feet. The storage capacity would be 700 acre-feet. This damsite would only be suitable for a flood control project because of its low elevation location.

The most recent damsite to be considered on City Creek is one currently being investigated by the Salt Lake City Water Department and is shown as site C in Figure VI-1. No conclusive data have been compiled yet. However, from a reconnaissance-level study of the area it appears feasible to construct a dam in an upper drainage basin approximately 3.5 miles upstream from Rotary Park. This dam would utilize a natural retention area where a lake forms during part of each year. The natural embankment would have to be raised, along with sealing some geological fracture zones which currently drain the lake each year. More investigation will be needed before this site can be considered feasible or not.

At the same location as site A a potential reservoir was analyzed during this study so that the results would be comparable to damsite data and cost estimates presented in other canyons. Pertinent dam and reservoir data are shown in Table VI-1. The total annual cost for each of the three reservoir sizes in Table VI-1 was divided by the storage capacity, and plotted in Figure VI-2 as unit storage costs. A curve was fit to the three data points to allow for interpolation of costs.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

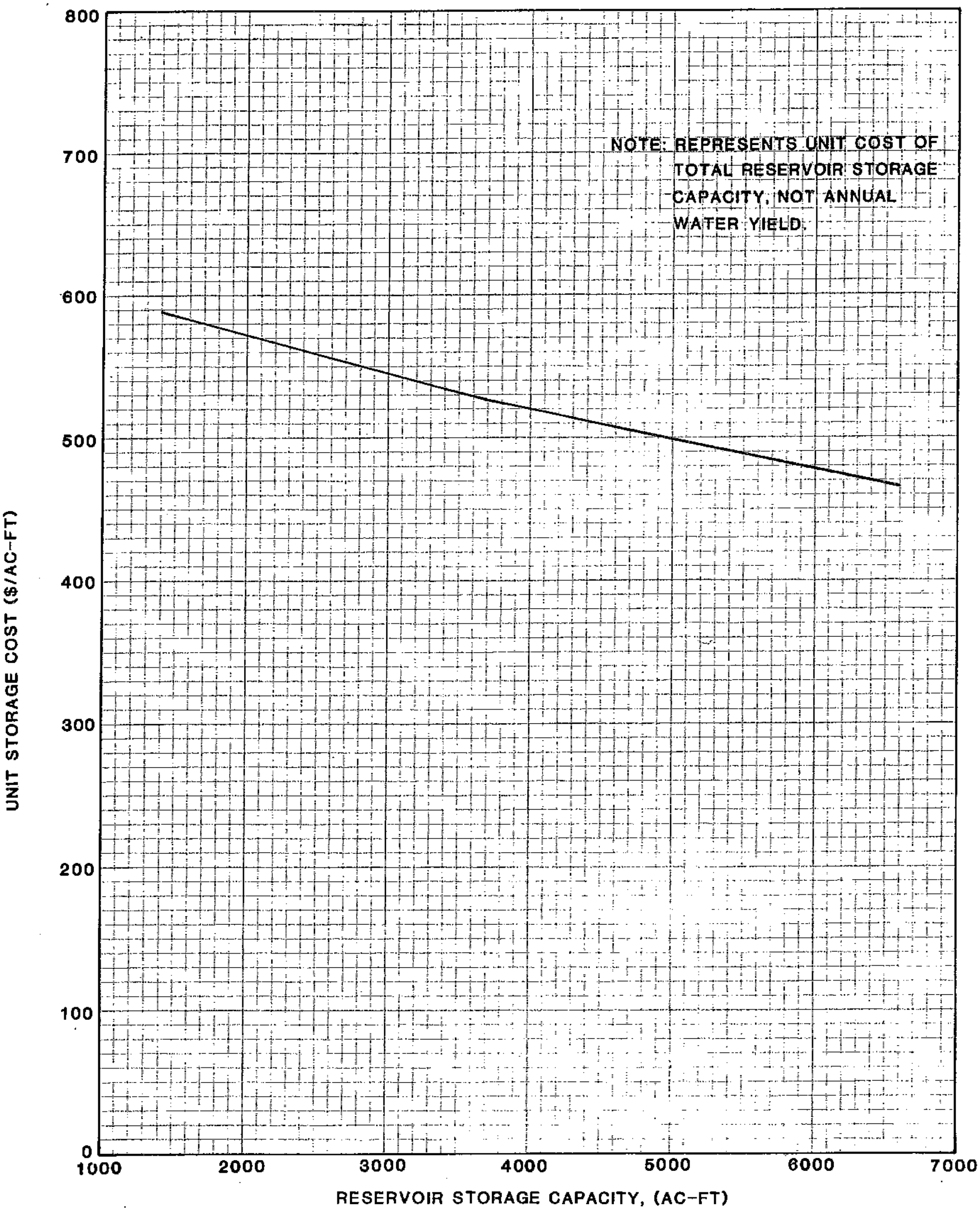
CITY CREEK

FIGURE VI-1

TABLE IV-1
PERTINENT PRELIMINARY DATA
CITY CREEK RESERVOIR SITE A

		RESERVOIR CAPACITY OPTIONS		
		1400 Ac-Ft	Spring Runoff Volume 3700 Ac-Ft	Mean Annual Yield 5600 Ac-Ft
GENERAL				
Drainage Area (square miles)		11.5	11.5	11.5
RESERVOIR				
Gross Pool Elevation (feet)		5546	5618	5653
Gross Pool Area (acres)		25.4	46.4	62.6
Gross Pool Storage (acre-feet)		1400	3762	5589
Ratio of Storage vs. Area (acre-feet/acre)		55.1	81.1	89.3
Probable Land Purchase Requirement (acres)		35.8	65.0	90.1
MAIN DAM				
Top Elevation (feet)		5554	5626	5661
Spillway Elevation (feet)		5546	5618	5653
Maximum Height at Dam Axis (feet)		132	196	231
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		570	900	970
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		15	15	15
Outlet Works Hydraulic Head (feet)		124	188	223
SPILLWAY				
Discharge Capacity (cfs)		136	136	136
Surcharge Head (feet)		3	3	3
COSTS				
Dam Capital Cost	($)	4,358,000	11,063,000	15,602,000
Total Dam & Reservoir Capital Cost	($)	6,739,000	15,929,000	22,279,000
Annual Operation and Maintenance Cost(a)	($)	33,700	79,600	111,400
Total Annual Cost(b)	($)	825,000	1,950,000	2,728,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

CITY CREEK RESERVOIR SITE A

FIGURE VI-2

TABLE VI-2

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
CITY CREEK, RESERVOIR SITE A

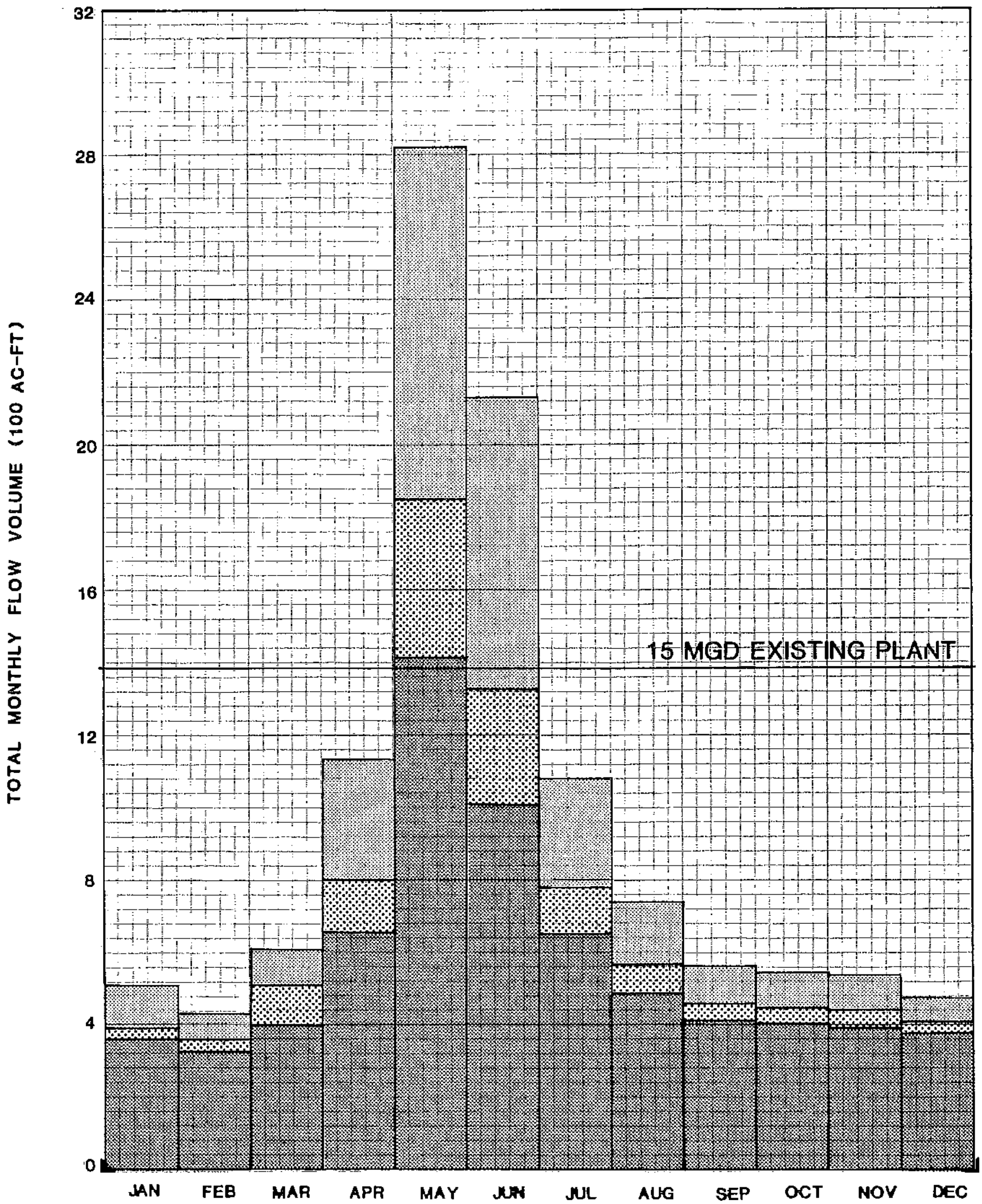
Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[(a)]	Ac-Ft	5072	5840	N/A
Carry-over Capacity[(b)]	Ac-Ft	3455	3455	N/A
Existing Annual Water Yield[(c)]	Ac-Ft	7362	7362	N/A
Developable Annual Water Yield[(d)]	Ac-Ft	1238	1238	N/A
Total Annual Water Yield[(e)]	Ac-Ft	8600	8600	N/A
Unit Storage Cost[(f)]	$/Ac-Ft	470	460	N/A
Unit Water Yield Cost for Reservoir[(g)]	$/Ac-Ft	1926	2170	N/A
Water Treatment Plant Capacity[(h)]	mgd	15	15	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[(j)]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[(k)]	$/Ac-Ft	1961	2205	N/A

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-2, adjusted for drainage area at water treatment plant site.
(c) The average annual water treatment plant production for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-2.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing plant capacity of City Creek Water Treatment Plant.
(j) 1981 average treatment costs.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.

Calculations were then made to determine the required reservoir capacities based on demand scenarios 1 and 2 previously described. If this reservoir were constructed as an equalizing facility the total storage volume would be 5072 acre-feet. The additional volume yielded, in excess of what is already being treated by the existing treatment plant, would be 1238 acre-feet. The total estimated annual cost of additional water developed, which includes storage, treatment and conveyance to the canyon mouth is $1961 per acre-foot, as shown in Table VI-2.

If used as a peaking facility the total storage volume would be 5840 acre-feet, with a yield of 1238 acre-feet of additional water per year. This yield is additional water above the flow currently being treated by the existing treatment plant. The total annual cost for this yield is estimated at $2205 per acre-foot, as summarized in Table VI-2. The data used to compute total annual costs for both scenarios are tabulated in Table VI-2.

WATER TREATMENT PLANTS: The existing water treatment plant has unused capacity for at least ten months of the year. Figure VI-3 shows the plant capacity in relation to the creek's annual hydrograph. Because of the unused capacity in the plant, the cost of expansion was not determined during this study.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

CITY CREEK

FIGURE VI-3

RED BUTTE CANYON:

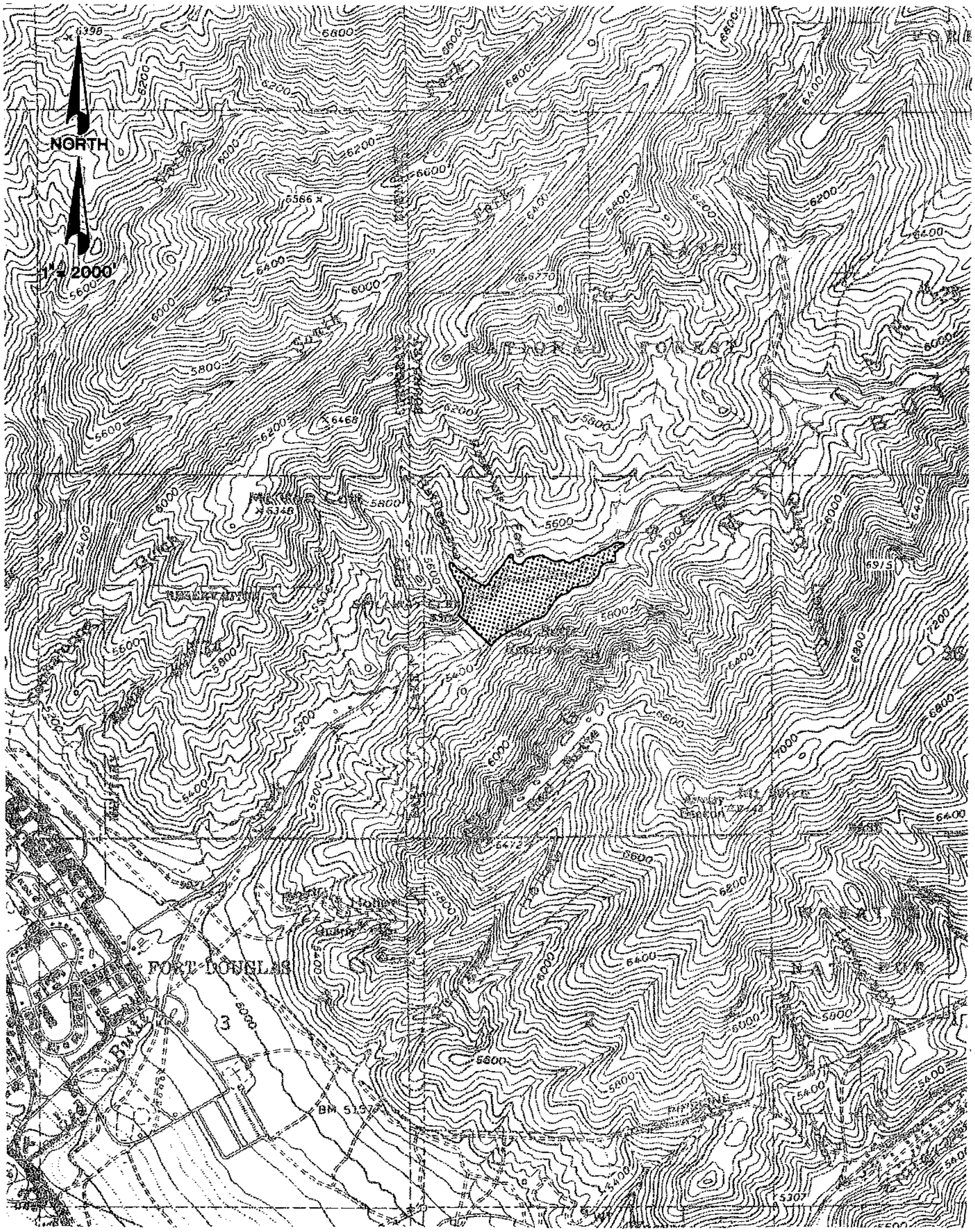
DAMSITES: An investigation was made by this study team to determine the costs of enlarging the existing earth dam within Red Butte Canyon located near the canyon mouth. The existing dam has an impoundment capacity of approximately 430 acre-feet.[41] The dam location is shown in Figure VI-4.

The estimated mean annual yield and spring runoff volume were used as the impoundment criteria for estimating costs of dam enlargements. The mean annual yield of 2450 acre-feet can be retained by raising the existing dam 73 feet. The spring runoff volume of 1250 acre-feet can be stored by raising the existing dam 37 feet. The water surface area of the greatest investigated enlargements is shown in Figure VI-4. Pertinent dam and reservoir data are tabulated in Table VI-3, and the unit costs are plotted in Figure VI-5 to provide a wide range of costs versus dam sizes.

The borrow material quantity estimates for enlarging the dam were made based on the assumption that the new embankment could be built directly upon the existing embankment on its downstream side. It was further assumed that the new impermeable core material could be sealed to the existing core zone by removing a portion of the downstream permeable layer from the upper portion of the existing dam.

Realignment of an existing light-duty asphalt road would be involved in the enlargement of the reservoir.

Calculations were made, based on the first two scenarios of probable reservoir use explained in the introduction, to determine probable reservoir sizes. For the first scenario, in which the reservoir would be used as an equalizing facility, it was determined that a reservoir capacity of 2011 acre-feet would yield 2355 acre-feet annually. For the second scenario, or use of the reservoir as a peaking facility, a reservoir capacity of 3114 acre-feet would yield 2355 acre-feet annually. Table VI-4 summarizes the capacities, yields and unit costs of developed water under these two schemes.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

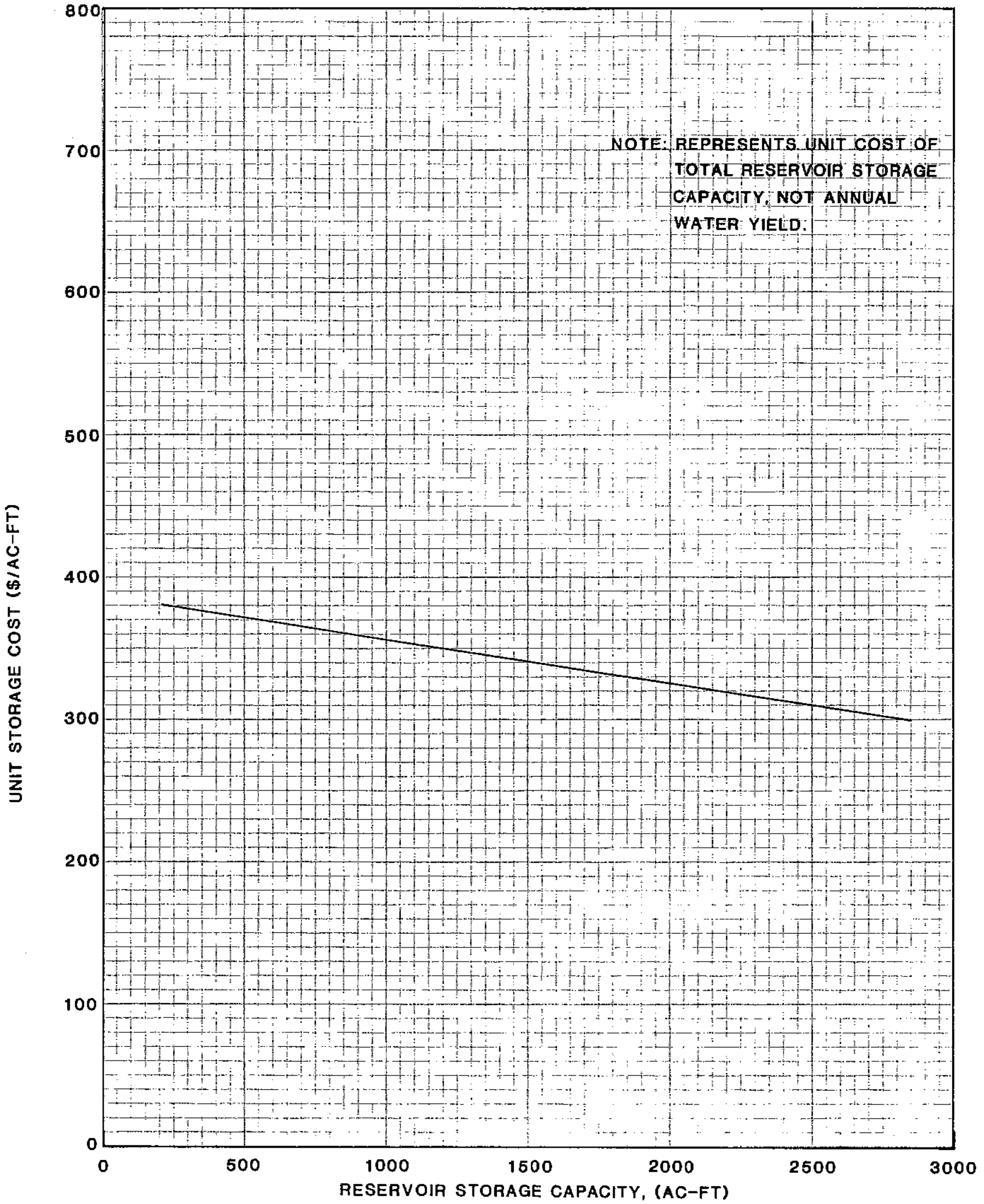
RED BUTTE CREEK

FIGURE VI-4

TABLE VI-3
PERTINENT PRELIMINARY DATA
RED BUTTE CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS		
		Existing + 400 Ac-Ft	Spring Runoff Volume 1250 Ac-Ft	Mean Annual Yield 2450 Ac-Ft
GENERAL				
Drainage Area (square miles)		8.0	8.0	8.0
RESERVOIR				
Gross Pool Elevation (feet)		5380	5417	5453
Gross Pool Area (acres)		13	28	37
Gross Pool Storage (acre-feet)		400	1250	2450
Ratio of Storage vs. Area (acre-feet per acre)		31.0	44.6	66.2
Probable Land Purchase Requirement (acres)		16	33	44
MAIN DAM				
Top Elevation (feet)		5388	5426	5462
Spillway Elevation (feet)		5380	5417	5453
Maximum Height at Dam Axis (feet)		60[(a)]	97	133
Upstream Side Slope		unknown	3:1	3:1
Downstream Side Slope		unknown	2.5:1	2.5:1
Crest Length (feet)		450	565	600
Crest Width (feet)		unknown	25	25
Outlet Works Capacity (cfs)		unknown	40	40
Outlet Works Hydraulic Head (feet)		unknown	89	125
SPILLWAY				
Discharge Capacity (cfs)		unknown	475	475
Surcharge Head (feet)		unknown	4	4
COST				
Dam Capital Cost	($)	unknown	1,944,000	3,664,000
Total Dam & Reservoir Capital Cost	($)	unknown	3,546,000	6,223,000
Annual Operation & Maintenance Cost[(b)]	($)	unknown	18,000	31,000
Total Annual Cost[(c)]	($)	unknown	435,000	762,000

(a) approximate
(b) 0.5% of Total Dam & Reservoir Capital Cost
(c) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

RED BUTTE CREEK RESERVOIR SITE FIGURE VI-5

TABLE VI-4

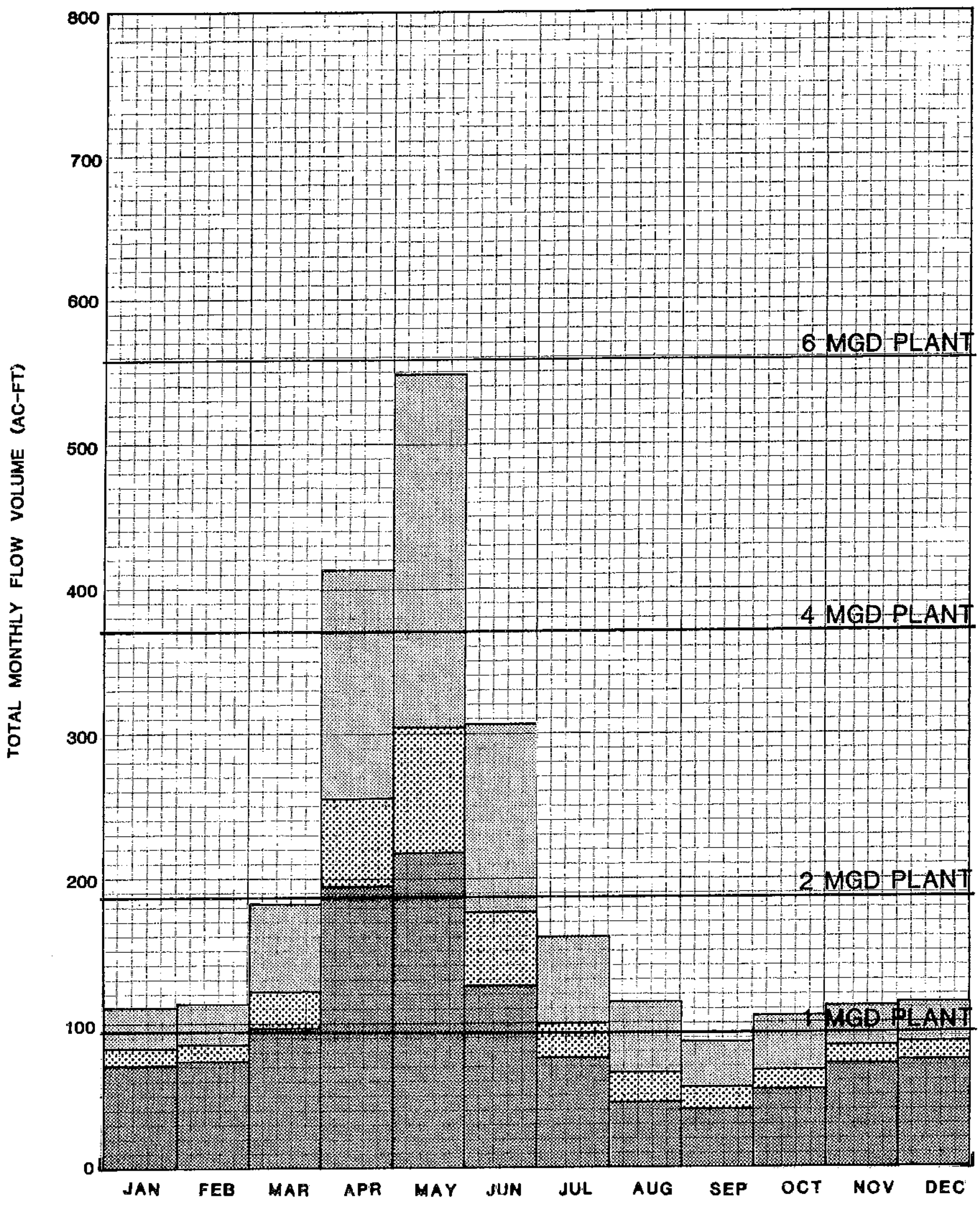
ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
RED BUTTE CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. Existing Storage Facility[m]
Reservoir Capacity	Ac-Ft	2011[a]	3114[a]	430[l]
Carry-over Capacity[b]	Ac-Ft	1220	1220	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield [d]	Ac-Ft	2355	2355	2355
Total Annual Water Yield[e]	Ac-Ft	2355	2355	2355
Unit Storage Cost[f]	$/Ac-Ft	325	275	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	278	364	0
Water Treatment Plant Capacity[h]	mgd	4.6	8.9	5.0
Annual Treatment & Conveyance Cost[i]	$1000	720	950	750
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	306	403	318
Total Unit Water Yield Cost[k]	$/Ac-Ft	584	767	318

(a) Includes storage and carry-over capacity, in excess to present Red Butte Reservoir capacity of 430 ac-ft.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-4.
(c) Assumes that no municipal water is presently developed. Although a small amount of municipal water is presently developed, it does not meet present health standards.
(d) Additional water developed in excess of existing annual water yields.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-5.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-7.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Existing capacity of Red Butte Reservoir.
(m) Reservoir is used, as far as possible, to store spring runoff for summer use. Otherwise, this scenario reflects unregulated flows.

WATER TREATMENT PLANTS: One alternative to provide treatment for the flow from Red Butte Canyon so that the water could be used as a source for public culinary water is to construct a treatment plant immediately downstream from the existing lower reservoir. Figure VI-6 shows the annual hydrograph for the stream in Red Butte Canyon with the capacities of various plant sizes indicated. Figure VI-7 shows the estimated annual costs (including the amortized capital cost) for such a plant. These costs include the cost of a finished water pipeline from the plant to the mouth of the canyon.

Another alternative for development is to locate a plant between Red Butte and Emigration Canyons and use both streams to supply raw water to the plant. Figure VI-8 shows the annual hydrograph for the combined flows with various plant sizes indicated. Figure VI-9 shows the annual costs for such plants. These costs are based on the plant being located near the mouth of Georges Hollow, a pipeline from the lower reservoir in Red Butte Canyon, and a pipeline from Rattlesnake Hollow in Emigration Canyon.

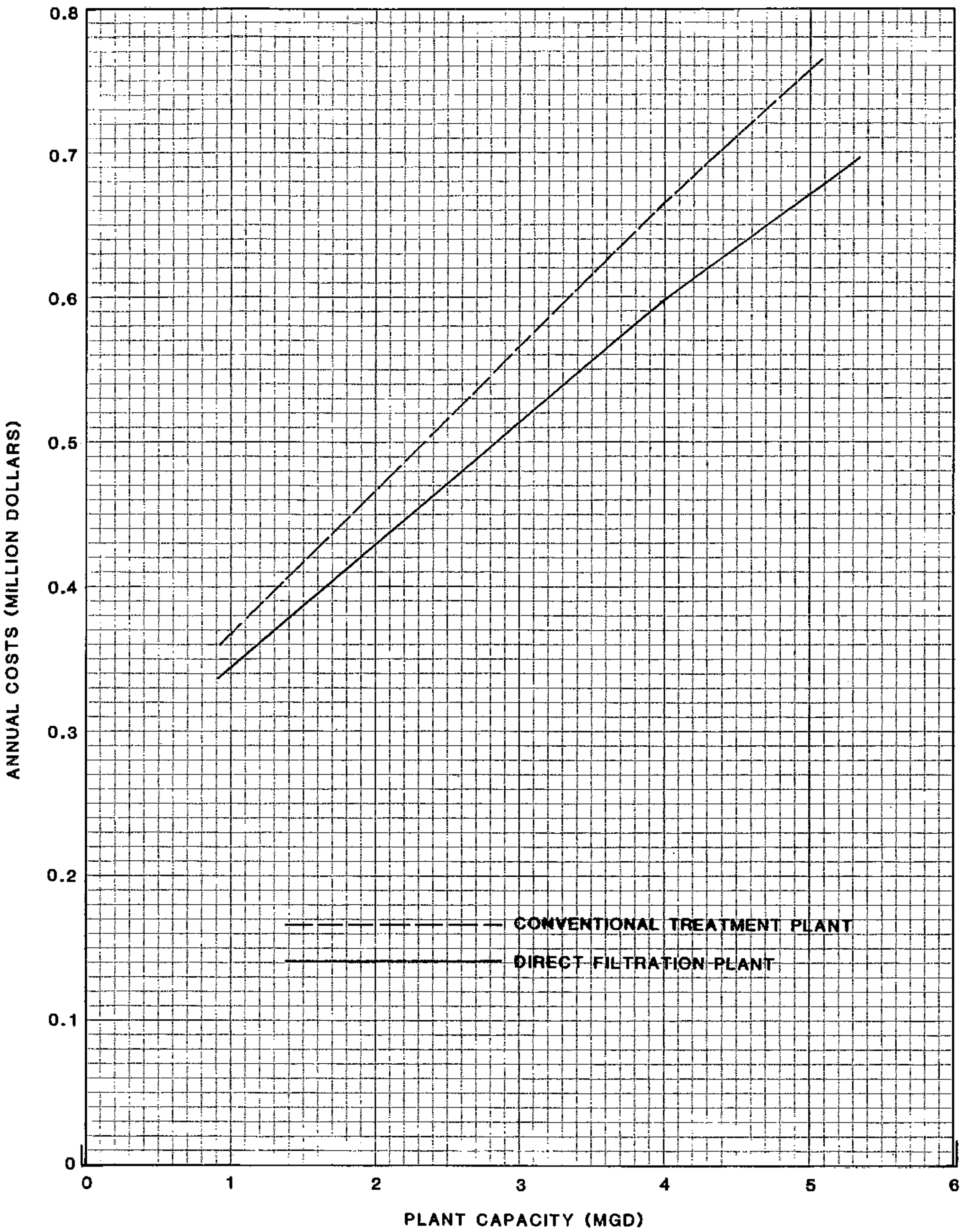


SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

RED BUTTE CREEK

FIGURE VI-6

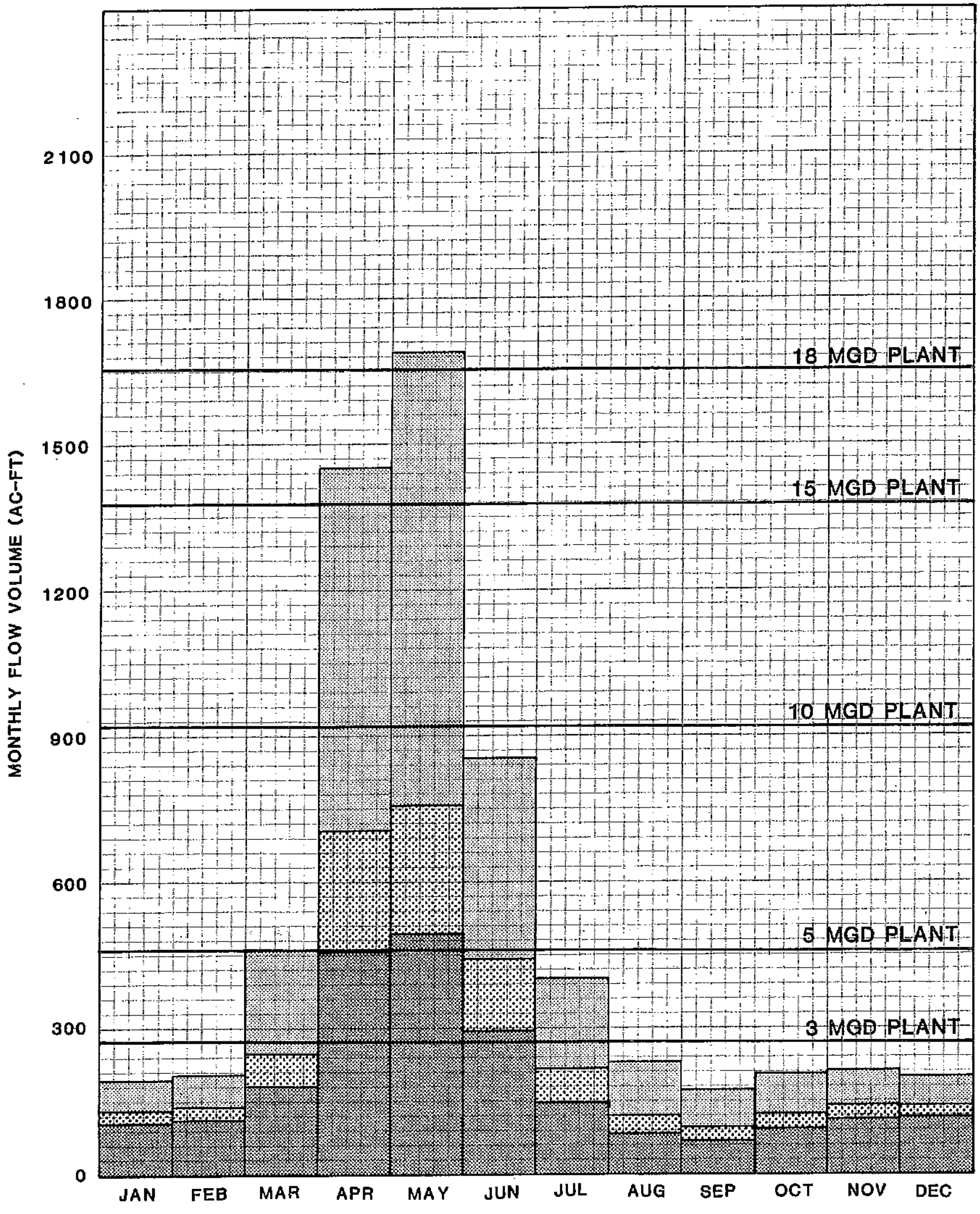


SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS

RED BUTTE CREEK

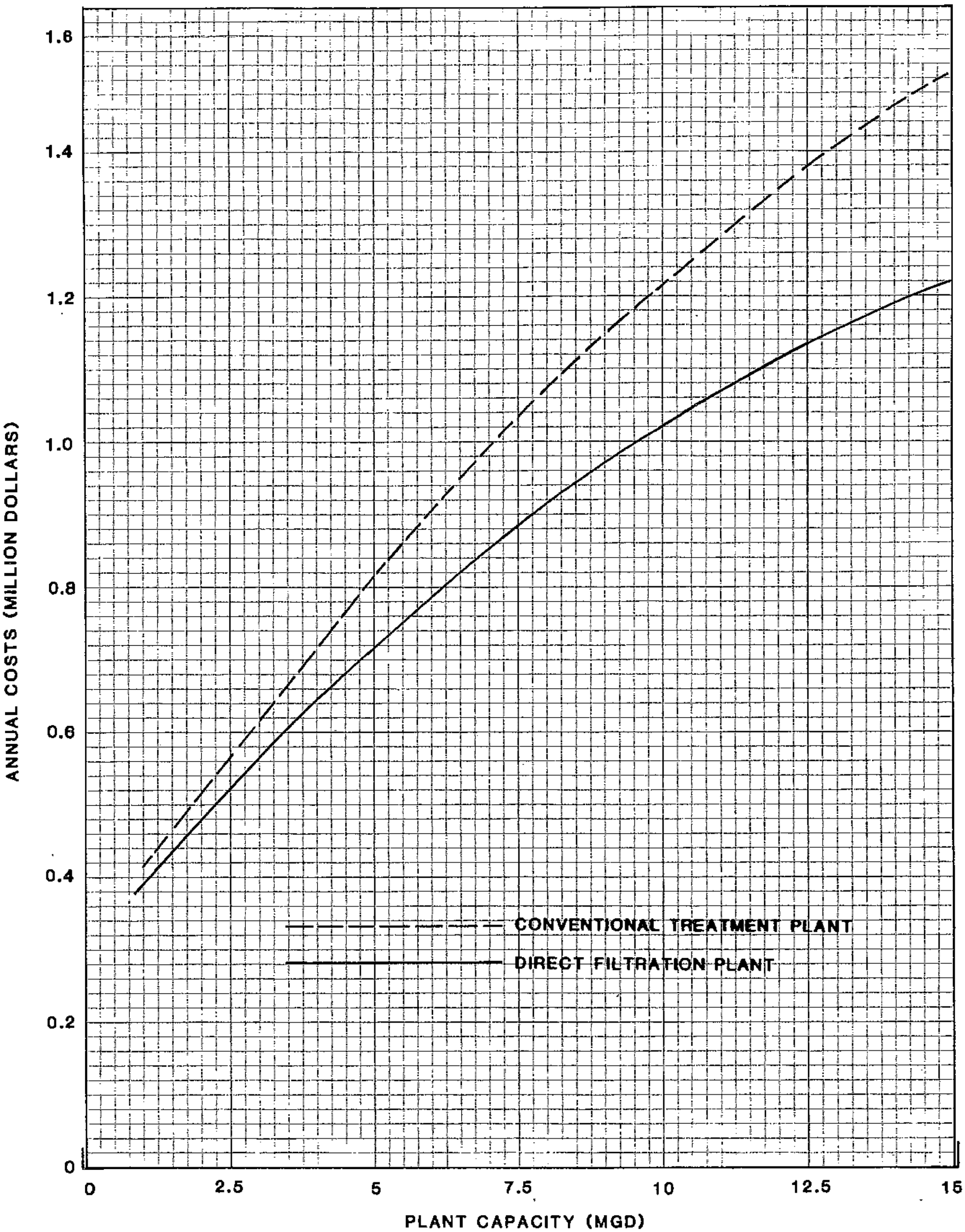
FIGURE VI-7



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH WITH PLANT CAPACITIES RED BUTTE AND EMIGRATION CREEKS COMBINED

FIGURE VI-8



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS
RED BUTTE AND EMIGRATION CREEKS COMBINED

FIGURE VI-9

EMIGRATION CANYON:

DAMSITES: No previous studies of potential damsites in Emigration Canyon were found. During this study two sites on Emigration Creek were chosen for preliminary analysis, one near the canyon mouth and the other in the upper portion of the canyon.

Reservoir site A lies about two miles above the canyon mouth at Perkins Hollow, as shown in Figure VI-10. Table VI-5 displays some pertinent information concerning the three preliminary dam designs. At least eight existing homes would be inundated by operation of a reservoir at this lower site. Also, relocations of about one and a half mile of State Highway 65 and several utilities would be required. A wide range of unit storage costs versus dam sizes is shown in Figure VI-11.

The first two scenarios of probable use, as explained in the introduction, are the basis for calculations made to determine the most probable reservoir sizes. If the reservoir were to be used as an equalizing facility, the total capacity would be 4577 acre-feet with an annual water yield of 3928 acre-feet. For use as a peaking facility under scenario two, the reservoir would contain 6175 acre-feet and yield 3928 acre-feet. Capacities, yields and unit cost estimates are summarized on Table VI-6 for both of these scenarios.

Reservoir site B is located on Emigration Creek about 600 feet downstream from Burr Fork. A dam at this site would impound water from both Burr Fork and Killyon Canyon Creek, as shown in Figure VI-10. Again, three dam sizes were studied which would store 1000 acre-feet, the spring runoff volume of 1609 acre-feet, and the mean annual yield of 2205 acre-feet.

Although this site lies above the majority of residential development in Emigration Canyon, at least eleven homes would be inundated at this site by construction of a dam. Relocations of a light-duty asphalt road, a dirt road and a few utilities would also be required prior to construction of a dam.

Table VI-7 is a tabulation of pertinent dam and reservoir data and Figure VI-12 shows the unit costs for storage plotted to provide a range of costs versus damsites.

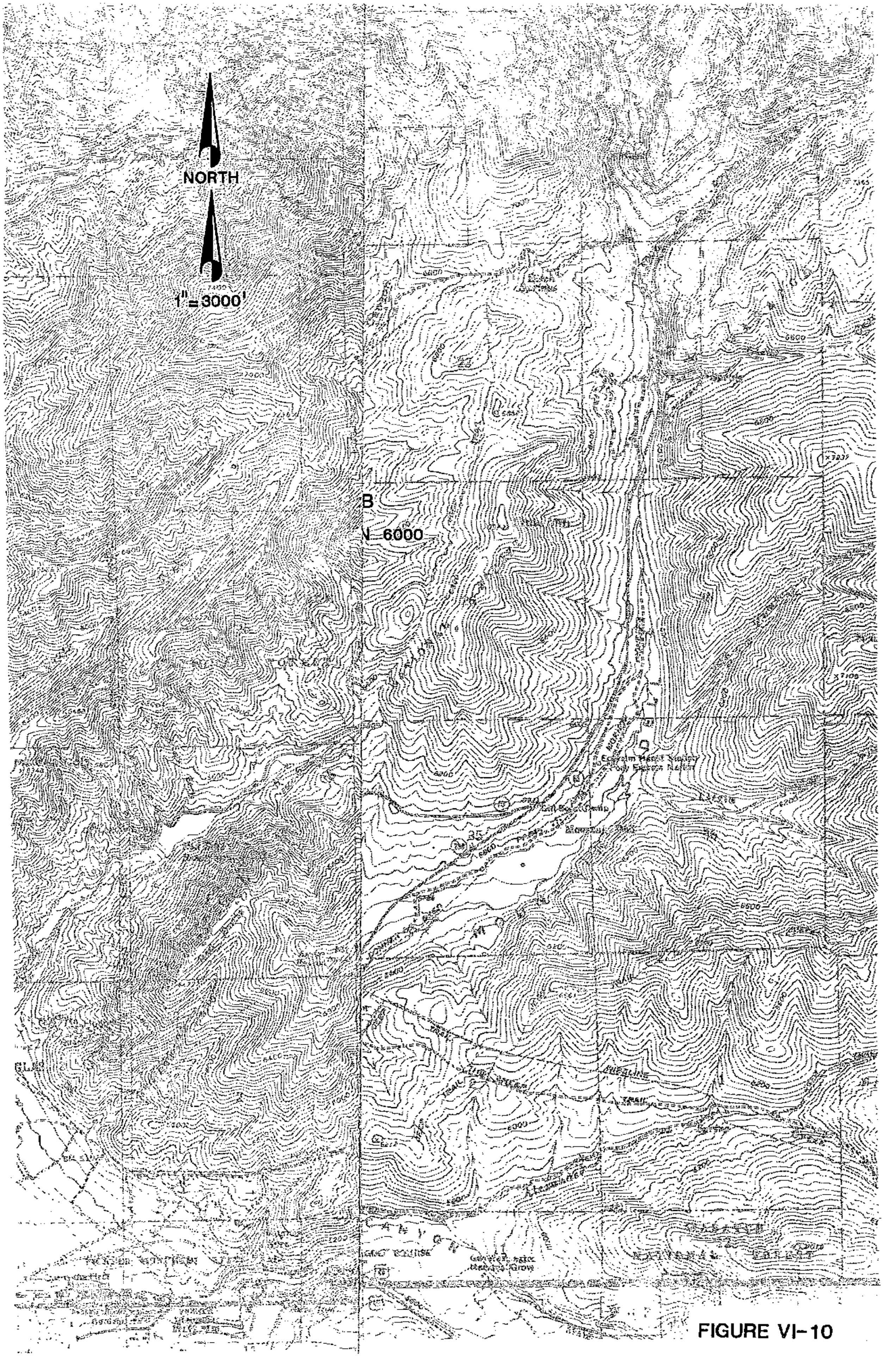
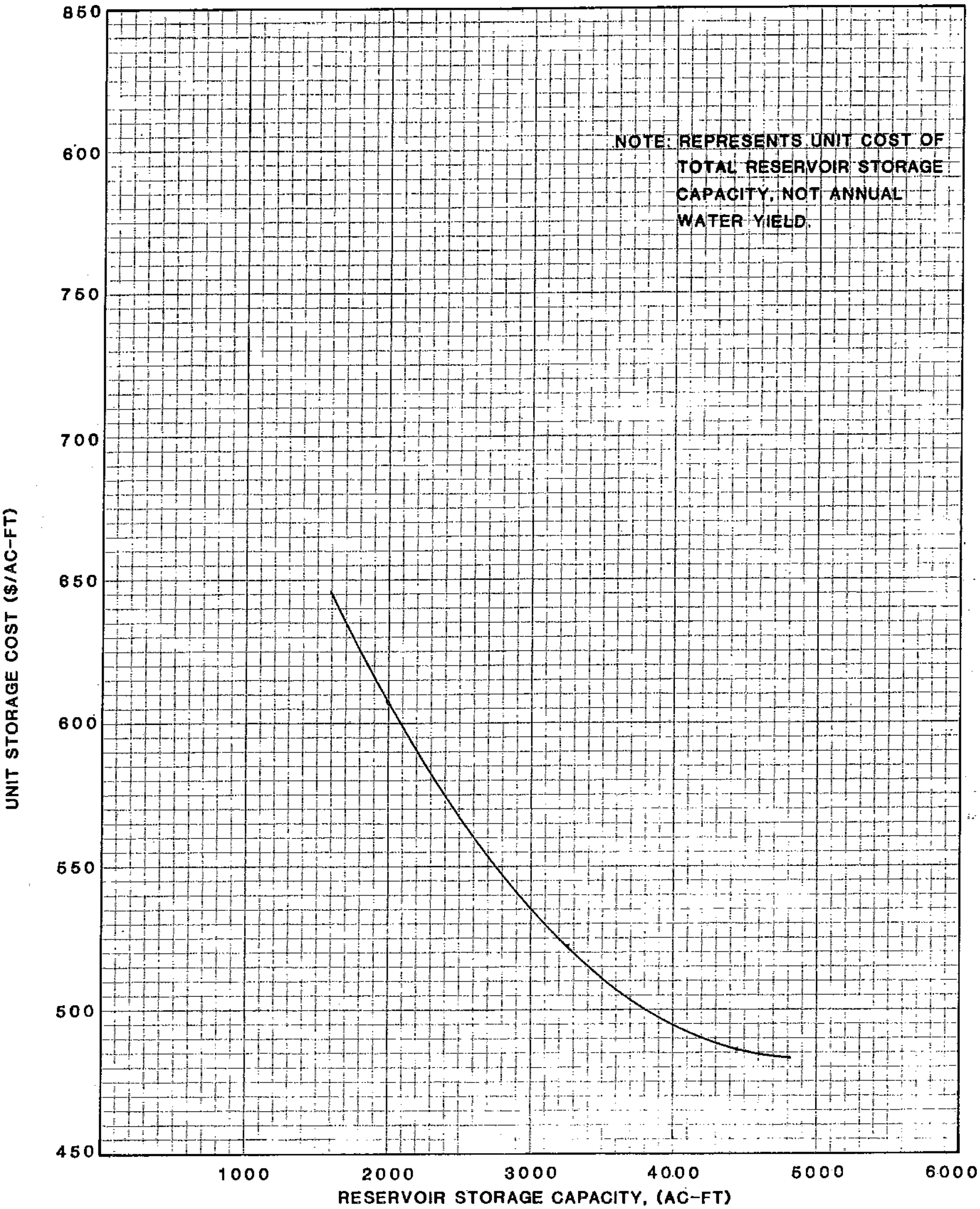


FIGURE VI-10

TABLE VI-5
PERTINENT PRELIMINARY DATA
EMIGRATION CREEK, RESERVOIR SITE A

		RESERVOIR CAPACITY OPTIONS		
		2000 Ac-Ft	Spring Runoff Volume 3240 Ac-Ft	Mean Annual Yield 4439 Ac-Ft
GENERAL				
Drainage Area (square miles)		18	18	18
RESERVOIR				
Gross Pool Elevation (feet)		5302	5324	5339
Gross Pool Area (acres)		51	64	82
Gross Pool Storage (acre-feet)		2000	3240	4439
Ratio of Storage vs. Area (acre-feet per acre)		39.2	50.6	54.1
Probable Land Purchase Requirement (acres)		66	85	108
MAIN DAM				
Top Elevation (feet)		5310	5333	5348
Spillway Elevation (feet)		5302	5324	5339
Maximum Height at Dam Axis (feet)		90	113	128
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		30	30	30
Crest Width (feet)		900	1100	1320
Outlet Works Capacity (cfs)		25	25	25
Outlet Works Hydraulic Head (feet)		93	107	132
SPILLWAY				
Discharge Capacity (cfs)		330	330	330
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	3,430,000	5,549,000	7,410,000
Total Dam & Reservoir Capital Cost	($)	9,897,000	13,822,000	17,624,000
Annual Operation & Maintenance Cost[a]	($)	49,000	69,000	88,000
Total Annual Cost[b]	($)	1,211,000	1,692,000	2,158,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

EMIGRATION CREEK, RESERVOIR SITE A

FIGURE VI-11

TABLE VI-6

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
EMIGRATION CREEK
RESERVOIR SITE A

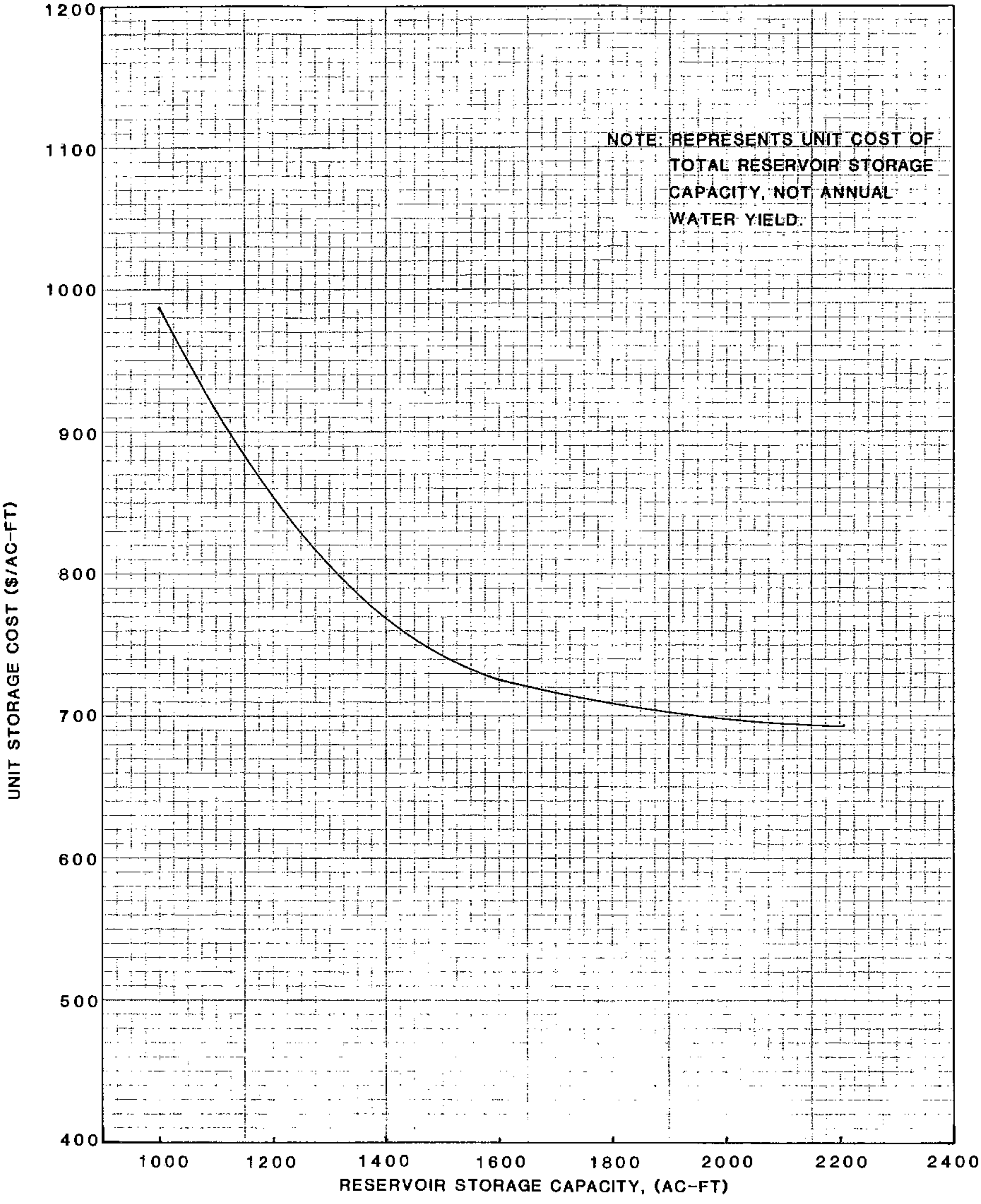
Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	4577	6175	0
Carry-over Capacity[b]	Ac-Ft	2798	2798	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	3928	3928	3928
Total Annual Water Yield[e]	Ac-Ft	3928	3928	3928
Unit Storage Cost[f]	$/Ac-Ft	488	480	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	569	755	0
Water Treatment Plant Capacity[h]	mgd	7.6	14.9	14.9[l]
Annual Treatment & Conveyance Cost[i]	$1000	980	1233	1233
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	249	314	314
Total Unit Water Yield Cost[k]	$/Ac-Ft	818	1069	314

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-5.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-11.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-14.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents unregulated stream flow pattern.

TABLE VI-7
PERTINENT PRELIMINARY DATA
EMIGRATION CREEK, RESERVOIR SITE B

		RESERVOIR CAPACITY OPTIONS		
		1000 Ac-Ft	Spring Runoff Volume 1609 Ac-Ft	Mean Annual Yield 2205 Ac-Ft
GENERAL				
Drainage Area (square miles)		6.0	6.0	6.0
RESERVOIR				
Gross Pool Elevation (feet)		5979	5989	6015
Gross Pool Area (acres)		25	35	43
Gross Pool Storage (acre-feet)		1000	1609	2205
Ratio of Storage vs. Area (acre-feet/acre)		40.0	46.0	51.3
Probable Land Purchase Requirement (acres)		31	42	52
MAIN DAM				
Top Elevation (feet)		5987	5998	6025
Spillway Elevation (feet)		5979	5989	6015
Maximum Height at Dam Axis (feet)		127	138	165
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		400	410	520
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		15	15	15
Outlet Works Hydraulic Head (feet)		119	129	155
SPILLWAY				
Discharge Capacity (cfs)		150	150	150
Surcharge Head (feet)		3	3	3
COSTS				
Dam Capital Cost	($)	3,298,000	3,896,000	5,640,000
Total Dam & Reservoir Capital Cost	($)	8,068,000	9,542,000	12,491,000
Annual Operation and Maintenance Cost[a]	($)	40,000	48,000	62,000
Total Annual Cost[b]	($)	988,000	1,169,000	1,529,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

EMIGRATION CREEK, RESERVOIR SITE B

FIGURE VI-12

Again, both scenarios of probable reservoir sizes were calculated for this damsite. Scenario one, an equalizing facility, would have a capacity of 1312 acre-feet and yield 3928 acre-feet of water at the canyon mouth. However, only the inflow to the reservoir is regulated under this plan. A reservoir used as a peaking facility would have a capacity of 1896 acre-feet and would also yield 3923 acre-feet of water annually of the canyon mouth. Unit water yield costs for developed water as well as capacities and yields are summarized on Table VI-8 for both scenarios.

WATER TREATMENT PLANTS: A treatment plant could be constructed near the mouth of Emigration Canyon to allow the stream to be developed into a source for culinary water. Figure VI-13 shows the stream's annual hydrograph with the capacities of various sized plants indicated. The estimated costs for these treatment plants are shown in Figure VI-14.

Another alternative is that the flows from Emigration and Red Butte Creeks could be combined to supply raw water to a single treatment plant. This alternative is discussed in the section concerning Red Butte Canyon.

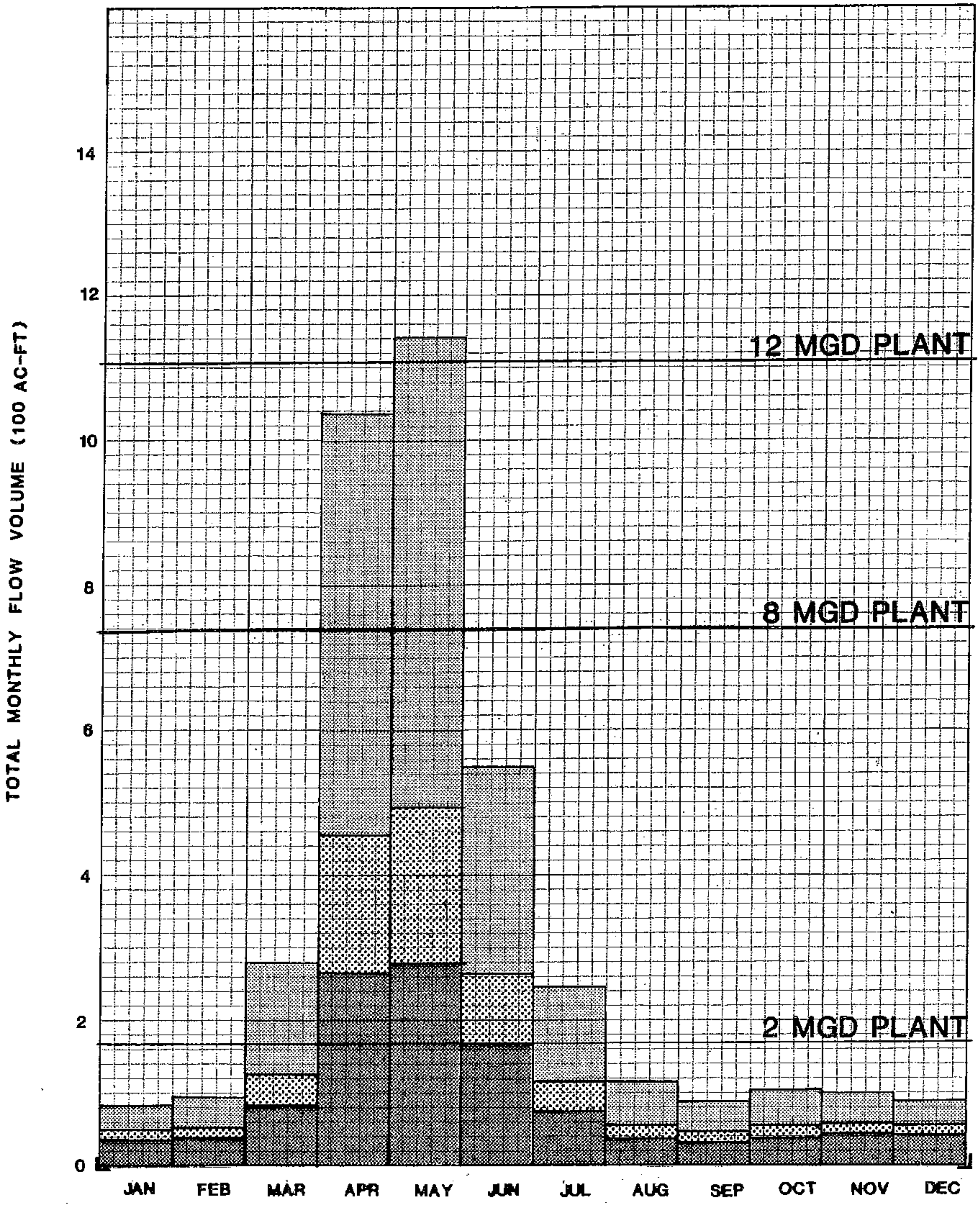
Also, a small treatment plant could be located near Burr Fork to supply the development in Lower Emigration Canyon with culinary water. The cost of such a plant would be similar to the costs shown in Figure VI-14.

TABLE VI-8

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
EMIGRATION CREEK
RESERVOIR SITE B

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	1312[n]	1896[n]	0
Carry-over Capacity[b]	Ac-Ft	659	659	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	3928	3928	3928
Total Annual Water Yield[e]	Ac-Ft	3928	3928	3928
Unit Storage Cost[f]	$/Ac-Ft	780	700	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	260	338	0
Water Treatment Plant Capacity	mgd	10.7[h]	10.7[h]	14.9[l]
Annual Treatment & Conveyance Cost[i]	$1000	1100	1040	1233
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	280	265	314
Total Unit Water Yield Cost[k]	$/Ac-Ft	540	603	314

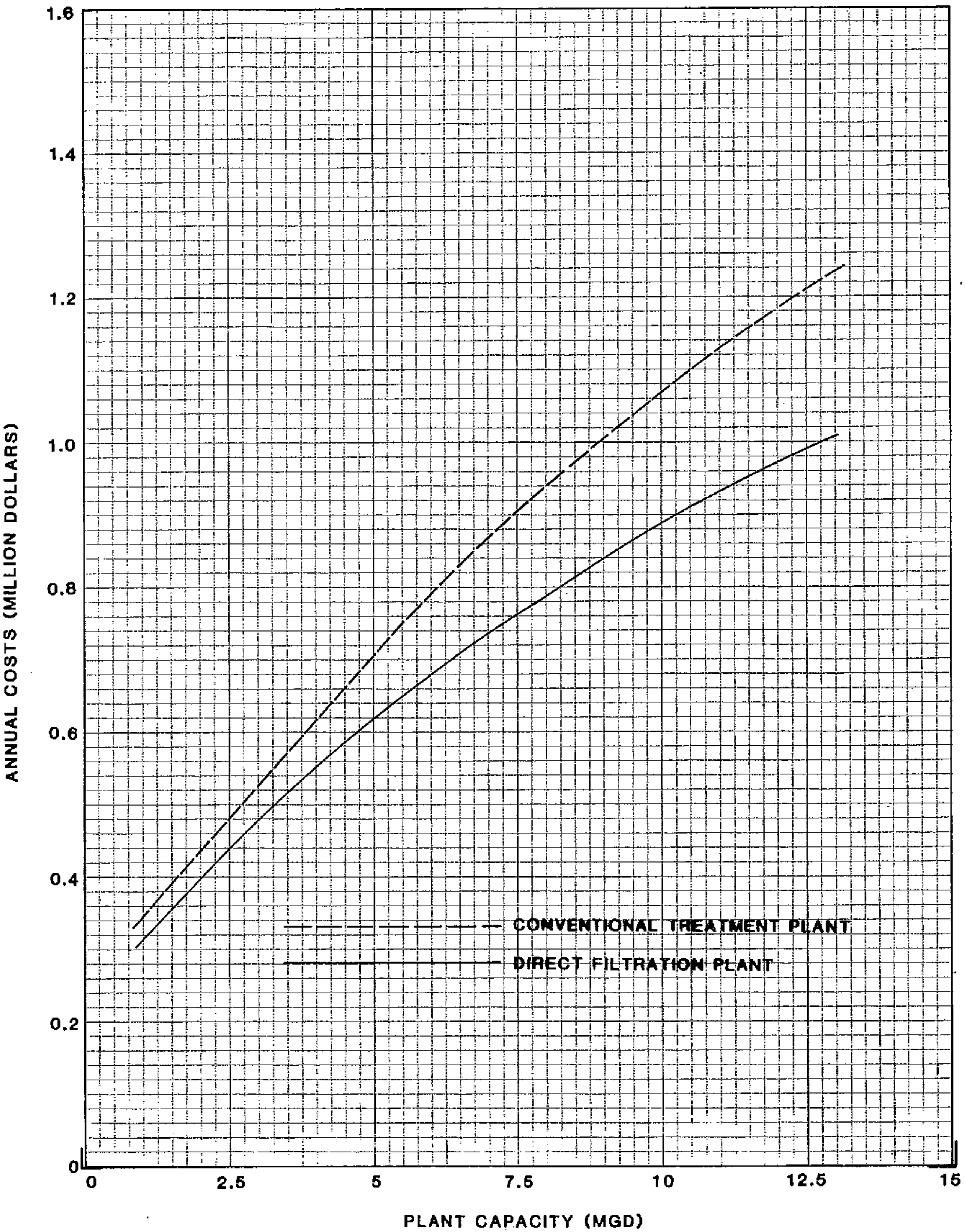
(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-5.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-12.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-14.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Plant capacity equals the sum of: (1) the average flow during the peak month flow released from the reservoir, and (2) 120% of the corresponding month regulated stream flow at the canyon mouth from the intervening drainage area.
(m) This represents natural unregulated stream flow pattern.
(n) The 50% probability annual yield at the reservoir site is redistributed according to the scenario distribution, and released to Emigration Creek.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH
EMIGRATION CREEK

FIGURE VI-13



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS

EMIGRATION CREEK

FIGURE VI-14

PARLEYS CANYON:

DAMSITES: Little Dell Reservoir and damsite have been studied extensively by various agencies. From these previous studies there appear to have been two preferred alternatives. The early reports analyze a reservoir with a capacity of 50,000 acre-feet. However, the most recent data favor a reservoir with a capacity of 30,000 acre-feet. Both of these alternatives would be located as shown in Figure VI-15, and they both would be utilized as multipurpose reservoirs. An overall project map of the Little Dell Reservoir is shown in Figure VI-16.

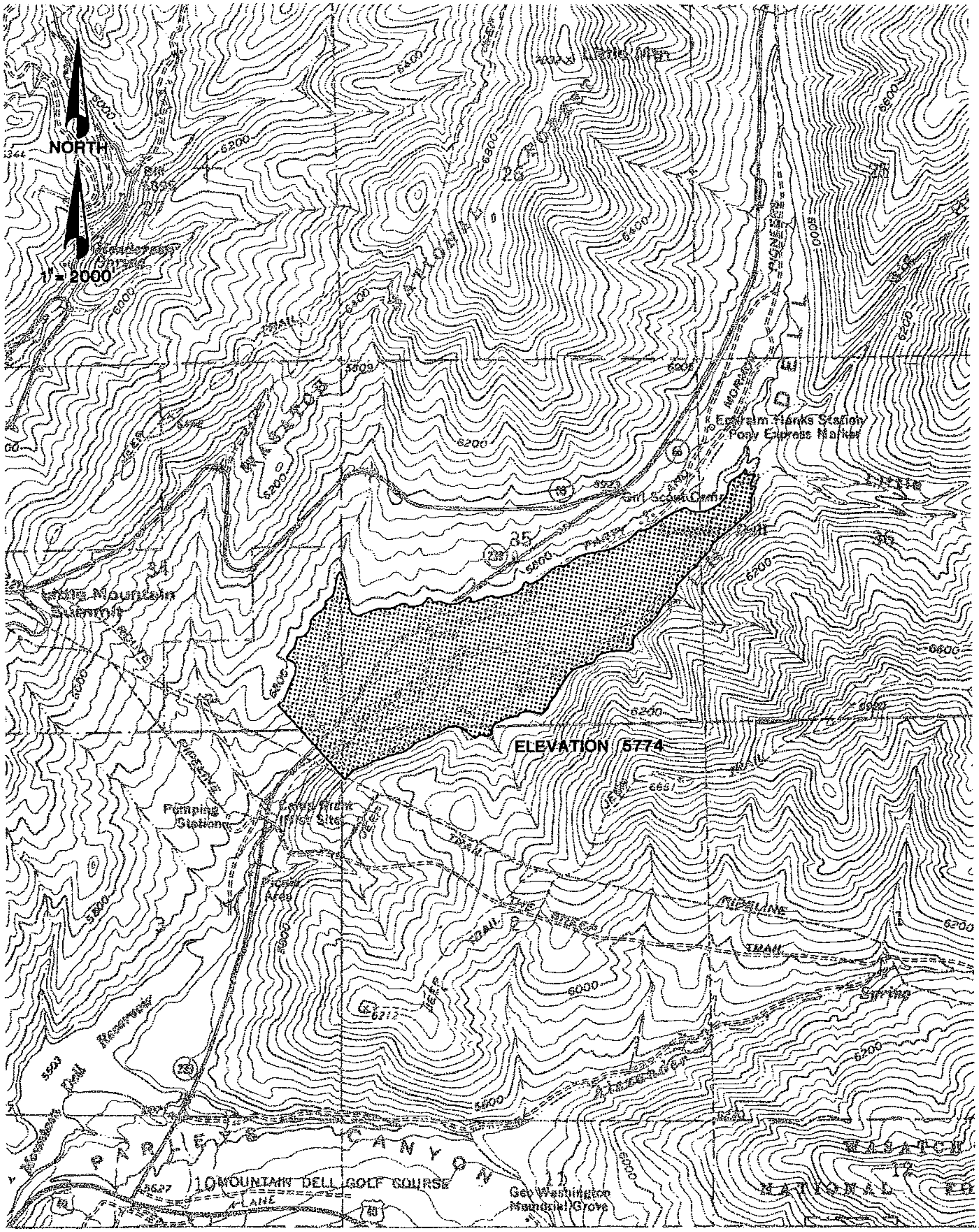
The 50,000 acre-foot reservoir proposal includes diversion projects on Mill Creek and Emigration Creek. Water would be diverted from Mill Creek through a tunnel into Lambs Canyon, then again diverted to Little Dell Reservoir. The diversion and tunnel from Emigration Creek would discharge directly into Little Dell Reservoir. Pertinent data for the dam, reservoir and diversions are shown on Table VI-9.

As an alternative to this dam, the Corp of Engineers considered a 50,000 acre-foot reservoir located just downstream from Mountain Dell Reservoir. The dam would be 280 feet high with a crest length of 1250 feet. This site would include diversions from Mill Creek and Emigration Canyons. The Corp of Engineers concluded that this alternative was economically infeasible .

The Corps of Engineers most recent proposal is a 30,000 acre-foot Little Dell Reservoir, which includes only the diversion on Emigration Creek. Pertinent data are shown on Table VI-10 for this alternative.

An Environmental Impact Statement has been prepared for the 30,000 acre-foot reservoir at Little Dell. A summary of the adverse environmental effects follows:

- 340 acres of land will be inundated including 35 acres of cultivated fields.
- Wildlife habitat including some meadowland and riparian vegetations will be lost.

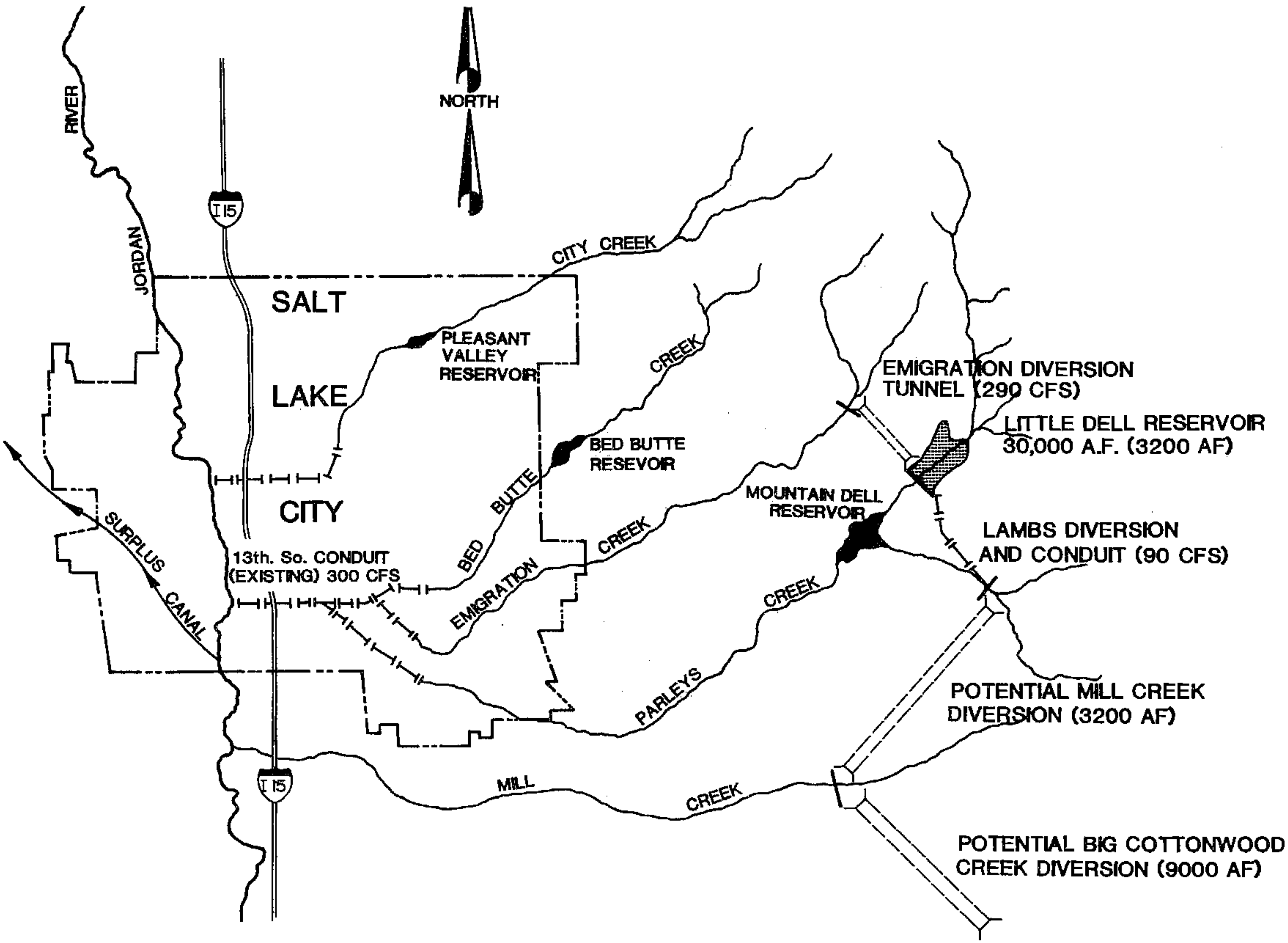


SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

PARLEYS CREEK

FIGURE VI-15



SALT LAKE COUNTY AREA-WIDE WATER STUDY

LITTLE DELL RESERVOIR MULTIPLE PURPOSE PROJECT

(FLOOD CONTROL, WATER SUPPLY & RECREATION)

FIGURE VI-16

TABLE VI-9.
PERTINENT DATA
PROPOSED 50,000 ACRE-FOOT LITTLE DELL DAM AND RESERVOIR PROJECT

RESERVOIR	
Drainage area	
Dell Creek at Dam	16.0 sq. mi.
Emigration Creek above diversion	5.8 sq. mi.
Mill Creek above diversion	7.8 sq. mi.
Lambs Canyon above diversion	13.6 sq. mi.
Total area	43.2 sq. mi.
Total mean annual inflow to reservoir	15,000 ac-ft
Active storage capacity	45,000 ac-ft
Reservoir pool elevations	
Gross pool	5,884.0 ft.
Inactive pool	5,723.0 ft.
Spillway design flood pool	5,891.0 ft.
Reservoir areas	
At gross pool	450 acres
At inactive pool	120 acres
At spillway flood pool	470 acres
Reservoir storage	
At gross pool	50,000 ac-ft
At inactive pool	5,000 ac-ft
At spillway flood pool	53,000 ac-ft
Length of reservoir	1.85 mile (approx)
MAIN DAM	
Type	Rolled impervious earthfill
Elevation - Top of Dam	5,896.0 ft.
Freeboard above spillway flood pool	5.0 ft.
Maximum height above streambed	309 ft.
Length of crest (not including spillway)	2,520 ft.
Width of crest	20.0 ft.
SPILLWAY	
Type and location	Detached, ungated, broad crest, with concrete lined chute
Crest length	16 ft.
Crest elevation	5,884 ft.
Discharge capacity at maximum pool (elevation 5,891.0 ft.)	900 cfs

TABLE VI-9 PERTINENT DATA (Cont'd)

FLOOD CONTROL AND WATER SUPPLY OUTLETS

Number	1
Type and location	Single barrel, 7'-0" diameter concrete to 36-inch steel pipe supported in an 8.0' diameter horseshoe tunnel
Discharge capacity	
At inactive pool elevation 5,723 ft.	200 cfs
At gross pool elevation 5,884 ft.	300 cfs

DIVERSIONS

Lambs Canyon to Little Dell Reservoir	
Diversion Dam	Concrete
Conduit	48" R.C. pipe
Length	3.13 miles
Capacity	90 cfs
Mill Creek to Lambs Canyon tributary	
Diversion Dam	Concrete
Conduit	6'-6" Horseshoe Tunnel
Length	1.75 miles
Capacity	240 cfs
Emigration Creek to Little Dell Reservoir	
Diversion Dam	Concrete
Conduit	6'-6" Horseshoe Tunnel
Length	1.03 miles
Capacity	240 cfs

TABLE VI-9 (con't)

Item	Subtotal ($)	Amount ($)
CAPITAL COST[c]		
Lands and damages		5,745,000 (a)
Relocations		1,489,000
Roads	1,018,000	
Utilities	471,000	
Reservoirs		91,000
Dam		35,534,000
Main Dam	32,768,000	
Spillway	699,000	
Outlet Works	2,067,000	
Mill Creek Diversion		4,560,000
Emigration Canyon Diversion		2,538,000
Lambs Creek Diversion		1,778,000
Roads		91,000
Recreation facilities		2,553,000
Buildings, grounds & utilities		182,000
Permanent operating equipment		122,000
Engineering and design		3,465,000
Supervision and administration		4,164,000
Total first cost		62,312,000 (b)

Source: Reference (80)
(a) Exclusive of Federal lands to be transferred to the project for recreation use (estimated market value of $20,000 included as economic cost in investment).
(b) Excludes cost of preauthorization studies, estimated at $100,000.
(c) Updated to 1981 by study team.

ANNUAL COSTS

20 year life @ 10%	$ 7,319,000

TABLE VI-10

PERTINENT DATA
PROPOSED 30,000 ACRE-FOOT LITTLE DELL DAM AND RESEVOIR PROJECT

1. General Data	
Name	Little Dell Lake
Stream	Dell Creek
County and State	Salt Lake County, Utah
Purpose	Flood control, municipal water supply recreation and fish & wildlife
Drainage area	
Emigration Creek above diversion	5.8 sq. mi.
Dell Creek above damsite	16.0 sq. mi.
Parleys Creek above diversion	13.5 sq. mi.
Parleys Creek above Mt. Dell Dam	41.0 sq. mi.
Runoff, mean annual (1930-1968)	
Emigration Creek at diversion	1,930 ac-ft
Dell Creek at damsite	5,600 ac-ft
Parleys Creek at diversion	5,700 ac-ft
Parleys Creek at Mt. Dell Dam	13,600 ac-ft
Cost	
Total project first cost (b)	66,186,000
Total annual cost (20 years @ 10%)	7,774,000
Benefits	
Flood control	2,145,000
Water supply	342,000
Recreation (a)	2,225,000
Total	4,712,000
2. Reservoir Data	
Reservoir pool elevation	
Inactive pool	5,694 ft., m.s.l.
Average recreation pool (June-Sept.)	5,818 ft., m.s.l.
Gross (full storage) pool	5,827 ft., m.s.l.
Spillway design flood pool	5,836.5 ft., m.s.l

Source: U.S. Army Corps of Engineers. "Little Dell Lake Project, General Design Memorandum, Phase I", September 1974.

(a) Includes fish and wildlife benefits of $40,000.
(b) Updated to 1981 by study team.

TABLE VI-10
PERTINENT DATA - (Con't)

2. Reservoir Data - (Con'd)

Reservoir areas	
Inactive pool	102 acres
Average recreation pool	300 acres
Gross pool	318 acres
Spillway design flood pool	339 acres
Reservoir storage	
Inactive pool	3,000 ac-ft
Average recreation pool	27,000 ac-ft
Gross pool	30,000 ac-ft
Spillway design flood pool (Maximum pool)	33,100 ac-ft
Length of reservoir	1.45 miles

3. Dam

Type	Rolled earthfill
Elevation - Top of Dam	5,842 ft. m.s.l.
Elevation, streambed at axis of dam	5,589 ft., m.s.l.
Maximum height above streambed at axis of dam	253 ft.
Freeboard above spillway flood pool	5.5 ft.
Length of crest (spillway not included)	2,250 ft.
Width of crest	30 ft.
Side slopes	
Upstream	1 on 2.5 above gross pool 1 on 3.5 above El. 5772.0 to gross pool 1 on 5.25 below El. 5772.0
Downstream	1 on 2.5 above gross pool 1 on 3.5 below gross pool

4. Dikes — None

5. Spillway

Type and location	Detached, ungated and unlined on right abutment of dam
Discharge capacity at spillway design flood pool (elevation 5,836.5 feet)	4,535 cfs

TABLE VI-10
PERTINENT DATA - (Cont'd)

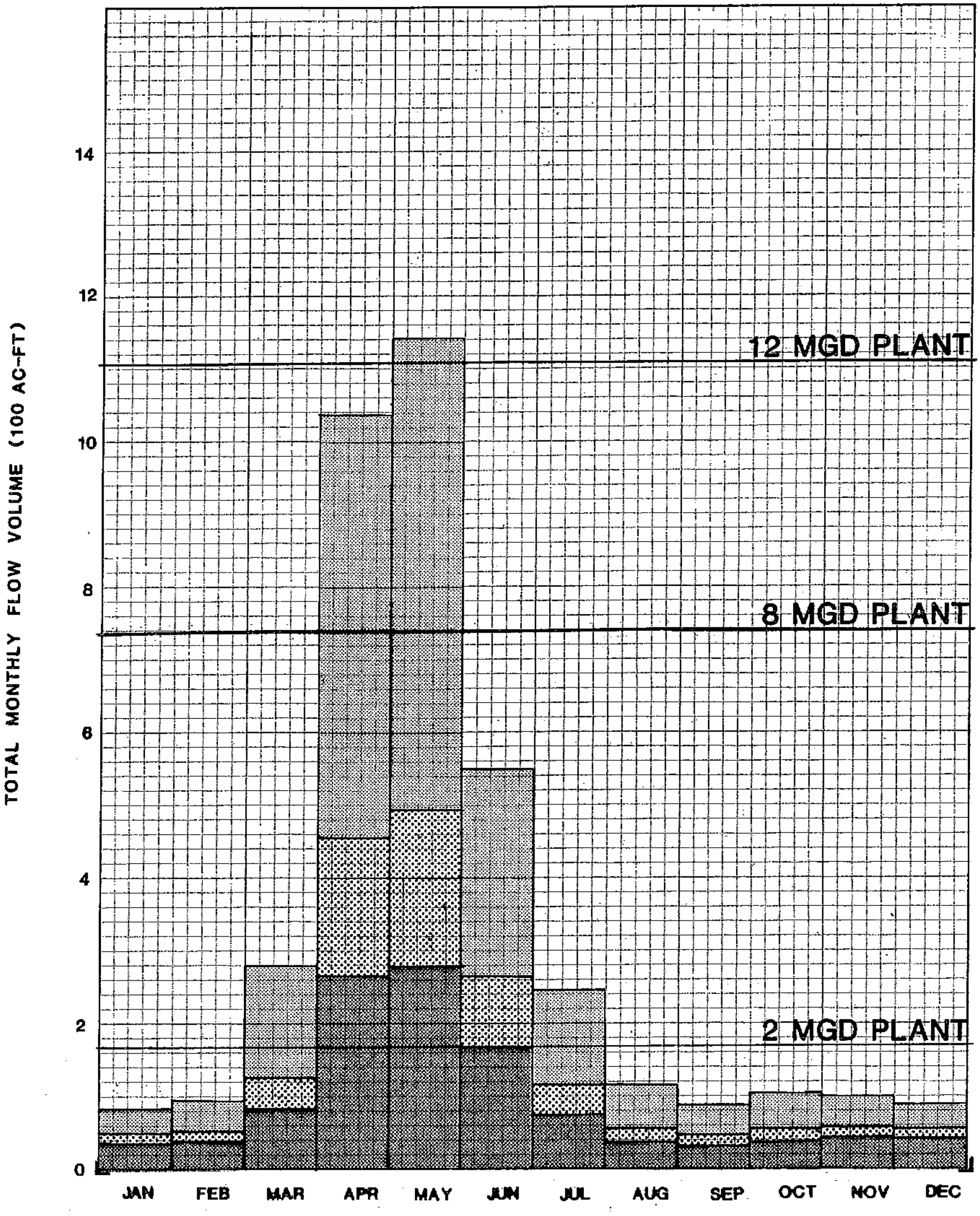
6. Flood control and water supply outlet works	
Type and location	Single-level submerged intake; mid-tunnel control shaft; single-barrel concrete-lined tunnel located in the left abutment and a stilling basin type energy dissipator.
7. Diversions	
Emigration Creek to Little Dell Lake	
Diversion Structure	Concrete - 5' x 40'
Tunnel	7'-0" circular, concrete lined
Length	1.03 miles
Capacity (maximum)	290 cfs
Parleys Creek to Little Dell Lake	
Diversion Structure	Concrete - 8 1/2' x 50'
Conduit	4'-0" dia. concrete pipe
Length	3.1 miles
Capacity (design capacity)	90 cfs
8. Recreation Facilities	
Visitor center	
Group picnic facilities	7 @ 200 people capacity
Family picnic sites	75 sites
Sand-swimming beach	1 1/2 acres
Boat-launching ramp	2 lane
Bike-hike trails	3 1/2 miles
Pioneer museum	
Athletic fields	
9. Mt. Dell Reservoir Capacity	3,000 ac-ft
10. Channel Improvement	None
11. Hydroelectric Power Facilties	None

TABLE VI-8

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
EMIGRATION CREEK
RESERVOIR SITE B

Item	Unit	Scenario: 1. Equalizing Facility	2. Peaking Facility	3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	1312[n]	1896[n]	0
Carry-over Capacity[b]	Ac-Ft	659	659	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	3928	3928	3928
Total Annual Water Yield[e]	Ac-Ft	3928	3928	3928
Unit Storage Cost[f]	$/Ac-Ft	780	700	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	260	338	0
Water Treatment Plant Capacity	mgd	10.7[h]	10.7[h]	14.9[l]
Annual Treatment & Conveyance Cost[i]	$1000	1100	1040	1233
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	280	265	314
Total Unit Water Yield Cost[k]	$/Ac-Ft	540	603	314

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-5.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-12.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-14.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Plant capacity equals the sum of: (1) the average flow during the peak month flow released from the reservoir, and (2) 120% of the corresponding month regulated stream flow at the canyon mouth from the intervening drainage area.
(m) This represents natural unregulated stream flow pattern.
(n) The 50% probability annual yield at the reservoir site is redistributed according to the scenario distribution, and released to Emigration Creek.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH
EMIGRATION CREEK

FIGURE VI-13

- 1.5 miles of the Historic Mormon Trail along with a Pony Express Station will be inundated or have to be moved to a new location.

- Diversion of Emigration Creek would diminish the trout fishing downstream from the diversion.

- The aesthetic quality of the lake will be effected during periods of infrequent heavy drawdowns.

This is the only proposed damsite in the report for which an Environmental Impact Statement (EIS) has been prepared. The final analysis is favorable towards the construction of Little Dell Reservoir. From what is given in the EIS, it is felt that the benefits derived from a reservoir at this site are greater than the costs, both environmentally and economically.

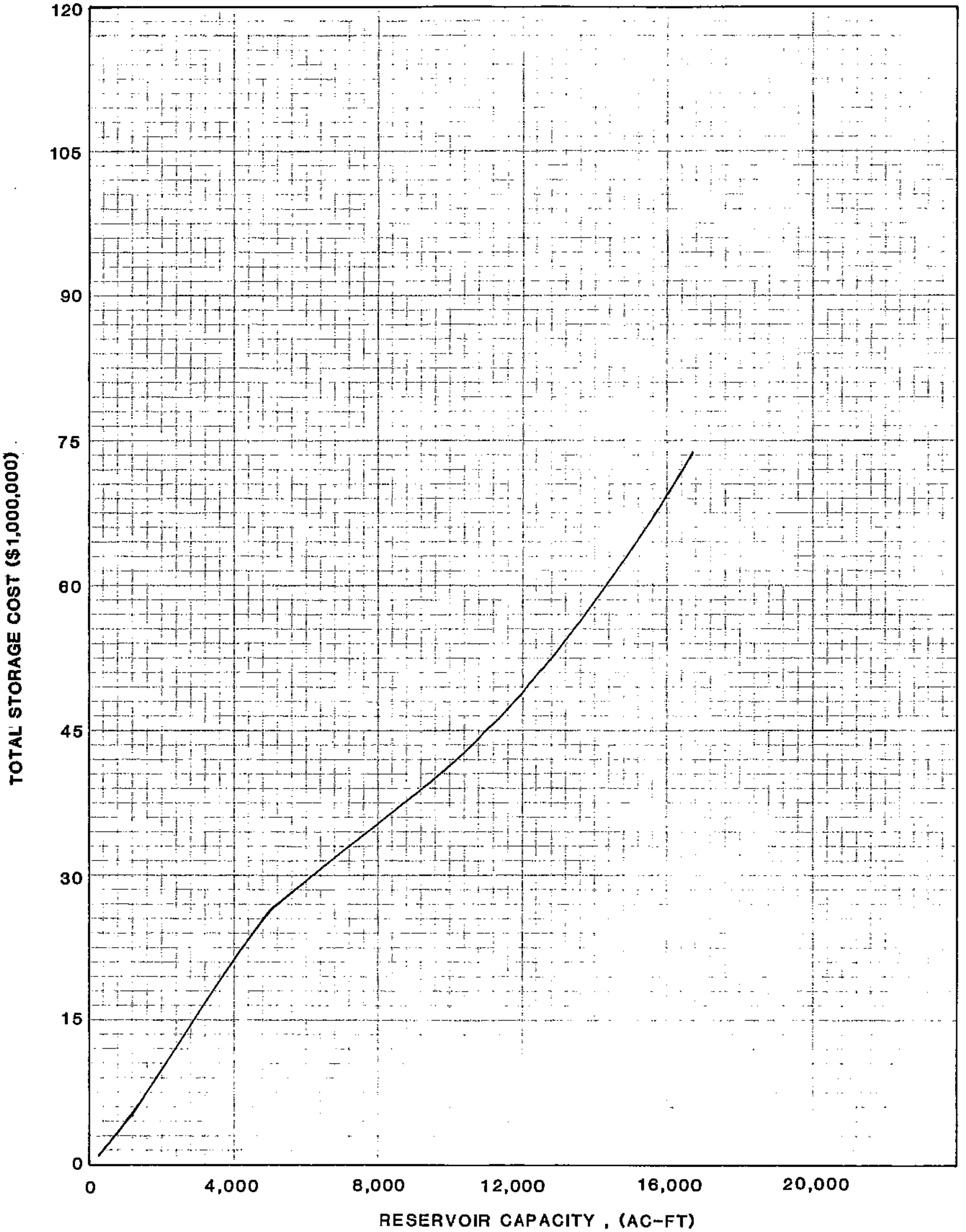
A review of the topography in Parleys Canyon during the present study, did not reveal any other potential damsites as well-suited for dam construction and reservoir operation as the Little Dell site.

During the present study, the costs for constructing and operating a single-purpose reservoir at the Little Dell site in Parleys Canyon for municipal water supply were estimated. Dams of several different sizes were investigated. The actual site is shown in Figure VI-15.

The reservoir capacities associated with four preliminary dams studied range from 1200 acre-feet to 16,700 acre-feet. This represents the range of average yields for several different combinations of water sources, less the existing capacity of Mountain Dell Reservoir in each case. The four water sources investigated are the direct stream supply to the reservoir from Dell Creek, and the diversion supplies from Emigration Creek at Burr Fork, Parleys Creek at the confluence with Lambs Canyon Creek and Mill Creek at Elbow Fork. The pertinent data used in estimating costs for the four dam sizes studied are shown in Table VI-11.

TABLE VI-11
PERTINENT PRELIMINARY DATA
PARLEYS CANYON RESERVOIR OPTIONS AT LITTLE DELL SITE

	RESERVOIR CAPACITY OPTIONS			
	1200 Ac-Ft	5000 Ac-Ft	10,000 Ac-Ft	16,700 Ac-Ft
GENERAL				
Drainage Area (square miles)	N/A	N/A	N/A	N/A
RESERVOIR				
Gross Pool Elevation (feet)	5618	5714	5749	5781
Gross Pool Area (acres)	11	109	173	238
Gross Pool Storage (acre-feet)	1200	5000	10,000	16,700
Ratio of Storage vs. Area (acre-feet per acre)	109.1	45.9	57.8	70.2
Probable Land Purchase Requirement (acres)	15	142	225	310
MAIN DAM				
Top Elevation (feet)	5633	5729	5764	5796
Spillway Elevation (feet)	5618	5714	5749	5781
Maximum Height at Dam Axis (feet)	44	140	175	207
Upstream Side Slope	3.5:1	3.5:1	3.5:1	3.5:1
Downstream Side Slope	3.5:1	3.5:1	3.5:1	3.5:1
Crest Length (feet)	440	1220	1380	1560
Crest Width (feet)	25	30	30	30
Outlet Works Capacity (cfs)	200	200	200	200
Outlet Works Hydraulic Head (feet)	30	125	160	192
SPILLWAY				
Discharge Capacity (cfs)	4535	4535	4535	4535
Surcharge Head (feet)	9.5	9.5	9.5	9.5



SALT LAKE COUNTY AREA-WIDE WATER STUDY

TOTAL STORAGE COSTS

PARLEYS CREEK, LITTLE DELL RESERVOIR SITE FIGURE VI-17

The total capital cost for each reservoir and dam is plotted versus reservoir capacity in Figure VI-17.

The combinations of water sources available at the Little Dell site that have been studied are as follows:

(1) With no diversion (Dell Creek supply only)
(2) With Emigration Creek diversion
(3) With Parleys Creek diversion
(4) With Emigration Creek and Parleys Creek diversions
(5) With Parleys Creek and Mill Creek diversions
(6) With Emigration Creek, Parleys Creek and Mill Creek diversions

Calculations were made to determine the required reservoir capacity for each water source alternative, based on the first two storage use scenarios as equalizing and peaking reservoirs. The existing storage capacity of Mountain Dell Reservoir was then subtracted from the calculated volumes to determine the appropriate capacity for a new reservoir at the Little Dell site.

For each water source combination, the total dam and reservoir capital cost for each scenario has been extracted from the graph in Figure VI-17. The capital cost of the required diversion conduits, if any, for each alternative scheme has been added to the corresponding dam and reservoir capital cost. The diversion conduit costs were obtained from 1975 Corps of Engineers estimates and updated by use of cost indices. The total capital cost was then amortized over 20 years at ten percent interest, and an annual operation and maintenance cost estimate (0.5 percent of the capital cost) was added, to obtain a total annual storage cost for each project alternative.

The total annual storage cost, divided by the developable annual water yield, becomes the unit water yield cost for reservoir storage. This cost, along with the reservoir capacity, yield, and other data are tabulated in Tables VI-12 through VI-17 for each water source alternative at the Little Dell site. Also included in these tables are the annual treatment and conveyance costs and the total unit water yield costs of developed and treated water.

TABLE VI-12

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
LITTLE DELL RESERVOIR WITH
NO DIVERSIONS

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	4152	6333	N/A
Carry-over Capacity[b]	Ac-Ft	6060	6060	N/A
Existing Annual Water Yield[c]	Ac-Ft	9494	9494	N/A
Developable Annual Water Yield[d]	Ac-Ft	6034	6034	N/A
Total Annual Water Yield[e]	Ac-Ft	15,528	15,528	N/A
Unit Storage Cost[f]	$/Ac-Ft	737	561	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	507	589	N/A
Water Treatment Plant Capacity[h]	mgd	40	40	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	542	624	N/A

(a) Includes storage and carry-over capacity, in excess of existing Mountain Dell Reservoir capacity of 3400 ac-ft.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-6, adjusted for drainage area at damsite. This is the total carry-over storage supplied by Mountain Dell and Little Dell Reservoirs.
(c) The average annual water treatment plant production for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-17, amortized at 10% interest for 20 years, a 0.5% annual O&M cost added, and divided by the reservoir capacity.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing plant capacity of Parleys Water Treatment Plant. However, the existing capacity of the Mountain Dell Conduit, 32 mgd, is the constraint.
(j) 1981 average treatment costs.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.

TABLE VI-13

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
LITTLE DELL RESERVOIR WITH
EMIGRATION CREEK DIVERSION

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	6614	9707	N/A
Carry-over Capacity[b]	Ac-Ft	7500	7500	N/A
Existing Annual Water Yield[c]	Ac-Ft	9494	9494	N/A
Developable Annual Water Yield[d]	Ac-Ft	8319	8319	N/A
Total Annual Water Yield[e]	Ac-Ft	17,813	17,813	N/A
Unit Storage Cost[f]	$/Ac-Ft	699	457	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	532	533	N/A
Water Treatment Plant Capacity[h]	mgd	40	40	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	567	568	N/A

(a) Includes storage and carry-over capacity, in excess of existing Mountain Dell Reservoir capacity of 3400 acre-feet.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-6, adjusted for drainage area at damsite. This is the total carry-over storage supplied by Mountain Dell and Little Dell Reservoirs.
(c) The average annual water treatment plant production for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) Derived from Figure VI-17, with the updated cost estimate for the diversion tunnel added. This sum was then amortized at 10% for 20 years, a 0.5% annual O&M cost added, and divided by the reservoir capacity.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing plant capacity of Parleys Water Treatment Plant. However, the existing capacity of the Mountain Dell Conduit, 32 mgd, is the constraint.
(j) 1981 average treatment costs.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.

TABLE VI-14

ESTIMATEO COSTS FOR DEVELOPABLE WATER FROM
LITTLE DELL RESERVOIR WITH
PARLEYS CREEK DIVERSION

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	4152	7621	N/A
Carry-over Capacity[b]	Ac-Ft	6060	6060	N/A
Existing Annual Water Yield[c]	Ac-Ft	9494	9494	N/A
Developable Annual Water Yield[d]	Ac-Ft	6034	6034	N/A
Total Annual Water Yield[e]	Ac-Ft	15,528	15,528	N/A
Unit Storage Cost[f]	$/Ac-Ft	798	499	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	549	631	N/A
Water Treatment Plant Capacity[h]	mgd	40	40	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	584	666	N/A

(a) Includes storage and carry-over capacity, in excess of existing Mountain Dell Reservoir capacity of 3400 acre-feet.

(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Tables V-5 & V-6, adjusted for available drainage areas. This is the total carry-over storage supplied by the Mountain Dell and Little Dell Reservoirs.

(c) The average annual water treatment plant production for the period 1977-1981.

(d) Additional water developed in excess of existing annual water yield.

(e) Sum of existing and developable annual water yields.

(f) Derived from Figure VI-17, with the updated cost estimate for the diversion added. This sum was then amortized at 10% for 20 years, a 0.5% annual O&M cost added, and divided by the reservoir capacity.

(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.

(h) Existing plant capacity of Parleys Water Treatment Plant. However, the existing capacity of the Mountain Dell Conduit, 32 mgd, is the constraint.

(j) 1981 average treatment costs.

(k) Sum of unit water yield costs for reservoir and treatment & conveyance.

TABLE VI-15

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM LITTLE DELL RESERVOIR WITH EMIGRATION CREEK AND PARLEYS CREEK DIVERSIONS

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	6614	10,995	N/A
Carry-over Capacity[b]	Ac-Ft	7500	7500	N/A
Existing Annual Water Yield[c]	Ac-Ft	9494	9494	N/A
Developable Annual Water Yield[d]	Ac-Ft	8319	8319	N/A
Total Annual Water Yield[e]	Ac-Ft	17,813	17,813	N/A
Unit Storage Cost[f]	$/Ac-Ft	708	576	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	563	761	N/A
Water Treatment Plant Capacity[h]	mgd	40	40	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	598	796	N/A

(a) Includes storage and carry-over capacity, in excess of existing Mountain Dell Reservoir capacity of 3400 acre-feet.

(b) Calculated as the diffeence between 50% and 90% probability yields. See annual sums, Tables V-5 & V-6, adjusted for available drainage areas. This is the total carry-over storage supplied by the Mountain Dell and Little Dell Reservoirs.

(c) The average annual water treatment plant production for the period 1977-1981.

(d) Additional water developed in excess of existing annual water yield.

(e) Sum of existing and developable annual water yields.

(f) Derived from Figure VI-17, with the updated cost estimates for the diversions added. The sum was then amortized at 10% for 20 years, a 0.5% O&M annual cost added, and was then divided by the reservoir capacity.

(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.

(h) Existing plant capacity of Parleys Water Treatment Plant. However, the existing capacity of the Mountain Dell Conduit, 32 mgd, is the constraint.

(j) 1981 average treatment costs.

(k) Sum of unit water yield costs for reservoir and treatment and conveyance.

TABLE VI-16

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM LITTLE DELL RESERVOIR WITH PARLEYS CREEK AND MILL CREEK DIVERSIONS

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	8609	12,140	N/A
Carryover Capacity[b]	Ac-Ft	8606	8606	N/A
Existing Annual Water Yield[c]	Ac-Ft	9494	9494	N/A
Developable Annual Water Yield[d]	Ac-Ft	12,347	9951[1]	N/A
Total Annual Water Yield[e]	Ac-Ft	21,841	19,445	N/A
Unit Storage Cost[f]	$/Ac-Ft	788	680	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	550	830	N/A
Water Treatment PLant Capacity[h]	mgd	40	40	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	585	865	N/A

(a) Includes storage and carry-over capacity, in excess of existing Mountain Dell Reservoir capacity of 3400 acre-feet.

(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Tables V-6 & V-7, adjusted for available drainage area. This is the total carry-over storage supplied by the Mountain Dell and Little Dell Reservoirs.

(c) The average annual water treatment plant production for the period 1977-1981.

(d) Additional water developed in excess of existing annual water yield.

(e) Sum of existing and developable annual water yields.

(f) Derived from Figure VI-17, with the updated cost estimates for the diversions added. The sum was then amortized at 10% for 20 years, a 0.5% annual O&M cost added, and then divided by the reservoir capacity.

(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.

(h) Existing plant capacity of Parleys Water Treatment Plant. However, the existing capacity of the Mountain Dell Conduit, 32 mgd, is the constraint.

(j) 1981 average treatment costs.

(k) Sum of unit water yield costs for reservoir and treatment and conveyance.

(1) Because of the capacity of the Mountain Dell Conduit as a constraint, 2396 acre-feet of available water cannot be developed under this scenario.

TABLE VI-17

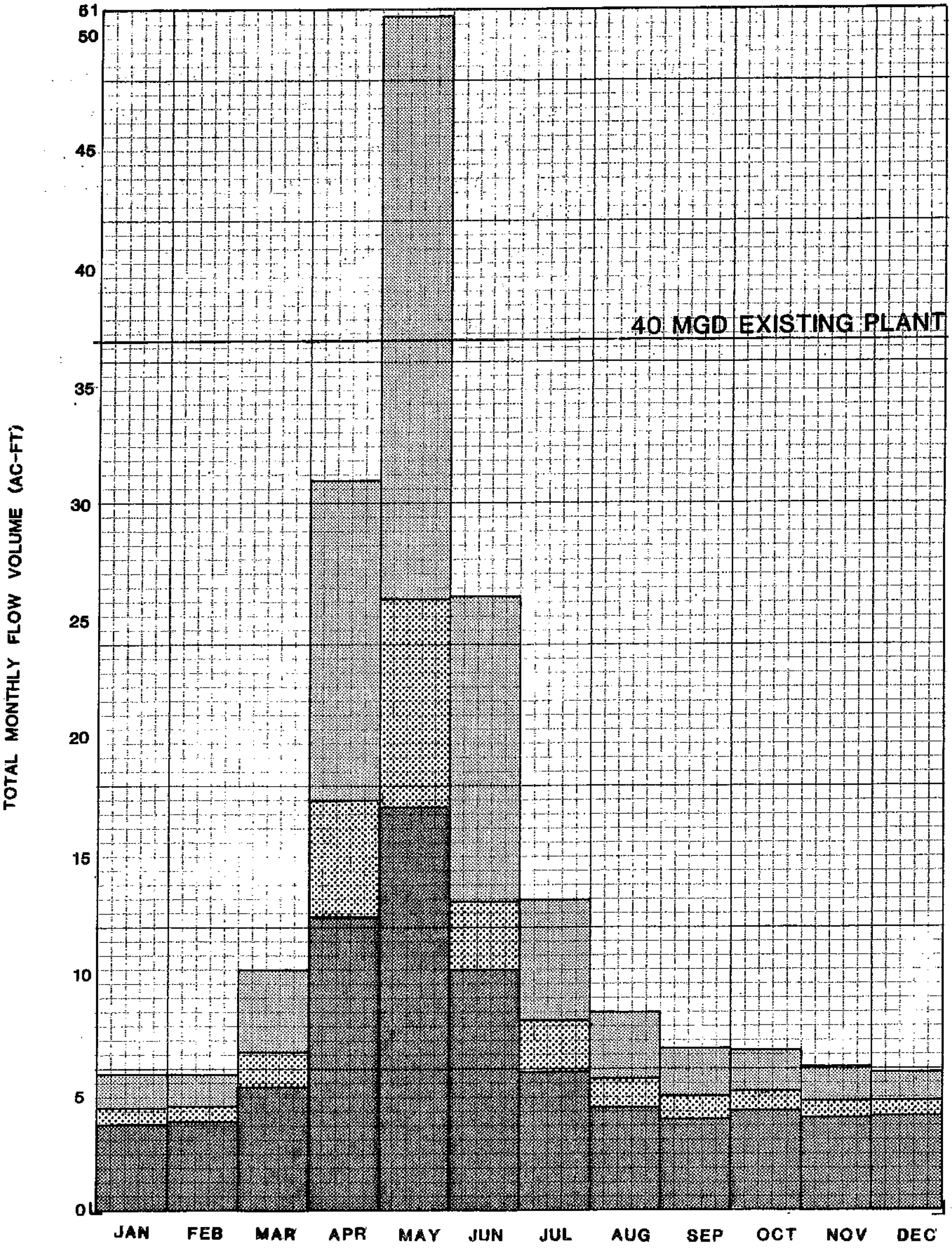
ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
LITTLE DELL RESERVOIR WITH EMIGRATION CREEK,
PARLEYS CREEK AND MILL CREEK DIVERSIONS

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity(a)	Ac-Ft	10,759	13,260	N/A
Carry-over Capacity(b)	Ac-Ft	10,046	10,046	N/A
Existing Annual Water Yield(c)	Ac-Ft	9494	9494	N/A
Developable Annual Water Yield(d)	Ac-Ft	14,632	9952	N/A
Total Annual Water Yield(e)	Ac-Ft	24,126	19,446(1)	N/A
Unit Storage Cost(f)	$/Ac-Ft	767	707	N/A
Unit Water Yield Cost for Reservoir(g)	$/Ac-Ft	564	943	N/A
Water Treatment Plant Capacity(h)	mgd	40	40	N/A
Unit Water Yield Cost for Treatment & Conveyance(j)	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost(k)	$/Ac-Ft	599	978	N/A

(a) Includes storage and carry-over capacity, in excess of existing Mountain Dell Reservoir capacity of 3400 acre-feet.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums Tables V-5, V-6 & V-7, adjusted for available drainage area. This is the total carry-over supplied by Mountain Dell and Little Dell Reservoirs.
(c) The average annual water treatment plant production for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) Derived from Figure VI-17, with the updated cost estimates for the diversions added. The sum was then amortized at 10% for 20 years, an 0.5% annual O&M cost added, and divided by the reservoir capacity.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing plant capacity, of Parleys Water Treatment Plant. However, the existing capacity of the Mountain Dell Conduit, 32 mgd, is the constraint.
(j) 1981 average treatment costs.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(1) Because of the capacity of the Mountain Dell Conduit as a constraint, 4680 acre-feet of available water cannot be developed under this scenario.

WATER TREATMENT PLANTS: The existing Parleys Water Treatment Plant has unused capacity during most of the year. Figure VI-18 shows the plant capacity of 40 mgd in relation to the creek's annual hydrograph. Because of the unused capacity in the plant, the cost of expansion was not determined during this study.

The Mountain Dell Conduit has an existing capacity of about 32 mgd, which is the constraint for water production at Parleys Water Treatment Plant. Because of this, the conduit capacity, rather than the plant capacity, was used in performing the calculations reflected in Tables VI-12 to VI-17.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH
PARLEYS CREEK

FIGURE VI-18

MILL CREEK CANYON:

DAMSITES: Because of the general steepness of both the canyon side slopes and the channel slope throughout Mill Creek Canyon, only one reasonable damsite was located. The damsite lies on Mill Creek about two channel miles upstream from the canyon mouth, near Scout Hollow. A majority of the Mill Creek drainage area contributes runoff to this damsite.

The three preliminary reservoir capacities considered would store 1500 acre-feet, the spring runoff volume of 3670 acre-feet, and the mean annual yield of 9742 acre-feet respectively. The damsite and reservoir areas are shown in Figure VI-19. Pertinent preliminary data are tabulated in Table VI-18. Figure VI-20 shows the unit costs plotted to provide a wide range of dam size versus cost information.

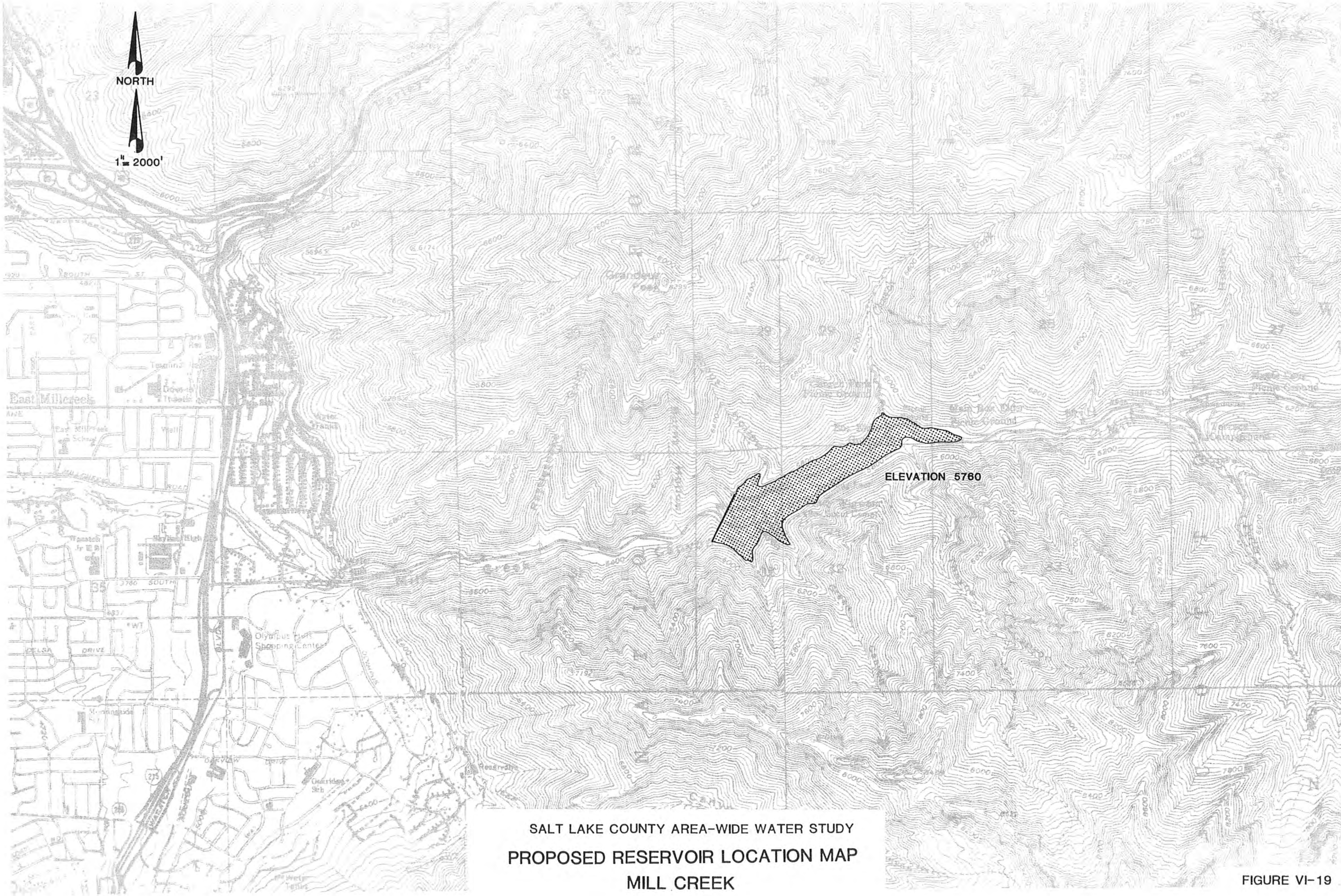
Construction of any of these three dams would inundate the Boy Scout Camp of Tracy Wigwam, the Box Elder Guard Station, and two picnic grounds. Also the paved asphalt road, as well as some utilities, would have to be relocated.

In order to determine probable reservoir sizes, calculations were made based upon the two scenarios of probable reservoir use as explained in the introducton. From these calculations it was determined that if the reservoir were used as an equalizing facility the total storage capacity would be 6039 acre-feet and it would have an annual yield of 10,588 acre-feet. If used as a peaking facility the total storage capacity would be 10,783 acre-feet with an annual water yield of 10,588 acre-feet. Capacities, yields and unit water yield cost estimates for developed water are summarized on Table VI-19.

TABLE VI-18
PERTINENT PRELIMINARY DATA
MILL CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS		
		1500 Ac-ft	Spring Runoff Volume 3670 Ac-Ft	Mean Annual Yield 9742 Ac-Ft
GENERAL				
Drainage Area (square miles)		19.6	19.6	19.6
RESERVOIR				
Gross Pool Elevation (feet)		5606	5606	5741
Gross Pool Area (acres)		33	52	94
Gross Pool Storage (acre-feet)		1500	3670	9742
Ratio of Storage vs. Area (acre-feet per acre)		45.4	70.6	103.6
Probable Land Purchase Requirement (acres)		40	68	117
MAIN DAM				
Top Elevation (feet)		5615	5667	5756
Spillway Elevation (feet)		5606	5656	5741
Maximum Height at Dam Axis (feet)		135	187	276
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		540	740	1150
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		20	20	20
Outlet Works Hydraulic Head (feet)		129	179	261
SPILLWAY				
Discharge Capacity (cfs)		230	230	230
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	5,134,000	9,687,000	22,246,000
Total Dam and Reservoir Cost	($)	11,351,000	18,681,000	37,479,000
Annual Operation & Maintenance Cost[(a)]	($)	57,000	93,000	187,000
Total Annual Cost[(b)]	($)	1,390,000	2,287,000	4,589,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.

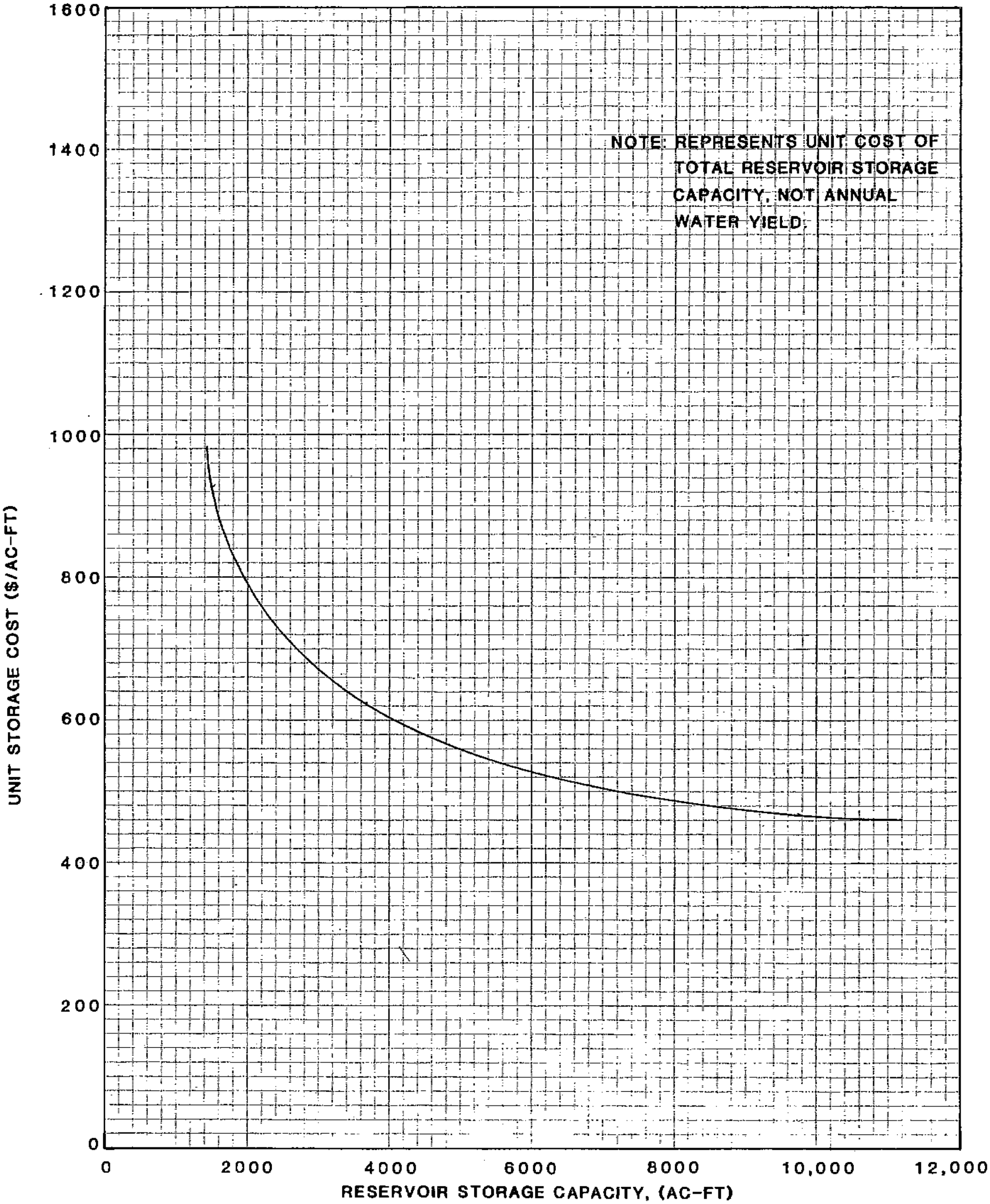


SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

MILL CREEK

FIGURE VI-19



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

MILL CREEK RESERVOIR SITE FIGURE VI-20

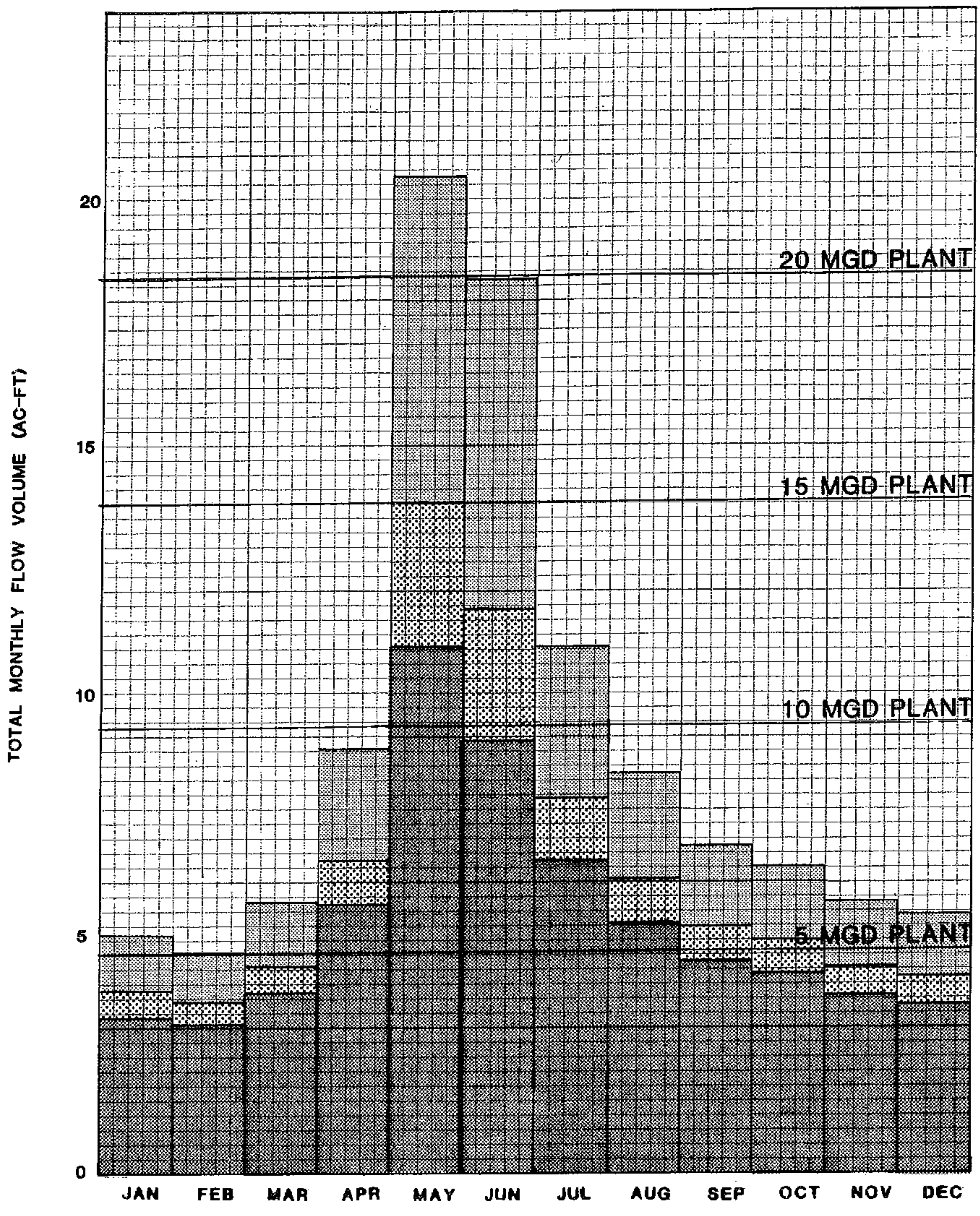
TABLE VI-19

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
MILL CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	6039	10,783	0
Carry-over Capacity[b]	Ac-Ft	3994	3994	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	10,588	10,588	10,588
Total Annual Water Yield[e]	Ac-Ft	10,588	10,588	10,588
Unit Storage Cost[f]	$/Ac-Ft	520	470	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	296	478	0
Water Treatment Plant Capacity[h]	mgd	18.9	36.8	22.4[1]
Annual Treatment & Conveyance Cost[i]	$1000	1920	2600	2160
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	181	245	204
Total Unit Water Yield Cost[k]	$/Ac-Ft	477	723	204

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-9, adjusted for drainage area at reservoir site.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-20.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-22.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(1) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.

WATER TREATMENT PLANT: Some studies were made during the late 1950's and early 1960's to determine the feasibility of a water treatment plant for Mill Creek.[66,67] The conclusion of these studies was that a treatment plant could be constructed near the mouth of the canyon. Figure VI-21 shows the hydrograph for Mill Creek with the capacities of various plant sizes indicated. The costs shown herein are based on a plant located southwest of the existing water tank on a piece of undeveloped land. The plant would be fed by diverting the flow from the stream directly into the plant. The estimated annual costs (including the amortized capital cost) for various plant sizes at this location are shown in Figure VI-22. The costs include a pipeline to Wasatch Boulevard for the treated water.

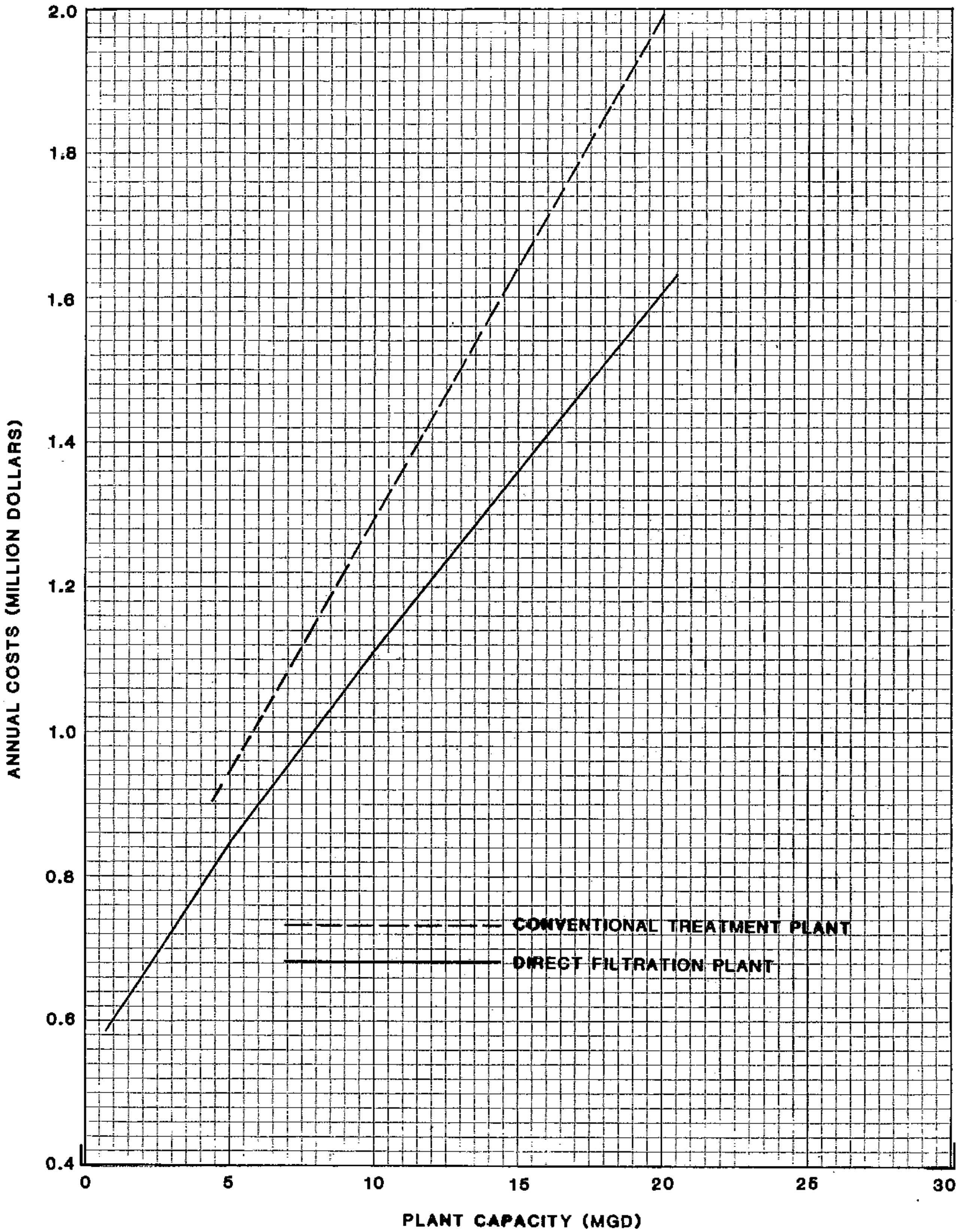


SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

MILL CREEK

FIGURE VI-21



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS

MILL CREEK

FIGURE VI-22

NEFFS CANYON:

DAMSITES: No known previous study has identified any potential damsites in Neffs Canyon. During this study, the feasibility of dam construction within the canyon was investigated, based on topography. Due to the steepness of the canyon, no reasonable site for dam and reservoir construction was found. In addition, it is not felt that the small amount of surface runoff warrants a reservoir study.

WATER TREATMENT PLANT: The water from Mount Olympus Spring is currently being used as a culinary supply. The existing collection facilities could be expanded to accommodate the total flow. A cost estimate of this expansion has not been made. As stated earlier in Chapter V, there is some indication that the water in Neffs Canyon contributes to springs which are west of Wasatch Boulevard. Further development in Neffs Canyon might affect the flow from the springs. This issue should be investigated prior to any modification of the existing situation.

TOLCATS CANYON:

DAMSITES: No known previous studies have identified or studied any damsites in Tolcats Canyon. During this study a cursory examination of the canyon topography was made to investigate the potential for construction of a dam. Because of the steepness of both the side slopes and the channel in the canyon, no reasonable damsite worthy of further study was found.

WATER TREATMENT PLANTS: The stream from Tolcats Canyon flows about four months during the year, therefore, a treatment plant was not considered for this stream. A pipeline to the Big Cottonwood Water Treatment plant was considered as a possible means of developing this water for culinary purposes. As the pipeline would cross the mouth of Heughs Canyon, it was assumed that the pipeline would be sized to carry the flows from both canyons. Table VI-20 shows the estimated total annual costs for pipelines of various sizes and the percentage of the 50 percent probability instantaneous peak flow which the pipeline could convey.

TABLE VI-20

COST ESTIMATES FOR TOLCATS AND HEUGHS CANYONS PIPELINE

Pipe Sizes (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
15 & 21	21.3	100 +	91,200
12 & 18	14.1	74	76,600
10 & 15	8.7	46	65,800

HEUGHS CANYON:

DAMSITES: No previous published studies have investigated damsites in Heughs Canyon. A cursory examination of the topography of the canyon during this study did not reveal any reasonable damsites worthy of further study. This is due to the steepness of both the channel and the canyon side slopes.

WATER TREATMENT PLANTS: The stream from Heughs Canyon flows about five months during the year; therefore, a treatment plant was not considered for this stream. A pipeline to the Big Cottonwood Water Treatment Plant was considered as a possible means of developing this water for culinary purposes. Table VI-21 shows the estimated total annual costs for the pipeline at various sizes and the percentage of the instantaneous peak flow which the pipeline could carry. Also, the pipeline could be sized to transport both the flows from Heughs and Tolcats Canyons. This alternative is discussed in the section on Tolcats Canyon.

TABLE VI-21

COST ESTIMATES FOR HEUGHS CANYON PIPELINE

Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
18"	14.1	100 +	55,200
15"	8.7	63	47,800
12"	4.8	35	37,600

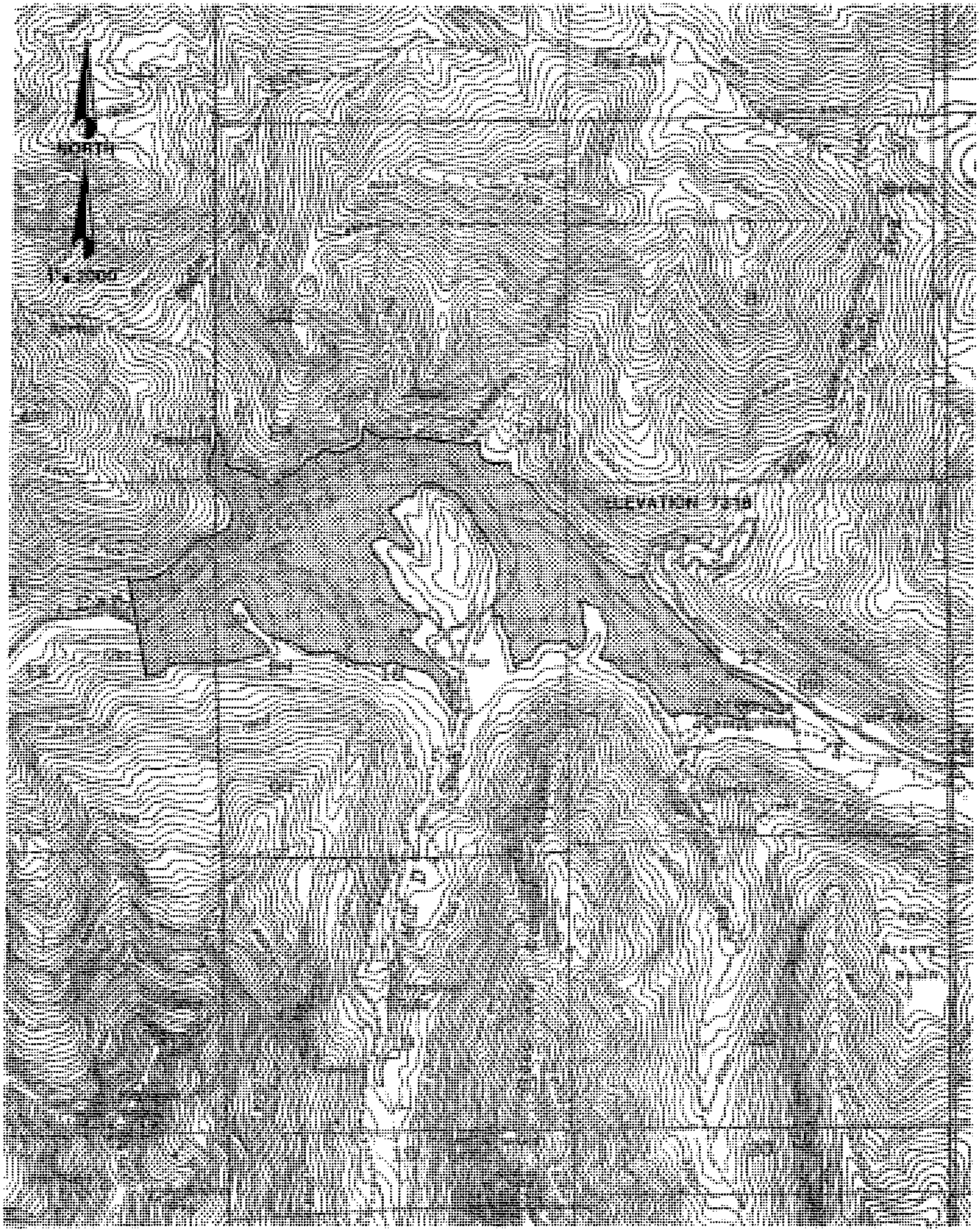
BIG COTTONWOOD CANYON:

DAMSITES: The proposed Argenta damsite located 7.5 miles upstream from the canyon mouth is shown in Figure VI-23. This is the only site in Big Cottonwood Canyon which has been previously studied. During the present study several reservoir sizes were considered for the Argenta site in addition to those previously proposed. Also, other potential reservoir sites were considered in Silver Fork Canyon and on Willow Creek at Willow Heights Lake. Expansion of Lakes Blanche, Florence and Lillian was also analyzed.

The previous studies considered three alternative reservoir sizes at the Argenta site. Each of these aternatives included multipurpose reservoirs used for municipal and industrial water supply, flood control and recreation.

The largest reservoir proposed has a capacity of 60,000 acre-feet with an earthfill dam 384 feet high and 1620 feet long. This alternative would include a five mile long tunnel and diversion structure from Little Cottonwood Canyon. Pertinent data for this particular alternative are given in Table VI-22.[73] The municipal and industrial water supply from this size reservoir would be 20,500 acre-feet per year. Total project costs have been estimated at $103.3 million which is equivalent to an amortized annual cost of $12.1 million. This cost includes the diversion structure and tunnel in Little Cottonwood Canyon. This is a cost of $590 per acre-foot of developed water.

The 30,000 acre-feet reservoir size has not been investigated as much as the larger reservoir. The following data are derived from various reports prepared by the U.S. Corps of Engineers. The dam would be located at approximately the same site as the larger dam as shown in Figure VI-23. This smaller reservoir would yield a municipal and industrial supply of 16,400 acre-feet. It would be an earthfill dam which would have a total cost of $80.2 million.[77] The equivalent annual cost is $9.4 million, thus yielding a $575 cost per acre-foot. This cost includes the necessary diversion structure and tunnel from Little Cottonwood Canyon.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

BIG COTTONWOOD CREEK, ARGENTA RESERVOIR SITE

TABLE VI-22[73]
PERTINENT DATA
ARGENTA RESERVOIR SITE
60,000 Acre-Feet

1. GENERAL DATA	
Name	Argenta Dam
Stream	Big Cottonwood Creek
Purpose	Flood control, water supply & recreation
Drainage Area at Damsite	
Big Cottonwood Creek	27.7 sq. mi.
Little Cottonwood Creek above Diversion	13.6 sq. mi.
Runoff Mean Annual	
Big Cottonwood Creek at Damsite	52,000 ac-ft
Little Cottonwood Creek at Diversion	26,000 ac-ft
2. RESERVOIR DATA	
Reservoir Pool Elevations	
Inactive pool	7,220 feet
Gross pool	7,405 feet
Spillway design flood pool	7,415 feet
Reservoir Areas	
At inactive pool	80 acres
At gross pool	490 acres
At spillway flood pool	520 acres
Length of Reservoir	2.0 miles (approx.)
3. MAIN DAM	
Type	Rockfill with an impervious earthfill core
Elevation - Top of Dam	7,420 feet
Freeboard above spillway flood pool	5 feet
Maximum height (at axis of dam)	380 feet
Side Slopes	1 on 2
Length of crest	1,620 feet
Width of crest	25 feet
Total volume of embankment, main dam	7,730,000 cu. yds.

TABLE VI-22 (con't)

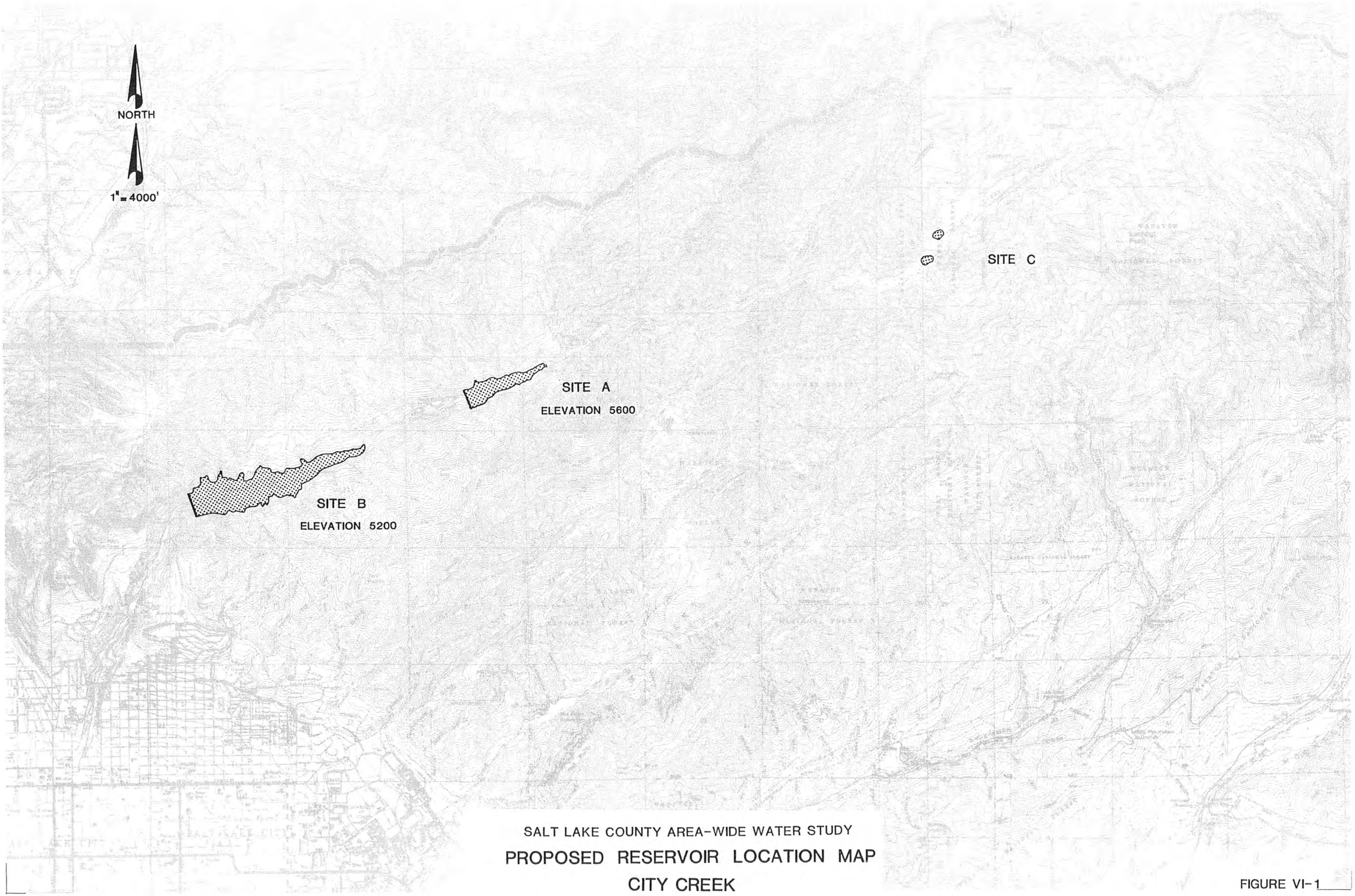
4. FLOOD CONTROL AND MUNICIPAL - INDUSTRIAL WATER SUPPLY OUTLETS	
Type and location	Single barrel 7' dia concrete, changing to a 36-inch steel pipe at an underground control chamber under crest of dam at left abutment, with a diversion structure for water supply, combined with an energy dissipator at the downstream toe of the dam.
5. LITTLE COTTONWOOD DIVERSION	
Type and Location	A concrete diversion structure across Little Cottonwood Creek with a 6'-6" concrete horseshoe tunnel, 5.0 miles long, between Little Cottonwood Creek and Big Cottonwood Creek.

The smallest reservoir previously considered impounds 10,000 acre-feet and would be located at the same site. The least amount of study data has been compiled on this alternative. In a brief summary, the Corps of Engineers has estimated the total project cost to be $72.5 million with an equivalent annual cost of $8.5 million. This is a cost of $1038 per acre-foot. This cost includes the Little Cottonwood diversion project.[77] Municipal and industrial supply from this 10,000 acre-foot reservoir would be 8,200 acre-feet.

For all three of these alternative sizes for a dam and reservoir at the Argenta site, the Corps of Engineers has concluded that they are not efficient or acceptable and warranted no further consideration.

Three additional reservoirs considered at the Argenta site were sized for the mean annual yield, the spring runoff volume and an arbitrary volume of 10,000 acre-feet during the present study. The design of the earthfill dams was considered to be the same as for the previous alternatives. Pertinent dam and reservoir data are shown in Table VI-23, with unit storage costs plotted in Figure VI-24.

An equalizing reservoir at this site would have a storage capacity of 28,566 acre-feet with an annual yield of 23,393 acre-feet. The unit storage cost for this scenario was interpolated from Figure VI-24. The total unit water yield cost of developed water, including storage, treatment and conveyance to the canyon mouth is $478 per acre-foot. The reservoir capacity for the peaking scenario is 24,689 acre-feet, with an annual yield of 13,416 acre-feet and a total unit water yield cost of $758 per acre-foot. Other pertinent costs for equalizing and peaking scenarios are shown in Table VI-24. These costs include an expanded treatment plant capacity of 60 mgd.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

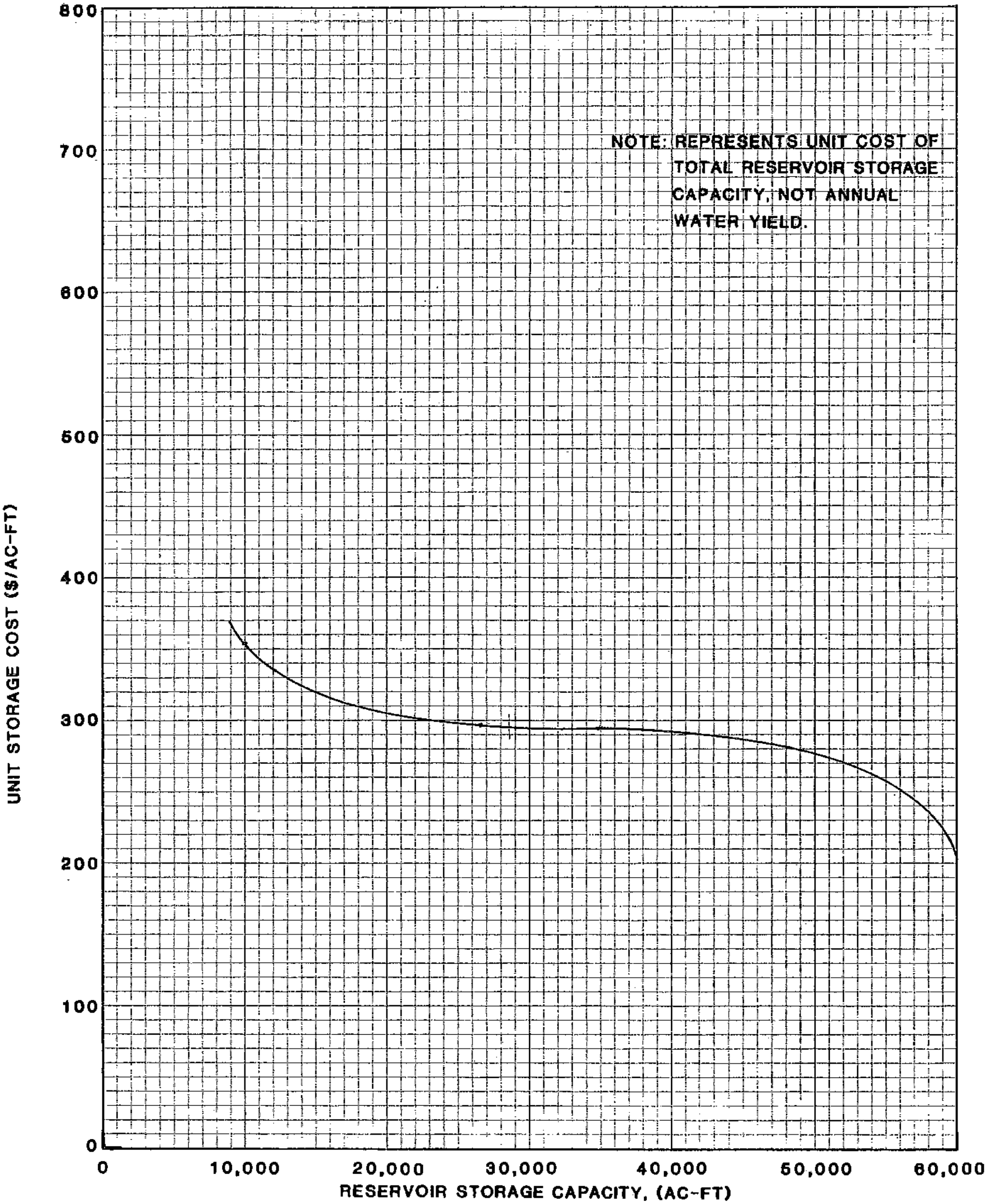
CITY CREEK

FIGURE VI-1

TABLE VI-23
PERTINENT PRELIMINARY DATA
ARGENTA DAMSITE IN BIG COTTONWOOD CANYON

		RESERVOIR CAPACITY OPTIONS		
		10,000 Ac-Ft	Spring Runoff Volume 26,600 Ac-Ft	Mean Annual Yield 35,000 Ac-Ft
GENERAL				
Drainage Area (square miles)		29.1	29.1	29.1
RESERVOIR				
Gross Pool Elevation (feet)		7209	7293	7359
Gross Pool Area (acres)		80.7	193	370
Gross Pool Storage (acre-feet)		10,000	26,600	35,000
Ratio of Storage vs. Area (acre-feet/acre)		123.9	137.8	94.6
Probable Land Purchase Requirement (acres)		107	250	484
MAIN DAM				
Top Elevation (feet)		7222	7306	7372
Spillway Elevation (feet)		7209	7293	7359
Maximum Height at Dam Axis (feet)		195	278	344
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		890	1230	1460
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		80	80	80
Outlet Works Hydraulic Head (feet)		182	265	331
SPILLWAY				
Discharge Capacity (cfs)		700	700	700
Surcharge Head (feet)		5	5	5
COSTS				
Dam Capital Cost	($)	11,146,000	24,668,000	40,147,000
Total Dam and Reservoir Capital Cost	($)	28,794,000	64,916,000	84,968,000
Annual Operation & Maintenance Cost(a)	($)	144,000	324,000	424,000
Total Annual Cost(b)	($)	3,526,000	7,949,000	10,405,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BIG COTTONWOOD CREEK , ARGENTA RESERVOIR SITE

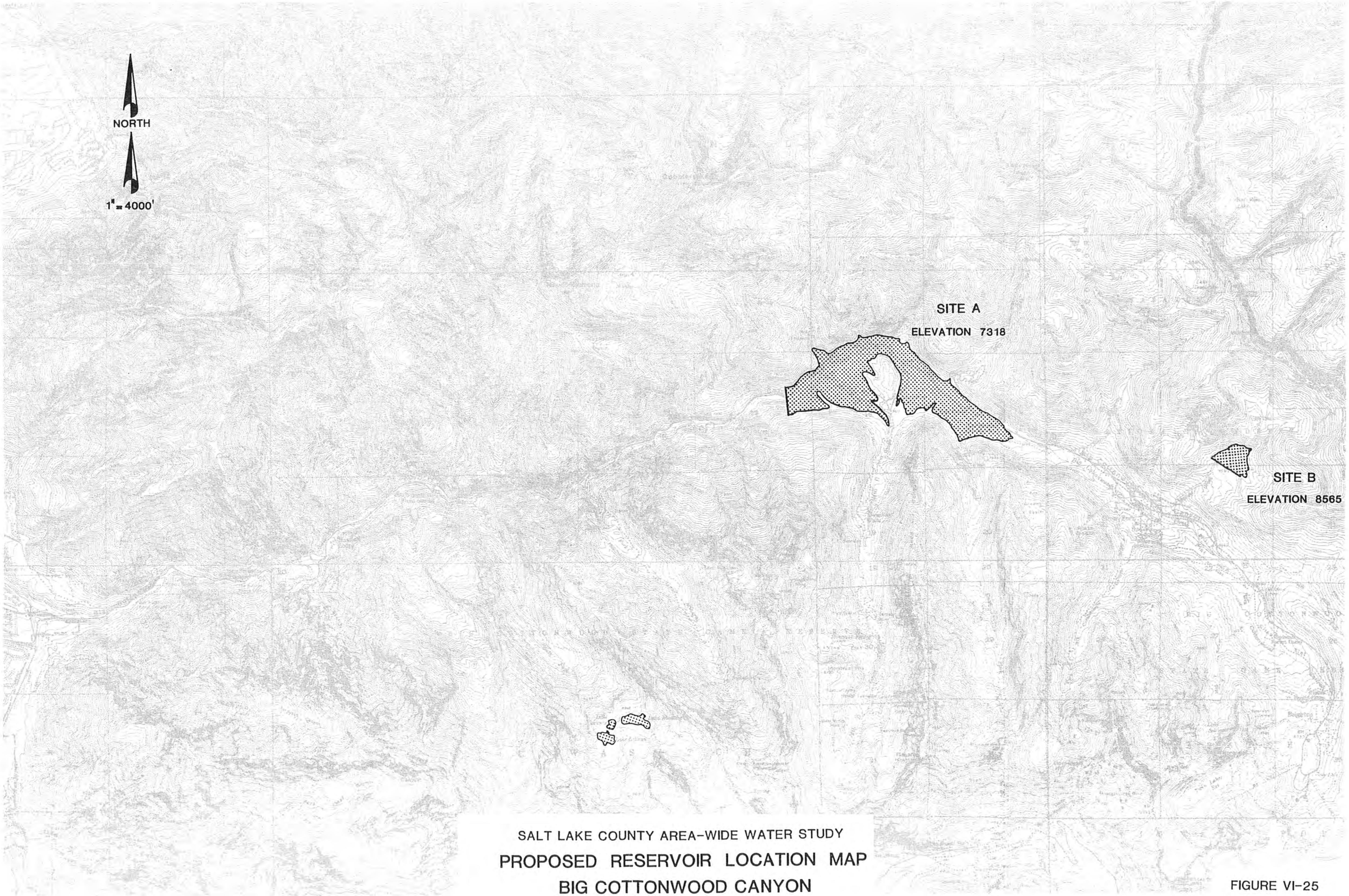
FIGURE VI-24

TABLE VI-24

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BIG COTTONWOOD CREEK
ARGENTA RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility[n]	Scenario 2. Peaking Facility[n]	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	28,566	24,689	N/A
Carry-over Capacity[b]	Ac-Ft	18,309	14,299	N/A
Existing Annual Water Yield[c]	Ac-Ft	22,160	22,160	N/A
Developable Annual Water Yield[d]	Ac-Ft	23,393[l]	13,416[m]	N/A
Total Annual Water Yield[e]	Ac-Ft	45,553	35,576	N/A
Unit Storage Cost[f]	$/Ac-Ft	300	320	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	366	589	N/A
Water Treatment Plant Capacity[h]	mgd	60	60	N/A
Annual Treatment and Conveyance Cost[i]	$1000	1800	1800	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	112	169	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	478	758	N/A

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-15, adjusted for fraction of 50% probability flow actually yielded.
(c) The average annual water treatment plant production for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-24.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) The Big Cottonwood Water Treatment Plant capacity is expanded from its present 42 mgd to 60 mgd.
(i) From Table VI-30, amortized over 20 years at 10% interest.
(j) Sum of: (1) annual treatment and conveyance cost divided by the developable annual water yield, and (2) the 1981 average treatment costs.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Because of the expanded Big Cottonwood Water Treatment Plant capacity as a constraint, 6212 acre-feet of available water could not be developed under this scenario.
(m) Because of the expanded Big Cottonwood Water Treatment Plant capacity as a constraint, 16,189 acre-feet of available water could not be developed under this scenario.
(n) The inflow to the reservoir is regulated such that the demand distribution for this scenario is satisfied at the canyon mouth.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP
BIG COTTONWOOD CANYON

FIGURE VI-25

Upon reviewing the remaining area of Big Cottonwood Canyon, three other potential sites suitable for developing water sources were identified. One potential damsite is at Willow Heights Lake on Willow Creek, located within a side canyon of Big Cottonwood Canyon, as shown in Figure VI-25. Pertinent preliminary data are shown in Table VI-25, with unit storage costs plotted in Figure VI-26. A reservoir here would store 1705 acre-feet and yield 1216 acre-feet if used as a peaking facility. Because of the small capacity of this reservoir in comparison to the total Big Cottonwood Creek yield, it was assumed that this reservoir would be used only as a peaking facility. The total unit water yield cost is estimated to be $1227 per acre-foot, as shown in Table VI-26.

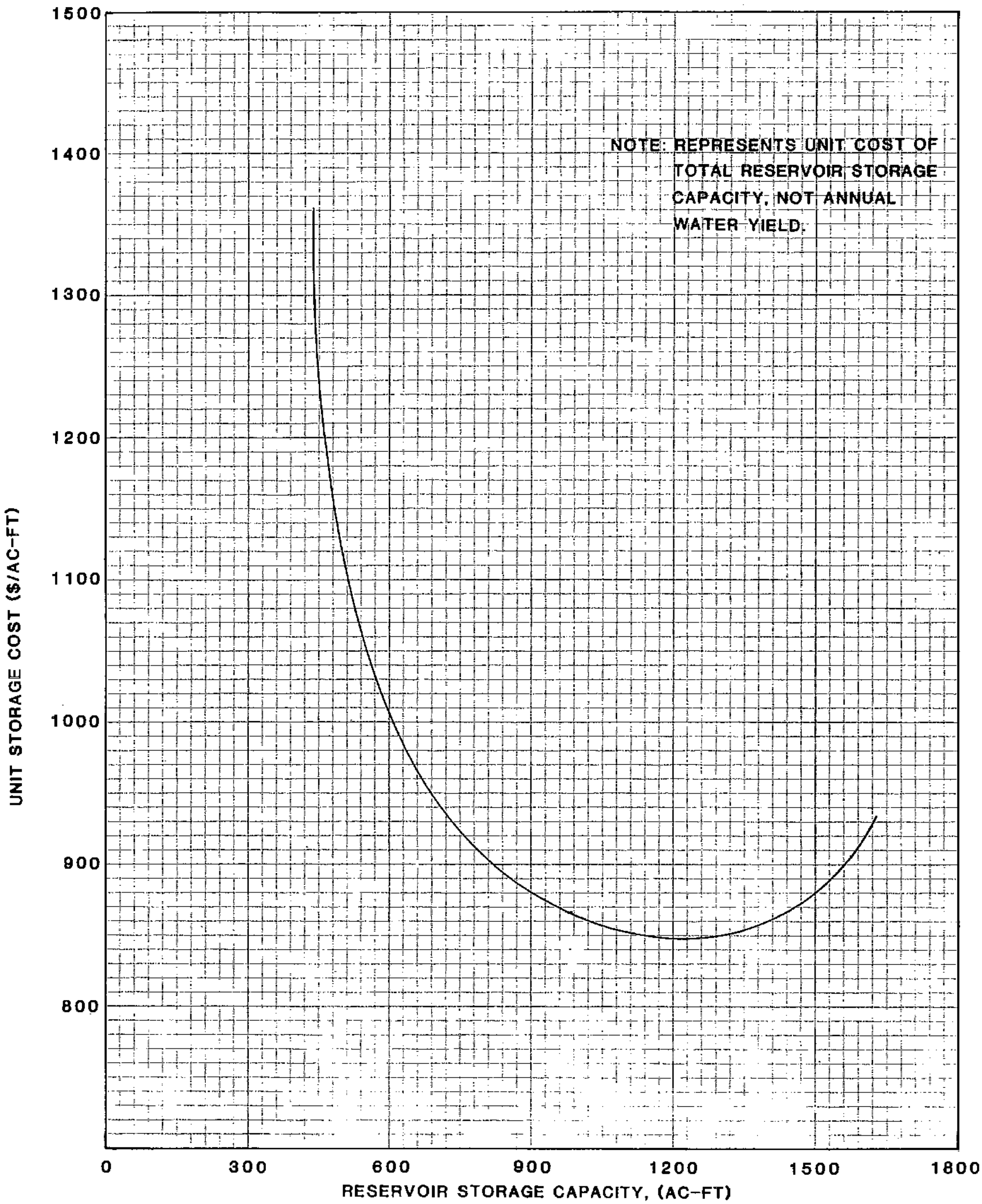
On the southern side of Big Cottonwood Canyon, in Silver Fork Canyon, is another small potential damsite, as shown in Figure VI-25. Pertinent data used in estimating dam and reservoir costs are shown in Table VI-27, and unit storage costs are plotted in Figure VI-27. As a peaking facility, the capacity of a reservoir at this site would be 2949 acre-feet, yielding 2505 acre-feet annually. Again, it has been assumed that the reservoir would be used only as a peaking facility, because of its relatively small size. The total unit water yield cost for stored and treated water at this site is $1083 per acre-foot, as shown in Table VI-28.

A third alternative water source development proposal is the construction of low concrete dams, with an average height of five feet, at Lakes Blanche, Florence and Lillian. These lakes are shown in Figure VI-25. These new dams would replace the three old stone and mortar dams originally built at these sites which have since been breached. Both the combined capacity and annual yield are estimated at 350 acre-feet, since the maximum reservoir capacity is less than the 50 percent or 90 percent probability drainage area yields. The total unit water yield cost of the developed water from this alternative is $965 per acre-foot. Storage, treatment and conveyance costs are tabulated in Table VI-29.

TABLE VI-25
PERTINENT PRELIMINARY DATA
WILLOW HEIGHTS RESERVOIR SITE, BIG COTTONWOOD CANYON

		RESERVOIR CAPACITY OPTIONS		
		440 Ac-Ft	Spring Runoff Volume 985 Ac-Ft	Mean Annual Yield 1576 Ac-Ft
GENERAL				
Drainage Area (square miles)		1.3	1.3	1.3
RESERVOIR				
Gross Pool Elevation (feet)		8520	8540	8562
Gross Pool Area (acres)		20.2	26.1	32.6
Gross Pool Storage (acre-feet)		440	985	1576
Ratio of Storage vs. Area (acre-feet/acre)		21.8	37.7	48.3
Probable Land Purchase Requirement (acres)		27.8	36.8	47.1
MAIN DAM				
Top Elevation (feet)		8527	8548	8570
Spillway Elevation (feet)		8520	8540	8562
Maximum Height at Dam Axis (feet)		47	68	90
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:2	2.5:1
Crest Length (feet)		1380	1530	1710
Crest Width (feet)		25	25	25
Outlet Works Capacity (cfs)		20	20	20
Outlet Works Hydraulic Head (feet)		40	60	72
SPILLWAY				
Discharge Capacity (cfs)		170	170	170
Surcharge Head (feet)		3	3	3
COSTS				
Dam Capital Cost	($)	2,342,000	3,312,000	7,522,000
Total Dam and Reservoir Capital Cost	($)	4,652,000	6,982,000	11,627,000
Annual Operation & Maintenance Cost(a)	($)	23,300	34,900	58,000
Total Annual Cost(b)	($)	569,000	854,900	1,424,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BIG COTTONWOOD CANYON , WILLOW HEIGHTS RESERVOIR SITE

FIGURE VI-26

TABLE VI-26

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BIG COTTONWOOD CANYON
WILLOW HEIGHTS RESERVOIR SITE

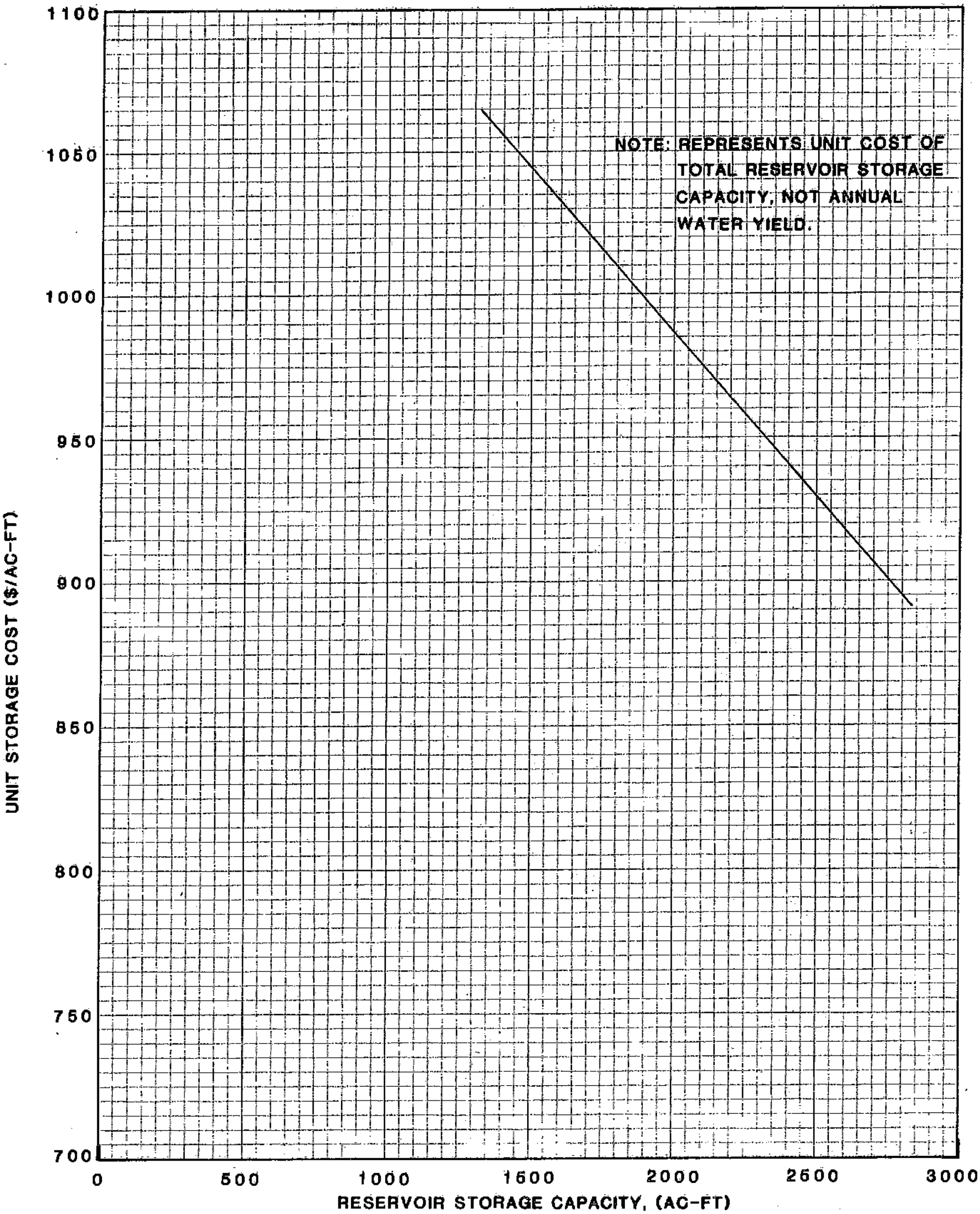
Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[(a)]	Ac-Ft	N/A	1705	N/A
Carry-over Capacity[(b)]	Ac-Ft	N/A	489	N/A
Existing Annual Water Yield	Ac-Ft	N/A	0[(c)]	N/A
Developable Annual Water Yield[(d)]	Ac-Ft	N/A	1216	N/A
Total Annual Water Yield[(e)]	Ac-Ft	N/A	1216	N/A
Unit Storage Cost[(f)]	$/Ac-Ft	N/A	850	N/A
Unit Water Yield Cost for Reservoir[(g)]	$/Ac-Ft	N/A	1192	N/A
Water Treatment Plant Capacity[(h)]	mgd	N/A	42	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[(j)]	$/Ac-Ft	N/A	35	N/A
Total Unit Water Yield Cost[(k)]	$/Ac-Ft	N/A	1227	N/A

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-15, adjusted for available drainage area.
(c) Assume municipal water is presently developed from Willow Creek Canyon for summer peaking use.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-26.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing Big Cottonwood Water Treatment Plant capacity.
(j) Average 1981 treatment cost at Big Cottonwood Water Treatment Plant.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.

TABLE VI-27
PERTINENT PRELIMINARY DATA
SILVER FORK RESERVOIR SITE, BIG COTTONWOOD CANYON

		RESERVOIR CAPACITY OPTIONS	
		Spring Runoff Volume 1566 Ac-Ft	Mean Annual Yield 2505 Ac-Ft
GENERAL			
Drainage Area (square miles)		2.0	2.0
RESERVOIR			
Gross Pool Elevation (feet)		8235	8264
Gross Pool Area (acres)		27.3	35.2
Gross Pool Storage (acre-feet)		1566	2505
Ratio of Storage vs. Area (acre-feet/acre)		57.4	71.2
Probable Land Purchase Requirement (acres)		38.9	50.6
MAIN DAM			
Top Elevation (feet)		8243	8273
Spillway Elevation (feet)		8235	8264
Maximum Height at Dam Axis (feet)		131	161
Upstream Side Slope		3:1	3:1
Downstream Side Slope		2.5:1	2.5:1
Crest Length (feet)		860	1040
Crest Width (feet)		30	30
Outlet Works Capacity (cfs)		25	25
Outlet Works Hydraulic Head (feet)		123	152
SPILLWAY			
Discharge Capacity (cfs)		230	230
Surcharge Head (feet)		3	3
COSTS			
Dam Capital Cost	($)	7,161,000	10,736,000
Total Dam and Reservoir Capital Cost	($)	13,252,000	18,978,000
Annual Operation and Maintenance Cost(a)	($)	66,300	94,900
Total Annual Cost(b)	($)	1,623,000	1,324,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BIG COTTONWOOD CANYON SILVER FORK CREEK RESERVOIR SITE

FIGURE VI-27

TABLE VI-28

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BIG COTTONWOOD CANYON
SILVER FORK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	N/A	2949	N/A
Carry-over Capacity[b]	Ac-Ft	N/A	1017	N/A
Existing Annual Water Yield	Ac-Ft	N/A	0[c]	N/A
Developable Annual Water Yield[d]	Ac-Ft	N/A	2505	N/A
Total Annual Water Yield[e]	Ac-Ft	N/A	2505	N/A
Unit Storage Cost[f]	$/Ac-Ft	N/A	890	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	N/A	1048	N/A
Water Treatment Plant Capacity[h]	mgd	N/A	42	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	N/A	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	N/A	1083	N/A

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-15, adjusted for available drainage area.
(c) Assume no municipal water is presently developed from Silver Fork Canyon for summer peaking use.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-27.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing Big Cottonwood Water Treatment Plant capacity.
(j) Average 1981 treatment cost at Big Cottonwood Water Treatment Plant.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.

TABLE VI-29

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM BIG COTTONWOOD CANYON, LAKES BLANCHE, LILLIAN & FLORENCE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	N/A	350	N/A
Carry-over Capacity[b]	Ac-Ft	N/A	0	N/A
Existing Annual Water Yield	Ac-Ft	N/A	0[c]	N/A
Developable Annual Water Yield[d]	Ac-Ft	N/A	350	N/A
Total Annual Water Yield[e]	Ac-Ft	N/A	350	N/A
Unit Storage Cost[f]	$/Ac-Ft	N/A	930	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	N/A	930	N/A
Water Treatment Plant Capacity[h]	mgd	N/A	42	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	N/A	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	N/A	965	N/A

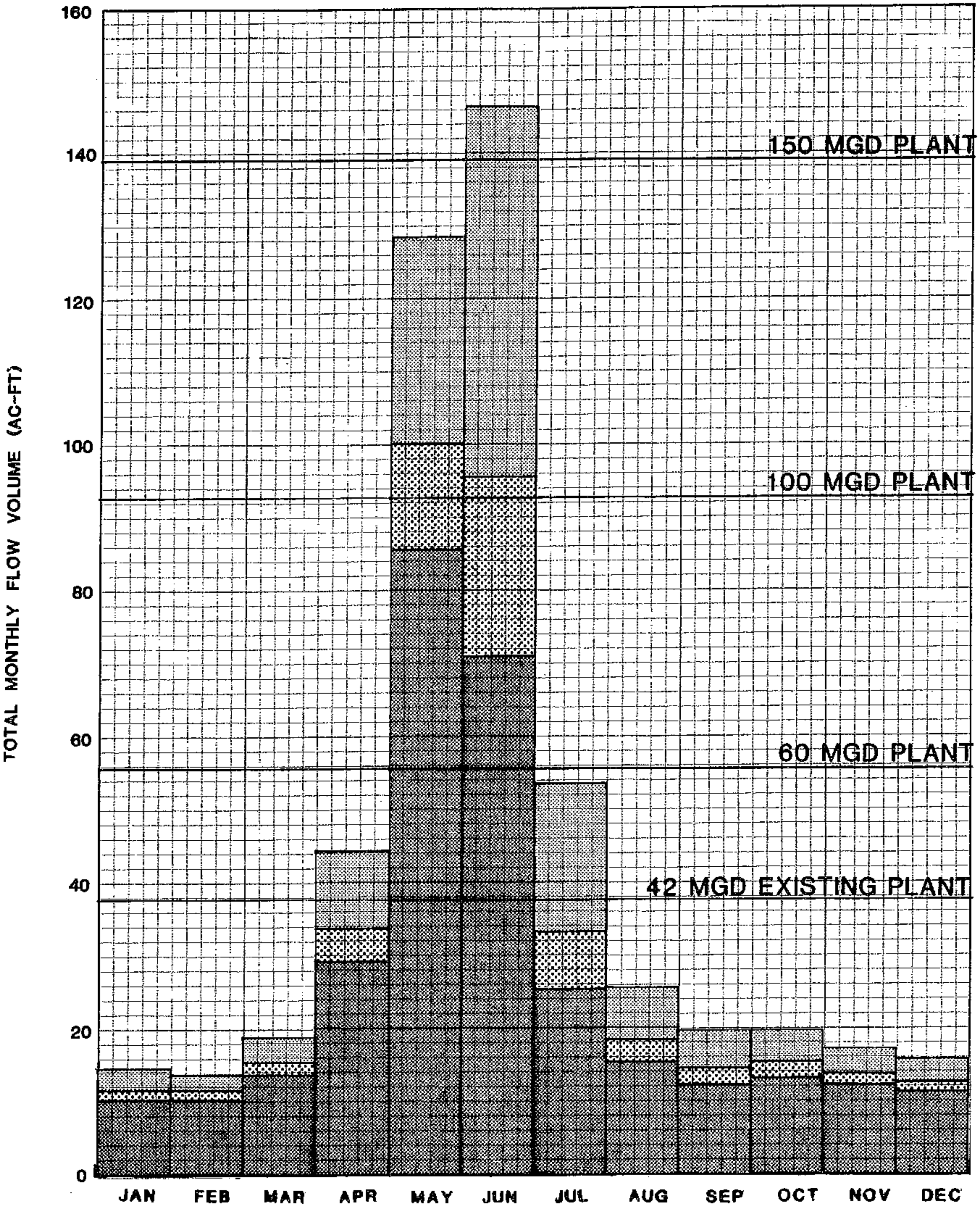
(a) Includes storage capacity only, without carry-over storage.
(b) No carry-over storage needed since 90% probability stream yield is greater than maximum reservoir capacity.
(c) Assume no municipal water is presently developed from Lakes Blanche, Lillian and Florence for summer peaking use.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From calculations submitted to sponsoring agencies.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Existing Big Cottonwood Water Treatment Plant capacity.
(j) Average 1981 treatment cost at Big Cottonwood Water Treatment Plant.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.

WATER TREATMENT PLANTS: Figure VI-28 shows the annual hydrograph for Big Cottonwood Creek with various plant sizes indicated. The expansion of the existing plant is limited to a total capacity of 60 mgd by the available land area. Enlargement of the plant will require the construction of new pretreatment mixing and filtration treatment processes and extensive modification of the flocculation and sedimentation and existing filtration unit processes. New chemical handling and wash water recovery facilities will also be required to handle the increased treatment capacity. Table VI-30 shows the estimated cost for plant expansion.

TABLE VI-30

BIG COTTONWOOD WTP EXPANSION TO 60 MGD

Description		Cost Estimate
(New Construction)		
Flow Diversion, Grit Removal, Bar Screens, Flow Measurement Structure, and Mixing Chamber		$ 760,000
Chemical Storage and Feed System		$ 165,000
New Filters		$ 2,200,000
Wash Water Recovery		$ 750,000
Yard Piping and Other		$ 250,000
(Modifications)		
Flocculation Basins		$ 275,000
Sedimentation Basins		$ 1,600,000
Existing Filters		$ 700,000
Administration Building		$ 360,000
	Subtotal	$ 7,060,000
(Other)		
Electrical (20%)		$ 1,412,000
Instrumentation (10%)		$ 706,000
	Subtotal	$ 9,178,000
Contingency (25%)		$ 2,544,000
	Construction Subtotal	$11,722,000
Legal, Fiscal, and Engineering (35%)		$ 3,603,000
	Total Project	$15,325,000



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BIG COTTONWOOD CREEK

FIGURE VI-28

FERGUSON CANYON:

DAMSITES: No known previous studies have identified or investigated any damsites in Ferguson Canyon. During this study a cursory examination of the canyon topography was made to investigate the potential for dam constructon. However, because of the general steepness of side slopes and the channel in the canyon, no reasonable damsite worthy of further study was found.

WATER TREATMENT PLANT: The stream from Ferguson Canyon flows only about two months during the year, therefore, a treatment plant was not considered for this stream. A pipeline to the Big Cottonwood Water Treatment Plant was considered as a possible means of developing this water for culinary purposes. Table VI-31 shows the estimated costs for the pipeline at various sizes and the percentage of the instantaneous peak flow which the pipeline will handle.

TABLE VI-31

COST ESTIMATES FOR FERGUSON CANYON PIPELINE

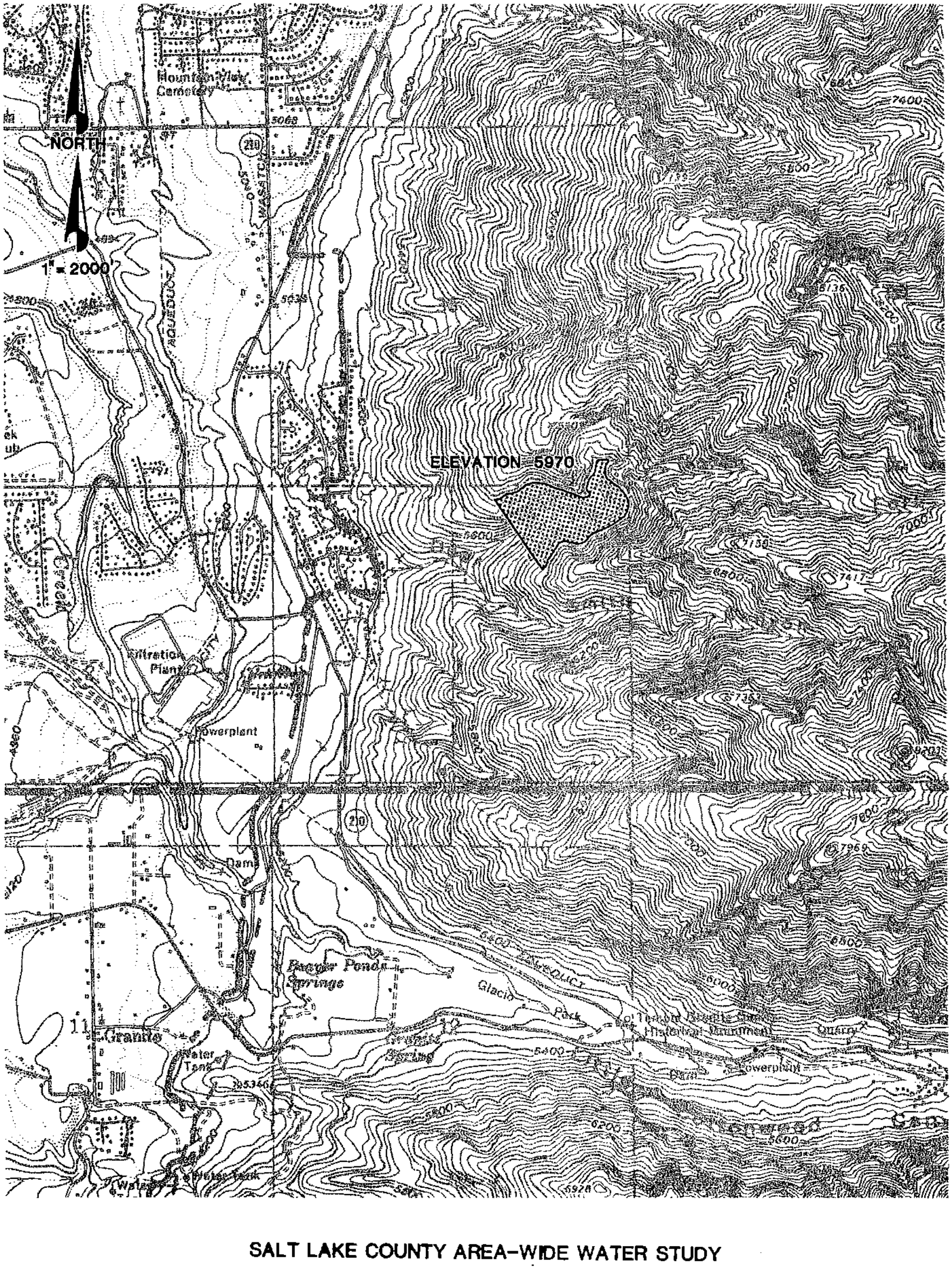
Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
15	13.2	100 +	11,700
12	7.4	65	8,700
10	4.5	39	6,600

DEAF SMITH CANYON:

DAMSITES: No known previous studies have been made concerning damsites in Deaf Smith Canyon. A search for possible damsites during this study indicated that because of the channel steepness there are no suitable damsites in the upper portion of the drainage basin. A possible damsite near the canyon mouth was selected for further investigation, even though the canyon side slopes and channel slope are still quite steep. The site is approximately one half mile above the canyon mouth, as shown in Figure VI-29. Reservoir capacities and other pertinent data are tabulated in Table VI-32. As can be seen, the dams are quite high, compared to the storage capacities. However, no road or utility relocations would be required. Figure VI-30 shows the unit storage costs plotted to provide a wide range of costs versus dam sizes.

Based on the two scenarios of probable reservoir use, calculations were made to determine probable reservoir sizes. For scenario one where the reservoir is used as an equalizing facility the capacity was determined to be 2786 acre-feet with an annual yield of 4417 acre-feet. Scenario two calls for a peaking facility with a reservoir capacity of 5953 acre-feet and an annual yield of 4417 acre-feet. Capacities, yields, and unit water yield cost estimates for developed water are summarized in Table VI-33.

WATER TREATMENT PLANT: Figure VI-31 shows the hydrograph for Little Willow Creek with the capacities of various plant sizes indicated. The costs shown herein are based on a plant located immediately south of the mouth of the canyon. The plant would be fed by diverting the flow from the stream into a pipe which would transport the water to the plant. The estimated annual costs (including the amortized capital costs) for various plant sizes at this location are shown in Figure VI-32.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

LITTLE WILLOW CREEK

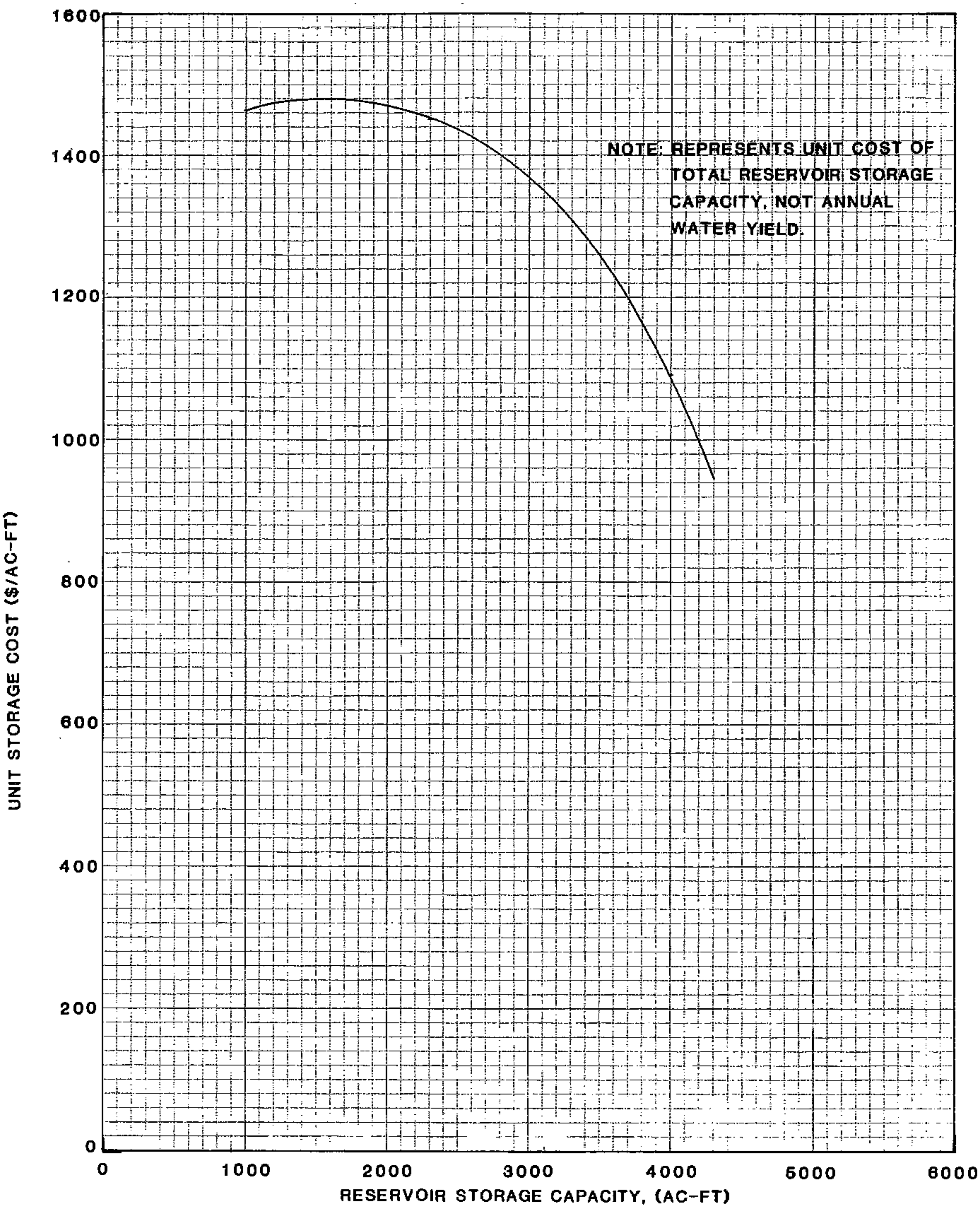
(DEAF SMITH CANYON)

FIGURE VI-29

TABLE VI-32
PERTINENT PRELIMINARY DATA
LITTLE WILLOW CREEK (DEAF SMITH CANYON)

		RESERVOIR CAPACITY OPTIONS		
		1000 Ac-Ft	Spring Runoff Volume 2370 Ac-Ft	Mean Annual Yield 4400 Ac-Ft
GENERAL				
Drainage Area (square miles)		2.6	2.6	2.6
RESERVOIR				
Gross Pool Elevation (feet)		5749	5848	5894
Gross Pool Area (acres)		11	15	28
Gross Pool Storage (acre-feet)		1000	1660	4400
Ratio of Storage vs. Area (acre-feet per acre)		90.0	110.7	157.1
Probable Land Purchase Requirement (acres)		16	32	45
MAIN DAM				
Top Elevation (feet)		5761	5863	5910
Spillway Elevation (feet)		5749	5848	5894
Maximum Height at Dam Axis (feet)		201	303	350
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		580	880	1080
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		20	20	20
Outlet Works Hydraulic Head (feet)		189	288	334
SPILLWAY				
Discharge Capacity (cfs)		227	227	227
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	8,478,000	$20,498,000	$28,680,000
Total Dam & Reservoir Capital Cost	($)	11,944,000	$28,035,000	$39,227,000
Annual Operation & Maintenance Cost[a]	($)	60,000	$ 140,000	$ 196,000
Total Annaul Cost[b]	($)	1,463,000	$ 3,433,000	$ 4,804,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir CapitalCost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

LITTLE WILLOW CREEK (DEAF SMITH CANYON) RESERVOIR SITE

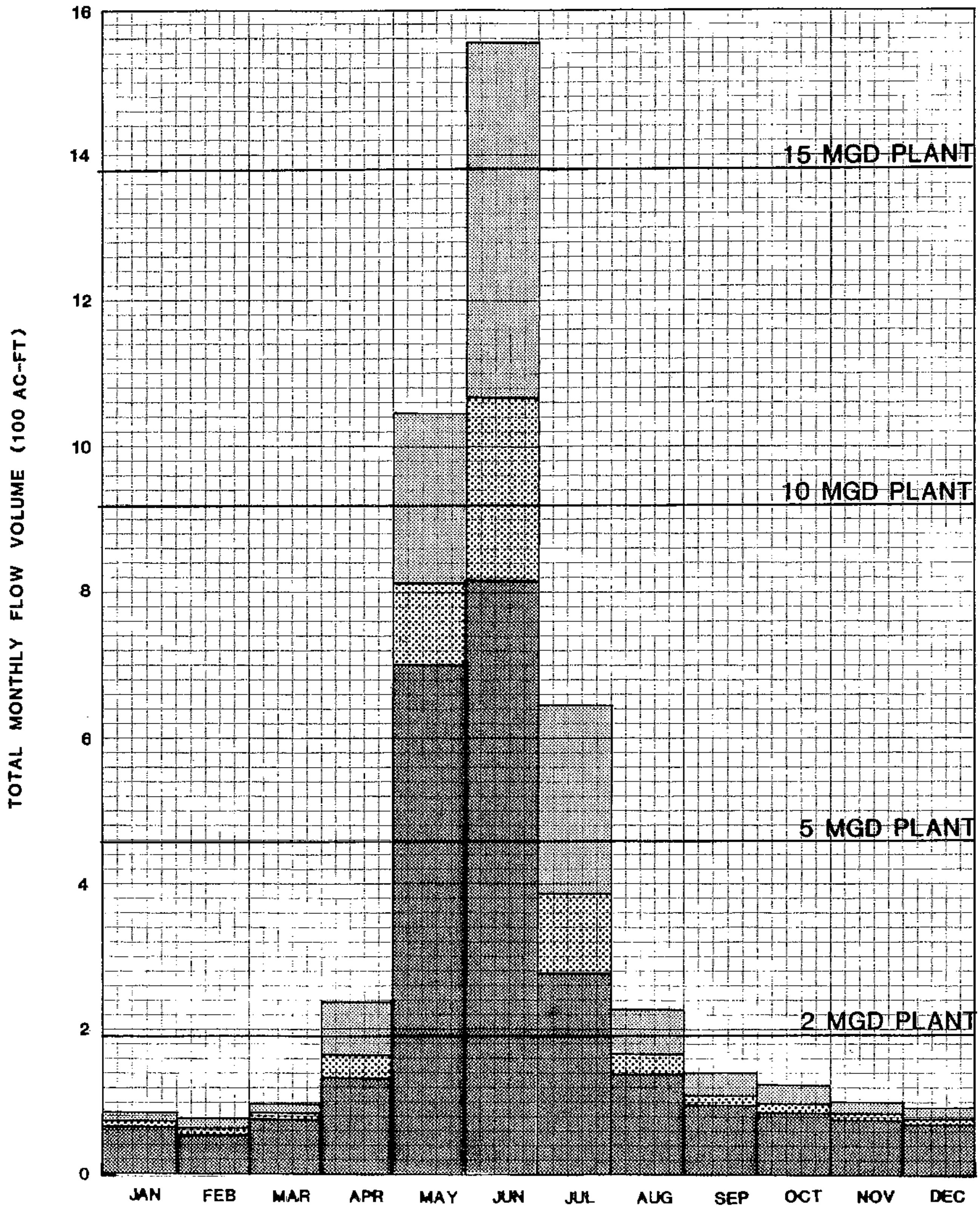
FIGURE VI-30

TABLE VI-33

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
LITTLE WILLOW CREEK (DEAF SMITH CANYON) RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	2786	5953	0
Carry-over Capaity[b]	Ac-Ft	1486	1486	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	4417	4417	4417
Total Annual Water Yield[e]	Ac-Ft	4417	4417	4417
Unit Storage Cost[f]	$/Ac-Ft	1380	900	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	870	1213	0
Water Treatment Plant Capacity[h]	mgd	6.9	13.5	20.3[l]
Annual Treatment & Conveyance Cost[i]	$1000	830	1280	1680
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	188	290	380
Total Unit Water Yield Cost[k]	$/Ac-Ft	1058	1503	380

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-18.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-30.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-32.
(j) Annual treatment and conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.



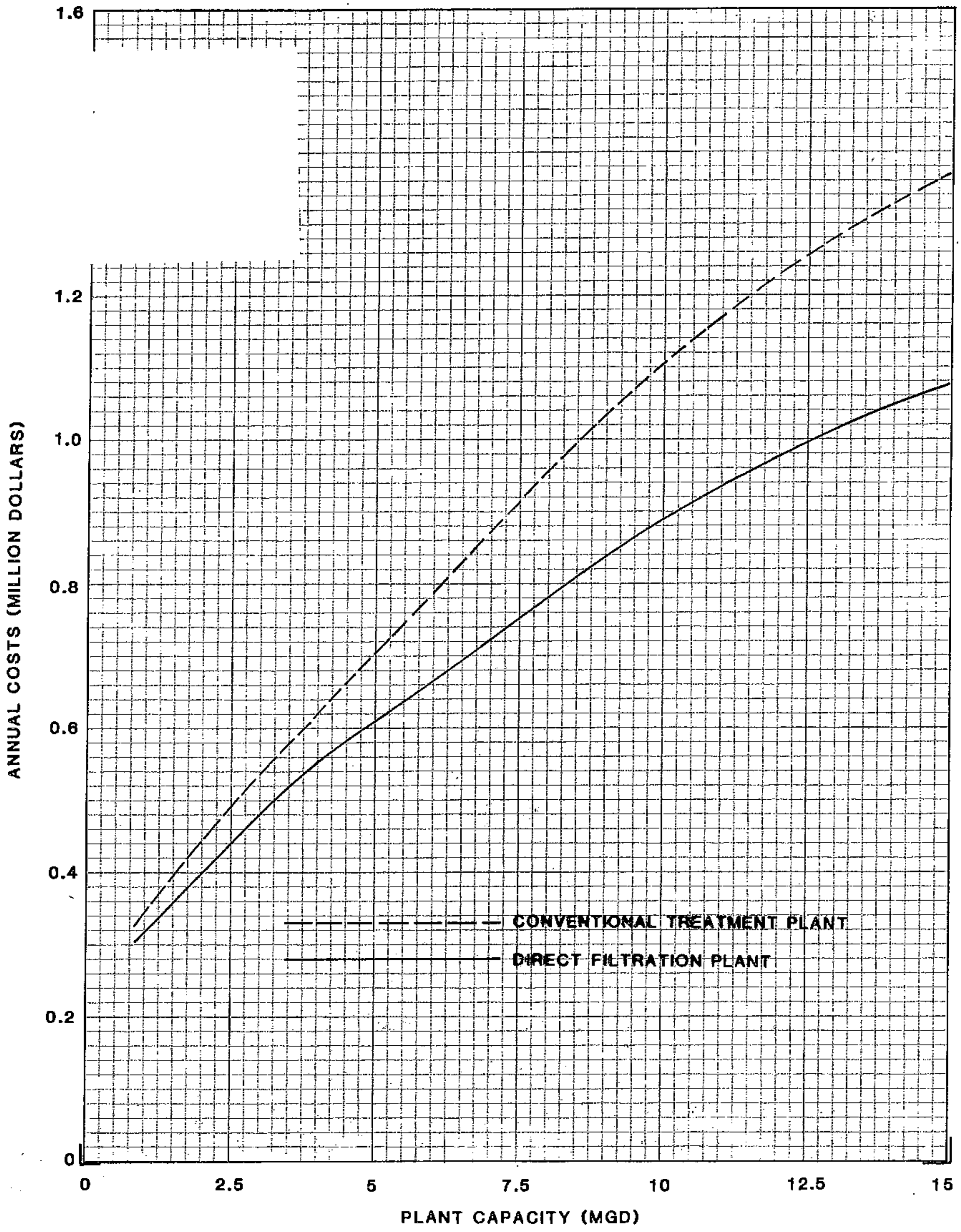
SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

LITTLE WILLOW CREEK

(DEAF SMITH CANYON)

FIGURE VI-31



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS

LITTLE WILLOW CREEK

FIGURE VI-32

Various pipeline sizes were also considered for transporting the water to the existing Metropolitan Water Treatment Plant. Table VI-34 shows the estimated equivalent annual costs for the pipeline and the percentage of the 50 percent probability instantaneous peak flow which the pipeline will handle. The cost of treating the water is not included in the annual costs shown.

TABLE VI-34

COST ESTIMATES FOR DEAF SMITH CANYON PIPELINE

Pipe Sizes (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
21	35.5	100+	43,400
18	24	67	38,800
15	14.5	41	34,200
12	8	23	28,500

LITTLE COTTONWOOD CANYON:

DAMSITES: There have been five damsites considered previously in Little Cottonwood Canyon and these are shown in Figure VI-33. These have been investigated to varying degrees and thus varying amounts of data are available for each of these sites. Another potential damsite, just above White Pine Fork, was located during this study.

The proposed dam at site A would be 410 feet high, 2250 feet long, and would retain 50,000 acre-feet of water.[7] Dam construction would be of earth and rockfill. A large reservoir at this location would provide regulation of the seasonal variation in runoff, carryover storage for unusually dry years, and flood protection for downstream areas.[7] It would be necessary to utilize import water to fill this reservoir. One potential source for the imported water could be the Provo River which would be delivered to the reservoir through the Salt Lake Aqueduct.

A dam at Site B would have a 295 foot high dam which would retain 20,000 acre-feet of water. The dam crest elevation would be at 5525 feet. In 1963 some geological studies were performed at this site and it was determined that a thin layer of impermeable overburden lies above a thick permeable water-bearing stratum which in turn overlies highly impermeable bedrock.[9] In many places the bedrock was relatively shallow. These characteristics, along with the fact that the dam would be located away from the fault zone, make for a favorable geologic assessment. The primary disadvantage of this site is the large fill volume necessary to build the dam when compared to other nearby damsites with similar capacity, specifically site D. Total cost estimates for this dam range from $42.45 million[10] to $57.24 million.[75]

Site C was considered in a report prepared in 1960.[9] The dam would be 500 feet longer and 10 feet lower than the dam in site B, and its capacity would be only 8900 acre-feet. Because of this reason, damsite C has been considered infeasible.

SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

LITTLE COTTONWOOD CANYON

FIGURE VI-33

Site D is located to the southwest of the mouth of Little Cottonwood Canyon in Dimple Dell Canyon.[10] The dam would have a maximum height of 204 feet and an approximate length of 1250 feet. The reservoir capacity would be 20,000 acre-feet and would have to be filled with water diverted from Little Cottonwood Creek and other sources. One of these other sources may be the spillage at Deer Creek Reservoir transported via the excess capacity in the Salt Lake Aqueduct which lies just downstream from the dam. The dam crest elevation would be at 4990 feet.

Geologic studies of site D have proven that this was once Little Cottonwood Creek's drainage way. However, during the Bonneville period glacial action in the canyon formed a moraine which has isolated Dimple Dell Canyon. The damsite is located about one mile from the Wasatch Fault zone with the eastern shore no closer than 1500 feet to the east of the fault. The depth of bedrock is estimated to be 2000 feet. Reports have shown that with remolding and compaction, soils within the reservoir area could be used for dam construction, thus keeping construction costs lower and increasing reservoir capacity.[10]

The Little Cottonwood Creek diversion canal would be 9000 feet long, falling 330 feet with no pumping necessary. Because of the lateral moraines it would have to traverse, the canal would have to be lined.

Three additional reservoir sizes for the Dimple Dell site (site D) were considered during this present study. Pertinent preliminary dam and reservoir data are shown in Table VI-35. A pipeline from Little Cottonwood Creek and a pumping facility would be required.

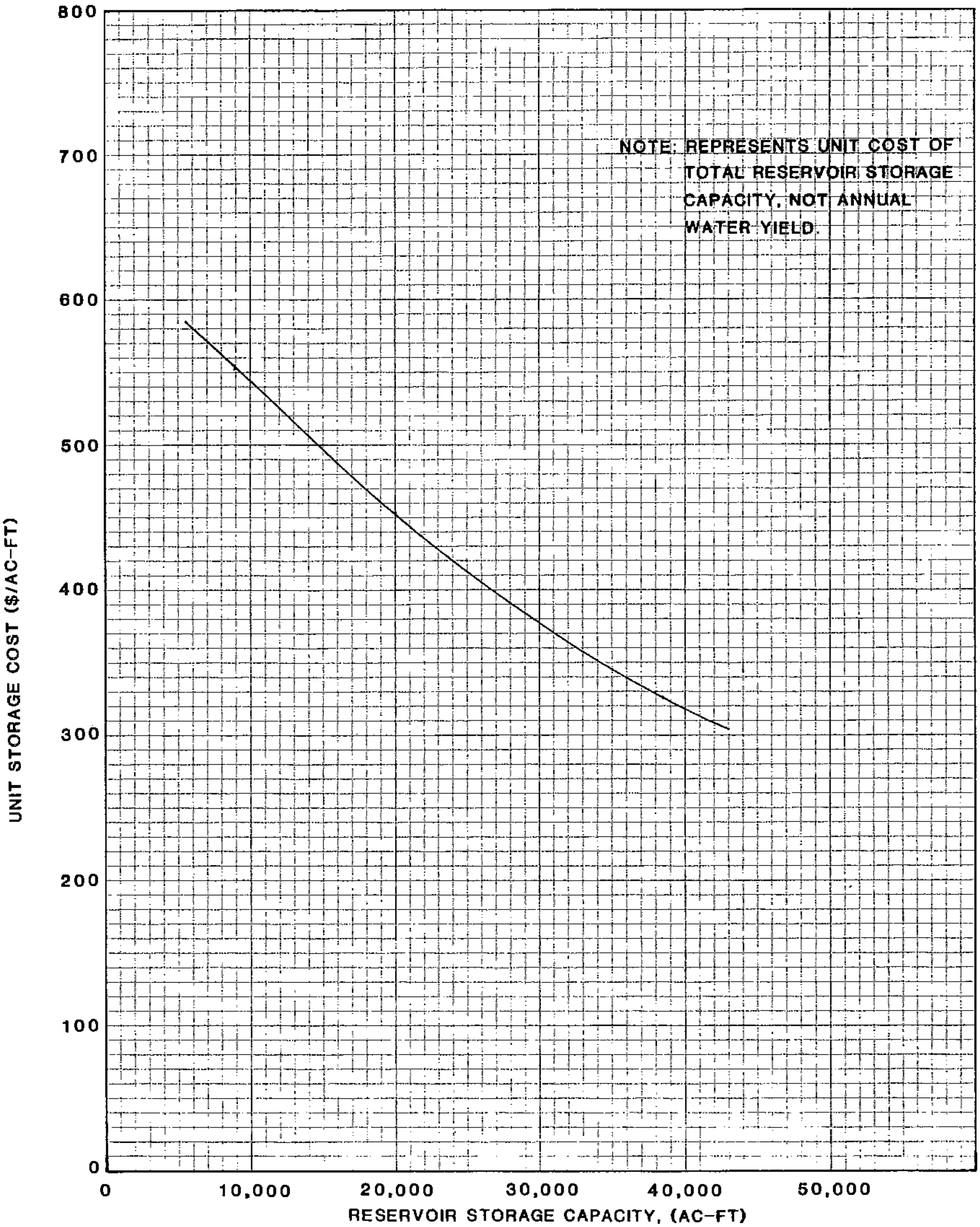
If an equalizing facility was built at the site, the total storage would be 35,153 acre-feet with an annual yield of 22,655 acre-feet. This yield represents additional water in excess of water currently treated by the Metropolitan Water Treatment Plant from Little Cottonwood Creek. The total unit water yield cost to store, convey, and treat this water is estimated to be $570 per acre-foot. The unit storage cost for this scenario was interpolated from Figure VI-34.

The total capacity would increase to 38,400 acre-feet, with an annual yield of 19,007 acre-feet, if this damsite were to be used as a peaking facility. Again, this yield is additional Little Cottonwood Creek water to that which is already being treated by the existing plant.

TABLE VI-35
PERTINENT PRELIMINARY DATA
LITTLE COTTONWOOD CREEK RESERVOIR SITE D

		RESERVOIR CAPACITY OPTIONS		
		9000 Ac-Ft	Spring Runoff Volume 20,000 Ac-Ft	Mean Annual Yield 38,400 Ac-Ft
GENERAL				
Drainage Area (square miles)		27.4	27.4	27.4
RESEVOIR				
Gross Pool Elevation (feet)		4942	4990	5040
Gross Pool Area (acres)		170	256	353
Gross Pool Storage (acre-feet)		9000	20,000	38,400
Ratio of Storage vs. Area (acre-feet/acres)		52.9	78.1	108.8
Probable Land Purchase Requirement (acres)		223	335	463
MAIN DAM				
Top Elevation (feet)		4952	5000	5050
Spillway Elevation (feet)		4942	4990	5040
Maximum Height at Dam Axis (feet)		156	204	254
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		1640	1800	2150
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		30	30	30
Outlet Works Hydraulic Head (feet)		146	194	244
SPILLWAY				
Discharge Capacity (cfs)		200	200	200
Surcharge Head (feet)		3	3	3
COSTS				
Dam Capital Cost	($)	13,437,000	15,384,000	23,797,000
Total Dam and Reservoir Capital Cost	($)	40,570,000	73,789,000	102,550,000
Annual Operation & Maintenance Cost[a]	($)	202,900	368,900	512,800
Total Annual Cost[b]	($)	4,968,000	9,032,000	12,557,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

LITTLE COTTONWOOD CREEK, RESERVOIR SITE D

FIGURE VI-3

The total unit water yield cost for this scenario is estimated at $682 per acre-foot. Other cost data for these two scenarios are listed in Table VI-36.

Site E, shown in Figure VI-33, has been excluded from further study because of tremendously high construction costs and its location on the Wasatch Fault.(9)

Another potential damsite (site F) was located up Little Cottonwood Canyon on the main channel just above White Pine Fork, as shown in Figure VI-33. Pertinent data for the dam and reservoir are shown on Table VI-37. If used as an equalizing reservoir the total storage capacity is estimated to be 33,803 acre-feet, yielding an additional 22,655 acre-feet above what is currently being treated. The total unit water yield cost is estimated at $587 per acre-foot. If used as a peaking facility the total storage capacity would increase to 47,861 acre-feet, with an annual yield of 22,188 acre-feet. This yield is additional water to what is already being treated. The total unit water yield cost for this scenario is estimated at $704 per acre-foot. Other cost data are presented in Table VI-38. The unit storage cost for both scenarios was interpolated from Figure VI-35.

WATER TREATMENT PLANTS: Figure VI-36 shows the stream hydrograph with various plant capacities indicated. The hydraulic capacity of the Metropolitan Water Treatment Plant is 150 mgd. The plant filters are rated for 3.0 gallons per minute per square foot which limits the capacity of the plant to 100 mgd. The plant capacity could be expanded by modifying the filters to high-rate capacity filters. Tests are currently being conducted to determine what additional modifications may be necessary to increase the plant capacity. Shown below is a tentative list of required modifications to expand the Little Cottonwood Creek inlet capacity and to increase filter rates.

1. A new screen house operating parallel to the existing unit and doubling the screen capacity.

2. New manifolded screen house feed piping from the Murray City Power Plant tailrace.

3. New feed piping from the Little Cottonwood Intake Conduit.

TABLE VI-36

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
LITTLE COTTONWOOD CREEK
RESERVOIR SITE D

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	35,153	38,400	N/A
Carry-over Capacity	Ac-Ft	18,767[b]	10,524[l]	N/A
Existing Annual Water Yield[c]	Ac-Ft	18,493	18,493	N/A
Developable Annual Water Yield[d]	Ac-Ft	22,655	19,007	N/A
Total Annual Water Yield[e]	Ac-Ft	41,148	37,500[m]	N/A
Unit Storage Cost[f]	$/Ac-Ft	345	320	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	535	647	N/A
Water Treatment Plant Capacity[h]	mgd	150	150	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	570	682	N/A

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-20.
(c) Average annual water treatment plant production from Little Cottonwood Creek for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-34.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Planned capacity after expansion in near future of Metropolitan Water Treatment Plant.
(j) 1981 average treatment cost.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Calculated as the difference between 76% and 90% probability yields.
(m) 76% probability yield, because of maximum reservoir capacity as a constraint.

TABLE VI-37
PERTINENT PRELIMINARY DATA
RESERVOIR SITE F, LITTLE COTTONWOOD CREEK

		RESERVOIR CAPACITY OPTIONS		
		10,000 Ac-Ft	Spring Runoff Volume 21,612, Ac-Ft	Mean Annual Yield 27,790 Ac-Ft
GENERAL				
Drainage Area (square miles)		11.8	11.8	11.8
RESERVOIR				
Gross Pool Elevation (feet)		7730	7809	7844
Gross Pool Area (acres)		95.6	169	205
Gross Pool Storage (acre-feet)		10,000	21,612	27,790
Ratio of Storage vs. Area (acre-feet/acre)		104.6	127.9	135.6
Probable Land Purchase Requirement (acres)		135	234	288
MAIN DAM				
Top Elevation (feet)		7741	7820	7855
Spillway Elevation (feet)		7730	7809	7844
Maximum Height at Dam Axis (feet)		201	280	315
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		1850	2310	2560
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		45	45	45
Outlet Works Hydraulic Head (feet)		190	269	304
SPILLWAY				
Discharge Capacity (cfs)		460	460	460
Surcharge Head (feet)		4	4	4
COSTS				
Dam Capital Cost	($)	24,240,000	48,635,000	55,691,000
Total Dam and Reservoir Capital Cost	($)	47,907,000	91,014,000	106,790,000
Annual Operation & Maintenance Cost[a]	($)	239,500	455,100	534,000
Total Annual Cost[b]	($)	5,866,000	11,149,000	13,076,000

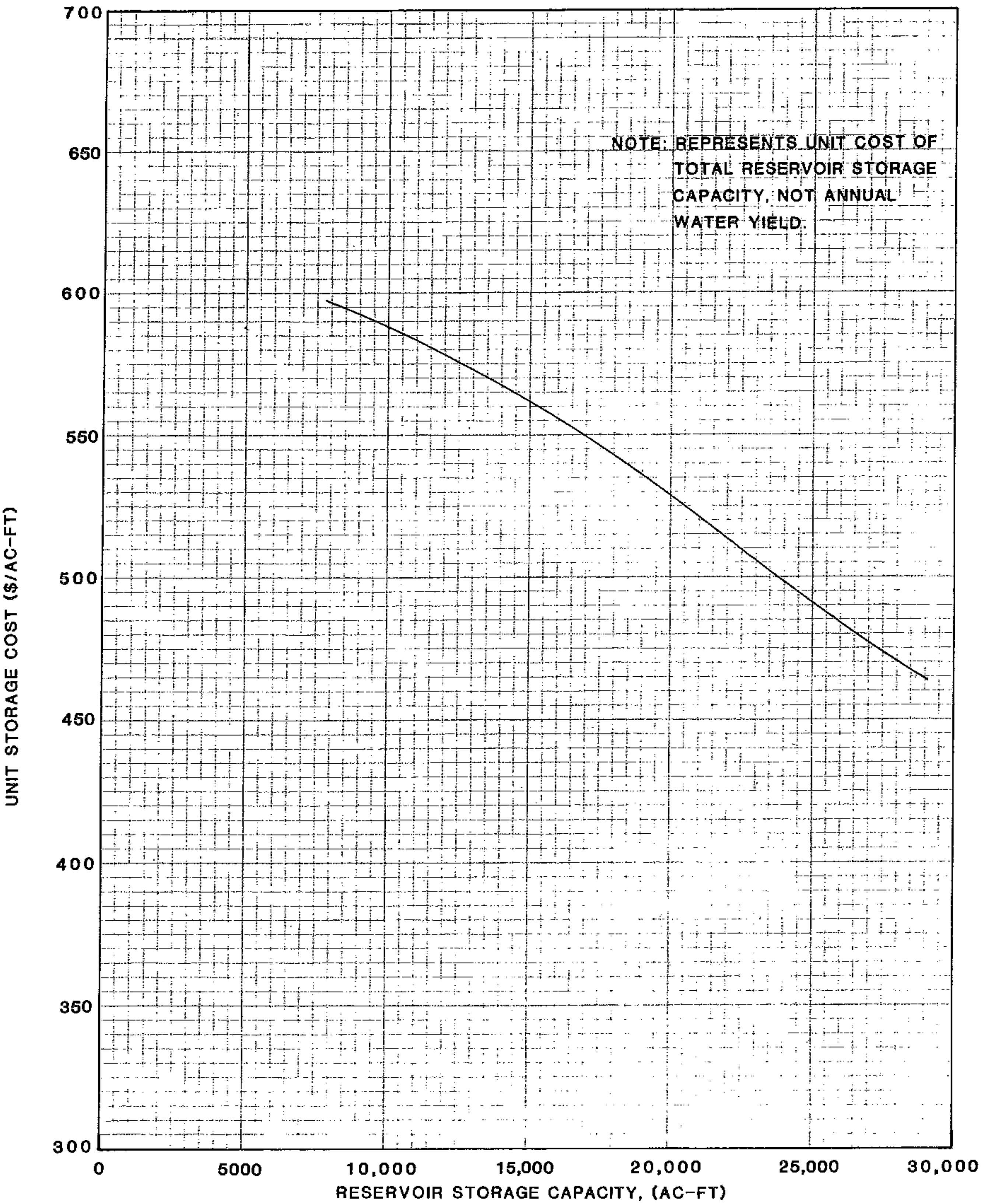
(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.

TABLE VI-38

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
LITTLE COTTONWOOD CREEK
RESERVOIR SITE F

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility
Reservoir Capacity[a]	Ac-Ft	33,803	47,861	N/A
Carry-over Capacity[b]	Ac-Ft	18,767	18,767	N/A
Existing Annual Water Yield[c]	Ac-Ft	18,493	18,493	N/A
Developable Annual Water Yield[d]	Ac-Ft	22,655	22,188	N/A
Total Annual Water Yield[e]	Ac-Ft	41,148	40,681	N/A
Unit Storage Cost[f]	$/Ac-Ft	370	310	N/A
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	552	669	N/A
Water Treatment Plant Capacity[h]	mgd	150	150	N/A
Annual Treatment & Conveyance Cost	$1000	N/A	N/A	N/A
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	35	35	N/A
Total Unit Water Yield Cost[k]	$/Ac-Ft	587	704	N/A

(a) Includes storage and carry-over capacity. Based on the two scenario demand distributions being satisfied at the canyon mouth.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-20
(c) Average annual water treatment plant production from Little Cottonwood Creek for the period 1977-1981.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-35.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Planned capacity after expansion in near future of Metropolitan Water Treatment Plant.
(j) 1981 average treatment cost.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.

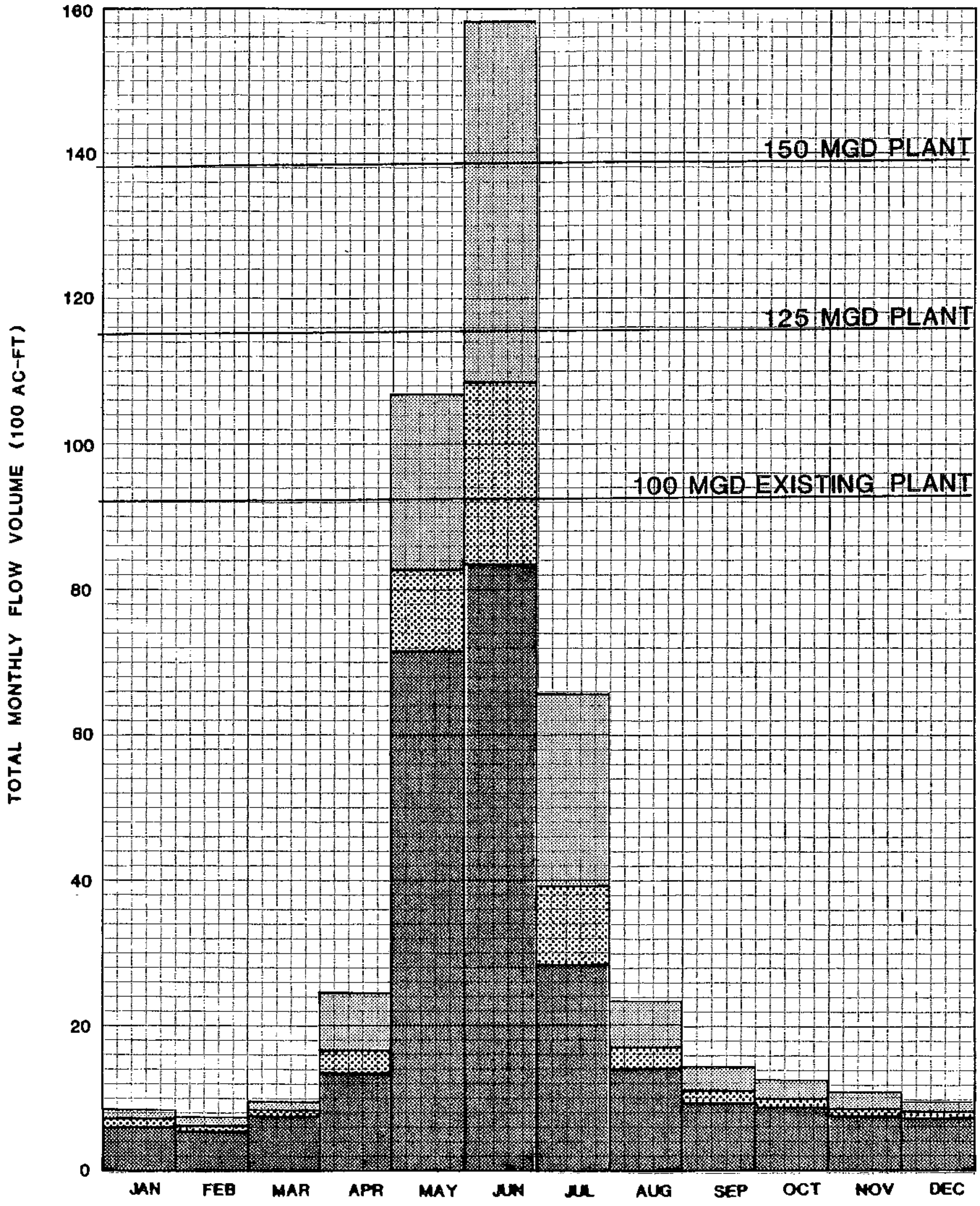


SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

LITTLE COTTONWOOD CREEK, RESERVOIR SITE F

FIGURE VI-35



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

LITTLE COTTONWOOD CREEK

FIGURE VI-36

4. New pipe and meters from the screen house to the inlet control structure.

5. Raise the overflow weir elevation in the existing Aqueduct Overflow Structure.

6. Probable replacement of the filter media with dual media (subject to final determinations of the Health Department).

7. Replace the filter rate controllers.

8. Increase plant effluent capacity at least equal to plant influent capacity.

An estimate of construction cost for the above listed work is as follows:

Items 1 through 5	=	$ 480,000
Items 6 and 7	=	1,470,000
Subtotal		$1,950,000
10% Contingencies		200,000
Total		$2,150,000

(No cost included for increasing capacity of pipelines to increase flow away from plant.)

BELLS CANYON:

DAMSITES: A review of the topography of Bells Canyon located three potential damsites. These damsites lie directly on the main stream channel, and are located in the upper, middle and lower portions of the canyon, respectively.

Upper Bells Canyon Damsite (site A): A small natural lake lies in a small drainage basin in the upper portion of Bells Canyon. During the early 1900's a small earthfill dam, with stone and mortar upstream and downstream faces, was built to form a reservoir in this natural basin. The dam had a maximum height of about 27 feet, and was later breached because of its deteriorating condition.

This is physically an excellent site for a small reservoir because of its natural basin characteristics. Its location is shown as site A in Figure VI-37. Estimates for reconstructing a dam at this site have been made. Two dam sizes have been studied, which would retain the mean annual yield of 697 acre-feet and the spring runoff volume of 524 acre-feet, respectively. A dam which would retain 524 acre-feet is only slightly larger than the existing dam. The pertinent data used in estimating costs are tabulated in Table VI-39. The unit storage costs are displayed graphically in Figure VI-38.

It has been assumed that the upper reservoir would be used only as a peaking facility, because of its small yield relative to the entire canyon yield. Calculations have been made to determine the annual yield, carry-over capacity, and total reservoir capacity. A reservoir capacity of 801 acre-feet was calculated.

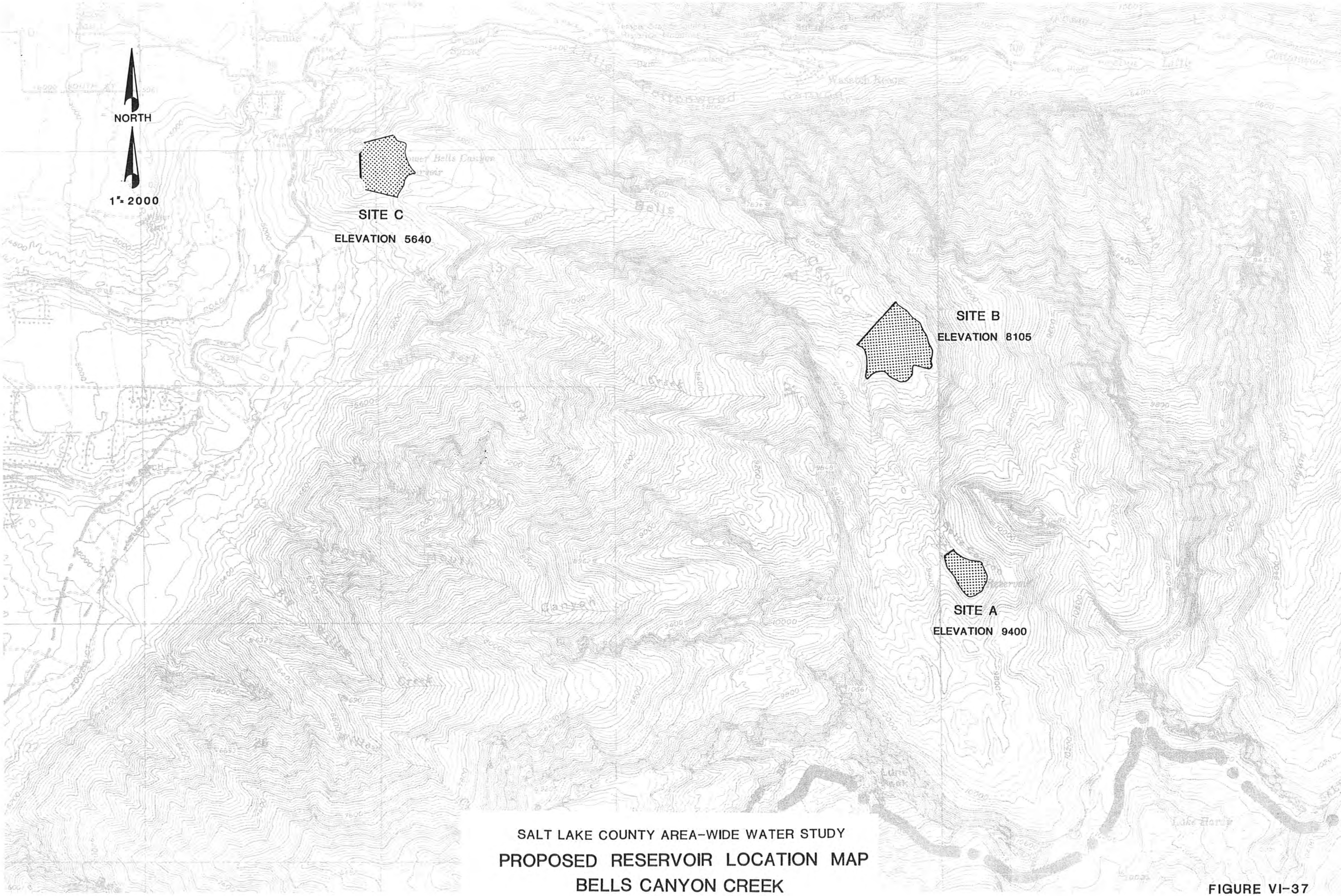
The unit storage cost for this reservoir size was extracted from Figure VI-38. The reservoir capacity, yield and costs, including treatment and conveyance costs, are tabulated in Table VI-40.

The estimated costs are relatively high because of the large expenses in mobilization and developing onsite borrow areas. It is doubtful that construction equipment could be delivered to the site by any means other than helicopters.

TABLE VI-39
PERTINENT PRELIMINARY DATA
RESERVOIR SITE A, BELLS CANYON CREEK

		RESERVOIR CAPACITY OPTIONS	
		Spring Runoff Volume 524 Ac-Ft	Mean Annual Yield 697 Ac-Ft
GENERAL			
Drainage Area (square miles)		0.3	0.3
RESERVOIR			
Gross Pool Elevation (feet)		Approx. 9396	Approx. 9407
Gross Pool Area (acres)		15	16
Gross Pool Storage (acre-feet)		524	697
Ratio of Storage vs. Area (acre-feet/acre)		34.7	43.6
Probable Land Purchase Requirement (acres)		18	19
MAIN DAM			
Top Elevation (feet)		Approx. 9402	Approx. 9413
Spillway Elevation (feet)		9396	9407
Maximum Height at Dam Axis (feet)		46	57
Upstream Side Slope		3:1	3:1
Downstream Side Slope		2.5:1	2.5:1
Crest Length (feet)		320	380
Crest Width (feet)		25	25
Outlet Works Capacity (cfs)		20	20
Outlet Works Hydraylic Head (feet)		40	51
SPILLWAY			
Discharge Capacity (cfs)		110	110
Surcharge Head (feet)		2	2
COSTS			
Dam Capital Cost	($)	634,000	938,000
Total Dam and Reservoir Capital Cost	($)	2,768,000	3,822,000
Annual Operation & Maintenance Cost[(a)]	($)	14,000	19,000
Total Annual Cost[(b)]	($)	339,000	468,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.

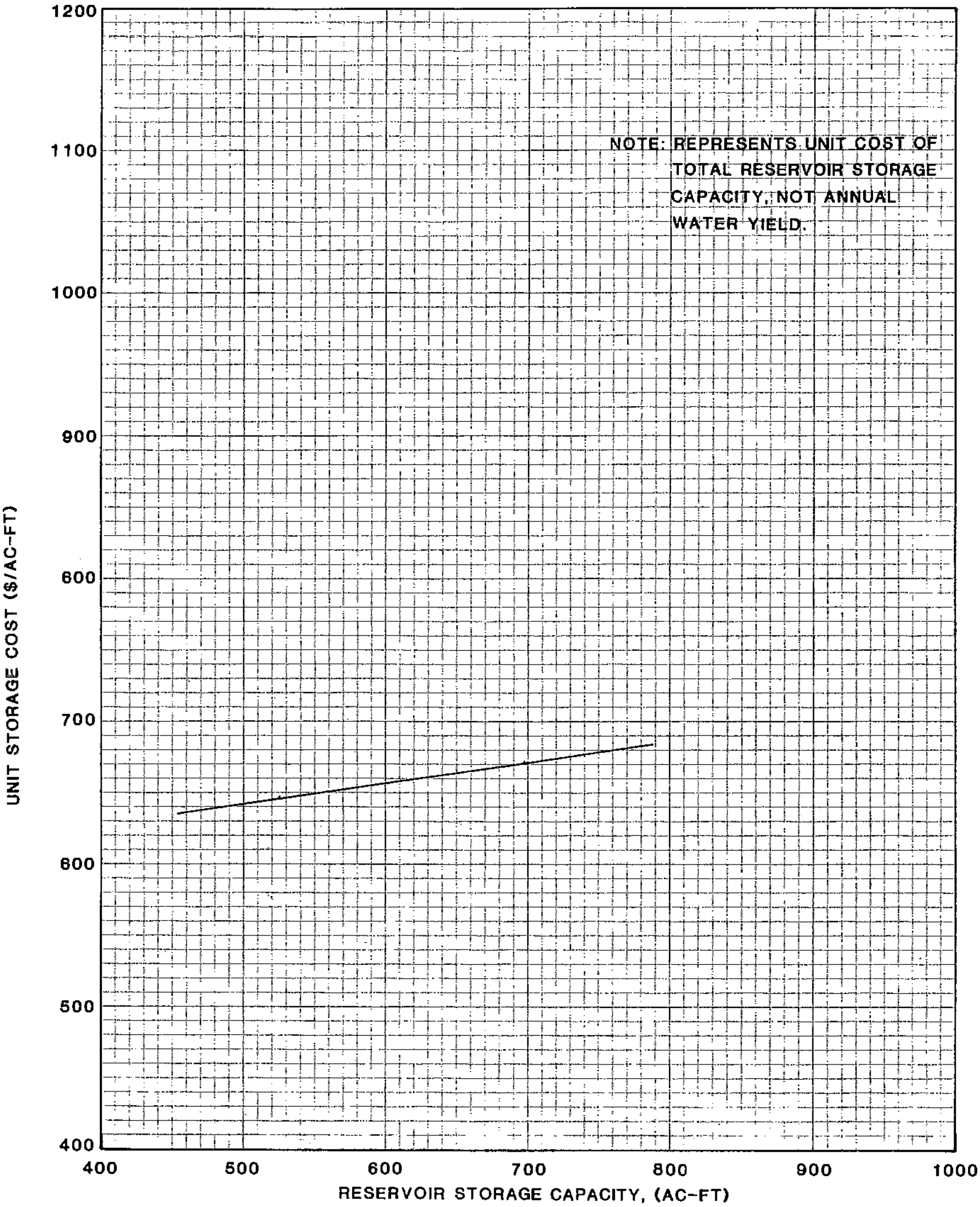


SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

BELLS CANYON CREEK

FIGURE VI-37



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BELL CANYON CREEK, RESERVOIR SITE A FIGURE VI-38

TABLE VI-40

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BELLS CANYON CREEK
RESERVOIR SITE A

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility[m]
Reservoir Capacity[a]	Ac-Ft	N/A	801	0
Carry-over Capacity[b]	Ac-Ft	N/A	283	0
Existing Annual Water Yield[c]	Ac-Ft	N/A	0	0
Developable Annual Water Yield[d]	Ac-Ft	N/A	6145	6145
Total Annual Water Yield[e]	Ac-Ft	N/A	6145	6145
Unit Storage Cost[f]	$/Ac-Ft	N/A	680	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	N/A	88	0
Water Treatment Plant Capacity[h]	mgd	N/A	25	25[l]
Annual Treatment & Conveyance Cost[i]	$1000	N/A	833	833
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	N/A	166	166
Total Unit Water Yield Cost[k]	$/Ac-Ft	N/A	254	166

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-22.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-38.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Planned capacity of Southeast Regional Water Treatment Plant.
(i) Total annual cost of Southeast Regional WTP ($7.1 million amortized @ 10% over 20 years).
(j) Total annual treatment and conveyance cost divided by the total annual production of the plant. (15,007 acre-feet)
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) Represents natural unregulated stream flow pattern.

Mid-Bells Canyon Damsite (site B): This potential damsite is located in a large natural basin about mid-way up the canyon. This is shown as site B in Figure VI-37. Three dam sizes were investigated, which would impound 2000 acre-feet, the spring runoff volume of 3800 acre-feet, and the mean annual yield of 5228 acre-feet, respectively. The pertinent data used in estimating costs are tabulated in Table VI-41, and a curve has been fit to the three unit storage costs plotted in Figure VI-39.

Calculations have been made to determine reservoir capacities and annual yields, based on the two storage use scenarios utilizing equalizing and peaking storage. Annual storage costs for these calculated reservoir capacities have been extracted from the graph of unit storage costs in Figure VI-39. This information, along with treatment and conveyance costs, is tabulated in Table VI-42.

These costs reflect the difficulty in delivering equipment to the site, as well as the necessity of developing an onsite borrow area. Helicopter transportation would probably be required.

Lower Bells Canyon Reservoir (site C): The existing reservoir at this site has a capacity of 420 acre-feet, and is directly supplied by the main stream in Bells Canyon. The man-made reservoir has been formed by damning a natural depression behind a glacial morraine.

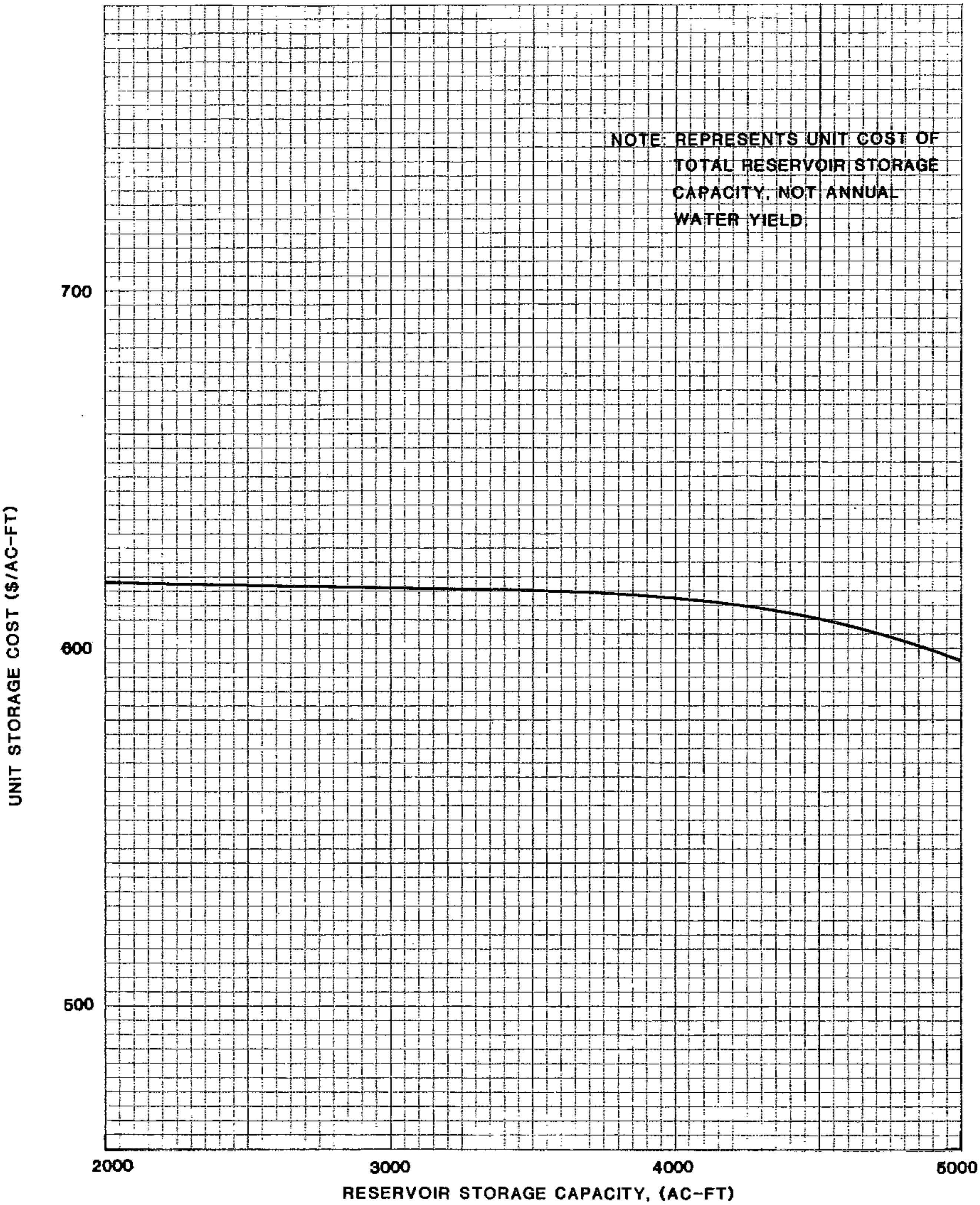
A study was made to estimate the costs of enlarging the existing dam. This site is shown as site C in Figure VI-37. It was assumed that the existing dam can be enlarged by exposing the impervious core on the downstream side, extending the core vertically and building a larger rockfill embankment on the south side.

Two dam sizes were investigated, which would impound 1000 acre-feet and 1535 acre-feet, respectively. The volume of 1535 acre-feet is much smaller than the spring runoff volume, but is the largest volume that could be retained within the natural depressions by filling in the low spots along the terminal morraine. The pertinent data regarding the two dam-enlargement options are tabulated in Table VI-43. Unit storage costs are displayed graphically in Figure VI-40. Unit storage, treatment and conveyance costs are tabulated in Table VI-44.

TABLE VI-41
PERTINENT PRELIMINARY DATA
RESERVIR SITE B, BELLS CANYON CREEK

		RESERVOIR CAPACITY OPTIONS		
		2000 Ac-Ft	Spring Runoff Volume 3800 Ac-Ft	Mean Annual Yield 5228 Ac-Ft
GENERAL				
Drainage Area (square miles)		2.8	2.8	2.8
RESERVOIR				
Gross Pool Elevation (feet)		7975	8046	8089
Gross Pool Area (acres)		22	25	36
Gross Pool Storage (acre-feet)		2000	3800	5228
Ratio of Storage vs. Area (acre-feet/acre)		90.9	152.0	145.2
Probable Land Purchase Requirement (acres)		31	37	56
MAIN DAM				
Top Elevation (feet)		7986	8060	8104
Spillway Elevation (feet)		7975	8046	8089
Maximum Height at Dam Axis (feet)		171	245	289
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		850	1170	1290
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		20	20	20
Outlet Works Hydraulic Head (feet)		160	231	274
SPILLWAY				
Discharge Capacity (cfs)		220	220	220
Surcharge Head (feet)		3	3	3
COSTS				
Dam Capital Cost	($)	6,071,000	12,846,000	18,213,000
Total Dam and Reservoir Capital Cost	($)	10,104,000	18,863,000	26,266,000
Annual Operation & Maintenance Cost[a]	($)	50,000	94,000	131,000
Total Annual Cost[b]	($)	1,237,000	2,260,000	3,216,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BELLS CANYON CREEK, RESERVOIR SITE B FIGURE VI-39

TABLE VI-42

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BELLS CANYON CREEK
RESERVOIR SITE B

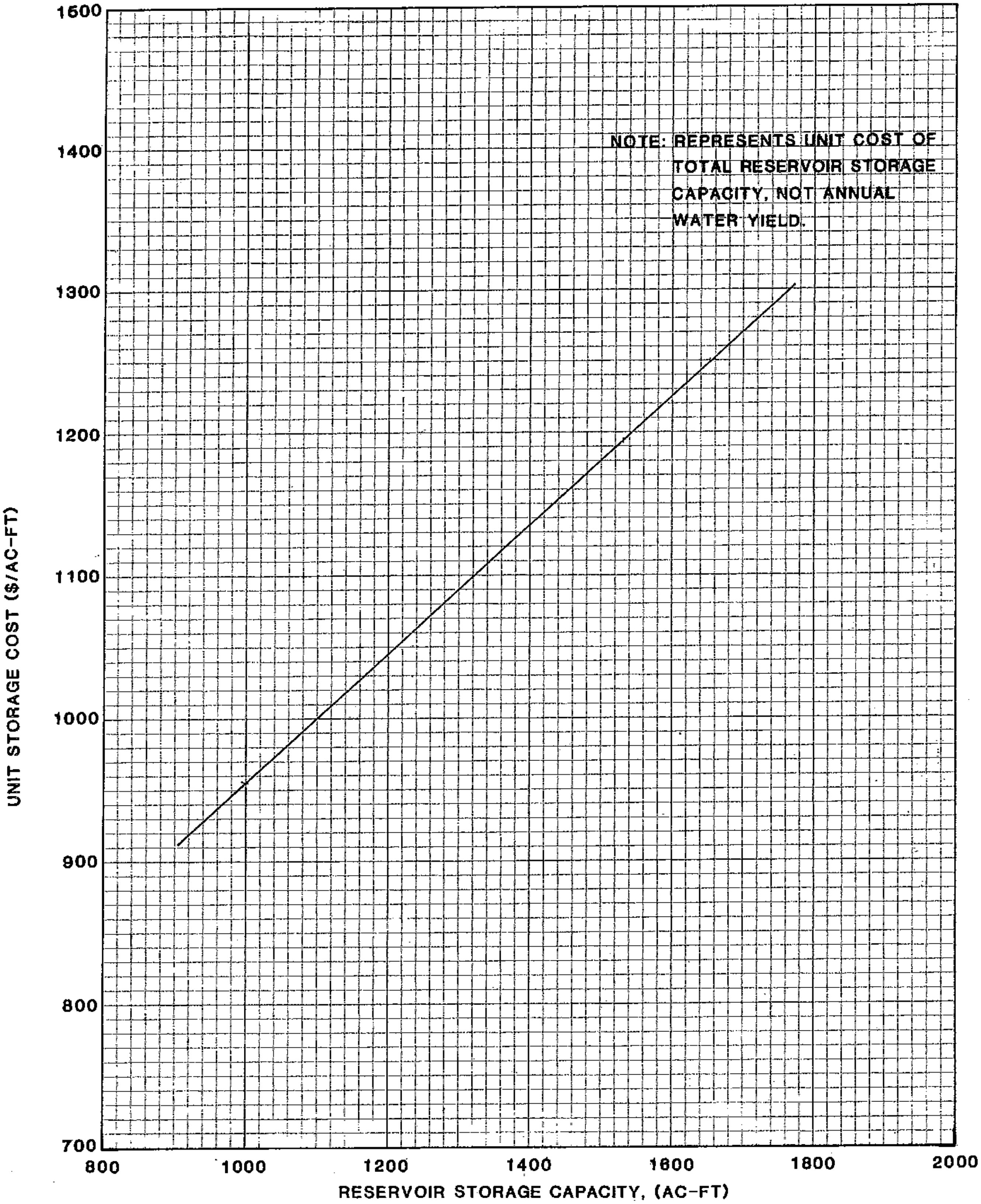
Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility[m]
Reservoir Capacity[a]	Ac-Ft	4412[n]	5953[n]	0
Carry-over Capacity[b]	Ac-Ft	2172	2172	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	6145	6145	6145
Total Annual Water Yield[e]	Ac-Ft	6145	6145	6145
Unit Storage Cost[f]	$/Ac-Ft	610	558	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	437	540	0
Water Treatment Plant Capacity[h]	mgd	25	25	25
Annual Treatment & Conveyance Cost[i]	$1000	834	834	834
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	166	166	166
Total Unit Water Yield Cost[k]	$/Ac-Ft	603	706	166

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-22.
(c) Assumes that no municipal water is presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-39.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Planned plant capacity of the Southeast Regional Water Treatment Plant.
(i) Total annual cost of Southeast Regional Water Treatment Plant. ($7.1 million amortized at 10% over 20 years).
(j) Total annual treatment and conveyance cost divided by the total annual production of the plant. (15007 acre-feet)
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(m) Represents natural unregulated stream flow pattern.
(n) The 50% probability yield at the reservoir site is redistributed according to the scenario demand distribution and released to the stream.

TABLE VI-43
PERTINENT PRELIMINATY DATA
RESERVOIR SITE C, BELLS CANYON CREEK

		RESERVOIR CAPACITY OPTIONS	
		1000 Ac-Ft	1535 Ac-Ft
GENERAL			
Drainage Area (square miles)		3.9	3.9
RESERVOIR			
Gross Pool Elevation (feet)		5611	5634
Gross Pool Area (acres)		22	25
Gross Pool Storage (acre-feet)		1000	1535
Ratio of Storage vs. Area (acre-feet/acre)		45.5	61.4
Probable Land Purchase Requirement (acres)		30	44
MAIN DAM			
Top Elevation (feet)		5618	5641
Spillway Elevation (feet)		5611	5634
Maximum Additional Height at Dam Axis (feet)		40	63
Upstream Side Slope		3:1	3:1
Downstream Side Slope		2.5:1	2.5:1
Crest Length (feet)		2300	2360
Crest Width (feet)		30	30
Outlet Works Capacity (cfs)		30	30
Outlet Works Hydraulic Head (feet)		70	93
SPILLWAY			
Discharge Capacity (cfs)		300	300
Surcharge Head (feet)		2	2
COSTS			
Dam Capital Cost	($)	4,491,000	9,376,000
Total Dam and Reservoir Capital Cost	($)	7,808,000	14,980,000
Annual Operation & Maintenance Cost[(a)]	($)	39,000	75,000
Total Annual Cost[(b)]	($)	956,000	1,835,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

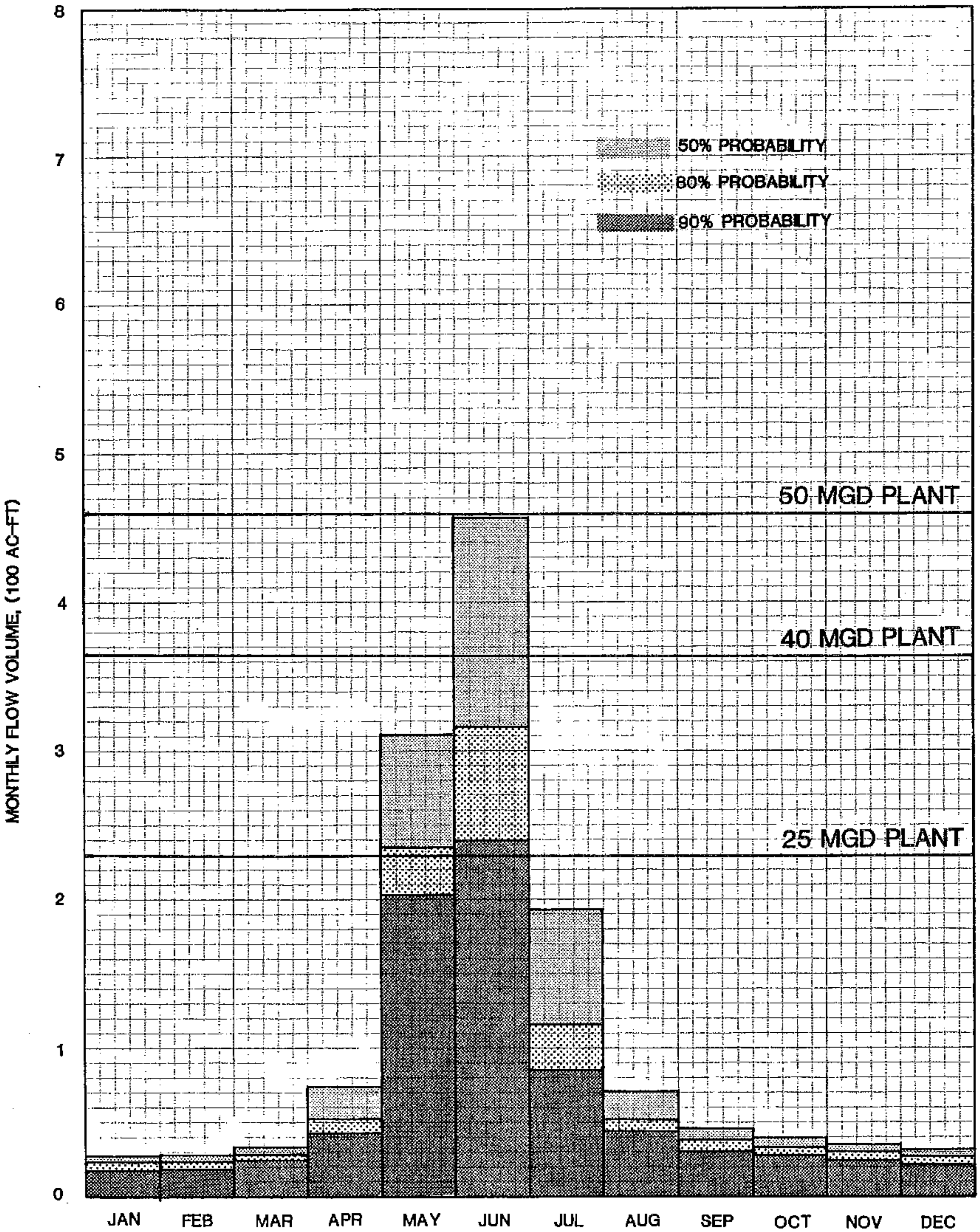
BELL CANYON CREEK , RESERVOIR SITE C FIGURE VI-40

TABLE VI-44
ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BELLS CANYON CREEK
RESERVOIR SITE C

Item	Unit	Scenario 1. Equalizing Facility[m]	Scenario 2. Peaking Facility[m]	Scenario 3. Existing Storage Facility[n]
Reservoir Capacity	Ac-Ft	1535[a]	1535[a]	420[l]
Carry-over Capacity[b]	Ac-Ft	0	0	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	6145	6145	6145
Total Annual Water Yield[e]	Ac-Ft	6145	6145	6145
Unit Storage Cost[f]	$/Ac-Ft	1190	1190	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	297	297	0
Water Treatment Plant Capacity[h]	mgd	25	25	25
Annual Treatment & Conveyance Cost[i]	$1000	833	833	833
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	166	166	166
Total Unit Water Yield Cost[k]	$/Ac-Ft	463	463	166

(a) Includes storage and carry-over capacity.
(b) No carry-over storage needed since storage limitation is less than 90% probability yield.
See annual sums, Table V-22.
(c) Assumes that no municipal water is presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-40.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on regulated Plant Inflow.
(i) Total annual cost of Southeast Regional Water Treatment Plant (7.1 million amortized @ 10% over 20 years).
(j) Total Annual Treatment & Conveyance Cost divided by the total Annual Production of the plant. (15,007 acre-feet)
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Existing capacity of lower Bell Canyon Reservoir.
(m) Storage calculations were performed for unregulated natural stream flow less required irrigation diversions.
(n) Reservoir is used, as far as possible, to store spring runoff for summer use. Otherwise this scenario reflects unregulated flows.

WATER TREATMENT PLANT: The Salt Lake County Water Conservancy District has recently begun plans to construct a water treatment plant east of Draper City. This plant will be capable of treating 25 mgd of the combined flows from Bells and Rocky Mouth Canyons, Middle Fork Dry, South Fork Dry, Big Willow and Little Willow Creeks. As shown in Figure VI-41, this size plant will handle the 90 percent probability peak monthly flows. The plant could be enlarged to handle the 50 percent probability peak monthly flows by adding additional capacity in the chemical feed systems, mixing chambers, flocculation basins, filters and sludge storage lagoons. Figure VI-42 shows the estimated annual costs for various size expansions. These costs are based upon use of the direct filtration treatment process.

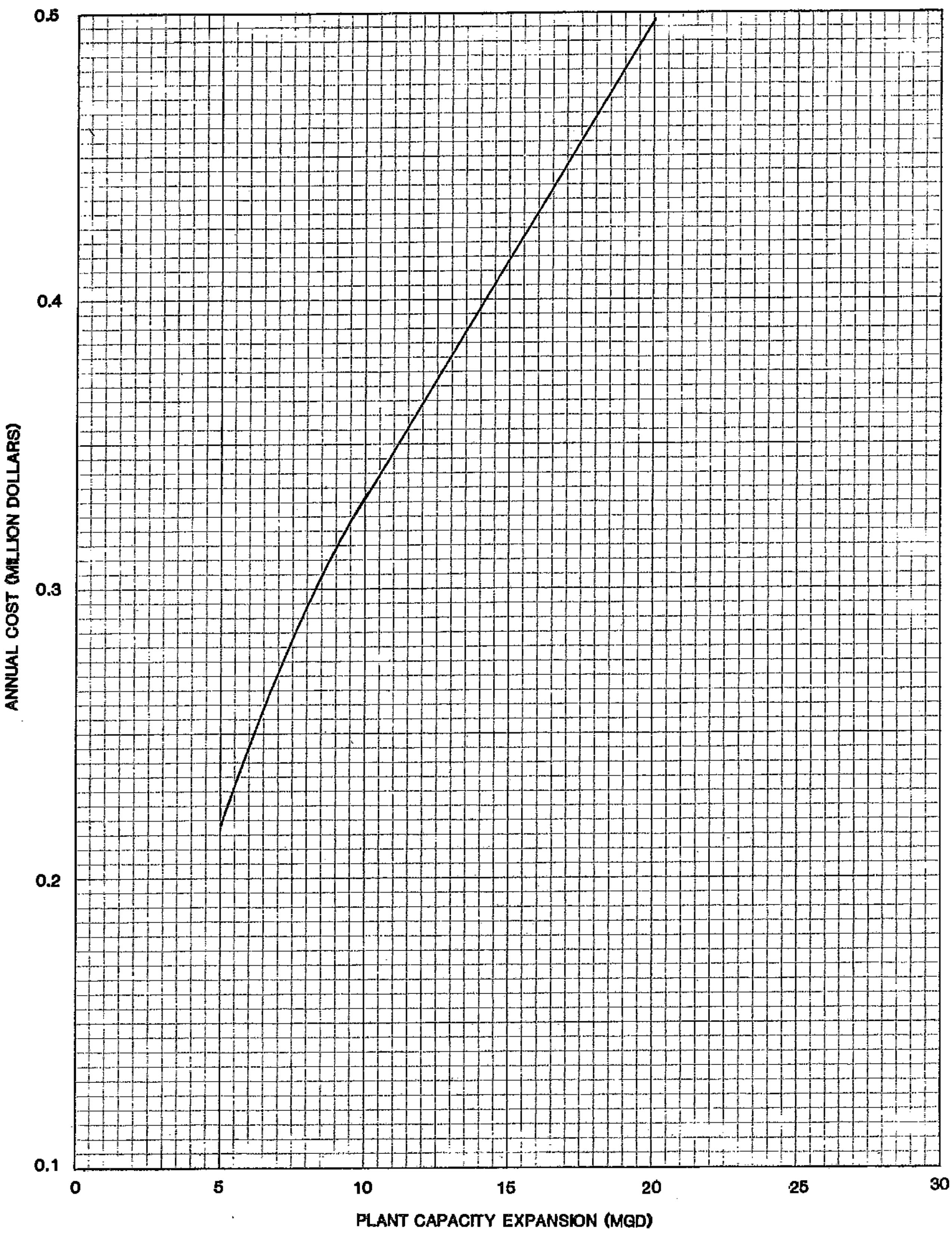


SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH WITH PLANT CAPACITIES

BELLS' MIDDLE FORK DRY CREEK' SOUTH FORK DRY CREEK, ROCKY MOUTH, BIG WILLOW, LITTLE WILLOW, COMBINED FLOWS

FIGURE VI-41



SALT LAKE COUNTY AREA-WIDE WATER STUDY

SOUTHEAST REGIONAL WATER TREATMENT PLANT EXPANSION ANNUAL COSTS

FIGURE VI-42

MIDDLE FORK DRY CREEK , SOUTH FORK DRY CREEK, ROCKY MOUTH, BIG WILLOW CREEK,AND LITTLE WILLOW CREEK CANYONS:

DAMSITES: No known previous study has investigated any damsites in these drainage basins. A cursory review of the topography was made during this study to evaluate the potential for dam construction. However, because of the general steepness throughout the canyons, no reasonable damsites worthy of further study were found.

WATER TREATMENT PLANT: Planned culinary use of the water from these streams is discussed in the section on Bells Canyon.

BEAR CANYON:

DAMSITES: No known previous study has investigated potential damsites in Bear Canyon. During this study a preliminary review of the canyon topography was made to locate possible damsites. However, due to the general steepness within the canyon, no reasonable site for a dam and reservoir was found.

WATER TREATMENT PLANTS: The flow from Bear Canyon was considered too small to justify the construction of a treatment plant for this stream. Therefore, diverting the water into the Salt Lake Aqueduct was determined to be a feasible alternative for developing the stream into a culinary source. The elevation of the hydraulic gradient of the aqueduct as it crosses Bear Canyon is 5065. The flow from Bear Canyon would be diverted upstream to provide sufficient head to enter the aqueduct. Table VI-45 shows the estimated total annual costs for various sized pipelines.

Another alternative for development is to construct a pipeline from the canyon to the new Salt Lake County Water Conservancy District plant near Draper. Table VI-46 shows the estimated costs for the pipeline at various sizes and the percentage of the instantaneous peak flow which the pipeline will handle.

TABLE VI-45

COST ESTIMATED FOR
BEAR CANYON PIPELINE TO SALT LAKE AQUEDUCT

Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
20	11.9	100+	9,800
18	9.0	89	9,000
16	6.4	64	8,400
14	4.5	45	7,700

TABLE VI-46

COST ESTIMATE FOR
BEAR CANYON PIPELINE TO
SOUTHEAST REGIONAL WATER TREATMENT PLANT

Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
20	11.2	100+	66,200
18	8.8	89	59,900
16	6.3	64	55.300
14	4.5	45	50,100

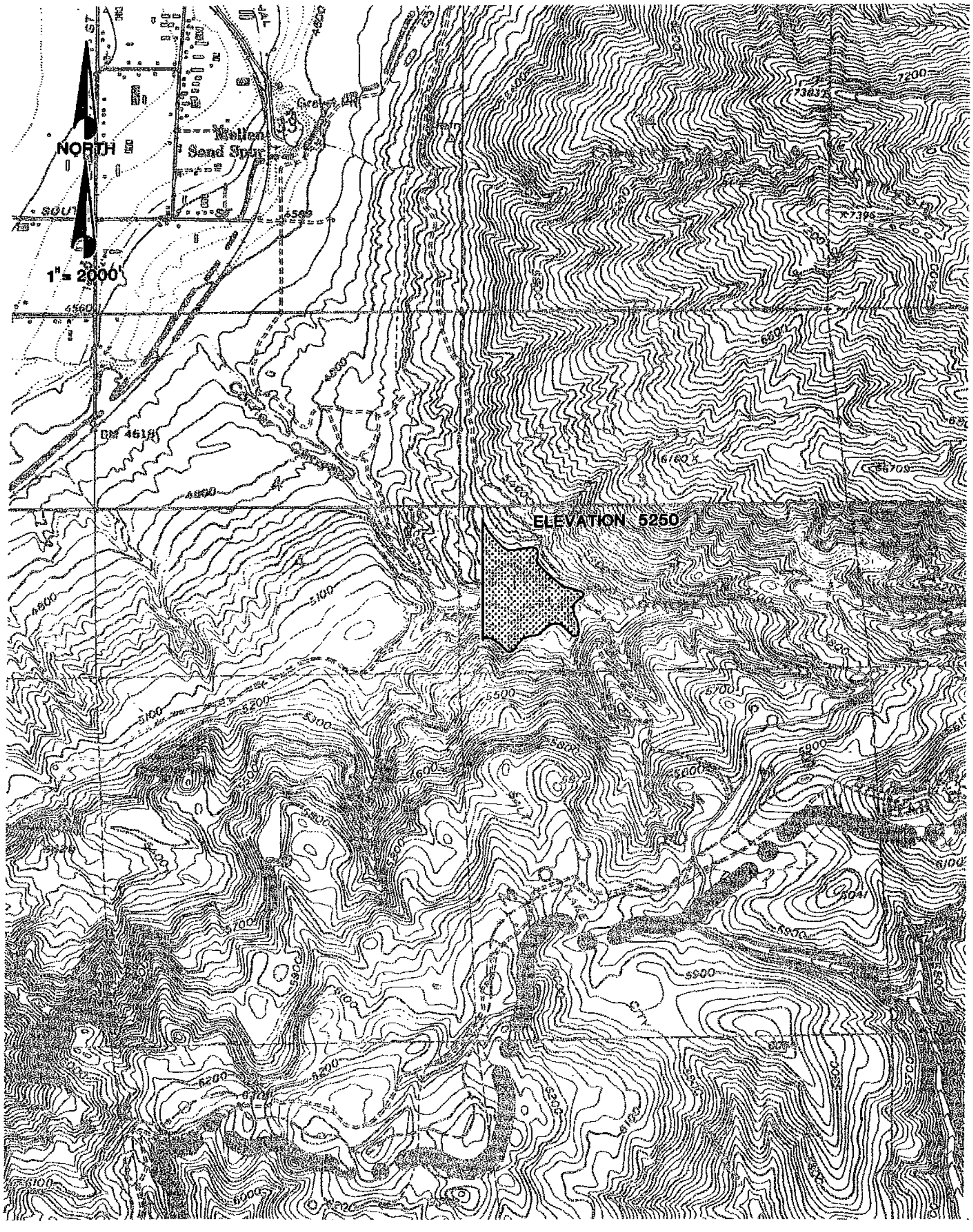
CORNER CANYON:

DAMSITES: There were no previous studies found which had investigated possible damsites in Corner Canyon. During this study, it was determined that the channels slope quite steeply in their upper reaches within the canyon, making damsites in the upper portion of the drainage basin infeasible. However, a more favorable spot exists lower in the canyon where the stream bed gradient decreases suddenly, and the canyon side slopes are mild. The spot selected for further study lies about half a mile upstream from the canyon mouth near a fork of two major tributaries as shown in Figure VI-43.

The dam sizes investigated would impound 250 acre-feet, the spring runoff of 510 acre-feet, and the mean annual yield of 1018 acre-feet, respectively. Pertinent data for the dams and reservoirs are tabulated in Table VI-47. The only relocation involved in the construction of these dams would be that of an existing dirt road.

Unit storage costs are plotted in Figure VI-44 to provide a wide range of costs versus dam sizes.

Calculations were made to determine probable reservoir sizes using the two storage use scenarios explained in the introduction as a basis. Scenario one, the equalizing facility, would require a reservoir capacity of 861 acre-feet and it would yield 1442 acre-feet. Under scenario two, the peaking facility, the reservoir capacity would be 1418 acre-feet and the annual yield would be 1442 acre-feet. Table VI-48 summarizes capacities, yields, and unit costs for developed water for both of the above scenarios.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

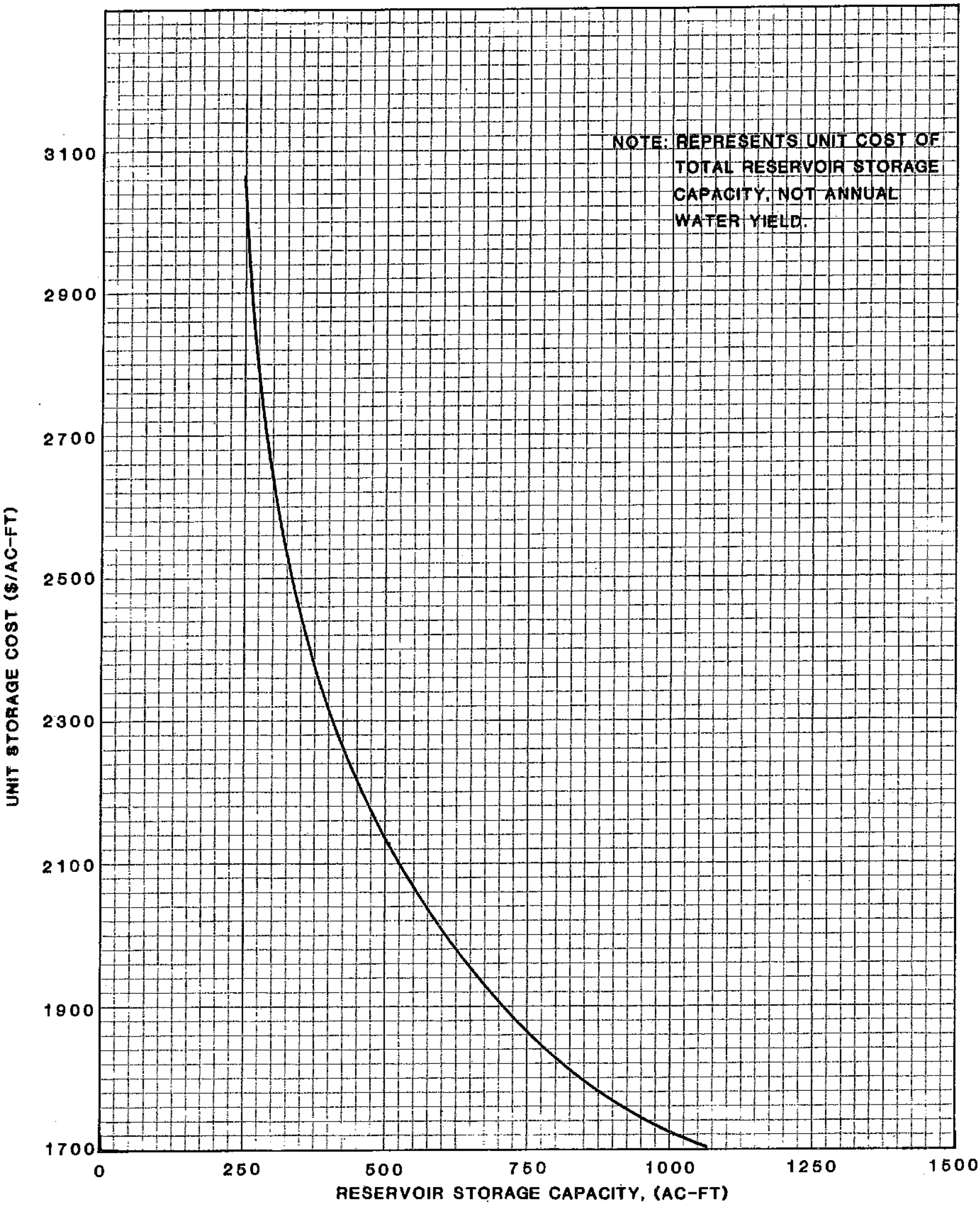
CORNER CANYON CREEK

FIGURE VI-43

TABLE VI-47
PERTINENT PRELIMINARY DATA
CORNER CANYON CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS		
		250 Ac-Ft	Spring Runoff Volume 510 Ac-Ft	Mean Annual Yield 1018 Ac-Ft
GENERAL				
Drainage Area (square miles)		2.5	2.5	2.5
RESERVOIR				
Gross Pool Elevation (feet)		5145	5181	5225
Gross Pool Area (acres)		8.5	8.8	14.2
Gross Pool Storage (acre-feet)		250	510	1018
Ratio of Storage vs. Area (acre-feet per acre)		29.4	58.0	71.7
Probable Land Purchase Requirement (acres)		12	13	25
MAIN DAM				
Top Elevation (feet)		5153	5191	5237
Spillway Elevation (feet)		5145	5181	5225
Maxium Height at Dam Axis (feet)		113	151	197
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		430	520	620
Crest Width (feet)		30	30	30
Outlet Works Capacity (cfs)		20	20	20
Outlet Works Hydraulic Head (feet)		105	141	185
SPILLWAY				
Discharge Capacity (cfs)		210	210	210
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	5,002,000	6,580,000	10,578,000
Total Dam and Reservoir Capital Cost	($)	6,253,000	8,873,000	14,289,000
Annual Operation and Maintenance Costs(a)	($)	31,000	44,000	71,000
Total Annual Cost(b)	($)	765,000	1,086,000	1,749,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

CORNER CANYON CREEK RESERVOIR SITE FIGURE VI-44

TABLE VI-48

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
CORNER CANYON CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	861	1418	0
Carry-over Capacity[b]	Ac-Ft	411	411	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	1442	1442	1442
Total Annual Water Yield[e]	Ac-Ft	1442	1442	1422
Unit Storage Cost[f]	$/Ac-Ft	1880	1540	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	1122	1514	0
Water Treatment Plant Capacity[h]	mgd	2.2	4.4	5.7[l]
Annual Treatment & Conveyance Cost[i]	$1000	154	154	154
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	107	107	107
Total Unit Water Yield Cost[k]	$/Ac-Ft	1229	1621	107

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-29.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-44.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) Includes cost of conveyance to and the treatment costs for, the Southeast Regional Water Treatment Plant.
(j) Annual Treatment & Conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.

WATER TREATMENT PLANTS: The flow from Corner Canyon is too small to be the sole source for a treatment plant. Therefore, diverting the water into the Salt Lake Aqueduct was determined to be a feasible alternative for developing the stream as a culinary source. The elevation of the hydraulic gradient of the aqueduct as it crosses Corner Canyon is 5080. The flow from Corner Canyon would be diverted upstream to provide sufficient head to enter the aqueduct. Table VI-49 shows the estimated total annual cost for various sized pipelines.

Another alternative for development is to construct a pipeline from the canyon to the new Salt Lake County Water Conservancy District plant near Draper. Table VI-50 shows the estimated costs for the pipeline at various sizes and the percentage of the instantaneous peak flow which the pipeline will handle.

TABLE VI-49

COST ESTIMATES FOR
CORNER CANYON PIPELINE TO SALT LAKE AQUEDUCT

Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
20	11.9	100	8,900
18	9.0	76	8,200
16	6.4	54	7,600

TABLE VI-50

COST ESTIMATE FOR
CORNER AND BEAR CANYONS PIPELINE TO
SOUTHEAST REGIONAL WATER TREATMENT PLANT

Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
24 & 27	26	100+	170,800
20 & 24	18.8	86	144,400
18 & 20	11.2	51	125,000

ROSE CANYON:

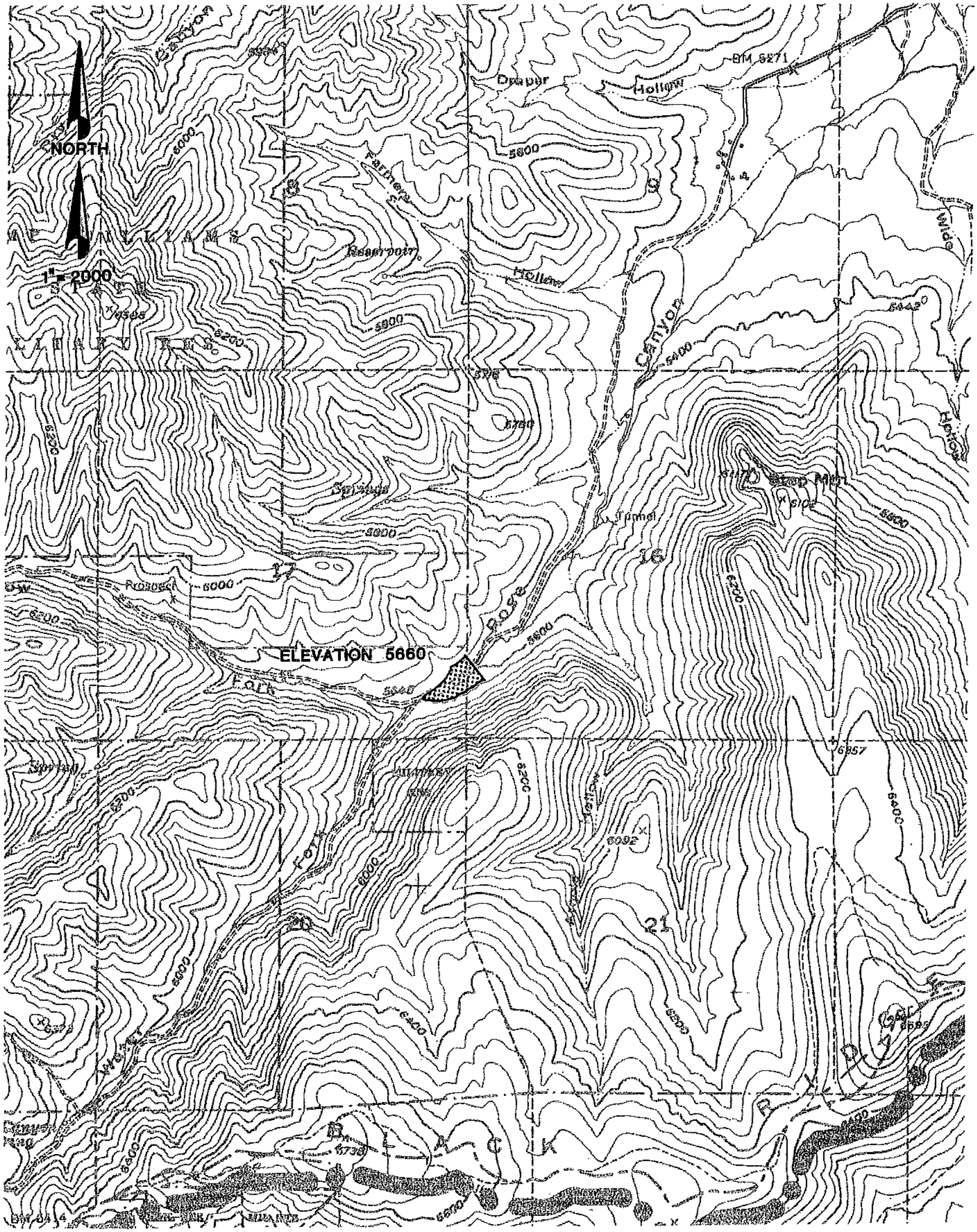
DAMSITES: No known previous studies have examined any potential damsites in Rose Canyon. During this study a reasonable site was located on the main channel about two and a half miles upstream from the canyon mouth, and just downstream from the confluence of Yellow Fork and Water Fork. The site is shown in Figure VI-45.

Three dam sizes were studied, which would impound 100 acre-feet, the spring runoff volume of 160 acre-feet, and the mean annual yield of 211 acre-feet, respectively. Pertinent data assumed for preliminary cost estimates are tabulated in Table VI-51. Figure VI-46 shows plotted unit storage costs to provide a wide range of dam sizes versus costs.

Construction of a dam at this site would require relocation of about one half mile of existing dirt road. No other utility relocations would be involved.

Both scenarios of probable reservoir use were the basis for determining probable dam sizes. For the first scenario where the reservoir is used as an equalizing facility the total capacity is 218 acre-feet with an annual yield of 493 acre-feet. If used as a peaking facility the reservoir capacity would increase to 298 acre-feet with a yield of 493 acre-feet. Capacities, yields and unit costs for developed water are summarized in Table VI-52.

WATER TREATMENT PLANT: The annual flow from Rose Canyon is very small when considering a water treatment plant. Therefore, the flows from Rose and Butterfield Canyons were combined as a single source for a small treatment plant. Figure VI-47 shows the hydrograph of the combined flows and the capacities of various plant sizes. The plant location was considered to be one and a half miles west of Herriman on Utah Highway 111. The existing concrete-lined ditch would be used to convey the Butterfield Creek flow to the plant. A new pipeline from Rose Canyon to the treatment plant would be required. The cost estimates for various plant sizes at this location are shown in Figure VI-48.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

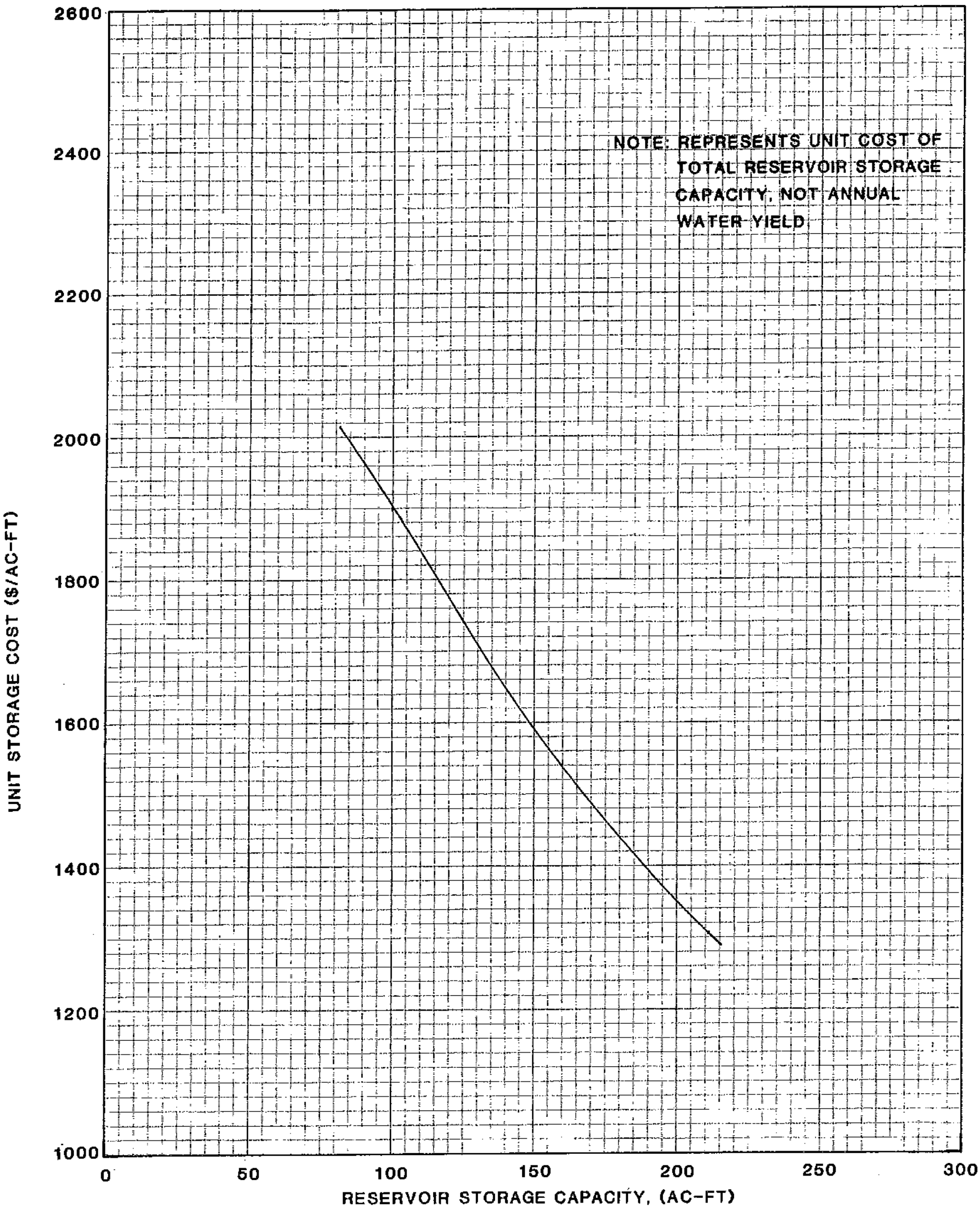
ROSE CREEK

FIGURE VI-45

TABLE VI-51
PERTINENT PRELIMINARY DATA
ROSE CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS		
		100 Ac-Ft	Spring Runoff Volume 160 Ac-Ft	Mean Annual Yield 211 Ac-Ft
GENERAL				
Drainage Area (square miles)		5.2	5.2	5.2
RESERVOIR				
Gross Pool Elevation (feet)		5636	5644	5648
Gross Pool Area (acres)		5	7	9
Gross Pool Storage (acre-feet)		100	160	211
Ratio of Storage vs. Area (acre-feet per acre)		20.0	22.9	23.3
Probable Land Purchase Requirement (acres)		7	9	11
MAIN DAM				
Top Elevation (feet)		5643	5651	5655
Spillway Elevation (feet)		5636	5644	5648
Maximum Height at Dam Axis (feet)		43	51	55
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		450	520	540
Crest Width (feet)		25	25	25
Outlet Works Capacity (cfs)		20	20	20
Outlet Works Hydraulic Head (feet)		36	44	48
SPILLWAY				
Discharge Capacity (cfs)		280	280	280
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	889,000	1,209,000	1,360,000
Total Dam and Reservoir Capital Cost	($)	1,551,000	2,018,000	2,260,000
Annual Operation and Maintenance Cost[(a)]	($)	8,000	10,000	11,000
Total Annual Cost[(b)]	($)	190,000	247,000	276,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS
ROSE CREEK RESERVOIR SITE

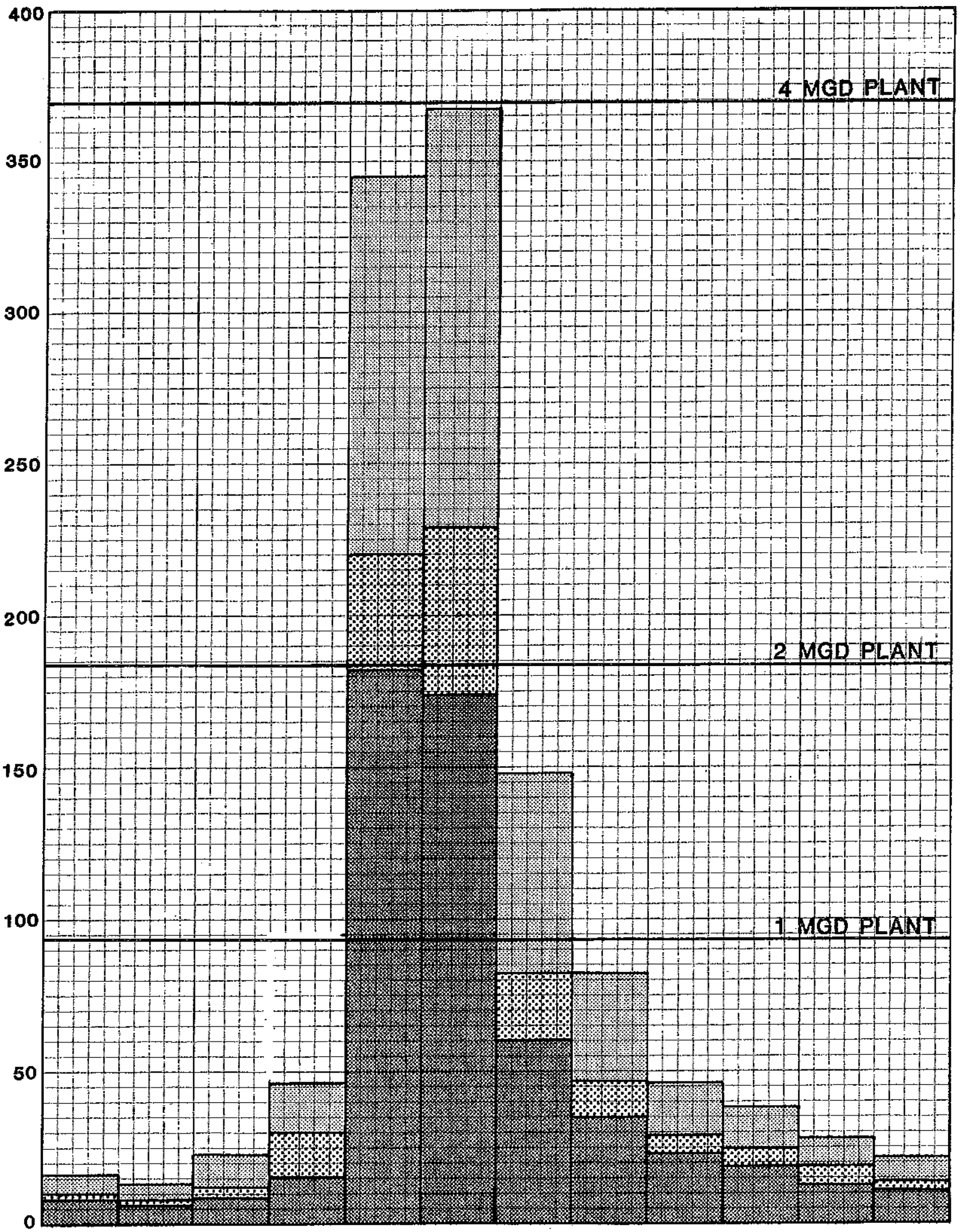
FIGURE VI-46

TABLE VI-52

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM ROSE CREEK RESERVOIR SITE

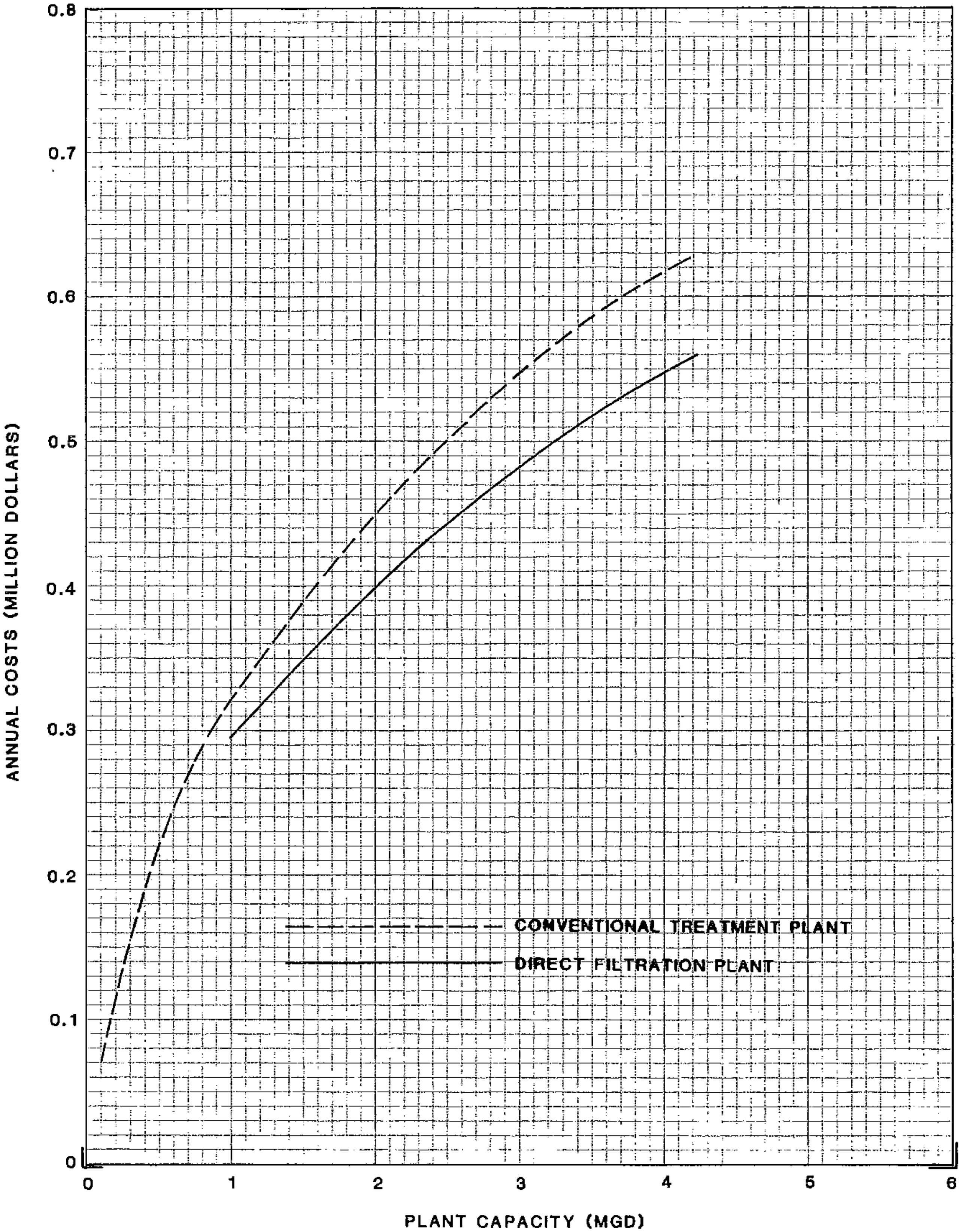
Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility[m]
Reservoir Capacity[a]	Ac-Ft	218	298	0
Carry-over Capacity[b]	Ac-Ft	127	127	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable annual Water Yield[d]	Ac-Ft	493	493	493
Total Annual Water Yield[e]	Ac-Ft	493	493	493
Unit Storage Cost[f]	$/Ac-Ft	1330	1125	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	588	680	0
Water Treatment Plant Capacity[j]	mgd	0.5	0.9	1.9[l]
Annual Treatment & Conveyance Cost[i]	$1000	220	310	440
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	446	628	892
Total Unit Water Yield Cost[k]	$/Ac-Ft	1034	1308	892

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-30, adjusted for drainage area at reservoir site.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-46.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-48.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) Represents natural unregulated stream flow pattern.



ROSE AND BUTTERFIELD CREEKS COMBINED

FIGURE VI-47



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS
ROSE AND BUTTERFIELD CREEKS COMBINED

FIGURE VI-48

Another alternative for treatment of the water from these two canyons is to convey it to the existing Jordan Water Purification Plant. This alternative would require a 5.6 mile pipeline. Table VI-53 shows the amortized capital costs for the pipeline. Treatment costs have not been included in the amounts shown.

TABLE VI-53

COST ESTIMATES FOR ROSE AND BUTTERFIELD CANYONS PIPELINE

Pipe Size (inches)	Capacity (mgd)	Total Annual Cost ($)
12 & 15	4	127,600
10 & 12	2	97,200
8	1	75,200

BUTTERFIELD CANYON:

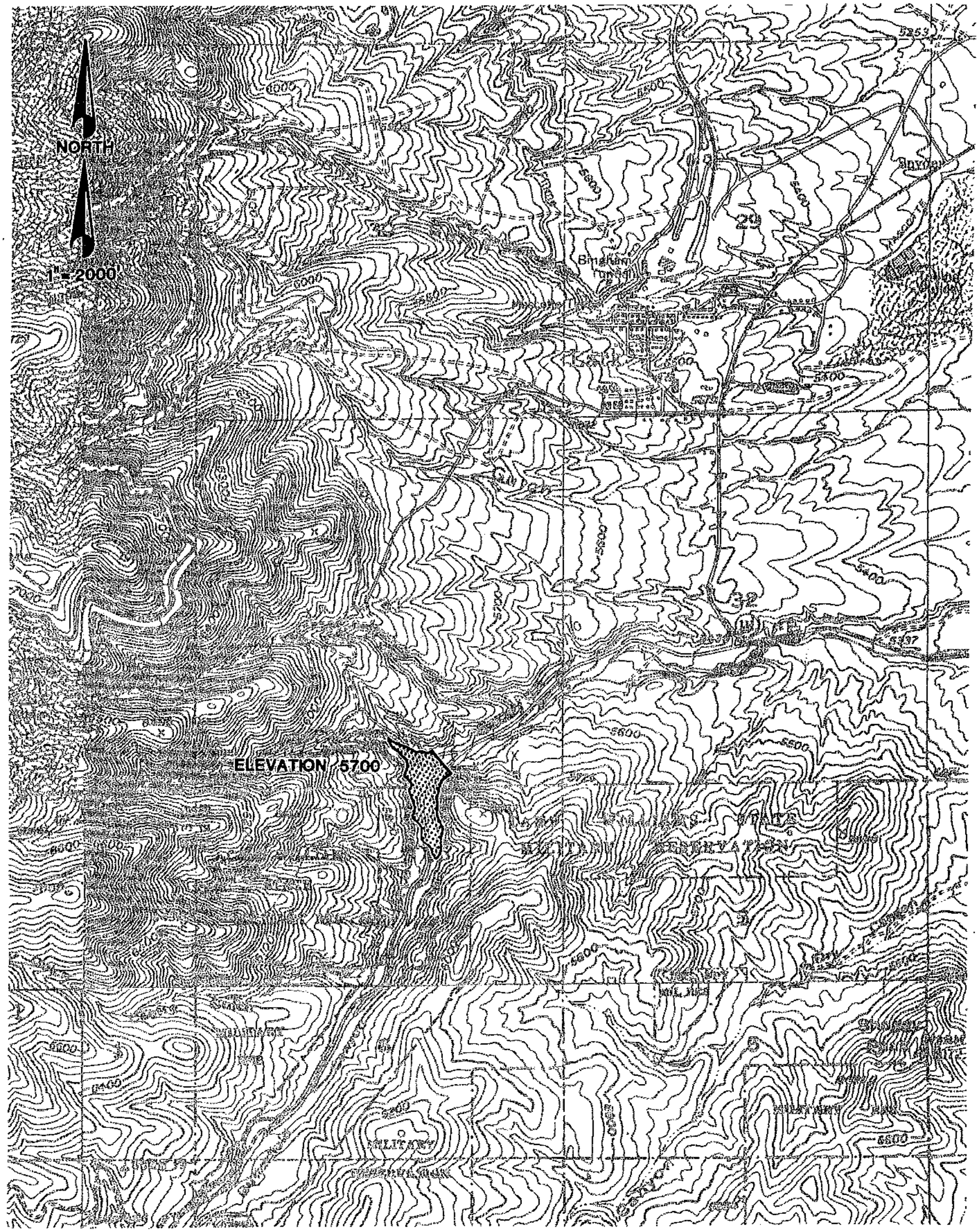
DAMSITES: No known previous study has investigated potential damsites in Butterfield Canyon. A review of the canyon topography indicated a reasonable damsite could be located along the main channel about a mile upstream from the canyon mouth, as shown in Figure VI-49.

The three dams considered would impound 200 acre-feet, the spring runoff volume of 412 acre-feet, and the mean annual yield of 536 acre-feet. Pertinent data regarding these dams are tabulated in Table VI-54.

Construction of a dam at this site would require relocation of about one half mile of existing dirt road. No other utility relocations would be involved. Unit costs were plotted in Figure VI-50 to provide a wide range of costs versus dam sizes.

The two scenarios of reservoir use were the basis from which calculations were made to determine probable reservoir sizes. If the reservoir is used as an equalizing facility the capacity would be 515 acre-feet and it would yield 730 acre-feet of water annually. If the reservoir is used as a peaking facility the capacity would be 726 acre-feet and the annual yield 730 acre-feet. Capacities, yields and estimated unit costs of developed water are summarized on Table VI-55 for both scenarios.

WATER TREATMENT PLANT: The annual flow from Butterfield Canyon is very small when considering a water treatment plant. Therefore, the flows from Butterfield and Rose Canyons were combined as a single source for culinary supply. The alternatives considered are discussed in detail in the preceding section concerning Rose Canyon.

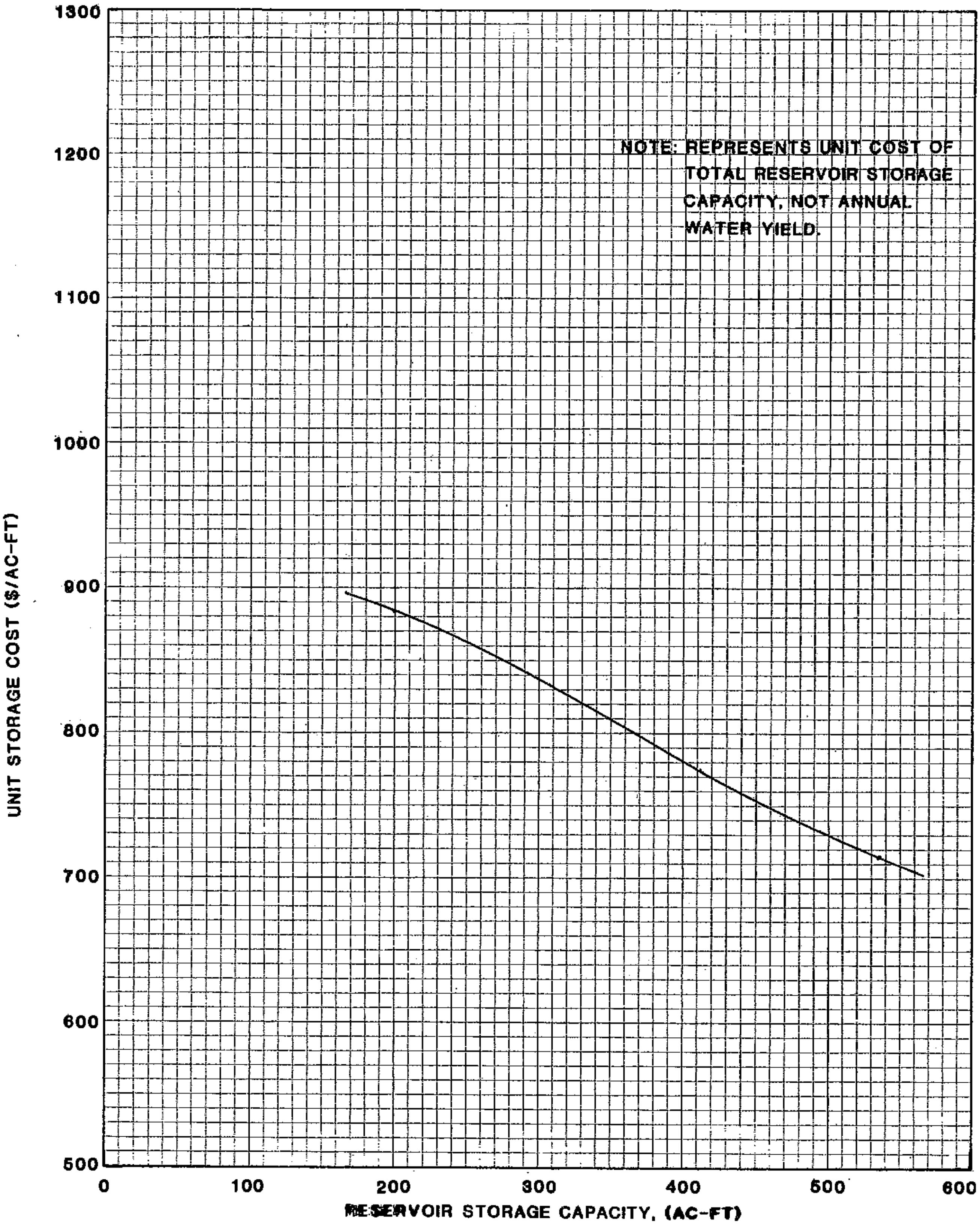


SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

BUTTERFIELD CREEK

FIGURE VI- 49



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BUTTERFIELD CREEK RESERVOIR SITE

FIGURE VI-50

TABLE VI-54
PERTINENT PRELIMINARY DATA
BUTTERFIELD CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS		
		200 Ac-Ft	Spring Runoff Volume 412 Ac-Ft	Mean Annual Yield 536 Ac-Ft
GENERAL				
Drainage Area (square miles)		9.3	9.3	9.3
RESERVOIR				
Gross Pool Elevation (feet)		5846	5870	5878
Gross Pool Area (acres)		8	14	16
Gross Pool Storage (acre-feet)		200	412	536
Ratio of Storage vs. Area (acre-feet per acre)		25.0	29.5	29.8
Probable Land Purchase Requirement (acres)		10	18	21
MAIN DAM				
Top Elevation (feet)		5853	5877	5885
Spillway Elevation (feet)		5846	5870	5878
Maximum Height at Dam Axis (feet)		43	67	75
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		290	370	380
Crest Width (feet)		25	25	25
Outlet Works Capacity (cfs)		30	30	30
Outlet Works Hydraulic Head (feet)		36	60	68
SPILLWAY				
Discharge Capacity (cfs)		340	340	340
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	748,000	1,510,000	1,862,000
Total Dam & Reservoir Capital Cost	($)	1,446,000	2,605,000	3,126,000
Annual Operation & Maintenance Cost (a)	($)	7,000	13,000	15,000
Total Annual Cost (b)	($)	177,000	319,000	383,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital cost over 20 years at 10 percent interest and Anual O&M Cost.

TABLE VI-55

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM BUTTERFIELD CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility[n]	Scenario 2. Peaking Facility[n]	Scenario 3. No Storage Facility[m]
Reservoir Capacity[a]	Ac-Ft	515	726	0
Carry-over Capacity[b]	Ac-Ft	291	291	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	730	730	730
Total Annual Water Yield[e]	Ac-Ft	730	730	730
Unit Storage Cost[f]	$/Ac-Ft	725	630	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	511	626	0
Water Treatment Plant Capacity[h]	mgd	1.4	2.2	2.4[l]
Annual Treatment & Conveyance Cost[i]	$1000	370	470	490
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	507	644	671
Total Unit Water Yield Cost[k]	$/Ac-Ft	1018	1270	671

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-31, adjusted for drainage area at reservoir.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-50.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-48.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.
(n) The mean annual yield of 530 acre-feet at the reservoir site is distributed according to the scenario distribution.

BINGHAM CANYON:

Because of the extensive mining activity in the canyon and the large cost of road, railroad and utility relocations, dams and water treatment plants are not considered feasible for Bingham Canyon.

BARNEYS CANYON:

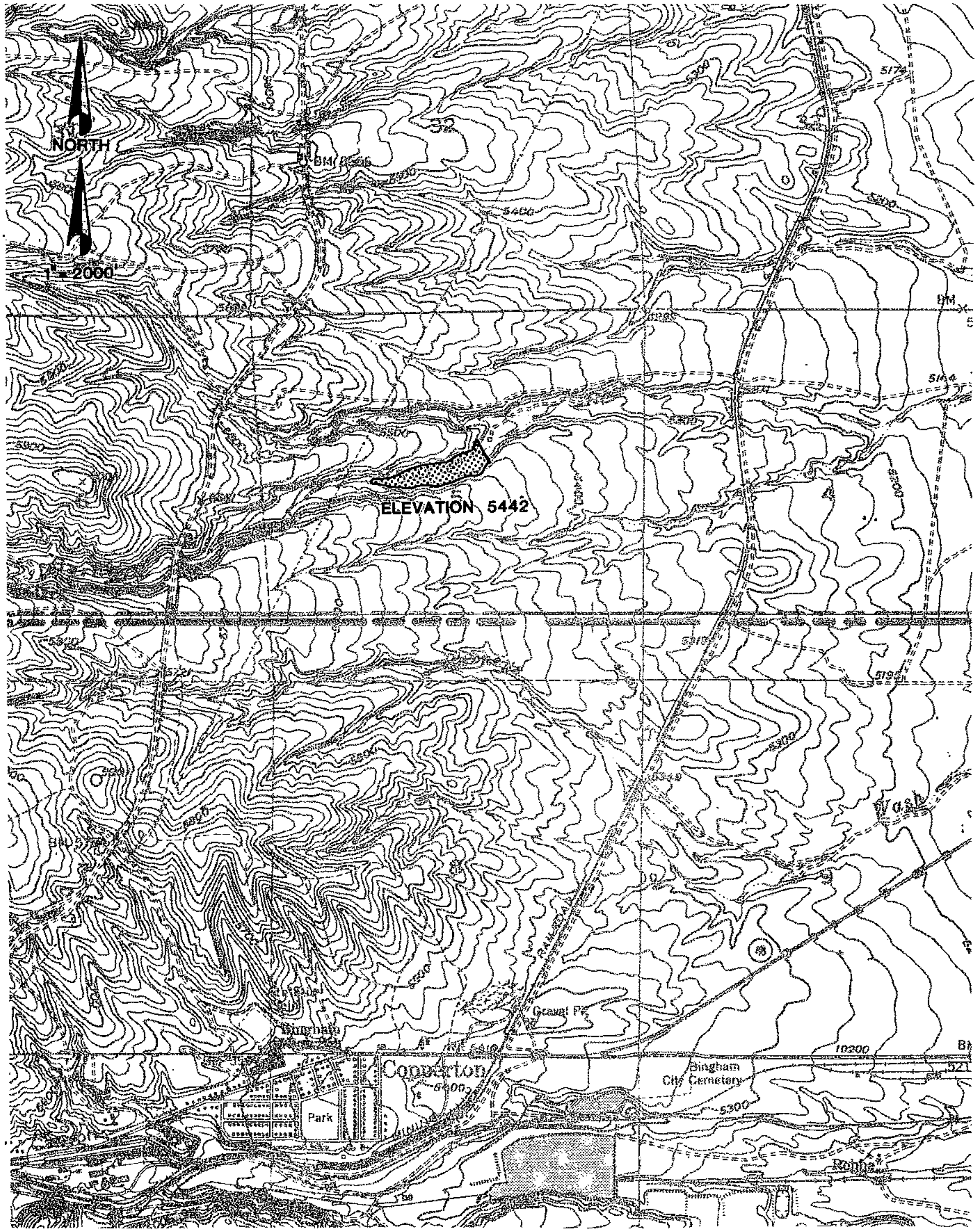
DAMSITES: No known previous study has investigated the possibility of constructing a dam in Barneys Canyon. During this study a potential site was found at the canyon mouth, as shown in Figure VI-51.

Barneys Canyon Creek is not a perennial stream, and normally flows only during the spring months. Because of the creek's intermittent nature, only two dam sizes were studied, one which would impound the mean annual yield of 234 acre-feet, and the other which would impound 100 acre-feet. The pertinent data used in estimating costs for these dams are shown in Table VI-56. Unit costs are plotted in Figure VI-52 to provide a wide range of dam cost versus size information.

The site is fairly well-suited for construction of a dam, based on topography. No utility or road relocations would be required at this site.

Both scenarios of reservoir use were the basis for calculations made to determine probable reservoir sizes. If the reservoir was used as an equalizing facility its capacity would be 260 acre-feet with an annual yield of 234 acre-feet. For scenario two, a peaking facility, the reservoir capacity would be 325 acre-feet with an annual yield of 234 acre-feet. Capacities, yields and unit costs for developed water are summarized in Table VI-57.

WATER TREATMENT PLANT: Because the stream is intermittent, a treatment plant was not considered for this stream. A pipeline to a treatment plant near the mouth of Coon Canyon was considered as a possible means of developing this water for culinary purposes. Table VI-58 shows the estimated total annual costs for pipelines of various sizes.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

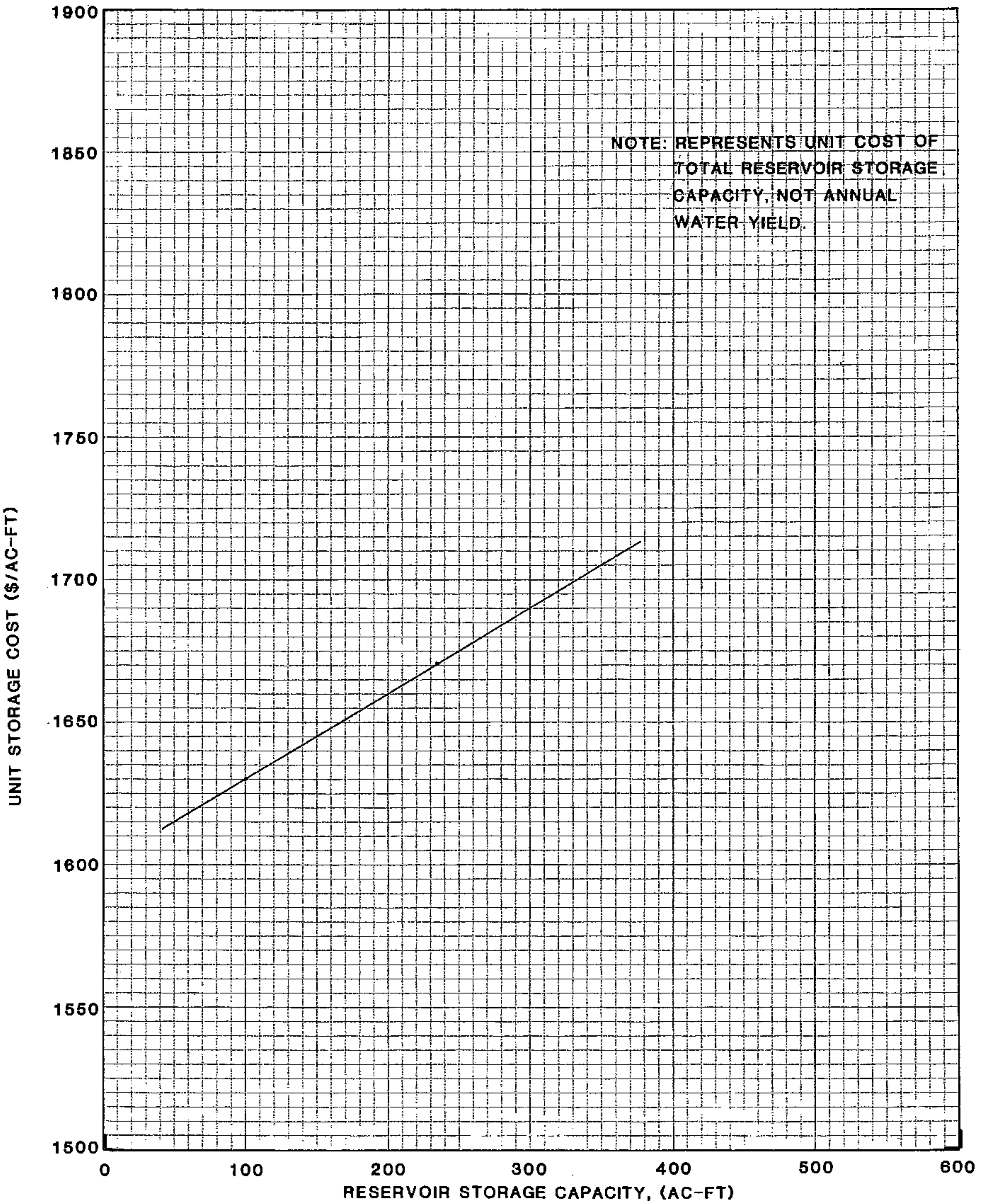
BARNEYS CREEK

FIGURE VI-51

TABLE VI-56
PERTINENT PRELIMINARY DATA
BARNEYS CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS	
		100 Ac-Ft	Mean Annual Yield 234 Ac-Ft
GENERAL			
Drainage Area (square miles)		4.0	4.0
RESERVOIR			
Gross Pool Elevation (feet)		5413	5432
Gross Pool Area (acres)		5.4	8.6
Gross Pool Storage (acre-feet)		100	234
Ratio of Storage vs. Area (acre-feet per acre)		18.5	27.2
Probable Land Purchase Requirement (acres)		7.6	12.2
MAIN DAM			
Top Elevation (feet)		5420	5439
Spillway Elevation (feet)		5413	5432
Maximum Height at Dam Axis (feet)		40	59
Upstream Side Slope		3:1	3:1
Downstream Side Slope		2.5:1	2.5:1
Crest Length (feet)		300	380
Crest Width (feet)		25	25
Outlet Works Capacity (cfs)		20	20
Outlet Works Hydraulic Head (feet)		33	52
SPILLWAY			
Discharge Capacity (cfs)		230	230
Surcharge Head (feet)		3	3
COST			
Dam Capital Cost	($)	748,000	1,289,000
Total Dam & Reservoir Capital Cost	($)	1,391,000	3,191,000
Annual Operation & Maintenance Cost(a)	($)	7,000	16,000
Total Annual Cost(b)	($)	163,000	391,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

BARNEYS CREEK RESERVOIR SITE

FIGURE VI-5

TABLE VI-57

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
BARNEYS CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	260	325	0
Carry-over Capacity[b]	Ac-Ft	127	127	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	234	234	234
Total Annual water Yield[e]	Ac-Ft	234	234	234
Unit Storage Cost[f]	$/Ac-Ft	1678	1705	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	1864	2368	0
Water Treatment Plant Capacity[h]	mgd	0.5	0.9	1.2[l]
Annual Treatment & Conveyance Cost[i]	$1000	387	477	517
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	1654	2038	2209
Total Unit Water Yield Cost[k]	$/Ac-Ft	3518	4406	2209

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-33.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-52
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-48 and Table VI-58.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.

TABLE VI-58

COST ESTIMATE FOR
BARNEYS CANYON PIPELINE TO
COON CANYON WATER TREATMENT PLANT

Pipe Size (inches)	Capacity (cfs)	Percent of Peak Flow (%)	Total Annual Cost ($)
20	15.6	100	242,900
18	12.3	88	213,300
16	8.8	63	191,000
14	6.4	46	166,800

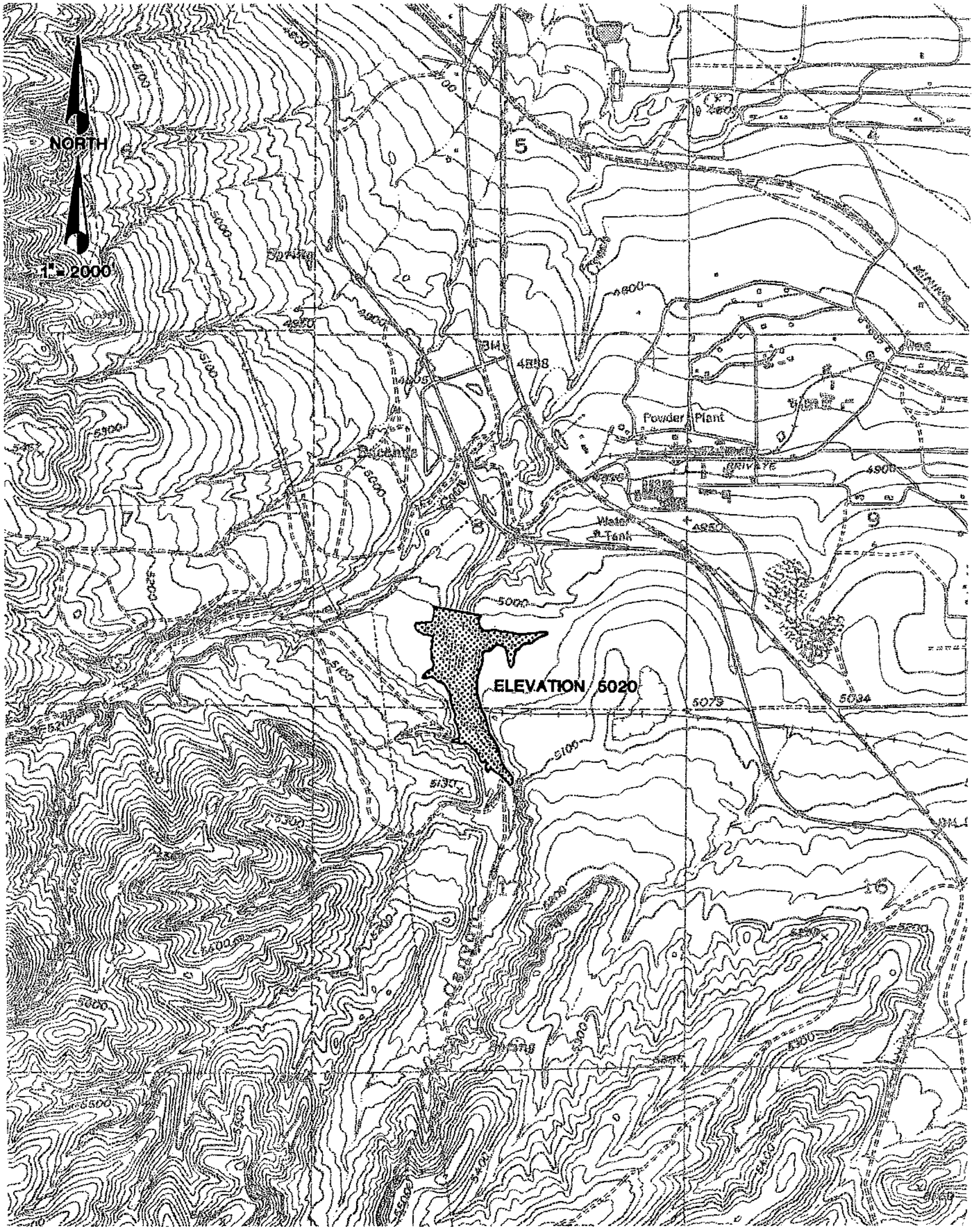
HARKERS CANYON:

DAMSITES: No known previous study has dealt with potential damsites in Harkers Canyon. During this study a reasonable site was found at the canyon mouth just upstream from Highway 111, as shown in Figure VI-53.

The proposed Harkers Canyon Creek damsite, which lies directly on the creek, is very close to Coon Creek, only 1200 feet away. Because of the possibility of installing a fairly inexpensive pipeline from Coon Creek to Harkers Creek, a dam which would impound more than the Harkers Canyon Creek mean annual yield has been studied, as well as two smaller dams. The three dam sizes studied, therefore, would impound 150 acre-feet, the Harkers Canyon Creek mean annual yield of 328 acre-feet, and the combined mean annual yield from both Harkers and Coon Creeks of 1040 acre-feet. The Harkers Canyon Creek damsite is better suited to combining watershed yields than is the Coon Creek site, due to more favorable topography.

The pertinent data used in estimating costs for these three dams are tabulated in Table VI-59. Unit costs are plotted in Figure VI-54 to provide a wide range of costs versus dam sizes. A dirt road relocation would be required for the largest alternative. The two larger alternatives would cause the reservoirs to extend past an existing Kennecott railroad line. Costs for relocating the rail line are included in the total cost estimates.

Calculations were made, based upon the two scenarios of reservoir use to determine probable reservoir sizes for both possible reservoir schemes, Harkers Canyon Creek alone and the combination of Harkers Canyon and Coon Creeks. For Harkers stream flow only, the reservoir capacity under scenario one (equalizing facility) would be 365 acre-feet. The total annual yield would be 328 acre-feet. If it were constructed as a peaking facility the reservoir capacity would be 465 acre-feet yielding 328 acre-feet of water annually. Estimated unit costs are tabulated in Table VI-60.

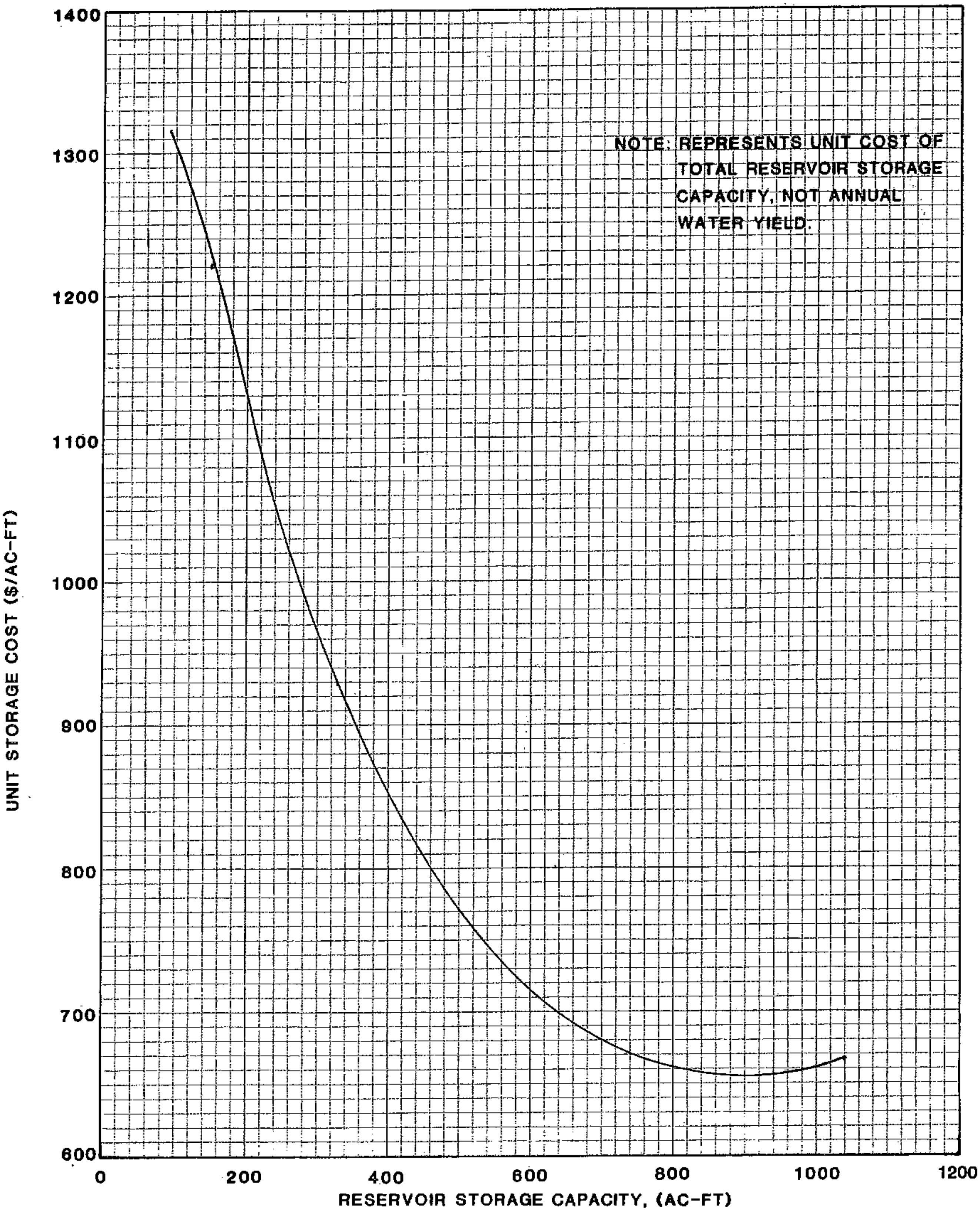


SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

HARKERS CANYON CREEK

FIGURE VI-53



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

HARKERS CANYON RESERVOIR SITE

FIGURE VI-54

TABLE VI-59
PERTINENT PRELIMINARY DATA
HARKERS CANYON CREEK RESERVOIR SITE

	RESERVOIR CAPACITY OPTIONS		
	150 Ac-Ft	Harkers Mean Annual Yield 328 Ac-Ft	Harkers & Coon Mean Annual Yield 1040 Ac-Ft
GENERAL			
Drainage Area (square miles)	6.5	6.5	15.0
RESERVOIR			
Gross Pool Elevation (feet)	4968	4985	5017
Gross Pool Area (acres)	8	14	34
Gross Pool Storage (acre-feet)	150	328	1040
Ratio of Storage vs. Area (acre-feet per acre)	18.8	23.4	30.6
Probable Land Purchase Requirement (acres)	11	19	47
MAIN DAM			
Top Elevation (feet)	4975	4992	5025
Spillway Elevation (feet)	4968	4985	5017
Maximum Height at Dam Axis (feet)	45	62	95
Upstream Side Slope	3:1	3:1	3:1
Downstream Side Slope	2.5:1	2.5:1	2.5:1
Crest Length (feet)	310	380	1200
Crest Width (feet)	25	25	25
Outlet Works Capacity (cfs)	30	30	30
Outlet Works Hydraulic Head (feet)	38	55	87
SPILLWAY			
Discharge Capacity (cfs)	340	340	340
Surcharge Head (feet)	3	3	3
COST			
Dam Capital Cost ($)	767,000	1,307,000	3,226,000
Dam & Reservoir Total Capital Cost ($)	1,500,000	2,495,000	5,668,000
Annual Operation & Maintenance Cost(a) ($)	7,000	12,000	28,000
Total Annual Cost(b) ($)	183,000	305,000	694,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.

TABLE VI-60

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM HARKERS CANYON CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility[m]
Reservoir Capacity[a]	Ac-Ft	365	465	0
Carry-over Capacity[b]	Ac-Ft	179	179	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water yield[d]	Ac-Ft	328	328	328
Total Annual Water Yield[e]	Ac-Ft	328	328	328
Unit Storage Cost[f]	$/Ac-Ft	930	885	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	1035	1255	0
Water Treatment Plant Capacity[h]	mgd	0.6	1.1	1.6[l]
Annual Treatment & Conveyance Cost[i]	$1000	260	340	410
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	793	1036	1250
Total Unit Water Yield Cost[k]	$/Ac-Ft	1828	2291	1250

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-34.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-54.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-58.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment & conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.

The combination of Coon and Harkers Canyon Creeks stream flows would result in a reservoir with a 984 acre-feet capacity if used as an equalizing facility. It would yield 1251 acre-feet of water per year. As a peaking facility these two stream flows would necessitate a 1128 acre-feet reservoir in Harkers Canyon with a yield of 1251 acre-feet. Table VI-61 summarizes capacities, yields, and unit cost estimates for developed water for both scenarios of Harkers Canyon Creek and Coon Creek combined.

WATER TREATMENT PLANT: The annual flow from Harkers Canyon is intermittent and was considered too small to be the sole source for a treatment plant. Therefore, the flows from Harkers and Coon Canyons were combined as a single source for culinary supply. This alternative is discussed in detail in the following section concerning Coon Canyon.

TABLE VI-61

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
HARKERS CANYON AND COON CREEKS COMBINED,
HARKERS CANYON CREEK RESERVOIR SITE

Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage Facility[m]
Reservoir Capacity[a]	Ac-Ft	984	1128	0
Carry-over Capacity[b]	Ac-Ft	483	483	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable annual Water yield[d]	Ac-Ft	1251	1251	1251
Total Annual Water Yeild[e]	Ac-Ft	1251	1251	1251
Unit Storage Cost[f]	$/Ac-Ft	680	640	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	535	577	0
Water Treatment Plant Capacity[h]	mgd	3.7	4.0	4.5[l]
Annual Treatment & Conveyance Cost[i]	$1000	580	600	650
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	464	480	520
Total Unit Water Yield Cost[k]	$/Ac-Ft	999	1057	520

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Tables V-34 and V-35.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yields.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-54.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-58.
(j) Annual treatment & conveyance cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.

COON CANYON:

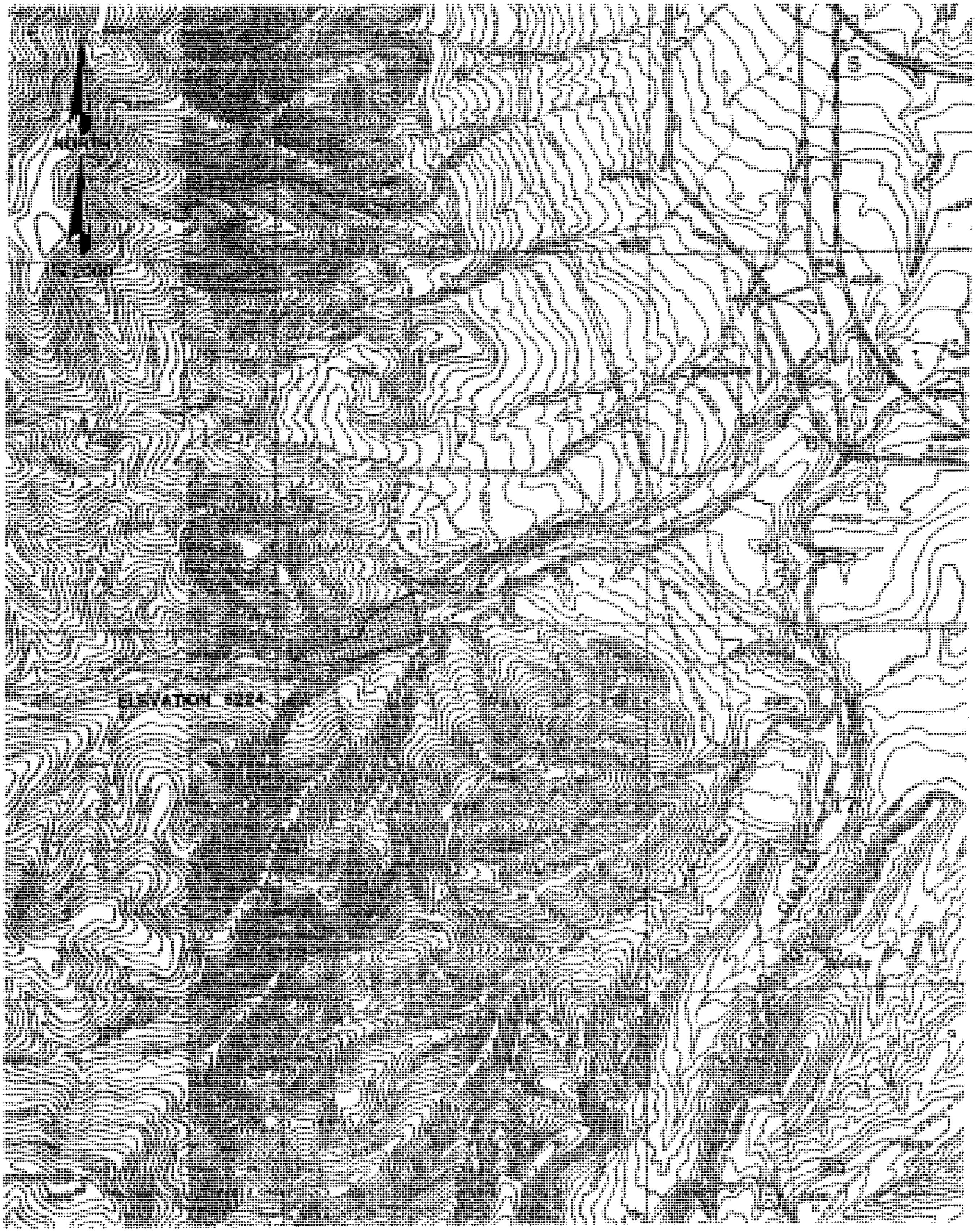
DAMSITES: No known previous study has addressed the possibility of constructing a dam in Coon Canyon. Although no ideal sites were located during this study, an acceptable site was found for estimating purposes. The damsite lies on Coon Creek about one half mile upstream from the canyon mouth, as shown in Figure VI-55.

The three dam sizes considered would impound 300 acre-feet, the spring runoff volume of 544 acre-feet, and the mean annual yield of 712 acre-feet. The pertinent data used in estimating costs are tabulated in Table VI-62. Unit costs are plotted in Figure VI-56 to provide a wide range of costs versus dam sizes.

About one half mile of existing dirt road would be relocated during construction of a dam at this site. No other road or utility relocations would be required.

Calculations were made, based on the two scenarios of reservoir use explained in the introduction, to determine probable reservoir sizes. If the reservoir is to be used as an equalizing facility, which is scenario one, the reservoir capacity would be 619 acre-feet and the annual yield would be 555 acre-feet. Scenario two, the peaking facility calls for a reservoir capacity of 773 acre-feet with an annual yield of 555 acre-feet. Table VI-63 summarizes the capacities, yields and unit costs of developed water under these two schemes.

WATER TREATMENT PLANT: The annual flow from Coon Canyon is very small when considering a water treatment plant. Therefore, the flows from Coon and Harkers Canyons were combined as a single source for a small treatment plant. Figure VI-57 shows the hydrograph of the combined flows and the capacities of various plant sizes. The plant location was considered to be near the community of Bacchus, west of Utah Highway 111. The plant would be fed by diverting the flow from each of the streams directly into the plant. The estimated annual costs (including the amortized capital cost) for various plant sizes at this location are shown in Figure VI-58.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

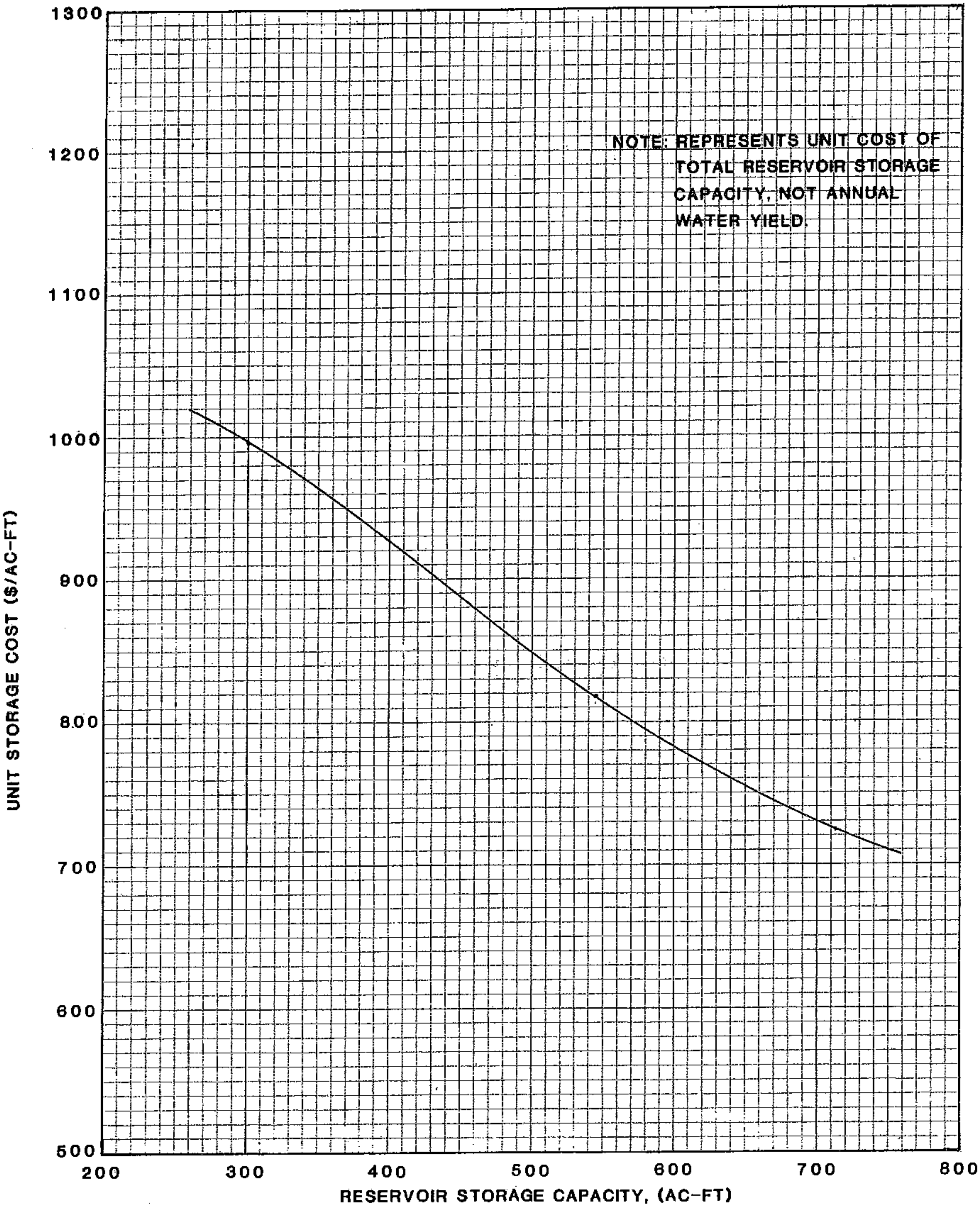
COON CREEK

FIGURE VI-55

TABLE VI-62
PERTINENT PRELIMINARY DATA
COON CREEK RESERVOIR SITE

		RESERVOIR CAPACITY OPTIONS		
		300 Ac-Ft	Spring Runoff Volume 544 Ac-Ft	Mean Annual Yield 712 Ac-Ft
GENERAL				
Drainage Area (square miles)		8.6	8.6	8.6
RESERVOIR				
Gross Pool Elevation (feet)		5192	5210	5220
Gross Pool Area (acres)		12	16	19
Gross Pool Storage (acre-feet)		300	544	712
Ratio of Storage vs. Area (acre-feet per acre)		25.0	34.0	37.5
Probable Land Purchase Requirement (acres)		16	22	26
MAIN DAM				
Top Elevation (feet)		5199	5218	5288
Spillway Elevation (feet)		5192	5210	5220
Maximum Height at Dam Axis (feet)		59	78	88
Upstream Side Slope		3:1	3:1	3:1
Downstream Side Slope		2.5:1	2.5:1	2.5:1
Crest Length (feet)		380	570	630
Crest Width (feet)		25	25	25
Outlet Works Capacity (cfs)		40	40	40
Outlet Works Hydraulic Head (feet)		52	70	80
SPILLWAY				
Discharge Capacity (cfs)		410	410	410
Surcharge Head (feet)		3	3	3
COST				
Dam Capital Cost	($)	1,423,000	2,246,000	2,763,000
Total Dam & Reservoir Capital Cost	($)	2,441,000	3,636,000	4,396,000
Annual Operation & Maintenance Cost(a)	($)	12,000	18,000	22,000
Total Annual Cost(b)	($)	299,000	445,000	515,000

(a) 0.5% of Total Dam & Reservoir Capital Cost
(b) Includes amortization of Total Dam & Reservoir Capital Cost over 20 years at 10 percent interest and Annual O&M Cost.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

UNIT STORAGE COSTS

COON CREEK RESERVOIR SITE

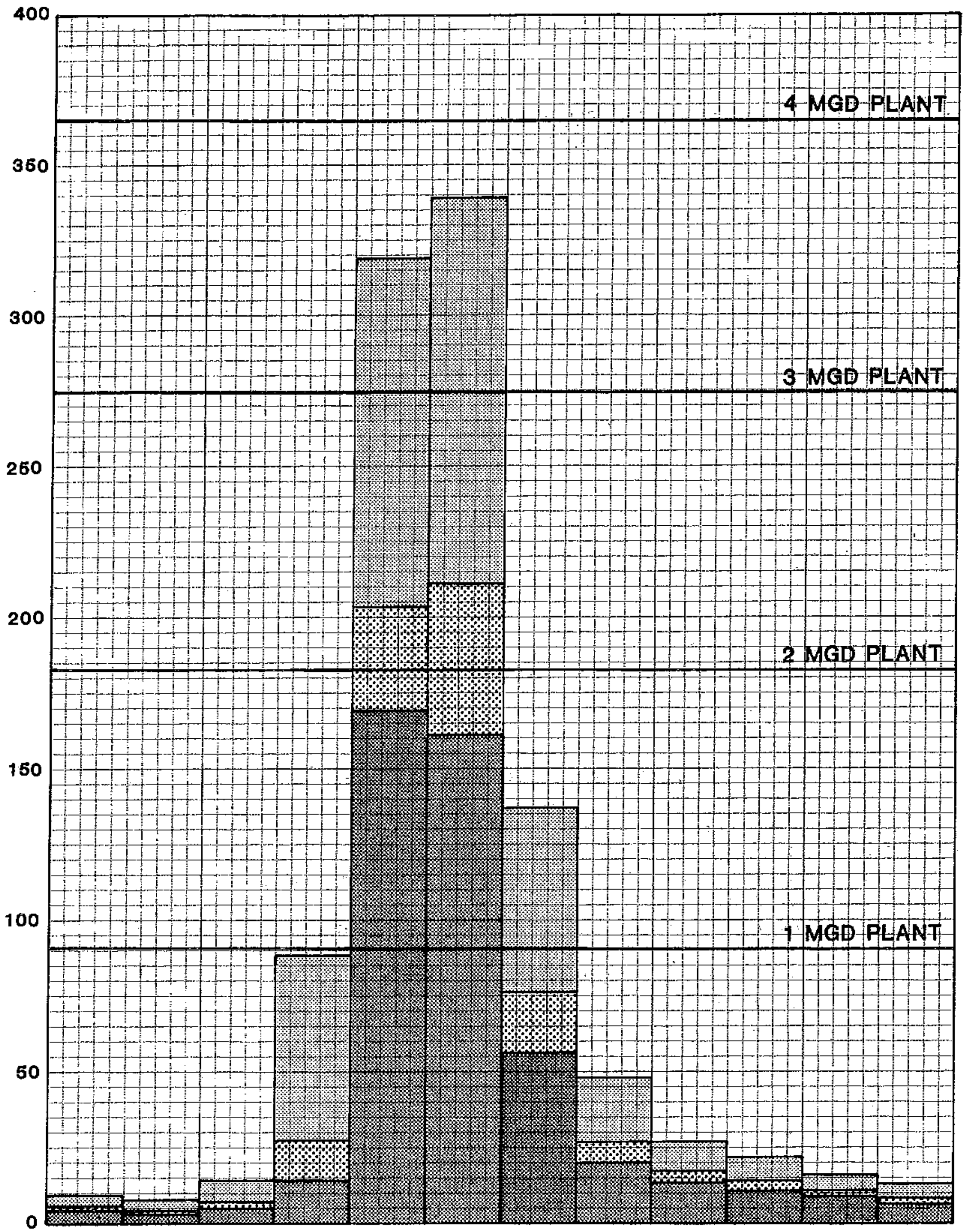
FIGURE VI-56

TABLE VI-63

ESTIMATED COSTS FOR DEVELOPABLE WATER FROM
COON CREEK RESERVOIR SITE

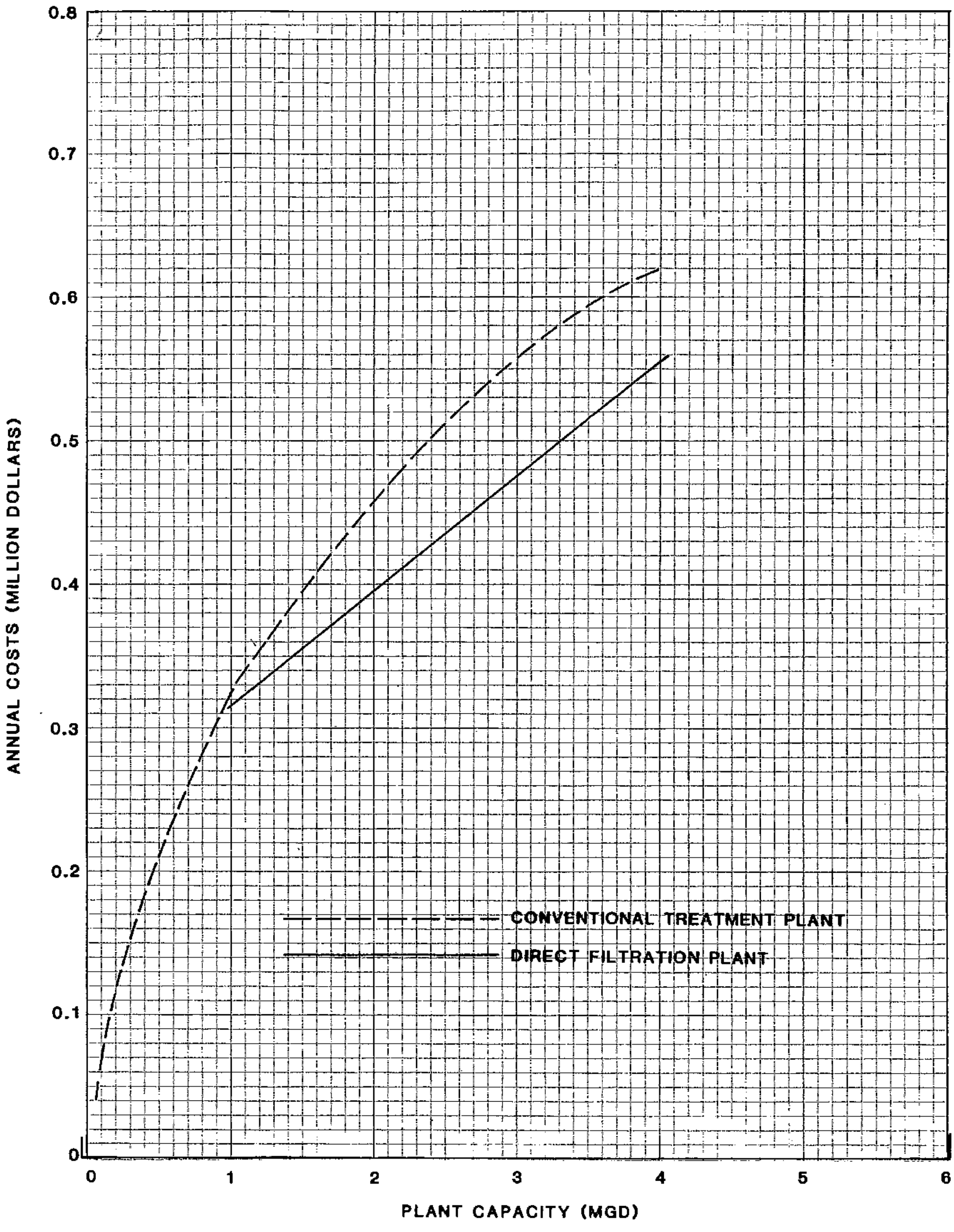
Item	Unit	Scenario 1. Equalizing Facility	Scenario 2. Peaking Facility	Scenario 3. No Storage[m] Facility
Reservoir Capacity[a]	Ac-Ft	619	773	0
Carry-over Capacity[b]	Ac-Ft	304	304	0
Existing Annual Water Yield[c]	Ac-Ft	0	0	0
Developable Annual Water Yield[d]	Ac-Ft	555	555	555
Total Annual Water Yield[e]	Ac-Ft	555	555	555
Unit Storage Cost[f]	$/Ac-Ft	805	725	0
Unit Water Yield Cost for Reservoir[g]	$/Ac-Ft	898	1009	0
Water Treatment Plant Capacity[h]	mgd	1.1	2.1	2.8[l]
Annual Treatment & Conveyance Cost[i]	$1000	340	430	510
Unit Water Yield Cost for Treatment & Conveyance[j]	$/Ac-Ft	613	775	919
Total Unit Water Yield Cost[k]	$/Ac-Ft	1511	1784	919

(a) Includes storage and carry-over capacity.
(b) Calculated as the difference between 50% and 90% probability yields. See annual sums, Table V-35.
(c) No municipal water presently developed.
(d) Additional water developed in excess of existing annual water yield.
(e) Sum of existing and developable annual water yields.
(f) From Figure VI-56.
(g) Total annual reservoir cost (unit storage cost multiplied by reservoir capacity) divided by developable annual water yield.
(h) Based on average flow during peak month demand.
(i) From Figure VI-58.
(j) Annual treatment & conveyancy cost divided by the developable annual water yield.
(k) Sum of unit water yield costs for reservoir and treatment and conveyance.
(l) Plant capacity equals 120% of average peak month stream flow. This assumes that water treatment plant can process all flows during a 50% probability (average) year.
(m) This represents natural unregulated stream flow pattern.



HARKERS AND COON CREEKS COMBINED

FIGURE VI-57



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL TREATMENT AND CONVEYANCE COSTS

HARKERS AND COON CREEKS COMBINED

FIGURE VI-58

JORDAN RIVER:

DAMSITES: Several damsites on the Jordan River have been considered in past reports. Each of the potential sites are located in the same general vicinity, but, they are each unique in specific characteristics. All of the damsites proposed for the Jordan River are located along the southern section of the river where topographical features make a dam feasible.

Three sites were briefly evaluated in the Berger Report.[7] Site A as shown in Figure VI-59 is located at 10600 South. The proposed dam would have a height of 65 feet with a crest length of 3560 feet. The dam would need 1.3 million cubic yards of earthfill for construction. The reservoir capacity would be 46,000 acre-feet.

A 35-foot high dam at site B as shown in Figure VI-59 would be 1600 feet in length and need an earth-fill volume of 160,000 cubic yards. This dam would retain 10,000 acre-feet of water.

Site C located at 12300 South would have a 65 foot dam, 3400 feet long. 1.56 million cubic yards of earthfill would be required for construction. Reservoir capacity would be 40,000 acre-feet.

The Berger Report concluded that Site A was the most feasible and the derived benefits of a dam at this site would be:

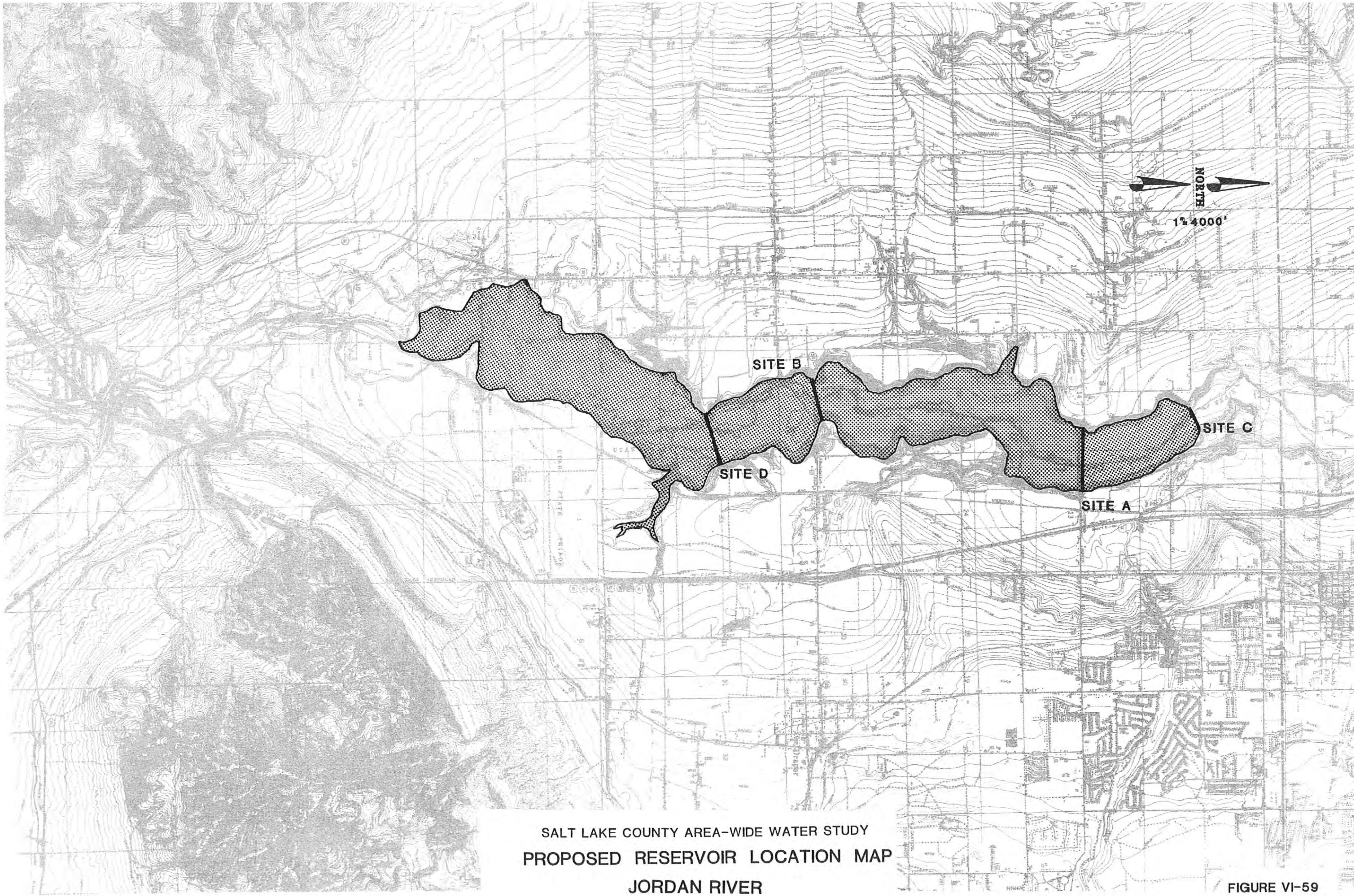
- Provide river regulation and carry-over storage.

- Reduce the channel capacity needed along the Jordan River for purpose of flood control.

- Improve the quality of water on the Jordan River downstream from the dam for all uses by reducing the amount of sediment and bacteria in the water while it is in the reservoir.

- Provide a large water surface area for boating, fishing and other recreational activities.

Another damsite at 10600 South was investigated by the U.S. Corps of Engineers in June 1970.[73] A multipurpose earthfill dam 71 feet high could be built at site A and it would impound 45,000 acre-feet of water. Pertinent data for the proposed dam are shown in Table VI-64.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROPOSED RESERVOIR LOCATION MAP

JORDAN RIVER

FIGURE VI-59

TABLE VI-64 (73)
PERTINENT DATA
JORDAN RIVER LAMPTON RESERVOIR SITE

1. GENERAL DATA	
Name	Lampton Dam
Stream	Jordan River
Purpose	Flood control, municipal and industrial water supply and recreation
Drainage Area at Damsite	3,200 sq. mi.
Runoff Mean Annual	55,000 ac-ft
2. RESERVOIR DATA	
Reservoir Pool Elevations	
Inactive pool	4,330.0 feet
Gross pool	4,365.0 feet
Spillway design flood pool	4,372.0 feet
Reservoir Areas	
At inactive pool	560 acres
At gross pool	1,800 acres
At spillway flood pool	2,020 acres
Reservoir Storage	
At inactive pool	5,000 ac-ft
At gross pool	45,000 ac-ft
At spillway flood pool	57,500 ac-ft
Length of Reservoir	4.3 miles
3. MAIN DAM	
Type	Rolled random gravel fill with impervious core and vertical and horizontal drains.
Elevation - Top of Dam	4,377.0 feet
Freeboard above spillway flood pool	5.0 feet
Maximum height (at axis of dam)	70 ± feet
Side slopes	
Upstream	1 on 3.5
Downstream	1 on 2.5
Length of Crest	3,600 feet
Width of Crest	32 feet
Width of Roadway	28 feet
Total volume embankment, main dam (includes riprap)	1,372,600 cu. yd.

In a report prepared for the Salt Lake County Commissioners in 1972, by Nielsen, Maxwell and Wangsgard Consulting Engineers, two alternative dam configurations were considered for the 12300 South site.(52) One alternative consisted of two small dams and the other alternative proposed one large dam. The two-dam alternative is shown as sites C and D in Figure VI-59 and the single-dam alternative is the same as site C in Figure VI-59. A comparison of some basic specifications is shown in Table VI-65.

TABLE VI-65
COMPARISON OF LAMPTON RESERVOIR ALTERNATIVES

	2 small dams	1 large dam
CAPACITY: (ac-ft)	42,700	46,000
SURFACE AREA: (acres)	1,970	1,920
SHORELINE: (miles)	21	17
TOTAL COST: ($)	16,303,000	25,530,000

The alternative of constructing two dams was favored by the 1972 report for the following reasons:

- Parkway between the two reservoirs can serve as hub of Upper Jordan River Parkway.
- Less costly.
- Most shoreline.
- Upper Reservoir could be used to reduce turbidity of water, and take major fluctuation resulting from future industrial water demand.

In conjunction with the 1972 report, a preliminary soils and design investigation was performed. The final recommendations were as follows:

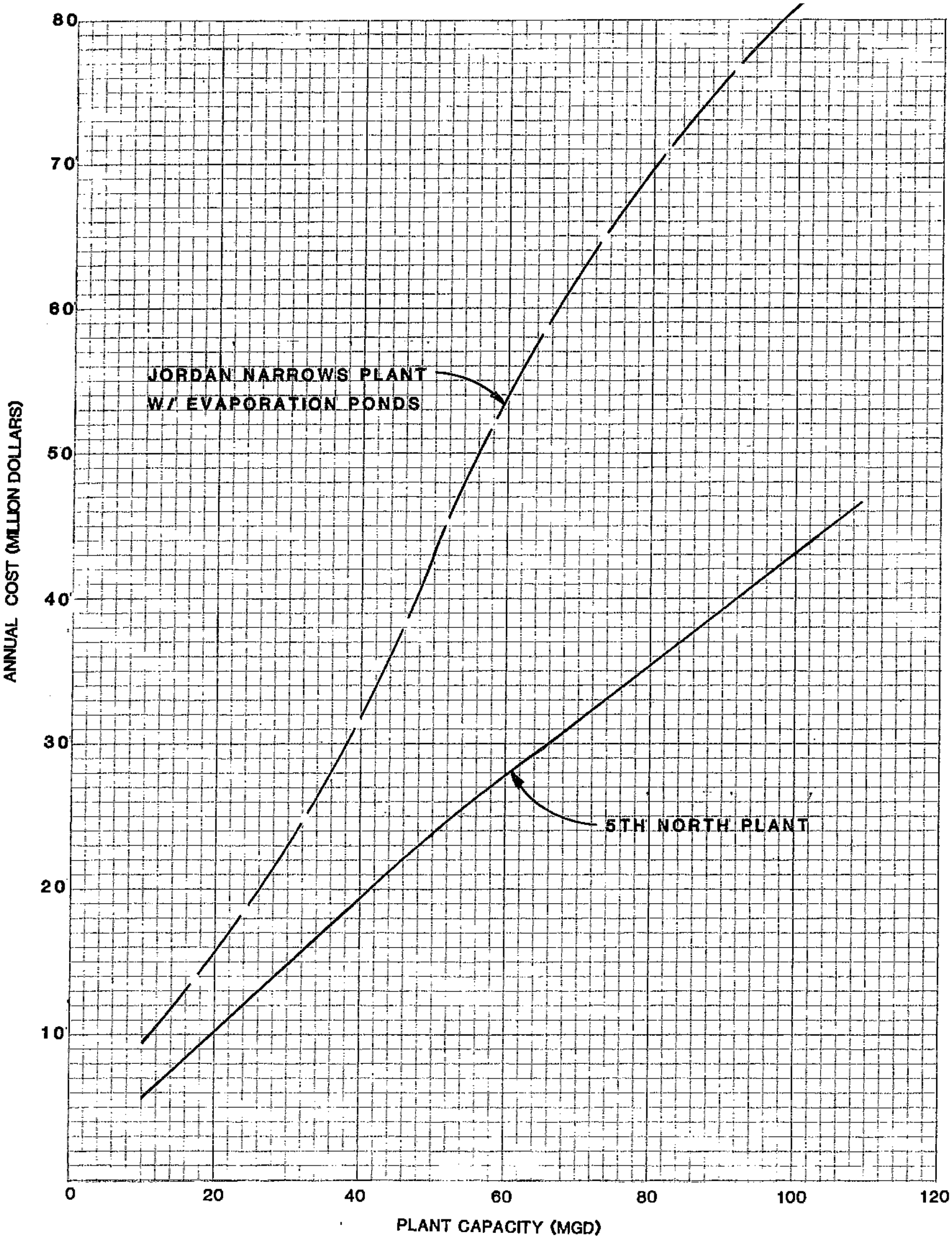
- Both of the damsites are suitable for the construction of the proposed dams and reservoirs.
- Seepage losses will be low.
- Material for dam constructon is available nearby.

Part of the 1972 report dealt with flood control, specifically for Little Cottonwood Creek. The proposed project included the potential for water being conveyed into Lampton Reservoir from Little Cottonwood Creek. Since this aspect of the project does not deal with water supply it was not considered further.

In a report prepared by the U.S. Corps of Engineers in 1978, they also felt that the two reservoir alternative was the most feasible.(75)

Because of the large quantity of water that is available in the Jordan River, the three scenarios assumed for sizing reservoirs and calculating the amount of water yielded from presently undeveloped mountain streams were not considered applicable to the Jordan River. Therefore, no additional damsites were considered in this study.

WATER TREATMENT PLANTS: For analysis purposes, the Jordan River was considered as a source of culinary water both at the south end of the county and the north. In the southern portion of the county, a plant was assumed to be located near the Jordan Narrows. The northernmost plant was considered to be near 500 North. Both plants would be conventional treatment plants followed by a reverse osmosis unit. The total dissolved solids concentration in the raw water was assumed to be 1000 and 1500 mg/l for the southern and northern plants respectively. The estimated annual costs (including the amortized capital cost) for various plant sizes at both locations are shown in Figure VI-60.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

JORDAN RIVER WATER TREATMENT PLANT ANNUAL COSTS

FIGURE VI-60

GREAT SALT LAKE:

The question of desalting water from the Great Salt Lake for culinary purposes is frequently asked. At a lake level of 4,198 feet, the volume of brine is about 14 million acre-feet. The salinity of the lake ranges from 100,000 to 340,000 mg/l.[22]

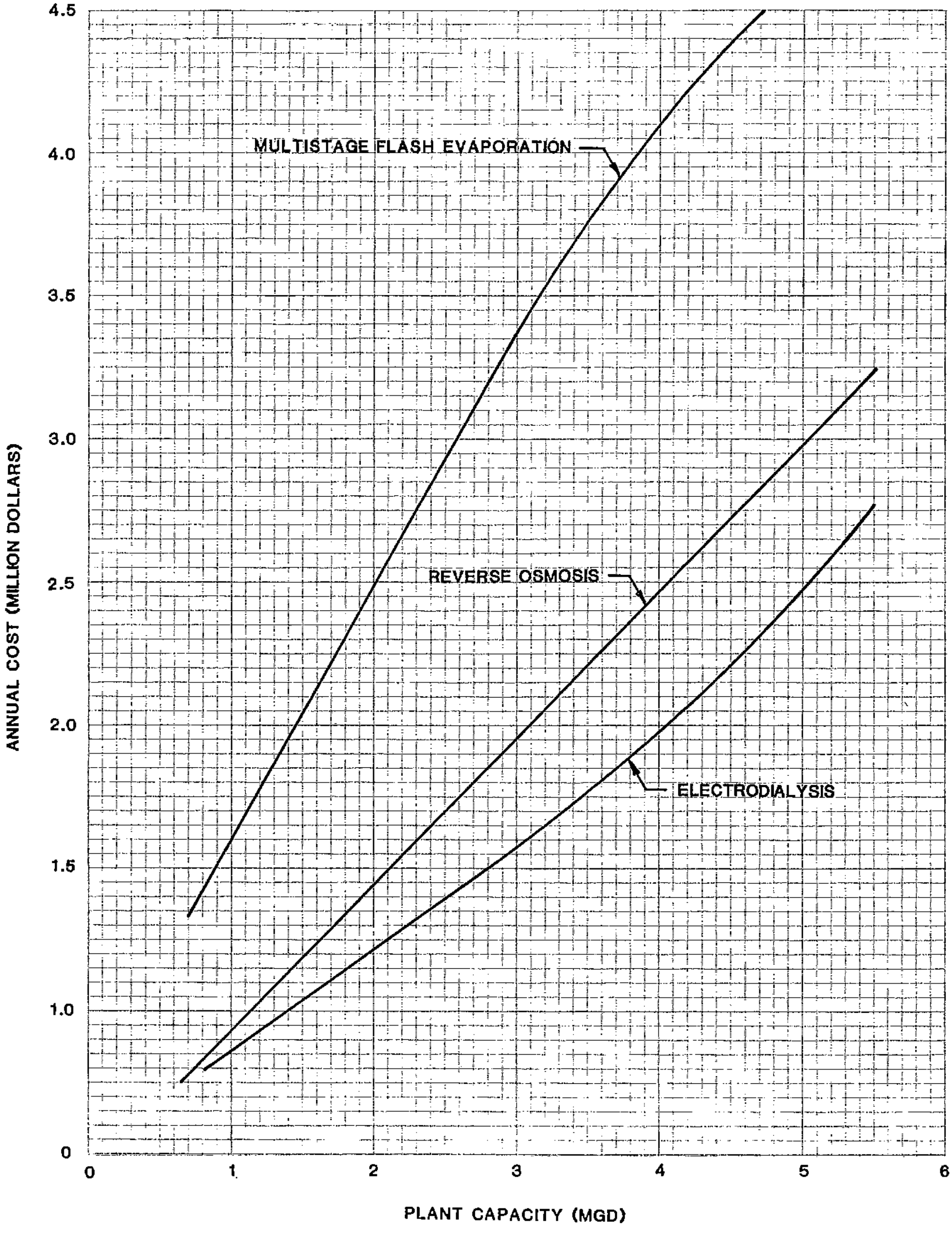
Previously in this chapter several desalting processes were described. The most favorable dissolved solids concentration range for each process was given. As is quickly apparent, the processes are not applicable to water with such a high salinity as the Great Salt Lake. In fact, with the present state of the various desalination processes, it is not economically feasible to desalt brines with a concentration greater than 50,000 mg/l total dissolved solids.[22]

The Utah Division of Water Resources and the Office of Saline Water, U.S. Department of the Interior prepared two studies on desalting water in the Salt Lake Valley. The first study was made in 1968 and proposed a power plant in conjunction with the desalting plant. The source of the water was not the Great Salt Lake, but the brackish water tributaries.[24] The second study, which was published in 1973, updated the costs of the previous study.[22] The alternative of treating the brackish water in the Jordan River is discussed in the previous section.

GROUND WATER:

Development of the ground water within Salt Lake County is being recognized as a means of increasing the water supply. By allowing the water table to rise in the spring and by drawing it down in the late summer, the aquifer acts as a large natural reservoir storing water for later use. As mentioned previously, the study currently being conducted by the U.S. Geological Survey for the water supply agencies of Salt Lake County and the Utah Division of Water Rights should answer the questions concerning the potential use of the ground water.

The water table has been rising in recent years in areas of lower quality water. This water could be used as a culinary source by reducing the dissolved solids concentrations. Shown in Figure VI-61 are the annual costs (including the amortized capital cost) of various desalting processes. The facility would consist of a well, a desalting unit, chlorination facilities, a clearwell, a finished water pumping station, and a two-mile reject-water pipeline.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

DESALINATION PLANT ANNUAL COSTS

FIGURE VI-61

SPECIAL PROJECTS:

DUAL SYSTEMS: A "dual system" exists when a separate irrigation system (usually pressurized) is provided for watering lawns and gardens in addition to a culinary system which may also be used for watering lawns and gardens. As the demand for culinary water increases, consideration is often given to the use of dual systems as a supplement or alternative to enlarging culinary water systems.

There is considerable variance of opinions and facts on dual water systems. Many well-qualified experts have been involved in the design, installation, financing, management, or operation and maintenance of dual systems. There is <u>not</u> complete agreement among these experts on the role of the dual system. A special Ad Hoc Committee is being organized by the Utah Safe Drinking Water Committee to begin within a year to study dual water systems in more detail on a state-wide basis.

The development of dual systems in most urban areas has been a natural occurrence. In some cases dual systems consist of small ditches to each lot, some use the gutter in the streets for delivery, others use buried pipeline under low pressure. Some irrigation is done by flooding lawns and by using furrows on gardens. In other cases water is delivered through pressurized pipelines to each lot and irrigation is by sprinkler.

In the smaller rural towns, it has generally proven economical to convert water use from irrigated commercial crops to lawns and gardens. In order for a pressurized sprinkler system to be economically feasible, it is usually necessary to have enough fall in elevation from the water supply to the place of use to operate the system by gravity pressure. Quite often open ditches and flood irrigation in towns are replaced with pipelines and sprinkler systems. This removes the unsightly and often hazardous ditches and allows easier and more efficient irrigation of lawns and gardens.

In the larger more densely populated metropolitan areas dual systems do not generally exist. (In some places surface dual systems probably existed but were replaced or abandoned when culinary water became more readily available.) The physical complexity of these areas discourages development of an extra system to deliver low quality water for lawns and gardens. There are several reasons for this. Less irrigation water is needed since there are fewer lawns and gardens in the business and industrial areas. The costs are higher for installing the dual systems due to higher land values and more restrictive design criteria. Operation and maintenance is more difficult as the congestion in the city increases.

Approximately 40 to 50 percent of water diverted for municipal use in Salt Lake County is applied to lawns and gardens.[33,41] Applying a 45 percent value to the 1962-75 average municipal diversion of 124,900 acre-feet would mean that approximately 56,200 acre-feet of high quality water was used annually for lawns and gardens. If this percentage of outdoor use continues, by the year 2000 about 115,800 acre-feet of high quality culinary water will be used for lawns and gardens in Salt Lake County.

Replacing all of this high quality water with low quality water using dual systems would be very difficult if not impossible. In residential areas where roads, utility lines, landscaping, and other developments are already in place, disruptions of facilities and costs would be prohibitive. However, as new urban areas are developed, dual systems could be installed along with other facilities, thus reducing costs. Also, where irrigated cropland is converted to residential use, irrigation water would probably be more readily available for dual systems. Costs would be at a minimum although they may still not be economically feasible in all cases.

A recent study of West Jordan City (7500 acres, 35 percent subdivided) indicated that a pressurized irrigation system that would deliver 4000 acre-feet of water would cost over $12 million to construct.[20] The benefit-cost ratio is 0.65:1.0 and the system is not economically feasible at present. A comparison of this pressurized irrigation system to an expanded culinary system to deliver the same amount of water but of higher quality, showed that the pressurized irrigation system would be feasible if the price of culinary water rose to $170 per acre-foot.[20] Culinary water rates are presently considerably below this. For example, the average wholesale rate for the Salt Lake County Water Conservancy District is $104 per acre-foot.

Apparently there is no clear-cut set of conditions under which dual systems become feasible. There are so many variables and factors involved that each system has to be evaluated on its own merits. Adequate design, installation, and management are as important for dual systems as they are for culinary systems. The following factors influence the desirability of dual systems and should be reviewed whenever dual systems are being considered:

a) Availability and reliability of irrigation and culinary water.
b) Location of the residential development in relation to the irrigation water source.
c) Cost of irrigation and culinary water.
d) Quality of irrigation water.
e) Slope and available head for pressure.
f) Size and shape of residential subdivisions and lots.
g) Soil characteristics.
h) Climate (rainfall, temperature, wind).
i) Existing irrigation and culinary distribution systems and organizations.
j) Water laws and ordinances.
k) Health and sanitary regulations.
l) Nature and extent of urban growth.
m) Other demands on water supplies.
n) Desires or demands of water users.
o) Public opinion.
p) Available financing.
q) Costs.

The major argument in favor of dual systems is that irrigation water generally costs less than culinary water. Also the distribution system for delivering irrigation water is usually less costly to install and operate than culinary systems. Most dual systems operate on a flat rate and do not meter individual water usage. The dual system, therefore, normally supplies adequate water for lawns and gardens without the fear of additional cost for occasional overuse.

The major argument against dual systems is the potential health hazard. Almost without exception, water used in dual systems for watering lawns and gardens is not fit for human consumption. Serious illness could result in some cases if the low quality water is taken internally. In areas where dual systems have been in use for a few years and people are accustomed to the systems and familiar with the hazards, fewer illnesses occur from inadvertently drinking the low quality water. The major problem occurs when the irrigation water system is cross-connected to the culinary water system. This can result in contamination of large areas of the culinary system and many people may unknowingly consume the polluted water. This may not only cause serious illness to a large number of people, but may cause considerable cost to each family or household that has to boil water of have clean water brought in. Also, the managers of the dual systems generally have substantial costs in locating the source of the contamination and correcting the situation. Sometimes there is contention between the managers of the culinary water system and the irrigation water system on assigning responsibility when this situation occurs.

CONSERVATION MEASURES: Conserving water means to manage it in such a way that it will last longer than it would without management. This means reducing waste to a minimum, increasing reuse to a maximum, and achieving the best balance possible between the immediate use of water and the anticipated long-term human needs. Water conservation requires that the users want to conserve water and that they know how to conserve water. Various ways on how to conserve water are shown in Table VI-66. The reduction in withdrawals or the amount of water "conserved" by these measures and the cost required to implement them are variable and were not analysed in this study.

Municipal: The use of low water using fixtures and appliances in residences, apartments, and commercial buildings is often listed as an important water conservation measure.(2) Measurable savings can be achieved by repairing leaks in delivery and distribution systems. It has been demonstrated that metering water results in a reduction in urban water use. The consumers' awareness that cost is related to the amount of water used is often an effective deterrent to waste. Pricing structures such as the increasing block rate may reduce water use in some areas but in Salt Lake County it is generally thought to be only temporary in nature unless the rate is extremely high.

A substantial savings can be realized through reductions in outside water use. In areas where dual water systems are installed, the use of treated culinary water has been reduced by 40 to 50 percent.[41] While this will reduce the demand on culinary water, the total water use may not decrease since outside demands are not changed.

Industrial: Many commercial and industrial establishments which use large amounts of water have the opportunity to reuse waste water. Car washes, for example, could filter and recirculate water. Proper planning of municipal waste-water treatment facilities to allow for reuse within the water service area can reduce requirements for fresh water production. Where it does not constitute a health hazard, waste water can be used on parks and golf courses, plant cooling, other forms of industrial use, maintenance of recreational lakes and ponds, and fish and wildlife enhancement.

Agricultural: One major opportunity for water conservation is to reduce the withdrawal for irrigated cropland. If the overall irrigation efficiencies in Salt Lake County were increased 20 percent, irrigation water diversion requirements could be reduced by about 50,000 acre-feet for the estimated 35,000 acres of irrigated cropland. This water would then be available for irrigation of additional cropland or for other uses.

Well designed and maintained irrigation distribution systems can greatly reduce seepage losses. Once the water is delivered to the farm, additional water conservation can be achieved by improved irrigation application methods and systems.

Although the first requirement of efficient use of water is a well-designed system, the greatest water savings will result from good management of the system. This means applying the right amount of water to the plant at the right time. Success requires a great deal of effort and proficiency on the part of the farm managers and the irrigator. Any agricultural water saving program will have to have a definite economic benefit to the farmer before it becomes reality.

TABLE VI-66

WAYS TO CONSERVE WATER[2,51]

In The Home

- Repair leaking faucets. A slow drip can waste as much as 170 gallons or water each day.
- Put a flow restrictor on shower heads to slow down the flow.
- Repair leaking toilets. The loss can be greater than a leaking faucet.
- Take quick showers rather than baths and wash hair in the shower. Turn the water off while soaping and shampooing; turn it on to rinse.
- Fill the sink with water for face washing or shaving rather than running the water. Turn off the water while brushing teeth.
- Attach water-saving devices to toilets and faucets. When buying a toilet or shower, look for new models that use less water.
- Avoid unnecessary flushing, and don't use the toilet for a trash basket.
- Always load washing machines and dishwashers to capacity - use light load setting whenever possible.
- Don't wash dishes with running water. Fill a dishpan or sink for washing and one for rinsing.
- Accumulate the garbage before running the disposal.
- Keep a container of drinking water in the refrigerator or keep a thermos of ice water on the counter.
- Use a small pan of water for cleaning vegetables rather than running water.
- Insulate all water pipes to avoid long delays and wasted water while waiting for the water to run hot.
- Check for leaks between the house and the meter.

In The Yard

- Water established lawns sparingly during the first cool weeks of springs to encourage deeper rooting of the grass.
- Landscape with trees and shrubs that require less water.
- Don't over water. Avoid runoff. Watering sidewalks and driveways will not make the grass greener.

- Avoid watering at windy times and during the heat of the day. This will reduce evaporation and give a more uniform distribution.

- A sprinkler system should be carefully designed to give uniform distribution on the lawn.

- Keep grass farily long. Taller grass holds moisture better.

- Never "sweep" walks and driveways with a hose. Use a broom instead.

- When washing the car, use a bucket of soapy water and use the hose only for rinsing.

On The Farm

- Install pipe or lining in canals and ditches to reduce seepage losses. This will also reduce the transpiration losses by ditch bank vegetation.

- Consolidate or realign parallel or overlapping ditches to reduce seepage and evaporation losses.

- Install measuring devices and control structures in delivery systems to provide for better management and distribution of irrigation water.

- Carefully consider the soil, crop, topography, water supply, and related costs before selecting an irrigation method or before changing to a different method. Select the method that will give the highest degree of efficiency. Border, furrow, sprinkler, and drip methods are all applicable in Salt Lake County.

- Design and operate the distribution system best suited to the application method selected. Typical improvements for various systems might involve ditch lining, pipelines, land leveling or smoothing, new control structures, measuring devices, tailwater recovery, gated pipe, and automation.

- Regardless of the application method or the distribution system, carefully manage the water to apply the right amount of water to the plant at the right time.

- Select a cropping pattern that will have a consumptive use demand similar to the available water supply. This will help avoid over irrigation in the spring when water supplies are generally abudnant, and underirrigation later in the season when water supplies decrease.

Downtown

- Recycle water at car washes, swimming pools, and fountains.

- Serve water in restaurants upon request only.

- Install water-saving devices and repair leaking fixtures and appliances in hotels, laundries, motels, restaurants and office buildings.

- Sweep streets and gutters with brooms and machines instead of water.

- Design landscaping around office buildings and retail businesses to minimize use of water.

<u>Within The County</u>

- Make use of modern technology that requires less water for cooling of powerplants, refineries, and similar industries.

- Use waste water to irrigate golf courses, parks and cemeteries.

- Landscape roads, churches, schools, hospitals and other institutions with plants that require minimum water. Design watering systems to distribute the proper amount of water at the right place and the right time.

- Initiate and support public education programs to make citizens "water conservers". People must see the need and benefits from saving water. Knowing how to conserve is not enough. Water conservation should be a way of life, not an alternative.

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