

Seattle City Clerk's Office

Comptroller File

218518

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

218518

City Council

16



1952

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

A WATER SUPPLY
for Greater Seattle

THE CITY OF SEATTLE
DEPARTMENT OF ENGINEERING

R. W. FINKE, CITY ENGINEER
MEMBER, BOARD OF PUBLIC WORKS

In Re:

September 26, 1952

The Honorable City Council
Seattle, Washington

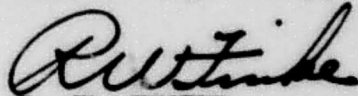
Gentlemen:

Today I have sent to each member of your honorable body a copy of a report entitled "A Water Supply for a Greater Seattle." This report, which is the result of months of careful study, makes a number of specific recommendations which, if adopted and acted upon, will set the pattern for the development of a water supply for Seattle and its environs for as far into the future as it is possible to foresee.

Your attention is directed to the fact that some of the recommendations require immediate consideration, as they involve needed improvements to the present system, as well as expansion to take care of new areas.

I believe that it would be helpful to you if a meeting could be arranged at which this report could be discussed in detail, and I respectfully suggest that such a meeting be scheduled at your earliest convenience.

Yours very truly,

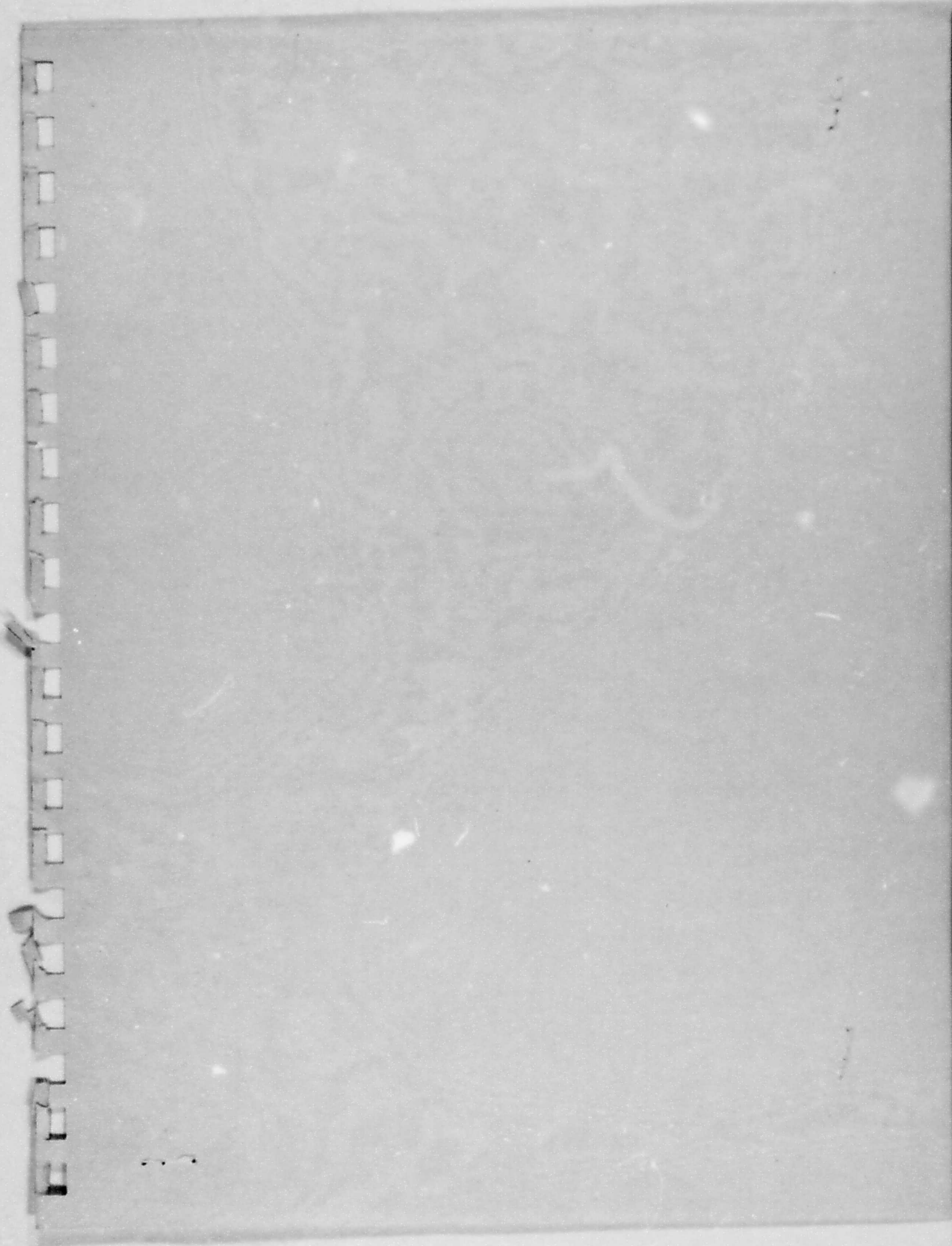


R. W. FINKE
City Engineer

RWF:vs

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



THE CITY OF SEATTLE
DEPARTMENT OF ENGINEERING

R. W. FINKE, CITY ENGINEER
MEMBER, BOARD OF PUBLIC WORKS

In Re:

Honorable City Council
Seattle, Washington

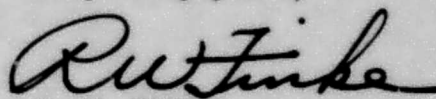
Gentlemen:

As directed by the City Council in its meeting of June 25, 1951, and authorized by Ordinance No. 80109, the Engineering Department has made engineering studies of a comprehensive plan for water supply to the metropolitan area surrounding the City of Seattle.

An aerial survey of the Tolt River Basin and proposed pipe line route into Seattle has been completed.

The results of these surveys and studies are contained in the following report which is respectfully submitted herewith.

Very truly yours,

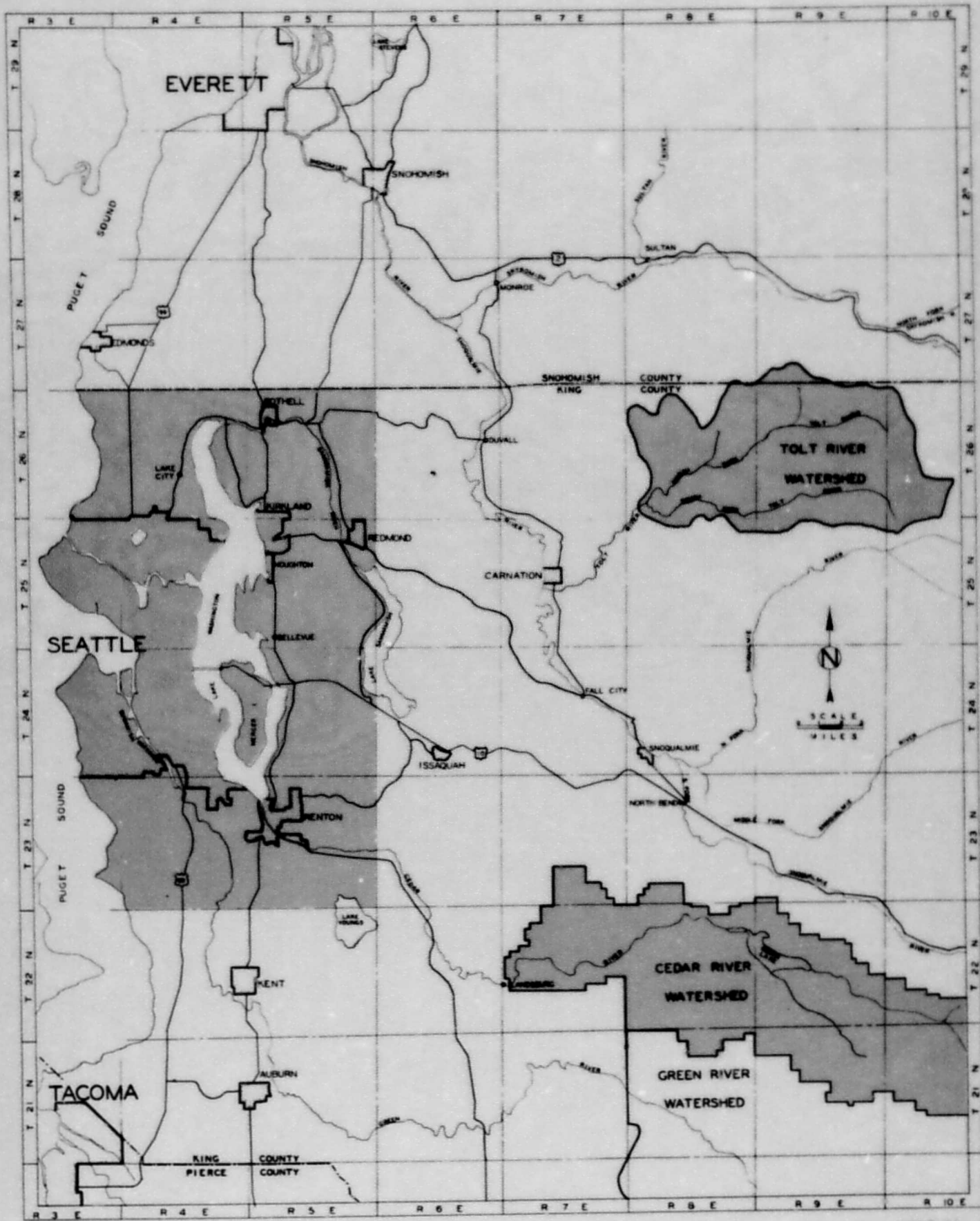


R. W. FINKE

City Engineer

HWT:dep

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



MAP No. 1

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE IT IS DUE TO THE QUALITY OF THE DOCUMENT.

INTRODUCTION

For many years since the construction of the diversion dam on the Cedar River at Landsberg and the control works at Lake Youngs, the Seattle Water System has enjoyed a steady and prosperous growth. There has always been an ample supply of highest quality water, requiring a minimum of treatment, available on the Cedar River. Diversion was made at an elevation high enough to supply most of the City by gravity flow through transmission lines to distribution reservoirs in the City. The system was built at a time when construction costs were low. Because of the low plant costs and good management by the Water Department the City of Seattle has enjoyed top quality water at the lowest rates.

The clay and glacial till deposits in the Seattle area have not proven productive of large quantities of ground water. This has led adjacent areas and water districts to buy their water from Seattle. It has been the policy of the City to serve these areas because of the probable eventual annexation to the City. The capacity of the water supply from the Cedar River has been ample in the past to supply all of these needs and it has seemingly been good business for the City to sell water to these neighboring water districts at wholesale rates. By doing so we have relieved them of the need for developing their own surces of water supply and have obligated ourselves to meet a continuing and ever increasing demand.

Construction of new transmission lines and supply facilities have not kept ahead of the demand and at present the pipe line capacity into the City is less than the daily demand on many days in the summer months. The excess demand is met by water withdrawn from the distribution reservoirs in the City. This situation is normal within certain limits, as these reservoirs are designed in part for this use.

The areas east of Lake Washington have also experienced this rapid growth, especially since the Lake Washington Floating Bridge has become toll free. Some of these cities or towns are handicapped in their expansion by lack of sufficient quantities of potable water and have expressed themselves as desirous of obtaining water from the City of Seattle System.

New construction will be required in the immediate future to supply the normal growth of the areas already committed. The City is faced with the decision of whether or not to supply further additional areas when requested. Failure by the City to assume responsibility of supplying its metropolitan area may precipitate the formation of a metropolitan water district which will compete with the City for the available water resources.

The development of any new or additional water supplies will be costly in relation to the cost of its present system and will require several years to accomplish. It is not probable that this cost will be less in the foreseeable future and with the increase of improved land, right of way costs may increase. These events have brought about the need for this water supply study.

PURPOSE

It is the purpose of this study and report to develop a plan whereby the water resources of the Cedar and Tolt Rivers can be distributed to the areas lying within their economic reach. The plan of development can and should be made according to a master plan so that costly duplications and replacements will not become necessary. These resources can be made available to incorporated cities and towns or to water districts lying within this area and distributed by them as well as by the City of Seattle in its present or expanded City limits.

SCOPE OF REPORT

The area treated in this report extends from Puget Sound on the west to Lake Sammamish on the east and from the Snohomish-King County line on the north to South 192nd Street on the south, roughly containing a land area of 307 square miles or approximately 4.3 times the

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

present area lying within the corporate limits of the City of Seattle. This area will adequately contain a future population of 1,380,000 people, based upon population densities predicted by the King County Planning Commission.

These boundaries are arbitrary and with a full development of the water resources available to the City of Seattle from the Cedar and Tolt Rivers may well be expanded further, particularly to the north where Seattle water already extends north of this political boundary. It is probable that the City of Everett will likewise expand its water distribution southward in the future and the common boundary for water supply purposes will be determined more by economic than by political subdivisions. With an added supply for future industrial use it is not unreasonable to expect a demand comparable to a population of 1,750,000 people by the year 2000.

It is also recognized that there may be a demand for water on the east side of Lake Sammamish and from towns along the route of a pipe line from the Tolt River into Seattle. These populated areas within economic reach of the pipe line can be supplied from the Tolt River, or other future sources.

SOURCES OF WATER SUPPLY

Several sources of water supply are available to the Seattle metropolitan area. They consist of the following:

Mountain streams including the Cedar River, the Tolt River and the north fork of the Skykomish River.

Underground water supplied by deep wells and springs.

Water taken from Lake Washington and treated to drinking water purity.

Of these available sources, the water from mountain streams is considered to be the best. Seattle can be justly proud of its gravity water supply from the Cedar River watershed. The purity of this water is such that it requires no treatment and the slight amounts of chlorine and ammonia added is a precautionary measure due to storage in open reservoirs. Analysis of the Tolt River water discloses a composition closely resembling that of the Cedar River and its purity can be likewise controlled. Filing was made on the water rights of the Tolt River in 1936. It is believed that there are no other legal claims to this water at present. Filing has recently been made on the water rights of the north fork of the Skykomish River by the City of Seattle as part of its long range program. Development of the Skykomish River will probably not be required for several decades and is therefore not discussed further in this report. Possibilities for development of the Tolt River are fully discussed later.

Underground water resources can be developed by drilling wells. The water available from this source is dependent upon many factors and the suitability of any area to ground water supply can only be proven by test drilling. The amount of water available depends upon the rainfall, permeability of the soil and the water capacity of the ground. A number of wells of limited capacity are in use in this area. The following table shows the known wells of over 100 g.p.m. capacity in the area considered in this report. The total capacity of existing wells is 22 m.g.d. or 10% of the total water used.

The quality of the water of these wells in general is not equal to the Cedar River water. Several have mineral content which impart a taste to the water which is objectionable and difficult to remove.

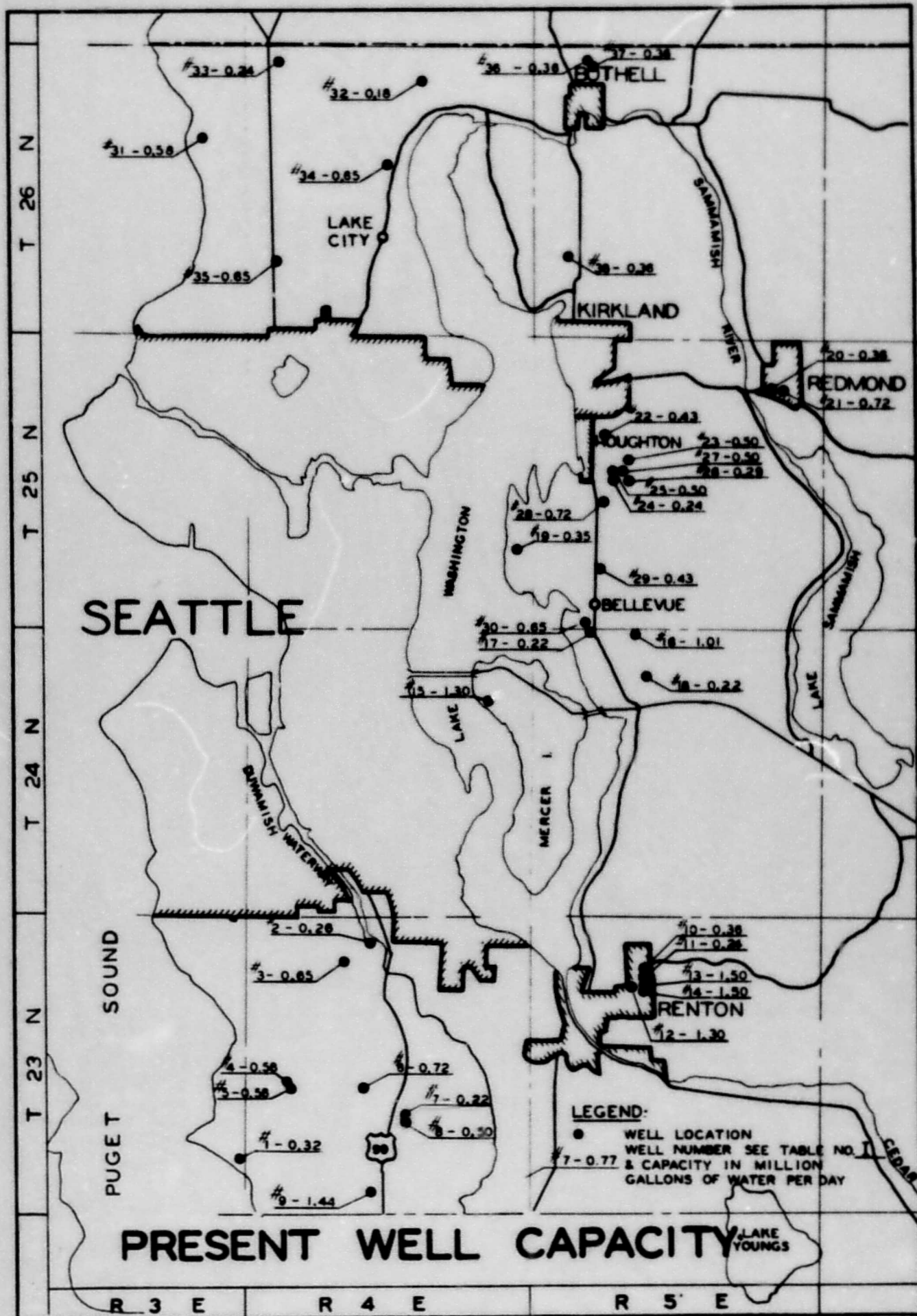
The deposits of clay and fine sand generally found in the Seattle area have not proved favorable to the development of large wells and it is our opinion that this means of water supply, if used, should augment the mountain stream supply rather than be a major source of supply.

TABLE I
WELLS IN NORTHWESTERN KING COUNTY WITH KNOWN YIELD OVER 100 GPM

Owner	Depth (feet)	Diameter (inches)	Yield (mgd)	Yield (gpm)	Remarks
1. Water Dist. #4	228	12	0.32	225	2817 S.W. 172nd St., Seattle.
2. Acme Packing Co.	686	12-8	0.26	180	Reported sand aquifer.
3. Rainier Golf Club			0.65	450	Reported gravel aquifer.
4. Water Dist. #49	533	10-8	0.58	400	Log available.
5. Water Dist. #49	352	8	0.58	400	Log available.
6. Riverton Heights	250		0.72	500	
7. So. Seattle Land Co.	327	10-6	0.22	150	Log available.
8. So. Seattle Land Co.	485	12	0.50	350	Log available.
9. Port of Seattle Bow Lake Airport	396	18-8	1.44	1000	Log available.
10. Northwest Water Co.	180	8	0.36	250	
11. City of Renton	175	22-10	0.24	170	Log available.
12. City of Renton	424	24-10	1.30	900	Log available.
13. City of Renton	82	26-16	1.50	1040	Log available.
14. City of Renton	82	26	1.50	1040	Log available.
15. Mercer Island Water Co-op	62	19	1.30	900	Log and analysis available.
16. Water Dist. #68	610	12-8	1.01	700	Log and analysis available.
17. W. K. Detwiller	500	8	0.22	150	Log available.
18. Norwood Village	140	10-8	0.22	150	Log and analysis available.
19. R. Reid	561	8	0.35	244	Log available.
20. John D. Graham	15	60	0.36	250	Log and partial analysis available.
21. City of Redmond	56	18-10	0.72	500+	Log and pumping test.
22. Lake Washington Shipyard	115	10	0.43	300	Log available.
23. City of Kirkland	200	12	0.50	350	Log available.
24. City of Kirkland	108	8-6	0.24	168	Log and analysis available.
25. City of Kirkland	131	10	0.50	350	Log available.
26. City of Kirkland	148	8	0.29	200	Log available.
27. City of Kirkland	134	8	0.50	350	Log available.
28. Water Dist. #68	244	12	0.72	500	Log and analysis available, Pumping Test.
29. Water Dist. #68	1125	24-12	0.43	300	Log and analysis available, Pumping Test.
30. Water Dist. #68	485	12	0.65	450	Log and analysis.
31. Boeing #2 Game Farm	320	10	0.58	400	Log available.
32. Lake Forest Park Water Co.	172	6	0.18	125	Log available.
33. Fred A. Rood	275	8	0.24	165	Log available.
34. Acacia Memorial Park	287	10	0.65	450	Log available.
35. Washelli Cemetery	250	12-10	0.65	450	Log available.
36. Bothell Water Dist.	224	8	0.36	250	Log and analysis available.
37. Bothell Water Dist.	230	8	0.36	250	Log available.
38. Water District #72	184	18-12	0.36	250	Log and analysis available.

From information furnished by the Underground Water Resources of the U. S. Geological Survey.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



MAP No. 2

Water taken from Lake Washington and treated presents many disadvantages of which a few are enumerated here.

Large and costly purification plants would be required to treat the quantity of water required. The treated water would all have to be pumped to storage reservoirs otherwise possible of supply by gravity. The temperature of the water would be high, which would stimulate objectionable algae growth in the reservoirs and require greater residuals of chemicals in the water than now used. These reasons were considered sufficient to reject this source by early engineers of our water supply and the increase of populated areas surrounding Lake Washington with the resulting sanitation problem has verified their vision.

Since the amount of water now entering Lake Washington is no more than necessary to provide lockage at Shilshole Bay, if any additional quantities were taken from the Lake, this water would have to be supplied from other sources. The question of lockage water is discussed further in this report.

Several large cities in the country treat water from adjacent lakes and streams but these cities have no choice. It is our opinion that the people of Seattle who are accustomed to the high quality water from Cedar River would not accept Lake Washington water as long as a mountain stream supply is available. Further consideration of this source of water supply therefore is not considered justified.

Considering the Cedar River and the Tolt River to be the most logical sources of water supply for the Seattle metropolitan district, the next question involved is whether the Tolt River should be developed now or whether the full resources of the Cedar River should be developed first. This is an economic study and depends upon present and future demand. Since the water supply to the area north of Seattle is now critical, this study is timely.

The principal factors involved in a water supply study are population, topography and source of water.

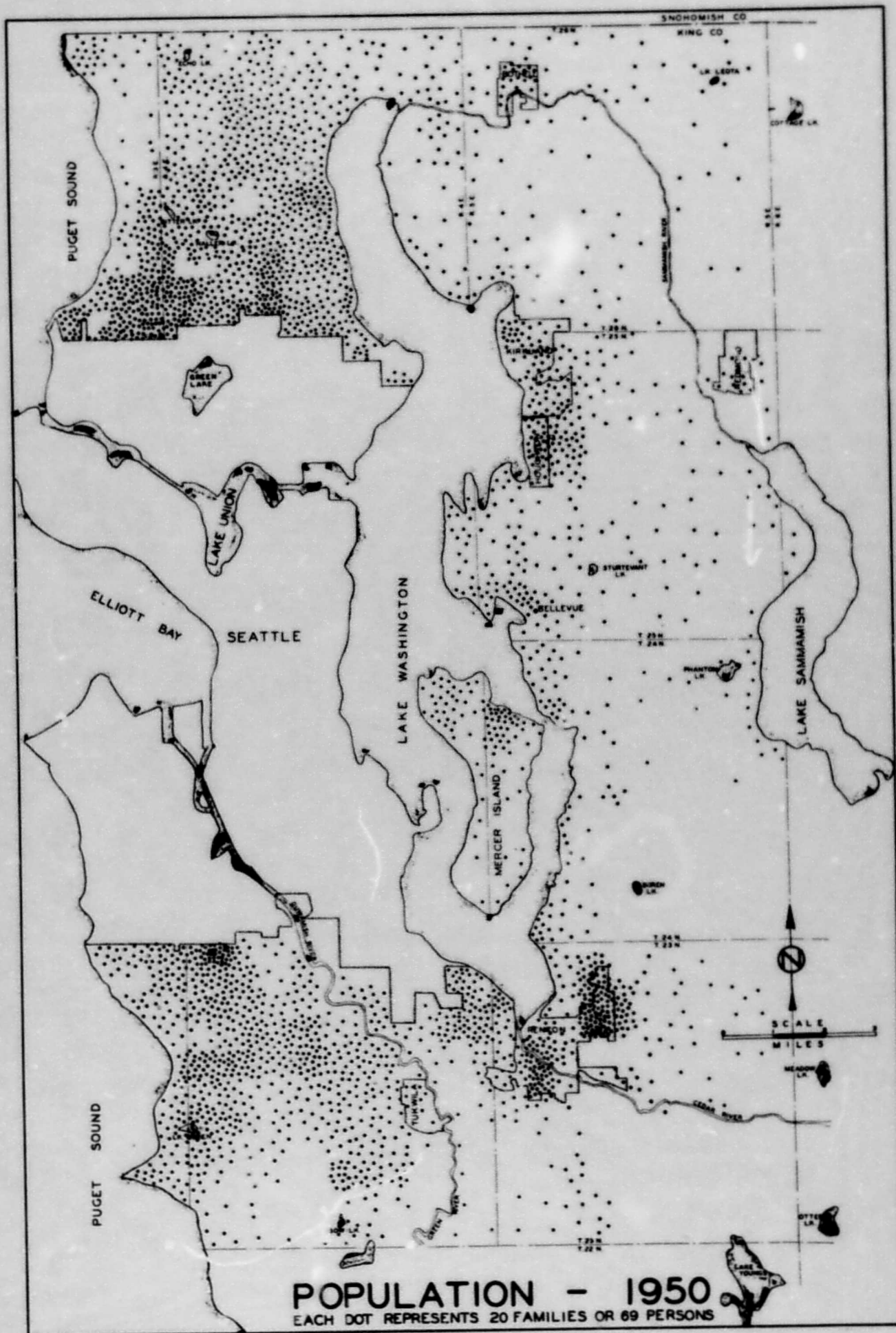
Population studies are shown on the attached maps and represent the present population, the predicted population for 1970 and the ultimate population based upon land use primarily for residences. These population studies have been made through information supplied by the King County Planning Commission and the Seattle Planning Commission. The total population forecast is somewhat less than obtained from other sources but presents a realistic basis for economic comparisons considering that the following studies are based entirely upon mountain stream supply without deduction for possible augmentation from ground water sources.

Topography is important because of the elevations to which the water must be delivered either by gravity or by pumping, the probable distribution reservoir locations, and division of areas into service zones of elevation to secure proper water pressure.

THE TOLT RIVER AS A WATER SUPPLY

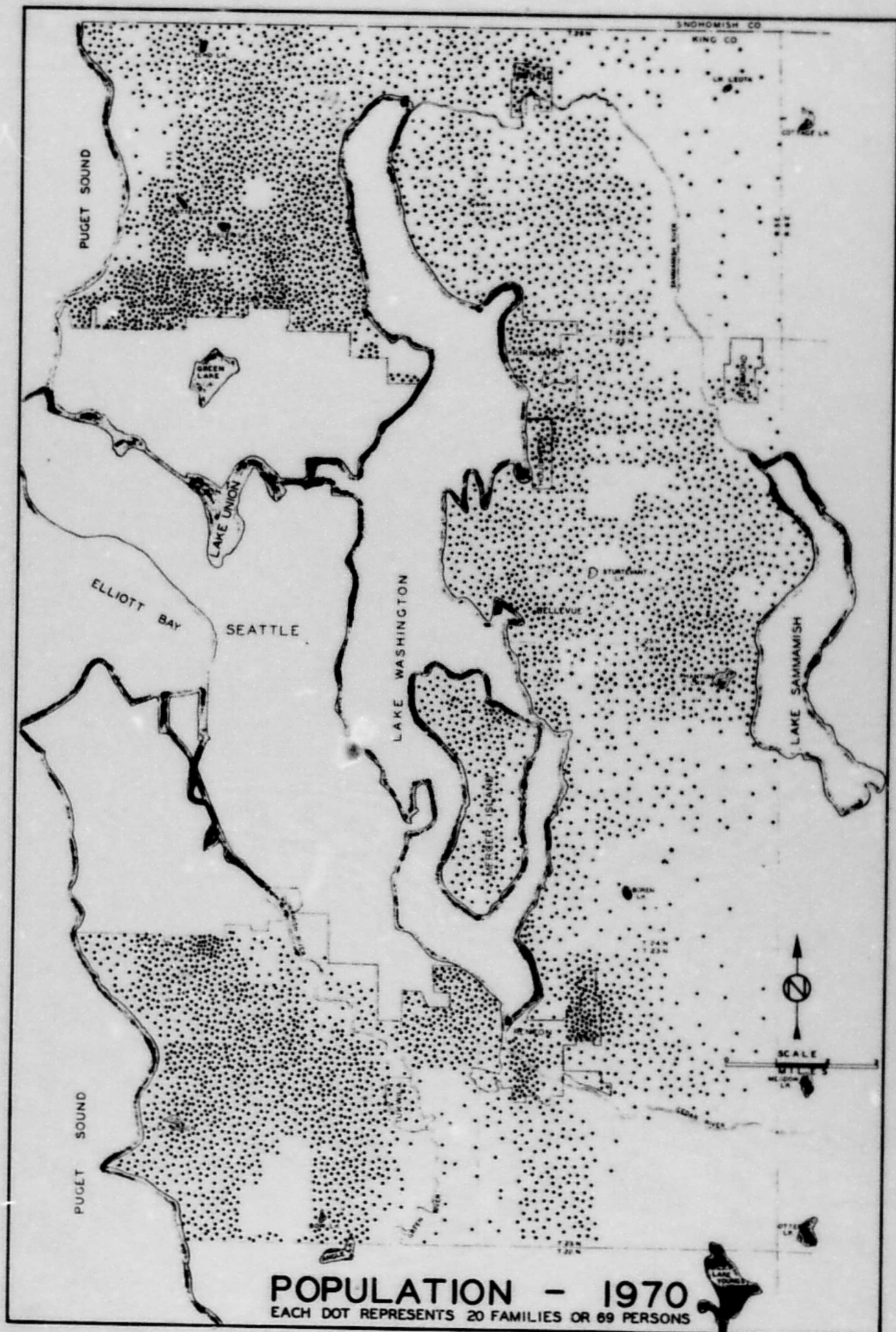
A preliminary survey and engineering study of the Tolt River Watershed for water supply purposes was made in 1936 by Mr. Lars Langloe which, in combination with studies of the Cedar River by Mr. T. H. Carver, was presented in City Engineer Thomas R. Beeman's "Preliminary Report on Additional Water Supply." The valuable data contained therein is referred to in this report and is supplemented by additional information now available from the recent aerial survey and from further studies. The aerial survey was made by the Aero Service Corporation under contract to the Board of Public Works. From this work the City obtained a set of aerial photographs, aerial mosaic and topographic map supported by ground control of the Tolt River Watershed.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



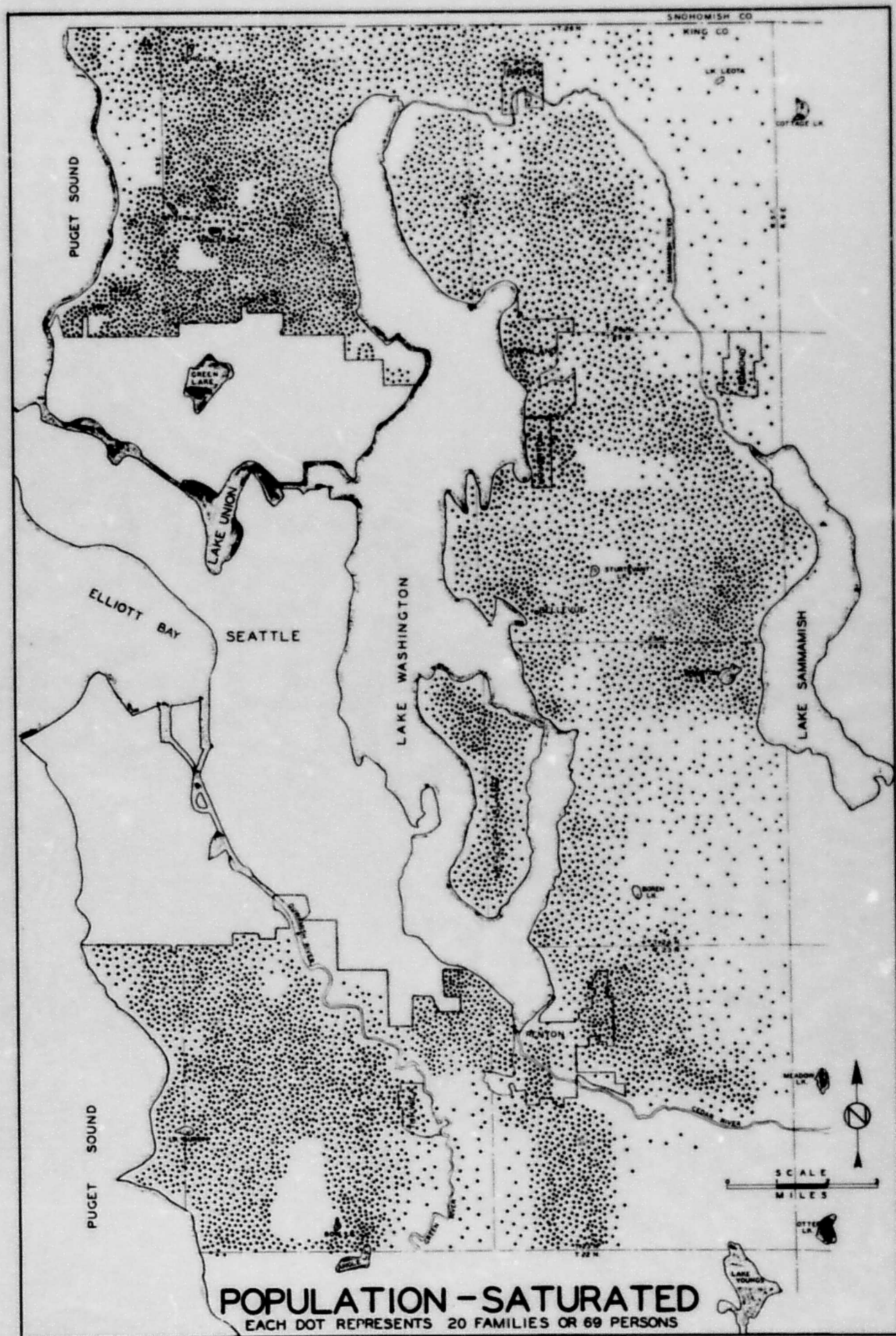
MAP No. 3

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

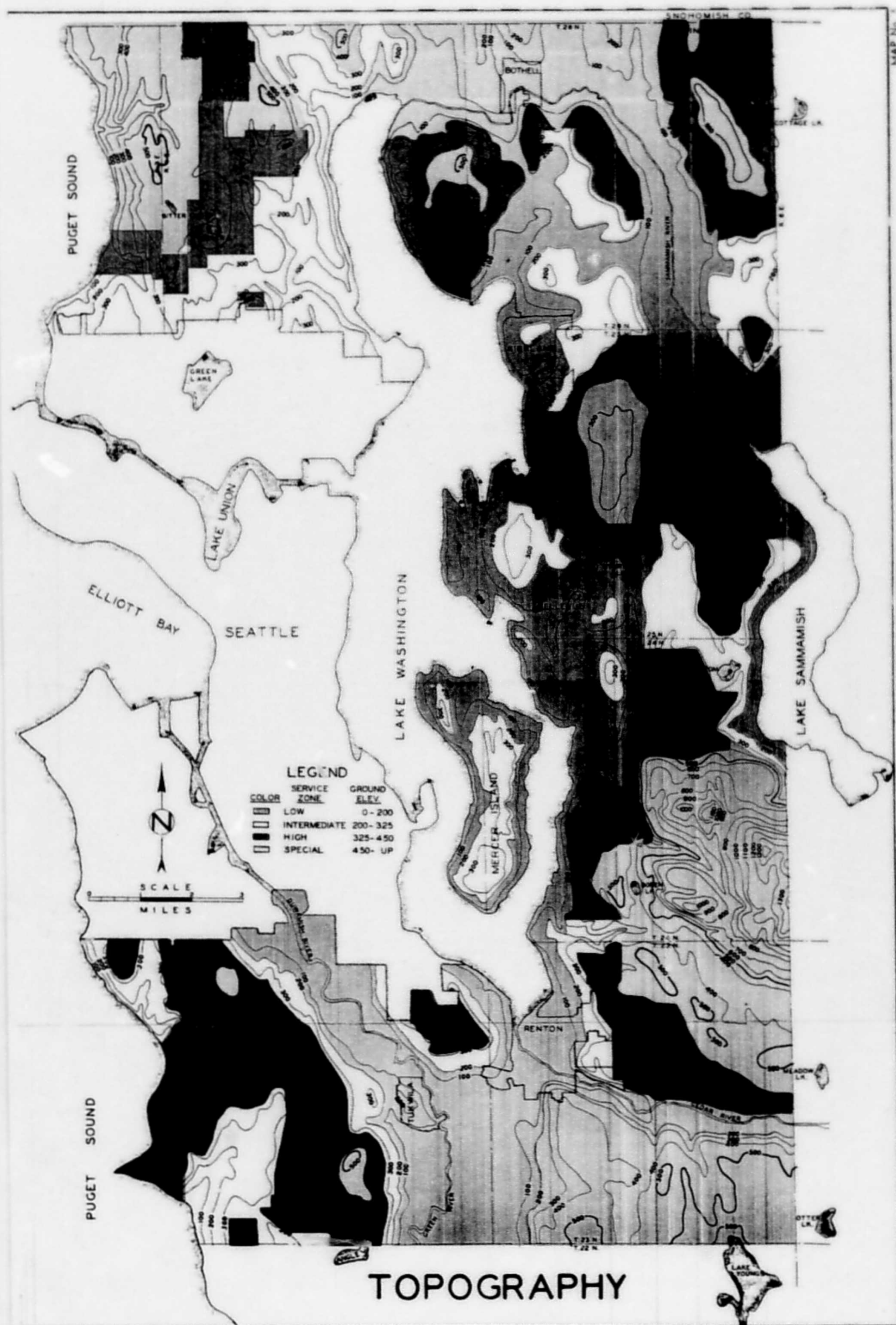


MAP No. 4

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



MAP No. 5



NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

Aerial photographs and mosaic of a pipe line route into the City were likewise made.

Logging operations by the Snoqualmie Falls Lumber Company have progressed in the intervening years since the preliminary survey was made and have made the area more accessible.

The discovery of a potential storage reservoir site on the upper reaches of the South Fork of the Tolt River, not mentioned in the 1936 report, presents interesting possibilities for development of the River not previously considered.

Further investigation of dam sites by test borings will be necessary before it is definitely assured that these storage basins are practical. Favorable results of these investigations would permit construction of storage reservoirs on each fork of the river of sufficient capacity to store the yearly run-off for summer use. The run-off from substantial areas below the storage reservoirs would provide the minimum stream flow required in the river to support fish life. This problem is discussed elsewhere in the report.

Separate development of each fork of the river lends itself to stage construction as the demand for water increases.

DIVERSION DAM AND CONTROL HOUSE

Diversion of water from the Tolt River at an elevation of 800 feet was mentioned in the Langloe report. This elevation would provide gravity flow to any point between Seattle and Everett and most areas east of Lake Washington.

Across the valleys of the Snoqualmie River and the Sammamish River, the water pressure in the transmission pipe would be about 320 p.s.i. and the thickness of pipe required would be a substantial factor in the cost of the pipe line. Diversion at a lower elevation would require pumping for the hilltop areas. Diversion below elevation 650 would not be practical because of high points in the proposed pipe line profile.

The two forks of the river come together at elevation 350. A diversion dam below the forks is therefore not practical. A diversion dam on one fork of the river, with a flume or conduit pipe from the storage dam in the other fork presents a logical solution. Since a pipe line from a diversion dam in the north fork provides the shortest and most direct route to the north end of Seattle, we have based our studies on this condition. (See Map No. 7.)

Assuming that we build the storage reservoir in the south fork and the diversion dam in the north fork as the first stage, we would have the benefit of the combined minimum natural flow of the north fork during the months of heavy flow and the controlled flow of the south fork stored for the summer months. A control house with metering and chlorinating equipment could be located at the point of diversion.

TURBIDITY OF WATER

There is no apparent reservoir and settling basin site on the pipe line route from the Tolt River Watershed comparable with Lake Youngs on the Cedar River. The site selected for this purpose in the Langloe report is the Canyon Creek basin. The use of this basin requires the construction of another dam and an additional pipe line distance of some five miles into north Seattle. This lack of a settling basin for use under flood conditions when the river water is muddy was at first considered to be a disadvantage to the development of the Tolt River for domestic water supply. A method of overcoming this difficulty is suggested here. Perhaps further planning will develop a better solution, but this solution is given to show that the problem is not insurmountable.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



UPPER SOUTH FORK DAM SITE

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



UPPER SOUTH FORK RESERVOIR BASIN

Assume a storage reservoir is built on one or both forks of the river with flume or conduit pipe diverting both forks into one stream and a diversion dam downstream on that branch of the river as the basic development. It will be noted that during periods of heavy rainfall and high turbidity the demand for water is less because there is little or no lawn sprinkling. This demand can be handled by a relatively small pipe from one of the storage reservoirs direct to the control works at the diversion dam and no water would be taken from the river at such times. The storage reservoir would thus act as a settling basin and because of its high altitude the temperature and algae problem common to Lake Youngs would not be present. Periods of heavy rainfall or local cloudbursts which sometimes occur in the mountains during the summer months will be checked by the wooded areas surrounding the proposed storage reservoirs. On Cedar Lake these conditions do not cause turbidity in the entire lake but only where streams run into the lake.

HYDROELECTRIC POWER DEVELOPMENT

Hydroelectric power development of a river used for water supply purposes is inconsistent with the water demand. In the case of the Cedar River development, large quantities of water are released at Cedar Falls for power purposes which flow over the diversion dam at Landsburg and are thereby lost for water use. In short, maximum power needs are not concurrent with maximum water use. Storage of water is limited on the Tolt River. It is, therefore, advisable that the Tolt River be controlled for water use.

It can be noted, however, that the electrical energy used for pumping water to hilltop areas is directly proportional to the amount of water released from the storage reservoir for water use. With the amount of head available on the Tolt, substantial quantities of electrical energy could be generated at those times and used for electric pumping of water. This thought will merit further study as the plan of construction is developed.

FISH AND GAME

The Tolt River watershed is the spawning ground for migratory steelhead trout and for other species of native trout which remain in the stream. The area is also the habitat for deer and other forms of wild life. What, exactly, will be the effect of diverting a portion of the stream flow for water supply and of closing a portion of the watershed to hunting? The State Game Commission has taken the position that they "stand unalterably opposed to the use of the Tolt River as a source of water for the City of Seattle . . . and will continue to be in direct opposition to your plan." Such a stand is tenable only on the grounds that the use of the water is incompatible with propagation of fish life and that sport hunting and fishing is more important to the future population of this area than a good water supply for domestic, industrial and fire protection use. Let us look into the problem further.

There are four principal streams tributary to the Tolt River. These are Stossel Creek, North Fork Creek, the North Fork and the South Fork. The total drainage area is 103 square miles and has 43 miles of stream large enough to support fish. The topography of the watershed is such that only 42 square miles of this drainage area are practical of development for water supply purposes. No development on Stossel Creek or North Fork Creek is contemplated. On the south fork the proposed dam site is above a waterfall 75 feet in height over which no fish can pass. The dam site on the North Fork at Dry Creek would close the upper 5 miles to spawning or fishing. This point is 12 miles from the nearest point accessible by public road. It can be assumed therefore, that few fishermen ever reach it. A private logging road owned by the Snoqualmie Falls Lumber Company reaches this area but no private cars are permitted to use it except by special permit which is not granted for fishing or hunting purposes. Artificial propagation of fish could easily supplant the spawning areas lost. Minimum stream flow which is necessary to

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



SOUTH FORK FALLS

Note—two men standing in lower right corner of picture

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



SOUTH FORK FALLS
Height of Falls 75'
Elevation top of Falls 1460'
Photo taken May 6, 1952

support fish life below the dams during the dry weather period could be provided for in the design of the dams, although the cost of the dams would be increased by this requirement.

Deer hunting in the Tolt basin would be good if it were available to the public. A casual observation disclosed plenty of deer sign. This condition prevails because the area is inaccessible to hunters. Most of the area is owned by private lumber interests. Exclusion of private cars from logging roads is understandable because the trucks used are wider than permitted on highways and many of the logging roads are only wide enough for one truck. Fire hazard is another reason for discouraging hunting in privately owned timber. Closure of watershed areas made necessary for sanitary reasons would provide a game sanctuary or reserve which should not be inconsistent with a game propagation program.

In conclusion, we believe that there is no reason why some reasonable agreement cannot be reached between the City of Seattle and the State Game Commission toward the best solution for both uses of the Tolt River water.

ADDITIONAL SUPPLY FROM THE CEDAR RIVER

The capacity of the Cedar River as a source of water supply has been summarized in Thomas R. Beeman's report of 1936 by Mr. T. H. Carver as follows:

"The record of gaugings made by the United States Geological Survey, of the flow of Cedar River at Landsburg, shows that the flow for the period July, 1914 - November, 1915 was the least for any period during which accurate measurements have been made. An analysis of this record shows that a diversion of 300,000,000 gallons daily during the months of August 1914 and August 1915 and proportionate diversions during the other months of the period might have been made. Had these diversions actually been made, it would have been necessary to have impounded water in Cedar Lake during flood flows and to have released it during periods of low water. When it is desired to utilize the river to its maximum capacity, as a source of water supply, it will be necessary to adjust the flow to the needs of the water system, rather than to those of the power plant as at present.

"Cedar River has a capacity to supply at least twice the present draft, or 800,000 consumers, provided the full regulated flow of the river, in years of low flow is utilized."

A further estimate of the capacity of the Cedar River has been made by Mr. W. C. Morse at 1,000,000 consumers, based upon average consumption in 1949. In 1951 a total of 601,769 consumers used a maximum of 202 million gallons per day. The total pipe line capacity into the city was 163 million gallons with reservoirs full or 168 million gallons with reservoirs lowered. The excess of maximum demand over pipe line capacity was supplied from distribution reservoirs in the City which were drawn down by an extended dry period to nearly half of their total storage of 365 million gallons.

The total pipe line capacity from Landsburg to Lake Youngs Control Works is 194 million gallons per day. When construction of the Bow Lake pipe line is completed (1953), the capacity of pipe lines from the Lake Youngs Control Works into the City will be 203 million gallons per day. New pipe lines therefore will have to be extended to Landsburg for adequate supply.

PLANS OF WATER SUPPLY

Six plans of supply utilizing the Cedar River and the Tolt River in various amounts are presented herein with comparative costs based upon present day prices. Analysis is made of needs for 1970 and for population saturation.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE IT IS DUE TO THE QUALITY OF THE DOCUMENT.

The term population saturation as applied here is based primarily upon one family dwelling with a greater land area per dwelling than is now found in some sections within the City limits. The small percentage of industrial or commercial property is not considered to have a material effect on these figures. Population forecasts are taken from King County Planning Commission studies based upon land use and a controlled population density.

Water consumption for pipe line design is based upon 250 gallons per capita per day. The maximum daily per capita use for the Seattle water system occurred in 1951, and was 336 gallons of which the pipe lines supplied 266 gallons and the balance was withdrawn from distribution reservoirs. Water consumption in Water Districts is somewhat less than the average so we consider 250 gallons to be a fair basis for pipe line design to the greater Seattle area. Demands for certain areas are concentrated at points of likely distribution reservoirs or withdrawal points. Equal quantities of water are used as the demand at these points and the pipe sizes fixed accordingly, with the exception that Cedar River water is supplied at a reservoir elevation of 420 feet in Plan E north of Seattle, while Tolt River water is supplied at a reservoir elevation of 520 feet.

Cost of storage reservoir dams on the Tolt River, evaluation of lost power, or cost of rehabilitating Cedar Lake for additional storage are not evaluated in these studies because these costs are not exactly ascertainable on account of unknown geological conditions at the storage dam sites, but these costs will appear in the ultimate development under any plan considered.

Our analysis and a statement of the merits of each plan, follows.

PLAN A provides for the maximum ultimate development of the Cedar River Supply and uses it to serve the future demands of the present corporate city limits, the Bellevue district, the South Seattle district, and the Duwamish Valley industrial area. It provides for the minimum size dam on the Tolt River at present and reserves much of the Tolt River potential supply for possible use of areas north or east of those considered herein. The immediate needs of Bellevue could be supplied from Lake Youngs at a cost less than that estimated from the east side pipe line.* It permits service to this critical area several years earlier than could be accomplished from the Tolt River.

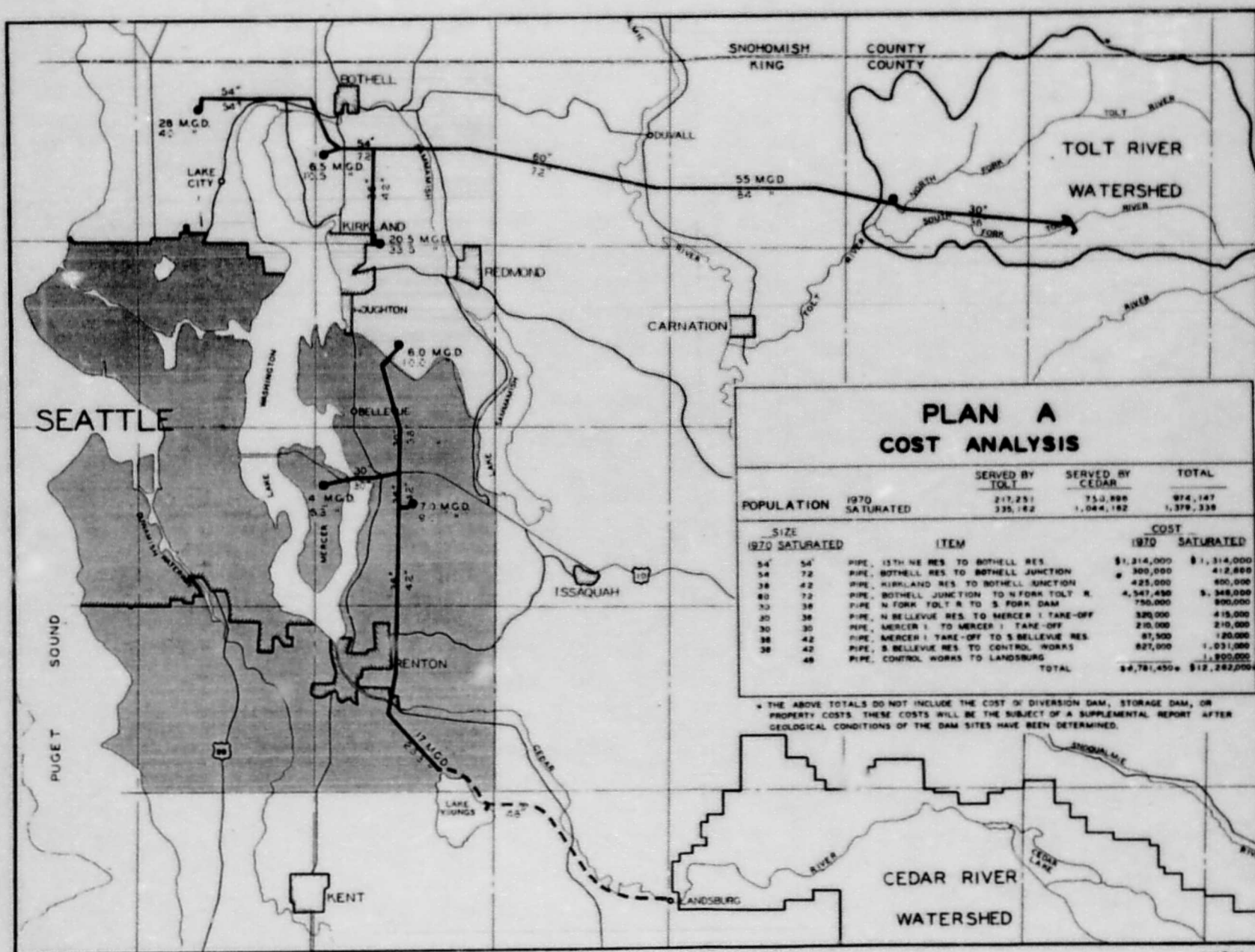
PLAN B provides for service to the Bellevue area from the Tolt River and is otherwise the same as Plan A. This plan does not use the entire capacity of the Cedar River in the ultimate development but makes greater use of the Tolt River which requires a higher dam in the initial stage.

PLAN C is a further extension of the use of the Tolt River by including all of North Seattle to the Lake Washington Ship Canal as well as the Bellevue area. The demand on the Tolt River reaches such proportions that it requires a high dam or even two dams, one for each main fork of the river. The Cedar River does not reach its full development in the ultimate demand under this plan.

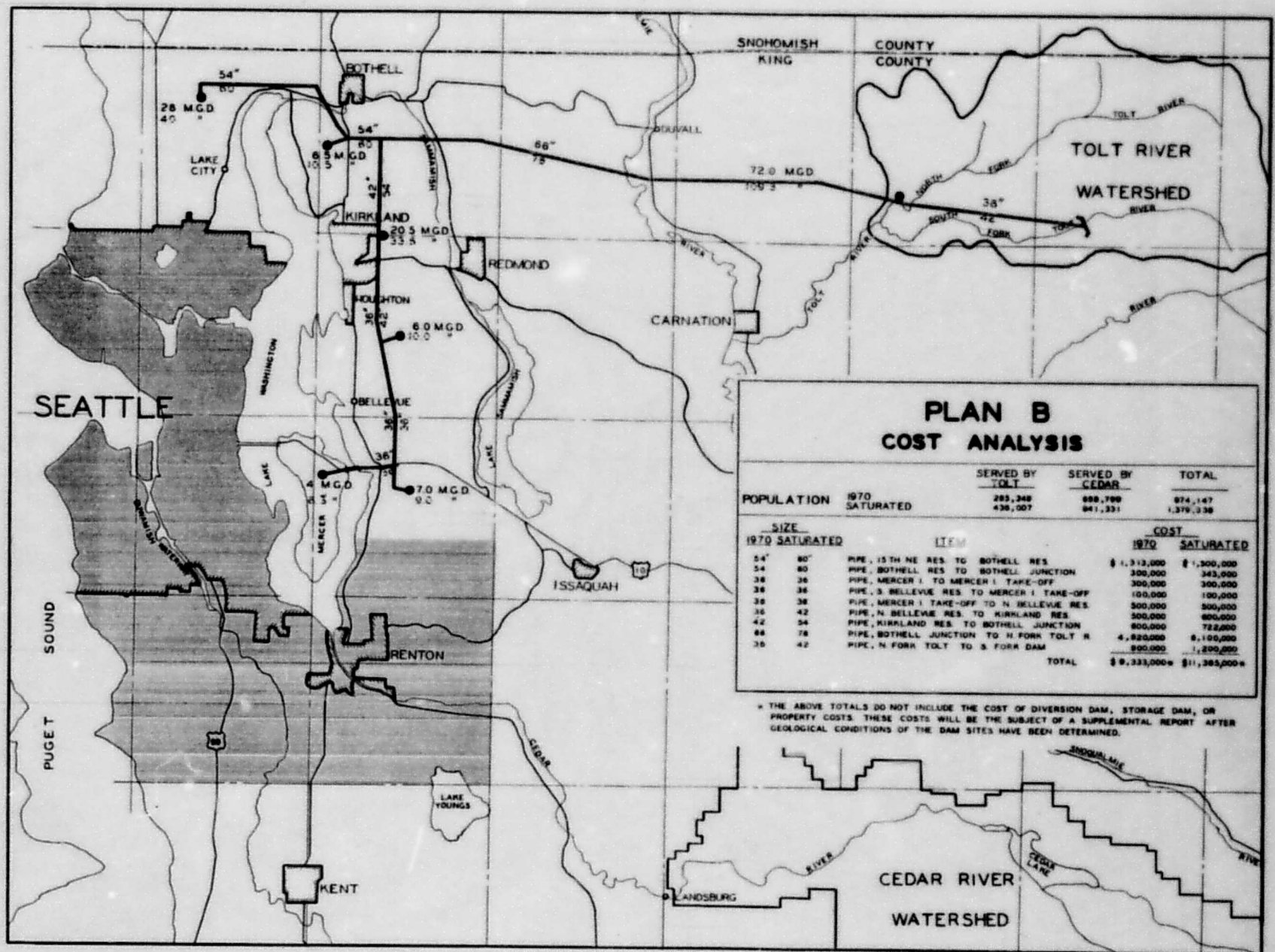
PLAN D extends the area served by the Tolt River south to the Lake Washington Ship Canal but serves the Bellevue area from the Cedar River. Since the area north of the canal is already adequately served by the Cedar River, there is no particular advantage to this plan over Plan A unless difficulties are encountered in full development of the Cedar River.

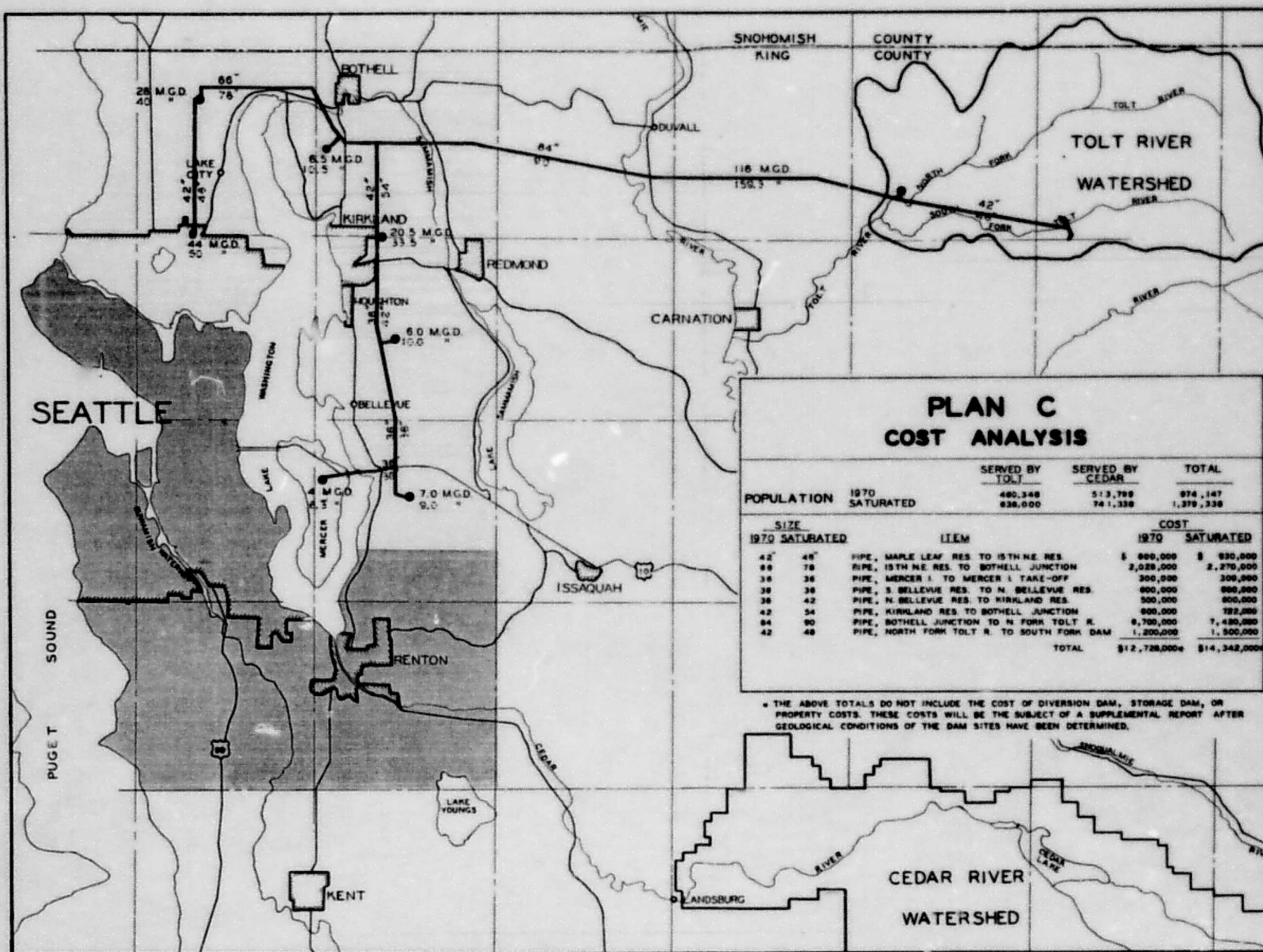
PLAN E contemplates serving the entire area from the Cedar River by a pipe line extending around the east side of Lake Washington and terminating in an intermediate service reservoir at Haller Lake at elevation 420 feet. Pipe sizes are larger than contemplated some years ago to provide the quantities of water now estimated and provide a basis of comparison with the

*R. W. Morse report of April 12, 1951.

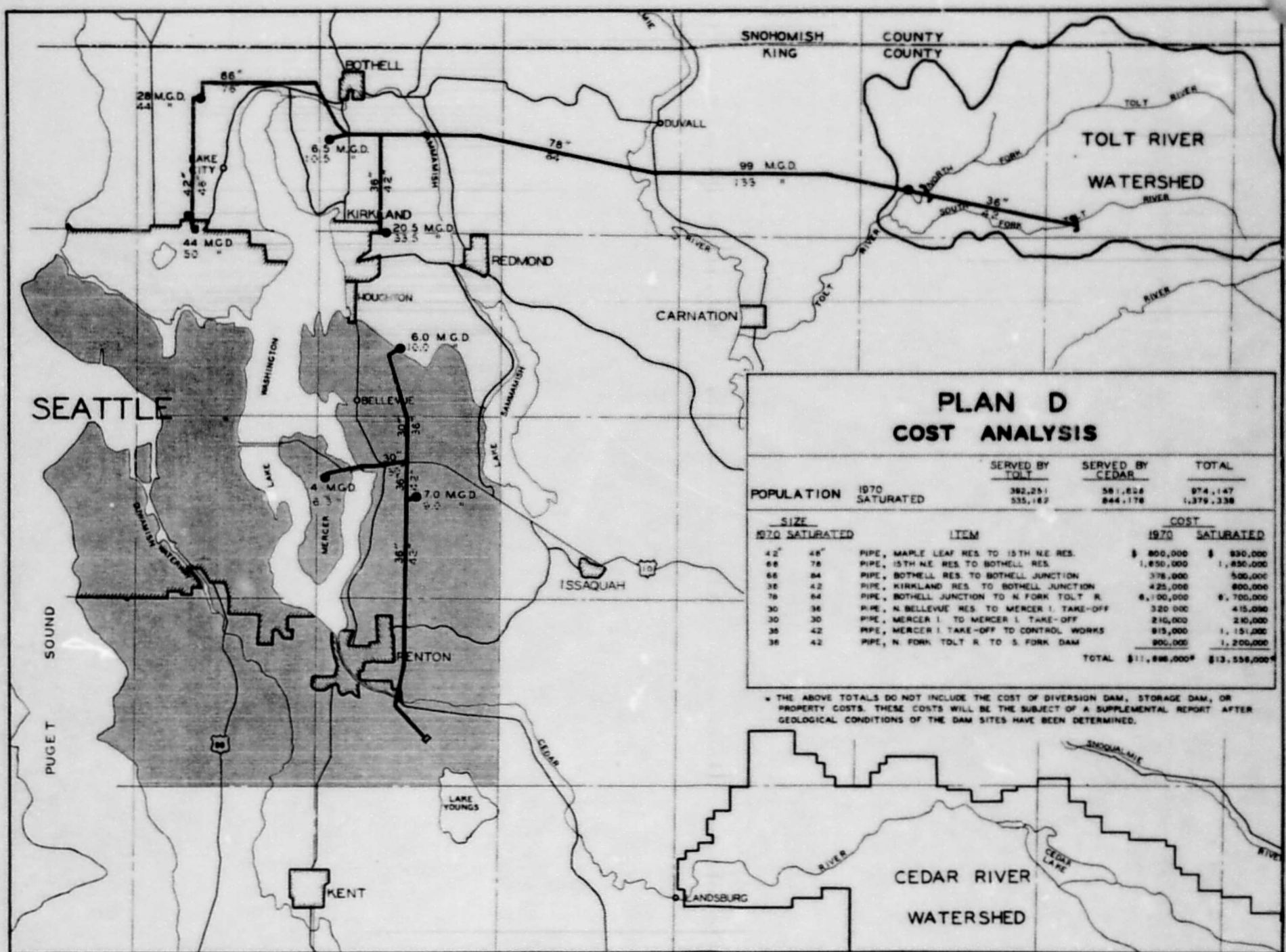


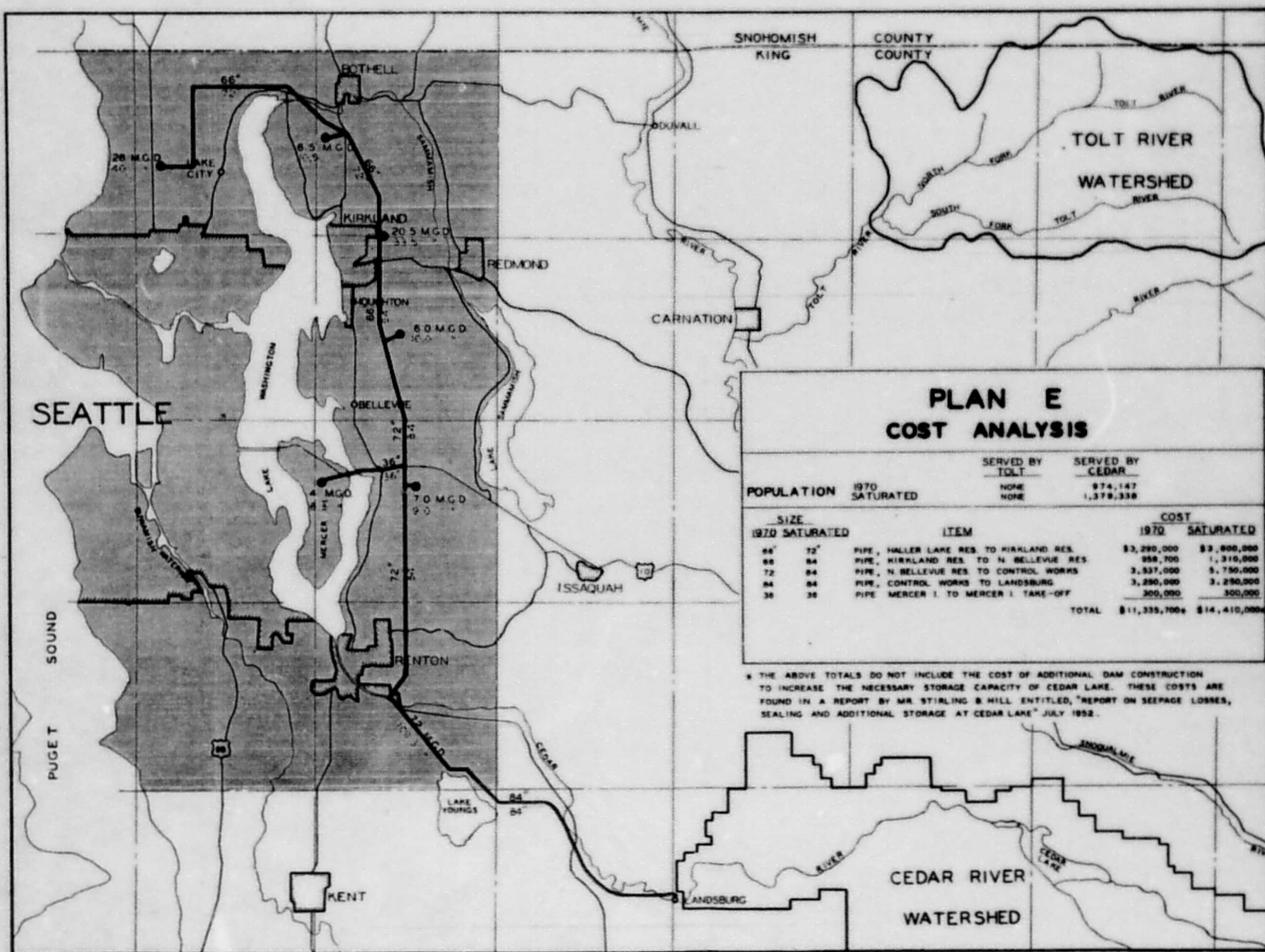
MAP No. 7

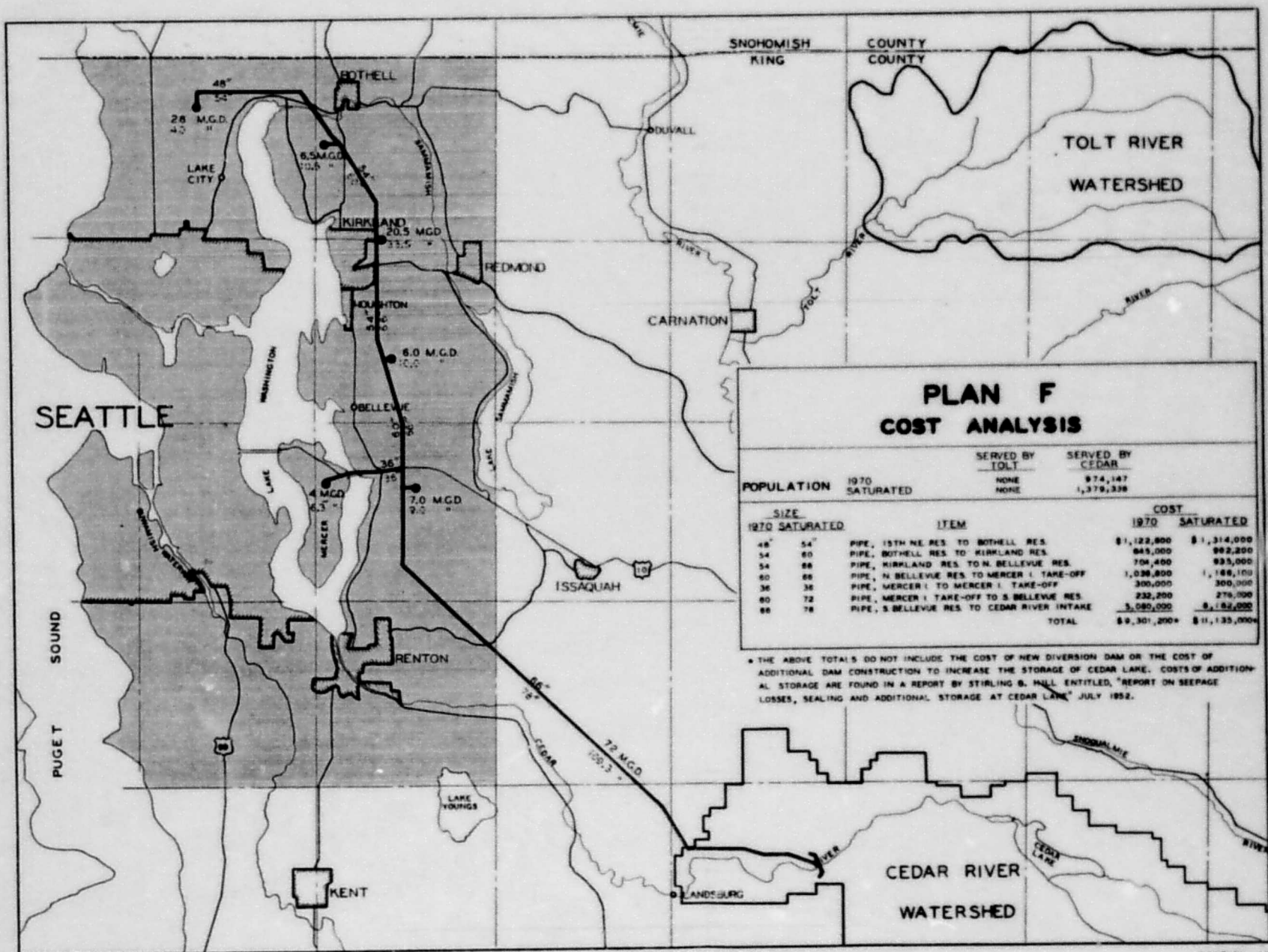


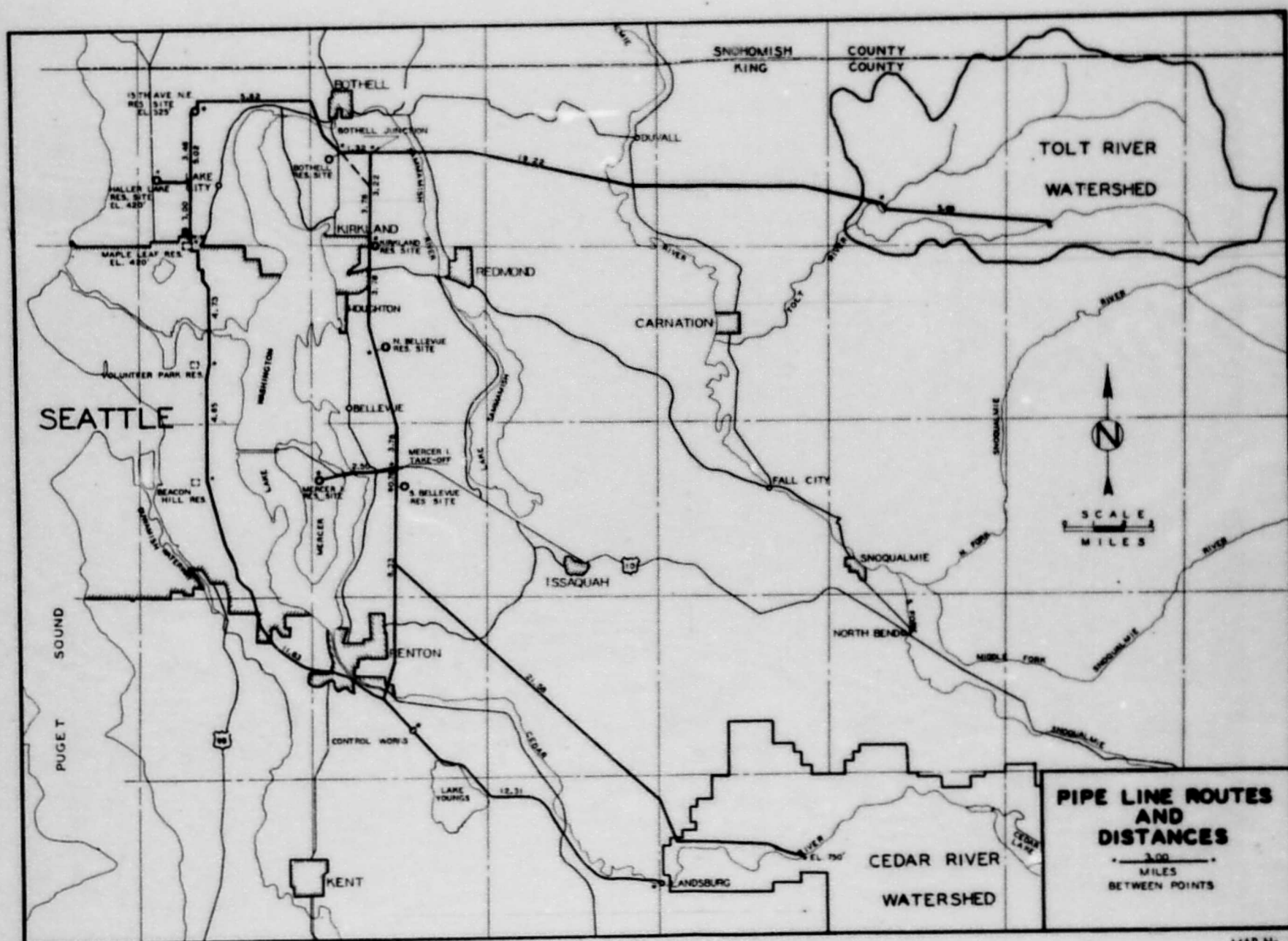


MAP No. 9









MAP No. 13

[illegible]

MAP No. 14

other plans. It will be noted that this plan will require pumping to all areas above elevation 325 feet. This includes large areas north of Seattle and also extensive areas east of Lake Washington. These pumping costs are not included in the cost analysis.

The demand will exceed the total capacity of the Cedar River shortly after 1970, unless some means are found to increase the storage above the dam at Cedar Falls Reservoir. This date agrees closely with other predictions* and additional sources will have to be tapped at that time. Assuming that the Tolt River is developed about 1970 and the north end is supplied from this source, the size of the pipe line under Plan E will then be much larger than required, with a corresponding economic loss.

PLAN F is similar to Plan E in the respect that it contemplates serving the entire area from the Cedar River. The essential difference is that diversion of Cedar River water is made at a higher elevation (750 feet) by means of a new diversion dam.

The pipe line route follows a natural low divide at an elevation of about 400 feet in almost a direct line to Bellevue and thence north around Lake Washington to North Seattle. Diversion at a higher elevation enables serving the higher elevations by gravity thereby reducing pumping costs and puts this plan on a par with the Tolt River plans in respect to elevation served by gravity water. Pipe sizes are reduced over Plan E because of the increase in hydraulic gradient with a consequent saving in pipe line costs.

This plan is also contingent upon increasing the storage in the Cedar Lake Reservoir after 1970. It also contemplates making full use of the Cedar River for water supply.

LOCKAGE WATER

Since the Lake Washington Ship Canal and the Government Locks were built in 1916, the level of Lake Washington has been controlled by the dam at Shilshole Bay. The water required to operate the locks, fish ladders and to keep salt water out of the lake above the locks is supplied from the streams flowing into Lake Washington, the principal ones of which are the Cedar River and the Sammamish River.

The lock gates have fresh water on the upper side and salt or brackish water on the lower side. To balance the head due to the brackish water in the lock, the lighter fresh water in the lake is at a higher elevation, which at times causes some difficulty in the operation of the gates. When the gates are opened, the downstream surface current of fresh water and the upstream undercurrent of salt water, resulting from their difference in density, would eventually turn the lakes into a salt-water reservoir if some means were not provided to return the salt water to the Sound. To overcome this difficulty, a basin was dredged immediately above the larger lock to a depth of about 20 feet below the channel, into which the heavier salt water may settle. From the lower end of this basin a pipe 30 square feet in area extends through the spillway dam, with its outlet 4 feet below high tide, making a head of from 9 to 11 feet forcing the salt water from the bottom of the basin through the drain into the lower pool. The flow is continuous and at the rate of 100 to 200 cubic feet per second. The discharge of salt water from the upper pool may be increased, if found necessary, by opening the valves in the culverts at times when the lock is not busy and when water can be spared for that purpose. These measures are ordinarily effective, but when there are a large number of consecutive lockages during the dry season, the salt water basin becomes filled with sea water faster than the drain can carry it off, and some salt water flows up the canal into the bottom of Lake Union, which acts as another settling basin preventing the salt water from reaching Lake Washington.

The volume of water required to operate the locks, fish ladders, and to flush out salt water has been estimated by the Corps of Engineers, U. S. Army, for the summer months, as shown in the following table.

*R. W. Morse report of April 12, 1951.

TABLE II
LOCKAGE WATER

Assuming locks operation as at present; inflow as of 1904; Seattle diversion as of 1949; and Lake Washington regulation between 7.0 feet and 8.8 feet.

Month	Operation Locks m.g.d.	Fish Ways m.g.d.	Salt Water Drain m.g.d.	Misc. Losses & Flushing m.g.d.	Total Daily Average m.g.d.	Total Used Monthly Ac-Ft.	Net Inflow Monthly Ac-Ft.	Monthly Drawdown Ac-Ft.	Storage Ac-Ft.
July 1	100	3	68	51	222	21,130	24,100	2,970	43,200
Aug. 1	97	3	68	50	218	20,730	0	20,730	43,200
Sept. 1	104	3	68	52	228	21,030	300	20,730	22,470
Oct. 1	78	3	68	45	194	18,430	10,300	8,130	1,740
									— 6,390*

* Additional Storage Needed.

The level of Lake Washington is maintained between the elevations of 7.00 and 8.80 feet Seattle Datum. This provides a storage in Lake Union, Lake Washington and Lake Sammamish of 43,200 acre feet. The balance of lockage water must be supplied from other sources of which the Cedar River is the principal source. Should the City of Seattle divert the maximum contemplated flow of 300 m.g.d. from the Cedar River, a shortage of 25,320 acre feet will occur, based upon the year of lowest flow on record (1904) and the present use of lockage water.

Use of lockage water has increased with the number of boat passages, but not in the same ratio. Development of a breakwater in Shilshole Bay will affect the number of boat passages by causing some pleasure boats to moor outside of the locks. Future demand for lockage water is therefore somewhat of a speculation, but the increase is not expected to reach alarming proportions.

Several methods of providing for future lockage water are under consideration by the Corps of Engineers.

1. A controlled outlet of Lake Sammamish would hold the water in the lake at the high water mark (not flood stage) until the summer months and release it as required. It has been estimated that this will provide 15,000 acre feet.

2. Lock openings could be operated on a time schedule during the critical months, thereby reducing the number of lock openings. The present method of opening locks on demand regardless of number of boats or time is unique to these locks and is not used in other places.

3. Some savings can be made in water used for flushing. Flushing is done by opening the flood gates in the locks after a boat passage to flush out the salt water carried above the locks. This is in addition to the salt water drain which flows continuously. Flushing can be reduced for short periods without detrimental effects.

4. Further reduction of the lake level can be made if emergency demands. The lake level at elevation 7.0 is fixed by custom and has no legal requirement. When it is necessary to draw the lake level below this elevation, the Corps of Engineers sends out notices of the emergency.

5. Some additional water will be returned to the lake as effluent from sewage treatment plants, as the population increases. The additional water consumed in water supply will therefore not be entirely lost to lockage use.

Our conclusions are that the problem of lockage water is not a serious consideration and can be provided by one or a combination of methods under consideration when the need arises.

Although the City of Seattle has prior rights to the water of the Cedar River, it would be advisable, in our opinion, to provide a minimum stream flow for lockage water as long as it is feasible to do so without jeopardy to the City's water requirements.

THE BELLEVUE WATER PROBLEM

Rapid growth in population of the Bellevue area in recent years has caused a critical water shortage. Drilled wells to date have not provided the necessary flow and temporary measures have been taken to augment this supply from Lake Washington. The final solution will be found either in wells, lake water, surface streams, or a connection to the City of Seattle water system. Investigation of wells and lake water is under study by engineers engaged by King County Water District No. 68, of Bellevue. A request by Water Districts—Bellevue, Medina and others—for consideration of a connection to the Seattle system has in part precipitated the above water supply study.

Predicted future growth indicates that by 1970 the Bellevue area may have a population of 69,000, of which 52,000 would be served from the Cedar River under Plan A. All of the proposed plans of water supply mentioned herein provide means of supplying Bellevue from one source or another.

Supply from the Tolt River or from a new diversion dam on the Cedar River (Plans B, C or F) would require 4 to 6 years before water would be available. Supply from the present control works at Lake Youngs could be made in the shortest time under Plan A with the least capital expenditure. Starting at the Wye on the Bow Lake Pipe Line at S. 160th Street, the present and future demand from the Bellevue area until 1970, or 13 m.g.d. can be supplied by a pipe line consisting of 21,700 feet of 36-inch pipe and 43,000 feet of 30-inch pipe at an estimated cost of \$1,144,000.00. If Mercer Island is to be added at 4 m.g.d., the pipe line should be 36-inch, with 30-inch branches to Mercer Island and North Bellevue at an estimated cost of \$1,445,000.00.

The cost of either of these two pipe lines from the Lake Youngs Control Works can be amortized at the current rates charged to Water Districts in approximately twenty years based upon an interest rate of $2\frac{1}{2}\%$ on the bonds and a predicted growth in the Bellevue area from 4,682 consumers in 1954 when the pipe line would be completed to 18,986 consumers in 1970. The predicted growth for Mercer Island is from 1591 consumers in 1954 to 4743 consumers in 1970.

The utilization of this water supply and the realization of this rate of growth involve construction of distribution reservoirs and a vigorous program of expansion of distribution water mains by the Water Districts.

Construction of the supply pipe line will involve the condemnation or purchase of a right of way. The proposed right of way located in 1940 passes through two new housing developments and will have to be relocated in part. Relocation and purchase of right of way and construction of a pipe line would require about two years after authorization. The supply to Lake Youngs from Landsberg will have to be increased by 1960 as a result of this and other increased demands. A proportionate share of this increased plant cost should also be amortized by revenues obtained from consumers in these districts.

The quality of water furnished from Cedar River is well known to all local people and is under constant analysis and control for purity by the Seattle Water Department. The decision of whether or not to proceed with this plan rests with the people of the Water Districts and the Seattle City Council.

THE NORTH SEATTLE WATER PROBLEM

Seattle is already committed to furnish water for large areas north of the City Limits. In certain of these areas the water is distributed through water districts and in other areas the Seattle Water Department sells water direct through individual meters. Water is supplied from the Maple Leaf Reservoir (60,000,000 gallon capacity) direct by gravity to those areas below elevation 325, and is pumped at the Foy Pumping Station and the new Northgate Pumping Station to the higher areas served by the Foy standpipe (1,000,000 gallon capacity). The Maple Leaf Reservoir is supplied by a 54-inch pipe which can be regulated to form practically a direct supply from the Lake Youngs Control Works. There is also a 42-inch pipe from the Volunteer Park Reservoir feeding the intermediate service north of the canal and terminating in the Maple Leaf Reservoir. The flow in this pipe may be either into the reservoir or drawing out of it, depending upon demand of the system.

During the summers of 1950 and 1951, the capacity of these pipe lines to supply the Maple Leaf Reservoir was severely taxed. The recent completion of the 16-inch Bothell Way pipe line to Kenmore supplying two new districts will aggravate this deficiency. Completion of the Bow Lake pipe line in 1953 will provide a new means of supplying West Seattle and will, in turn, relieve the demand on Cedar River pipe lines No. 1, 2, and 3, permitting more water to flow into central and north Seattle. The amount of water available to the Maple Leaf Reservoir will be increased only slightly by this expedient, and other means will be required to increase the supply to the Maple Leaf Reservoir.

The need for an additional pipe line to serve the normal growth of north Seattle will be felt immediately. The summer of 1953 may prove to be critical if we should have an extended period of dry weather.

Four to six years will be required to bring in a new pipe line from the Tolt or Cedar Rivers. In the meantime, the increased demand can be met by the installation of booster pumps in one or both of the present pipe lines supplying Maple Leaf Reservoir. This proposal was made several years ago by Mr. W. C. Morse and was temporarily dropped upon the construction of the tie-in between pipe lines 1 and 2 at Beacon Hill Reservoir and the reconstruction of Pipe Line No. 1. These pumps are urgently needed at the present time.

Reservoir capacity in the area north of the City limits has not kept pace with the population growth. Reservoirs serve two purposes, one of which is to provide an emergency supply in case of power failure, pump breakdown or pipe line shutdown for emergency repairs. Reservoirs also serve the purpose of equalizing the extreme demands from an extended dry weather period so that the pipe lines and pumping capacity do not have to equal the maximum peak demand.

The Maple Leaf Reservoir serves only those areas below elevation 325 by gravity. Large areas north of Seattle are above this elevation and are supplied by pumping to the Foy standpipe. The Seattle water system was originally designed for a storage capacity of 1,000,000 gallons per 1,000 population. This ratio was maintained until the population reached 340,000 and has since declined to the present ratio of 1,000,000 gallons per 1,300 population within the present City limits.

The present population served by the Foy standpipe is 34,000 which is estimated to increase to 52,000 by 1970 and to 70,000 at population saturation. At the above ratio, the system should have distribution storage of 30 million gallons now, and 40 million gallons by 1970.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

If all pumping were stopped at the Foy standpipe for any reason, this area would be out of water in two to four hours. We therefore recommend that one or more reservoirs be constructed to bring the distribution storage up to standards of good practice and that this storage be made at an elevation to supply the maximum area by gravity. This can best be brought about by constructing a new storage reservoir at elevation 520 feet and dividing the Foy area into two zones of distribution. Water from the Tolt River would flow by gravity to this elevation and the area served by pumped water would be reduced to about half of the present area.

Plans have been made for a one million gallon elevated tank at the old Firland Sanatorium site of North 195th Street and Fremont Avenue. This tank when completed will supplement the Foy standpipe and serve the hilltop area.

THE SOUTH SEATTLE PROBLEM

Construction of the 60-inch Bow Lake pipe line across South 160th Street from the Lake Youngs Control House to the Bow Lake Reservoir at 24th Avenue South is scheduled for completion in 1953. This new pipe line will supply water needs of south and southwest Seattle for many years.

Recent authorization of a flood control dam on the Green River by the Federal Government and the construction of this dam will open up a large potential industrial area in the Duwamish River valley. This is the only logical area for industrial expansion to the City of Seattle. An adequate water supply is of major importance to this industrial expansion. A consequent increase in population on the hills adjacent to the Duwamish Valley will also create an increasing demand for water. The ultimate expansion southward of the Seattle Water System and the northward expansion of the Tacoma Water System to a common boundary is probable within the next twenty years. The most logical source of water supply for this expanded Seattle system is the Cedar River. A new pipe line, in addition to the Bow Lake Pipe Line now under construction, running from the Lake Youngs Control House south and west to serve this area is probable in the future.

For this reason it is our opinion that a considerable portion of the capacity of the Cedar River Watershed should be reserved to serve the ultimate needs of the south industrial and residential areas.

CONCLUSIONS

1. Immediate steps should be taken to augment the water supply for the area north of Seattle to which Seattle is already committed.
2. The most logical source of water supply for this purpose is the Tolt River.
3. If the City of Seattle develops the Tolt River as a source of water supply, it will have appropriated the principal remaining source of mountain water available to the metropolitan area surrounding Seattle and is therefore, in our opinion, morally obliged to share this natural resource with the area which can be economically served by it.
4. Plan A is the most economical plan of development for all areas concerned from a standpoint of present and future costs. This plan is the most flexible one and lends itself most readily to stage development. The Bellevue area can be served now or at any time in the future or left out entirely in this plan. The Kirkland, Redmond and Bothell areas which have adequate water supplies at the present time can likewise be served at any time in the future, or not at all.
5. Development of the Tolt River in the immediate future provides an independent water supply thereby lessening the danger of disaster because of bombing or sabotage to our present pipe lines or of damage by earthquake.

6. Cost of land for the pipe line right of way and impounding reservoirs on the Tolt River will be less now, while the land is undeveloped, than it will be in the future.

7. The remaining capacity of water supply from the Cedar River should be held in reserve for the future demands of the present corporate city limits and the expanding industrial and residential areas south of Seattle.

8. Lockage water for the Lake Washington Ship Canal should continue to be supplied from the Cedar River for the present and as long as economically possible in the future.

RECOMMENDATIONS

1. The immediate increased demand in the north Seattle area should be satisfied by booster pumps in one or both of the pipe lines serving the Maple Leaf Reservoir and the reservoir capacity for this area should be increased.

2. Construct a pipe line to supply the Bellevue area, provided satisfactory agreements can be reached between the Bellevue area and the City of Seattle.

3. Geophysical studies of the underlying strata of the proposed dam sites on the Tolt River should be made and the practicability of the proposed dam sites should be definitely determined at once.

4. The Engineering Department should be authorized to engage the services of an expert in the matter of dam investigation and design.

5. Establish stream gauging stations at the proposed dam sites for one complete yearly cycle to obtain comparative constants for the gauging records now available.

6. Make application to State authorities for construction of a dam or dams on the Tolt River.

7. Make field survey for pipe line to north Seattle and acquire land for pipe line right of way by purchase or condemnation.

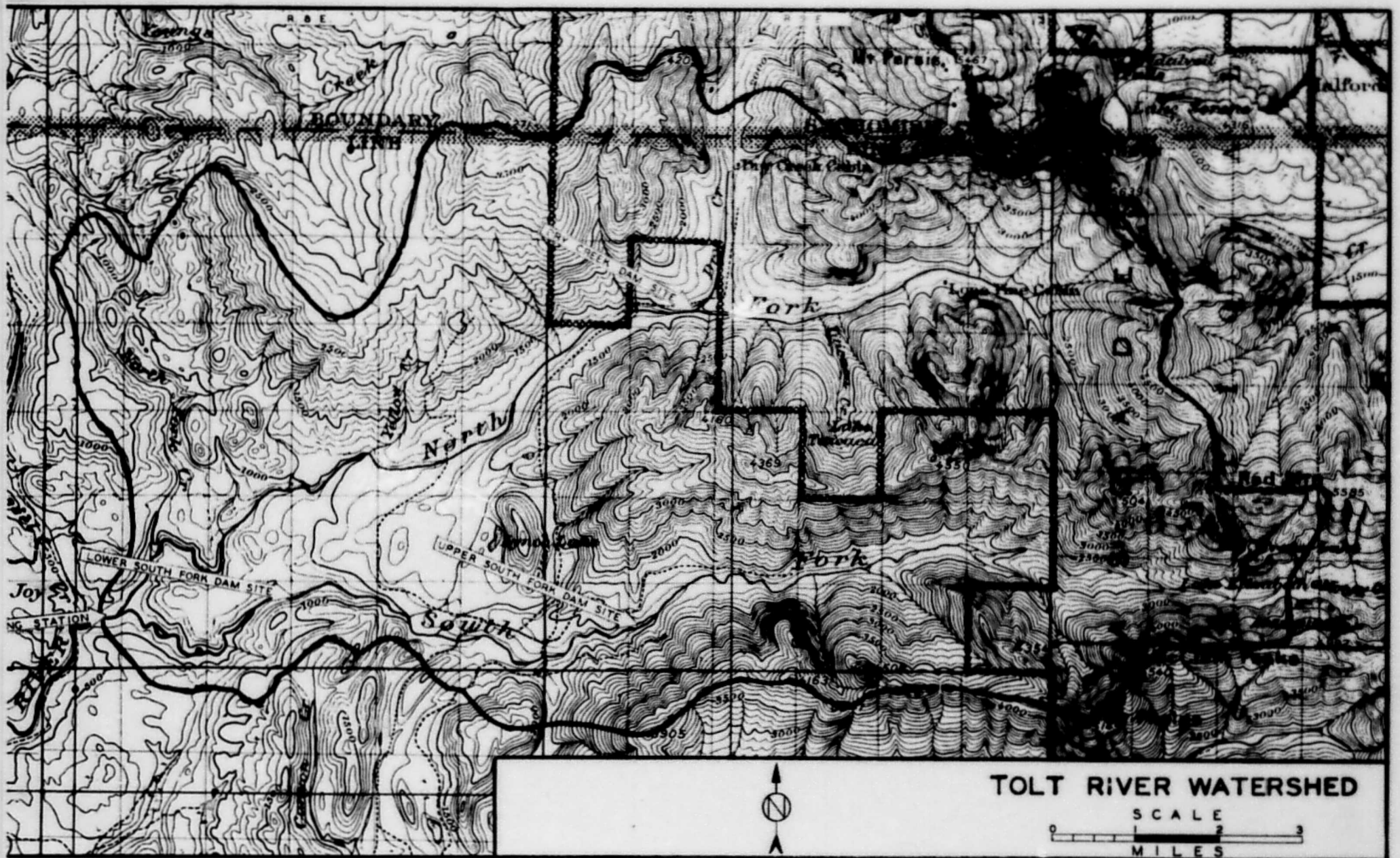
8. Acquire land for an impounding reservoir with provisions that the present owner remove the timber.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

TOLT RIVER WATERSHED

This map shows topography of the Tolt River Watershed, the boundary of the drainage area above the U.S.G.S. Gauging Station, and the location of three potential dam sites.

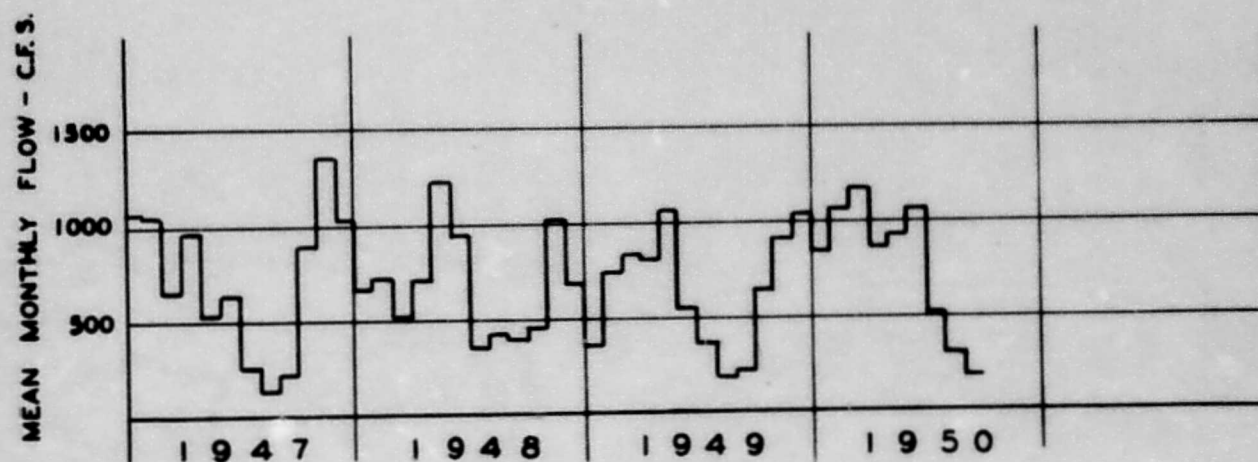
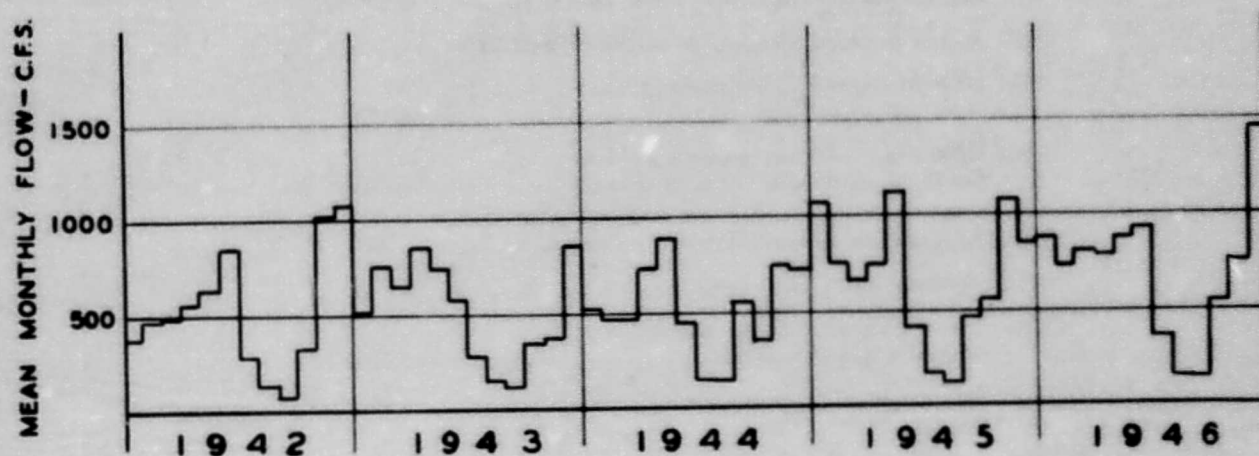
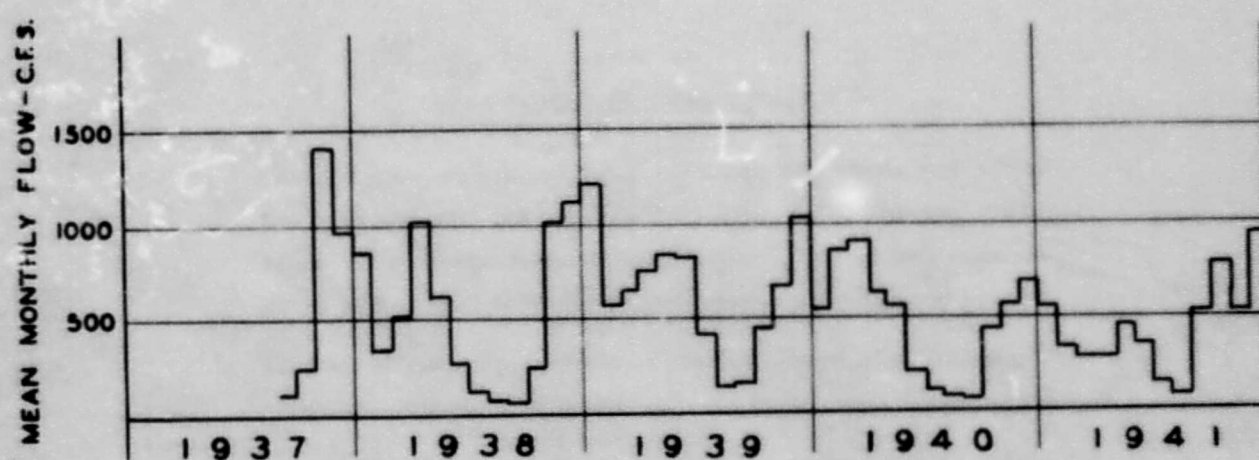
NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



MAP No. 15

HYDROGRAPH

TOLT RIVER AT U.S.G.S. GAGING STATION



NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

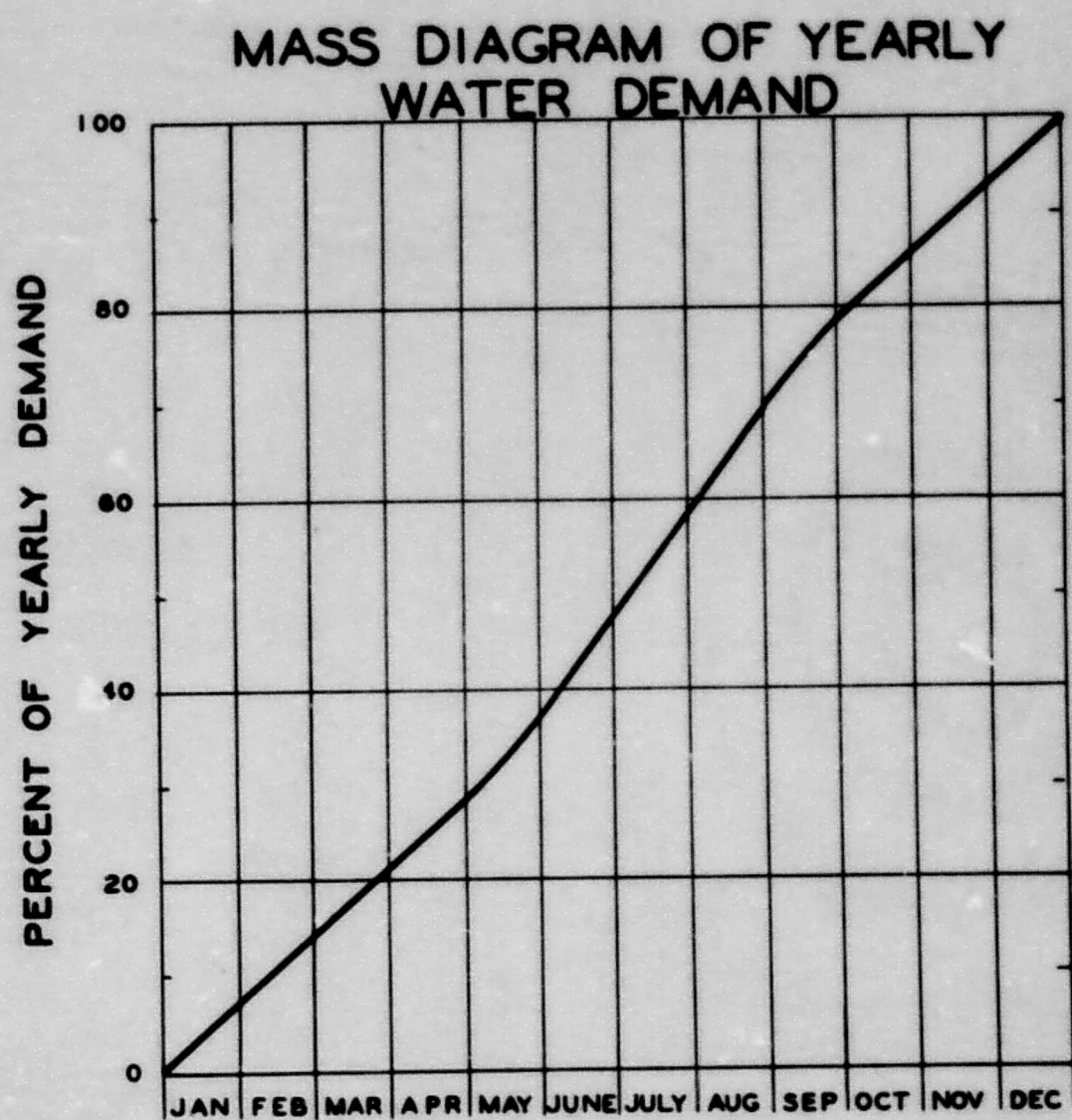
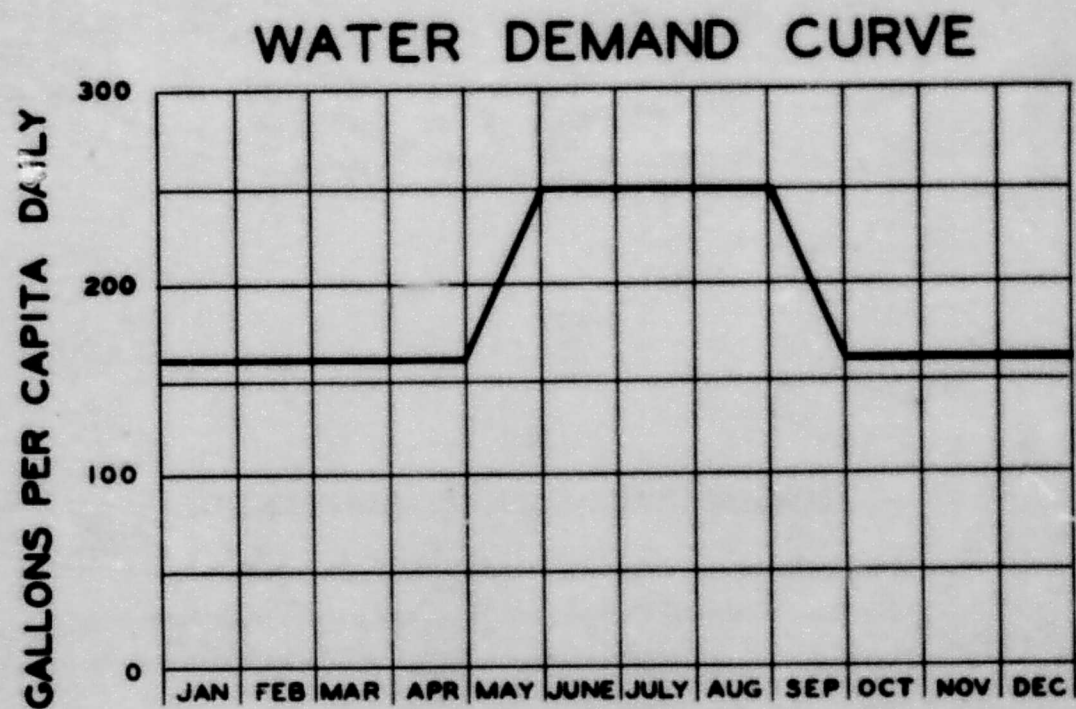
WATER DEMAND CURVES

This graph shows the quantities used for design purposes. 250 gallons per capita daily (g.p.c.d.) was used for pipe line flow and the Mass Diagram of Yearly Water Demand was used for water demand in computing storage necessary behind impounding dams.

The monthly variation in demand is closely proportional to the 1951 Seattle water consumption. For comparison, here are other statistics:

<i>Design Yearly Average</i>	191 g.p.c.d.
1951 Seattle yearly average through control works.....	193 "
1951 Seattle daily maximum consumption.....	336 "
Seattle present pipe line capacity.....	280 "
1950 Billed metered water consumption in Stattle.....	136 "
1950 Billed metered water consumption North of city limits.....	88 "
1950 Billed metered water consumption South of city limits.....	61 "
1950 Spokane mean annual water pumpage.....	261 "
1950 Spokane daily maximum.....	749 "
1948 Tacoma average daily consumption exclusive of pulp mills.....	221 "
1948 Tacoma maximum day (total).....	466 "

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

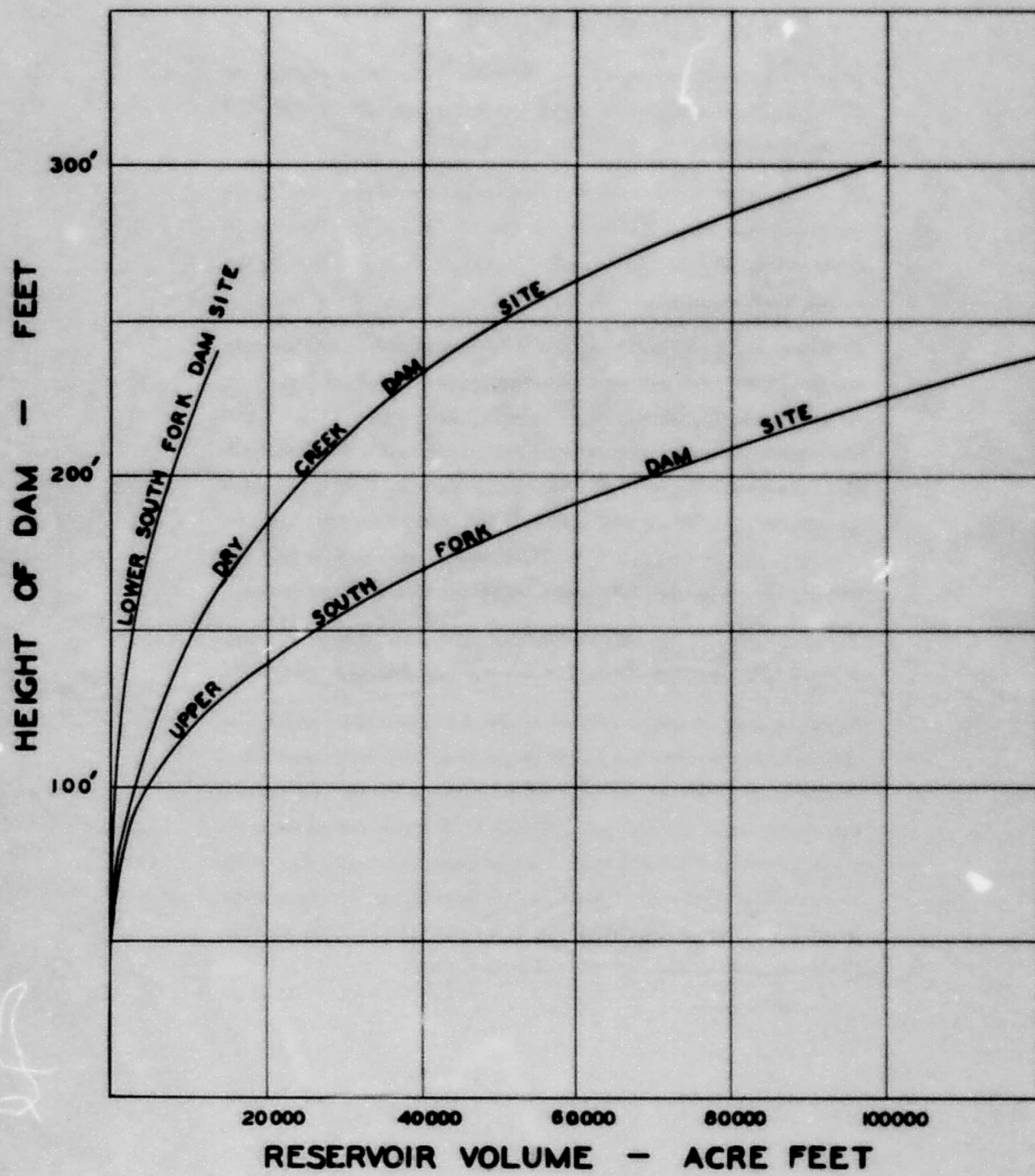
VOLUME OF STORAGE RESERVOIRS BEHIND DAM SITES

This graph gives a comparison of the physical valley storage capacities behind three possible dam sites. The graph is a plot of the height of dam against the amount of water possible to impound behind it.

The Lower South Fork Dam Site curve stops abruptly because at this dam height water begins to spill over into the Canyon Creek Basin. The graph plainly shows that the Dry Creek Dam Site would require a higher dam than at the Upper South Fork Dam Site for equal amounts of storage.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

VOLUME OF STORAGE RESERVOIRS BEHIND DAM SITES



NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

WATER AVAILABLE

The two water available curves show the theoretical storage required, or height of one dam, for various quantities of water diverted for water supply.

The heavy line would mean that the total flow of the river above the dam would be used whenever necessary. The lighter line would allow at least 20 c.f.s. (12.9 m.g.d.) (9,000 gal./min.) to flow in the stream at all times

For example: If 50 m.g.d. were needed to meet the demand, it would require 10,000 Ac. Ft. of storage at the upper South Fork Dam Site, or a dam nearly 120 feet high, using all of the flow in the river. During a dry season the reservoir would stand below the dam spillway elevation for a period of 6 consecutive months. If 50 m.g.d. were desired and 20 c.f.s. allowed to flow in the river to support fish life, etc., it would require 15,000 Ac. Ft. of storage or a dam nearly 130 feet high and a period of 8 months below the dam high water mark.

The steep parts of the curves show the maximum amount of water that could be diverted during the driest years of record.

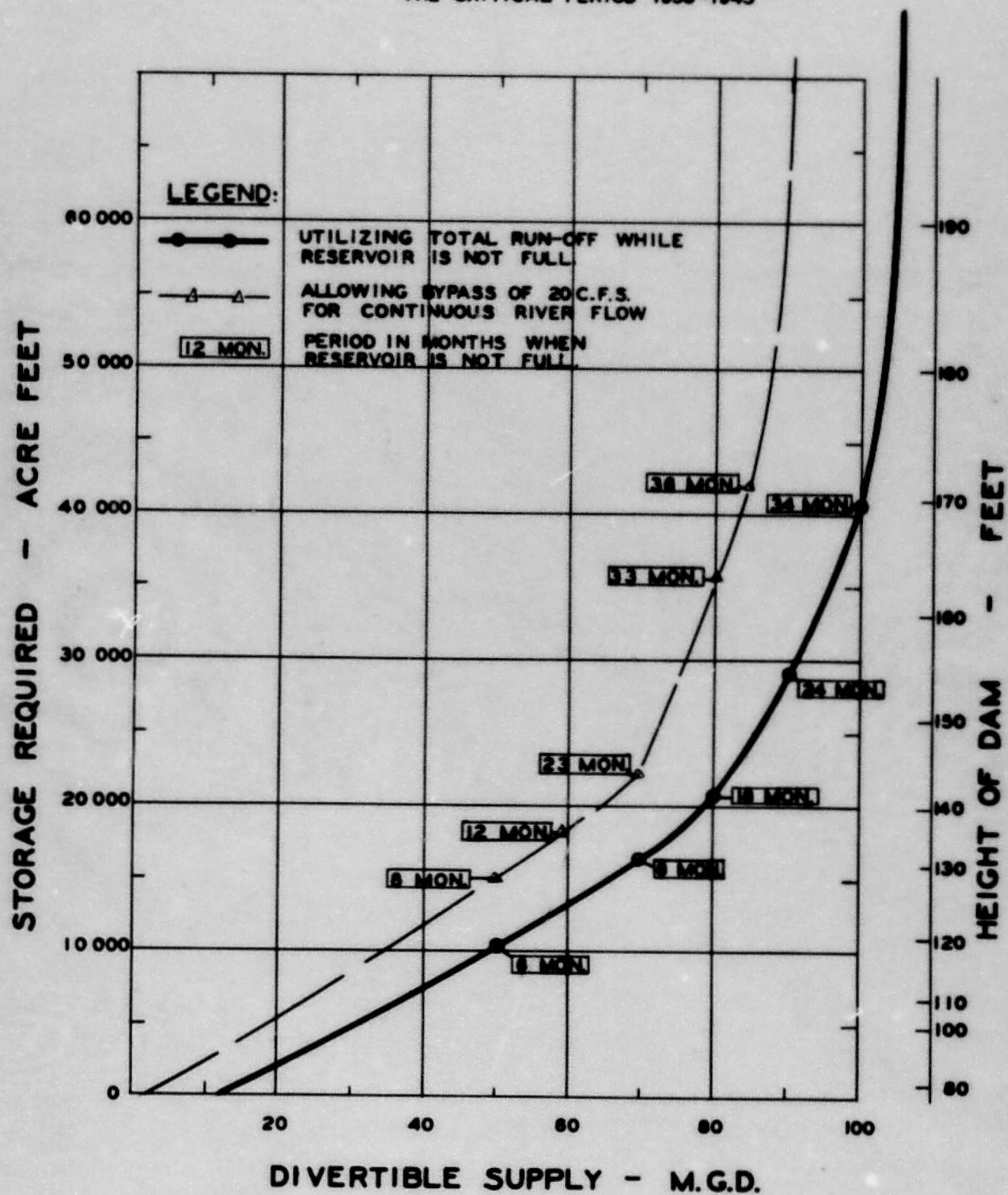
As no gauging station is located at the dam sites, the run-off was computed in proportion to the drainage area. "It is well known that in the Cascade Mountains and foothills precipitation and annual run-off generally increase with altitude."* For this reason the computed run-off above the dam sites was arbitrarily increased by 10%. The fact that the low summer flow mostly originates from melting snow in the upper regions of the water shed, would add another factor of safety to the run-off assumptions used.

* Lars Langloee report.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

WATER AVAILABLE ABOVE UPPER SOUTH FORK DAM SITE

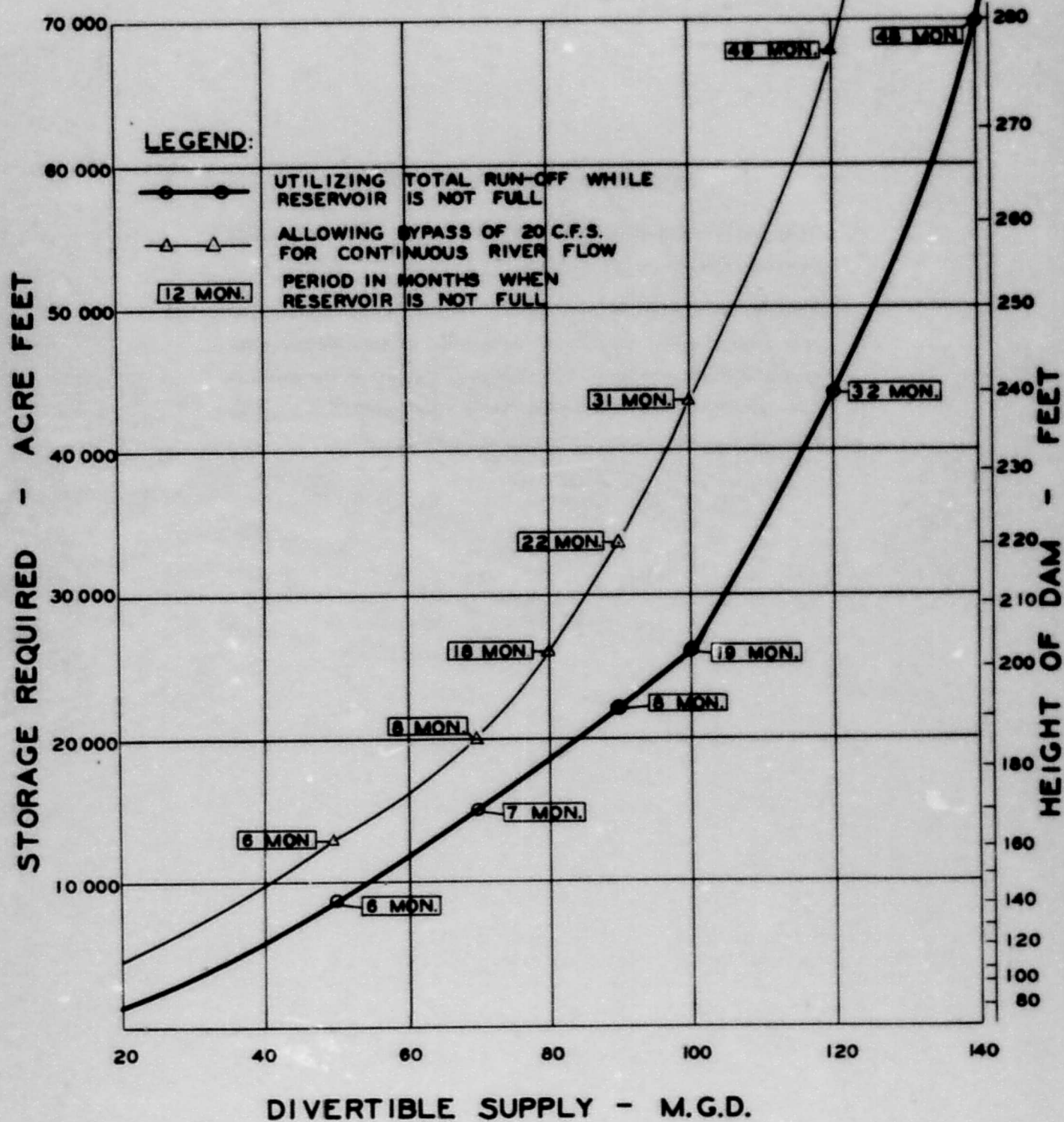
DETERMINED FROM RUN-OFF FOR
THE CRITICAL PERIOD 1938-1943



NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

WATER AVAILABLE ABOVE DRY CREEK DAM SITE

DETERMINED FROM RUN-OFF FOR
THE CRITICAL PERIOD 1938-1943



NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

DAILY HYDROGRAPH OF DRY SEASON

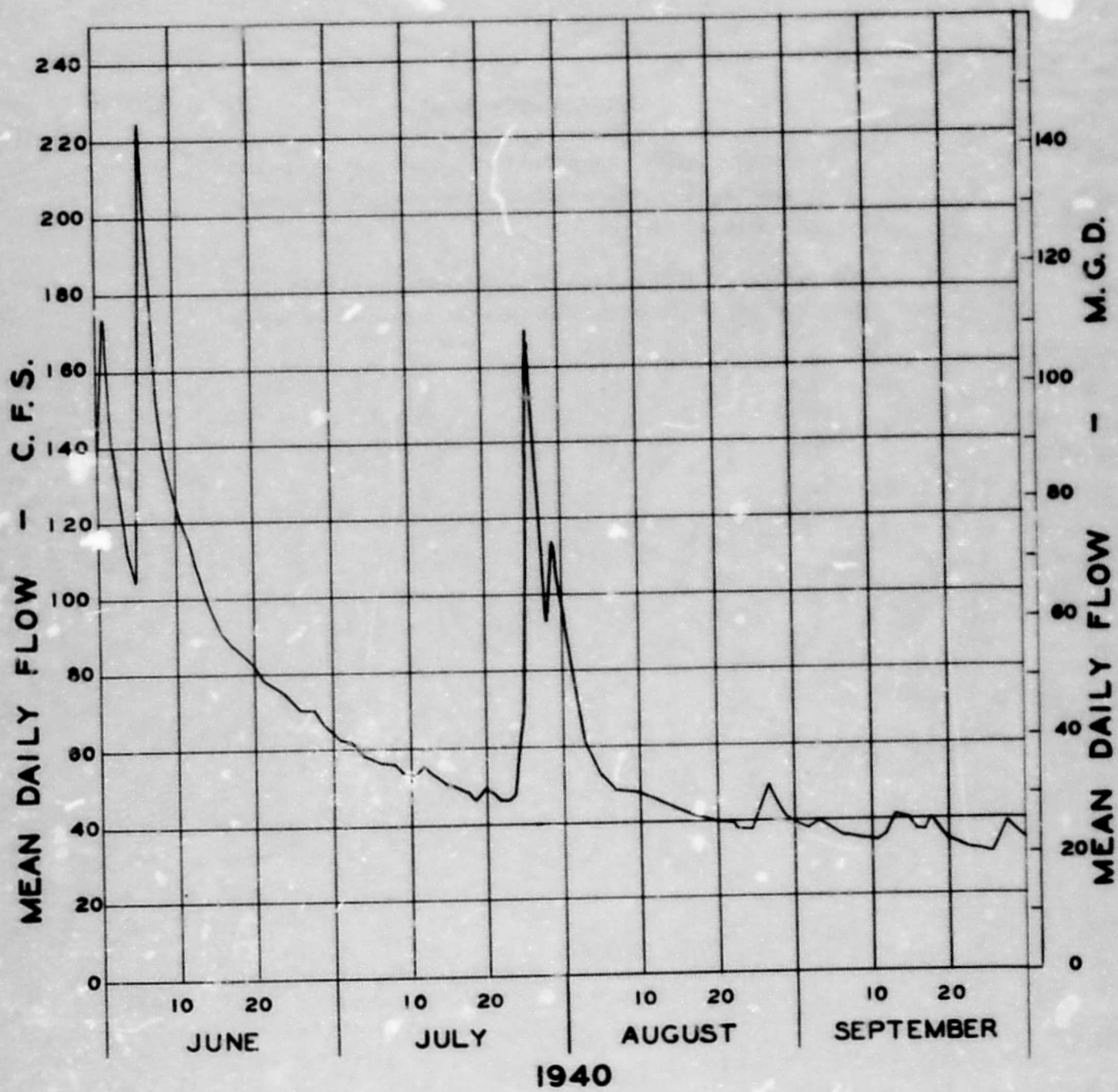
This graph is a plot of daily river flow at the site of a possible diversion dam on the North Fork.

Four dry months of 1940 were selected to show that at critical times only a very limited quantity of water could be diverted for water supply if there were no storage facilities. A glance at the monthly hydrograph will show, however, that a very substantial quantity could be diverted during the winter and spring months.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

DAILY HYDROGRAPH
OF
DRY SEASON

NORTH FORK TOLT RIVER
ABOVE 650 FT. ELEV.



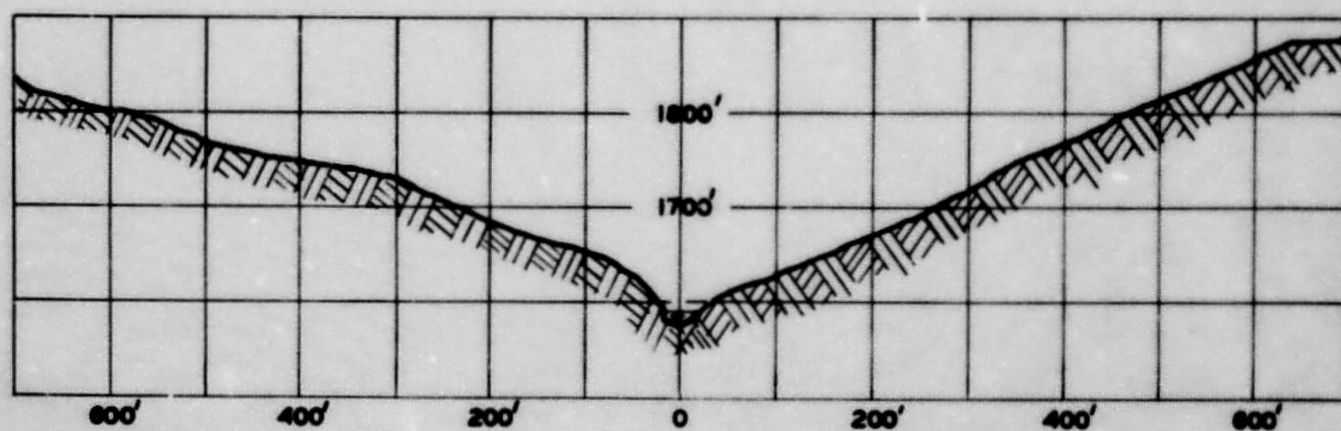
NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

UPSTREAM ELEVATIONS

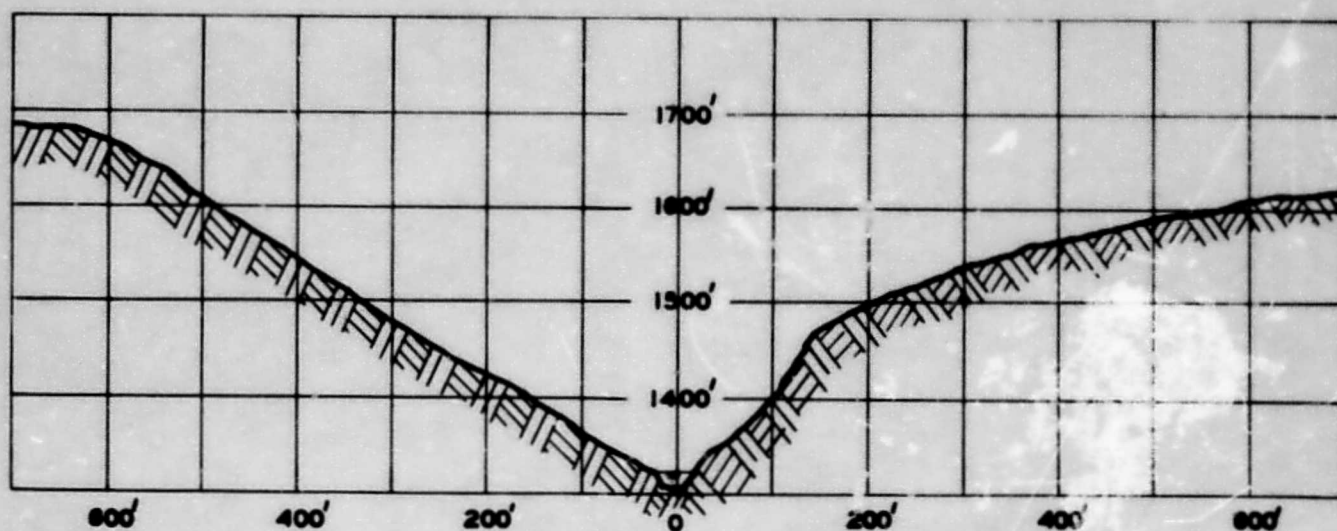
These are cross-section views of the earth surface looking upstream at the dam sites. It provides a means of measuring the crest length of a dam at these points.

For example: A 180-foot high Dry Creek Dam would have a crest length of 540 feet, assuming rock near the surface of the section.

NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.



UPSTREAM ELEVATION
UPPER SOUTH FORK DAM SITE



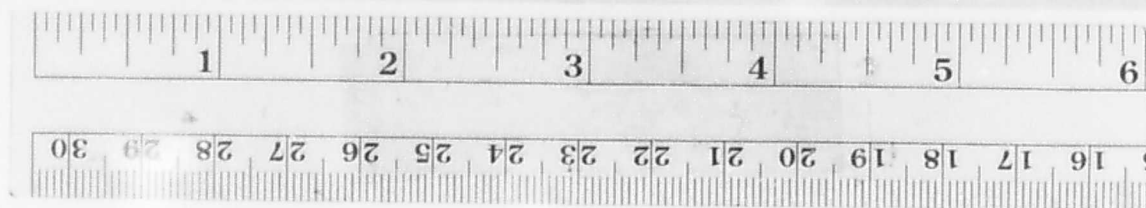
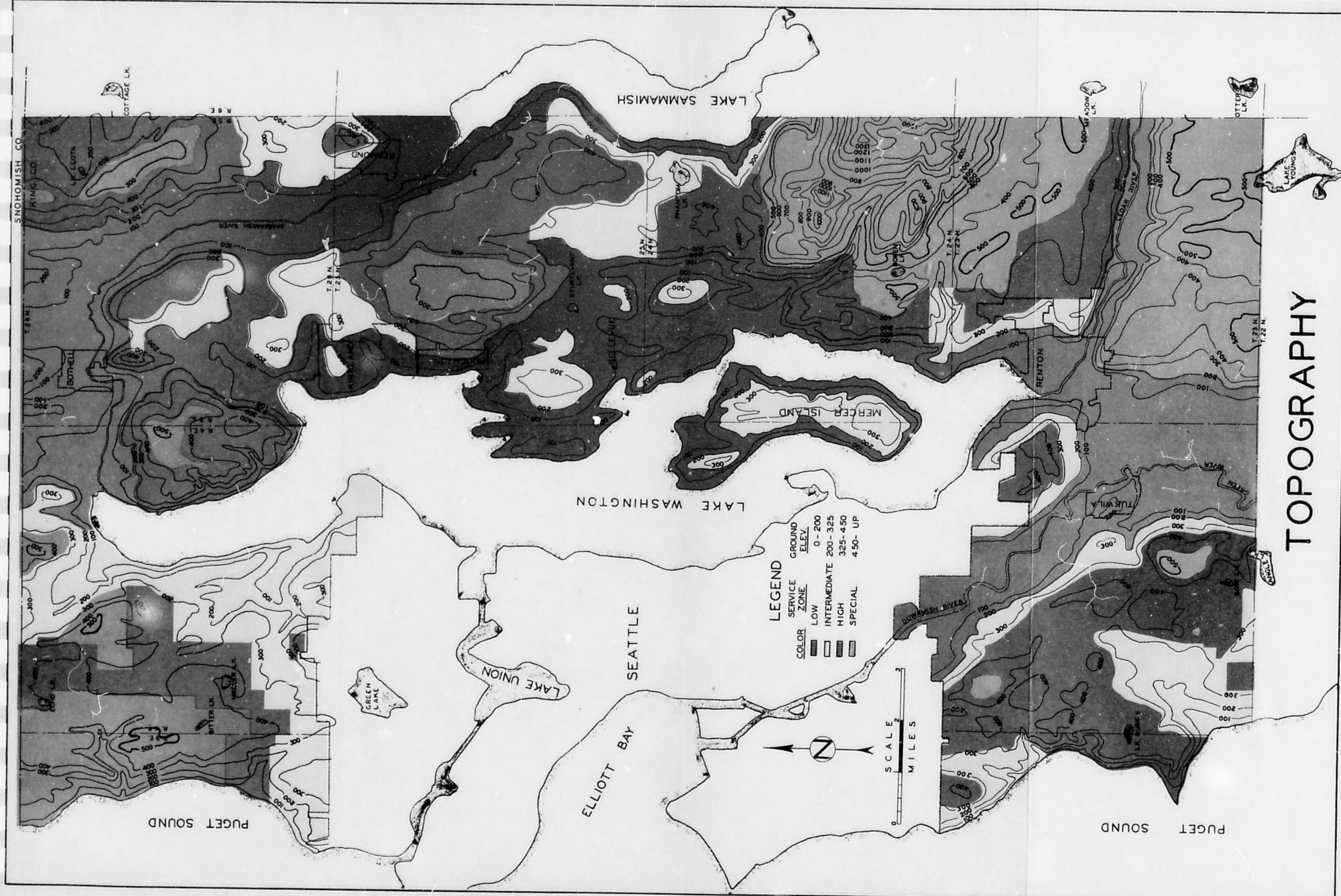
UPSTREAM ELEVATION
DRY CREEK DAM SITE

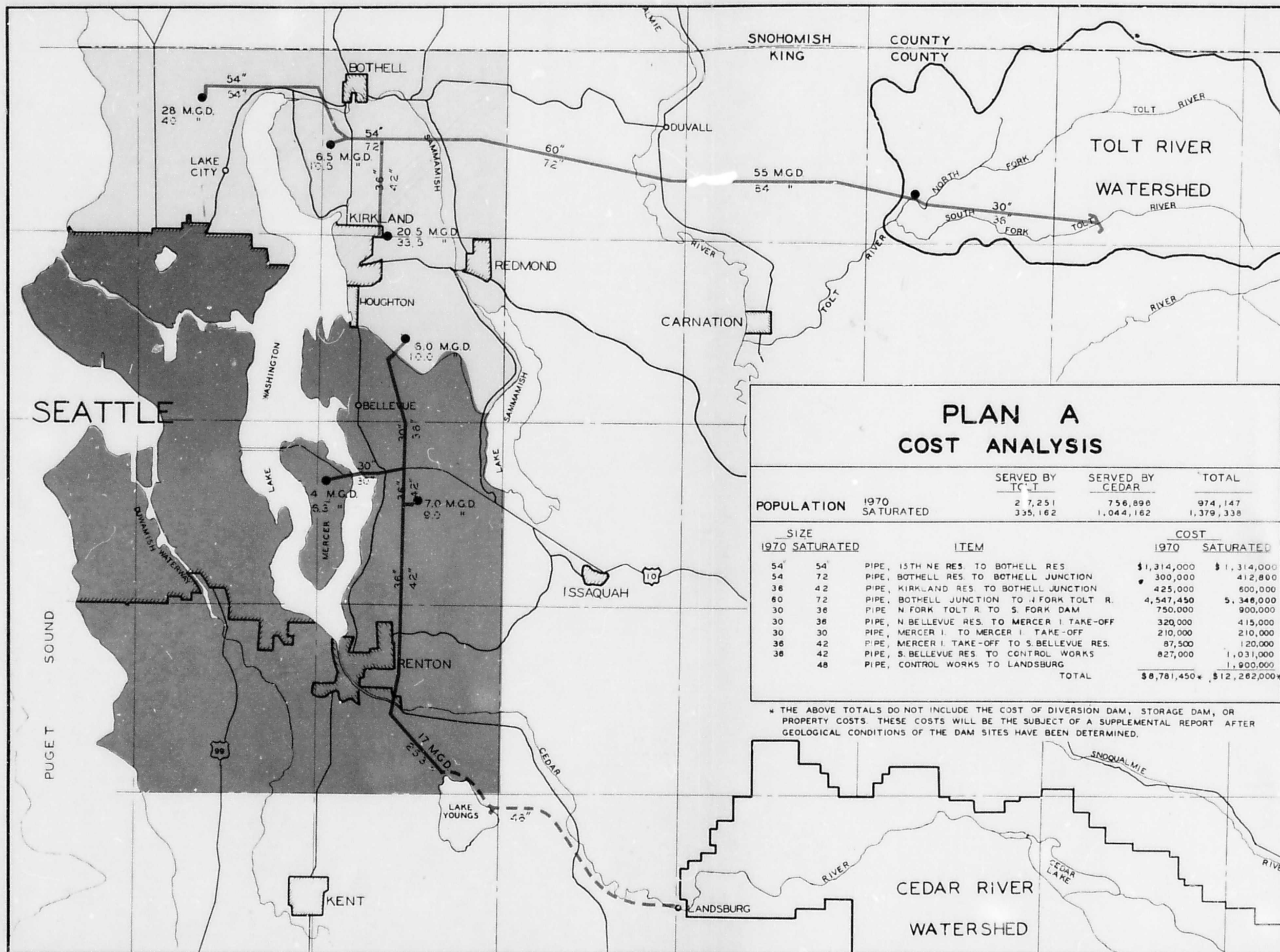
NOTICE: IF THE DOCUMENT IN THIS FRAME IS LESS CLEAR THAN THIS NOTICE
IT IS DUE TO THE QUALITY OF THE DOCUMENT.

Seattle City Clerk's Office

Comptroller File

218518



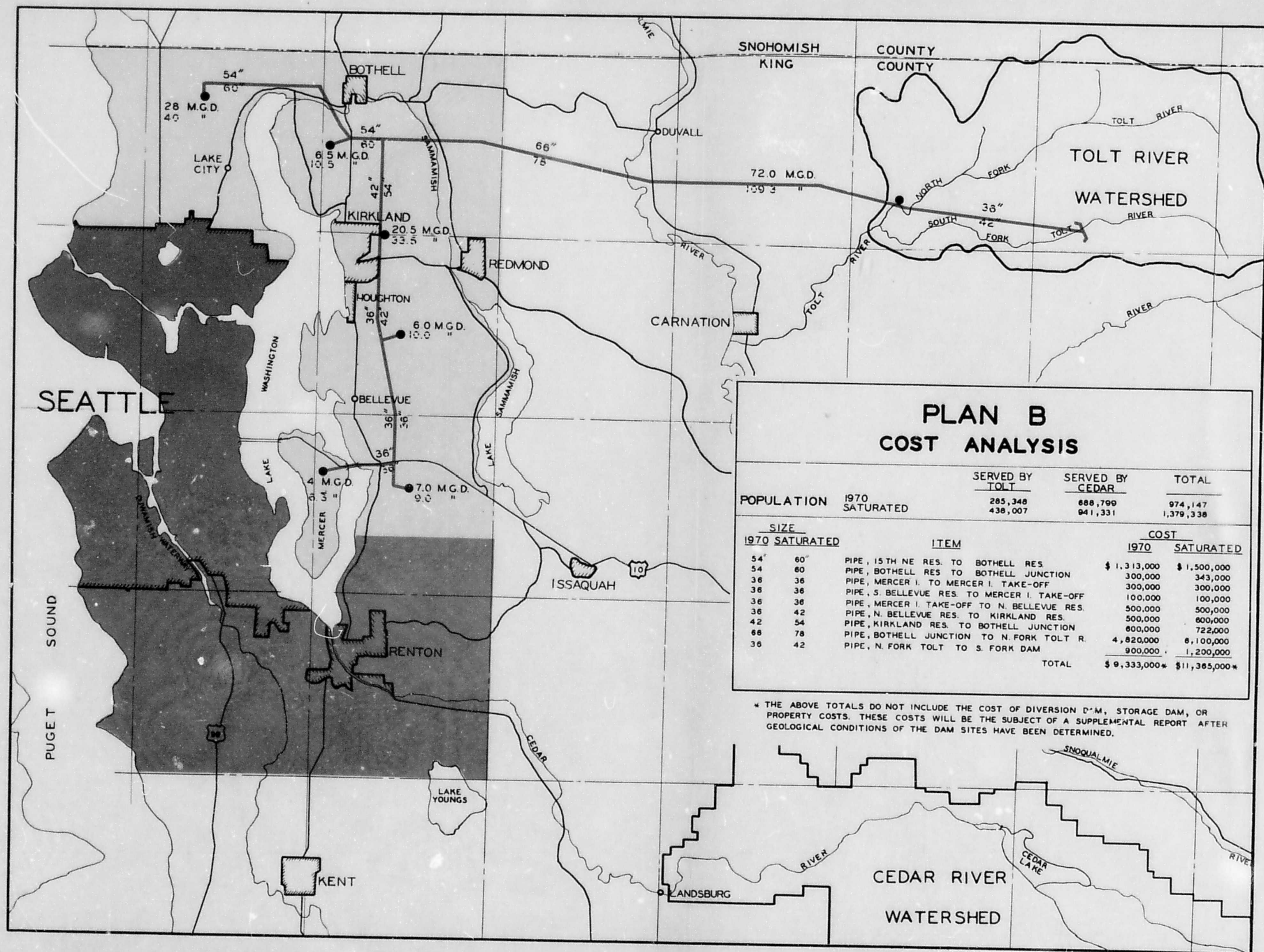


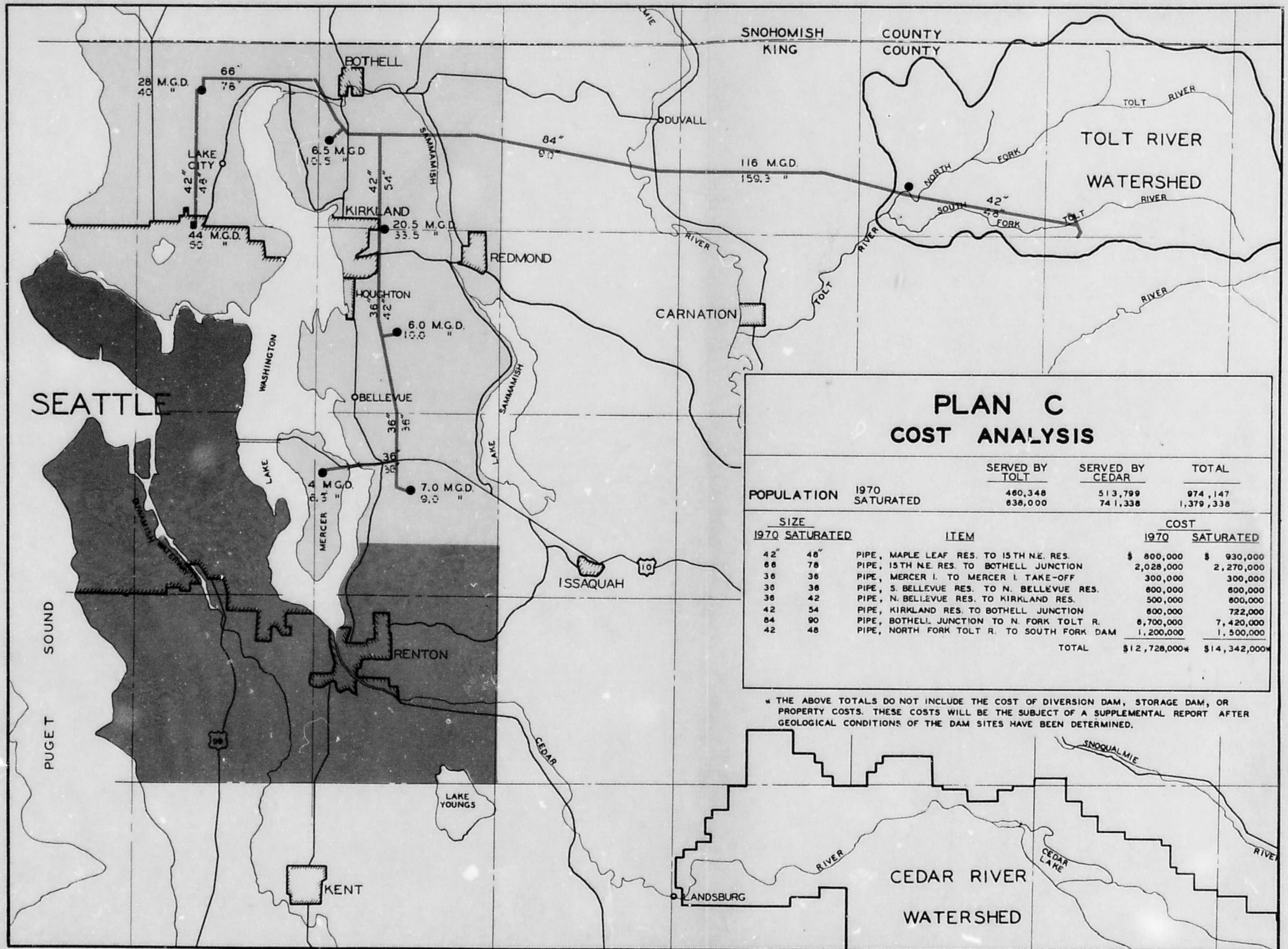
PLAN A COST ANALYSIS

POPULATION	1970 SATURATED	SERVED BY TOLT	SERVED BY CEDAR	TOTAL	
				1970	SATURATED
		2,7251	756,898	974,147	
		335,162	1,044,162	1,379,338	

SIZE 1970 SATURATED	ITEM	COST	
		1970	SATURATED
54"	PIPE, 15TH NE RES. TO BOTHELL RES.	\$1,314,000	\$1,314,000
54"	PIPE, BOTHELL RES. TO BOTHELL JUNCTION	300,000	412,800
36"	PIPE, KIRKLAND RES. TO BOTHELL JUNCTION	425,000	600,000
60"	PIPE, BOTHELL JUNCTION TO N. FORK TOLT R.	4,547,450	5,348,000
30"	PIPE, N. FORK TOLT R. TO S. FORK DAM	750,000	900,000
30"	PIPE, N. BELLEVUE RES. TO MERCER I TAKE-OFF	320,000	415,000
30"	PIPE, MERCER I. TO MERCER I TAKE-OFF	210,000	210,000
36"	PIPE, MERCER I. TAKE-OFF TO S. BELLEVUE RES.	87,500	120,000
36"	PIPE, S. BELLEVUE RES. TO CONTROL WORKS	827,000	1,031,000
48"	PIPE, CONTROL WORKS TO LANDSBURG		1,900,000
TOTAL		\$8,781,450*	\$12,262,000*

* THE ABOVE TOTALS DO NOT INCLUDE THE COST OF DIVERSION DAM, STORAGE DAM, OR PROPERTY COSTS. THESE COSTS WILL BE THE SUBJECT OF A SUPPLEMENTAL REPORT AFTER GEOLOGICAL CONDITIONS OF THE DAM SITES HAVE BEEN DETERMINED.





PLAN C COST ANALYSIS

POPULATION	1970 SATURATED	SERVED BY		TOTAL
		TOLT	CEDAR	
		460,348	513,799	974,147
		636,000	741,338	1,379,338

SIZE	1970 SATURATED	ITEM	COST	
			1970	SATURATED
42"	48"	PIPE, MAPLE LEAF RES. TO 15TH N.E. RES.	\$ 800,000	\$ 930,000
66"	78"	PIPE, 15TH N.E. RES. TO BOTHELL JUNCTION	2,028,000	2,270,000
36"	36"	PIPE, MERCER I. TO MERCER I. TAKE-OFF	300,000	300,000
30"	36"	PIPE, S. BELLEVUE RES. TO N. BELLEVUE RES.	600,000	600,000
36"	42"	PIPE, N. BELLEVUE RES. TO KIRKLAND RES.	500,000	600,000
42"	54"	PIPE, KIRKLAND RES. TO BOTHELL JUNCTION	600,000	722,000
84"	90"	PIPE, BOTHELL JUNCTION TO N. FORK TOLT R.	6,700,000	7,420,000
42"	48"	PIPE, NORTH FORK TOLT R. TO SOUTH FORK DAM	1,200,000	1,500,000
TOTAL			\$12,728,000*	\$14,342,000*

* THE ABOVE TOTALS DO NOT INCLUDE THE COST OF DIVERSION DAM, STORAGE DAM, OR PROPERTY COSTS. THESE COSTS WILL BE THE SUBJECT OF A SUPPLEMENTAL REPORT AFTER GEOLOGICAL CONDITIONS OF THE DAM SITES HAVE BEEN DETERMINED.

