WORKING PAPER NO. 21

COLUMBIA RIVER BASIN PROJECT
For Water Supply and Water Quality Management

PRELIMINARY INVESTIGATION OF MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND STREAM QUALITY CONTROL REQUIREMENTS AND BENEFITS ASSOCIATED WITH MULTIPLE-PURPOSE STUDIES OF THE PROPOSED SCOGGINS RESERVOIR, TUALATIN PROJECT, WASHINGTON COUNTY, OREGON

DATE: March 1962

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Reviewed by________

Approved by________

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General________

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Region IX

Division of Water Supply and Pollution Control
Room 570 Pittock Block
Portland 5, Oregon

This working paper contains preliminary data and information primarily intended for internal use by the Columbia River Basin Project staff and cooperating agencies. The material presented in this paper has not been fully evaluated and should not be considered as final.

REPORT ON TUALATIN RIVER BASIN STUDIES

Preliminary Investigation of Municipal and Industrial Water Supply and Stream Quality Control Requirements and Benefits Associated with Multiple-Purpose Studies of the Proposed Scoggins Reservoir, Tualatin Project, Washington County, Oregon

Prepared at the Request of and
in Cooperation with the Area Engineer,
Lower Columbia Development Office,
Bureau of Reclamation, Salem, Oregon

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Public Health Service
Water Supply and Pollution Control Program, Pacific Northwest
Region IX, Portland, Oregon

March 1962

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2. U. S. Geological Survey and State Engineer of Oregon, Preliminary Report on the Ground Water Resources of the Tualatin Valley, Oregon, January 1956

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INTRODUCTION

This report represents a preliminary examination of present and future municipal and industrial water supply and stream quality control needs in the Tualatin River Basin with particular reference to the feasibility of providing storage and/or flow regulation to serve these needs in the Bureau of Reclamation's proposed Scoggins Reservoir of the Tualatin River Project, Washington County, Oregon.

Request for the investigation and report was made by the U. S. Department of the Interior, Bureau of Reclamation, Lower Columbia Development Office, Salem, Oregon by letter dated August 14, 1961 asking for assistance in carrying out provisions set forth in the Water Supply Act of 1958 (Title III, P.L. 500, 85th Congress) for implementation of water supply programs and for an evaluation of needs, release requirement and benefits applicable to flow regulation for control of stream quality as provided in the Federal Water Pollution Control Act Amendments of 1961.

The report identifies uses and sources of water in the Tualatin Valley area and describes sources of waste, waste treatment practices and the effect of waste effluents and other materials on the quality of specific reaches of the Tualatin River.

Included also is a preliminary economic evaluation of the area, the findings of which have formed the basis for the projected municipal and industrial water demands and waste and land use effects on stream quality presented.

Since this investigation has been made in advance of study schedules planned for establishment of a Comprehensive Water Supply and Water Quality Control Program for the Columbia River Basin, certain materials presented must necessarily await later confirmation.

It is believed, however, that the needs for municipal and industrial water supply storage as described, the low flow releases for quality control indicated, and the basis for benefit computations as defined, possess a degree of finality suitable for preliminary project planning and use in determining project feasibilities and justifications.

SUMMARY

1. The population of the Tualatin Basin is expected to increase from 92,000 in 1960 to 207,000 and 500,000 by the years 1980 and 2010, respectively.

2. It is expected that most of the future growth in the Tualatin Basin will take place westward of the "urbanized" development extending out from Portland.

3. "Urbanized" development by the year 1980 is expected to extend to a line roughly connecting Tualatin, Bull Mountain, Orenco, and North Plains and by the year 2010 is expected to extend to a line roughly defined by North Scholls, Farmington, Hillsboro and North Plains.

4. Industrial development is expected to consist of electronics-scientific and food-processing type industries.

5. It is estimated that, by the years 1980 and 2010, respectively, 145,000 and 350,000 persons will be served by waters taken from Tualatin Basin sources and that 62,000 and 150,000 persons will be served by the Portland Bull Run supply.

6. Surface water sources within the Tualatin Basin are expected to serve approximately 60,000 and 160,000 persons by the years 1980 and 2010, respectively.

7. The annual demand for municipal and industrial water supply from surface sources within the basin is expected to be approximately 14,000 and 51,000 acre-feet for the years 1980 and 2010, respectively.

8. It is reported that surface supplies in the Hillsboro-Forest Grove area have experienced difficulties in availability of supply in recent years.

9. It is estimated that, by the years 1980 and 2010, respectively, a total of 407,000 and 770,000 population equivalents of domestic, municipal, and industrial wastes will be produced in the Tualatin River Basin.

10. Assuming that 75 percent of the population within the basin will be served by sewage collection systems by the year 1980 and 90 percent by the year 2010 and that municipal and industrial waste treatment will accomplish 85 percent removal of the biochemical oxygen demand, approximately 53,000 and 107,000 population equivalents of residual waste, respectively, will be received in Tualatin Basin water courses.

11. Sufficient natural stream flows are not continuously available to adequately assimilate and dilute future residual waste materials expected to be received in the Tualatin River.

12. Minimum stream flow requirements to achieve water quality objectives for recreation and protection of land values from the Scoggins site to river mile 38 (below the mouth of Rock Creek) of the Tualatin River for the year 1980 range from a winter flow of 93 cfs to a summer flow of 130 cfs and for the year 2010 from a winter flow of 194 cfs to a summer flow of 270 cfs as shown in Figure 4 of the report.

13. Minimum stream flow requirements to achieve quality objectives for recreation and protection of land values between river mile 38 and the mouth of the Tualatin River for the year 1980 range from a winter flow of 57 cfs to a summer flow of 80 cfs and for the year 2010 from a winter flow of 126 cfs to a summer flow of 175 cfs as shown in Figure 5 of the report.

14. Flow regulation in the Tualatin Basin, in addition to assisting in the control of stream quality within the basin, would be expected to provide improvements in downstream reaches of the Willamette River and Portland Harbor.

CONCLUSIONS

1. At the rate of growth anticipated and with the additional demand for municipal and industrial water supply expected, it is apparent that early development of additional sources of supply is needed in the Tualatin Basin.

2. The future municipal and industrial water supply requirements to be satisfied by surface waters will involve provisions for storage to supplement various municipal and industrial water rights being exercised at the present time as well as to supplement the shortages in natural yields that are expected to occur.

3. The annual benefit assignable to the inclusion of future municipal and industrial water supply as one of the multiple functions of the Tualatin Project would be equivalent to the annual cost of developing, on a local level and in the absence of the project, the most likely sources of surface supply available.

4. Benefits assignable to the proposed Scoggins Reservoir for quality control by low flow augmentation would be equivalent to construction, operation, and maintenance costs involved in providing similar regulation by single-purpose means as, for example, from the Gaston, McKay, Gales, or Scoggins Creek sites, whichever would be the cheapest.

5. Flow requirements for quality control between the Scoggins site and river mile 38 may be composed of natural inflow, return irrigation flows,

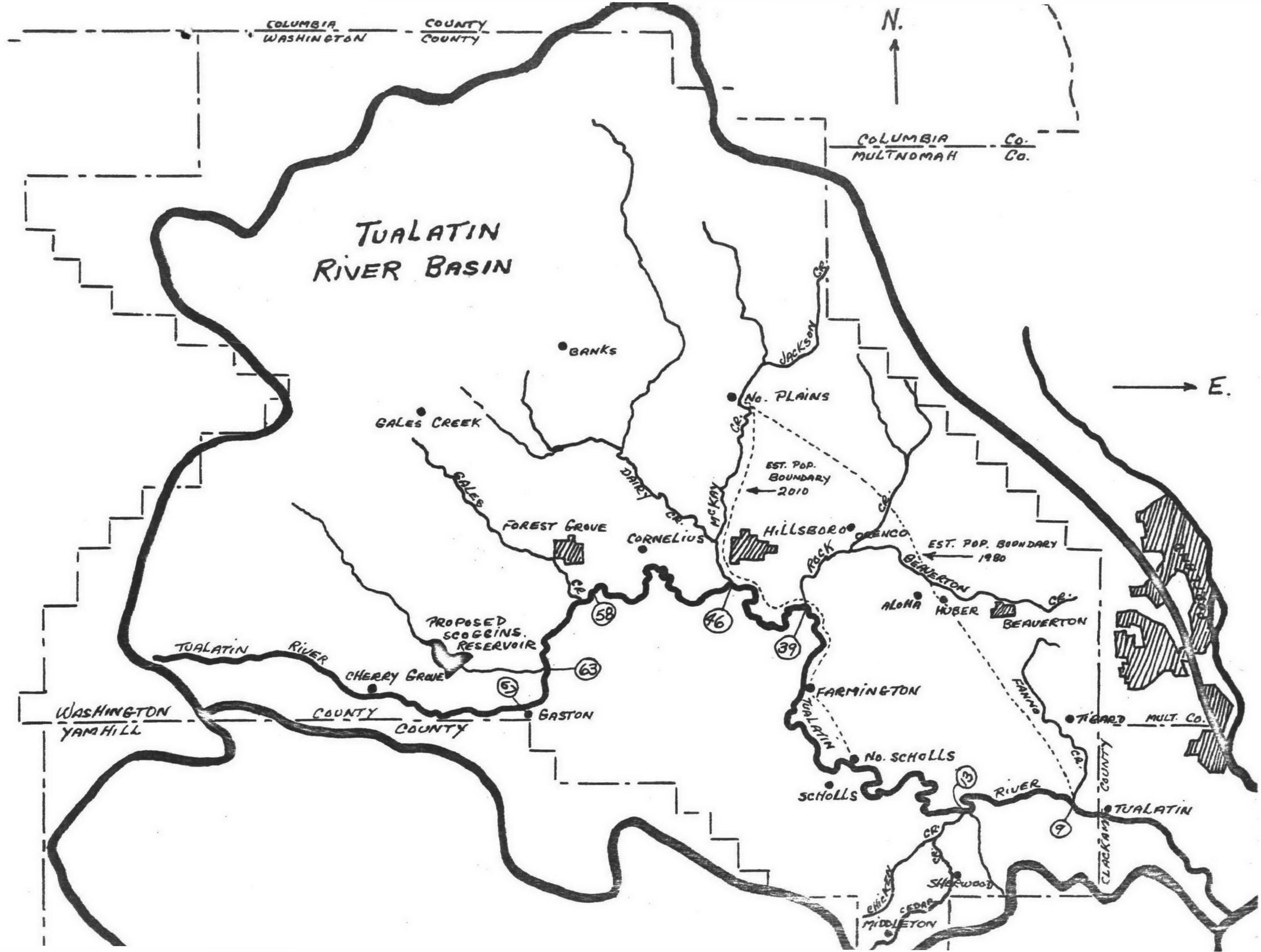
municipal and industrial return flows and releases from storage. Benefit would apply to all storage which make up the required flows for water quality control.

6. Inasmuch as waste effluents would have been received in upper reaches of the Tualatin River, diversions may be made downstream from the mouth of Rock Creek without loss to the control of quality providing the lower rate of flow required downstream is maintained.

7. In event that, upon allocation of storage for the various project purposes, any part of the requirements for municipal and industrial water supply or quality control cannot be met with the Scoggins Reservoir, Tualatin Project, it is assumed that these will be incorporated in future development planning or will be satisfied by local or other means.

8. Comments on factors associated with the final formulation of the project will be made at the time of formal inter-agency review.

9. In view of the multiplicity of beneficiaries and extent of local participation included in the achievement of water quality goals in this region, benefits attributable to provisions for water quality control as a project function are believed to be of public interest and, therefore, may be regarded as widespread and national in scope.



COLUMBIA COUNTY
WASHINGTON COUNTY
N.
COLUMBIA Co.
MULTNOMAH Co.
TUALATIN RIVER BASIN
BANKS
JACKSON CR.
No. PLAINS
E.
GALES CREEK
EST. POP. BOUNDARY 2010
McKAY CR.
DAIRY CR.
GALES CR.
FOREST GROVE
CORNELIUS
HILLSBORO
ORENCO
ROCK CR.
EST. POP. BOUNDARY 1980
BEAVERTON CR.
ALOHA
HUBER
BEAVERTON
58
46
39
PROPOSED SCOGGINS RESERVOIR
TUALATIN RIVER
CHERRY GROVE
63
67
GASTON
FARMINGTON
FANNO CR.
WASHINGTON COUNTY
YAMHILL COUNTY
TIGARD
MULT. CO.
CLACKAMAS COUNTY
TUALATIN
No. SCHOLLS
SCHOLLS
13
RIVER
9
TUALATIN
SHERWOOD
CHICKEN CR.
CEDAR
MIDDLETON

TUALATIN RIVER WATERSHED

LOCATION AND SIZE

The Tualatin River Sub-basin occupies the northwestern part of the Willamette Basin in Washington County, Oregon, and has a total area of 710 square miles. The Tualatin empties into the Willamette by two routes - one a diversion via Lake Oswego with an outlet about seven miles above the center of the city of Portland, the other by its natural channel seven miles further above Portland at the town of West Linn southwest of Oregon City.

Rising in the southwest corner of Washington County in the Coast Range, the Tualatin flows east about eight miles to Cherry Grove, where Roaring Creek enters. Some six miles further east it leaves the foothills and enters its broad valley at Gaston, where Wapato Creek enters, and turns north. A mile downstream, Scoggins Creek enters, and about three miles beyond, Gales Creek. Meandering eastward in the flat valley, it is joined by its major tributary, Dairy Creek, near Hillsboro. Four or five miles further, it is joined by Rock Creek, and turns south for about eight miles to Scholls. Then it turns east into a narrower valley through the hills south of Portland some twenty-three miles to its confluence with the Willamette. The Lake Oswego Canal diversion is about six miles above the mouth of the Tualatin.

The basin is roughly triangular in shape. It drains the basalt hills along the Willamette River to the northwest of Portland, the eastern side of the Coast Range with its sedimentary and metamorphic rocks, the old valley fill in the center of the basin, and the basalt hills along the Willamette River southwest of Portland.

PHYSIOGRAPHY

Northwest of Portland the basin boundary lies at elevations[1/] of 2,000 feet or more, reaching 2,215 feet atop Green Mountain in the northernmost corner. To the southwest along the western rim of the basin in the Coast Range, elevations range from 2,000 feet to the high point of 3,461 feet atop Saddle Mountain. In the Chehalem Mountains on the south side of the basin, elevations at the rim range from 800 to 1,600 feet. At the confluence of the Tualatin with the Willamette, the elevation is only a little over 50 feet. The broad valley in the center of the basin occupies elevations of 150 to 200 feet.

Topography around the rim is fairly rough. Valley walls are steep in the mountain areas, with slopes up to 40 percent common. Sunday Creek and the main Tualatin in the headwaters drop 400 feet in two and a half miles, and another 400 feet in the next four miles. Below Gaston, the channel gradient is very flat, dropping only about 50 feet in twelve miles. Through the 50 miles of its course in the flat valley below Gaston, the Tualatin has numerous meanders and oxbow loops.

Along the north side of the basin the hills trend from southeast to northwest, rising highest at the northernmost point. On the west side,

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1/ Place names and elevations from USGS topographic Quadrangles.

the Coast Range trends north to south, with the highest elevations about in the center. Dairy Creek and its tributaries, McKay, East Dairy, West Dairy, Cedar, and Council Creeks drain the north and northwest parts of the basin. Rock Creek and Fanno Creek drain the Portland suburban area in the northeastern part of the basin. Gales Creek, Scoggins Creek, and the upper Tualatin drain the western part. Wapato Creek enters from the south at Gaston, and McFee, Chicken, and Rock Creeks drain the low Chehalem Mountains across the southern side of the basin.

GEOLOGY AND SOILS

Along the northeastern edge of the basin the geologic formations are made up of Pliocene and Miocene volcanic rocks, principally basalt. These formations support medium to heavy-textured soils generally of a reddish color. Subsoils are often clayey and show a tendency to slump and slide. Similar geology and soils are found in the eastern Chehalem hills and south of Portland around the lower course of the Tualatin River.

The lower hills on the western side of the basin are also in the Miocene volcanics, but the main body of the Coast Range is made up of Eocene and Oligocene marine sedimentary rocks. These are primarily fine-grained sandstones with occasional interbedded shales. Soils are heavy in texture, red to brown in color, and classified generally as silty clay loams.

The central flat portion of the basin, the Tualatin Valley, is made up of old glacial debris and alluvium. Soils are deep and medium to heavy-textured. Soil color is brown or black where swampy conditions have led to development of peaty soils high in organic matter.

The U. S. Department of Agriculture Land Use Capability Classification[1] shows the uppermost third of the basin land - the hill and mountain areas - as suitable primarily for forestry. The valley floor, on flat to gentle slopes, is shown suitable for agriculture with few or no limitations such as erosion hazard. The lower hill areas in intermediate position around the edge of the valley are suitable for orchard or grazing use with proper soil management because of a high erosion hazard. Present land use follows the capability classification fairly well. However, a large portion of the northeastern part of the basin is being converted to suburban residential area.

COVER VEGETATION

The upper elevations of the Tualatin Basin, about a third of the area, support a forest cover in which Douglas-fir is the dominant species. Associated species include western hemlock and western red cedar. Practically all of the old growth forest has been cut and most of the forest area now supports vigorous stands of young second-growth Douglas-fir. However, there are scattered patches of hardwood brush

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1/ Columbia River Basin Agricultural Program Report, USDA 1954.

here and there where for one reason or another regeneration of the conifers has not been successful.

In low-lying swampy areas and along streams the hardwoods are dominant. These include red alder, Oregon ash, bigleaf maple, cottonwood, and willows. Some of the drier sites on the lower hills (as in the Chehalem Mountains) support occasional stands of Oregon white oak.

Most of the lower hills are cultivated, some areas to orchards, some to grain and hay crops. Other parts of the hilly fringe of the valley have been cleared for pasture. All of the main valley is cultivated or is in the process of suburban development.

CLIMATE

The climate is moderate, strongly influenced by nearness of the Pacific Ocean sixty miles to the west across the relatively low Coast Range. Winters are wet and summers dry. Prevailing winds are westerly, from the ocean. Surface winds are usually light to moderate.

Temperatures recorded at Forest Grove, a long-term station near the center of the Tualatin Basin, range from a maximum of 106°F to a minimum of -15°F. Such extremes are rare; average July temperature is 66°F, and average January temperature 37°F. The frost-free growing season ranges from 160 to 200 days. Both summer hot periods and winter cold periods are of short duration.

Rainfall in the Coast Range headwaters of the Tualatin River reaches 90 inches average annual, but decreases rapidly eastward to the valley floor which gets from 35 to 50 inches annually depending on aspect and local topography. Days with measurable rain amount to about 160 per year. Climatologic averages[1] for Forest Grove are as follows:

Item	Month												Annl.
	J	F	M	A	M	J	J	A	S	O	N	D	
Precip.,in.	7.4	6.1	4.8	2.7	1.9	1.3	0.4	0.5	1.7	3.3	7.5	8.3	45.9
Snowfall,in.	8.7	4.0	0.6	0	0	0	0	0	0	0	0.3	2.5	16.1
Temp., °F	37.1	40.6	44.8	49.6	55.5	60.9	65.9	66.5	60.2	52.2	44.2	38.9	51.4
Max., °F	43.5	48.4	55.0	61.6	68.4	74.8	82.3	83.2	73.8	64.0	52.2	44.9	62.7
Min., °F	30.7	32.6	34.8	37.8	42.7	47.0	49.6	49.8	46.1	40.3	36.2	32.9	40.0

Humidity is fairly high in winter, moderate in summer. Extreme low humidity accompanies the occasional east winds in fall and winter. Sunshine averages about half the total possible. Night and morning fogs are fairly common in late fall and winter. Evaporation rates are moderate, averaging about 25 inches for the six-month growing season, and transpiration is moderate except during the hot dry months of July and August when drafts on ground water are heavy.

HYDROLOGY

The stream flow regime of the Tualatin River follows that of the rainfall, high in winter, low in summer. Snow storage rarely builds up to three feet and is not great enough in the Coast Range headwaters to carry over significant amounts of water from winter to spring.

The Tualatin itself is gaged at several places, and the tributaries Scoggins, Gales, Dairy, and McKay Creeks are or have been gaged. The major diversion to the Lake Oswego Canal is also gaged.

1/ Climatic Summary of the U.S., Sec. 3 - Western Oregon, USWB 1930.

AVERAGE STREAM FLOW[1/] CFS, TUALATIN BASIN

Stream, Station Drainage Area	O	N	D	J	F	M	A	M	J	J	A	S	Annual
E. Fk. Dairy Crk., Mountaindale, 43 sq. mi.	23	103	206	219	304	191	110	63	32	20	13	13	107
McKay Creek, North Plains, 29 sq. mi.	10	76	177	176	198	114	57	24	12	5	3	3	71
Scoggins Creek, Gaston, 44 sq. mi.	33	158	315	327	361	242	141	68	32	14	8	8	141
Gales Creek Forest Grove, 66 sq. mi.	55	273	508	547	589	388	208	100	48	25	16	16	230
Tualatin River, Gaston, 51 sq. mi.	64	267	452	449	481	330	200	95	45	21	13	14	201
Tualatin River, Dilley, 133 sq. mi.	91	436	903	913	1077	680	401	185	79	31	18	21	400
Tualatin River, Farmington, 568 sq. mi.	212	1074	2929	3400	3942	2473	1358	565	243	98	50	62	1356
Oswego Canal	59	49	124	91	93	78	64	50	53	55	54	58	69
Tualatin River, Willamette, 710 sq. mi.	172	1093	3023	3772	3751	2751	1658	641	277	94	32	43	1433

1/ Taken from compilations made by Oregon State Water Resources Board

Two stations one on Gales Creek and one on West Fork Dairy Creek, were not included because of their short periods of record.

Recorded maximum and minimum flows are as follows, according to State Water Resources Board compilations:

Station	Maximum cfs	Date	Minimum cfs	Date
E.Fk.Dairy Crk., Mtndale	1,420	Feb.'49	7	1944
McKay Crk., N. Plains	2,100	Feb.'49	0.4	1951
Scoggins Crk., Gaston	5,320	Dec.'55	0	46-47
Gales Crk., Forest Grove	6,410	Feb.'49	3.1	1952
Tualatin R., Gaston	8,170	Dec.'55	0.2	51-52-53
Tualatin R., Dilley	13,200	Dec.'55	0.4	1951
Tualatin R., Willamette	23,300	Dec.'33 1/	3	1929 2/

1/ Dec.'37 and Dec.'55 within 10 percent of this total, also.
2/ This is the only 30-year record station; others are only 11 to 19 years.

Nineteen of twenty peak flows occurred in December or January or February, and one in April. The dates of greatest peak flows coincide with the dates of major floods, as might be expected. December 1933, December 1937, February 1949, December 1955 and December 1960 all marked major flood occurrences. Some cropland areas are inundated nearly every year because of inadequate channel capacity through the flat valley floor.

Extreme minimum flows are unfortunately far more common. Irrigation and municipal supply diversions take a considerable toll during the months of low flow. For the Tualatin near its mouth, including diversion to Lake Oswego monthly flows have been below 100 cfs 20 percent of the time in July, 90 percent in August, 80 percent in September, and 30 percent in October.

The valley fill, largely clay and silt, extends to 900 feet in depth below the valley plain. It contains some sand strata, but very few gravel beds. The essentially horizontal sand strata are aquifers, and are found at depths of 40, 100, 200 and 300 feet. The Columbia basalts underlying the basin also are aquifers. Springs flow from the base of this and other lava formations in the basin. The water table stands at elevations close to 200 feet in most of the basin, not far below the surface of the valley plains. Present rates of pumping have not caused any general decline in the water table, and recharge from precipitation and from cross-valley streams is sufficient to compensate pumping draft.

PROPOSED PROJECT

The project area comprises an estimated 17,000 irrigable acres in the Tualatin River Basin, the center of which is located about 15 miles west of the Portland city limits. Water for irrigation would be provided from storage in the Scoggins Reservoir together with natural stream flow.

In addition to provisions for irrigation, project studies involve storage for flood control, fish and wildlife, municipal and industrial water supply, quality control by flow regulation and recreation.

The site of the proposed Scoggins Dam is about five miles upstream from the mouth of Scoggins Creek which enters the Tualatin River approximately five miles south of Forest Grove and ten miles southwest of Hillsboro, Washington County, Oregon. Approximately 61,000 acre-feet of water would be stored in this area to serve the various anticipated purposes.

The municipalities of Forest Grove, Hillsboro and Beaverton have indicated support of the project for municipal and industrial water supplies. The Tigard Water District has expressed interest in an additional source of water supply and the Lake Oswego Corporation is desirous of obtaining releases from storage to maintain sanitary conditions at Lake Oswego during summer months of low in-flow.

STUDY OBJECTIVES AND PROCEDURES

The objective of this study and report is to establish, by use of existing and projected data, preliminary conclusions on the feasibility of providing in the Scoggins Reservoir, storage space for municipal and industrial water supply and storage and/or flow regulation for stream quality control and to enumerate where practicable the benefits that would accrue to the project with these purposes included.

Existing sources of municipal and industrial water supply are examined and with projected demand data, the adequacy or suitability of these sources in meeting future demands is estimated. Where warranted, alternate supplies to either replace or supplement the developed sources are identified and explanations are given on procedures to be followed for determining whether use of the Federal project, in lieu of other development possibilities, would be feasible or justified and if so, on what basis benefits may be derived.

Flow regulation requirements relate to the control of specific quality parameters and achievement of specific objectives as governed by the beneficial uses enumerated and the particular quality required to satisfy these uses. Whereas flow regulation for quality control is regarded as a supplement to waste treatment or other measures of control at the source, computations involving needs for additional waste assimilation capacity and dilution in the stream reflect provisions for such treatment. In cases where the quality of irrigation return flows may be suspected of contributing significantly to reduced stream quality, i.e., nutrient or mineral enrichment (excessive slime and algal growth), toxicity, turbidity, bio-chemical oxygen demand, etc., a statement to this effect is included with an explanation of the intent of the Public Health Service to conduct studies and surveys at a later date on which to base recommendation for possible further means of control.

Inasmuch as flow regulation requirements for quality control include allowances for reasonable degrees of waste treatment, the alternate method and hence, the benefit assignable to the storage associated with such regulation is considered equivalent to construction, operation and maintenance costs involved in the development of the least costly single-purpose alternate impoundment structure so designed as to provide the recommended regulation. Although, for example, such alternates as waste distillation or underground disposal would accomplish similar control, these methods are not at this time considered to be feasible or equivalent alternates. Annual benefits assignable to flow regulation for quality control, therefore, may be based on amortized costs plus annual operation and maintenance expenses involved in achieving similar regulation by the single-purpose impoundment and release method.

As it may not always be possible in a given multiple-purpose project to provide the full amount of storage and/or releases necessary to meet recommended quality objectives, a range of stream flows showing relative degrees of control are prepared from which a selection of benefits based on the extent of shortages and the relative protection afforded the stream use or values may be determined. Unless for reasons of practicality or physical limitations any portion of the recommended objectives cannot be achieved by a given project, it is generally assumed that such deficiencies would be incorporated in the planning of future projects.

PRELIMINARY ECONOMIC REPORT AND ESTIMATE OF GROWTH, 1960-2010

INTRODUCTION

Purpose of This Analysis

This analysis is intended to provide a preliminary estimate of the economic potentials and a broad guide to the anticipated growth of the subject area.

Definition of the Area

The Tualatin River drainage basin conforms approximately to the boundaries of Washington County, and for purposes of this analysis, the county has been used as the unit of study. In terms of area, the small departures of the physical basin boundary from the political county boundary are roughly offsetting. In terms of population, a small but urbanized area in southwestern Multnomah County which is part of the Tualatin Basin is excluded by using the Washington County boundary. The mouth of the Tualatin River also lies outside Washington County. However, the convenience and accuracy of using available statistics and existing forecasts, all on a county basis, and the impracticality of attempting estimates for such small fringe areas, make use of the county boundary advisable.

Study Period

The study period is the 50-year period 1960-2010 with an interim point at 1980.

Limitations of This Analysis

Two limitations apply to this study. The first is that it is intended only as a preliminary estimate of the outlook for the subject area's growth. Subsequently, in connection with the Columbia River Basin Project for Water Supply and Water Quality Management, an analysis will be made on an industry-by-industry basis of the growth potential in the various sub-basins. At that time, this preliminary estimate will be reviewed, and revised if necessary.

The second limitation is that this study is intended for use particularly in assessing future water needs. Emphasis has been placed on the analysis of those industries which make heavy demands upon the water resource. Other industries have been considered only insofar as they may have a significant effect on future population. For this reason, this study is not submitted as a detailed industrial forecast.

PRESENT ECONOMIC BASE

Geography of the Study Area

The Tualatin River Basin, which, for purposes of this analysis, is equivalent to Washington County, is located in the northwest corner of the Willamette Valley. It consists of a broad, fertile valley floor almost entirely surrounded by ranges of hills and mountains. The county is about 35 miles from east to west and about 30 miles from north to south.

Rainfall is about 35 to 50 inches in most of the Tualatin River Basin. At Forest Grove, average January temperature is 37 degrees and average July temperature 66 degrees. The growing season in the Basin, the time between the last occurrence of 32-degree temperature in spring and the first such temperature in fall, averages 175 days.

The valley floor supports a mixed agricultural economy, including dairying, grains and vegetables, and the hillsides are used for orchards.

Land Use

According to a 1959 survey by the Oregon State Conservationist of the U. S. Department of Agriculture, the area of Washington County was distributed among the following uses:

Land Use	Acres, Thousands
Forest and wooded	249
Farms and cropland	146
Urban and built-up	44
Pasture and range	6
Federal land	12
Water	1
Total Acreage in County	458

The "urban and built-up" classification includes roads, airports, parks, and commercial, industrial and residential uses. The bulk of this is in the eastern portion of the county.

More than 11,000 of the 12,000 acres of federal land is U. S. Bureau of Land Management timber land.

At the time of the 1959 Census of Agriculture, there were 106,000 acres of harvested cropland in the county. This was a decline from 113,000 in 1954. Irrigated acreage declined from 17,000 in 1954 to 15,000 in 1959. The number of farms declined from 3700 in 1954 to 2800 in 1959, and the average size of farm increased from 64 to 76 acres. Nearly half of the harvested cropland in 1959 was used for wheat, oats and barley.

Water Uses

At present, the principal non-consumptive use of water associated with the Tualatin River is at Oswego Lake, which draws its water supply from the Tualatin. This is an important recreational facility, not only for the residents of Oswego, but also for the Portland Metropolitan Area. Almost the entire shoreline of Oswego Lake is developed residentially; 480 homes have lake frontage. Over 700 boats are licensed to use the lake. Many other residences not on the lake have lake-use privileges. In addition, there is a public swimming concession which is used by hundreds of persons on summer days.

Recreational uses along the Tualatin River itself are limited, due to the poor quality of the water, the low flow during the summer, and the eroded shoreline resulting from extreme variation in flow during the year. Despite these handicaps, there are a number of public picnicking, swimming and boating facilities along the river, testifying to the need and demand for such facilities in the Portland Metropolitan Area. On some summer days, several thousand persons use these public facilities.

In addition to the public facilities, the lower reaches of the river have over 200 residences directly on the river's shore, with private boating and swimming facilities.

Population

Population of Washington County as of April 1, 1960 was 92,237. This gave the county an average density of 129 persons per square mile, the second highest among the state's 36 counties and exceeded only by Multnomah's 1233 persons per square mile.

Despite its high average density, the fact that a large part of the county's population is concentrated along its eastern fringe means that most of the county area retains a predominantly rural character. This can be seen by separating the 1960 population into the following four parts:

Portland "Urbanized" Area population, portion in Washington County, 36,889. This was defined by the federal census to include the contiguously built-up area extending out from Portland. Beaverton, population 5,937, is included in this portion. This population equalled 40 percent of the county total, though the area involved represented less than 3% of the county's total 458,000 acres. The density in this "urbanized" area was about 3 persons per acre in 1960.

Other Urban population, 13,860. "Urban" population is defined by the census to include incorporated areas of 2500 or more population. Aside from Beaverton, included in the "urbanized" portion, there are only two other cities in this class: Forest Grove, 5628; and Hillsboro, 8232. This population equalled 15 percent of the county total.

Small incorporated places, total population 2852. The five small communities included in this total equalled 3 percent of the county total. The communities and their 1960 population are: Gaston, 320; Cornelius, 1146; Sherwood, 680; Tualatin, 359; and Banks, 347.

Rural population, 38,636. These persons, living on farms or outside any organized community, comprised 42 percent of the county's total population.

The concentration of population in the eastern fringe of the county is a result of two economic factors: (1) the function of the area as a bedroom satellite for persons employed in Portland; and (2) the location in the area of the large oscilloscope firm which provides over half of total manufacturing jobs in the county.

The other two principal population concentrations (Hillsboro and Forest Grove) contain some food products and lumber-wood products manufacturing and provide retail service functions for the surrounding farm population.

The Present Industrial Pattern

The economy of Washington County differs from that of the rest of the state in several important respects. Washington County is part of the Portland Metropolitan Area, and many of its service functions are performed in the core area, so that employment in service industries is relatively low in Washington County. Manufacturing employment, on the other hand, is significantly higher in Washington County than in the state as a whole. Among the manufacturing industries, lumber and wood products, so dominant in other parts of the state, provide a relatively small share of employment. Specialization has developed in electronics, with one oscilloscope firm providing more than half of all manufacturing employment in the county.

Table 1 shows how the distribution of non-agricultural employment in Washington County compared, as of April 1960, with the distribution in the state as a whole. The data are for "covered employment" only (that is, employees covered by the state unemployment compensation law) and exclude self-employed persons.

Table 1
Covered Employment in Non-Agricultural Industries
Actual Employment by Industry in Washington County, April 1960
and Percentage Distribution in Washington County and in Oregon

Industry	Number of Employees, Washington County	Percentage Distribution Washington County	Percentage Distribution State of Oregon
Mining	43	.39	.27
Construction	1024	9.30	5.82
Manufacturing, total	5256	47.75	34.27
Lumber, wood prod., furn. & fixtures	754	6.85	18.12
Metal, prim. & fabr.	59	.54	2.57
Machinery, non-elec.	23	.21	1.32
Electr. machinery	2995	27.21	1.00
Prof.,Scient.equip.	284	2.58	.27
Transport. equip.	68	.62	.99
Food and kindred	511	4.64	4.12
Paper and allied	180	1.63	1.76
Print., publ.	110	1.00	1.25
Chemicals, allied	46	.42	.37
Stone, clay, glass	68	.62	.69
Apparel, textiles	24	.22	1.31
All other mfr.	134	1.22	.50
Trans., Comm., Util.	623	5.66	7.78
Wholesale Trade	347	3.15	7.43
Retail Trade	2175	19.75	19.29
Fin., Ins., R.E.	311	2.82	4.74
All other services (x)	1002	9.10	9.72
Government	229	2.08	10.68
TOTAL	11010	100.00	100.00

(x) Includes business and repair services, entertainment and recreation, and professional services.

Source: Oregon Dept. of Employment, Covered Employment and Payrolls, Second Quarter, 1960.

ESTIMATED GROWTH, 1960-2010

Factors Influencing Future Growth

Three major factors are expected to provide the economic base for the large population increase anticipated for Washington County. The principal factor will be the continued development of the "bedroom satellite" function of eastern Washington County, in relation to Portland.

A second growth factor is expected to be the further expansion of the electronics-scientific instrument industries which are already the primary manufacturing activities in the county. The electronics and scientific instrument industries got an early start in Washington County, and it is expected that the existing nucleus of manufacturing facilities and skilled labor force will attract other such firms to the area. The establishment of the Oregon Regional Primate Research Center near Orenco will also help to attract other supporting scientific activities. In addition to the power of attraction of existing firms, other assets seem likely to bring new industries to Washington County. Among these assets are the availability of large industrial sites with room for expansion, desirable living conditions, convenient transportation, industrial zoning, and a growing regional market.

A third factor which can help support the future economic base, though it will be less important than the previous two, is the potential increase in food processing industries. As regional demand for food grows, with increasing population, it is expected that there will be a gradual shift from grain acreage to specialty crops, suitable for canning or freezing. The Scoggins Creek project, under consideration by the Bureau of Reclamation, would more than double the existing irrigated acreage in the county. This would provide additional crops to support some expansion of the food-processing industries. This expansion in irrigated acreage will be partially offset by the gradual withdrawal of some agricultural land from production as urban uses displace farming. However, in this connection, the establishment in 1962 of a "farm zone" by the Washington County Planning Commission is expected to help sustain the agricultural base of the county. The County Planning Commission staff believes that food processing industries will be more willing to come into the county if land zoned for "farming" cannot freely be converted to other uses.

The distribution of agricultural production, in terms of the value of product, in Washington County in 1958 was as follows:

Product	% of Total County Agricultural Products[1/]
Fruits and nuts	31
Dairy products	22
Eggs and poultry	14
Grain and hay	12
Vegetables	7
Livestock	5
Forage crop seeds	4
Miscellaneous	5
	100

1/ Source: State of Oregon Department of Employment, Area Occupational Index for Washington County, March-July 1959, p. 15

Lumber and wood products manufacturing is less important in the county than elsewhere in the state and is expected to remain so. Table 1 shows that, at present, lumber and wood products manufacturing provides about 14 percent of total manufacturing employment. While significant to the economy, this proportion is far below the state average. Present employment in this category is not expected to increase significantly in the future. Factors operating against any increase in employment are the gradual decline in forest acreage as other land uses expand, the continuing trend of increasing productivity per worker, and the fact that most logs now processed in the county are brought in from forests outside the county. Competition for logs is likely to result in consolidation of some of the small sawmills, possibly resulting in the logs going to larger plants outside this Basin. Factors which could increase employment are the trend toward secondary manufacturing and the development of new products based on the timber resource, and the fact that more than half of the total forest area in the county has been reforested and is now growing a new timber crop. On balance, it appears that employment in lumber and wood products manufacturing in this Basin is not likely to increase significantly in the future. Establishment of an additional pulp or paper manufacturing plant in the Basin is considered unlikely.

Future Population

It is expected that the growth rate in population of Washington County during the study period will be one of the highest in the state. Its growth rate during the decade 1950-1960 was nearly three times the state average and the forces that caused that rapid growth are likely to continue to operate in the period ahead.

Projections by the U. S. Bureau of Census for future Oregon population indicate an accelerated growth during the period 1960-80 due to in-migration. During the period 1980-2010, the state growth rate is expected to decline, although it will still remain above the national average. The Portland Metropolitan Area (which includes Multnomah, Clackamas and Washington Counties) is expected to receive a larger than proportionate share of the increase in state population. Growth in the metropolitan area will result from its role as the trade and service center for the region, from the fact that it is the only diversified manufacturing economy in the region, and from the presence in the metropolitan area of specialized transportation functions not found in other parts of the region.

Beginning about 1940, population growth in relatively densely built-up Multnomah County began to spill over into Washington County. At the present time, the contiguously built-up area of greater Portland extends farther to the east and south than it does to the west into Washington County. Growth into Washington County was held below what it would otherwise have been by problems of sewage disposal, by a lack of water utilities, and by relatively less convenient access to downtown Portland. Where these problems have been solved, growth has been rapid. Developments now planned will further overcome these handicaps, and it is expected that Washington County will represent an increasing proportion of total metropolitan area population.

Table 2 shows projected population for Washington County, and growth rates for the county compared with other areas.

Table 2
Projected Population and Growth Rates
for Washington County Compared with Other Areas
1920-2010

	1920	1930	1940	1950	1960	1980	2010
Washington County, population, to nearest thousand	26	30	39	61	92	207[a/]	500
Percentage increase compound annual rate, during period ending in year shown							
Washington County		1.4	2.6	4.6	4.2	4.1[a/]	3.0
Oregon		2.0	1.3	3.4	1.5	2.0	1.7
U. S.		1.5	0.7	1.4	1.7	1.6	1.4

a/ A population projection for Washington County to 1975 was made in 1960 by the Portland Metropolitan Planning Commission. That projection included high, medium and low estimates. If the growth rates in that study for 1960-75 were extended to 1980, its medium estimate would be about 6 percent below the 1980 figure in Table 2, or about 194,000. In view of the methodology in the two projections, it is considered that the two projections are compatible.

While it is impossible to pinpoint exactly the future location of this increased population in the county, it is expected that most of it will represent a further extension westward of the "urbanized" development extending out from Portland. It is probable that the growth of the rural population and of the small incorporated places will be very much less than the county average. Hillsboro and Forest Grove, on the other hand, are likely to grow somewhat more rapidly than the area surrounding them, as the trend toward urbanization continues. Of the total county population increase of 115,000 projected for the period 1960-1980, about

18,000 would accrue to Hillsboro and Forest Grove if their growth rate were 4.1 percent per year, that is, equal to the county average. These assumptions would mean that, during the period 1960-1980, about 90,000 persons would be added to the "urbanized" area along the eastern edge of the county.

On the basis of the previous assumptions, Table 3 shows estimates of the future distribution of population in Washington County.

Table 3
Estimates of Future Population
Distribution in Washington County

(Population figures in thousands)

Area	1960 Pop.	1960-80 Rate of Increase, %/year	1980 Pop.	1980-2010 Rate of Increase, %/year	2010 Pop.
Total County	92	4.1	207	3.0	500
Portion of Portland Urbanized Area	37	6.4	127	3.6	362
Hillsboro + Forest Grove	14	4.1	31	3.0	76
Hillsboro	8	4.5	20	3.2	51
Forest Grove	6	3.4	11	2.8	25
Five Small Incorporated Places	3	2.0	5	2.0	8
Rural	38	.7	44	.7	54

Future Land Use

On the basis of the population growth projected in the preceding sections, urban-type uses of land will increase considerably in the future.

The exact location and extent of growth in urban acreage is difficult to predict because of possible variations in the density of development. Depending upon a number of factors, such as subdivision regulations, zoning, water and sewer utility availability, and convenience of access, "built-up" development may range from one family per acre to four or more families per acre. In the "urbanized" portion of Washington County, the average density in 1960 was one family per acre.

Some of the increase in population foreseen for Washington County will be absorbed in the present urban and urbanized areas, increasing their density. The rest of the population increase will result in a westward expansion of the built-up area. It seems likely that, within the growth framework assumed above, the "urbanized" area, which included about 12,000 acres at the eastern edge of the county in 1960, will at least double by 1980. Much of this increase in urban acreage may come out of land which is at present in agricultural uses, although the "farm zone" will tend to resist encroachment upon agricultural land. Some decline in agricultural land will occur, although this can be partially offset by converting to crops numerous scattered wooded areas. It is anticipated that "urbanized" development by 1980 will have extended to a line roughly connecting Tualatin, Bull Mountain, Orenco and North Plains.

For the period 1980-2010, a continuation of the trends anticipated for 1960-80 is assumed. "Urbanized" development by 2010 may have reached the Tualatin River from North Scholls to Hillsboro. It is not expected that this large area will be uniformly built-up, however, since contemporary trends in local planning and zoning favor a heterogeneous mixture of agricultural, residential, recreational, and controlled industrial uses.

On the basis of the preceding assumptions and for the purpose of this preliminary analysis, the pattern of land use in 1980 and 2010 is estimated to be as shown in Table 4. The changes assumed in Table 4 for the period 1960-80 are generally consistent with the rate of change for the period 1960-75 forecast by the Oregon State Conservationist of the U. S. Department of Agriculture.

Table 4
Assumed Future Land Use
Washington County

(Areas in thousands of acres)

Land Use	1960	1980	2010
Forest and wooded	249	243	224
Farms and cropland	146	138	127
Urban and built-up	44	60	90
Pasture and range	6	4	4
Federal land (mostly forest)	12	12	12
Water surface	1	1	1
Total County, thousands of acres	458	458	458

Potential Water Uses

Because of the large future population projected for the Portland Metropolitan Area, demand for swimming, boating, fishing, and various riparian recreations along the Tualatin River will increase many fold within the study period. Recreational demand is increasing even more rapidly than population, because of greater leisure and higher incomes. The potential demand for recreational uses and facilities on the Tualatin River will be particularly great because of the limited number of comparable streams in the metropolitan area.

PRESENT WATER SUPPLY

GENERAL

Developed surface and ground water sources throughout the Tualatin River Basin serve rural, municipal, industrial and irrigation needs amounting to approximately 16,100 acre feet annually (excludes water delivered to the area from the Portland Bull Run supply). Surface sources provide 11,900 acre feet of this supply with ground water sources providing the remainder (4,200 acre feet).

Surface and ground water produced within the Tualatin Basin serve about 65,000 persons, eight self-supplied industries and nearly 10,000 acres of irrigated land. Land irrigation constitutes the largest single use of water in the basin (10,300 acre-feet annually). Table 5 summarizes these uses and sources.

Table 5
Tualatin River Basin
Water Uses and Sources

Ground Water	Pop.,(1) Plants,(2) Acres(3)	Sources	Annual Ac.Ft.
Rural domestic	25,000(1)	5000-6000 wells	700
Municipal	17,000(1)	17 wells - 2 sprs.	1200
Industrial (self-supplied)	8(2)	Wells	150
Irrigation	1,125(3)	Wells, sprs.	1700
Surface Water			
Municipal	20,500(1)	Tualatin & Tribs.	2200
Industrial	5(2)	Municipal systems	775
Irrigation	8,640(3)	Tualatin & Tribs.	8600

Note: Excludes uses and purposes served by the Portland Bull Run Supply.

GROUND WATER - MUNICIPAL AND INDUSTRIAL

Developed municipal and industrial ground water supplies exist mainly in the middle to lower portion of the Tualatin Basin. Major communities using ground water in these areas are: Beaverton, Tigard, Sherwood, Tualatin, Oswego and the Lake Grove Water District. Municipal ground water supplies in upper basin areas exist only at Banks and North Plains with the Aloha-Huber area being served only partially by ground water. Beaverton and Oswego have water main connections with the Portland Bull Run supply from which water is drawn continuously at maximum capacity of the line and the Wolf Creek Water District supply from Bull Run is supplemented by water from Johnson Spring.

According to ground water records compiled by the U. S. Geological Survey, no appreciable decline in the ground water levels has occurred in the major areas of municipal and industrial ground water use.

SURFACE WATER - MUNICIPAL AND INDUSTRIAL

Uses of surface water from Tualatin Basin sources occur in the following upper basin area: Forest Grove, Hillsboro, Cornelius, Gaston, Cherry Grove and the Aloha-Huber Water District. Hillsboro obtains its supply from the Tualatin River and Seine Creek and Forest Grove obtains its supply from Clear Creek and Gales Creek. Gaston, Cherry Grove, Cornelius and the Aloha-Huber Water District each obtains water from the Hillsboro supply.

Table 6 lists the areas, purposes and uses of surface water as supplied from Tualatin Basin sources.

Table 6
Tualatin River Basin
Municipal and Industrial Surface Water Supplies

Use Area	Population Served	Annual Ac.ft.
Hillsboro-Cornelius		
Municipal	11,000	1,480
Industrial	-	450
Forest Grove		
Municipal	6,000	700
Industrial	-	325
Gaston, Cherry Grove	500	85
Aloha-Huber	3,000	250
Totals	20,500	3,290

It is estimated that about 45 percent of the total annual demand shown in Table 6 occurs during the period July-October when stream flows at the intakes become most critical. It is understood, for example, that supply difficulties were experienced in these areas during the dry summers of 1952 and 1956.

PORTLAND BULL RUN SUPPLY

A large portion of the suburban area along the eastern section of the basin use the Portland Bull Run supply as serviced by the West Slope, Metzger and Wolf Creek Highway Water Districts. Partial service is also provided to Beaverton and Oswego.

FUTURE WATER SUPPLY

It is estimated that, of the 92,000 persons residing in Washington County in 1960, 70 percent were supplied by waters taken from sources developed within the Tualatin River Basin. Assuming this percentage to remain constant and based on projected populations previously presented, an additional 80,000 persons will be served by these sources by the year 1980 and an additional 285,000 persons by the year 2010.

Table 7 lists the future populations, by residence category, expected to utilize basin sources for future water supply.

Table 7
Future Populations Expected to
Utilize Tualatin Basin Water Supply Sources

Residency	Populations 1980	Populations 2010
Rural and Rural non-farm	30,500	37,500
Urban	110,000	304,500
Small Incorporations	4,500	8,000
Totals	145,000	350,000

In event that future surface and ground water supplies are developed in proportion to the existing populations served by each, the total populations to be served by ground water by the years 1980 and 2010 would be 85,000 and 189,875 persons, respectively, and by surface water, 60,000 and 160,125 persons, respectively.

By virtue of the nature of industrial activity in the Tualatin Basin water use by self-supplied industries constitutes only a relatively minor portion (2 percent) of the total water used from basin sources.

For purposes of computing total water requirements, therefore, the self-supplied and municipally supplied industrial water requirements are combined in single rates representing future municipal and industrial (M&I) supply demands. Table 8 lists estimates of 1980 and 2010 reouirements by use category and supply sources for the basin.

Table 8
Future Water Supply Requirements
by Uses and Sources Within
the Tualatin River Basin

Use Category and Source	Pop.	Avg.(1) gpcd	Avg MGD	Annual MG	Annual Ac.Ft.
	1980				
Rural & rural non-farm					
Private wells (ground)	27,500	37	1.02	372	1,140
Urban - M&I (ground)	54,000	118	6.4	2,300	7,050
Urban - M&I (surface)	56,000	202	11.3	4,130	12,700
Small inc. and assoc. non-farm (ground)	3,500	118	0.41	150	460
Small inc. and assoc. non-farm (surface)	4,000	160	0.64	235	720
Totals	145,000		19.77	7,187	22,070
	2010				
Rural & rural non-farm					
Private wells (ground)	34,250	52	1.78	650	2,000
Urban - M&I (ground)	151,000	168	25.3	9,250	28,400
Urban - M&I (surface)	154,500	287	44.0	16,000	49,000
Small inc. and assoc. non-farm (ground)	4,625	168	0.78	285	880
Small inc. and assoc. non-farm (surface)	5,625	225	1.26	460	1,410
Totals	350,000		83.12	26,645	81,690

(1) Estimated 1960 per capita uses compounded at 2 percent per annum.

PRESENT WASTE SOURCES

Wastes produced within the Tualatin River Basin consist of domestic sewage, cannery wastes, slaughtering and meat packing wastes, paper-board plant wastes, tannery wastes, milk products waste and miscellaneous wastes such as those produced in the processing of potato chips and dog food. In terms of five-day bio-chemical oxygen demand (BOD_5)[1] it is estimated that raw domestic, municipal and industrial wastes produced within the Tualatin Basin on an annual basis average approximately 240,000 population equivalents (PE's). Wastes produced by industrial sources contribute the greater portion of this amount.

Because of the particular nature of some of the industries in the Tualatin Basin, seasonal variability occurs in volumes and strengths of wastes produced. It is estimated, for example, that raw industrial

---

(1) BOD of sewage, sewage treatment plant effluents, industrial wastes, or polluted waters is a measure of the oxygen required to stabilize decomposable organic matter by aerobic bacterial action. Complete stabilization requires more than 100 days at 20°C, but such long periods of incubation are impractical. Consequently, a much shorter period of incubation is used. Incubation for 5 days at 20°C (BOD_5) is the recommended standard procedure. Measurements of daily BOD in time series (long term BOD) when plotted produce a logarithmic curve from which deoxygenation velocity constants can be computed. Use of these values is made in computing critical dissolved oxygen concentrations to be expected at various rates of stream flow and waste loadings.

wastes produced in the winter months average 124,000 population equivalents per day and during the summer months, 172,000 population equivalents. It is known, also, that, on a day-to-day basis, even greater extremes can occur.

A variety of waste treatment methods and disposal practices exist throughout the Tualatin River Basin. Septic tanks with sub-surface disposal are employed in many areas not yet served by collection systems. Conventional waste treatment facilities designed for the removal of solids, reduction of biochemical oxygen demand and other waste constituents are in existence in localities where municipalities and sanitary districts have provided collection systems. Industrial wastes are in some instances treated in combination with municipal waste and in other instances industrial waste treatment is accomplished by lagooning and/or by land disposal and crop irrigation. Not all wastes, particularly those produced by certain industries, are treated. Constant improvements in systems, facilities and practices, however, are taking place generally throughout the Tualatin River Basin area.

On a basin-wide basis, it is estimated that waste treatment together with other disposal practices accomplish removal of about 75 percent of the biochemical oxygen demand or population equivalents produced.

Table 9 summarizes estimates of population equivalents produced and those received in Tualatin Basin streams.

Table 9
Wastes Produced and Loadings
Received in Tualatin Basin Streams

Sources	Raw Waste PE's/day	Disposed Waste PE's/day
Domestic (unsewered)	48,400	---(1)
Municipal and Sanitary District (sewered)	43,600	6,100
Industrial		
Summer	171,500	8,300
Winter	123,500	110,800
Avg. Annual	147,500	60,000

(1) Sub-surface disposal

On an average annual basis, it is estimated that, of the population equivalents disposed to basin water courses, 86 percent are received in streams above and including McKay Creek; 11 percent are received in the drainage system between Fanno Creek and McKay Creek; and 3 percent are received above the mouth of the Tualatin River to and including the Fanno Creek drainage system.

FUTURE WASTE SOURCES

It is estimated that by the years 1980 and 2010 a total of 407,000 and 770,000 population equivalents of waste per day will be produced in the Tualatin River Basin. Assuming 75 percent of the populations to be served by sewage collection systems by the year 1980 and 90 percent served by the year 2010 and that 85 percent treatment (BOD_5 reduction) of municipal and industrial wastes were achieved throughout the basin for these years, approximately 53,000 and 107,000 population equivalents, respectively, would be received in basin water courses.

Whereas the raw industrial wastes presently produced in the basin exceed municipal and domestic population equivalents by approximately 3.5 times, this factor is expected to reduce to approximately 1.3 by the year 1980 and to 0.6 by the year 2010 as a result of rapid population growth and trends toward dry process type industries. Table 10 summarizes by reaches and river miles, the future waste loadings expected to be received in Tualatin River Basin streams.

Table 10
Future Waste Loadings
Tualatin River

	Mileage - PE's		
Year	62 - 46	45 - 10	9 - 0
1960(1)	18,800	7,350	2,500
1980	21,000	24,000	8,000
2010	27,000	59,000	21,000

(1) Present sewerage and 85% treatment of municipal and industrial wastes.

WATER QUALITY

According to stream sampling data collected by the Oregon State Sanitary Authority in July and August of 1960, four distinct depressions in the dissolved oxygen resource of the Tualatin River were noted as a result of the exertion of bio-chemical oxygen demanding substances in the stream. Figure 1 shows the profiles of these effects. At the time of sampling in July the stream flows at miles 65 and 60 were in the order of 7 and 16 cfs, respectively, and at miles 8 and 4 were in the order of 80 and 40 cfs, respectively (mi. 4 downstream from Oswego diversion). Stream flows during the August sampling at miles 65 and 60 were in the order of 5 and 7 cfs, respectively, and at miles 8 and 4 were in the order of 32 and 16 cfs, respectively.

The stream conditions as described above could be expected to persist for extended periods and at times be even more pronounced. For example, it is found by examination of gaging records for the Tualatin River that stream flows similar to those encountered during the sampling can occur for more than a month's time on an average of once in ten years. Much lower rates than those encountered during the sampling can also occur. Table 11 lists the durations and frequency of minimum stream flows that can be encountered in the Tualatin River.

Table 11
Duration and Frequency of Minimum
Stream Flows in the Tualatin River

	River Mile - cfs		
Days in 10 Years	65	35	8
30	2.0	8.0	22
21	0.8	6.0	19
14	0.5	4.0	18
7	0.5	3.0	15
1	0.2	0	15

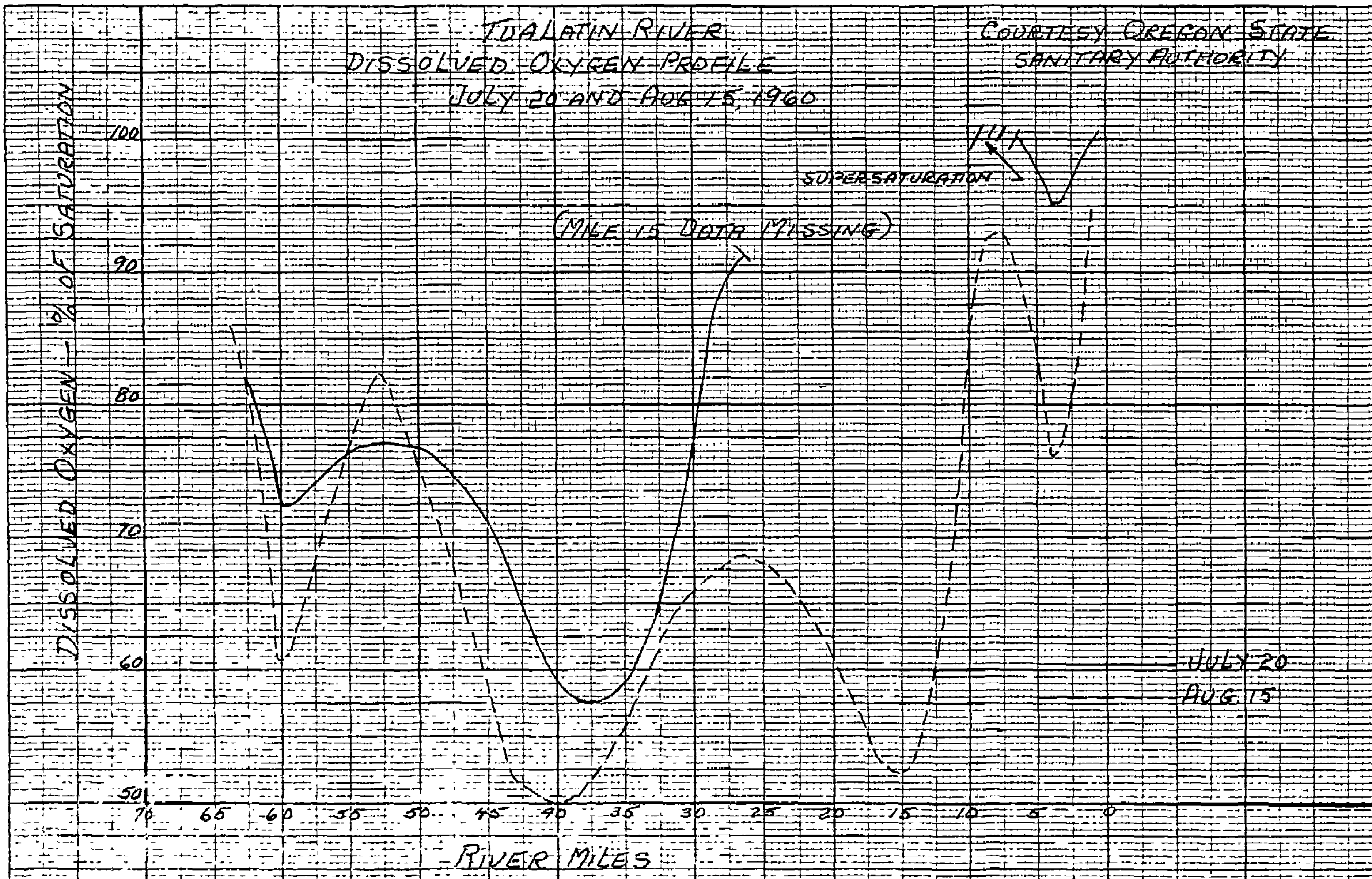

TUALATIN RIVER
DISSOLVED OXYGEN PROFILE
JULY 20 AND AUG 15, 1960
COURTESY OREGON STATE
SANITARY AUTHORITY
111
SUPERSATURATION
(MILE 15 DATA MISSING)
JULY 20
AUG 15
DISSOLVED OXYGEN — % OF SATURATION
100
90
80
70
60
50
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
RIVER MILES

FIGURE 1

It is apparent from the foregoing that sufficient stream flow is not continuously available to adequately assimilate and dilute waste materials entering the Tualatin River system. It is also apparent that with the waste loadings expected for the future, critical stream conditions would become more frequent and prolonged.

QUALITY CONTROL

In view of the particular characteristics of waste effluents produced in the Tualatin River Basin and the types of uses made of the stream, flow regulation for the control of the dissolved oxygen resource of the stream is chosen as the governing control parameter. Without knowledge at this time of such things as the nutrient enrichment effects of return irrigation flows on the stimulation of nuisance algae and slime growths, regulation or recommendations for the specific control of these effects cannot at this time be made. Studies on the effects of irrigation return flows and possibilities for control are planned for conduct at later date. It should be understood, however, that the extent of regulation required to maintain suitable dissolved oxygen levels would provide, by means of dilution and increased assimilative capacity, significant control of the effects of land drainage as well as control of the effects of residual materials not removed from wastes by known conventional treatment means.

Figures 2 and 3 show the estimated rates of stream flow required to achieve various levels of dissolved oxygen from the Scoggins site to river mile 38 (Rock Creek) and from Rock Creek to the mouth of the Tualatin River, respectively, during periods of critical loading and maximum stream temperature for the years 1980 and 2010. Figures 4 and 5 are annual hydrographs of minimum flows recommended for maximum utilization and protection of uses and values along the Tualatin River.

Tualatin River
Stream Flow — Dissolved Oxygen Relationships
Scoggins Site To Mile 38
Years 1980 and 2010

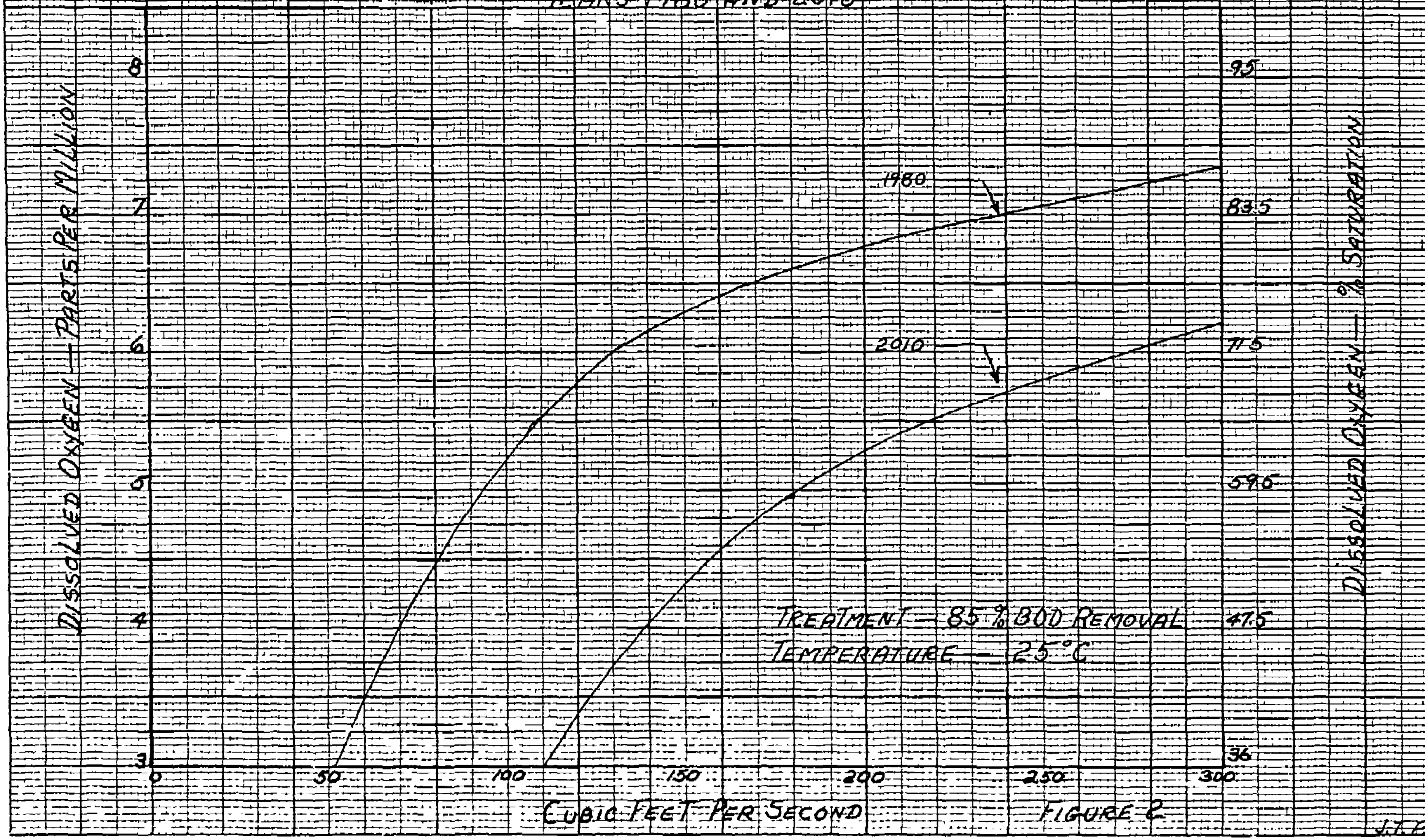
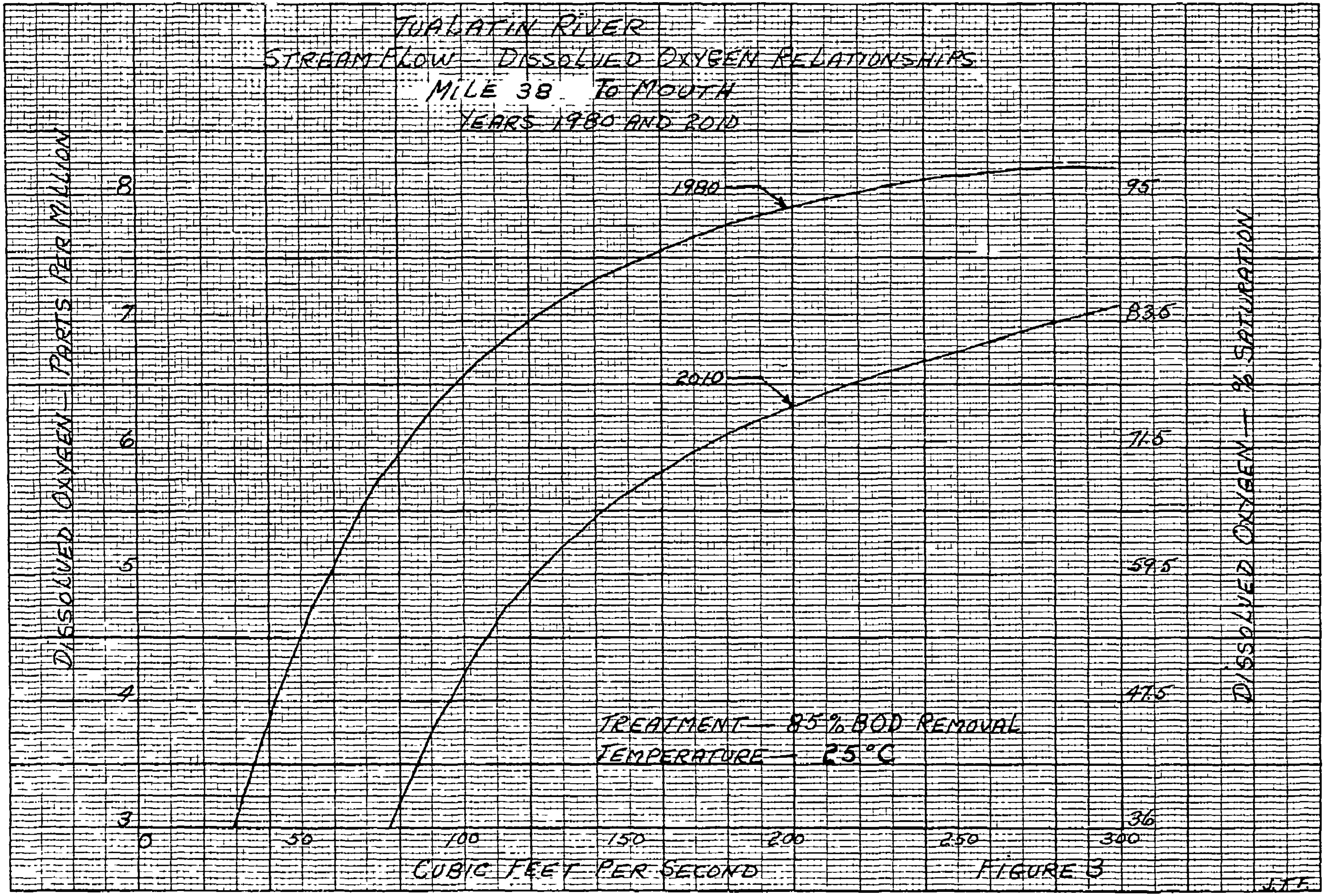


Figure 2



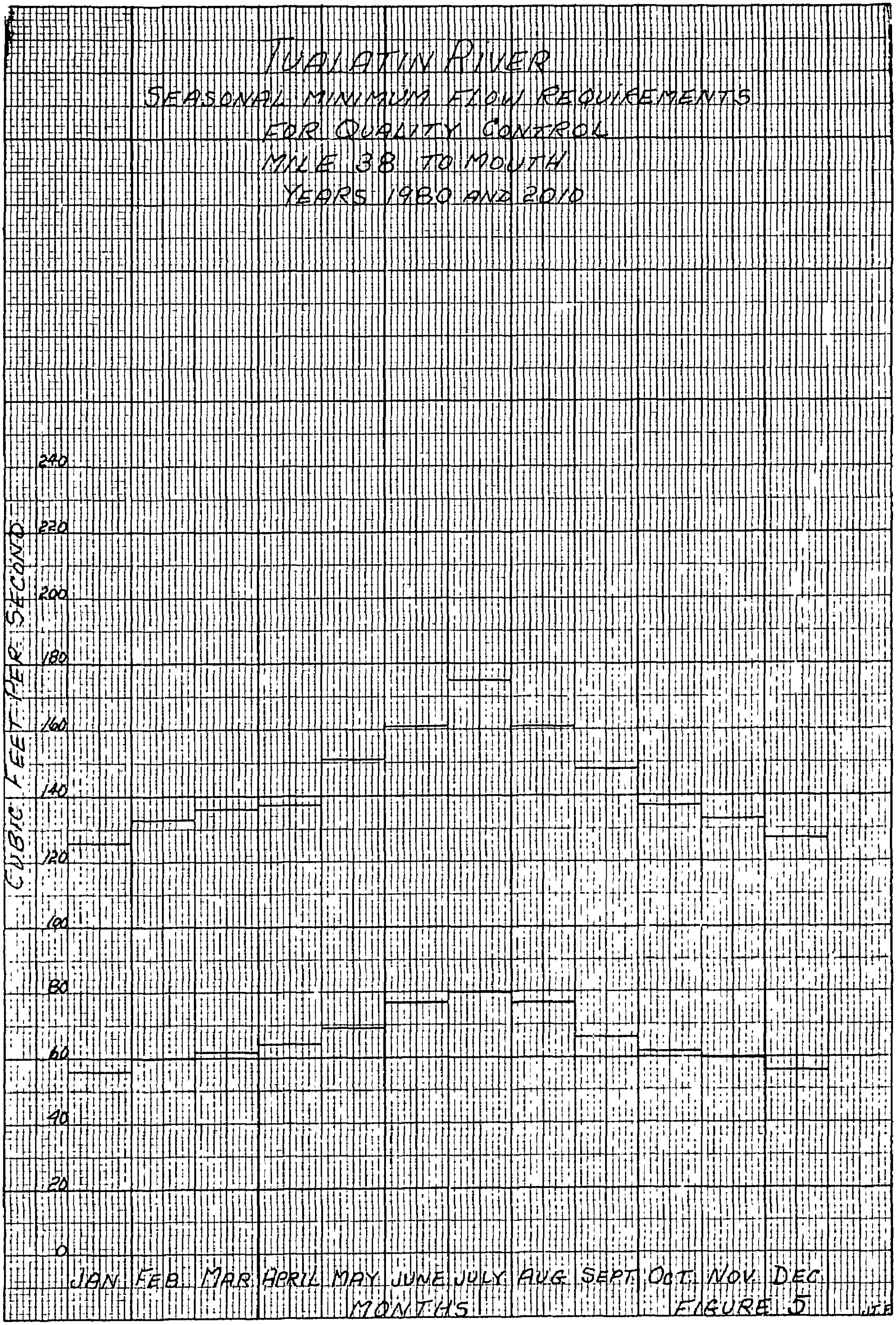
TUALATIN RIVER
STREAMFLOW — DISSOLVED OXYGEN RELATIONSHIPS
MILE 38 TO MOUTH
YEARS 1980 AND 2010
DISSOLVED OXYGEN — PARTS PER MILLION
3
4
5
6
7
8
DISSOLVED OXYGEN — % SATURATION
36
47.5
59.5
71.6
83.6
95
1980
2010
TREATMENT — 85% BOD REMOVAL
TEMPERATURE — 25°C
0
50
100
150
200
250
300
CUBIC FEET PER SECOND
J.T.F.

FIGURE 3

TUALATIN RIVER
SEASONAL MINIMUM FLOW REQUIREMENTS
FOR QUALITY CONTROL
SCOGGINS SITE TO MILE 38
YEARS 1980 AND 2010

FIGURE 4

JTF


TUALATIN RIVER
SEASONAL MINIMUM FLOW REQUIREMENTS
FOR QUALITY CONTROL
MILE 38 TO MOUTH
YEARS 1980 AND 2010
CUBIC FEET PER SECOND
240
220
200
180
160
140
120
100
80
60
40
20
0
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
MONTHS
FIGURE 5

DISCUSSION

GENERAL

The protection of public health through the provision of a safe water supply has long been a matter of primary concern to the public health profession and has been a significant contributing factor to the high health standards of the Nation. However, the problem of providing adequate amounts of safe potable water has become increasingly difficult due to the pyramiding water demands of a rapidly expanding population. Furthermore, the resulting increase in waste flows has caused a gradual degradation in the quality of the Nation's waters. While improved methods of treatment and disinfection of both wastes and water have served to maintain the quality within tolerable limits, the progress in pollution abatement and water treatment has not kept pace with this population growth and industrial expansion.

The familiar problems of pollution by bacteria, organic matter, and chemicals of known toxicity and behavior have been further intensified and complicated by problems of mineral enrichment due to water reuse and by new types of contaminants associated with our chemical and atomic age. The effects of these newer contaminants on water treatment processes and on the human consumer are largely unknown. The deficiencies in knowledge and the prospect of even greater quantities of yet more complex pollutional materials reaching our surface waters emphasize the urgency of intelligent water quality management.

It is recognized that water for human consumption holds the highest priority of all water uses. The increased demands on quantity by an increasing variety of uses has also brought about many conflicts which can be solved only by intelligent and long-range management practices. Unfortunately, practically every water use results in some degradation of quality. As the supply becomes more critical and conflicts in use increase, water quality is assuming increasing importance.

Where alternate sources are available it is desirable to reserve the highest quality water available for domestic use and to satisfy other lower priority demands with waters of lesser quality. In areas of limited supply the ultimate water requirements can be met only by water re-use. Thus, dependence must be placed upon improved and more effective methods of water and waste treatment and other control methods in order to maintain the highest possible standards of quality for human consumption and other uses. However, in such instances every effort should still be made to reserve a sufficient quantity of high quality natural waters for domestic use before they flow on to supply other less critical demands.

It is sound planning to utilize highest quality water for highest priority uses, and the protection of this quality against irreversible and potentially hazardous degradation must be practiced to the fullest extent possible.

Inasmuch as maintenance of a high level of water quality for all uses is basic to public health and the general well-being of the populations and economy, planning for future water demand and uses requires the utmost of care with application of a reasonable degree of optimism. This is especially true when planning for needs many years in advance as is the objective of this evaluation.

WATER SUPPLY

As indicated in an earlier chapter, the developed surface supplies in the Tualatin Basin have experienced difficulties in supply in recent years. At the rate of growth anticipated and with the additional demands for municipal and industrial supply that are expected to accompany this growth, it is apparent that early development of additional sources of supply is needed. For example, by the year 1980 the four month (July-October) demand for surface water (6,350 ac.ft.) would be approximately equal to the minimum four month natural or unregulated yield returning once in twenty years for the entire basin, and by the year 2010 the four month summer demand for surface water (24,000 ac.ft.) would exceed the minimum four month natural yield returning once in five years for the entire basin by more than 14,000 acre feet. Since much of this yield is not distributed evenly in relation to areas of demand, it is apparent that source development by impoundment will be required.

The future municipal and industrial water supply requirements to be satisfied by surface waters will involve provisions for storage to serve new development areas to supplement various municipal and industrial rights being exercised at the present time as well as to supplement the shortages in natural yields that would be expected to occur. For example, the 1980 annual demand for surface water in the Tualatin Basin is expected to be about 14,000 acre-feet with approximately 45 percent of this demand occurring throughout the months of April through October when yields are at a minimum. The active storage required to meet this demand, therefore, would be equal to 6,325 acre-feet minus existing rights in acre-feet for this period of time plus any deficit or apportioned shortage of rights that would occur upon return of critical historical low stream flows.

The annual benefits assignable to the inclusion of future municipal and industrial water supply as one of the multiple functions of the Tualatin Project would be equivalent to the annual cost of developing the most likely alternative source in the absence of the project. For example, the alternatives that are available to supply the future municipal and industrial requirement to be satisfied from surface sources in the basin would be development of storage within the Tualatin Basin and development of storage in the Wilson River or Trask River Basins located on the western slope of the Coast Range.

Inasmuch as benefits assignable to project storage for municipal and industrial purposes apply only to waters made available at the outlet of the dam, such a determination involves estimates of costs to store, pump, transport and treat waters from the alternative site and costs to pump, transport and treat waters (each to common point of use) from the project. In event that the cost of the most likely alternative plan is greater than costs to pump, transport and treat waters from the project, the difference between the two total costs may be regarded as the benefit assignable to project storage for M&I supply. It may be assumed for benefit computation purposes that the cost to treat waters stored in the project or at any alternate site would be essentially the same.

QUALITY CONTROL

In view of the importance of the water resource to the economy of the Tualatin River Basin and surrounding region, it is imperative that every effort be made to preserve and protect this valuable resource. Any possible means of maintaining control of water quality, whether it be to protect health, property or aesthetic values, would possess particular value to the region.

Municipal and industrial waste treatment and disposal practices in the Tualatin Basin, although generally quite adequate in relation to present conventional standards, provide only limited protection of the uses and values of the stream. With the extent, duration and frequency of low stream flows that occur in the Tualatin River and with increasing populations and industrial activity expected in the region, stream quality will become more and more critical. Such values as the aquatic environment and natural self-purification properties of the stream would become increasingly affected, and nuisance conditions that could arise would become more frequent and severe.

It is for the above reasons and those stated in earlier chapters that the minimum stream flows shown in Figures 4 and 5 are recommended.

As these stream flows in combination with waste treatment offer the only presently known means of achieving the prescribed quality objectives, (distillation possible but more expensive and underground disposal would not be acceptable) benefits assignable to the Scoggins reservoir for quality control by low flow augmentation would be equivalent to construction, operation and maintenance costs involved in providing similar regulation by single-purpose means, as for example, from the Gaston, McKay, Gales or Scoggins Creek sites, whichever would be the cheapest.

Whereas the flow requirements shown in Figures 4 and 5 refer to total stream flows required, it is understood that these may be composed of natural inflow, return irrigation flows, municipal and industrial return flows and releases from storage. Benefits would apply to all storage which make up the required flows for water quality control.

It should be noted, also, that diversions downstream from Rock Creek of no greater than the difference between the flows required in the Scoggins to river mile 38 reach and the reach from river mile 38 to the mouth of the Tualatin River could occur with no loss to the control of quality.

Flow regulation in the Tualatin Basin, in addition to assisting in the control of stream quality within the basin would be expected to provide improvements in downstream reaches of the Willamette River and Portland Harbor.

In event that upon allocation of storage for the various project purposes any part of the requirements for municipal and industrial water supply or quality control as given within the study period cannot be met with the Scoggins Reservoir, Tualatin Project, it is assumed that these will be incorporated in future development planning or will be satisfied by local or other means.

Comments on these factors and any other details associated with the final formulation of the project will be made at the time of formal inter-agency review.

The quality objectives and related flow requirements recommended in this report are designed for achievement of the following purposes:

1. Prevent development of nuisance conditions;

2. Enhance the aesthetic and health values of the stream and adjacent areas;

3. Provide an environment suitable for propagation of resident and anadromous fish life;

4. Protect and enhance the natural self-purification capabilities and assets of the stream waters;

5. Reduce and neutralize the effect of residual fertilizers, weedicides, and insecticides.

The beneficiaries of water quality maintenance and values resulting from achievement of the above purposes are:

1. Land values--protection and enhancement;
2. Resident populations--health, social and economic improvement;
3. Livestock--health and well-being;
4. Natural resources--
    a. Fish and wildlife preservation;
    b. Preservation of the natural self-purification assets of the water resource;
5. Recreation--protection and enhancement;
6. Waste disposal--assimilative capacity (supplemental waste treatment).

By virtue of the multiplicity of values (tangible and intangible) that are derived through maintenance of stream quality, the benefits attributable to provisions specifically designed for such maintenance may be regarded as "widespread."

Inasmuch as the water quality control program set forth in this report involves a reasonable degree of local participation in achieving the stated goals, it is believed of interest to the public that low flow augmentation as one of the requisites in achieving fulfillment of this goal be provided. Benefits attributable to provisions for water quality control where shown to be justified as a project function, therefore, are believed to be national in scope.