~~Allen W. Sammons~~ Yolk

SKAGIT RIVER

REPORT
MARCH 1965

U.S. ARMY ENGINEER DISTRICT SEATTLE - CORPS OF ENGINEERS

FLOOD CONTROL AND OTHER IMPROVEMENTS

Summers

SUPPLEMENT TO
REVIEW REPORT ON FLOOD CONTROL
AND OTHER IMPROVEMENTS ON
SKAGIT RIVER, WASHINGTON

U. S. ARMY ENGINEER DISTRICT, SEATTLE

CORPS OF ENGINEERS

MARCH 1966

1. PURPOSE. - This supplement to the Skagit River Review of Reports of March 1965, on Flood Control and Other Improvements, presents information on project formulation, for proposed levee and channel improvements as related to basin planning, consideration of alternatives and to maximizing of net benefits.

2. SCOPE. - The proposed levee and channel improvements in the main report are considered as elements of a Skagit River basin plan for flood control that could include the authorized, but not constructed, Avon Bypass Projects, and upstream storage. The data already developed for the survey report and for separate studies of the Avon Bypass Project were utilized in this supplement. The presentation follows this sequence of development:

a. planning objectives;

b. the basin plan for flood control;

c. evaluation of alternatives;

d. optimization of design for Avon Bypass;

e. optimization design for levee and channel improvements and the Avon Bypass.

3. PLANNING OBJECTIVES. - A public hearing was held 8 February 1961 in Mount Vernon, Washington, to obtain expressions of needs for water resource development from representatives of Federal, State and local governments and from residents of the area. The overwhelming sentiment at the hearing was for improved flood control measures in the basin, particularly in the delta, as a first priority endeavor.

Ensuing studies confirmed that improved flood protection in the 68,000-acre flood plain delta downstream from Sedro Woolley is the highest priority water resource requirement in the basin. Flood control measures are needed to prevent large flood losses in farm and urban areas that are now partially protected by levees and that have developed markedly since the last major floods in 1951, in 1921, and in the preceding decades. The average annual flood damage estimate of $2,216,000 in the Skagit flood plain downstream from Sedro Woolley, under 1963 conditions, attests to the economic importance of improved flood control measures. Other river basin needs under study for long-range development are additional water supply for municipal and industrial purposes; low-flow augmentation for fisheries; hydroelectric power; recreation; and irrigation.

4. EXISTING LEVEL OF FLOOD PROTECTION IN THE BASIN. - The entire Skagit River system downstream from the Burlington-Mount Vernon area, including both the North and South Fork distributaries at the mouth, has been leveed piecemeal over a long period of time. There are about 43 miles of levees along the river banks that vary greatly in top widths and height. These levees, with minor sandbagging of the extreme low areas, are only capable of withstanding flows of 91,000 to 143,000 c.f.s., corresponding to floods with probable recurrences ranging from once in 3 years to once in 14 years. Flooding of low areas begins when flows at Mount Vernon exceed 84,000 c.f.s.

5. BASIN PLAN FOR FLOOD CONTROL. - The basin planning for new projects is directed toward developing first priority flood control and related measures that can be constructed with sound economic feasibility under present-day conditions, and assuring that these projects will retain their feasibility when considered with possible future projects. The first priority projects are the authorized Avon Bypass and proposed levee and channel improvements downstream from the Bypass. Addition of recreation to the Bypass as an added purpose, becomes possible with construction of these first priority projects. Future water resource planning will consider upstream storage to provide increased flood protection for the delta and for the area upstream from Sedro Woolley, together with water supply, low-flow augmentation, irrigation, recreation, and related purposes.

6. INITIAL FLOOD CONTROL IMPROVEMENTS.

a. Proposed Levee and Channel Improvements. The Skagit River channel capacity would be increased from the Burlington-Mount Vernon area downstream to the mouth of both Forks, by raising low points and by strengthening the existing levees and by widening the channel at selected locations to contain a design flow of 120,000 c.f.s. These improvements would raise the minimum level of flood protection from once in 3 years to once in 8 years. About 34 miles of the existing levee system would be improved, including 13 miles on the main river downstream from river mile 16.5, and 8 and 13 miles on the North and South Forks, respectively. Widening is proposed for three constricted reaches of the river channel, from river mile 3.8 to 4.7 and 7.0 to 8.1 on the North Fork, and from 3.7 to 4.5 on Freshwater Slough on the South Fork. Widening would remove serious obstructions to flood flows, lower channel velocities and reduce upstream river stages.

The design flow of 120,000 c.f.s. was found to be the maximum that could be developed without raising nearly all of the 43 miles of existing levee on both banks of the river. Further raising of levees was considered impracticable because the existing levee system rests on a foundation of silts and sands common to the delta area. Differential heads of water in flood flow periods result in seepage through levee embankment and levee foundations, causing boils and blowouts that flood adjacent croplands. The semipervious foundation conditions make any general raising of levees inadvisable because of the extensive and indeterminate nature of the seepage hazard.

Based on costs and benefits presented in the main report, the overall cost could be $6,007,000 and the corresponding benefit to cost ratio would be 3.1, in a plan which shares benefits with the Avon Bypass through coordinated operation. First added, the benefit-to-cost ratio would be 3.2. The foregoing benefit-to-cost ratios are based on a 50-year project life as used in the report.

b. Avon Bypass. - The Flood Control Act of 1936, authorized the Avon Bypass channel, a project for the partial control of floods in the Lower Skagit Valley, by diversion of a portion of Skagit River flows. The diversion channel was to be constructed between a location on the river just downstream from Burlington to Padilla Bay. The project was not undertaken at that time because local participation requirements could not be satisfied. The Chief of Engineers has authorized restudy of the Bypass Project because the prospect for fulfillment of local cooperation assurances are now much more favorable.

The present plan for the project has an 8-mile channel with intake from the Skagit River about one mile downstream from Burlington and proceeding westward through Gages Slough and along the southerly fringe of Bayview Ridge to Padilla Bay. The channel would be 360 feet wide at the bottom. Flow depths would be about 25 feet. The channel would have four control structures, including a gated concrete intake, two collapsible-type intermediate weirs to control groundwater levels, and an ungated concrete outlet structure to control channel velocities and to prevent saltwater intrusion into the channel. The project also includes improvement and extension of four miles of levee on the right bank of Skagit River, immediately above the Bypass intake. The purpose of the levees is to prevent overflow of floodwaters into Burlington and the low divide between the Skagit and Samish River valleys. The capacity of the Bypass was fixed at 60,000 c.f.s., considering the project first added to the existing levee system. The 60,000 c.f.s. design flow was established by maximizing net benefits, as discussed subsequently in paragraph 10. The flood protection afforded by the Bypass first added, would increase the minimum level of flood protection in the river basin downstream from Sedro Woolley from about 84,000 c.f.s. at the present time, to 144,000 c.f.s. The corresponding decrease in flood frequency would be from once in 3 years to once in 14 years. Cost of the Bypass would be $23,940,000 and the resulting benefit-to-cost ratio would be 2.9, considered first added, and 2.2 when considered in a plan which shares benefits with the levee and channel improvements through coordinated operation.

7. ULTIMATE FLOOD CONTROL. - The Skagit River delta flood plain area now is predominatly devoted to agriculture, but includes important urban centers such as Mount Vernon, Burlington and other smaller communities. In the past 30 years there has been an increasing trend toward conversion of agricultural lands to urban, commercial and light industrial usage. Present and forecasted future development, which is in keeping with the overall growth

pattern of the Puget Sound region, warrants at least 100-year flood protection in this area. Provision of upstream storage is the final element of a basin flood control plan. The purpose of upstream flood storage would be to supplement the Bypass and proposed levee and channel improvements in order to realize at least 100-year flood protection in the delta area. Upstream storage would also provide greater flood protection for the reach of river upstream from Sedro Woolley and would permit utilization of lands not now protected, as for example, the Nookachamps Creek basin across the Skagit River from Burlington.

Ross Dam, on the upper main stem of the Skagit River, reserves 120,000-acre-feet of storage for winter flood control. This storage controls the Skagit River watershed upstream from Ross Dam. Operation of this storage has been assumed in all plans studied. There are only a few remaining potential sites for upstream storage development in the Skagit River basin. A private power company has developed potential sites on the Baker River for hydroelectric power. The Cascade site, located on the Cascade River about eight miles from its confluence with the Skagit River, and the Copper Creek site, on the main stem of the Skagit River at about Mile 87, are being considered for development by the city of Seattle for run-of-river power projects. Only minor flood control storage could be provided at these sites. Storage at the Faber site, located about eight miles above Concrete, has been investigated in previous studies. Dam site foundation and abutment conditions at this site are not favorable. A structure at this site also would be a major barrier to the passage of migratory fish. Storage has been considered on the Lower Sauk River as an alternative to the Faber site. The Lower Sauk River now appears to be the only location in the Skagit River basin at which major upstream storage is possible.

A favorable site has been found on the Sauk River six miles upstream from its confluence with the Skagit River. A dam at this site could develop approximately 700,000 acre-feet of storage, of which 250,000 acre-feet of storage would be needed to increase from 35 to 100 years, the flood protection in the delta afforded by the Avon Bypass and downstream levee and channel improvements. A dam at the Sauk River site is limited to a maximum height of 200 feet. A dam height in excess of 200 feet would cause overflow into the Stillaguamish River basin. Multiple-purpose storage in the Sauk project could provide hydroelectric power, irrigation, recreation, and low-flow augmentation in addition to flood storage. Fish passage problems, although less than at the Faber site, would also occur at the Sauk site. Feasibility studies of a Sauk River dam will extend over the next two to three years.

8. SUMMARY OF PLANNING. - Flood control has the highest priority of the immediate water-control needs in the Skagit River basin. The present flood damage expectancy is once in 3 to once in 10 years, varying with individual diking districts. An intermediate level of flood protection, corresponding to protection from flooding of once in 35 years, can be achieved in the delta by constructing the authorized Avon Bypass in combination with the proposed levee and channel improvements downstream from the Bypass. These improvements are well justified when considered as first elements of a basin plan. They also retain their justification when considered as last added; or, in a plan for upstream storage, which would yield a much higher level of flood protection as well as other water resource benefits. Because of strong concern by fisheries interests about the effect of the Sauk River storage project on fish and because hydroelectric power from the project would not be marketable until 1975, construction of the Sauk project at this time can only be considered as a potential element of a future plan of water resource development. Thus, the Bypass and downstream levee and channel improvements are the only flood control proposals now attainable.

9. EVALUATION OF ALTERNATIVES. - Alternative plans of flood control in the delta have been considered. These plans are (a) channel deepening; (b) channel widening; (c) channel dredging at the mouth of the river; and (d) raising levees.

a. Channel Deepening. - Deepening the Skagit River to carry flood flows is not feasible. Substantial deepening of the river to carry flood flows would tend to undermine existing levees along the river banks and thereby require costly erosion protection measures. The Skagit River carries large quantities of bed sediment estimated at more than 500,000 cubic yards annually. A deepened channel would require maintenance dredging of a sediment basin above the improved reach of the river at an estimate of at least $200,000 annually. In addition major dredging of more than 20 miles of river channel would be necessary for increased channel capacity as well as set back of levees at the mouth of the river, channel excavation and maintenance to carry flood flows would have an extremely adverse effect on the salmon and steelhead trout fishery resource. Because the Skagit River is the most important river in the entire Puget Sound area for salmon and steelhead spawning and for sport fishery, any major dredging of the river would be totally unacceptable to fishery interests. For these reasons channel deepening was considered impracticable and cost estimates were not made for this plan.

b. Channel Widening. Flood protection by widening the Skagit River channel and setting back levees was also considered. To achieve the same results as the Bypass and the levee improvements, the channel would have to be widened from 300 to 600 feet from the downstream limits of Sedro Woolley to the mouth of the river, a distance of over 20 miles. This work would cost about

six to seven million dollars more than the cost of equivalent flood protection with the Bypass and downstream levee and channel improvements, and therefore is not economically feasible. One of the principal reasons for the high cost of this plan is that much of the land on both banks of the river is well developed, and widening would require costly relocations and acquisition of land.

c. Channel Dredging at the Mouth. - Dredging and widening of the river at its mouth, proposed as a flood control measure by some residents in the basin, would provide only very localized flood protection. Such widening would lower flood stages slightly for a short distance upstream from the mouth of the river, but would not provide flood protection for the upper delta in the vicinity of Mount Vernon and Burlington.

d. Levee Raising. - Major raising of the levee system was found uneconomical. The costs of providing flood protection by major raising of levees to accommodate a flow of 144,000 c.f.s. downstream from Sedro Woolley, would exceed $28,000,000. This compares to the estimated $23,940,000 cost of the Avon Bypass to provide essentially the same degree of protection. Major levee raising would result in backwater effects from confining flows between levees that would cause more than a 3-foot rise in water surface upstream from Sedro Woolley. The cost of levees to protect upstream areas from these backwater effects is not included in the above major levee raising cost. Because these studies showed the Avon Bypass to be a more economical and more effective plan than raising the levees, no further consideration was given to major raising of the levee system.

10. OPTIMIZATION OF DESIGN FOR AVON BYPASS. - As the Avon Bypass is an integral part of a long-range basin plan for flood control with permanent type concrete control structures, a 100-year economic life has been utilized in optimizing the design. The 100-year life also corresponds to the objective of 100-year or greater flood protection.

The Avon Bypass was first considered without the levee and channel improvements. In this plan, the Bypass would begin operation at 84,000 c.f.s. flow downstream from Sedro Woolley. Operation of the Bypass in this manner would retain freeboard in the existing levee system with a minimum of flood fighting. Based on this plan of operation, curves showing average annual costs and average annual benefits were plotted against a scale of varying Bypass channel capacities. As illustrated by the right-hand series of curves on the Exhibit at the end of this supplement, the maximum net benefit value is realized for a Bypass capacity of about 60,000 c.f.s., corresponding to a B/C ratio of 2.9. A channel

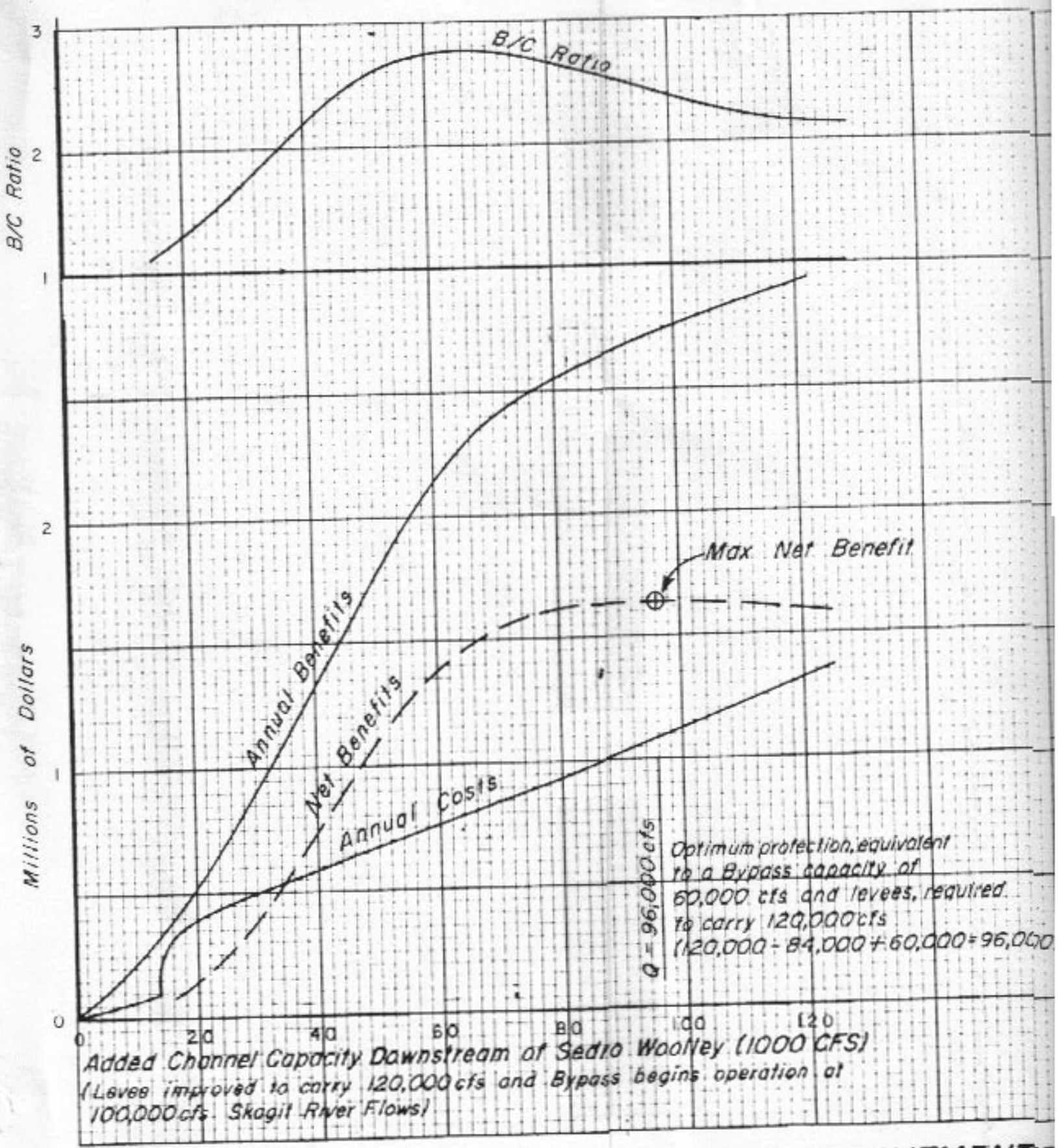
of this capacity would provide full flood protection from flows of 144,000 c.f.s. downstream from Sedro Woolley. Overall protection afforded by the Bypass in the delta area would range from 14-year protection along the lower North and South Forks to more than 35-year protection upstream.

11. OPTIMIZATION OF LEVEE AND CHANNEL IMPROVEMENTS AND THE AVON BYPASS. - Protection afforded by the Bypass downstream from Sedro Woolley, with 60,000 c.f.s. diversion capacity, first added, would range from 14-year protection along the lower North and South Forks, to more than 35-year protection upstream of the confluence of the Forks, as discussed in preceding paragraph. The proposed levee and channel improvements downstream of the Bypass would increase the channel capacity from 84,000 c.f.s. to 120,000 c.f.s. Further raising of levee was considered impracticable, as discussed in paragraph 6. This increased channel capacity, together with the Bypass, would increase flood protection to a minimum 35-year level downstream from Sedro Woolley. The 35-year level of flood protection provided by the Avon Bypass, with levee and channel improvements, would protect against 79 percent of average annual flood damages under present conditions. These flood damages are 75 percent agricultural and only 25 percent urban. Therefore, the project is now required essentially for the protection of agricultural lands, and the 35-year level of protection is well suited to present development. The Avon Bypass, when considered jointly with levee and channel improvement, would begin operation at about 100,000 c.f.s. Operation on this basis would permit the addition of a sport fishery and recreation to the Bypass channel. Curves of total average annual costs and average annual flood control benefits for the combined Bypass and levee and channel improvement projects were plotted against a scale of added channel capacity downstream of Sedro Woolley. The economic life of 100 years that was used in the analysis of levee costs included a factor for major levee rehabilitation. As illustrated by the curves on the left side of the Exhibit at the end of this supplement, the maximum net benefit value for the combined projects is realized from an added channel capacity of 96,000 c.f.s. corresponding to a Bypass capacity of 60,000 c.f.s., and a 36,000 c.f.s. increase in the main river minimum capacity from 84,000 to 120,000 c.f.s. The combined B/C ratio of the flood control features for the added channel capacity of 96,000 c.f.s. is 2.5.

12. CONCLUSIONS. - The project formulation presented herein pertains to projects that provide first priority flood control protection as elements of a basin flood control plan, and that can be constructed with sound economic feasibility under present-day conditions. Alternative solutions considered in project formulation have been presented. Identification has been made of the plans and projects which would maximize net tangible benefits. The Avon Bypass has maximum net benefits for a channel capacity of 60,000 c.f.s.

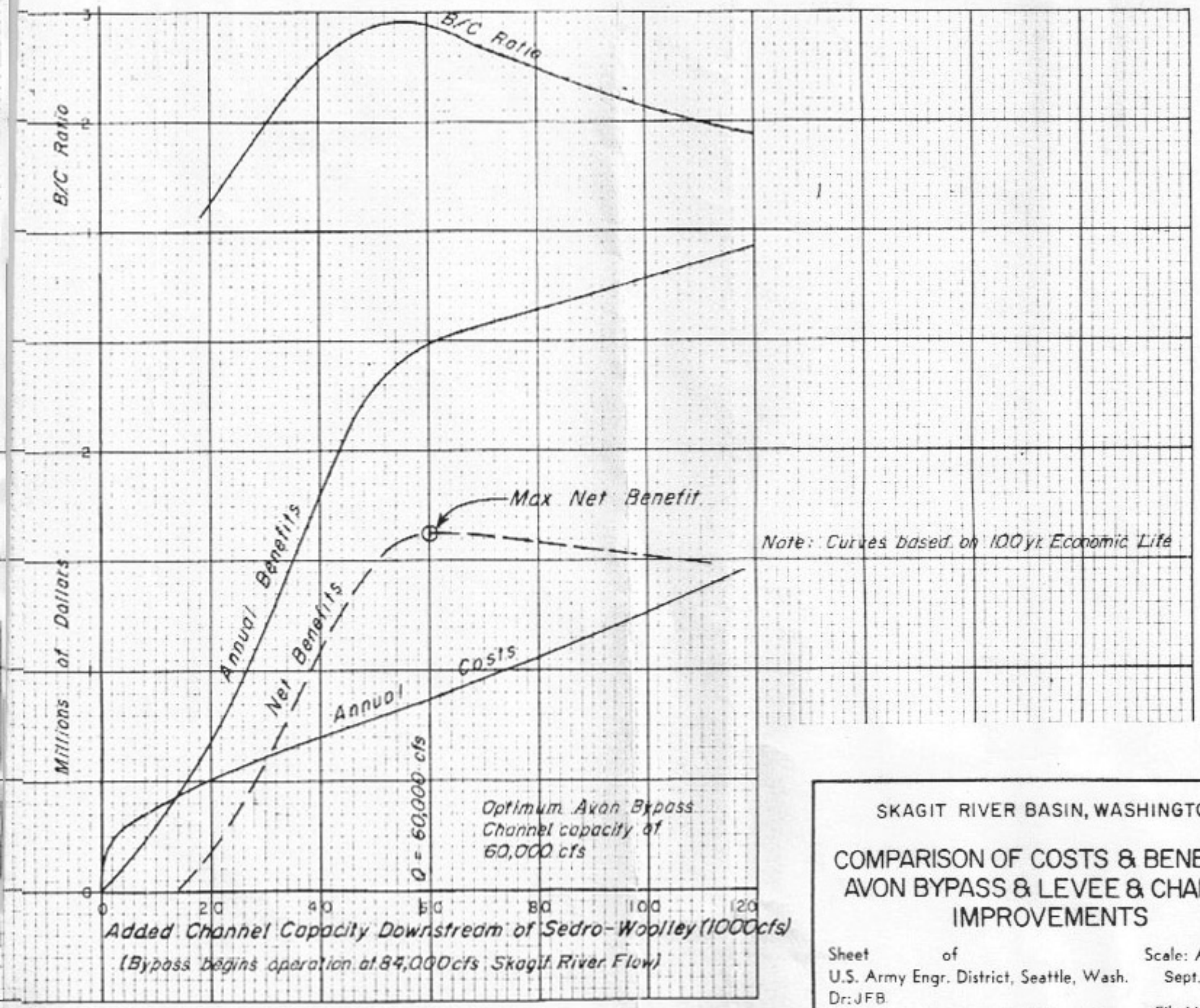
Levee and channel improvements plus the Avon Bypass realize maximum net benefits in an increase in the downstream channel capacity by 36,000 c.f.s. to a total channel capacity of 120,000 c.f.s., and by 60,000 c.f.s. channel capacity in the Bypass.

CORPS OF ENGINEERS



AVON BYPASS + LEVEE & CHANNEL IMPROVEMENTS

U. S. ARMY



AVON BYPASS ONLY

SKAGIT RIVER BASIN, WASHINGTON

COMPARISON OF COSTS & BENEFITS AVON BYPASS & LEVEE & CHANNEL IMPROVEMENTS

Sheet of
U.S. Army Engr. District, Seattle, Wash.
Dr: J F B
Tr: A.L. C.M.C.
Ck: R.A.S.
Transmitted with report dated

Scale: As shown
Sept. 1964
File No.
E-6-6-248

EXHIBIT 1

SKAGIT RIVER BASIN, WASHINGTON

FLOOD CONTROL AND OTHER IMPROVEMENTS

Prepared by
U. S. Army Engineer District, Seattle
Corps of Engineers
March 1965

SYLLABUS

This report presents the first stage of a comprehensive long-range plan for flood control in the Skagit River basin in northwestern Washington. The report is concerned with the 68,000-acre lower river flood plain downstream from the City of Sedro Woolley. The lower river flood plain lies predominantly within the Skagit River delta and includes a portion of the Samish River delta. Approximately 22,000 people live in this highly developed agricultural and urban area.

This flood plain is highly susceptible to flood damage and, under present day conditions, these damages would average $2,216,000 annually. The flood plain is protected by 43 miles of riverbank levees. These levees have varying capacities of from 91,000 to 143,000 cubic feet per second. The levee system now protects against floods with an expected occurrence of once in 3 to 14 years. Improvements proposed in this report would give the entire levee system a minimum capacity of 120,000 cubic feet per second to protect against floods with an expected occurrence of once in eight years.

The other elements of the plan for basin flood control are construction of the Avon Bypass channel (authorized by the Flood Control Act of 1936), and addition of upstream storage. Improvements proposed herein, namely levee strengthening and removal of channel constrictions, when combined with the Avon Bypass would increase the minimum level of protection from flooding to once in more than 35 years. The addition of upstream storage, beyond that now available, to the presently proposed improvements could increase protection against damaging floods to a recurrence interval of once in about 100 years. Upstream storage will be considered in detail in the comprehensive studies now underway for Puget Sound and adjacent waters.

The estimated cost of the levee and channel improvements proposed herein is $6,007,000 of which $237,000 is non-Federal. Annual benefits would average $751,000 and annual costs $245,000, giving a benefit-to-cost ratio of 3.1.

The report also shows development of recreation as an added purpose of the Avon Bypass that would be made possible by the proposed levee and channel improvements. Because the Avon Bypass is a local flood protection project, responsibility for development of recreation is primarily with local interests. Authorization is sought to permit the Federal Government to modify proposed flood control features of the Bypass for usage in recreation developments. The principal recreation features in which there is a project related Federal interest, are boat ramps in conjunction with use of the Bypass for a resident fishery and the provision of access to Padilla Bay.

Boat ramps for the resident fishery require addition to the Bypass structures at an estimated Federal cost of $19,000. Access to Padilla Bay would require the provision of a boat launching facility at an estimated Federal cost of $15,500. Non-Federal responsibilities for the resident fishery include 50 percent of the first cost of these improvements, initial stocking and all operation and maintenance. Non-Federal responsibilities for access to Padilla Bay include 50 percent of the first cost of these improvements and operation and maintenance. Average annual benefits of $104,400 for the resident fishery compared to annual costs of $13,400, yield a benefit-to-cost ratio of 7.8. Average annual benefits of $5,800 for access to Padilla Bay compared to annual costs of $2,500, yield a benefit-to-cost ratio of 2.3.

The District Engineer recommends authorization and early construction of the local flood protection project described herein, consisting of levee and channel improvements on the Skagit River at an estimated Federal cost of $5,770,000. The District Engineer further recommends modification of the authorization for the Avon Bypass project, as set forth in the Flood Control Act of 1936, to permit Federal participation in development of the recreational aspects of the Bypass. Project at an estimated Federal cost of $34,500.

Assurances of local cooperation essential for construction of levee and channel improvements and for Federal participation in recreation improvements of the Avon Bypass Project have been furnished by the Skagit County Board of County Commissioners.

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U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
1519 SOUTH ALASKAN WAY
SEATTLE 4, WASHINGTON 98134

ADDRESS REPLY TO
DISTRICT ENGINEER
(NOT TO INDIVIDUALS)

REFER TO FILE NO.
NPSEN-BP

March 1965

SUBJECT: Review of Reports on Flood Control and Other Improvements, Skagit River, Washington

TO: Division Engineer
U. S. Army Engineer Division, North Pacific

SECTION 1 - INTRODUCTION

1. AUTHORIZING RESOLUTIONS

Preparation of this review of reports was directed by similar resolutions adopted 4 January and 9 June 1960 by the Senate and House Committees on Public Works, 86th Congress. The Senate resolution states:

> "Resolved by the Committee on Public Works of the United States Senate that the Board of Engineers for Rivers and Harbors created under Section 3 of the River and Harbor Act, approved 13 June, 1902, be and is hereby requested to review the reports of the Chief of Engineers on Skagit River, Washington, published as House Document No. 187, 73rd Congress, 2d Session, and other reports, with a view to determining whether any modification of the recommendations contained therein is desirable at the present time, with particular reference to flood control and allied improvements in the basin."

The study was initiated in October 1960.

The 1962 Flood Control Act, 87th Congress, 2d Session, authorized a comprehensive study of Puget Sound, Washington, and adjacent waters, including tributaries, in the interest of flood control, navigation and other water uses, and related land resources. That study includes all river basins in the Puget Sound region and encompasses the precepts of Senate Document No. 97, 87th Congress. Senate Document 97 is a report on "Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water

and Related Land Resources," prepared under the direction of the President's Water Resources Council. The comprehensive study, begun in January 1964, will develop plans for long-range water resource development of the various Puget Sound river basins. The proposals made in this review report are compatible with the overall objectives of the comprehensive study.

2. SCOPE

This report is primarily concerned with levee and channel improvements in the lower Skagit River delta flood plain (downstream from Sedro Woolley), as a first phase of a comprehensive flood control plan for the river basin. The levee and channel improvements are considered with respect to their initial benefits and to their long range significance in the comprehensive plan. The report also considers the recreational development of the authorized Avon Bypass Project which would be made possible by the levee and channel improvements.

The comprehensive flood control plan reported on involves three elements: The Avon Bypass diversion channel, an authorized project; levee and channel improvements on Skagit River downstream from the Bypass; and future upstream multiple-purpose storage. The Avon Bypass was authorized by the Flood Control Act of 1936 as a flood control project to divert a portion of the flood waters from Skagit River between Burlington and Mount Vernon into Padilla Bay. Local interests could not provide the requirements of local participation and the project was classified inactive in 1952. Responsible local support of the authorized Bypass Project has now developed and evidence has been received that local cooperation requirements may be satisfied. This report summarizes important aspects of the present Bypass plans. Upstream storage plans are preliminary and are intended primarily to demonstrate how a high level of flood protection can be achieved by upstream multiple-purpose storage in combination with other elements of the comprehensive flood control plan.

3. FIELD AND OFFICE STUDIES

Field and office hydraulic studies were made to establish flood profiles and the effects of various plans of improvements on these profiles for the reach of river from Sedro Woolley to the mouth. Hydrology data and frequency curves were updated. Previous flood damage appraisals were updated to 1963 levels by extensive field surveys. Current economic studies of the Puget Sound region of the State of Washington and of the nation have been utilized in evaluation of present development and forecasted growth. Subsurface investigations were made at representative locations along the river banks to determine the soil classifications and general characteristics of the existing foundation and levee materials. The District staff has made numerous field trips to review the siting of proposed improvements and to discuss these improvements with local interests. Detailed information developed by these studies is presented in the report appendices.

4. COORDINATION

The following Federal and State agencies have been directly involved in planning and coordinating the studies:

Federal	State of Washington
Bureau of Outdoor Recreation	Department of Game
U. S. Fish & Wildlife Service	Department of Conservation
	Department of Fisheries
	Highway Commission
	Parks & Recreation Commission

Close liaison was maintained throughout the study with the Skagit County Board of County Commissioners, the County Engineer, the Skagit County Flood Control Council and the Diking Districts.

5. OTHER REPORTS UNDER STUDY

a. Navigation study. In May 1947 a resolution was adopted by the U. S. House of Representatives authorizing the review of reports on the Skagit River, Washington, for navigation. A report is now being completed on the feasibility of providing a shallow draft navigation channel in the Skagit River from its mouth to Concrete, Washington. The outcome of the navigation study will have no effect on the plans of improvement proposed in this report.

b. Comprehensive study. A study to develop a comprehensive plan of water and related land resource development in the Puget Sound region began in January 1964. This report has been coordinated in the comprehensive planning of basin developments.

6. PRIOR REPORTS

The Corps of Engineers has prepared four prior reports on flood control for the Skagit River basin. These reports are summarized below:

Report	Date	Improvements Considered	Recommendations
H. D. 125 69th Congress 1st Session	1925	Basin flood control	Survey for flood control
H. D. 187 73rd Congress 2d Session	1933	Basin flood control including Avon Bypass	Flood control improvements could not be recommended at that time
Preliminary Examination (Not Published)	29 March 1937	Basin flood control	Additional surveys for flood control were recommended
Survey Report (Not Published)	21 Feb 1952	Flood protection in delta area	Flood control improvements could not be recommended at that time

7. EXISTING PROJECTS

There are no Federal flood control projects in the Skagit River basin. Navigation projects are inactive and have no bearing on the present study.

SECTION 2 - BASIN DESCRIPTION

8. LOCATION AND EXTENT

The Skagit River basin, plate 1, is in the northwest corner of the State of Washington. The basin comprises an area of 3140 square miles, extending about 130 miles in a north-south direction and about 80 miles from east to west between the crest of the Cascade Mountains and Puget Sound. The northern end of the basin extends 28 miles into British Columbia, Canada, where it borders the Frazer River basin. Within the United States, the Skagit River drainage basin lies south of the Nooksack River and north of the Stillaguamish and Snohomish Rivers. All of these rivers flow into Puget Sound.

The entire floor of the Skagit River valley and the deltas of the Samish and Skagit Rivers comprise the flood plain. The flood plain covers 90,000 acres, 68,000 acres of which are fertile delta land downstream and west of the city of Sedro Woolley, and 22,000 acres are river bottom land east and upstream of this city. The extent of the flood plain is indicated by the brown shaded area on plates 1 and 3. The major portion of the bottom land east of Sedro Woolley is in developed farmsteads, and the remainder is mostly uncleared or swampy. Figures 1 and 2 show urban and agricultural development in the flood plain. Farms in the delta are highly developed, with well maintained buildings, residences, and other improvements. Encroaching on the agricultural lands of the delta are the urban communities of Burlington, LaConner, and part of Mount Vernon.

9. MAPS

In addition to maps contained in this report, the following U. S. . . Geological Survey maps have been made of the Skagit River basin:

a. USGS quadrangles 1:24,000 scale, 1956, with contour intervals of 20 feet covering the Skagit River flood plain from the mouth to Sedro Woolley.

b. USGS quadrangles 1:62,500 scale, dated from 1940 to 1956 with contour intervals of 50 and 80 feet covering the Skagit River flood plain from Sedro Woolley to Newhalem, except 6 miles near Rockport.

c. USGS quadrangles 1:125,000 scale, 1899, of the flood plain near Rockport and of the Sauk River.

Fig. 1. View of delta area looking Northwesterly. Mount Vernon in the foreground is separated from Burlington in the right background by the Skagit River. Padilla Bay and Samish Bay are shown in the extreme background. (Northwest Air Photos)

Fig. 2. View of delta area looking Southwesterly. Mount Vernon and Skagit River are in the foreground and the Straits of Juan de Fuca are in the extreme background. The North and South Fork distributaries are at the left. (Northwest Air Photos)

d. USGS river sheets 1:24,000 scale, 1938, of the flood plain from Concrete to Newhalem and the Sauk River to Darrington.

10. STREAMS

The Skagit River originates in a network of narrow, precipitous mountain canyons in Canada and flows west and south into the United States where it continues 135 miles to Puget Sound. The stream falls rapidly from its source at an elevation near 5000 feet to the United States border at elevation 1600 feet. Stream profiles on plate 2 show that within the first 40 miles south of the International Boundary the river falls 1100 feet, and that the remaining 500 feet of fall is distributed along 95 miles of the river. The Skagit River crosses a broad outwash plain in its lower reaches and divides between two principal distributaries in the last 9-1/2 miles at its mouth. These forks are nearly equal in length and during the usual range of river discharge, the flow is so divided that about 60 per cent is carried by the North Fork and 40 per cent by the South Fork.

11. PRINCIPAL TRIBUTARIES

The Sauk River is the largest tributary in the Skagit River basin. Drainage areas of the Skagit River and its principal tributaries are shown in upstream to downstream order in table 1. In addition, there are many lesser named and unnamed streams not shown in table 1.

Table 1

SKAGIT RIVER AND PRINCIPAL TRIBUTARIES
DRAINAGE AREAS AND LOCATIONS

River	Skagit River Mileage	Drainage Areas Square Miles
Cascade River	78	185
Sauk River	65	732
Whitechuck River (Sauk River mile 26)		86
Suiattle River (Sauk River mile 13)		346
Baker River	56	298
Skagit River at Ross Dam	104	999
Skagit River near Concrete	54	2737
Skagit River near Sedro Woolley	24	3015
Skagit River at Mount Vernon	13	3102

12. STREAM CHARACTERISTICS

Mean annual flows of the Skagit River range from 10,000 to 20,000 c.f.s. at Mount Vernon. Maximum discharges generally occur upstream from Mount Vernon because of valley storage. The maximum discharge recorded at Sedro Woolley was 220,000 c.f.s. in 1909, and the minimum was 2,830 c.f.s. in 1915. Base flow is normally low in August and September. Average discharges usually increase to reach a base flow peak in November and December. Freezing temperatures in the high tributary area during the remaining winter months reduce runoff and cause a drop in the river flows, which reach a winter low in March. Snowmelt increases river discharges during April and May, and causes a peak flow in June. This peak is again followed by a decline to the lowest levels of the year in September and early October. Storms cause sharp increases above the base level the year around. However, winter flows are particularly subject to frequent, sharp rises. All major recorded floods on the Skagit River have occurred between November and February and have been caused by high rates of precipitation with accompanying snowmelt.

13. CLIMATE

The wide ranges in elevation throughout the Skagit River basin, varying from mean sea level to 10,000 feet, result in marked differences in temperature and precipitation. Extremes in temperature recorded in or near the basin have reached a maximum of 109°F. at Newhalem and a minimum of -14°F. at Darrington Ranger Station and at Mount Baker Lodge. The average growing season varies from 105 days at Mount Baker Lodge to 236 days at Anacortes.

Approximately 75 per cent of the precipitation in the Skagit basin falls during the period October through March. Heavy winter snows occur in the higher elevations and remain until late spring or early summer. The average snowfall is 530 inches at Mount Baker Lodge and 5.9 inches at Anacortes. The total annual precipitation varies from 108 inches at Mount Baker Lodge to 26 inches at Anacortes.

The principal agricultural portion of the basin lies west of Sedro Woolley and has a mild climate without extremes of heat or cold. Precipitation is likewise moderate, averaging 45 inches annually at Sedro Woolley, with lesser amounts on the farmlands to the west. In many years, spring and summer rainfall is adequate for crop production; yet, in common with the rest of the Puget Sound area, the summer season is the driest period of the year. Some farmers irrigate with sprinklers, obtaining water from wells or river channels, but the practice is not widespread.

14. GEOLOGY AND SOILS

The Skagit River basin has been severely glaciated by continental and valley glaciers. Alpine glaciers still exist above elevation 5,000 feet. Glacial activity has resulted in the carving of hundreds of cirques, increasing the ruggedness of the higher areas, broadening stream valleys to U-shaped cross profiles, subduing the lowland hills, and depositing sediments in the lower areas.

During and following the most recent glacial recession, which occurred only about 15,000 years ago, immense volumes of coarse and fine grained sediments have been worked by the Skagit River. Courses of the Suiattle and Sauk Rivers were changed, and the courses of the Skagit and Baker Rivers were modified locally. Glaciation has cut down high river banks and filled low plain areas as the river reestablished its gradient. The Skagit River delta has been extended by the river since pleistocene time to form very extensive flats west of Sedro Woolley. In this process the bedrock surface has been buried with an unknown, but probably great, thickness of sediments except for scattered low hills that rise above the delta plain. These hills are identical to the islands of Puget Sound. Most of the drainage basin is underlain by ancient greenstone, phyllite schist, marble and other metamorphosed sediments intruded locally by igneous bodies. Mount Baker and Glacier Peak are formed from andesite lava.

The extensive delta of the Skagit River consists of silty clay, sandy silt and silty fine sand laid down by overflow of the river. Natural drainage of the sandy silt and silty sand is generally good, while that of the clay soil is very poor, requiring artificial measures. These types of soil are extremely fertile. Soil lying in the uplands of the transitional areas between the flood plain and the valley walls consists of a gravelly sandy silt derived from the weathering of glacial drift. This soil, because of its natural drainage, is not suited for general farming, but can be made to produce profitable yields by intensive cultivation.

15. VEGETATION

The Skagit River basin can be roughly divided into three separate vegetation zones: the portion above timberline which supports only the meadow grasses and mosses that exist at high elevations; the heavily forested areas between timberline and the lower foothills; and the cultivated flood plain and gentle slopes of the foothills. Most of the forested area contains, or is capable of producing, marketable timber. Commercial species include Western hemlock, cedar, Douglas fir, and other firs. Hardwood species such as alder, cottonwood, maple, etc., make up the remainder of the commercial timber in the basin. Undergrowths prevalent throughout the basin in the forested and other undeveloped areas include huckleberry, salal, oregon grape, wild blackberry and many species of ferns. Much of the cultivated land is used for vegetable production,

including peas, broccoli, corn, carrots, etc. Strawberries, seeds, bulbs and specialty crops are also produced in quantity. Pastureland in the basin generally supports a heavy growth of lush grasses which thrive during the summer months and survive to a certain extent the year around.

16. DAMS

Hydropower projects have been developed in the Skagit River basin by the City of Seattle, the Puget Sound Power and Light Company, and the Lone Star Cement Corporation.

Seattle City Light has constructed three power dams on the main river. Ross Dam, at river mile 105, has a reservoir with a usable storage of 1,028,000 acre-feet of which 120,000 acre-feet are reserved for flood control from 1 December to 15 March. Installed generator capacity is 360,000 kw. Ross Dam reservoir supplements low flows for run-of-river plants at Diablo and Gorge Dams downstream. Diablo Dam at river mile 100 has a generator capacity of 122,000 kw and Gorge Dam at river mile 96 has a generator capacity of 134,000 kw.

The Puget Sound Power and Light Company operates two dams on the Baker River, one of the main tributaries of the Skagit. The first constructed and downstream dam was completed in 1927 and now has an installed capacity of 103,000 kw. The upstream dam at Baker Lake was completed in 1959, and has a generator capacity of 94,000 kw.

The Lone Star Cement Corporation operates two small plants on Bear Creek, a tributary of the Baker River. These plants have a combined capability of 2100 kw and are operated to service the company-owned cement plant at Concrete.

17. EXISTING AND AUTHORIZED FEDERAL FLOOD PROTECTIVE WORKS

a. Avon Bypass. There are no existing Federal flood control works in the basin. The Flood Control Act of 1936 authorized the Avon Bypass channel, a project for the partial control of floods in the lower Skagit Valley by diversion of a portion of Skagit River flows. The diversion channel was to be constructed between a location on the river just downstream from Burlington to Padilla Bay. The project was not undertaken at that time because local participation requirements could not be satisfied. The Chief of Engineers has recommended re-activation of the Bypass Project, and reasonable assurances have been received that local cooperation requirements will be satisfied.

Current studies to develop the basin plan have shown that the design capacity of the Avon Bypass channel should be 60,000 c.f.s. The Bypass would

increase the minimum level of flood protection in the river basin downstream from Sedro Woolley from about 90,000 c.f.s. at the present time to 150,000 c.f.s. In combination with the proposed levee and channel improvements, the minimum capacity would be 180,000 c.f.s., corresponding to an estimated frequency of once in more than 35 years.

Modification of the authorization for the Avon Bypass is an important part of this report. Accordingly, a detailed description of the proposed Bypass is included herein. The present plan for the project, shown on plate 7, has an eight mile channel with intake from the Skagit River about 1 mile downstream from Burlington and proceeding westward through Gages Slough and along the southerly fringe of Bayview Ridge to Padilla Bay. The channel would be 360 feet wide at the bottom. Flow depths for a normal capacity of 60,000 c.f.s. would be about 25 feet. The channel would have four control structures, as shown on plate 8, including a gated concrete intake, two collapsible type intermediate weirs to control groundwater levels, and an ungated concrete outlet structure to control channel velocities and to prevent saltwater intrusion into the channel. The intake and outlet structures would be equipped with gated and screened sluices to control channel water levels during non-flood periods, to accommodate interior drainage runoff, and to prevent entrapment of migratory fish. The route would require construction of eight highway and two railroad bridges, alteration of a natural gas pipeline and an oil pipeline, and relocation of miscellaneous local utilities. The project also includes improvement and extension of four miles of levee on the right bank of Skagit River immediately above the Bypass intake. The Avon Bypass would cost $23,940,000, and would have a benefit-to-cost ratio of 1.6 to 1 with other elements of the basin plan.

b. Flood storage. The Federal Power Commission License for Ross Dam requires a winter flood storage reservation of 120,000 acre-feet for the benefit of the downstream valley. The F.P.C. license for Upper Baker Dam requires a flood storage reservation of 16,000 acre-feet to compensate for valley storage lost because of the dam. All stream flows and flood frequencies in this report include full allowance for Ross Dam flood storage unless otherwise noted.

18. EXISTING LOCAL FLOOD PROTECTIVE WORKS

Farmland and towns in the delta flood plain west of Sedro Woolley are protected by levees that prevent flooding from the river and from tidal salt water. Plate 3 indicates the location and general extent of the existing diking districts in the Skagit and Samish River valleys, and plate 4 shows the existing levee system downstream of Burlington. About 43 miles of main line river levees prevent flooding of land by spring floods and by minor winter floods. Levees along saltwater bays and channels prevent inundation by tidal flows. There are 16 diking districts inclosing a total of 45,000 acres of land within levees.

Individual owners have inclosed an additional 1,000 acres of land. The present levee system protects from flows ranging from 91,000 c.f.s. to 143,000 c.f.s. Overtopping of low areas in the levee system begins at flows of 84,000 c.f.s. Through sandbagging of low areas and minor flood fighting, the levees can provide capacity for a 91,000 c.f.s. flow with an average minimum freeboard of one foot. Table 2 gives the area inclosed by each levee, length of levee, date of organization of levee district, and estimated maximum river discharge that the levees can withstand without failure. The capacity is based upon assumption of failure when flows reach a stage one foot below the average low points of existing levees. The levees, varying in height from 5 to 10 feet, with top widths of 3 to 12 feet, usually have been constructed of river sediments ranging from fine sandy silt to silty fine sand. Coarser grained material encountered in some areas indicates hillside borrow has been used to a minor extent for original construction or repair. Sod is grown on levee slopes to minimize erosion, with riprap generally provided in the vicinity of river bends. The State, Skagit County, and diking and drainage districts, as well as the Federal Government, have given aid in rebuilding sections of levees damaged by floods. To 1963, local interests have expended a total of $5,594,000 in levee construction and other flood control improvements. Table 3 presents a breakdown of the non-Federal expenditures.

19. FEDERAL PARTICIPATION IN CHANNEL AND LEVEE MAINTENANCE

During the period 1936-1939, approximately $400,000 was spent by the Works Progress Administration in constructing revetments of steel cables and brush mats along both banks of the Skagit River between Burlington and Concrete. Since 1947, the Corps of Engineers have spent $194,000 on reconstruction of flood-damaged or destroyed levees on the Skagit River at nine locations under continuing flood control authorities.

Table 2

SKAGIT RIVER DIKING DISTRICTS

Diking Dist. No.	Date organized	Area Protected (acres)	Miles of levee: Bordering saltwater bays & channels	Miles of levee: Bordering river channels 1/	Maximum flow river levees will withstand (c.f.s.) 2/	Probable interval of flooding in District (years) 3/
1	1897	8,264	0	7.9	108,000	5
2	1897	2,669	0	6.4	91,000	3
3	1897	6,365	0	11.5	101,000	4
4	1897	1,577	4.1	2.5	123,000	8
5	1897	2,847	6.6	2.0	123,000	8
8	1897	632	2.1	0.9	108,000	5
9	1897	1,419	3.5	1.7	108,000	5
12	1897	13,379	12.6	6.5	108,000	5
13	1897	1,869	2.6	2.6	91,000	3
15	1903	885	1.8	1.9	91,000	3
16	1904	407	0	2.9	101,000	4
17	1910	1,263	0	4.5	143,000	14
18	1918	576	1.4	0.6	91,000	3
19	1919	1,961	2.7	1.8	123,000	8
20	1919	537	0	3.0	143,000	14
21	1922	391	2.1	0	91,000	3
Private Dikes	-	1,000	5.7	9.5	91,000	3
Totals		46,041	45.2	66.2		

1/ Skagit and Samish Rivers and primary and secondary sloughs.
2/ Assumes river at stage 1 foot below average low sections of levee. (Mount Vernon gage) and sandbagging of extreme low areas.
3/ For failure of levee protecting District. This does not take into account flooding from failure of cross levees.

Table 3

NON-FEDERAL FLOOD CONTROL EXPENDITURES

SKAGIT RIVER

Year	State	County	Diking Districts	Drainage Districts	Others
1947 thru 1957	$528,431	$323,209	$259,081	$615,935	$ 1,650
1958 thru 1959	136,308	73,390	153,991	108,430	-
1960 thru 1961	86,929	70,626	261,590	132,113	29,083
1962 thru 1963	20,590	24,595	257,074	141,155	-
Subtotal	$816,702	$491,820	$901,736	$997,633	$30,733

Local Expenditures:

To 1947	$2,355,000
1947 to 1963	$3,239,000
Total	$5,594,000

20. GENERAL

The Skagit River basin comprises most of Skagit County, as well as parts of Snohomish and Whatcom Counties and a very small portion of British Columbia. Most of the land area and developments are within the boundaries of Skagit County. There are 1,110,000 acres of land in Skagit County. Timberland covers about 848,000 acres, representing about three-fourths of the land area. Most of the timber is classified as commercial type. Of the remaining land, approximately 13 per cent or 142,000 acres are farmland, another 9,000 acres are urban and industrial, and 111,000 acres are alpine areas.

21. POPULATION

The population of Skagit County was 51,350 in 1960. The population statistics of the county are summarized and compared with State and national totals in table 4.

Table 4

POPULATIONS COMPARISONS

	1930	1940	1950	1960
Skagit County	35,142	37,650	43,273	51,350
Anacortes	6,564	5,875	6,919	8,414
Mount Vernon	3,690	4,278	5,230	7,921
Burlington	1,407	1,632	2,350	2,968
Washington State (In 1,000's)	1,563	1,736	2,379	2,853
United States (In 1,000's)	123,202	132,165	150,845	179,326

Source: U. S. Census of Population - Number of Inhabitants
U. S. Department of Commerce, Bureau of Census

22. EMPLOYMENT

Forest, agriculture and fishing industries provided the chief sources of employment and income in Skagit County during the settlement and development years prior to 1940. However, growth during the past two decades has been characterized by an increasing diversification of employment. The increasing diversification is evidenced by the decline in extractive employment from 2,678 in 1950 to 2,182 in 1960, while total employment increased from 13,799 in 1950 to 17,269 in 1960.

23. AGRICULTURE

Agriculture is a predominant element of the Skagit County economy. Most of the farms are in the 68,000 acre fertile Skagit River delta. About 17,000 acres of this bottom land is U.S.D.A., Class 1, rated at high productivity with high farm income. Another 20,000 acres is U.S.D.A., Class II, which has above average productivity and high income. The value of farm products sold has increased from $10,127,000 in 1949 to $15,891,000 in 1959. The "value added by manufacture" during 1958 from processing food and kindred products was $10,600,000 out of a total of $41,036,000 reported for the county.

24. TIMBER INDUSTRIES

In 1960, log production in Skagit County was about 178 million board feet, of which about 84 million board feet came from privately owned lands. During the last 11 years, annual log output has averaged 157 million board feet. Most of this log cut is moved by truck to pulp and lumber mills in Everett and Bellingham. In Skagit County the "value added by manufacture" from lumber and wood products manufacturing was $6,200,000 during 1958.

25. FISHERIES

The Skagit River has large migratory runs of salmon and steelhead which constitute a significant part of both the sports and commercial fishery of the region. In 1961, the commercial fishermen caught 175,000 fish in Skagit Bay near the mouth of the Skagit River, as compared to 1,287,000 fish in the entire Puget Sound area. The larger portion of the Skagit River salmon catch is processed at LaConner and Anacortes. Plants in these areas also process fish from the Puget Sound and offshore waters.

The abundance of all varieties of anadromous fish, together with a heavy resident trout population in the Skagit River, provides an important sport fishery resource. The records of the Washington State Department of Fisheries indicate that the average annual angler days during the past 7 years was 38,000, with a high of about 80,000 in 1959. The recreation value of this fishery to residents of the adjacent metropolitan areas is high. The local area gains income by providing service to sportsmen.

26. MINING

Fewer than one per cent of the employed workers in the county are engaged in mining and processing of minerals. The only stable employment in the mining industry is at a limestone quarry for a cement plant at Concrete. Limestone is exported for cement manufacture and other uses in the Puget Sound

region, as well as used for cement manufacture at Concrete. The value of mineral production in Skagit County totaled $3-1/2 million in 1960. Included in this total were cement, sand and gravel, stone, olivine, talc, soapstone, strontium and chromite.

27. OTHER MANUFACTURING

Increasing diversification of manufacturing has characterized growth during the past two decades. One of the earliest manufacturing plants is the cement plant at Concrete, which has a daily capacity of 6,000 barrels of raw cement. The Skagit Steel and Iron Works was founded in Sedro Woolley in 1902 as a foundry and machine shop, and has since expanded to include the repair and manufacture of sawmill and heavy logging equipment. Construction of two refineries and a petrochemical plant near Anacortes has provided the base of new activity during the past decade.

28. TRANSPORTATION

Navigation contributes to the economy of the basin. In 1960, 7.7 million tons of foreign and coastal water traffic passed through Anacortes, and 41,100 tons of coastwise and internal shipments moved up and down the Skagit River. The bulk river traffic in recent years has consisted of rafted logs. Major commodities moving through the Port of Anacortes are petroleum, forest and fish products, chemicals, and sand and gravel.

Main coastal railroad and highway routes from British Columbia to California cross the western part of the county. The Great Northern and Northern Pacific Railways pass through Mount Vernon and Burlington as does U. S. Highway 99, (Interstate 5). There are five small airfields within the basin but no commercial air service is available.

29. RECREATION

The Skagit River basin provides a full range of recreational opportunities. In its upper reaches, the river flows through the Mount Baker National Forest where there are more than 30 mountains over 8,000 feet high, with glaciers and alpine lakes, having outstanding scenic values. From its source in this rugged, mountainous terrain, the stream flows through a mountain valley with timber-covered slopes which gradually widen to a gentle, sloping outwash plain on the shore of Skagit Bay.

The upland areas support big game populations of deer, black bear, mountain goats and elk. The lower Skagit River valley lies within the Pacific flyway of migratory waterfowl. The river supports large runs of anadromous fish and has a heavy population of resident trout. These natural resources provide for

all-purpose recreational use. Recreational use of the Skagit basin is rapidly increasing because of its proximity to the Seattle-Tacoma metropolitan area, which has a population of over one million.

The U. S. Forest Service maintains 40 improved campgrounds and 45 unimproved campsites, most of which are in the upper, mountainous area. The Washington State Parks and Recreation Commission operates the Bayview State Park on the shores of Padilla Bay. This park has an area of 19 acres. Records of attendance show an increase from 3,412 visitor days in 1950 to 45,300 in 1962. Excellent fishing and hunting draw sportsmen from both the State of Washington and from out of the state. The angler days of sport fishing on the Skagit River increased from about 10,000 in 1956 to about 80,000 in 1959 and 64,000 in 1961.

30. TRENDS

The trend of present economic growth in the Skagit River basin is demonstrated in table 5 by a comparison of selected indicators for Skagit County with those of the State of Washington and the nation.

Table 5

COMPARISON OF SKAGIT COUNTY GROWTH TRENDS

Indicator	Average annual growth rate in per cent		
	Skagit County	Wash. State	United States
Population			
1940-1950	1.4	3.2	1.4
1950-1960	1.7	1.8	1.8
Employment			
Manufacturing (1950-1960)	3.0	3.3	0.9
Non-manufacturing (1950-1960)	2.1	1.3	2.1
Total	2.3	1.8	1.7
Personal Income (1950-1960)	2.2	3.0	3.6
Production			
Value of farm products sold (1949-1959)	4.6	4.8	3.8
Value added by manufacture (1947-1958)	4.6	5.9	3.4

Note: Growth trends have been computed from the U. S. Census of Population; the U. S. Census of Agriculture; the U. S. Census of Manufactures; and data from Washington State Department of Commerce and Economic Development. Values have been adjusted to 1963 price levels.

The surge in population growth of the county from 1950 to 1960, shown in table 5 is primarily attributable to employment created by the construction of two oil refineries and a petrochemical plant near Anacortes, which is outside the Skagit River flood plain. The population growth in the flood plain during this period is estimated to be about 1.4 per cent annually, based on examination of census divisions.

Total employment in Skagit County increased by 2.3 per cent annually over the period 1950-1960, which was greater than that of the State (1.8 per cent) or nation (1.7 per cent). The manufacturing employment segment, which increased by three per cent annually, has risen more rapidly than total employment in the county but is still slightly under the rate of increase of 3.3 per cent for the State. This trend shows a gradual shift from extractive to manufacturing and service industries, and reflects the recent industrial expansion near Anacortes.

Value added by manufacture over the period 1947 to 1958 was above the national average, but below that for the State. During the period 1954 to 1958, the trend was above that of the State of Washington, a condition which reflects the recent increase in industrial development in Skagit County. Growth of personal income in Skagit County is below that for the State. A depressing factor is the predominance of seasonal industry related to harvesting and processing agricultural products, forestry and fishing.

The value of farm products sold in Skagit County has increased from 1949 to 1959 at an annual rate of 4.6 per cent. However, this increase has not been reflected in farm income due to considerably higher production costs. Generally, expansion of farm income depends on conversion of lands to higher value crops and increased productivity. Future increase of farm income in Skagit Valley will result primarily from higher yields on existing crop types because of the relatively high stage of agricultural development.

The median annual family income is about $5,717. Unemployment has averaged above 9 per cent during the period 1958 to 1961, dropping to 8.5 per cent in 1962 and 8.4 per cent in 1963. Records indicate that the recent drop in unemployment partially results from migration of workers from the area. Skagit County has been designated as a redevelopment area 5A under the Area Redevelopment Act and is eligible for assistance under the terms of this legislation. Persistent unemployment stems from the predominance of seasonal industry not compensated by a stabilized manufacturing sector.

31. ECONOMIC EVALUATION

The Skagit River basin has a fertile flood plain of 90,000 acres, 848,000 acres of timberlands, a currently adequate water supply, large commercial and sports fishery, deep water ports and hydroelectric power. These assets are the

basis for substantial economic growth which will be reflected primarily in manufacturing and commercial activities. Residential, industrial, commercial and agricultural activities now exist in the flood plain. A high level of flood protection would permit expansion of these activities in keeping with the resource development potential of the basin. The existing levee system and present upstream storage will not provide the degree of flood control required for expansion of residential, urban or industrial facilities into the flood plain.

Under the existing degree of flood protection, the annual growth factor applicable to flood damages is forecast to be 1.4 per cent. This factor is based on anticipated increases in farm productivity and personal income. National forecasts of crop yields shown in "A 50-Year Look Ahead at U. S. Agriculture," published by the U. S. Department of Agriculture in June 1959, indicates an annual increase in appropriate crop yields per acre of about 1.1 per cent. Since only limited conversion to higher usage of agricultural lands is expected in the flood plain, the growth rate of 1.1 per cent was assumed for land crop damages. Personal income growth is assumed to be an appropriate measure of changes in damageable value of buildings, utilities and other improvements. For this analysis, a personal income growth rate of 2.2 per cent is used. These growth rates, when applied to their respective damages, produce a resultant growth factor of 1.4 per cent.

32. GENERAL

The United States Weather Bureau has maintained 23 climatological stations in or near the basin, of which 17 are currently operated. A station operated by the Department of Agriculture, Province of British Columbia, has been inactive since 1955. These stations vary in elevation from 14 feet at Mount Vernon to 4150 feet at Mt. Baker Lodge.

33. RUNOFF AND STREAMFLOW DATA

Stream gaging in the Skagit River basin was inaugurated in 1908 when the United States Geological Survey established stations on the Skagit River near Newhalem and Sedro Woolley. Since that time, they have maintained 60 stations on the river and six lake and reservoir stations, but are currently obtaining data from only 32 stations. The locations of these gaging stations are shown on plate B-2 of Appendix B.

The normal annual runoff varies from more than 130 inches on the headwaters of the Baker River to 35 inches on the upper Skagit River, principally that portion of the basin in British Columbia.

34. FLOODS OF RECORD

All major floods of record on the Skagit River have occurred in the winter and have been caused by high rates of precipitation and warm winds causing snowmelt. This type of flood has a higher crest and shorter duration than the annual spring snowmelt high water. Several winter rises may be expected each year. The most severe winter floods have been experienced in November and December with some of lesser magnitude in February.

Occasionally, two or more floods follow in close succession as in the floods from 23 November to 30 November 1909, and from 19 December 1917 to 1 January 1918. No constant relationship can be found between the peak flood discharge at upstream points and that at Mount Vernon. Discharges in excess of the channel capacity spread out across the valley above the delta and remain until the river drops. When a peak flow is of short duration the discharge in the delta area can be much reduced by valley storage, as occurred in 1949. This results in a lesser discharge at Mount Vernon than upstream. However, if the near-peak flow continues for an extended period, the discharge can be greater at Mount Vernon than at upstream points because of downstream inflows and the reduced effectiveness of valley storage. The Nookachamps Creek area, on the

left bank between Mount Vernon and Sedro Woolley, is a major source of natural valley storage during flood flows. Storage in this area can reduce major flows from 15,000 to 25,000 c.f.s. downstream from Sedro Woolley.

Table 6 summarizes available data for four gaging stations relating to major and minor floods of record and the known historical floods. A discussion of methods used in determining discharges for these early floods is in Appendix B. The figures for the six historical floods listed in table 6 from 1815 to 1908 were obtained from detailed studies by the U. S. Geological Survey, published as Water Supply Paper No. 1527, "Floods in the Skagit River Basin." Data for the floods of February 1932, January 1935, November 1949 and February 1951 should not be compared with the earlier floods shown because discharges of these later floods were modified by storage in upstream reservoirs. The lower Baker River Project was completed in June 1927. Diablo Dam on the upper Skagit River was completed in 1930. Ross Dam, approximately five miles upstream from Diablo Dam, was completed in 1948 and has a gross storage of 1,400,000 acre-feet. Prior to 1953, flood regulation was a by-product of power storage. Since the installation of the spillway gates at Ross Dam in 1953, 120,000 acre-feet of storage, during the period 1 December to 15 March each year, have been reserved for flood control in accordance with the project license issued by the Federal Power Commission.

35. STANDARD PROJECT FLOOD

A standard project flood, approved by the Office, Chief of Engineers, March 1950, was derived for the Skagit River at Sedro Woolley by application of the unit hydrograph procedure to rainfall and snowmelt resulting from heavy precipitation over the basin combined with other hydrological factors favorable to a rapid runoff. The standard project flood so derived at Sedro Woolley is 440,000 second-feet without upstream storage. Flood control storage in Ross Reservoir would reduce that discharge to 415,000 second-feet. The standard project flood has twice the discharge of the maximum flood of record since establishment of the gaging station in 1908 and is 110 per cent of the estimated maximum historical flood which occurred about 1815. The standard project flood will be reviewed during comprehensive basin studies.

36. FREQUENCY CURVES

Cumulative frequency curves for the maximum annual regulated peak discharges at Concrete, Sedro Woolley and Mount Vernon are presented in Appendix B. These curves illustrate the effect of the operation of Ross Reservoir and also indicate the probable effects of the potential storage available on the Sauk River. A cumulative frequency curve illustrating the effect at Mount Vernon of the potential Sauk River storage as a first added project was also computed by these methods,

Table 6

RECORD FLOOD DISCHARGES, SKAGIT RIVER
(Published Data)

Station	Skagit River near Concrete		Skagit River near Sedro Woolley		Skagit River near Mount Vernon	
Drainage Area	2,737 sq. mi.		3,015 sq. mi.		3,093 sq. mi.	
	Crest Discharge		Crest Discharge		Crest Discharge	
Date	cfs	cfs/sq.mi.	cfs	cfs/sq.mi.	cfs	cfs/sq.mi.
1815	500,000 1/	182	400,000 1/	135		
1856	350,000 1/	128	300,000 1/	101		
16 Nov. 1896			185,000 1/	62		
18-19 Nov. 1897	275,000 1/	100	190,000 1/	64		
16 Nov. 1906			180,000 1/	60	180,000 1/	58
18 Nov. 1908			97,000	33		
29-30 Nov. 1909	260,000 1/	95	220,000	74		
21 Nov. 1910			114,000	38		
29-30 Dec. 1917	220,000 1/	81	195,000	66		
12-13 Dec. 1921	240,000 1/	88	210,000	71		
27 Feb. 1932	147,000	54				
13 Nov. 1932	116,000	42				
22 Dec. 1933	101,000	37				
25 Jan. 1935	131,000	48				
27 Nov. 1949	154,000	56	140,000 2/	47	114,000 3/	37
10 Feb. 1951	139,000	51	150,000 2/	51	144,000	47
3 Nov. 1955 4/	106,000	39	113,000 2/	38	107,000	35
23 Nov. 1959 4/	89,300				91,600	30

1/ Calculated by U. S. Geological Survey.
2/ Estimated by Corps of Engineers.
3/ Mount Vernon gage installed October 1940.
4/ Include effect of 120,000 acre-feet of flood storage established at Ross Dam in 1953.

and is shown on Appendix plate B-10. The cumulative frequency curves for the annual regulated peak discharges near Sedro Woolley and Concrete are shown on Appendix plates B-8 and B-9.

SECTION 5 - FLOOD DAMAGES

37. FLOOD PLAIN VALUES

The flood plain contains thousands of structures and includes a full range of farm, residential, commercial, and industrial buildings with connecting roads and utilities. The total valuation of lands and improvements in the 68,000 acre delta area through and below Sedro Woolley is estimated at $113,300,000 under 1962 conditions and is broken down as follows:

Urban (1,270 acres)	$ 82,000,000
Agricultural (66,730 acres)	31,300,000
Total	$113,300,000

This area includes the Samish River valley and lands northwesterly of the drainage basin in the delta as shown on plate 1. Because the bottom land areas east of Sedro Woolley would not be affected by the Avon Bypass or the downstream levee system improvements, they are not considered in this report.

38. FLOOD DAMAGES

The delta lands west of Sedro Woolley have been inundated many times by the Skagit River since the area was first settled about 1869. Figures 3 to 8 illustrate the damaging effects of several past floods. River levees in the diking districts are not capable of preventing damages from high winter floods. Protection against flooding varies in the several districts. Capability of levees to withstand flood flows ranges from 91,000 c.f.s. in some districts to about 143,000 c.f.s. in others, provided sufficient time is available to place sandbags and strengthen weak points in the levees. Estimates of damages from major floods of record under 1963 prices and conditions are presented in table 7.

39. FLOOD DAMAGE APPRAISALS

Basic data for estimates of flood damages were obtained by field appraisals made in 1940, 1950, and 1961. The appraisals in 1961 included a field review of all previous appraisals and a survey of damages from the 1959 flood. Data available to the 1961 field team consisted of high water marks and damage appraisals of floods, aerial photographs of the flood plain flown in 1956, a 1961 profile of the top of all existing levees, and computed river profiles for several river discharges measured at the Mount Vernon gage. Detailed maps containing elevations throughout the flood plain and the topography of the uplands provided further information.

Fig. 3. December 1921 view of flooded area of the corner of Fairhaven Avenue and Anacortes Street in Burlington. The photo faces west on Fairhaven Avenue. (Courtesy Mrs. Fred Pulver)

Fig. 4. December 1921 flood water flowing over road between Burlington and Bayview Ridge. The photo faces eastward toward Burlington. (Courtesy Mrs. Melvin Bell)

Fig. 5. View of water on Riverside Drive near Mount Vernon during the November 1949 Flood. (Photo by Bill Foreman)

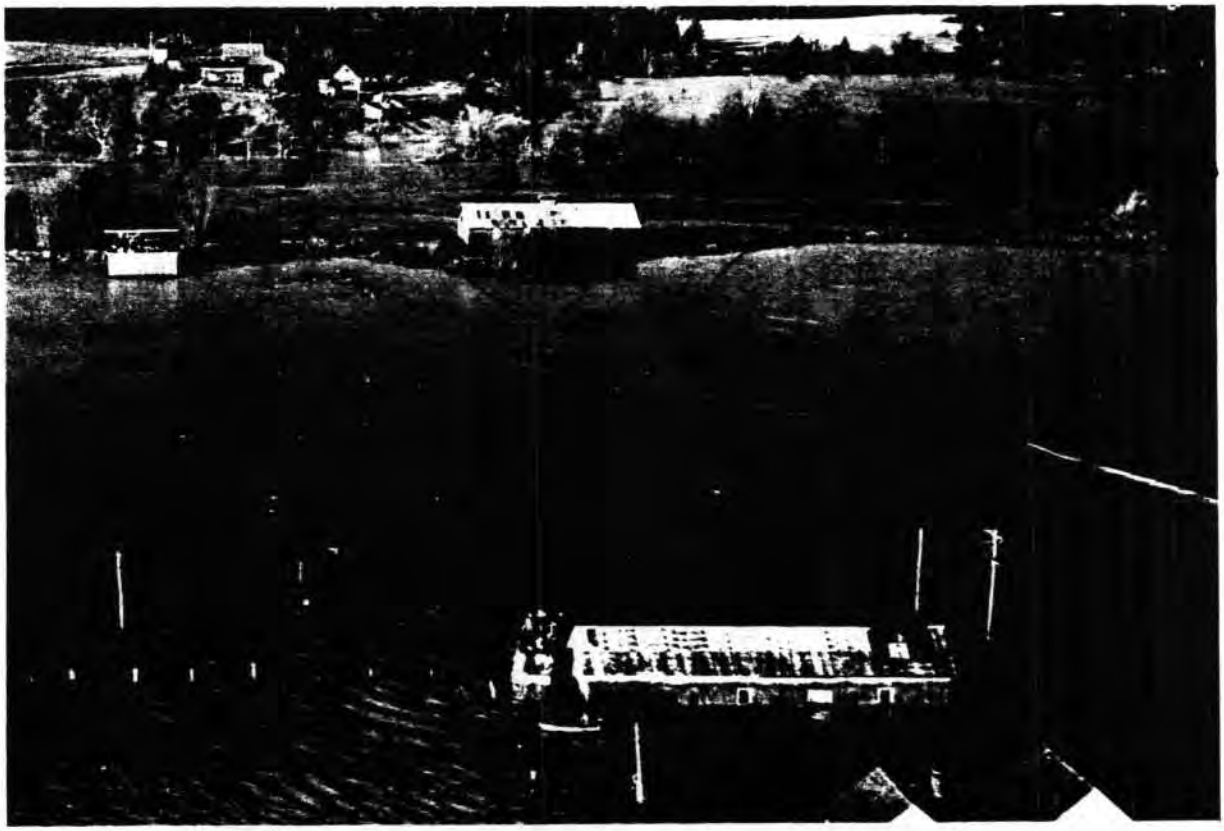


Fig. 6. November 1949 Flood (Seattle Times Photo)

Fig. 7. West Mount Vernon and Skagit River during February 1951 Flood. River is near peak flow of 144,000 cfs. (Photo by Bill Foreman)

Fig. 8. Skagit River at Mount Vernon during February 1951 Flood. River is near peak flow of 144,000 cfs. (Photo by Bill Foreman)

Each levee system in the flood plain was examined and weak areas located. A pattern of levee failures was established on the basis of past experience. In general, levees were assumed to fail when flow profiles were within one foot of the average top height of the levees. An individual pattern of flooding was prepared for each river discharge. An appraisal was made for three flood flows representing the full range of probable flows. Present land use was determined by an examination of the flood plain. The effect of flooding on agriculture was estimated from interviews with owners, operators, and agricultural organizations.

Table 7

FLOOD DAMAGES DOWNSTREAM
FROM SEDRO WOOLLEY FOR MAJOR FLOODS

Dates of flood	Discharge near Concrete (c.f.s.) 1/	Discharge near Sedro Woolley (c.f.s.) 1/	Damages in flood plain west of Sedro Woolley 2/
16 Nov. 1896	-	185,000	$11,900,000
19 Nov. 1897	-	190,000	11,980,000
16 Nov. 1906	-	180,000	11,810,000
30 Nov. 1909	-	220,000	14,060,000
30 Dec. 1917	-	195,000	12,067,000
12-13 Dec. 1921	-	210,000	13,273,000
27 Feb. 1932	147,000	-	10,609,000
13 Nov. 1932	116,000	-	6,600,000
22 Dec. 1933	101,000	-	2,350,000
25 Jan. 1935	131,000	-	9,050,000
27 Nov. 1949	-	140,000	6,870,000
10 Feb. 1951	-	150,000	11,360,000
30 Apr. 1959	90,700	92,000	500,000
24 Nov. 1959	89,300	91,000	390,000

1/ These are actual discharges. Ross Dam partially effective 1949 and 1951, fully effective after 1953.

2/ Damages are for 1963 prices and development, and based on full use of Ross Dam flood control storage for all flows.

A field survey was made to determine damages to buildings and other improvements. A real estate evaluation was made of the flood plain to determine current land values and estimated changes in values with flood protection.

Table 8 summarizes damages under 1963 prices and developments that would result from floods of the magnitude of February 1932, December 1921, and once in 100 years. At Mount Vernon the 1932 flood of 140,000 c.f.s. has a 13-year frequency, the 1921 flood of 182,000 c.f.s. has a 37-year frequency, and a flood of 223,000 c.f.s. would have a 100-year frequency. A discharge-damage relationship was established for each flooded area as the basis of a composite discharge-damage curve for the flood plain. The discharge-damage curve and flood frequency data were combined to develop damage-frequency curves and thus to estimate average annual damages. The average annual damage in the Skagit flood plain downstream from Sedro Woolley was found to be $2,216,000 at 1963 prices and conditions. Frequency and damage estimate curves are contained in Appendix A.

Table 8

FLOOD DAMAGES DOWNSTREAM FROM SEDRO WOOLLEY
FOR SELECTED FLOODS IN SKAGIT RIVER BASIN

No.	Item	Feb. 1932 Flood (157,000 cfs) 1/	Dec. 1921 Flood (210,000 cfs) 2/	100-Year Flood (239,000 cfs) 3/
1	Flood fighting & restoration of levees, dikes, tide gates, & drainage facilities	$175,000	$234,000	$326,000
2	Buildings and contents, yards, autos & refugee costs	1,692,000	3,477,000	5,481,000
3	Land and crops, and dairy losses	8,414,000	9,099,000	12,369,000
4	Power and telephone facilities	15,000	20,000	28,000
5	Railroads	20,000	54,000	110,000
6	Highways, roads, streets & sewers	293,000	389,000	616,000
		$10,609,000	$13,273,000	$18,930,000

1/ 140,000 c.f.s. at Mount Vernon gage and 157,000 c.f.s. at Sedro Woolley.
2/ 182,000 c.f.s. at Mount Vernon gage and 210,000 c.f.s. at Sedro Woolley.
3/ 223,000 c.f.s. at Mount Vernon gage and 239,000 c.f.s. at Sedro Woolley.

Note: Damages are for 1963 prices and upstream storage regulation developments. Discharges indicated are recorded flows.

40. GROWTH IN THE FLOOD PLAIN

Section 3 of this report discusses the economic environment of Skagit County and forecasts a growth of 1.4 per cent annually under the existing degree of flood protection. The present worth of this growth of 1.4 per cent over the next fifty years is equivalent to 33 per cent of current values. The average annual damage in the flood plain, including this future growth, is estimated to be $2,947,000.

SECTION 6 - BASIN PLANNING FOR FLOOD CONTROL AND OTHER WATER RESOURCE DEVELOPMENT

41. PLANNING OBJECTIVES

A public hearing was held 8 February 1961 in Mount Vernon, Washington, at the outset of the study. The purpose of the hearing was to obtain expressions of needs for water resource development from representatives of Federal, state and local governments and from residents of the area. The overwhelming sentiment at the hearing was for improved flood control measures in the basin, particularly in the delta, as a first priority endeavor. A summary of the hearing is in Section 8.

Ensuing studies confirmed that improved flood protection in the delta downstream from Sedro Woolley is the highest priority water resource requirement in the basin. Flood control measures are needed to prevent large flood losses in areas that are now partially protected by levees and that have developed markedly since the last major floods in 1951, in 1921, and in the preceding decades. The average annual flood damage estimate of $2,216,000 in the Skagit flood plain downstream from Sedro Woolley under present-day conditions is an excellent indicator of the economic importance of improved flood control measures. Other river basin needs under study for long-range development are additional water supply for municipal and industrial purposes; low-flow augmentation for fisheries; hydroelectric power; recreation; irrigation; a higher level of flood protection in the delta than the 35-year frequency from projects already authorized and proposed in this report; and extension of flood protection upstream from the delta.

The basin planning for new projects described herein is directed toward developing first priority flood control and related measures that can be constructed with sound economic feasibility under present-day conditions; and assuring that these projects will retain their feasibility when considered with possible future projects. The first priority projects are the authorized Avon Bypass and levee and channel improvements downstream from the Bypass. Addition of recreation to the Bypass as an added purpose, becomes possible with construction of these first priority projects. Future planning relates to full development of the water resources to best satisfy the needs enumerated in the preceding paragraph.

42. EXISTING LEVEL OF FLOOD PROTECTION IN THE BASIN

Paragraph 18 describes existing flood protection works in the delta. The entire Skagit River system downstream from the Burlington-Mount Vernon area,

including both the North and South Fork distributaries at the mouth, has been leveed piecemeal over a long period of time. There are about 43 miles of levees along the river banks that vary greatly in top widths and height. As shown in table 2, these levees are only capable of withstanding flows of 91,000 to 143,000 c.f.s. with minor sandbagging of the extreme low areas. Most of the levees protect in the range of 91,000 to 123,000 c.f.s. Figure 9 shows the relationship of diking district channel capacities to frequencies of flood occurrences, and shows that the present levee system protects against floods of 3- to 14-year recurrence intervals.

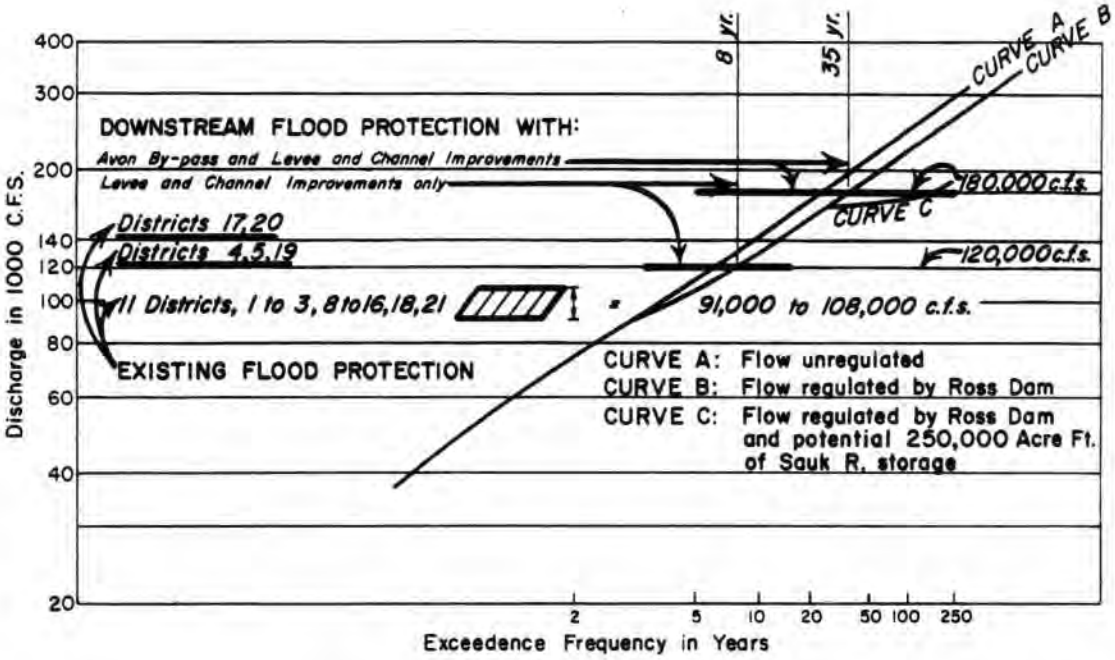


Fig. 9 Flood protection frequencies of existing and proposed works, Mount Vernon gage.

43. IMPROVEMENT OF EXISTING LEVEE SYSTEM

The existing levee system rests on a foundation of silts and sands common to the delta area. Differential heads of water in flood flow periods result in seepage through levee embankment and levee foundations, causing boils and blowouts that flood adjacent croplands. The semi-pervious foundation conditions preclude any general raising of levees without extensive broadening of the levee sections, construction of cutoffs to reduce seepage and relocation of the road systems adjacent to the levee system. Major raising of the levee system was found uneconomical. The costs of providing flood protection by

major raising of levees to accommodate a flow of 144,000 c.f.s. downstream from Sedro Woolley would exceed $28,000,000. This compares to the estimated $23,940,000 cost of the Avon Bypass to provide essentially the same degree of protection. Major levee raising would result in backwater effects from confining flows between levees that would cause more than a 3-foot rise in water surface upstream from Sedro Woolley. The cost of levees to protect upstream areas from these backwater effects is not included in the above major levee raising cost. Because these studies showed the Avon Bypass to be a more economical and more effective plan than raising the levees, no further consideration was given to major raising of the levee system.

A study was made of minor raising of low areas in the existing levee system downstream from Burlington and channel widening in selected locations to develop a minimum channel capacity of 120,000 c.f.s., with two feet of freeboard. Low sections of the river levees would be raised where necessary to achieve the desired minimum freeboard. Narrow sections of levees would be strengthened by increasing top widths and flattening side slopes. Channel widening, to remove constricted reaches, would be accomplished at two locations on the North Fork and at one location on Freshwater Slough on the South Fork. The total cost of levee and channel improvements is $6,007,000. Annual flood control benefits have been computed for a plan including both the Bypass and the minor levee and channel improvements. Flood control benefits creditable to the levee and channel improvements are $660,000, and the benefit-to-cost ratio is 2.7. Details of the minor levee raising and channel widening plans are given in Section 7.

The economic feasibility of levee and channel improvement was established for the four conditions described in paragraphs 44, 45, 46 and 48. The conditions are: first added to the existing systems; added in conjunction with the Bypass; last added to the Bypass; and last added to the Bypass and upstream storage. These conditions also presume a 50-year economic life and an annual growth rate of 1.4 per cent.

Under first added conditions the delta area is protected against floods up to an 8-year frequency of occurrence. The other conditions would raise the level of flood protection to more than a 35-year frequency in the delta. Protection against a flood having a 35-year frequency occurrence would not result in appreciable change in land use within the flood plain. The farmland in this area has reached a high stage of development with large acreages in specialized crops. This agricultural development has taken place because the high fertility of delta land and the lack of recent floods have encouraged farm operators to accept the risk of major flood damage. Accordingly, growth in the flood plain with 35-year frequency flood

protection is forecast to be 1.4 per cent annually, the same as established in paragraph 31 for existing conditions. Flood protection in the range of 75 to 100-year frequency would be required to permit urban, residential or industrial developments.

44. LEVEE AND CHANNEL IMPROVEMENTS FIRST ADDED

The levee and channel improvements considered, without the Bypass, would have annual flood control benefits of $780,000 and a benefit-to-cost ratio of 3.2. As illustrated by figure 9, this plan of improvement to develop a 120,000 c.f.s. minimum capacity channel would provide a minimum level of dependable flood control protection for an 8-year frequency flood recurrence. This degree of flood protection, in itself, is not considered adequate for a Federal flood control project to protect the existing agricultural and urban developments in the delta.

45. LEVEE AND CHANNEL IMPROVEMENTS WITH THE AVON BYPASS

The Avon Bypass project is described in paragraph 17. From a practical standpoint, the plan of operation for the Bypass in conjunction with the proposed levee and channel improvements, would be similar to the plan illustrated in figure 10. In this plan, the Bypass would begin operation when the river flow reaches 100,000 c.f.s. The flow in the Bypass would be increased gradually so that, when the total river flow is 180,000 c.f.s., the Bypass would convey 60,000 c.f.s., and the remaining 120,000 c.f.s. would flow downstream between levees.

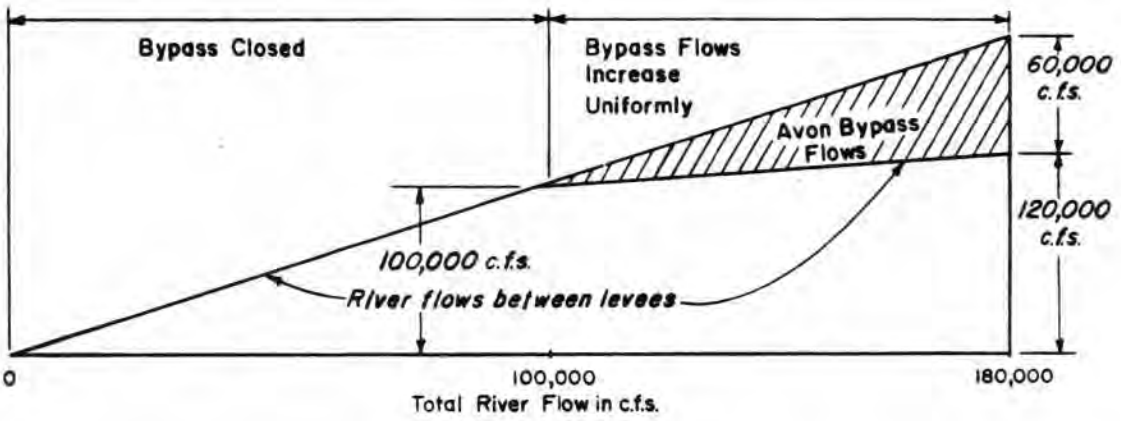


Fig. 10 - Plan of Operation

Figure 9 illustrates that the channel and levee improvements, as part of the proposed operating plan with the Avon Bypass, would increase flood protection

in the Skagit River delta to a 35-year level. The operating plan also would permit utilization of the Bypass for fishery purposes. Without the proposed levee and channel improvements, operation of the Bypass would be required whenever river flows at Mount Vernon exceed 84,000 c.f.s., corresponding to a frequency of once in about two years. With such frequent operation, it would be infeasible to maintain a resident fishery in the Bypass. With the proposed levee and channel improvements, and the proposed plan of operation, maximum use of the Bypass would be once in about four years and a resident fishery would be possible. Under this plan, the levee and channel improvements would realize annual benefits of $751,000, of which $91,000 would be a fishery benefit shared with the Bypass, and the balance would be flood control benefits. The benefit-to-cost ratio would be 3.1.

46. LEVEE AND CHANNEL IMPROVEMENTS LAST ADDED TO THE BYPASS

Without the levee and channel improvements, the Bypass would begin operation at a flow of about 84,000 c.f.s. at Mount Vernon. The Bypass, with 60,000 c.f.s. capacity would provide flood protection with adequate freeboard for flows of 144,000 c.f.s. in the lower delta. Overall protection afforded by the Bypass in the delta would range from 14-year protection along the lower North and South Forks to more than 35-year protection upstream of the confluence of the Forks. Construction of the levee and channel improvements would increase flood protection to a minimum 35-year level. With the levee and channel improvements, addition of a resident fishery to the Bypass is possible, as explained in paragraph 45. Under these conditions, the last added annual benefits creditable to the levees would be $288,000 including a shared fishery benefit of $91,000, and the benefit-to-cost ratio would be 1.2. Thus, the levee and channel improvements, last added to the Bypass, are feasible.

47. UPSTREAM STORAGE

Ross Dam, on the upper main stem of the Skagit River, reserves 120,000 acre-feet of storage for winter flood control. This storage controls the Skagit River watershed upstream from Ross Dam. Operation of this storage has been assumed in all plans studied. Additional upstream flood storage is necessary to achieve the higher level of flood protection warranted in the delta for expansion of urban-type development, and to aid in protecting lands not now protected. In this last category, are lands upstream from Sedro Woolley and lands in the delta in the vicinity of Nookachamps Creek, across the river from Burlington. As an initial criterion, an objective of a minimum 100-year frequency flood protection has been established for important urban areas. Subsequent studies will consider standard project flood protection. Preliminary hydraulic and hydrologic studies indicate that added flood storage of approximately 250,000 acre-feet are required in the upper river system for 100-year frequency flood protection.

River and the downstream levee and channel improvements. The Sauk River flood storage, plus the downstream levee and channel improvements, would yield 26-year frequency flood protection in the delta. The Bypass last added to this system would increase the level of flood protection to more than 100-year frequency. The residual flood damage benefits, plus enhancement benefits, would yield a benefit-to-cost ratio of 1.3 for the Bypass, thus confirming its feasibility.

50. ADDED PURPOSES OF THE BYPASS

The Bypass site is within about two hours travel of the heavily populated Seattle metropolitan area, and is adjacent to Interstate Highway 5, the principal north-south route west of the Cascades. The communities of Mount Vernon and Burlington are within two miles of the project site. Numerous state and county highways would provide convenient access to the entire shoreline of the Bypass. The accessibility of the Bypass and its potential for excellent trout fishing, hunting, and general recreation facilities would make the Bypass an outstanding attraction for recreational use. These recreation benefits could be achieved by a small expansion of the Federally-constructed facilities and with State and County support and assistance. The Washington State Department of Game has expressed willingness to develop a resident trout fishery. To maintain a resident fishery, the levee and channel improvements downstream from the Bypass must be operated in conjunction with the Bypass. Coordinated operation of these facilities would reduce usage of the Bypass for flood control to an average of not more than once in four years, thus avoiding a loss of the resident fishery from too frequent flooding. The Federal cost of the resident fishery would be $19,000. Gross annual benefits would be $195,000. Annual costs are estimated to be $13,400, thus yielding an incremental benefit-to-cost ratio of 15.0.

The Washington State Department of Fisheries has expressed an interest in the enhancement of anadromous fish runs and has suggested the provision of spawning and rearing areas in, or appurtenant to, the Bypass channel. As their plans are preliminary, only a general authorization for a future anadromous fishery development is possible at this time to permit such Federal participation as may be appropriate when a definite plan is formulated by the State.

The Bypass project lies within the Pacific Flyway for migratory waterfowl. The sloughs and channels in the area provide a resting and feeding area for large numbers of ducks of many species. Padilla Bay, into which the Bypass waters would discharge, is a conservation area for waterfowl. The project could be developed to realize substantial recreation benefits from hunting. State and local interests could fully develop the hunting potential of the

project by acquiring easements for adjacent lands and by stocking upland game birds. Picnicking, camping and daytime recreation would be possible in the gently-sloping forested areas along the central reaches of the channel on the right bank.

The responsibility for developing hunting and other recreational facilities rests primarily with non-Federal entities. Interest in the foregoing plans has been expressed by the Washington State Department of Game and the State Parks and Recreation Commission. However, their planning has not yet advanced to the stage where they are prepared to make definite commitments. Accordingly, only a general authorization for hunting and other recreational facilities is possible at this time to permit such Federal participation as may be appropriate when a definite plan is formulated by the State and County.

51. OTHER ALTERNATIVE PLANS

Deepening the Skagit River to carry flood flows is not feasible. Substantial deepening of the river to carry flood flows would undermine existing levees along the river banks. The Skagit River carries large quantities of bed sediment estimated at more than 500,000 cubic yards annually. An excavated channel of sufficient depth to carry flood flows would require annual dredging to remove deposited sediment and would be economically impracticable. Widening the Skagit River to carry flood flows is also infeasible. To achieve the same results as the Bypass and levee and channel improvements would produce, the channel would have to be widened from 300 to 600 feet from the downstream limits of Sedro Woolley to the mouth of the river, a distance of over 20 miles. The cost of this work would be about six to seven million dollars more than the cost of equivalent flood protection with the Bypass and downstream levee and channel improvements. One of the principal reasons for the higher cost of this plan is that much of the land on both banks of the river is well developed, and widening would require costly relocations and acquisition of lands.

Widening of the river at the mouth has also been proposed as a flood-control measure by local residents in the basin. Such widening would lower flood stages slightly for a short distance upstream from the mouth of the river, but would not provide flood protection for the upper delta in the vicinity of Mount Vernon and Burlington.

52. SUMMARY OF PLANNING

Flood control is the highest priority, immediate water-control need in the Skagit River basin. The present flood damage expectancy is once in 3 to 14 years, varying with individual diking districts. An intermediate level of flood protection, corresponding to protection from flooding of once

in more than 35 years, can be achieved in the delta by constructing the authorized Avon Bypass in combination with the proposed levee and channel improvements downstream from the Bypass. These improvements are well justified when considered as first elements of a basin plan. They also retain their justification when considered as last added; or, in a long-range plan for upstream storage, which would yield a much higher level of flood protection as well as other water resource benefits.

Substantial recreation benefits can be achieved from the Bypass with small expansion of Federally constructed Bypass facilities and with local assistance. Realization of the fishery benefits, which would be a large part of the recreation benefits, is dependent upon construction of both the Bypass and the levee and channel improvements as a first element in the basin plan. There is no change in the basic flood control justification or planning because of the recreation developments.

PART 1 - LEVEE AND CHANNEL IMPROVEMENTS

53. GENERAL

The Skagit River channel, from the Burlington-Mount Vernon area downstream to the mouths of both Forks, would be improved by raising and strengthening the levees and widening the channel to contain a design flow of 120,000 c.f.s. About 34 miles of the existing levee system will be improved, including 13 miles on the main river downstream from river mile 16.5, and 8 and 13 miles on the North and South Forks respectively. Levee improvements would include raising to provide a minimum of two feet of freeboard, increasing top widths to a minimum of 10 feet for vehicular access, flattening overly steep side slopes to a maximum of 1 on 2, and addition of riprap at critical locations. Widening is proposed for three constricted reaches of the river channel: from river mile 3.8 to 4.7 and 7.0 to 8.1 on the North Fork, and from 3.7 to 4.5 on Freshwater Slough on the South Fork. Widening would remove serious obstructions to flood flows, lower channel velocities and reduce upstream river stages. Report plans are shown on plates 4 through 6. The plans and cost estimates in this report establish overall requirements for providing flood protection for river flows of 120,000 c.f.s. During final design, minor changes may be made in the proposed amount and location of channel widening, removal of channel obstruction, and of levee raising.

54. HYDRAULIC DESIGN

Water surface profiles for design flows of 120,000 c.f.s. were computed for the Skagit River below Sedro Woolley by standard backwater methods. Basic data for these computations included observed water surface profiles, channel cross sections at about every one-half mile for the river system below Burlington, and rating curves for gaging stations at Mount Vernon and Sedro Woolley. A freeboard of two feet selected for the design flow is adequate to protect lands in the delta area. Profiles of the design flow were computed to show the effect of widening the constricted channel reaches and to determine the location of levee improvement areas. These profiles showed that channel widening could lower the water surface up to three feet immediately upstream from the constricted reaches.

The numerous distributary channels in the lower delta complicate the evaluation of flow distribution in the North and South Forks. Measurements of flow by the U. S. Geological Survey at the head of the North and

South distributaries and hydraulic computations indicate that the flow distribution during flood periods is about 60 per cent in the North Fork and 40 per cent in the South Fork. Channel widening proposed for the North Fork and Freshwater Slough will cause a small change in the distribution of flow, resulting in about a 3 per cent increase in the North Fork, and a corresponding decrease in the South Fork. These enlargements would result in lower river stages in the area of enlargement and for a short distance upstream. Slight changes in the division of flow would have little or no effect on water surface profiles at Mount Vernon. Significant changes in flow distribution have occurred in the North and South Forks since 1911 when sills were constructed in the distributaries to aid navigation. These changes in flow distribution have had little effect on upstream river stages. Flood stages have increased approximately one foot at the U.S.G.S. gage in Skagit River near Mount Vernon since installation of the gage in 1940. This increase is attributed to extensive levee construction accomplished by local interests during the past 25 years along Skagit River downstream from Mount Vernon. Some increase in river stages may occur in the future due to gradual increased length of distributaries because of the extension of delta sediment deposits. Further increases in river stage at Mount Vernon should not exceed about one foot over the next 50-year period.

The sills constructed in distributaries in 1911 to aid navigation have deteriorated. Their function of providing increased flow and thereby increasing navigation depths in the South Fork has not proved successful, except possibly in log moorage areas at several locations along distributary sloughs of the South Fork. These sills may cause some restriction of flood flows. The benefits from removal of sills for flood control purposes and possible adverse effect of such removal on navigation will be determined during final design.

Average velocities of the 120,000 c.f.s. design flow without channel widening would vary from 3.5 to 7.5 feet per second in the main stem of the Skagit River, from 4 to 10 feet per second in the North Fork, and would be 3 to 5 feet per second in the South Fork and 7.5 feet per second in Freshwater Slough, a distributary of the South Fork. Widening the channel at two constricted reaches on the North Fork would reduce velocities between miles 3.8 and 4.7 from 10 to 6 feet per second, and in the upper constricted reach between miles 7.1 to 8.1 from 7 to 6 feet per second. The channel widening in Freshwater Slough between miles 4.0 and 4.7 would reduce the maximum velocity from 7.5 to 3.5 feet per second. Reduction of velocities is an important benefit in reducing tendencies for bank scour and the necessity for bank protection with riprap.

55. LEVEE IMPROVEMENTS

Detailed profiles and typical sections are shown on Appendix plates C-1 and C-7. The major work to be accomplished is as follows:

a. Right bank, main stem and North Fork. Levee improvements on the right bank upstream from Mount Vernon would increase the top widths and flatten the riverward slope for about two miles between river miles 13 and 15. Adequate freeboard exists in this reach except for a few short sections near river mile 13.1 where minor raising is necessary. Levees at Mount Vernon have sufficient height and top width, with the exception of a short section at the approach to the west end of State Highway 1 bridge. The cost of raising this portion of State Highway 1 would be excessive, and raising of other roads at the intersection would be impractical. Therefore, a sandbag closure would be required during flood periods. Immediately downstream from Mount Vernon, the levee top serves as a base for a gravel road. Side slopes in this section of the levee are steeper than 1 on 2, but top widths are broad enough to provide an adequate levee section and no slope revisions are planned. Levee raising to provide minimum freeboard is required for a short reach of about 600 feet at river mile 11.4. The levee from river mile 11.2 to 10.2 requires reconstruction as slopes are steep and the top width is narrow. About three-fourths mile of levee in the vicinity of river mile 9.0 requires flattening of slopes and increasing the top width. Minor levee raising at three locations to provide freeboard is required between river miles 6 and 7. The remaining levees are adequate.

b. Left bank, main stem and South Fork. Left bank levees, from river mile 16.5 near the Interstate Highway 5 bridge downstream to river mile 13.4 near Mount Vernon, require widening to provide a 10-foot top width and side slopes of 1 on 2. Levees protecting the city of Mount Vernon's main business district are generally adequate to provide 2 feet of freeboard, with the exception of about 1,000 feet of levee south of State Highway 1 bridge. This reach would have from 0.5 foot to 2 feet of freeboard for the design flood. Provision of two feet of freeboard for this 1,000 foot reach would require raising of paved city streets and parking areas, or constructing flood walls, that would eliminate present parking areas. These parking areas are essential for community business and there are no alternative locations. The city has raised streets, presently serving as levees, the maximum amount that will permit entrance to stores from the street level. Accordingly, city officials have requested that no levee improvement be made in this location and have stated that they prefer to sandbag low areas in the street during flood periods rather than suffer the inconvenience of floodwall installation or further raising of the streets. There is no question but that the public works construction capacity of the city and county would be adequate to undertake any required sandbagging to develop 2- to 3-feet of freeboard in the event of a major flood threat. City officials have requested

that a study be made of channel widening to reduce flood stages at Mount Vernon. This request will be considered during final design studies. Improvements along the left bank downstream between Mount Vernon and Conway generally involve increasing top widths and flattening riverward slopes. Raising of low levee areas totaling about 2-1/2 miles in length is required along this reach. Raising present levees of a tributary stream near river mile 4.5 is required, as well as widening of approximately 1-1/2 miles of levee south of Milltown.

c. Left bank, North Fork. This levee requires widening throughout most of its length below the confluence of the North Fork and the main stem. Minor raising to provide two feet of freeboard is required at many locations along four miles of levee between river miles 5 and 9.

d. Right bank, South Fork. This levee requires widening to a 10-foot top width for a distance of about six miles from river mile 9.5 to the mouth of Freshwater Slough. Intermittent raising of 2-1/2 miles of levee is required to provide two feet of freeboard.

56. CHANNEL IMPROVEMENTS

Plans and typical sections of the channel improvements are shown on plates 4 and 6 in this report, and on Appendix plates C-1 and C-7. Channel work in the North and South Forks should be scheduled during the period 15 June to 15 August to minimize the effects of siltation on the fish runs. The following paragraphs briefly describe the widening plans.

a. North Fork, river miles 3.8 to 4.7. A rock bluff on the right bank and levees constructed directly adjacent to the low water channel on the left bank restrict flows during flood periods. The channel in this reach could be widened along the left bank, and the adjacent levee relocated to the bank of the improved channel. Another solution would be to raise the levees. As several local residents have opposed the channel widening, a final determination, as to widening or raising would be made in preconstruction planning.

b. North Fork, river miles 7.0 to 8.1. Uncoordinated levee construction on both banks has constricted this channel. Excavation is proposed to straighten and to enlarge the channel. Levees would be reconstructed adjacent to both banks of the new channel.

c. South Fork at Freshwater Slough, river miles 4.0 to 4.7. Levees along both banks of the low water channel seriously restrict flows. The channel would be widened adjacent to the left bank in such a manner as to

provide the desired flow area without affecting existing low water depths. The existing levee on the left bank would be removed and replaced with a levee along the new channel, utilizing spoil from channel excavation.

57. DESIGN OF LEVEES

The Skagit River levee system, consisting of about 43 miles of riverbank levees downstream from the Burlington-Mount Vernon area, has been constructed piecemeal over a period of more than 60 years. The present system, which is primarily constructed of a fine sandy silt prevalent in the delta area, varies greatly in height and top width. The levee foundation materials are semi-pervious and occasionally experience failure due to boils and blow-outs when subjected to flood flow durations of more than three or four days. Major raising of the levees would require construction of cutoff walls or relief wells to control the seepage conditions. Capacity of the present system to withstand flood flows range from 91,000 c.f.s. in some locations to about 140,000 c.f.s. in others, provided sufficient time is available to place sandbags and strengthen weak areas.

Existing top widths vary from 3 to 15 feet. Landward side slopes are very steep and at some locations may be nearly vertical. Riverward slopes are generally satisfactory, with an average slope of about 1 on 2. Proposed levee improvements will provide side slopes of 1 on 2, and a top width of 10 feet.

Present levees have a thick sod cover that provides partial protection against erosion from river flows. Existing rock riprap slope protection is generally confined to river bends where higher velocity currents impinge upon the levee foundations. Sod would be stripped from the levee sections to be improved and stockpiled for resodding after completion of levee improvements. Where sod is not available, topsoil would be bladed over freshly constructed slopes. These slopes would be seeded to reestablish protective cover as soon as possible. Riprap protection to be provided would be limited to reinforcement and extension of existing protective works installed by local interests along chronic erosion areas.

Raising and widening of the levees would require about 956,000 cubic yards of added embankment. About 200 acres would need stripping and seeding. About 44,000 cubic yards of riprap with gravel bedding would be placed along river banks. The three channel-widening projects would require about 1,447,000 cubic yards of excavation.

Exploration to determine the classification and general characteristics of the existing levee and foundation soils consisted of 33 hand auger holes drilled at 17 different areas. The exploration program required

test holes at 14 locations to provide a soil profile that would include the foundation material and the existing levee material, particularly in areas where riverside borrow may be practicable. The location and logs of the test holes are shown on Appendix plates C-8 and C-9. Levee and foundation materials consist predominately of nonplastic fine sandy silt and silty fine sand. Occasionally, a stratum of fine sand was encountered in the levees or levee foundation. At some locations the hand auger met refusal on coarse material in the levee section. The presence of coarse material in the levees is believed due to import of hillside borrow in the past during original construction, repair or raising of the levees. Riverward borrow, where available, will generally be acceptable as a semi-pervious embankment material, provided construction is accomplished during low river stage and during dry weather. Hillside borrow may be required in some areas where riverward borrow is not available or if wet weather prohibits use of the finer grained soil. A bedding layer of sandy gravel will be required under all riprap.

Sources of materials for embankment, and riprap, are located on the lower slopes of the foothills along the easterly fringes of the flood plain between Mount Vernon and Conway. Haul distances from these sources average about eight miles. Additional sources of riprap are in the Pleasant Ridge area near the mouth of the North Fork. Material excavated from channel widening areas may be spoiled along existing levees and, if suitable, used in levee improvements.

58. NON-FEDERAL REQUIREMENTS AND COOPERATION

Local participation requirements include easements for approximately 334 acres of right-of-way, and relocation of buildings, utilities, roads and fences presently in the right-of-way area. The local sponsor would also be required to hold and save the United States free from damages and claims that might result from construction of the project, and operate and maintain the project after completion. In addition, to prevent a false sense of security in urban areas, local interests will be requited annually to notify the public of the limited protection provided by the proposed project. Estimated local costs are $122,000 for easements and rights-of-way and $115,000 for relocations, or a total of $237,000. Skagit County officials are aware of the local cooperation requirements of the proposed flood control improvements and have expressed their willingness to sponsor the project (see letter dated 4 January 1964, Exhibit 1). The Washington State Department of Fisheries has examined the plans for levee and channel improvements and has given general approval to these plans (see letter dated 9 January 1964, Exhibit 2).

59. COST OF LEVEE AND CHANNEL IMPROVEMENTS

The total cost of the levee and channel improvements is $6,007,000, of which $5,770,000 is Federal. A summary cost estimate of the levee and channel improvement plan on the basis of July 1964 prices is shown in table 9. A detailed estimate is presented in Appendix C. The construction period for the levee and channel improvements is estimated to be 18 months, including two full working seasons.

In determining annual costs, a 50-year economic life has been assigned to the levee and channel improvements as main line levee protection. This levee protection is an essential element of a plan which includes the Avon Bypass to provide long-term flood protection for the 68,000-acre delta area. Physical life of the project over a 50-year period is assured by inclusion of a $300,000 replacement cost at the end of the first 25 years. Maintenance and operation of the existing levee system are excellent, and the Skagit County diking districts are among the best operated districts in the State of Washington.

Operation and maintenance costs are excluded from the computation of annual costs for the levee and channel improvements because these improvements would result in decreased operation and maintenance costs for the existing system. This decrease would exceed any operation and maintenance costs associated with the new work.

60. BENEFITS FOR LEVEE AND CHANNEL IMPROVEMENTS

Flood control benefits are based on the reduction of flood damages by combined operation of the Bypass and levee and channel improvements essentially in accordance with the operating plan shown in figure 10 and paragraph 45. An equitable division of the flood control benefits creditable to the Bypass, and levee and channel improvements can be determined on the basis of the operating plan. As a practicality, the levee and channel improvements were credited with prevention of all flood damages to 100,000 c.f.s., the Bypass was credited from 100,000 to 160,000 c.f.s., and the levees from 160,000 to 180,000 c.f.s. On the foregoing basis, the reduction of flood damages creditable to the levee and channel improvements amounts to $660,000 annually at 1963 prices and forecasted future development. Average annual damage in the flood plain over a 50-year period, with forecasted growth of 1.4 per cent annually, as set forth in paragraph 40, is $2,947,000. The Avon Bypass would reduce these flood damages by $1,660,000 annually. An average annual residual flood damage of $627,000 would exist after construction of the Bypass and channel and levee improvements.

Table 9

SUMMARY COST ESTIMATE AND ANNUAL CHARGES
LEVEE AND CHANNEL IMPROVEMENTS

CONSTRUCTION COSTS	
Federal	
Levee reconstruction	$3,003,000
Channel improvement	847,000
Contingencies	961,000
Engineering and design	540,000
Supervision and administration	419,000
Total	$5,770,000
Non-Federal	
Rights-of-way	$ 122,000
Relocations	115,000
Total	$ 237,000
TOTAL PROJECT COST	$6,007,000
ANNUAL CHARGES	
Federal	
Interest at 3-1/8 per cent and amortization over 50 years	$ 229,600
Non-Federal	
Interest at 3-1/8 per cent and amortization over 50 years	$ 9,400
Major replacements	$ 5,500
TOTAL ANNUAL CHARGES	$ 244,500
Round to	$ 245,000

Construction of the levee and channel improvements would reduce use of the Avon Bypass for flood flows from once in 1 to 2 years to not more than about once in 4 years. On this basis, the addition of a resident fishery to the Bypass is possible. Because the levee and channel improvements contribute to making the resident fishery possible, they share in these benefits. Details of the distribution of fishery benefits are given in paragraph 64. Average annual benefits attributable to the levee and channel improvements, including fishery benefits of $91,000 and flood control benefits of $660,000, total $751,000.

61. BENEFIT-TO-COST RATIO

Average annual benefits of $751,000 for the levee and channel improvements, and average annual costs of $245,000 yield a benefit-to-cost ratio of 3.1 for the project. For flood control only, the average annual benefits of $660,000 compared with annual costs of $245,000 yield a benefit-to-cost ratio of 2.7.

In addition to the benefits outlined above, the project would realize some area redevelopment benefits. These benefits were estimated as the value of local labor that would be used in project construction which, in the absence of the project, would be unemployed. On this basis, the average annual redevelopment benefits would be $37,000. The benefit-to-cost ratio, on the shared project basis, for the levee and channel improvements would then increase from 3.1 to 3.2 with the addition of these benefits.

62. LEVEE AND CHANNEL IMPROVEMENTS CONSIDERED INCREMENTALLY

To insure economic justification, the proposed levee and channel improvements were divided into three subareas as determined by the physical characteristics of the delta. Each subarea was found to be a justified separate increment of the overall plan. The areas investigated are described and estimated annual costs and benefits are outlined below. Detailed cost breakdowns for each area are presented in Appendix C.

Area 1. Left bank of main river and South Fork. This area includes towns of Mount Vernon and Conway, Washington, and about 7,000 acres of agricultural land. The estimated total cost of the improvements is $1,780,000. Average annual first added flood control benefits of $122,000 compared to annual costs of $76,000 yield a benefit-to-cost ratio of 1.6.

Area 2. Left bank of North Fork and right bank of South Fork. This area encompasses about 6,000 acres of agricultural land. The estimated total

cost of the improvements is $2,363,000. Average annual first added flood control benefits of $411,000 compared with annual cost of $100,000 yield a benefit-to-cost ratio of 4.1.

Area 3. Right bank main river and North Fork. This area includes the town of Avon, the western portion of the town of Mount Vernon, the town of LaConner, and 22,000 acres of agricultural land. The estimated total cost of the improvements is $1,617,000. Average annual first added flood control benefits of $238,000 compared with annual costs of $69,000 yield a benefit-to-cost ratio of 3.4.

As shown in the above paragraphs, the levee and channel improvements are well justified when considered as separate increments.

Part 2 - ADDITIONAL PURPOSES OF THE AVON BYPASS

63. GENERAL

The Avon Bypass would develop a completely controlled, 7-mile-long lake, with excellent access to populated areas. The banks formed by dredged spoil material from the channel would be 50 to 100 feet wide. The top width of the channel would be about 400 feet. The project would have about 340 acres of water surface and about 440 acres of adjacent land for public use. Construction of the levee and channel improvements would limit use of the Bypass to divert flood flows to once in about 4 years, for a duration of only one to three days. During the remainder of the time, the Bypass would be fully usable for recreation purposes.

Evaluations were made of the Avon Bypass project to determine its potential for multi-purpose recreation, including fishing, hunting, and general recreation such as boating, swimming, camping and picnicking. The Washington State Departments of Fisheries and Game, together with the Bureau of Sports Fisheries and Wildlife of the U. S. Fish & Wildlife Service, investigated the fish and wildlife aspects of the project. The possibilities of general recreation were studied by the Corps of Engineers in cooperation with the Bureau of Outdoor Recreation and the Washington State Parks Commission. These studies showed that the Bypass project had a high recreation potential. The fish and wildlife agencies developed a plan to create a resident trout fishery in the Avon Bypass project, a plan to provide for possible future use in spawning and rearing of anadromous fish and a plan to develop and manage the water and land area for wildlife. Their report is attached in Appendix D. Region-wide studies of recreation showed a high demand for general recreation developments such as boating, swimming, camping, picnicking, and water oriented recreation. A

gently sloping, timber covered area midway of the Bypass channel is highly adaptable for general recreation development. Recreation studies are detailed in Appendix D.

The 1936 Flood Control Act authorized the Avon Bypass as a local flood control project, with no provision for addition of recreation. Present day Federal policies encourage recreation, fishery and wildlife developments as added features of water resource projects, but place a large measure of responsibility on local interests. As a local flood protection project, the Federal interest in recreation, fish and wildlife for the Avon Bypass is limited to only those developments which involve some modification or addition to basic project features. Further requirements of Federal participation are, in general, that the non-Federal entity: provide all lands and rights-of-way; contribute in cash or through purchase of lands 50 per cent of the first cost of such recreation developments; agree to operate and maintain; and to assure access to all on equal terms.

Other recreation, fish and wildlife developments which may be desirable, but are not related to project features, may be added at any time by local interests, providing there is no conflict with flood control operation of the project. The acquisition of land, first costs, and operation and maintenance of such added features would be entirely the responsibility of local interests.

In this section of the report, the full recreation potential of the project is described. Each recreation aspect is identified as being eligible for Federal assistance or as a matter entirely of local interest responsibility.

64. FISHERIES

The U. S. Fish and Wildlife Service and the Washington State Department of Game have recommended that a resident trout fishery be created in the Bypass channel. A copy of a letter from the Washington State Department of Game, dated 30 December 1963, regarding the addition of a resident trout fishery to the Bypass is attached to this report as Exhibit 3. The resident fishery would require maintaining adequate water depths and flows; a water right for minimum flows; annual stocking with trout; and providing access for boats. A possible future use of the project for spawning and rearing of anadromous fish was also proposed by the U. S. Fish and Wildlife Service and the Washington State Department of Fisheries.

a. Resident trout fishery. The planned use of the Avon Bypass for a resident trout fishery would require only minor additions to the flood control features. The ground-water table in lands adjacent to the Bypass will be affected by the water level in the Bypass channel. To maintain approximately

the same level of ground-water elevations in these adjacent lands, two intermediate adjustable weirs are planned in the Bypass channel between the headworks and tail water control structures. Five boat ramps would be constructed to give the public access to the water surface. A minimum flow through the headworks of 100 c.f.s. or more from the Skagit River is necessary to provide fresh water for the fishery. Local interests would be required to obtain a water right for this flow. The flood control design of the project provides for screening of inlet and outlet sluices to exclude anadromous fish. The channel would be drawn down as required for scrap fish control and to salvage migratory fish trapped during the infrequent flood control operations. The U. S. Fish and Wildlife Service estimates that the average annual use would be 130,000 fisherman days, with a benefit of $195,000 annually.

Federal participation in the resident fishery is in construction of boat launching ramps as an added feature of the channel side slope construction. The establishment of the resident fishery in Bypass waters is dependent upon construction of both the levee and channel improvements and the Bypass channel, as discussed in Section 6. Therefore, the excess benefits for the fishery improvements have been distributed equally between the two projects. Gross benefits for the resident fishery facilities are $195,000, as set forth in Appendix D. Deducting specific costs of $13,400 (Table 10) for the facilities, leaves net benefits of $181,600. Distribution of these average annual net benefits results in $91,000 (rounded), attributable to the levee and channel improvements and $91,000 (rounded), to the Avon Bypass. Total annual fishery benefits attributable to the Bypass would be $104,400.

Construction and annual costs of the resident fishery in the Bypass, and the division of these costs by Federal and non-Federal interests, are given in table 10. The cost of the five boat launching ramps with suitable parking areas is estimated to be $38,000, of which $1,000 is for land acquisition for parking areas at boat launching ramps. Annual costs, as given in table 10, would be $13,400, based on an amortization period of 50 years at 3-1/8 per cent interest, of which non-Federal costs would be $12,600. Replacement costs are for complete replacement of facilities after 30 years. A comparison of annual benefits of $104,400 with annual costs of $13,400 gives a benefit-to-cost ratio of 7.8.

b. Anadromous fishery. The enhancement of anadromous fish runs is a possible future purpose of the Avon Bypass project. The Washington State Department of Fisheries has requested that future planning for the Bypass include studies to determine the feasibility of adding spawning and rearing facilities for an anadromous fishery. Justification for inclusion of this feature would be dependent upon future studies by the U. S. Fish and Wildlife Service and the State Department of Fisheries.

Table 10

COSTS FOR ADDING RESIDENT FISHERY TO BYPASS

Resident Trout Fishery

Construction costs

Boat launching ramps	$22,700
Rights-of-way for ramps	1,000
Contingencies	5,700
Engineering and design	5,700
Supervision and administration	3,000
Totals	$38,100
Round to	$38,000

Allocated costs	Federal	Non-Federal
Rights-of-way		$ 1,000
Construction costs	$19,000	18,000
Totals	$19,000	$19,000

Annual costs

Interest at 3-1/8 per cent amortization over 50 years	$ 760	$ 760
Stocking		7,500
Operation and maintenance		4,000
Replacements		360
Totals	$ 760	$12,620
Round to	$ 800	$12,600
Total annual costs		$13,400

65. WILDLIFE

Padilla Bay, into which the waters of the Avon Bypass would discharge, is the site of one of the greatest concentrations of Black Brandt (a species of Canadian goose) north of California, and is also the feeding and resting area for large numbers of ducks of many species. The Bypass lies across important

waterfowl flight lanes. The fish and wildlife agencies propose the construction of a launching ramp immediately below the downstream control structure to provide access for waterfowl hunters along the reaches of the project and in Padilla Bay. Their recommendation also includes the acquisition of 180 acres adjacent to the project along Padilla Bay for public shooting and the development of lands along the channel for waterfowl and pheasant shooting.

a. Waterfowl hunting and fishery on Padilla Bay. The construction of a boat launching ramp for use as access to project waters and Padilla Bay for waterfowl hunting and fishing is project connected. The fish and wildlife agencies estimate that the average annual waterfowl hunter-day use would be 760 days with a benefit of $3,400 a year, and that additional annual benefits of $2,400 would be realized by fishermen using the ramp as access to Padilla Bay and lower Bypass waters. The total annual costs are estimated at $2,500, as summarized in table 11. Comparing the estimated total annual benefits of $5,800 with this cost yields a benefit-to-cost ratio of 2.3 for the access ramp to Padilla Bay and the Bypass.

b. Waterfowl and pheasant hunting along Bypass channel. Project land could be open to hunting in those reaches where urban and suburban residential development are not affected. Because of the limited width of the project, easements from adjoining property owners would be necessary to permit retrieval of birds. Foot stiles would be needed for crossing fences. The project area would provide good ringneck pheasant release sites, and, with proper management, could add substantially to this type of hunting. The U. S. Fish and Wildlife Service has estimated 2,500 pheasant and 6,200 waterfowl hunter days could be realized. Comparison of estimated annual benefits of $35,500 with annual costs of $15,400 gives a benefit-to-cost ratio of 2.3. The costs of this feature would be entirely non-Federal and involve mainly real estate rights, operation and maintenance. This project purpose would not involve the Federally-constructed project and is therefore entirely a local interest responsibility. The benefits and costs have not been included as a feature of the Avon Bypass.

c. Waterfowl land acquisition and development. The Washington State Department of Game recommended the purchase and development of approximately 180 acres of land above mean high water on the shores of Padilla Bay adjoining the Bypass right-of-way on the south in the east half of Section 6, Township 34N, Range 3WM. The purpose of this acquisition would be to provide public access to tidal waters for hunting and fishing. This would give the Avon Bypass a sufficient land area to develop fully its potential for waterfowl hunting. This feature is not sufficiently project-connected to warrant its inclusion as a part of the authorized project. Implementation of this part of the fish and wildlife plan is a matter to be resolved by joint action of the Federal and State fish and wildlife agencies.

Table 11

COSTS FOR ADDING ACCESS TO PADILLA BAY

Access to Padilla Bay

Construction costs

Boat launching ramp	$17,700
Rights-of-way	4,000
Contingencies	4,400
Engineering and design	3,200
Supervision and administration	2,000
Total	$31,300
Round to	$31,000

Allocated costs	Federal	Non-Federal
Rights-of-way		$ 4,000
Construction costs	$15,500	11,500
Total	$15,500	$15,500

Annual costs

Interest at 3-1/8 per cent and amortization over 50 years	$ 620	$ 620
Operation and maintenance		1,000
Replacements		300
Totals	$ 620	$ 1,920
Round to	$ 600	$ 1,900
Total annual costs		$ 2,500

66. U. S. FISH AND WILDLIFE SERVICE REPORT

Proposed Federal participation in developing features for adding fish and wildlife purposes for the Bypass project are not as extensive as those recommended by the U. S. Fish and Wildlife Service, but are the maximum that can be accepted as a Federal responsibility under present laws and administrative procedures. The resident trout fishery, and access to lower project area and Padilla Bay for waterfowl hunting and fishing, have been incorporated into the Bypass project at Federal cost essentially as recommended by the U. S. Fish and Wildlife Service because they involve only modification of project

features. The U. S. Fish and Wildlife Service has recommended that Federal funds be used to obtain easements along the Bypass channel and to install foot-stiles on fence lines along the channel for hunters to retrieve waterfowl and pheasants. They have also recommended that Federal funds be used to acquire 180 acres of land along Padilla Bay adjacent to the Bypass channel for water-fowl hunting. These features can be made a part of the project development, but are a local interest responsibility. Differences between the project plan and the U. S. Fish and Wildlife Service recommendations are discussed in Appendix D.

67. GENERAL RECREATION

The 7-mile long lake which would be created by the Bypass channel adjacent to Interstate Highway 5 has a high potential for boating, swimming, camping, picnicking and water-oriented recreation. All-purpose facilities to accommodate this recreational use can be provided by the development of a gently sloping, timber-covered area of about 230 acres located along the Bypass channel. The Washington State Parks and Recreation Commission, after an examination of the project potential, endorsed general recreation on the Avon Bypass, saying that it had a great recreation potential and Congress should be so informed. A copy of a letter from the Director of the Commission is attached as Exhibit 4.

General recreation development of the project is in the category of a state or county park responsibility. Park facilities could be an important aspect of multi-purpose development. Accordingly, studies were made to establish the justification for recreation, exclusive of fish and wildlife use. These studies disclosed that full development of all-purpose general recreation could be accomplished at an estimated cost of $1,428,000. The average annual public use of these facilities is forecast to be approximately 300,000 visitor days over a 50-year life. This forecast is supportable from the record of attendance at Washington state parks in the vicinity and by national fore-casts of recreational growth. Benefits from this recreational use are estimated to be $300,000 annually based on $1.00 per visitor day. This value has been accepted for projects which offer a large diversified opportunity for general recreation. Comparison of the annual benefits of $300,000 a year with an annual cost of $94,000, including operation and maintenance, shows that the benefits exceed the costs by a wide margin. These recreation evaluations were reviewed by the Bureau of Outdoor Recreation, U. S. Department of Interior, which concurred in the recreation potential and in general with the total program. A copy of a letter from the Bureau of Outdoor Recreation, dated 24 February 1964, is contained in Appendix D. The letter indorses general recreation development in the Avon Bypass Project from both a local, state and regional standpoint. This purpose is not sufficiently project-connected to warrant its inclusion as a part of the proposed authorized Federal

project. Implementation of the general recreation features is a matter to be resolved by joint action between Skagit County Officials and the Washington State Parks and Recreation Commission.

68. LOCAL COOPERATION

The formal requirements for Federal participation in development of the resident fishery and access to Padilla Bay are that the non-Federal sponsoring entity agree to:

a. Provide all additional lands, or rights in lands, required to insure public control of the development;

b. Where the appraised value of the land provided under a, above, amounts to less than 50 per cent of the total first cost of the recreational development, make additional contributions sufficient to bring the non-Federal share to at least that level; which additional contribution may consist of the actual cost of carrying out an agreed-upon portion of the development, or a cash contribution, or a combination of both;

c. Operate and maintain for the life of the Federal project the recreational areas and facilities thereto;

d. Assure access to all on equal terms.

The principal sponsor would be Skagit County, acting through its Board of County Commissioners. The Commissioners would also seek participation from appropriate State of Washington agencies. By letter, Exhibit 5, the County Commissioners have affirmed their willingness to satisfy the sponsorship requirements.

69. SUMMARY

A resident trout fishery, access to Padilla Bay, hunting and general recreation as project purposes would each add benefits substantially in excess of costs. An anadromous fishery development is a potential project purpose, subject to demonstration of feasibility. The only recreation developments for which Federal assistance is possible as a part of the overall project construction, are in facilities for a resident fishery and for access to Padilla Bay. All of the foregoing recreation improvements are permissive in the sense that they do not affect the overall feasibility of the Bypass and can be implemented at such times as local interests consider appropriate. In evaluating the import of these added purposes to the economics of the Bypass, only those purposes involving a proposed expenditure of Federal funds have been considered. These purposes

are addition of a resident trout fishery and access for waterfowl hunting and fishing on lower project waters and Padilla Bay.

70. ECONOMICS OF BYPASS WITH ADDED PURPOSES

Table 12 summarizes costs and benefits of the Avon Bypass for flood control with the above noted added purposes. Annual benefits for recreation added to the Bypass project would be $110,200, consisting of $104,400 for resident fishery and $5,800 for waterfowl hunting and salt-water fishing in lower project waters and Padilla Bay. Total annual benefits for the Avon Bypass project would be increased from $1,660,000 for flood control to $1,770,200 with recreation added. Total average annual costs would increase from $1,050,000 to $1,065,900. The overall benefit-to-cost ratio of 1.6 would not change. However, comparison of the incremental annual benefits of $110,200 to incremental annual costs of $15,900 yield a benefit-to-cost ratio of 6.9 for added purposes.

Table 12

SUMMARY OF COSTS AND BENEFITS FOR AVON BYPASS PROJECT

Feature	Construction Cost	Annual Cost	Annual Benefits
Avon Bypass Flood Control Project	$23,940,000	$1,050,000	$1,660,000
Added Recreation Purposes			
Resident fishery	38,000	13,400	104,400
Access to Padilla Bay for waterfowl hunting and fishing	31,000	2,500	5,800
Total (Added purposes)	$ 69,000	$ 15,900	$ 110,200
Total Project	$24,009,000	$1,065,900	$1,770,200

Incremental benefit-cost ratio = 6.9

Total project benefit-cost ratio = 1.6

SECTION 8 - PUBLIC HEARINGS AND COORDINATION WITH OTHER AGENCIES

71. GENERAL

Investigations for plans of improvement presented in this report were coordinated with all interested Federal, State, County and local agencies. Formal and informal meetings beginning in February 1961 and continuing through March 1964 were held with members of interested civic organizations and agencies.

72. PUBLIC HEARING - 8 FEBRUARY 1961

An initial public hearing for the Skagit River basin study was held in Mount Vernon, Washington, on 8 February 1961. There were 154 in attendance, including representatives of Federal, State and County governments, landowners, businessmen, sportsmen and farmers from the basin.

Potential flood damages were the subject of several prepared statements presented orally or submitted as exhibits for the record. The City Manager of Anacortes, Washington, and a Public Utility Commissioner for Skagit County, stated that floods overtopping the levees in the Mount Vernon-Burlington vicinity would immobilize the entire water distribution system for West Skagit County, including the cities of Anacortes, Burlington, Mount Vernon, and all the major industries. The Superintendent of Public Works for the city of Mount Vernon outlined probable damages that would occur in the event of flooding in the city's business district. These included property damage of $3,600,000, loss of business of $2,400,000 and public works losses of $200,000. Data on flood damages were also presented by representatives of the city of Burlington, the Washington State Highway Department, the Soil Conservation Service, the Skagit County Dairymen's Association, the Skagit County Agricultural Council, the Skagit County Strawberry Association, the Skagit County Public School System and several diking and drainage districts.

Desired methods of obtaining flood control suggested at the hearing included upstream storage, levee construction and improvement, channel dredging and flood diversion. Possible sites for upstream storage on the main stem and on several major tributaries were mentioned. Flood control by upstream storage was generally opposed by the Washington State Departments of Game and of Fisheries. Levee improvement in the delta area, with no major increase in existing levee heights, was favored by the Skagit County Engineer and representatives of several diking districts. The possibility of substantially increasing existing levee heights was opposed by the City Engineer of Mount Vernon and representatives of diking

districts because of the hazard of underseepage and blowouts through porous foundation materials. Dredging of the existing channel downstream from Mount Vernon was favored by Drainage District No. 17. Dredging of the river upstream from Mount Vernon was favored by the Mount Vernon Chamber of Commerce and the Skagit County Development Association on the basis of possible navigation uses. Dredging of the river upstream of Mount Vernon was opposed by the State Department of Game because of possible losses of spawning areas for game fish. The Avon Bypass diversion channel was indorsed by the State Department of Fisheries and the Skagit County Engineer.

73. PUBLIC HEARING - 10 JANUARY 1964

A public hearing was held in Mount Vernon, Washington, on 10 January 1964 to present the Corps' plans for levee and channel improvements, and for the inclusion of recreation in the Bypass project. There were about 230 in attendance, including representatives of Federal, State and local agencies. Skagit County officials, Skagit County Flood Control Council, Diking District Commissioners, and residents in the area were represented. Plans for levee and channel improvements received general support and were endorsed by Skagit County officials, representatives of diking districts, the Washington State Department of Game, and the Division of Flood Control of the State Department of Conservation, the city of Mount Vernon, the Washington State Grange, and the Pomona Grange of Skagit County, and other individuals. A petition signed by 214 persons was presented by a citizens' group. The petition requested that the Corps of Engineers implement an immediate and continuing program to provide flood control for the lower Skagit River Valley. Representatives of the Washington State Department of Game and the U. S. Fish and Wildlife Service stated that the proposed levee and channel improvements would not adversely affect the runs of anadromous fish in the Skagit River, and that the channel widening construction may require some measures to safeguard fish runs depending upon the type of equipment used for channel excavation.

The addition of fishing, waterfowl hunting, and general recreation to the Avon Bypass was endorsed by the Skagit County Engineer, the City Engineer of Mount Vernon, the U. S. Fish and Wildlife Service, the Washington State Department of Game, the Washington State Department of Commerce and Economic Development, and many local residents. The Bayview-Padilla Bay Civic Association opposed recreation and fish and wildlife facilities on the grounds that attendance at other recreation facilities in the area might be adversely affected, and deposition of silt from diversion of flows through the Bypass would reduce the recreational value of Padilla Bay.

The flood control aspects of the Avon Bypass project were not intended for major discussion at the hearing because the project is already authorized. However, the public announcement of the hearing stated that any outstanding

comments on the project would be heard. The Avon Bypass project for flood control was endorsed by the Washington State Departments of Conservation, and Commerce and Economic Development, the Skagit County Board of Commissioners, the Skagit County Flood Control Council, the City Engineer of Mount Vernon, and local residents. The Chairman of the Skagit County Board of Commissioners stated that the people and taxpayers of Skagit County could be assured that they would have the right to vote on funding of local cooperation requirements for the project. Opposition to the Bypass project was expressed by representatives of Fire District No. 6 and Diking District No. 12 on the grounds that the Bypass cost would be excessive and would sever both districts and make access difficult. A petition signed by 740 persons was presented by a citizens' group that opposed the Bypass and any plans to modify the Bypass for other purposes. The petition opposed addition of recreation to the Bypass, project, and stated that the Bypass would not provide protection from major floods; that it would be beyond the means of the county to maintain; that it would endanger a new area to flood hazard; and that it would eventually cause silting up of shallow Padilla Bay. Several landowners along the path of the Bypass channel objected to the loss of farmland that would result from construction of the project.

74. COORDINATION WITH STATE AND FEDERAL AGENCIES

a. Fish and wildlife. The fish and wildlife plans proposed in this report were prepared by the U. S. Fish and Wildlife Service and the Washington State Departments of Fisheries and of Game.

b. Recreation. Investigations of the recreation potential of the Avon Bypass project were reviewed by the Bureau of Outdoor Recreation and the Washington State Parks and Recreation Commission.

c. Flood control. The State Supervisor, Washington State Division of Flood Control, Department of Conservation, worked closely with representatives of the District Engineer in developing the flood control plans presented in this report.

75. COORDINATION WITH LOCAL INTERESTS

Numerous meetings were held during preparation of this report with the Skagit County Engineer, Skagit County Commissioners, Skagit County Flood Control Council, commissioners of the 16 diking districts in the Skagit River delta, Chambers of Commerce in the area, and many civic organizations.

76. CONCLUSIONS

Flood protection in the Skagit River basin is considered by local interests, State agencies and the Corps of Engineers to be the most urgent water resource development need. There has not been a major flood in the Skagit River basin since 1951, and prior to that 1921. However, in the period 1896 to 1921, six floods occurred which exceeded the 1951 flood. Recurrence of a flood of 1921 or greater magnitude under 1963 conditions would cause flood damages estimated to be more than $13,000,000.

Elements of a basin plan have been evolved which will afford a high degree of flood protection in the Skagit River basin, particularly the well developed 68,000-acre flood plain downstream from Sedro Woolley. The key segments of this plan are the downstream levee and channel improvements presented in this report, reactivation of the authorized Avon Bypass project, and future upstream storage.

The proposed levee and channel improvements would increase the level of flood protection in the delta flood plain from once in 3 to 14 years, to a minimum of once in 8 years. However, constructed with the Bypass, protection would be accomplished for floods with an expected recurrence of once in 35 years. Addition of upstream storage would make possible protection from floods with an expected recurrence interval equal or exceeding 100 years. To avoid a false sense of flood security, the levee and channel improvements should be constructed as an integral part of a basin plan for flood control, which as a minimum should include provision for construction of Avon Bypass project or upstream storage.

The Avon Bypass project is in the process of being reactivated. Final alinement studies of the Bypass channel are planned in 1965 and 1966. Investigation of the feasibility of upstream storage for flood control and multiple-purpose development are being made under authority of the Puget Sound and Adjacent Waters Comprehensive Study.

A project for channel widening and improvement of the downstream levee system to accommodate a minimum flow of 120,000 c.f.s. throughout will develop annual flood control benefits of $660,000 and fishery benefits of $91,000, totalling $751,000, if the project is constructed in conjunction with the Avon Bypass. The project is well justified with annual costs of $245,000, and a resulting benefit-to-cost ratio of 3.1. The project is also justified when considered last added to other elements of a basin plan. The levee and channel improvements would be a local flood protection project and responsible local interests have signified their willingness to satisfy sponsorship requirement.

Studies should be made during final design to determine feasibility of removing remains of sills constructed in distributaries of Skagit River in 1911 as aids to navigation, but which have not been maintained and which may aggravate flood conditions.

The levee and channel improvements in a coordinated plan of development with the Avon Bypass, also make recreational use of the Bypass possible. Recreation improvements would be primarily a local interest responsibility. Only the addition of a resident fishery and boat access to Padilla Bay, have been considered for Federal participation. The estimated annual cost of $13,400 for the resident fishery facilities, compared with an average annual benefit of $104,400, yields a benefit-to-cost ratio of 7.8. An estimated average annual cost of $2,500 for access to Padilla Bay compared with an average annual benefit of $5,800, yields a benefit-to-cost ratio of 2.3. In addition, the Bypass affords a potential for anadromous fish rearing and spawning facilities, and for picnicking, camping and pheasant hunting. All of the above developments are primarily local interest responsibilities. Federal participation is important so that modification of authorized flood control facilities can be accomplished in the interest of recreation. Local interests have expressed willingness to undertake sponsorship of the resident fishery and access to Padilla Bay for waterfowl hunting and fishing purposes. On a long-range basis, there is good evidence that the other recreation developments mentioned herein will take place. The authorization of the Avon Bypass did not include recreation as a project purpose. Accordingly, modification of the authorization is necessary to permit Federal participation in appropriate areas of planning and construction of the Bypass for recreation developments.

77. RECOMMENDATIONS

I recommend, as elements of a plan for comprehensive development of the water resources of the Skagit River Basin, Washington, authorization for construction of a levee and channel improvement project for protection of the Skagit River valley, downstream of Sedro Woolley, at an estimated cost to the United States of $5,770,000; and modification of the Avon Bypass project to permit Federal participation in the construction of recreation facilities at an estimated cost to the United States of $34,500; all as generally described herein and as shown on the accompanying plates, provided that, prior to construction, local interests agree to:

a. Provide without cost to the United States, all lands, easements, and rights-of-way necessary for construction of the projects;

b. Hold and save the United States free from damages due to the construction works;

c. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army;

d. Provide without cost to the United States all relocations of buildings and utilities, roads, sewers, related and special facilities necessary for construction of the projects;

e. Provide assurances that encroachment on improved channels will not be permitted;

f. Notify the public annually of the limited flood protection provided by the recommended works subsequent to their construction;

g. Secure the water rights necessary for operation of the recommended works for recreational purposes;

h. With respect to recreational facilities, provide cash, equivalent work, or lands so that the non-Federal share shall be at least 50 per cent of the total first cost of the development;

i. Assure public access for all on equal terms, for recreation development;

j. Submit plans for any additional recreational development of the Avon Bypass project to the Secretary of the Army for approval and determination of the Federal interest prior to construction.

C. C. HOLBROOK
Colonel, Corps of Engineers
District Engineer

NPDEN-PL (Mar 65) 1st Ind
SUBJECT: Review of Reports on Flood Control and Other Improvements, Skagit River, Washington

U. S. Army Engr Div, North Pacific, Portland, Ore., 16 June 1965

TO: Chief of Engineers

I concur in the views and recommendations of the District Engineer.

P. C. HYZER
Brigadier General, USA
Division Engineer

STATE OF
WASHINGTON
ALBERT D. ROSELLINI
GOVERNOR

DEPARTMENT OF
FISHERIES
GEORGE C. STARLUND
DIRECTOR

ROOM 115, GENERAL ADMINISTRATION BUILDING
OLYMPIA, WASHINGTON 98502

January 9, 1964

U. S. Army Engineer District, Seattle
Corps of Engineers
1519 Alaskan Way South
Seattle, Washington 98134

RE: NPSEN-PP Flood Control Measures and Improvements, Skagit River.

Gentlemen:

This department has examined the proposed plans for the lower Skagit River Improvement.

The plans, as proposed at this present time, have a general approval from the Department of Fisheries. These improvements downstream in the Skagit River should provide adequate lower river flood protection as related to recent years of high flow runoff.

This department will require a hydraulic approval for each project, and at the time of approval we will give provisions for the protection of fish life, with regards to siltation, removal of debris and the prevention of blocks to the passage of anadromous fish.

We are pleased to comment on these projects and feel the proposals are satisfactory for the purpose indicated.

Very truly yours,

George C. Starlund

George C. Starlund, Director
DEPARTMENT OF FISHERIES

GCS-GW:lj

cc: Bureau of Fisheries and Wildlife-Portland
Game
Flood Control
C. Stockley
B. Gufler

Exhibit 2

Keep Our Waters Clean
POLLUTION KILLS FISH

SKAGIT COUNTY

STATE OF WASHINGTON
MOUNT VERNON

January 4, 1964

Ernest L. Perry
Colonel, Corps of Engineers
District Engineer
1519 Alaskan Way South
Seattle, Washington

Dear Sir:

This letter is in reply to your letter dated December 16, 1963. Your letter requests local cooperation requirements on the levee improvements and recreation additions to the Avon Bypass, which is scheduled for a Public Hearing on Friday, January 10, 1964.

A meeting was held on December 31st at 1:30 P.M. with the affected Dike District Commissioners, who number eighteen (18) and of which sixteen (16) were in attendance. An affirmative vote was given by the attending dike district commissioners for the Corps of Engineers' project of improvements. The affected dike district commissioners indicated their willingness to work with the County in providing the necessary rights of way for the proposed project; hold the United States free from damages due to construction works; and maintain and operate all of the works after the completion of construction in accordance with the regulations prescribed by the Secretary of Army. The Skagit County Dike Districts have a high record of quality maintenance on their systems so this item is of no consequence.

We, the Board of County Commissioners, wish to affirm the intent of the County to provide the local cooperation in behalf of the dike districts and the people of Skagit County, as set forth in your request.

Respectfully submitted,

BOARD OF COUNTY COMMISSIONERS,
SKAGIT COUNTY, WASHINGTON.

Scott D. Richards
Chairman

Claude B Wilson

Jack Wylie

BCC
LHJ/vy

Exhibit 1

STATEMENT OF THE DEPARTMENT OF GAME ON THE PROPOSED FLOOD PROTECTION PROJECTS PROPOSED BY THE CORPS OF ENGINEERS FOR THE LOWER SKAGIT RIVER

Fishing and hunting in the State of Washington is a one hundred million dollar a year industry and therefore is very vital to our economy. The Department of Game as a conservation and wildlife management agency seeks to preserve this economy by protecting our fish and wildlife resources. We, therefore, are vitally interested in all river projects that may have either a detrimental or beneficial effect on these resources. If the project is detrimental, we have an obligation to determine the best method to limit the extent of damage and to recommend means to mitigate the losses. If the project is deemed beneficial, we lend our knowledge of the habits of fish and wildlife to the constructing agency to make the benefits as worthwhile as possible at the most reasonable cost. It is with these thoughts in mind that we are here today to comment on the projects proposed by the Corps of Engineers for flood protection in the lower Skagit River.

The Skagit River is the most important producer of winter run steelhead in the State of Washington. It produces an average catch of 15,686 winter steelhead each year with a record catch of 22,488 in the 1955-56 season. The river provides an average of 84,700 man-days of fishing each year during the winter season. The Skagit is also an important producer of sea-run cutthroat, dolly varden, whitefish and resident species of trout.

The fisheries resources of the Skagit River contribute substantially to the economy of Skagit County. In addition to the money spent in the area for lodging, meals, gas, clothing and equipment by fisherman, there are 19 professional guides that operate on the river deriving an income of nearly $25,000.00 annually. The loss of any of the fishery resources of the river will affect the economy of this area, the degree of impact being dependent upon the degree of damage to the fishery resource itself.

The area at the mouths of the North Fork and South Fork of the Skagit River is very important as waterfowl production and hunting lands. The Skagit Game Range, for example, located between Freshwater and Steamboat Sloughs provided a kill of 19,184 ducks, geese and pheasants in 1962 and provided 18,631 man-days of hunting. This game range had a larger kill of waterfowl and provided a greater number of man-days of waterfowl hunting than any other game range in the state. We are therefore, vitally concerned with any project that may affect the waterfowl production of the lowland areas at the mouth of the Skagit River.

This Department has worked with the Corps of Engineers in developing plans for safeguarding fish and wildlife in the projects under discussion here today. We feel that the proposed levee and channel widening project below Mount Vernon and the Avon Bypass Project will provide a great measure of flood protection for the lower Skagit River area and also will cause minimum problems as far as

Game Commissioners / Charles T. Graham, Chairman, Colville
Arthur S. Coffin, Yakima; James H. Ralls, Wilson Creek;
Richard S. Seward, Seattle; Harold A. Pebbles, Olympia;
Albert T. Prichard, Kalama

Director of Game / John A. Biggs

State of Washington

DEPARTMENT OF GAME

600 North Capitol Way / Olympia, Washington 98502

December 30, 1963

District Engineer, Seattle District
Corps of Engineers, U. S. Army
1519 Alaskan Way South
Seattle 4, Washington

Dear Sir:

Attached is a statement by the Department of Game relative to the proposed levee and channel widening project and the Avon Bypass project on the lower Skagit River.

We desire that this statement be included in the official records of the hearing to be held in Mount Vernon on 10 January 1964.

Very truly yours,

THE DEPARTMENT OF GAME

John A. Biggs, Director

RWL/mjb

Attachment

Exhibit 3

WASHINGTON STATE PARKS & RECREATION COMMISSION

ALBERT D. ROSELLINI, GOVERNOR

[illegible]

[illegible]

December 3, 1963

Mr. E. J. Gullidge
Corps of Army Engineers
Seattle District
1519 Alaskan Way South
Seattle 4, Washington

RE: Avon Bypass

Dear Mr. Gullidge:

Thank you for the excellent presentation you made at the November 18, 1963, meeting of the Washington State Parks and Recreation Commission.

Please be advised that the Commission went on record saying that, "they believed that the Avon Bypass area has a great recreational potential, and Congress should be so informed."

Would you be sure that the proper members of Congress are so advised.

Thank you.

Sincerely,

Charles H. Odegaard

CHARLES H. ODEGAARD
Director

CHO:ls

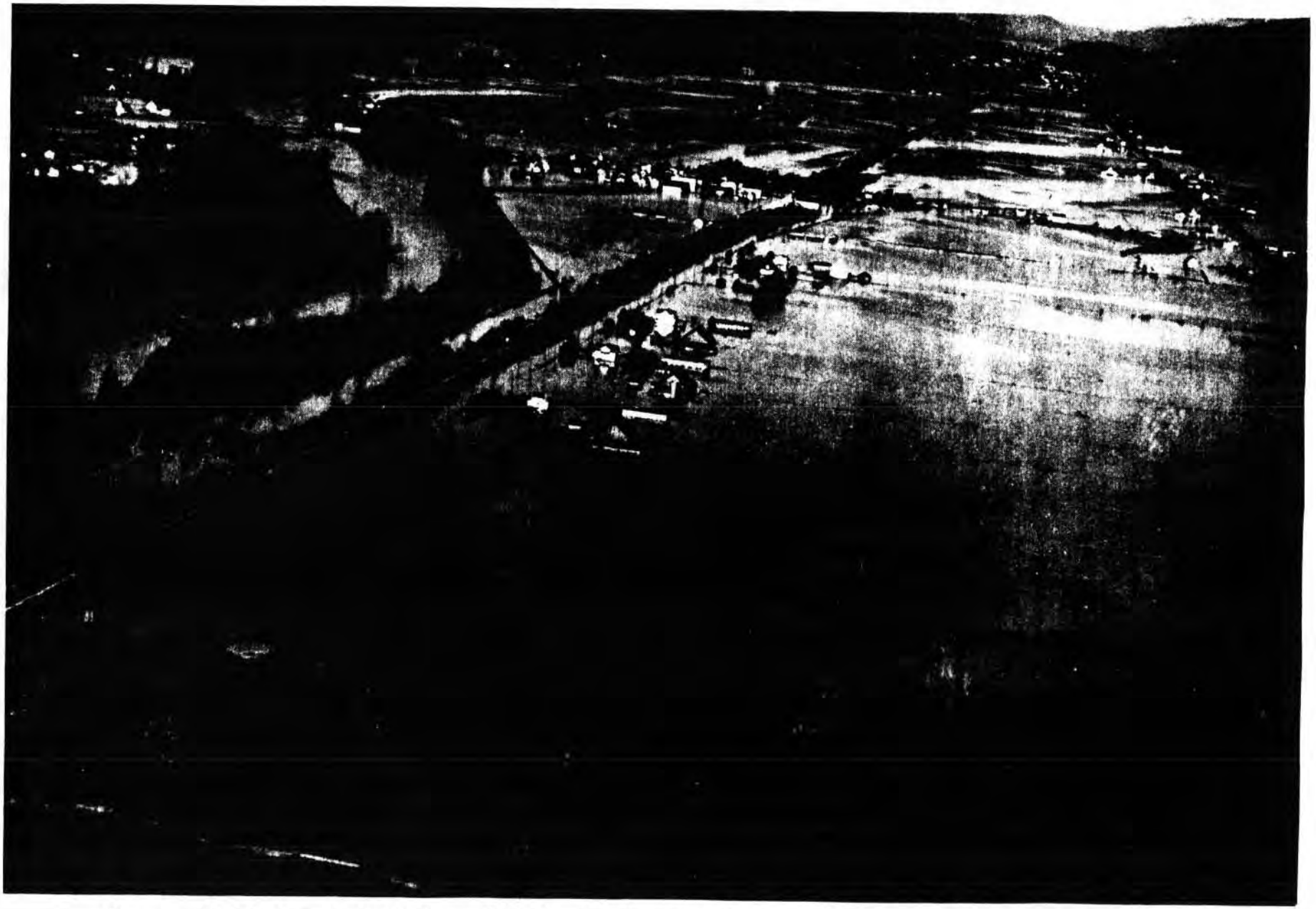
Exhibit 4

fish and wildlife are concerned. The channel widening phase of the project may require some measures to safeguard fish, depending upon the type of equipment used to accomplish the desired results, however, we do not feel that the required safeguards will materially affect this project.

The proposed inclusion of fish, wildlife and recreation purposes to the Avon Bypass adds materially to the benefits of this project. With proper management and fish stocking, the Bypass could add materially to the economy of Skagit County. The proper development of this area, however, will be dependent upon proper screening of the inlet and outlet, development of adequate boat launching facilities, parking areas and an adequate year around water supply. This Department will sincerely attempt to develop the fishing potential in the Bypass.

The additional possibilities for developing upland bird hunting and waterfowl hunting will also add to the value of the Bypass as a recreational area. We feel, therefore, that fish and wildlife benefits should be included as a purpose of the Avon Bypass.

We wish to express our appreciation for the opportunity to appear at this hearing and express our views relative to the proposed Skagit River flood protection projects.



Conway, Washington during February 1951 Flood. View is northeast with the South Fork [illegible] at the left

WASHINGTON STATE PARKS & RECREATION COMMISSION

ALBERT D. ROSELLINI, GOVERNOR

[redacted]

[redacted]

December 3, 1963

Mr. E. J. Gullidge
Corps of Army Engineers
Seattle District
1519 Alaskan Way South
Seattle 4, Washington

RE: Avon Bypass

Dear Mr. Gullidge:

Thank you for the excellent presentation you made at the November 18, 1963, meeting of the Washington State Parks and Recreation Commission.

Please be advised that the Commission went on record saying that, "they believed that the Avon Bypass area has a great recreational potential, and Congress should be so informed."

Would you be sure that the proper members of Congress are so advised.

Thank you.

Sincerely,

Charles H. Odegaard

CHARLES H. ODEGAARD
Director

CHO:ls

Exhibit 4

SKAGIT COUNTY

STATE OF WASHINGTON
MOUNT VERNON

April 28, 1965

U. S. Army Engineer
District Engineer
Corps of Engineers
1519 Alaskan Way South
Seattle, Washington 98134

Re: NPSEN-BP

Attention: C. C. Templeton
Acting Deputy Engineer

Gentlemen:

We acknowledge receipt of your letter dated April 23rd, 1965 regarding the inclusion of recreation as a project purpose in the Avon Bypass.

We believe there will be no problem in providing the recreation participation on Skagit County's part. The Washington State Department of Fisheries, The Washington State Game Department and the U. S. Wildlife Service are very interested in the potential recreation of the Avon Bypass project.

While no budget funds are on hand to provide the cash contribution estimated at $30,000.00, it is our belief that the necessary sponsors' funds will be provided by the above named parties and the Skagit County Park Department, with adequate time for planning and budgeting.

We, the Board of Skagit County Commissioners, agree to satisfy the requirements as requested in your letter and believe there is a willingness and ability to pay for this participation in Skagit County together with the cooperation of the various state agencies.

Respectfully,

BOARD OF SKAGIT COUNTY COMMISSIONERS

Claude B Wilson — Chairman

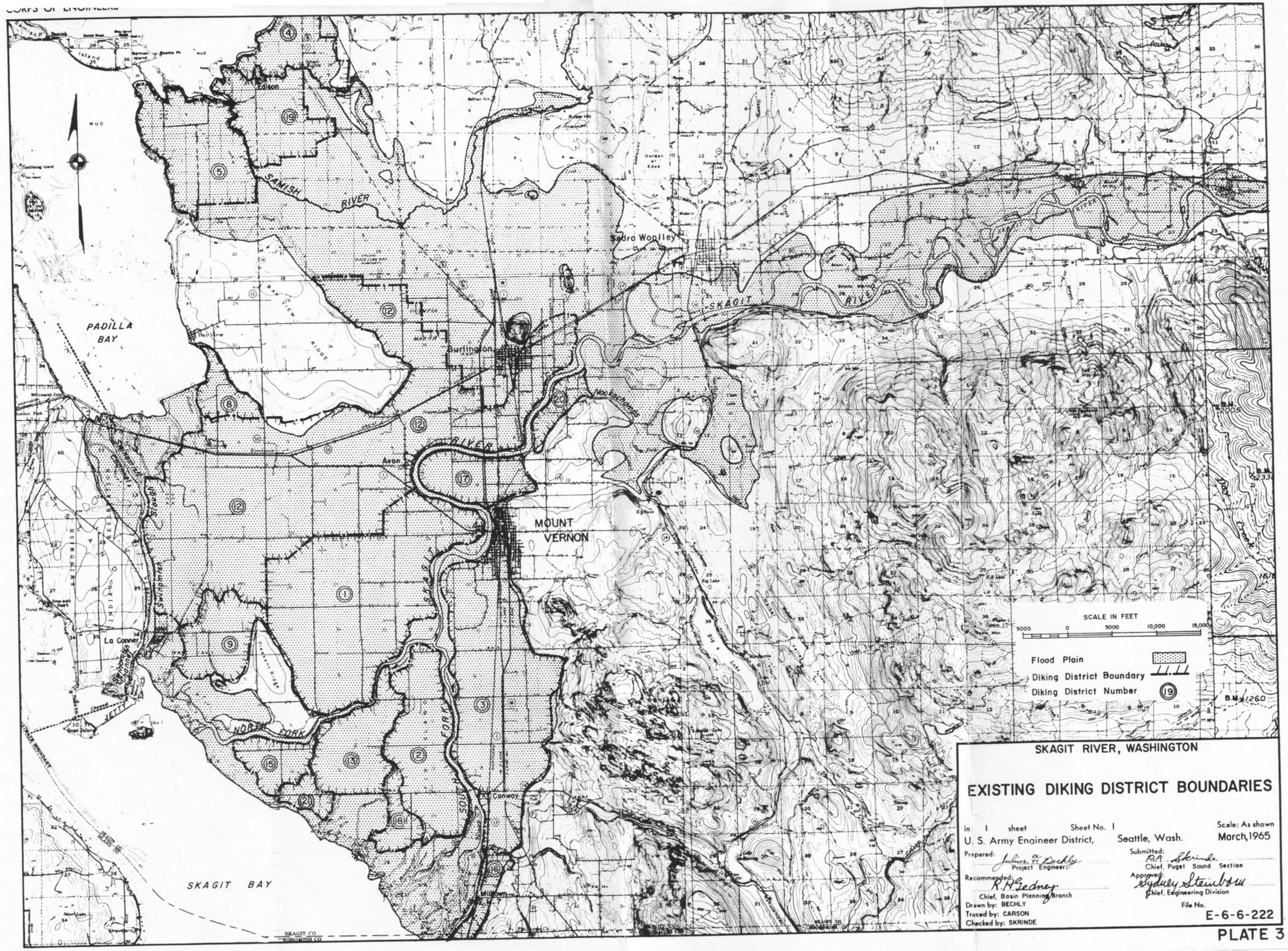
Mel Halgren — Commissioner

Jack Wylie — Commissioner

LHJ/vy

Exhibit 5

CORPS OF ENGINEERS



SKAGIT RIVER, WASHINGTON

EXISTING DIKING DISTRICT BOUNDARIES

In 1 sheet Sheet No. 1

Scale: As shown

U. S. Army Engineer District, Seattle, Wash.

March, 1965

Prepared: Julius M. Bechly, Project Engineer

Submitted: R.A. Skrinde, Chief, Puget Sound Section

Recommended: R. H. Gedney, Chief, Basin Planning Branch

Approved: Sydney Steinbom, Chief, Engineering Division

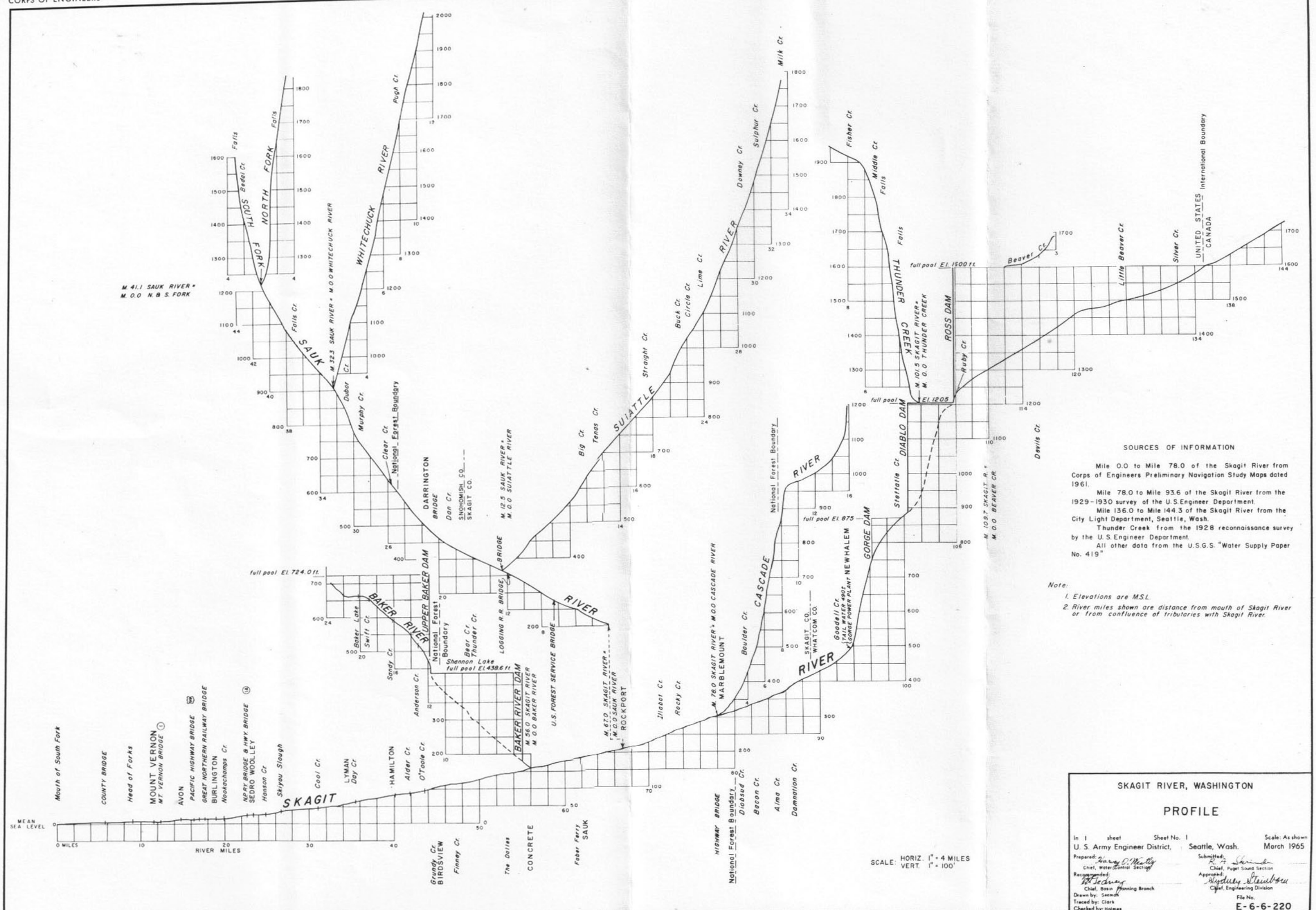
Drawn by: BECHLY

Traced by: CARSON

Checked by: SKRINDE

File No. E-6-6-222

PLATE 3



SOURCES OF INFORMATION

Mile 0.0 to Mile 78.0 of the Skagit River from Corps of Engineers Preliminary Navigation Study Maps dated 1961.

Mile 78.0 to Mile 93.6 of the Skagit River from the 1929-1930 survey of the U.S.Engineer Department.

Mile 136.0 to Mile 144.3 of the Skagit River from the City Light Department, Seattle, Wash.

Thunder Creek from the 1928 reconnaissance survey by the U.S.Engineer Department.

All other data from the U.S.G.S. "Water Supply Paper No. 419"

Note:

1. Elevations are M.S.L.
2. River miles shown are distance from mouth of Skagit River or from confluence of tributaries with Skagit River.

SCALE: HORIZ. 1" = 4 MILES
VERT. 1" = 100'

SKAGIT RIVER, WASHINGTON

PROFILE

In 1 sheet Sheet No. 1 Scale: As shown

U. S. Army Engineer District, Seattle, Wash. March 1965

Prepared: Chief, Water Control Section
Submitted: Chief, Puget Sound Section
Recommended: Chief, Basin Planning Branch
Approved: Chief, Engineering Division
Drawn by: Seemah
Traced by: Clark
Checked by: Holmes
File No. E-6-6-220

PLATE 2

SKAGIT RIVER BASIN, WASHINGTON
REPORT ON FLOOD CONTROL AND OTHER IMPROVEMENTS

APPENDICES TO ACCOMPANY MAIN REPORT

APPENDIX A - ECONOMIC ANALYSIS

APPENDIX B - HYDROLOGY, HYDRAULIC DESIGN AND METEOROLOGY

APPENDIX C - PLANNING DETAILS AND COST ESTIMATES

APPENDIX D - RECREATION

APPENDIX A

ECONOMIC ANALYSIS

APPENDIX A
ECONOMIC ANALYSIS

CONTENTS

TABLES

APPENDIX A
ECONOMIC ANALYSIS

CONTENTS (Cont'd)

APPENDIX A
ECONOMIC ANALYSIS

CONTENTS (Cont'd)

Number

PLATES (Cont'd)

SECTION 1 - ECONOMIC DEVELOPMENT

1. GENERAL

This appendix supplements economic information in the report.

2. POPULATION, EMPLOYMENT AND INCOME

Table A-1 presents the historical population totals and rates of population growth for Skagit County and its principal cities, and compares these to Washington State and to the United States.

Table A-1

POPULATION OF UNITED STATES, STATE OF WASHINGTON
SKAGIT COUNTY AND PRINCIPAL CITIES OR TOWNS

Area	Total population				Ann. rates of pop. growth		
	1930	1940	1950	1960	1930-40	1940-50	1950-60
U. S. 1/	123,202	132,165	151,326	179,323	0.7	1.4	1.7
Wash. State 1/	1,563	1,736	2,379	2,853	1.1	3.2	1.8
Skagit County	35,142	37,650	43,273	51,350	0.7	1.4	1.7
Anacortes	6,564	5,875	6,919	8,414	-1.1	1.6	2.0
Mount Vernon	3,690	4,278	5,230	7,921	1.5	2.0	4.2
Burlington	1,407	1,632	2,350	2,968	1.5	3.7	2.4
Sedro Woolley	2,719	2,954	3,299	3,705	0.9	1.1	1.2
Remainder of Co.	20,762	22,911	25,475	28,342	1.0	1.1	1.1

Source: U. S. Census of Population - Number of inhabitants, U. S. Dept. of Commerce, Bureau of Census

Table A-2 contains Skagit County and Washington State employment data, by industry, for the years 1950 and 1960. Total employment in Skagit County has increased from 13,799 in 1950 to 17,269 in 1960, or at an average annual rate of 2.3 percent. This compares to an annual rate of increase in employment of 1.8 percent for the State and to the annual population growth rate for Skagit County of 1.7 percent for this same period. The most important sources of employment in basic industries as of 1960 are agriculture, lumber products and miscellaneous manufacturing. Due to the seasonal nature of the agricultural and lumbering industries, unemployment in Skagit County is greater than

Table A-2

TREND OF EMPLOYMENT 1950-1960

Industry Classification	1950			1960		
	Skagit County		Washington	Skagit County		Washington
	Number	% Total	State	Number	% Total	State
Total employed workers	13,799	100.0	840,062	17,269	100.0	1,001,909
Extractive industries	2,678	19.4	88,943	2,182	12.6	67,985
Agriculture	2,389	17.3	78,220	2,000	11.6	61,766
Forestry & fisheries	250	1.8	6,834	161	0.9	4,667
Mining	39	0.3	3,889	21	0.1	1,552
Processing industries	3,213	23.3	178,430	4,307	24.9	246,938
Lumber, furniture & wood products	1,777	12.9	61,286	1,581	9.1	51,839
Metal products, incl. machinery	463	3.4	50,004	486	2.8	103,952
Miscellaneous Manu.	973	7.0	67,140	2,240	13.0	91,147
Service industries	7,908	57.3	572,689	10,780	62.5	686,986
Retail & wholesale trade	2,563	18.6	173,970	3,291	19.1	196,256
Transportation, communication & utilities	811	5.9	76,886	841	4.9	77,188
Construction	972	7.0	68,948	1,360	7.9	67,471
Other service industries	3,295	23.9	240,119	5,031	29.1	317,051
Industry not specified	267	1.9	12,766	257	1.5	29,020

Source: U. S. Census of Population 1960, Washington, General Social and Economic Characteristics, Dept. of Commerce, Bureau of the Census, p. 49-169.

U. S. Census of Population 1950, Washington, General Characteristics, U. S. Dept. of Commerce, Bureau of the Census, pages 47-58, 47-96.

that for the State. In each of the two years shown, Skagit County unemployment was between 8 and 9 percent of the active labor force, whereas for the entire State unemployment was about 6.6 percent. Employment trends are characterized by a relative shift from the extractive industries to service industries, with employment in processing industries remaining relatively stable. Within the processing industries, however, there has been a shift from the manufacture of lumber products to other types of manufacturing.

Personal income in Skagit County totaled $96,400,000 in 1960, as compared to $62,800,000 in 1950. Table A-3 shows income by major source and the percentage of income from each source for Skagit County in 1950, and for both Skagit County and Washington State in 1960.

3. LAND USE

Table A-4 shows land use in Skagit County. Timberland covers over three-fourths of the area, most of which is classed as commercial. Approximately 13 percent of the land is in farms, 1 percent is in community and industrial use, and 10 percent is in parks and alpine areas.

Bottom lands of the Skagit River provide some of the best farmland in the nation. These flats are composed of rich river silt deposited over many centuries. Class 1 land (above-average productivity and above-average farm income) lie west of Burlington and Mount Vernon. An additional 20,000 acres of sloping, rolling bottom lands (fair productivity and average income) are located east of Burlington. (Land classification from U.S.D.A.)

Frequent flooding has resulted in limited utilization of the flood plain of the Skagit River. The land is of such high fertility, however, that row cropping has proceeded rapidly in spite of recurring floods and damage to crops. Crops and croplands have also been damaged when the sea dikes breach and high tides saturate the land with salt water. The effect of salt water inundation is reflected in reduced crop yields over a period of several years.

4. AGRICULTURE

Agricultural employment is important in the economy of Skagit County. In 1960 about 2,000 persons were employed on farms the year around and were assisted by an undetermined number of migrant workers during harvest. As a result of the favorable climatic and soil conditions in the Skagit valley, agricultural production is high and numerous processing plants have located in the area. Dairy products are processed to serve the local urban areas with fresh milk and for shipment to other areas. Most of the crops

are frozen or canned for shipment to other areas. Employment in food processing plants averaged 700 during 1960 and exceeded 2,400 during the seasonal peak. 1/

1/ Employment and payrolls in Washington - Employment Security Department Research and Statistics Section, FY-62.

Table A-3

PERSONAL INCOME BY MAJOR SOURCE,
SKAGIT COUNTY AND WASHINGTON STATE
(Millions of Current Dollars)

Item	1950		1960		
	Skagit County		Skagit County		Washington State
	Income	% of Total	Income	% of Total	Income	% of Total
Personal income	62.8	100.0	96.4	100.0	6625.6	100.0
Wages & salaries	33.9	54.0	58.1	60.3	4447.1	67.1
Farms	1.8	2.9	2.6	2.7	70.3	1.1
Mining and construction	2.4	3.8	3.5	3.6	302.6	4.5
Manufacturing	13.6	21.7	21.9	22.7	1263.3	19.1
Trade, finance & utilities	7.8	12.5	13.9	14.3	1398.6	21.1
Services	2.1	3.3	4.6	4.8	381.0	5.8
Government	6.0	9.6	11.3	11.7	1011.9	15.3
Other industries	0.2	0.3	0.3	0.3	19.3	0.3
Other labor income	1.0	1.6	2.4	2.5	152.6	2.3
Proprietor's income	16.3	25.9	17.5	18.2	842.0	12.7
Farm	7.3	11.6	5.3	5.5	203.6	3.1
Non-farm	9.0	14.3	12.2	12.7	638.4	9.6
Property income	5.4	8.6	10.2	10.6	807.7	12.2
Transfer payments	6.9	11.0	10.0	10.4	531.6	8.0
Less personal contributions	0.7	1.1	1.8	1.9	155.4	2.3

Table A-4

LAND USE - SKAGIT COUNTY - 1959

	Areas	Percent of total
Agricultural land 1/	141,770	12.8
Irrigated cropland and pasture	5,577	0.5
Dry cropland	52,819	4.8
Dry farm pastures	47,500	4.3
Other farmland	35,874	3.2
Timberland 2/	848,186	76.4
Commercial	724,277	65.2
Non-Commercial:		
Productive reserved	23,350	2.1
Unproductive	100,559	9.1
Urban and Industrial 3/	9,000	0.8
Alpine areas	111,444	10.0
Total land area	1,110,400	100.0

1/ U. S. Census of Agriculture 1959. - Washington Counties, U. S. Department of Commerce.

2/ Forest Statistics for Skagit and Whatcom Counties, Washington. Forest Survey Report No. 133, September 1959. Pacific NW Forest and Range Experiment Station. U. S. Department of Agriculture.

3/ Urban and industrial areas estimated from U. S. Coast and Geodetic Survey Maps.

There has been a considerable increase in the production of specialty crops in Skagit County. Table A-5 shows the increased acreage being placed in peas, corn, seeds and strawberries. The dollar value of livestock products had a substantial increase, but considerably less land is being devoted to these purposes. Total pastureland in the county has decreased from 65,400 acres in 1945 to 51,100 acres in 1959. Acreage devoted to forage crops has stabilized at about 28,000 acres.

5. TIMBER INDUSTRIES

In 1957 the U. S. Forest Service classed 724,277 acres, or 65.2 percent of the county, as commercial forest land. Saw timber stands occupy approximately 61 percent of the forest land. The remainder consists of pole timber, seedlings and saplings--38 percent; and nonstocked areas 1 percent. The estimated volume of live saw timber exceeded 15 billion board feet (Scribner rule) in 1957 (the most recent inventory). Due to the pressure of past cutting, only about 14 percent of the present saw timber volume is Douglas fir. Remaining saw timber, primarily hemlock (38 percent) and other fir (36 percent), is located at higher elevations. The U. S. Forest Service recognizes five degrees of site quality for both Douglas fir and spruce-hemlock land, with Class 1 as the highest class of land and Class 5 as the poorest. They have placed the bulk of Skagit County forest land in site Class 3 or better.

In 1960 total log production in Skagit County was 178 million board feet, Scribner rule, of which about 84 million board feet were from privately owned lands. During the last 13 years, log output has averaged 157 million board feet annually, ranging from 107 million in 1954 to 219 million in 1950 as shown in table A-6. Most of this log cut is moved by truck to pulp and paper mills in Everett and Bellingham. The only log dump now maintained on the Skagit River for water transport of logs is at Mount Vernon. The growth and harvest of timber will support a continuing industry.

6. FISHERIES

The fisheries of the Skagit River are of great importance to the entire region. For the State as a whole, the Skagit River migratory run of salmon and steelhead is second only to the Columbia River. While the contribution of the Skagit run to the overall Puget Sound and offshore fish population cannot be accurately determined, the Skagit is the prime supplier of chinook, chum, pink and silver salmon. Table A-7 presents salmon catch statistics for Puget Sound and the mouth of the Skagit River, exclusive of sockeye salmon. Catches at the mouth of the Skagit, while important, represents only a small portion of the river's total contribution toward the Puget Sound catch.

Table A-5

AGRICULTURAL TRENDS

Item	1940	1954	1959
General			
Land area in County (acres)	1,110,400	1,110,400	1,110,400
Number of farms	3,242	2,352	1,740
Land in farms (percent)	13.8	13.6	12.8
Average size of farms (acres)	47	64	82
Cropland harvested (acres)	59,461	56,219	58,396
Rural farm population	12,285	10,480	5,516
		(1950)	
Total County population 1/	37,650	43,273	51,350
Cash farm income (in $1,000)			
Value of all farm products sold	3,632	12,023	15,891
Value of all livestock & livestock products sold	2,432	6,863	9,168
Dairy products	1,550	4,478	5,551
Poultry & products	560	1,126	1,576
Other 2/	322	1,259	2,041
Value of all crops sold	1,179	5,160	6,723
Major acreage uses			
Peas (acres)	1,961	11,773	13,066
Sweet corn "	80	2,984	2,497
Seeds, bulbs "	-	1,231	1,335
Oats "	19,954	9,492	6,854
Winter wheat "	532	968	1,581
Barley "	548	149	1,748
Hay & grain for forage "	27,977	24,850	27,630
Strawberries "	554	1,156	1,108
Pastureland "	65,435	60,827	51,090
	(1945)		

1/ County population is that reported in 1940, 1950 and 1960.

2/ Includes value of all livestock and livestock products sold except dairy products and poultry and poultry products.

Source: U. S. Census of Population - 1960 General Social & Economic Characteristics. U. S. Census of Agriculture - 1959, P. 144, table 1.

Table A-6

TIMBER HARVEST AND LUMBER PRODUCTION SKAGIT COUNTY, 1949 - 1962

Year	Lumber Production (1000 board feet)	Timber harvested (1000 board feet) (Scribner Scale)	Area harvested (Acres)	Yield (1000 bd. ft. per acre)
1949	39,000	176,000	5,680	31
1950	48,400	219,000	7,020	31
1951	45,600	207,000	8,040	26
1952	48,500	157,000	8,040	20
1953	28,300	151,000	6,240	24
1954	45,400	107,000	4,230	25
1955	39,400	176,000	5,820	30
1956	43,600	126,000	4,830	26
1957	44,500	123,000	5,840	21
1958	56,500	117,000	4,430	26
1959	60,100	169,000	6,000	28
1960	67,800	178,000	6,760	26
1961	65,300	133,000	5,950	22
1962	66,100	145,000	6,220	23

Source: U.S.F.S., and Washington State Department of Natural Resources; and 1961-62 Statistical Year Book, West Coast Lumberman's Association.

Table A-7

ANNUAL COMMERCIAL SALMON CATCH SKAGIT RIVER AND BAY (In numbers of Fish)

	Species			
Years	Pink	Chinook	Silver	Chum
1956	-	11,747	14,876	1,218
1957	58,702	10,112	6,919	1,589
1958	-	12,161	32,302	32,749
1959	69,425	12,115	14,307	27,947
1960	-	17,054	10,053	4,297
1961	104,407	24,090	37,801	8,995
Ave. 1935-55	148,598	-	-	-
Ave. 1935-60	-	23,425	32,553	26,668

Source: Dept. of Fisheries, State of Washington. 1961 Fisheries Statistical Report.

The larger portion of the Skagit River salmon catch is processed at LaConner and Anacortes. These plants also process considerable amounts of fish from other areas of Puget Sound and offshore waters. In addition, bottom fish, crab and tuna are processed. Crab landings in the Skagit Bay area have averaged 30,000 to 40,000 in recent years.

Sport fishing on the Skagit River is heavy, with the emphasis during the months of July to October. Table A-8 presents the sport catch of salmon in or near the Skagit River.

Table A-8

ANNUAL SPORT FISHERMAN CATCH

SKAGIT RIVER AND BAY

Year	Angler days*	Catch (No. of fish)
1956	10,098	801
1957	12,246	5,080
1958	40,787	4,997
1959	79,863	22,152
1960	36,781	7,382
1961	63,998	55,221
1962	20,038	2,285

Source: Washington State Department of Fisheries.

* Angler-day is defined as any day or portion thereof spent fishing by one person.

7. MINERAL RESOURCES AND INDUSTRIES

Less than one percent of employed workers in the county are engaged in mining or processing of minerals. At present, the only stable employment is provided by a cement plant at Concrete. The value of mineral production in Skagit County totaled $3.5 million in 1960. Included in this total were cement, sand and gravel, stone, olivine, talc and soapstone, strontium and chronite. 1/ Occurrence of silica, basalt, slate, pumicite, graphite, low grade manganiferous magnitite iron ore, nickel, gold, silver, copper and zinc are known to exist, but the extent of deposits has not been evaluated. Mineral industries probably

1/ Twentieth Biennial Report of the Department of Conservation and Economics, State of Washington, July 1, 1958 - June 30, 1960, page 72.

will continue to be based on non-metalics, of which limestone quarrying and cement manufacture will remain foremost. Sand, gravel and basalt rock will be utilized on a limited basis. Prospects for expanded production of talc and silica appear to be promising. Further production of other minerals requires a combination of conditions, such as low cost water transportation, roads into wilderness areas, development of markets for these products, and, for some of the ores, technological improvements in metal extraction processes.

8. MANUFACTURING INDUSTRIES

While forest, agricultural and fisheries industries provided the chief source of employment and income during the settlement and development years prior to 1940, increasing diversification in manufacturing has characterized growth during the past two decades. The cement plant at Concrete, which occupies a 40-acre site, was one of the earliest to be established. This plant, operated by the Lone Star Cement Corporation, has a daily capacity of 6,000 barrels of raw cement. The corporation owns 336 acres of lime rock in the vicinity and operates a hydroelectric plant at Bear Creek to supply part of its power requirements.

The Skagit Steel and Iron Works was founded in 1902 at Sedro Woolley. This plant was initially a foundry and machine shop to repair sawmill and heavy logging equipment. The company is now the largest foundry and machine shop in northwestern Washington for the repair and manufacture of sawmill and heavy logging equipment.

Construction of two refineries and a petrochemical plant at Marches Point between Anacortes and Mount Vernon provided the stimulus for renewed activity during the past decade. Table A-9 shows comparative statistics on employment, payrolls and value added. The value added in manufacture, per worker and man-hour, in Skagit County compares favorably with the State and with neighboring counties.

9. TRANSPORTATION

Anacortes has a harbor deep enough to accommodate ocean-going vessels. A second deepwater harbor, used primarily by the petroleum industry, is located at Marches Point. In 1960 a total of 7.7 million tons of foreign and coastwise traffic passed through Anacortes, and 41,100 tons of coastwise or internal shipments moved up and down the Skagit River. The bulk of river traffic in recent years has consisted of rafted logs. Major commodities moving over the docks at Anacortes consist of petroleum, forest and fish products, chemicals, sand and gravel.

Table A-9

MANUFACTURING IN SKAGIT COUNTY IN COMPARISON

WITH THE UNITED STATES, STATE AND NEIGHBORING COUNTIES - 1958

	1/ United States	Washington State 2/	Skagit County	Snohomish County	Whatcom County	King County
All Employees						
Number	15,964,000	212,049	3,347	9,220	3,982	105,070
Payrolls ($1,000)	77,983,000	1,157,119	17,828	44,183	21,515	611,254
Production workers						
Number	11,644,000	157,260	2,674	7,928	3,546	71,175
Man hours (1,000)	22,633,000	305,811	5,254	14,727	6,633	142,017
Wages ($1,000)	49,504,000	761,376	13,036	35,345	16,830	351,267
Value added by manufacture ($1,000)	$141,270,000	2,166,632	41,036	104,899	53,944	959,964
Value added per man-hour	$7.24	$7.09	$7.81	$7.12	$8.13	$6.76
New capital expenditure ($1000)	9,076,000	160,445	51,965	7,382	1,708	49,395

1/ Statistical Abstract of the United States 1961.

2/ Washington, 1958 Census of Manufacturers, U. S. Department of Commerce, Bureau of the Census.

Prior to construction of roads and railroads, the Skagit River provided the principal means of transportation through the basin. Water transport is now considered impractical for extensive year round traffic upstream from Mount Vernon because periods of low streamflow result in water depths of less than three feet over shoals, and because of severe bank erosion. Downstream from Mount Vernon, the river has an extremely irregular, unmarked channel which separates into two forks. The North Fork carries 85 percent of the traffic. River traffic must move over the flats at the mouth of the Skagit River during medium or high tides. Total ton-miles traveled on the river has declined steadily from 3,856 in 1950 to 452 in 1962.

The main coastal railroad and highway routes from British Columbia to California pass through the western part of the county. The Great Northern

and Northern Pacific Railways between Seattle, Washington, and Vancouver, British Columbia, pass through Mount Vernon and Burlington, as does U. S. Highway 99, a recently improved throughway. Construction is underway on an east-west highway across the rugged Cascade Mountains to eastern Washington. This important inter-tie will be completed in several years. There are five airfields within the basin, but no commercial air service is available.

10. HYDROELECTRIC POWER DEVELOPMENT

Hydroelectric power has been developed in the Skagit River basin by the city of Seattle, the Puget Sound Power and Light Company, and the Lone Star Cement Corporation.

Seattle City Light has constructed three power dams. Ross Dam, completed in 1949 at River Mile 105, has a watershed of 900 square miles and a reservoir capacity of 1.2 million acre-feet. Impounded water is used for the powerplant and to supplement low flows of the Skagit River for the powerplants at Diablo and Gorge Dams downstream. The installed capacity of Ross Dam now totals 360,000 kw. Diablo Dam was completed in 1930 at a point about five river miles below the present Ross site. Hydro units built in 1936 and 1958 provide a capacity of 159,000 kw. Gorge Dam, about four miles downriver from Diablo Dam, was completed in 1961 and has an installed capability of 175,000 kw.

Powerplants on the Baker River, owned by the Puget Sound Power and Light Company, provide Skagit County with electrical service. The first plant, completed in 1927 at a site near the mouth, has an installed capability of 106,000 kw. The second unit at Baker Lake, eight miles north and upstream of the first unit, was completed in 1959 with a 94,000 kw. capability.

The Lone Star Cement Corporation has two small plants on Bear Creek, a tributary of the Baker River. These plants have a combined capacity of about 1,000 kw., and are operated to service the cement plant at Concrete.

11. WATER SUPPLY

The maritime air masses from the Pacific Ocean have a great influence on the precipitation in the Skagit River basin. As shown in Appendix B, normal annual basin precipitation above Sedro Woolley is 93.5 inches. However, total annual precipitation varies from 113 inches at Silverton to 26 inches at Anacortes. This precipitation produces an average annual discharge at Mount Vernon of 16,332 c.f.s., or a total average annual runoff of 11.8 million acre-feet. There is a seasonal shortage of precipitation during the months of April through September. Because of this shortage, some reservoir storage

for future water supply needs is required. Currently sufficient storage is provided naturally in the form of snow and ice packs. Additional manmade storage will be required to meet future water supply requirements.

The delta of the Skagit River has groundwater supply for current needs with some test wells producing over 500 g.p.m. However, the groundwater supply in the upper Skagit River basin is limited due to the close proximity of bedrock to the surface.

The current problem of usable fresh water is quality not quantity. Forty percent of the 51,000 people living in Skagit County in 1960 were concentrated in three centers: Anacortes, Mount Vernon, and Sedro Woolley. Pollution from these towns and industrial wastes from plants along the rivers are factors of considerable impact on the supply of usable fresh water.

SECTION 2 - FLOOD DAMAGE BENEFITS

12. FLOOD DAMAGES

The discharge damage curve shown on plate A-1 was developed from the flood damage appraisals described in paragraph 39 of the report. This relationship is based on 1963 prices and conditions. Damages were related to frequency (plate B-10) and the damage-frequency curve was developed on plate A-3. From this total, average annual damages without future growth are estimated to be $2,216,000. Figures A-1 to A-4 illustrate effects of flooding in the delta area.

13. FLOOD DAMAGE BENEFITS

The effects of the Avon Bypass and the downstream levee and channel improvements were plotted on the damage-frequency curve (plate A-3). Without future growth, the annual reduction in damages by the Avon Bypass and downstream levee and channel improvements was found to be $1,248,000 and $496,000, respectively. This would leave an annual residual damage of $472,000.

The annual growth rate in the flood plain, without flood control improvements, was estimated to be 1.4 percent. This growth rate was discounted by present worth methods at an interest rate of 3-1/8 percent for 50 years, and an equivalent annual growth factor of 1.33 was derived. This growth factor was applied to the estimated reduction in damages, at 1963 prices and conditions, that would result from construction of the Avon Bypass and downstream levee and channel improvements. On this basis, the average annual reduction of damage at 1963 prices and future conditions was $1,660,000 for the Avon Bypass and $660,000 from downstream levee and channel improvements.

14. LAND VALUE CHECK

The flood control evaluation of agricultural damages was checked with land values pursuant to EM 1120-2-111. A real estate evaluation showed that the agricultural land values in the Skagit River basin would increase from a present value of $400 per acre to about $850 per acre with further protection against floods. Based on 6 percent net return, the annual benefits per acre from flood control are approximately $27, yielding a total annual net increase of $1,802,000 for 66,730 acres of farmland. The flood control appraisal evaluated annual damages to these agricultural lands at $1,940,000. Comparing this with the increase net return provides a reasonable check on the relationship of flood damages and flood control benefits.

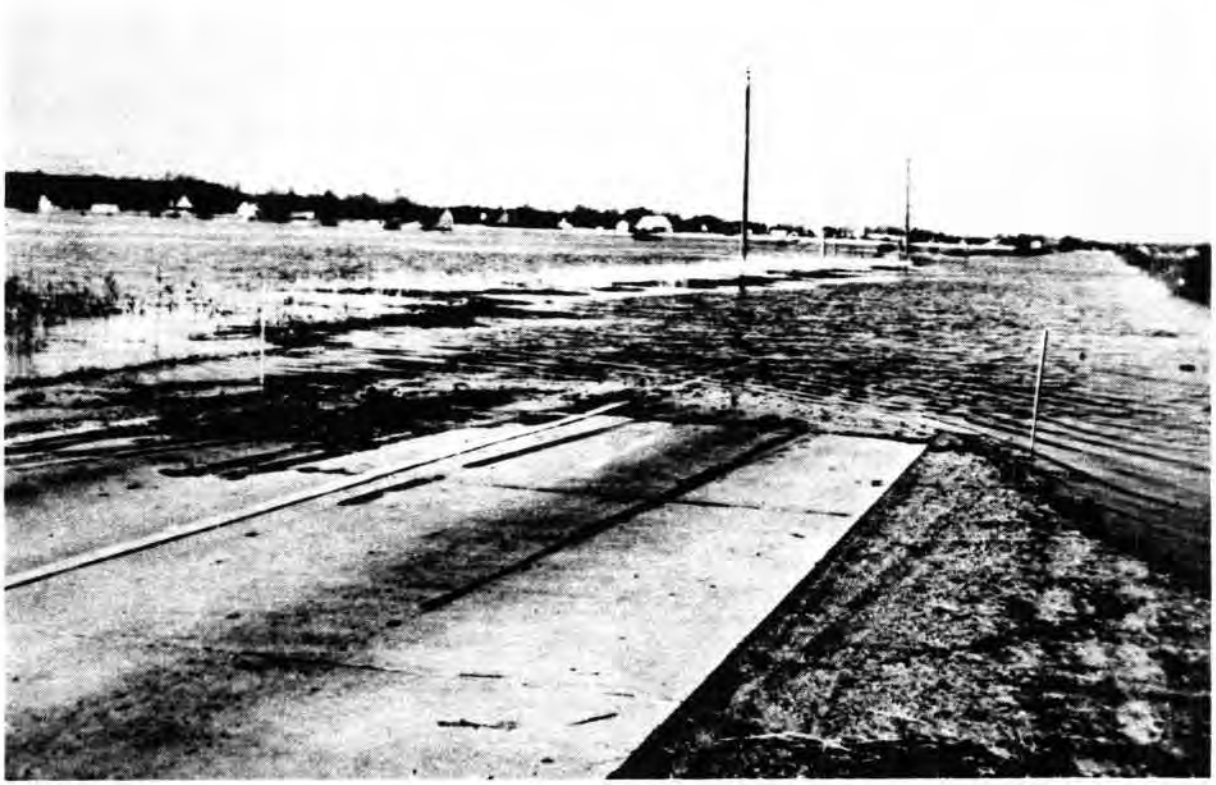


Fig. A-1. Flood water backed over Highway 99 about six miles south of Mount Vernon in February 1951. The highway was closed to traffic for seven days because of the resulting damages. (Soil Conservation Service Photo)

Fig. A-2. Erosion damage to Burlington water main and State Highway 1 between Burlington and Sedro Woolley caused by the February 1951 Flood. (Soil Conservation Service Photo)

Fig. A-3. Maintenance crew preparing to rebuild a section of the Great Northern mainline south of Conway, washed out during the November 1949 Flood. (Soil Conservation Service Photo)

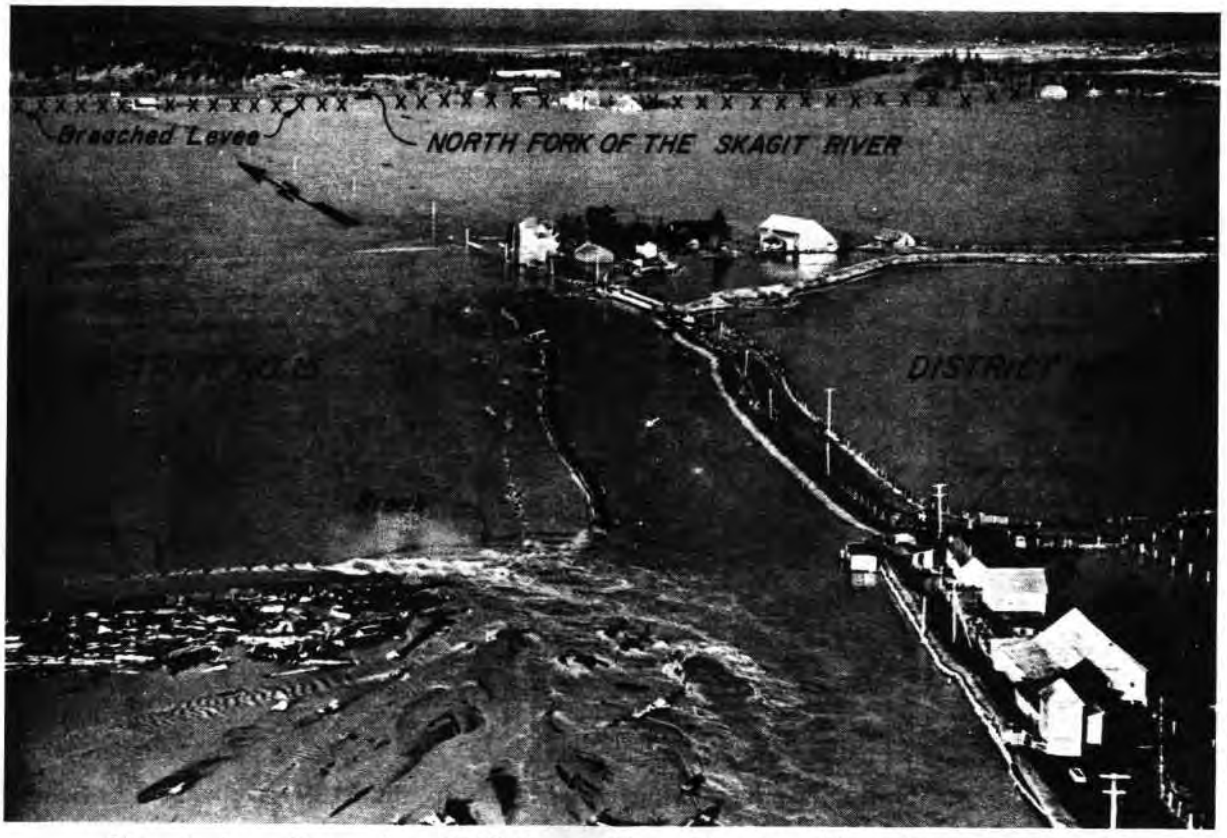


Fig. A-4. November 1949 Skagit River Flood. (Seattle Times Photo)

15. LEVEE AND CHANNEL IMPROVEMENTS FIRST ADDED

Flood control benefits were evaluated considering the levee and channel improvements without the Bypass. This is discussed in paragraph 44 of the report. The study assumed that the levees would be constructed prior to other river improvements and that they would be capable of containing 120,000 c.f.s. (Mount Vernon gage). The discharge-damage curve shown on plate A-2 was developed from the flood damage appraisals and is plotted under natural conditions and 1963 prices. From this curve and the discharge-frequency curve on plate B-10, the damage-frequency curve was developed. This curve is shown on plate A-4. One curve shows damage under natural conditions, another shows damage with the levees in operation. The total average annual damages without future growth are estimated to be $2,216,000. The annual reduction in damages from the levee and channel improvements would be $584,000. This would leave an annual residual damage of $1,632,000. By applying a growth factor of 1.33 to the reduction in damages, annual benefits of $780,000 are creditable to the levees and channel improvements under a first added analysis.

16. LEVEE AND CHANNEL IMPROVEMENTS FIRST ADDED CONSIDERED INCREMENTALLY

The leveed area downstream of the Avon Bypass was divided into three areas, and damages and benefits for each incremental area were developed. Area 1 contains approximately 7,000 acres of agricultural land and includes the towns of Mount Vernon and Conway, Washington. Area 2 is along the left bank of the North Fork and the right bank of the South Fork and contains approximately 6,000 acres of agricultural land. Area 3 includes the town of Avon and part of Mount Vernon and approximately 22,000 acres of agricultural land. Plate A-7 shows discharge-damage curves for each area under natural conditions and 1963 prices and under conditions when the levees are protecting to 120,000 c.f.s. From these curves and the discharge-frequency curves on plate B-10, the damage-frequency curves were developed for each area. Plate A-8 shows that average annual damages for Area 1 are $388,300. The benefits creditable to the levees in this area excluding future growth are $92,000. The average annual damages for Area 2 are shown on plate A-9 to be $631,000 and the benefits to the levees are $309,000. For Area 3, the average annual damages are shown on plate A-10 to be $1,064,000 and the benefits to the levee protection are $179,000.

17. LEVEE AND CHANNEL IMPROVEMENTS LAST ADDED TO THE AVON BYPASS

Flood control benefits were evaluated by considering construction of the levee and channel improvements after construction of the Bypass. This is discussed in paragraph 46 of the report. The study assumed that the Bypass would be built prior to construction of the levees and would begin operation when the river reached 84,000 c.f.s. (Mount Vernon gage). Levees capable of containing flows of 120,000 c.f.s. would be improved after the Bypass had been constructed. The discharge-damage curve shown on plate A-1 was developed from the flood damage appraisals and is plotted under natural conditions and 1963 prices. From this curve and the discharge-frequency curve on plate B-10, the damage-frequency curve was developed. This curve is shown on plate A-5. One curve shows damages under natural conditions, another shows damage with the Bypass in operation, and another shows damages with both the Bypass and levees in operation. The total average annual damages without future growth are estimated to be $2,216,000. The annual reduction in damages from the Bypass would be $1,596,000. The levees last built would reduce damages an additional $148,000, leaving an annual residual damage of $472,000. Applying a growth factor of 1.33 to the reduction in damages credits the Avon Bypass with average annual benefits of $2,123,000 attributable to flood damage prevention and the levees with $197,000 average annual flood control benefits.

18. LEVEE AND CHANNEL IMPROVEMENTS LAST ADDED TO UPSTREAM STORAGE AND AVON BYPASS

To fully evaluate the levee and channel improvements, they were considered last added to 250,000 acre-feet of flood control storage on the Sauk River and flood flow diversion of 60,000 c.f.s. through the Avon Bypass. The levees would be improved to contain a riverflow of 120,000 c.f.s., measured at the gage near Mount Vernon. The damage-frequency curves shown on plate A-11 were developed from flood damage appraisals and the discharge-frequency curve shown on plate B-10 (Curve D). Damage-frequency curves are shown for damages under natural conditions, damages with the Sauk Dam and the Bypass, and damages still occurring after the Sauk Dam, the Avon Bypass, and the levees have been improved. The total average annual damages without future growth are $2,216,000. The reduction in annual damages for the Sauk Dam and Avon Bypass are $2,026,000. As last added, the benefits to the levee and channel improvements would be $24,000. This would leave an annual residual damage of $166,000. Including future growth of 33 percent over the 50-year life of the project, the benefits to the levee and channel improvements would be $31,900. In addition, land enhancement benefits of $825,000 annually as shown in paragraph 20 would be realized by the levee and channel improvements for this condition.

19. AVON BYPASS LAST ADDED TO UPSTREAM STORAGE AND LEVEE AND CHANNEL IMPROVEMENTS

Flood control benefits were evaluated considering provision of upstream storage and improvement of levees and channel prior to construction of the Bypass. The study assumed that 250,000 acre-feet of storage would be provided in the Sauk River valley and that levee and channel improvements on the Skagit River capable of containing flows of 120,000 c.f.s. would precede construction of the Bypass. The Bypass would then be placed in operation when river flows reached 100,000 c.f.s. (Mount Vernon gage). The discharge-damage curve shown on plate A-2 was developed from the flood damage appraisals and is plotted under natural conditions and 1963 prices. From this curve and the discharge-frequency curve on plate B-10, the damage-frequency curve was developed. This curve is shown on plate A-6. Curves show damages under natural conditions, with Sauk River Dam storage, with Sauk River Dam storage plus levees and channel improvements, and with Sauk River Dam storage plus levees plus the Avon Bypass. The total average annual damages without future growth are estimated to be $2,216,000. The annual reduction in damages from the Sauk River Dam would be $1,551,000. Inclusion of the levee and channel improvement would reduce damages $188,000 annually. As last added, the Bypass would reduce average annual damages $406,000. This would leave annual residual damages of $71,000.

20. LAND ENHANCEMENT

Provision of levee and channel improvements and Sauk River valley storage would reduce the frequency of flood to about once in every 25 years, which is adequate for full agricultural development. The change in agricultural land values results primarily from prevention of flood damages. Inclusion of the Avon Bypass would further reduce the frequency of flooding to about once in every 100 years. As conversion of land to urban and industrial use requires protection against flooding for about 75 to 100-year frequency, this degree of protection would be provided by the Avon Bypass as last added to levee and channel improvements and upstream storage, and also by the levee and channel improvements last added to upstream storage and the Avon Bypass. With this degree of protection, an expansion of the urban areas of Burlington, Mount Vernon and LaConner can be forecast. An adequate measurement of this growth requires an economic base study of the Puget Sound region because of the inter-relation of the Skagit basin to the economy of the whole region. A study of this magnitude is beyond the scope of this report. Accordingly, a forecast was made on the basis of a real estate appraisal. The change in land use values from agriculture, under present conditions, to urban and industrial, protected against floods of 100-year frequency, is estimated to be:

	In 20 Years	In 50 Years
Increased urban and industrial acreage	1,250	3,200
Increased value	$16,500,000	45,600,000
Increased annual income at 6 percent	990,000	2,740,000
Increased annual income from flood control (60 percent related to lands and 40 percent related to future improvements)	594,000	1,644,000

The total present worth at 3-1/8 percent of increased annual income from flood control enhancement for the 50-year life is $22,455,000. The average annual equivalent of the land enhancement from flood control at 3-1/8 percent is $893,600. The enhancement due to the prevention of flood damages on this land is estimated to be $69,000 annually. The net annual enhancement from protection against 100-year frequency floods is $893,600 less $69,000, or $824,600 annually. This estimate was rounded to $825,000 for the purpose of this report. If built as last added to levee and channel improvements and upstream storage, the average annual benefits creditable to the Avon Bypass for flood prevention would be $825,000 for land enhancement and $540,000 for flood damage prevention based upon a 50-year economic life and including future growth and developments. If the levee and channel improvements were built as last added to upstream storage and the Avon Bypass, the average annual benefits to them would be $31,900 for flood prevention including 50-year growth, and $825,000 for land enhancement, giving a total benefit of $856,900.

21. AREA REDEVELOPMENT BENEFITS

Since Skagit County is classed as an area of chronic unemployment by the Area Redevelopment authorities, an amount of benefits can be claimed by the levee and channel improvement project for relief of this unemployment. Based on information from several construction companies in the area, it was estimated that approximately 85 percent of the labor used in project construction would come from the local area and would otherwise be unemployed. Their salaries were estimated to total $926,000. There are no new operations and maintenance costs associated with the levee and channel improvement project. The average annual area redevelopment benefit for the 50-year life of the project based on the labor salaries of $926,000 would be $37,000.

SKAGIT RIVER, WASHINGTON

Information called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

Problems considered: The lower river flood plain of the Skagit River downstream from Sedro Woolley, Washington, occupies 68,000 acres of the deltas of the Skagit and Samish Rivers, and comprises 75 per cent of the total flood plain. The deltas are highly developed for agriculture, and include the communities of Mount Vernon and Burlington. The present diking system in this area protects against floods with an expected recurrence interval of only once in 3 to 14 years, corresponding to flows of 91,000 to 143,000 c.f.s. Average annual flood damages under present day conditions are estimated to be $2,216,000.

The Avon Bypass, a diversion channel to substantially reduce flows of the lower Skagit River during flood periods, was authorized as a local flood protection project in the 1936 Flood Control Act. Local interests were unable to furnish the requirements of local cooperation and the project was classified inactive in 1952. Present studies have established that the Bypass is an important element of a basin flood control plan which includes the recommended improvements and future development of upstream storage. Responsible local support for the Bypass project has now developed and evidence has been received that the local cooperation requirements may be satisfied. Accordingly, a plan of flood control improvements has been developed for the lower river which includes the Bypass as a consideration.

Recommended improvements: Improvements proposed in the main report concern both flood control and recreation facilities. The flood control improvements would increase the minimum flow capacity of the existing diking systems to 120,000 c.f.s. The improvements would be accomplished by raising and strengthening the existing levee system and by channel widening. Levee modifications total about 34 miles on both banks, including the main river and its north and south fork distributaries. The channel widening totals about 2.7 miles in length, including about 2.0 miles covering two locations on the North Fork and 0.7 miles on the South Fork.

The report also proposes modification of the proposed Avon Bypass project, as authorized in the Flood Control Act of 1936. The modification would permit addition of recreation to the Avon Bypass as a project purpose. If the Bypass and the proposed levee and channel improvements are constructed, a high potential for recreation development would occur in the Bypass. The responsibility for recreation development would be primarily with local interests. However,

authority to permit additions to and modifications of Federally constructed features for usage in a recreation development is essential. Proposed recreation improvements consist of construction of boat launching facilities along the Bypass for development of a resident fishery; and a boat launching facility for access to the Bypass outlet channel and to Padilla Bay for waterfowl hunting and fishing.

Project costs and economic analysis: The total first cost of improvements, based on July 1964 price levels, are:

First Costs	Flood Control (Levee & Channel Improvements)	Recreation (Avon Bypass)
Federal	$5,770,000	$34,500
Non-Federal	237,000	34,500 1/
Total	$6,007,000	$69,000

1/ Non-Federal responsibilities also include stocking and operation and maintenance of fishery facilities, which costs are not included as an initial construction cost.

In determining annual costs for the basic report, a 50-year economic life was assigned to the levee and channel improvements because they would provide main line levee protection and are an essential element of a plan to provide long term flood protection in the lower river flood plain. Other elements of the plan are the Avon Bypass and upstream storage or an equivalent development.

In order to compute annual charges for a 100-year analysis, the physical life of the levee and channel improvements was insured by inclusion of a $3,000,000 major replacement cost at the end of the first 50 years. The annual charges for the flood control and fish and wildlife improvements based on 50- and 100-year economic lives are:

Annual charges (50-year)	Flood Control	Recreation
Federal	$229,600	$ 1,400
Non-Federal	14,900	14,500
Total	$244,500	$15,900
Round to	$245,000	$15,900

Annual charges (100-year)	Flood Control	Recreation
Federal	$189,000	$ 1,128
Non-Federal	28,900	15,932
Total	$217,900	$17,060
Round to	$218,000	$17,100

Operation and maintenance costs of the existing levee system would be reduced much more by the flood control improvements than the operation and maintenance costs of the improvements; therefore, the non-Federal annual charges for flood control do not include operation and maintenance costs. Non-Federal annual charges for the recreation facilities include $7,500 for stocking of the resident fishery, rights-of-way, operation and maintenance, and major replacements.

Benefits and benefit-to-cost ratio: Benefits of the recommended levee and channel improvements have been evaluated as part of a basin plan for flood control which includes the authorized Bypass project. In addition, the recommended improvements have been tested as last added to the Bypass project to assure feasibility. Flood control benefits are estimated to be $660,000 annually on 1963 prices and forecasted future development over the life of the project. In addition, construction of the levee and channel improvements would reduce the frequency of discharges through the Avon Bypass project, making possible the development of a resident fishery in the Bypass channel. Accordingly, the excess benefits of the resident fisheries have been distributed equally between the Bypass project and the levee and channel improvements. The U. S. Fish and Wildlife Service has estimated that the gross benefits from the resident fishery would be about $195,000 annually. The excess fishery benefits attributable to the levee and channel improvements are $91,000 annually.

Total annual benefits of $751,000 for the levee and channel improvements compared with annual charges of $245,000 yield a benefit-to-cost ratio of 3.1, based on an economic life of 50 years. Based on an economic life of 100 years, total annual benefits of $891,000 compared with annual charges of $218,000 yield a benefit-to-cost ratio of 4.1.

The Avon Bypass project for flood control is well justified economically and has a benefit-to-cost ratio of 1.6, based on an economic life of 50 years. Additional benefits would accrue to the project from the resident fishery and from the waterfowl hunters and fishermen using the project as access to Padilla Bay. The total incremental first cost of these added purposes in the Bypass project is $69,000. Comparison of incremental annual benefits of $110,200 to incremental annual costs of $15,900 yield a benefit-to-cost ratio of 6.9,

based on a 50-year economic life. Based on an economic life of 100 years, the incremental annual benefits of $132,500 compared with the incremental annual costs of $17,100 yield a benefit-to-cost ratio of 7.7.

Other project effects: The recommended flood control improvements would help to eliminate the need for evacuation of families under difficult conditions and the inconvenience caused by delays and detours resulting from flooding of highways and railways. The recommended improvements as part of a comprehensive basin plan for flood control could also result in a savings of life during flood periods. In addition, the improvements would substantially reduce secondary economic losses incurred as a result of flooding of metropolitan areas. Indirect flood control and recreation benefits would extend to some degree, to the entire state and nation.

Current and future needs: The lower Skagit River flood plain is one of the most highly developed agricultural and urban areas in the Puget Sound region. There is an outstanding potential for future development as well as for substantial flood damage in the basin. The recommended flood control improvements constitute an important first step in achieving a basin plan of water resources development which could provide a high degree of flood control, as well as many other benefits. Future water resource needs of the basin will be concerned with added water supply, recreational development, hydropower development and management of the important fishery resource of the Skagit River basin. The Puget Sound region needs a rapidly expanding recreational program to satisfy a growing population. The authorized Bypass project would be well located near major highways. Addition of recreation to the Bypass would provide a large capacity and versatile facility to readily serve the Skagit basin communities, as well as metropolitan areas from Bellingham to Seattle.

Cost apportionment and local cooperation: All of the construction costs of the recommended flood control improvements are allocated to the Federal Government, in accordance with established policy on local flood protection projects. Local interests will be required to: furnish all lands, easements and rights-of-way, and relocate roads and utilities necessary for construction; operate and maintain the project in accordance with regulations prescribed by the Secretary of the Army; and agree to hold and save the United States free from damages due to construction of the project. As a matter of interest, the proposed flood control improvements would add to an existing levee system in which state and local interests have invested more than $5,600,000 to 1963.

Construction costs for the recommended recreation improvements of the Avon Bypass allocated to the Federal Government are only for modification of project connected flood control facilities. Local interests will be required to: furnish 50 per cent of the first cost of the improvements, secure water rights and relocate all roads and utilities necessary for construction and

operation of the added project purposes; maintain, operate, police and develop the project in a manner necessary to realize the benefits claimed; submit plans for any additional recreation development to the Secretary of the Army for approval and determination of the Federal interest prior to construction.

Extent of interest in the projects: Local interests have expressed approval of the proposed improvements and officials of Skagit County have indicated their willingness and ability to meet the requirements of local cooperation.

Alternative plans: Alternatives considered for flood control in the flood plain, include a major raising of the existing levee system; widening or deepening of the river channel to form a floodway; and widening the river at its mouth. All these alternatives have a much smaller benefit-to-cost ratio than that of the recommended plan of the Avon Bypass combined with minor levee and channel improvements.

Flood plain zoning or evacuation was also considered, but present day development of the area renders these alternatives infeasible.

Discussion: This report has been coordinated with all Federal and State agencies having an interest in the developments recommended. There have been no objections to the recommended improvements from these agencies. Federal and State agencies concerned with fish and wildlife and with general recreation have evidenced strong support for development of the recreation potential of the Bypass.

ACKNOWLEDGMENTS

The studies reported herein were made under the general direction of Colonel Charles C. Holbrook, District Engineer, and Mr. Sydney Steinborn, Chief, Engineering Division. Supervision was by Mr. Robert H. Gedney, Chief, Basin Planning Branch. Mr. Raymond A. Skrinde, Chief, Puget Sound Section was responsible for detail planning. Other engineers contributing to this study are listed below:

Project Engineer Coordination - Julius F. Bechly and Roland W. Edens.

Foundation and Materials - Hervey S. Bardsley, Glen R. Butterfield, and Robert J. Yunker.

Project Layout - Harvey L. Miller, Sidney C. Knutson, and Ted M. Uomoto.

Cost Estimates - Vincent D. Kemp, Chester I. DePew and Larry L. Nichols.

Hydraulic and Hydrologic Studies - Harvey O. Westby, George A. Lemke, Norman J. MacDonald, Richard P. Regan, JoReen Sommerseth, George D. Holmes, and John W. Seeman.

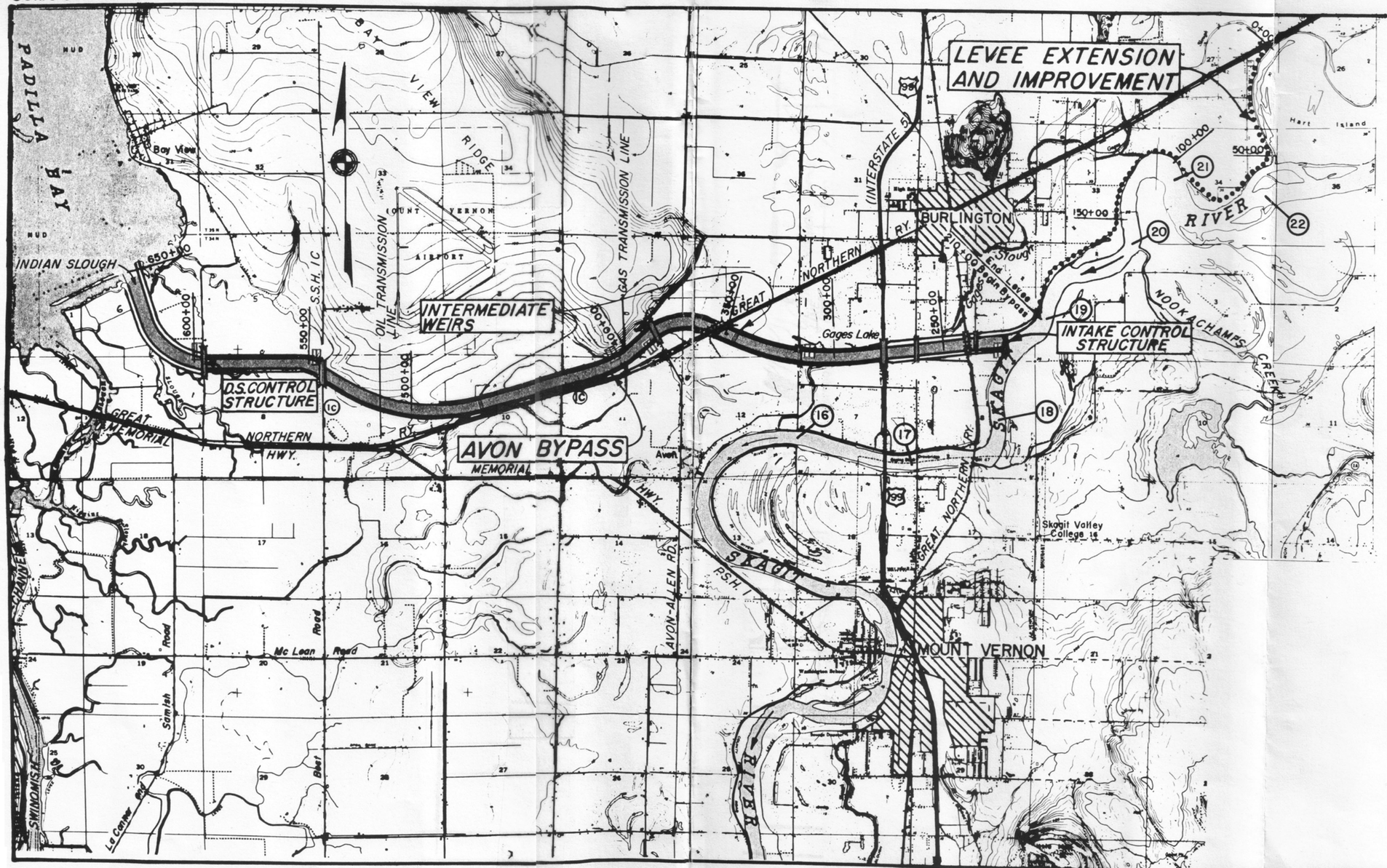
Economic Studies - Ellsworth J. Gullidge, Meyer E. Peyser, Willard W. Whipple, and Allen W. Summers.

Recreation Studies - Peter P. Denny, Richard P. Sellevold and Peter O. Hengesteg.

Real Estate - Kelvin Greenstreet and Thomas A. Doyle.

CORPS OF ENGINEERS

U.S. ARMY



VICINITY MAP

LEGEND

AUTHORIZED

BRIDGE CROSSINGS HWY. RR.

WATER AREA

LEVEE

RECOMMENDED

BOAT LAUNCHING FACILITIES

SCALE IN MILES

1 1/2 0 1

SKAGIT RIVER, WASHINGTON

AVON BYPASS

FISH AND WILDLIFE FACILITIES

In 1 sheet Sheet No.1 Scale: As shown

U.S. Army Engineer District, Seattle, Wash. March, 1965.

Prepared: R.A. Skrinde, Chief, Puget Sound Sect.

Recommended: C. Stoumbaris, Chief, Engineering Division

Submitted: R.H. Gedney, Chief, Basin Planning Branch

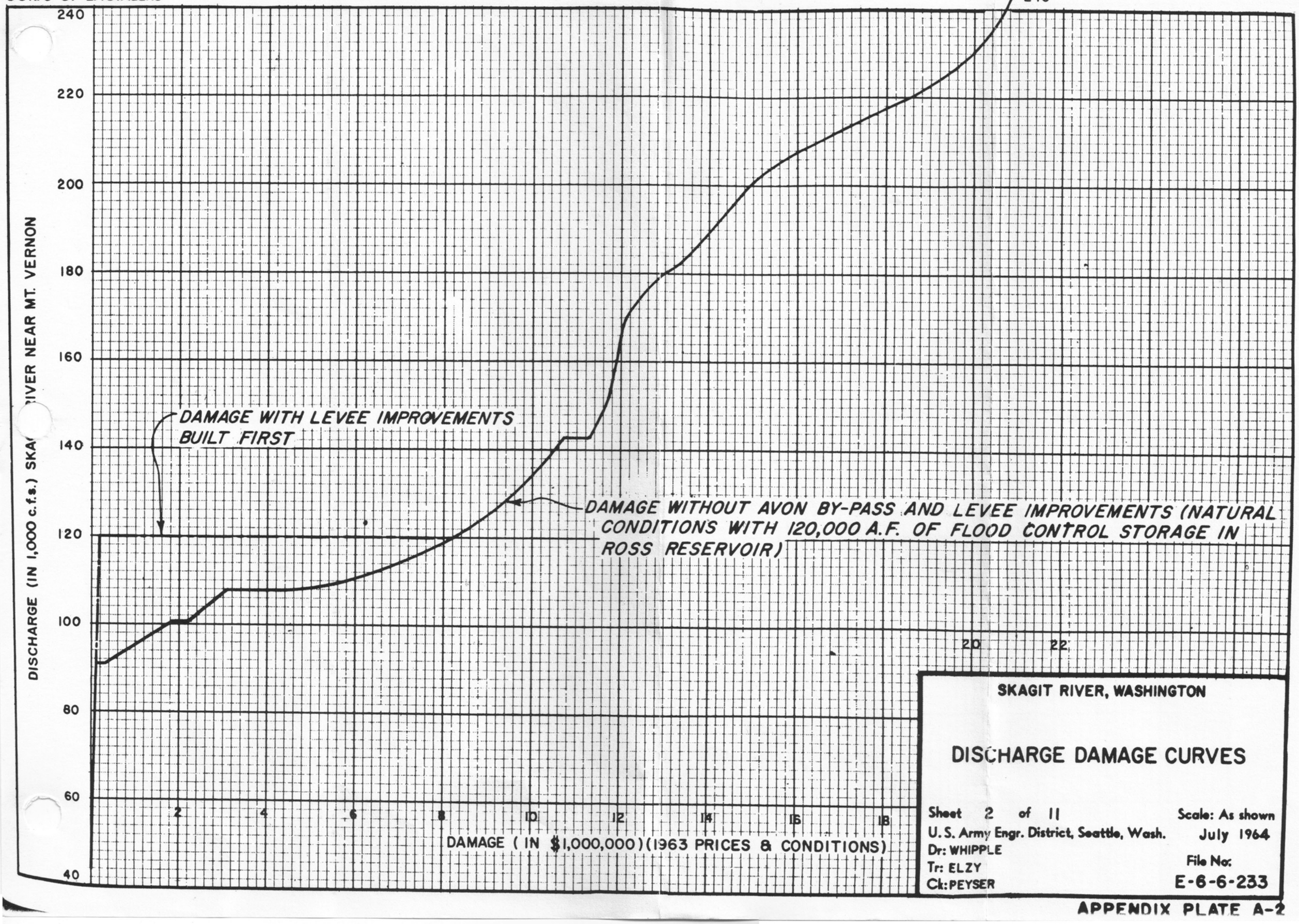
Approved: C.E. Bollroth, Colonel, Corps of Engineers

Dr: BECHLY
Tr: W.E.W., R.E.P
Ck: SKRINDE

File No. E-6-6-213

PLATE 7

CORPS OF ENGINEERS



SKAGIT RIVER, WASHINGTON

DISCHARGE DAMAGE CURVES

Sheet 2 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: WHIPPLE
Tr: ELZY
Ck: PEYSER

Scale: As shown
July 1964
File No:
E-6-6-233

APPENDIX PLATE A-2

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

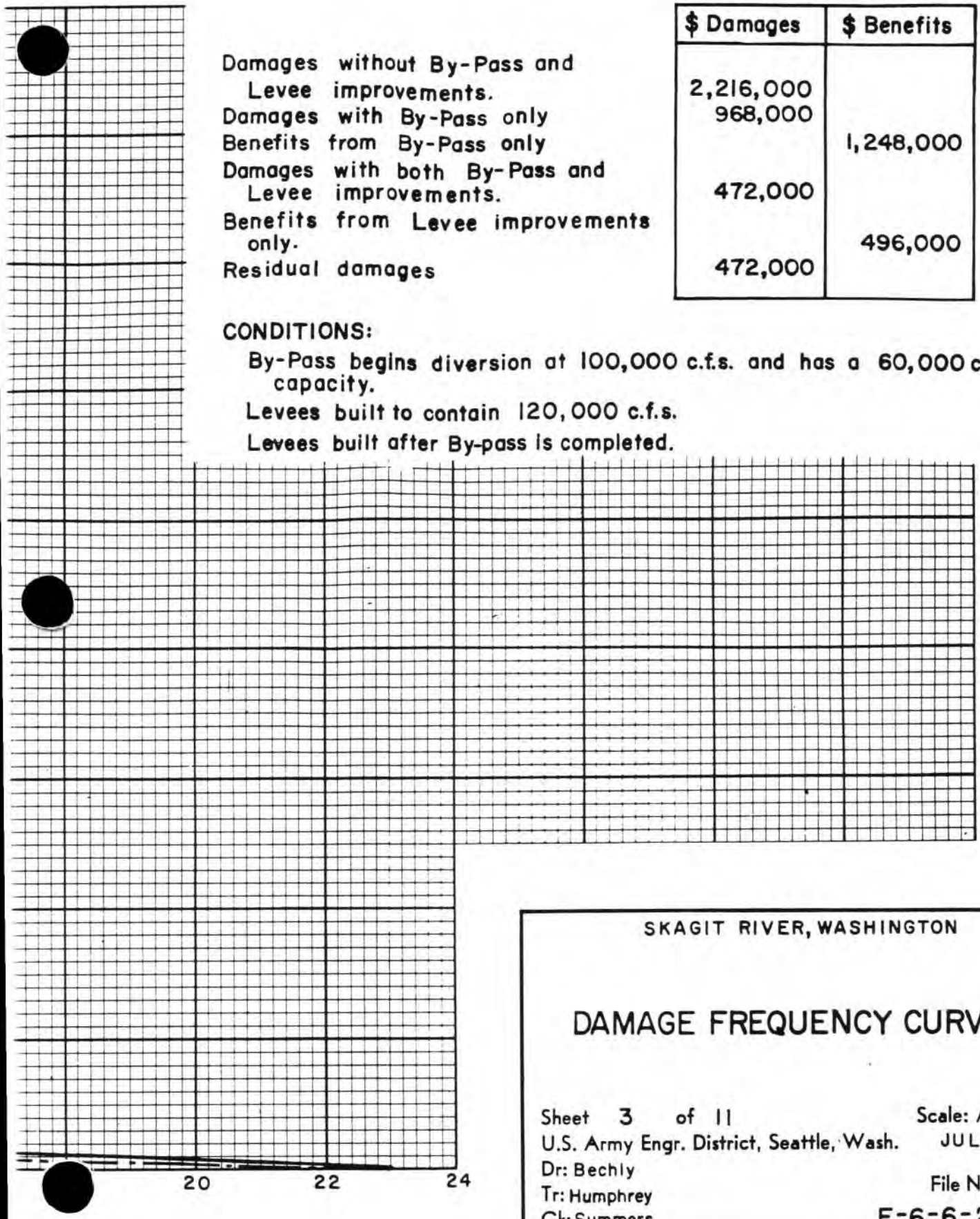
	$ Damages	$ Benefits
Damages without By-Pass and Levee improvements.	2,216,000	
Damages with By-Pass only	968,000	
Benefits from By-Pass only		1,248,000
Damages with both By-Pass and Levee improvements.	472,000	
Benefits from Levee improvements only.		496,000
Residual damages	472,000	

CONDITIONS:

By-Pass begins diversion at 100,000 c.f.s. and has a 60,000 c.f.s. capacity.

Levees built to contain 120,000 c.f.s.

Levees built after By-pass is completed.



SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES

Sheet 3 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Bechly
Tr: Humphrey
Ck: Summers

Scale: As shown
JULY 1964

File No.
E-6-6-233

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

	$ Damages	$ Benefits
Damages without By-Pass and Levee Improvements and Sauk Dam.	2,216,000	
Damages with Levees improved.	1,632,000	
Benefits from Levees only.		584,000
Damages with Levees improved and flood storage at Sauk River Dam.	546,000	
Benefits from Sauk Dam only.		1,086,000
Damages with Levees improved, flood storage at Sauk River Dam & Avon By-pass in operation.	140,000	
Benefits from By pass only.		406,000
Residual damages	140,000	

CONDITIONS:

Levees built to contain 120,000 c.f.s.
250,000 A.F. of flood control storage is provided in the Sauk River
The Avon By-Pass will be built after the levees and dam and will begin operation at 100,000 c.f.s. and have a capacity of 60,000 c.f.s.

(EXCEPT ROSS DAM)

-PASS BUILT LAST

20 22

SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES

Sheet 4 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Bechly
Tr: Elzy
Ck: Summers

Scale: As shown
SEPT. 1964

File No.
E-6-6-233

APPENDIX PLATE A-4

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

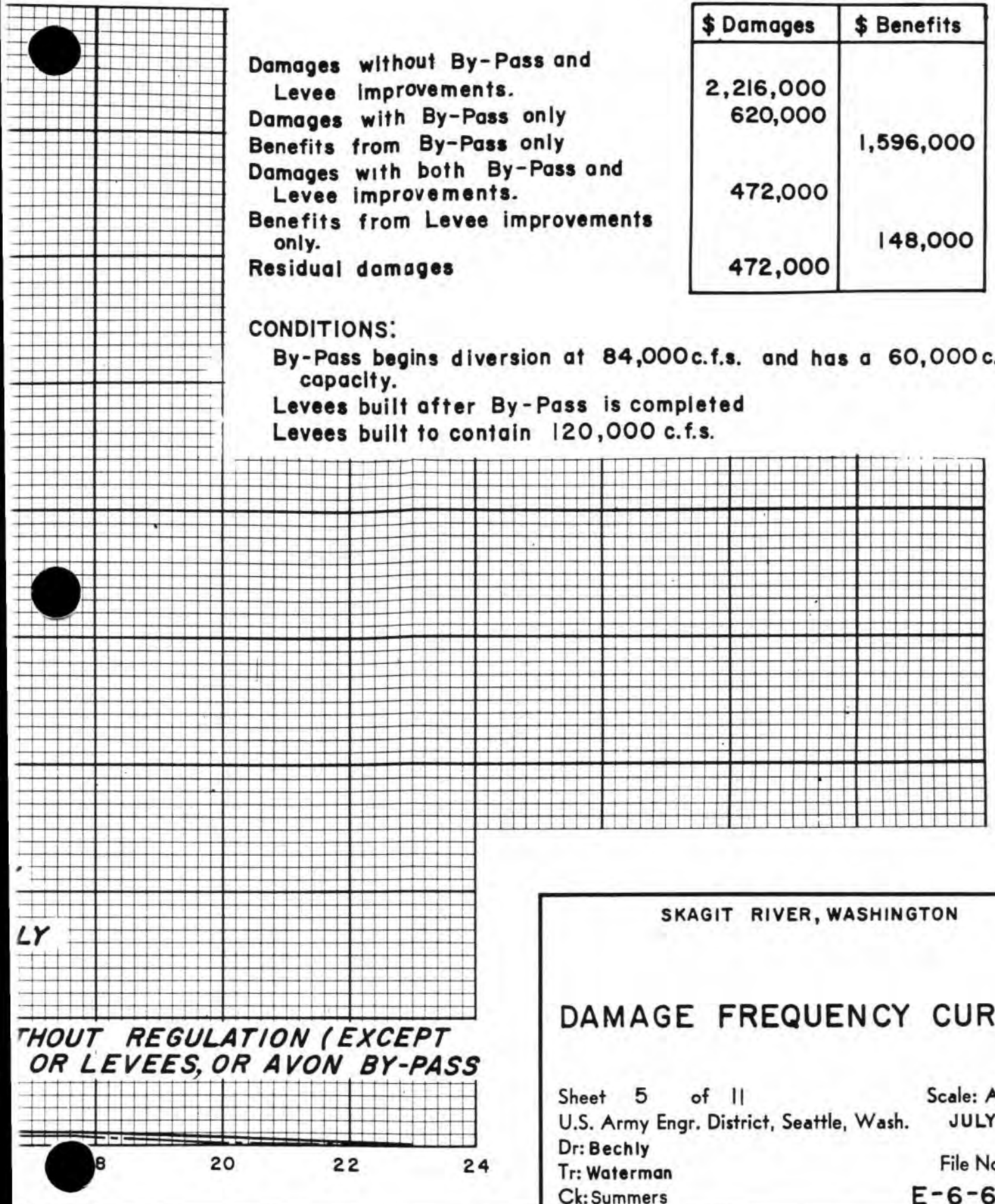
	$ Damages	$ Benefits
Damages without By-Pass and Levee improvements.	2,216,000	
Damages with By-Pass only	620,000	
Benefits from By-Pass only		1,596,000
Damages with both By-Pass and Levee improvements.	472,000	
Benefits from Levee improvements only.		148,000
Residual damages	472,000	

CONDITIONS:

By-Pass begins diversion at 84,000 c.f.s. and has a 60,000 c.f.s. capacity.

Levees built after By-Pass is completed

Levees built to contain 120,000 c.f.s.



SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES

Sheet 5 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Bechly
Tr: Waterman
Ck: Summers

Scale: As shown
JULY 1964

File No.
E-6-6-233

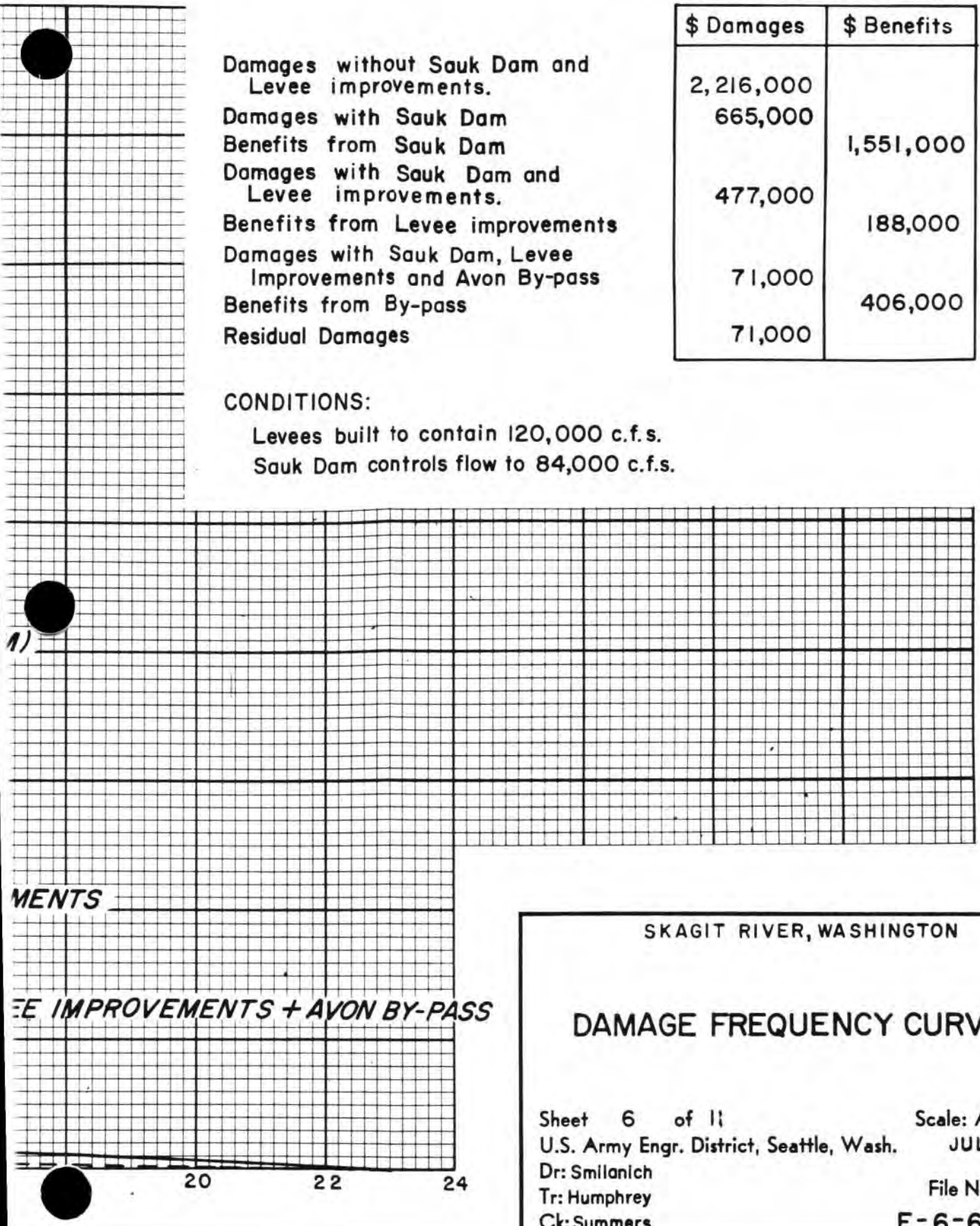
ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

	$ Damages	$ Benefits
Damages without Sauk Dam and Levee improvements.	2,216,000	
Damages with Sauk Dam	665,000	
Benefits from Sauk Dam		1,551,000
Damages with Sauk Dam and Levee improvements.	477,000	
Benefits from Levee improvements		188,000
Damages with Sauk Dam, Levee Improvements and Avon By-pass	71,000	
Benefits from By-pass		406,000
Residual Damages	71,000	

CONDITIONS:

Levees built to contain 120,000 c.f.s.

Sauk Dam controls flow to 84,000 c.f.s.



SKAGIT RIVER, WASHINGTON

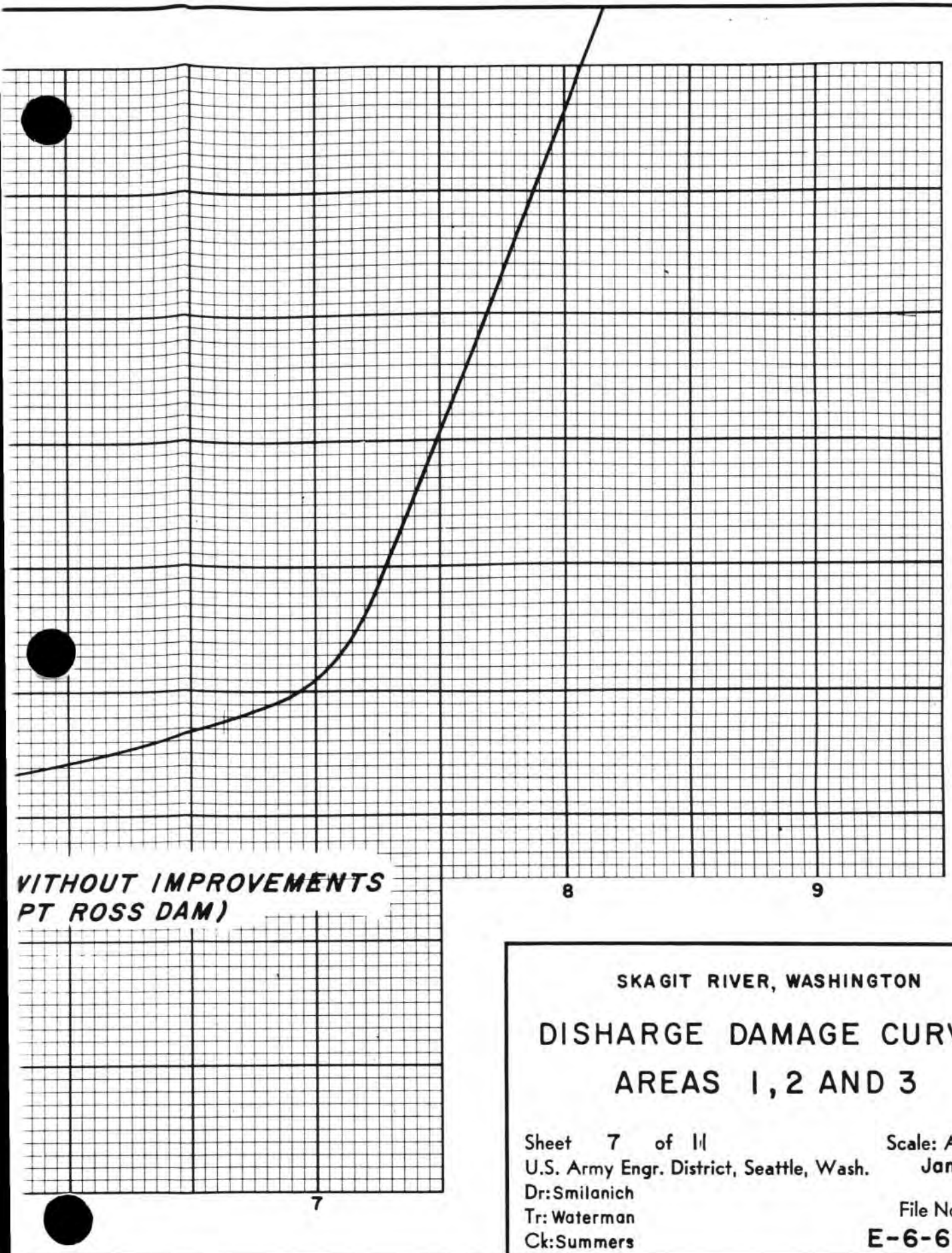
DAMAGE FREQUENCY CURVES

Sheet 6 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Smilanich
Tr: Humphrey
Ck: Summers

Scale: As shown
JULY 1964

File No.
E-6-6-233

APPENDIX PLATE A-6



SKAGIT RIVER, WASHINGTON

DISHARGE DAMAGE CURVES
AREAS 1, 2 AND 3

Sheet 7 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Smilanich
Tr: Waterman
Ck: Summers

Scale: As shown
Jan. 1965

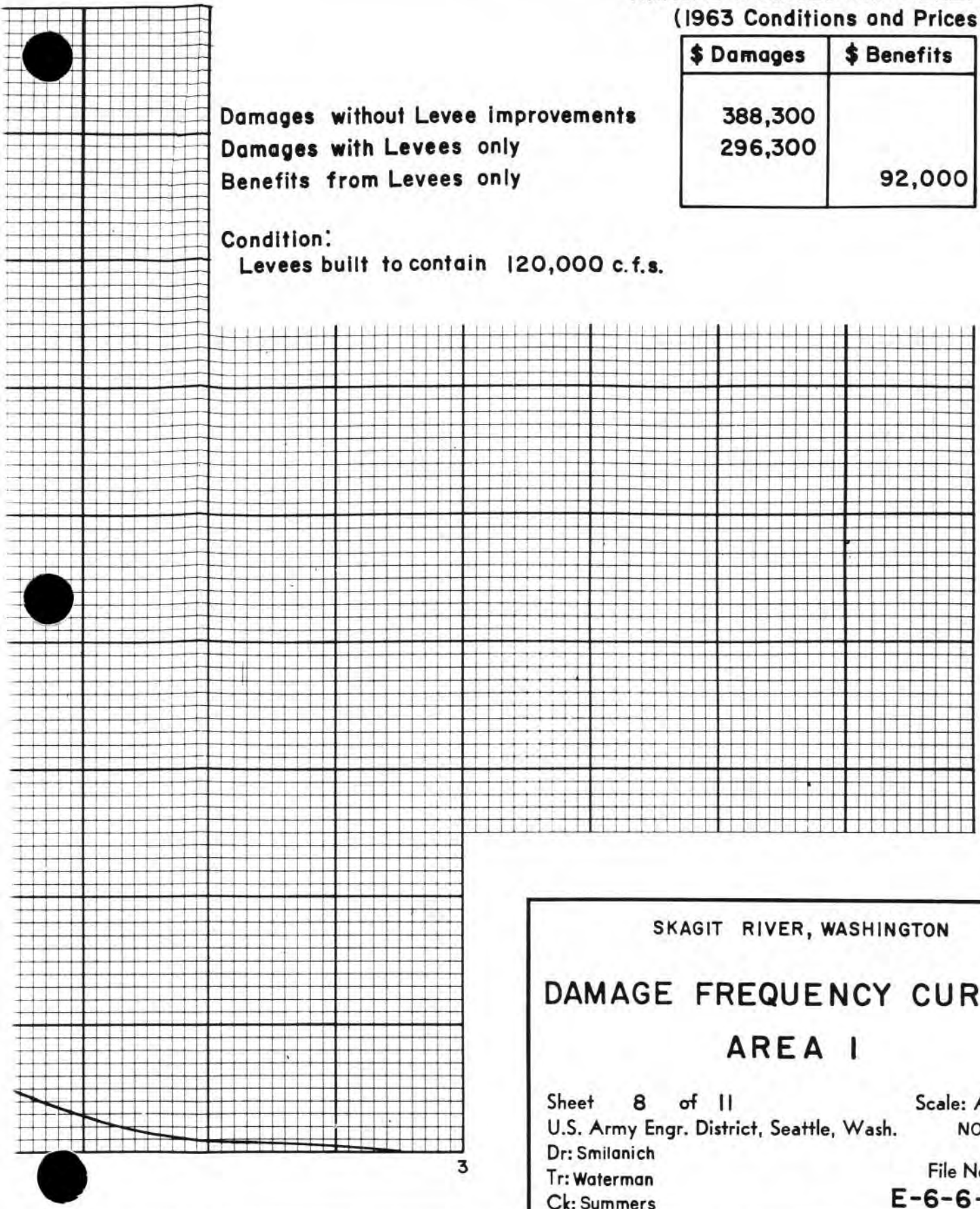
File No.
E-6-6-233

APPENDIX PLATE A-7

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

	$ Damages	$ Benefits
Damages without Levee improvements	388,300	
Damages with Levees only	296,300	
Benefits from Levees only		92,000

Condition:
Levees built to contain 120,000 c.f.s.



SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES
AREA I

Sheet 8 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Smilanich
Tr: Waterman
Ck: Summers

Scale: As shown
NOV. 1964

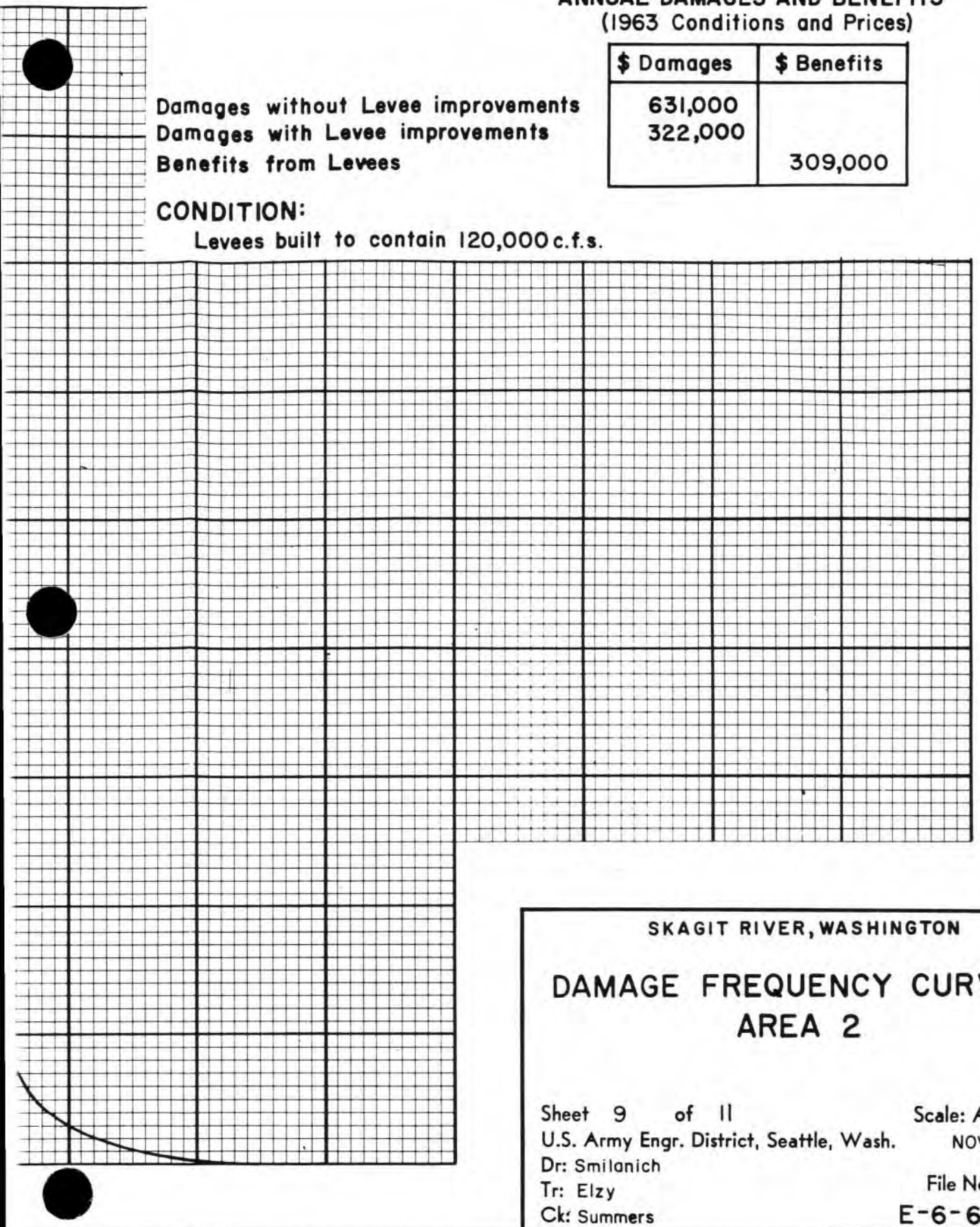
File No.
E-6-6-233

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

	$ Damages	$ Benefits
Damages without Levee improvements	631,000	
Damages with Levee improvements	322,000	
Benefits from Levees		309,000

CONDITION:

Levees built to contain 120,000 c.f.s.



SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES
AREA 2

Sheet 9 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Smilanich
Tr: Elzy
Ck: Summers

Scale: As shown
NOV. 1964

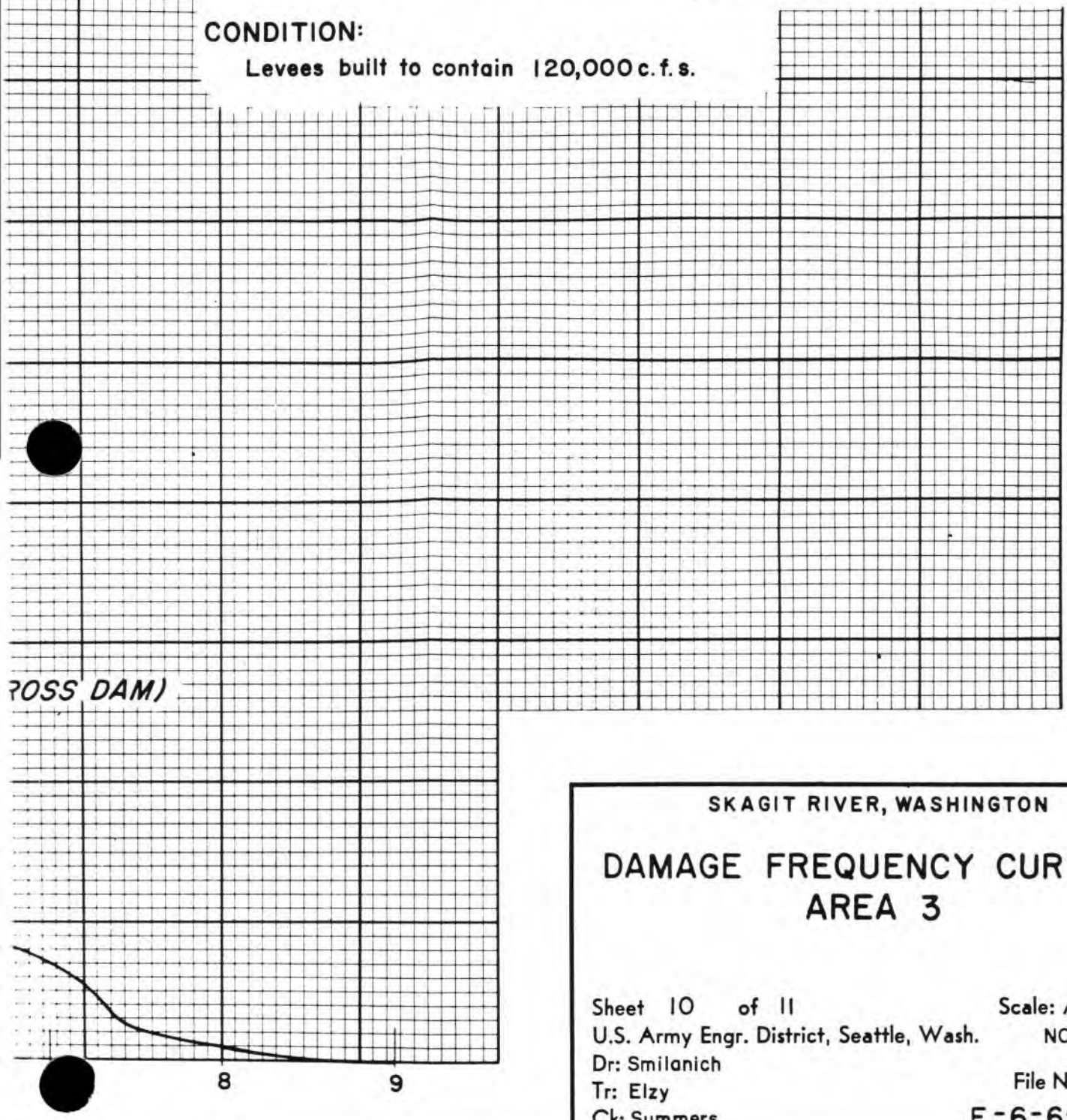
File No.
E-6-6-233

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

	$ Damages	$ Benefits
Damages without Levee improvements	1,064,000	
Damages with Levees only	885,000	
Benefits from Levees only		179,000

CONDITION:

Levees built to contain 120,000 c.f.s.



SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES AREA 3

Sheet 10 of 11
U.S. Army Engr. District, Seattle, Wash.
Dr: Smilanich
Tr: Elzy
Ck: Summers

Scale: As shown
NOV. 1964

File No.
E-6-6-233

ANNUAL DAMAGES AND BENEFITS
(1963 Conditions and Prices)

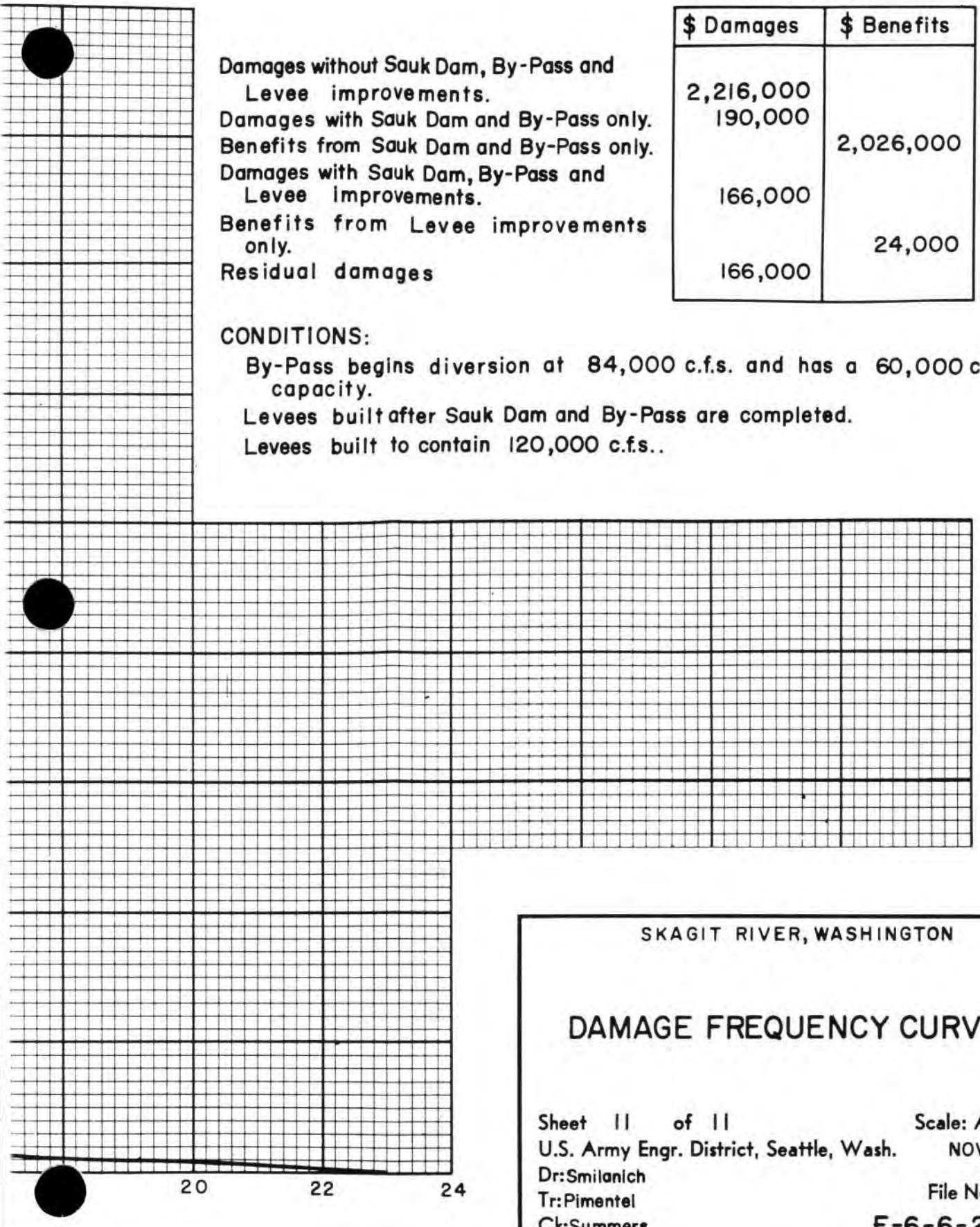
	$ Damages	$ Benefits
Damages without Sauk Dam, By-Pass and Levee improvements.	2,216,000	
Damages with Sauk Dam and By-Pass only.	190,000	
Benefits from Sauk Dam and By-Pass only.		2,026,000
Damages with Sauk Dam, By-Pass and Levee Improvements.	166,000	
Benefits from Levee improvements only.		24,000
Residual damages	166,000	

CONDITIONS:

By-Pass begins diversion at 84,000 c.f.s. and has a 60,000 c.f.s. capacity.

Levees built after Sauk Dam and By-Pass are completed.

Levees built to contain 120,000 c.f.s..



SKAGIT RIVER, WASHINGTON

DAMAGE FREQUENCY CURVES

Sheet 11 of 11 Scale: As shown

U.S. Army Engr. District, Seattle, Wash. NOV. 1964

Dr:Smilanich

Tr:Pimentel File No.

Ck:Summers E-6-6-233

APPENDIX PLATE A-11

APPENDIX B

HYDROLOGY, HYDRAULIC DESIGN AND METEOROLOGY

APPENDIX B
HYDROLOGY, HYDRAULIC DESIGN AND METEOROLOGY

CONTENTS

APPENDIX B
HYDROLOGY, HYDRAULIC DESIGN AND METEOROLOGY

CONTENTS (Cont'd)

SECTION 1 - INTRODUCTION

1. SCOPE

This section outlines the available data, the methods used, and the conclusions reached in developing the hydraulic and hydrologic portions of the report.

2. DESCRIPTION OF WATERSHED

The Skagit River Basin lies on the western slope of the Cascade Range in the northern part of the State of Washington. The drainage basin covers 3,140 square miles, extending south from Canada to the watersheds of the Stillaguamish and Snohomish Rivers, and west from the summit of the Cascades to Puget Sound. A small part of the northern mountainous portion of the basin lies in Canada.

3. STREAM, VALLEY, AND TRIBUTARIES

The Skagit River begins in British Columbia, Canada, about 20 miles north of the International Boundary. From there, the river flows in a generally southwestward direction. As it passes through the Cascade Range, the river flows in a deep, narrow canyon about 10 miles long. This canyon is the site of the Ross, Diablo, and Gorge Dams. The drainage area is about 1,160 square miles where the river emerges from its canyon section at the Gorge power plant. Within a distance of 20 miles the Skagit is joined by the Cascade, Sauk, and Baker Rivers, its three largest tributaries. The Cascade River joins the Skagit River from the south at the town of Marblemount and drains an area of approximately 185 square miles. The Sauk also enters the Skagit from the south and is the largest of the Skagit River tributaries with a drainage area of 732 square miles. The Baker River heads on the eastern slope of Mount Shuksan, flows south 24 miles through Upper and Lower Baker Dams, and joins the Skagit at the town of Concrete, draining a total area of 298 square miles. About 35 miles downstream from the mouth of the Sauk River, the Skagit River emerges upon its delta plain near the city of Sedro Woolley, draining an area of about 3,000 square miles. At Sedro Woolley the river changes course to the southwest and flows along the southeastern and landward side of its delta. Finally, the river divides into typical delta distributaries and empties into Skagit Bay, draining a total area of 3,140 square miles.

4. STREAM PROFILES

From its source in Canada to Rockport, Washington, a distance of 70 miles, the Skagit River has an average slope of 15 feet per mile. Between Rockport and Sedro Woolley, the river has an average slope of 4 feet per mile. In the delta below Sedro Woolley, the normal water surface profile averages about 1 foot per mile. The major tributaries generally have steep river slopes ranging from 30 to 80 feet per mile. A profile of rivers in the Skagit basin is shown on plate 2 in the main report.

SECTION 2 - CLIMATOLOGY AND HYDROLOGY

5. CLIMATE

Due to the proximity of the Pacific Ocean to the Skagit basin, the influence of the maritime air masses is pronounced in both the temperature and precipitation regimes, producing a mild but wet climate. During the winter the Skagit basin, lying directly in the storm path of cyclonic disturbances from the Pacific, is subject to frontal showers, which are frequently rather heavy and may follow in quick succession. On the mountain slopes, storm precipitation is heavy and almost continuous as a result of combined frontal and orographic effects. During the summer months the weather is warm and relatively dry as a result of the semi-permanent Aleutian low pressure system being displaced by a semi-permanent high pressure system.

6. CLIMATOLOGICAL RECORDS

The U. S. Weather Bureau has maintained a total of 23 climatological stations in or near the basin, of which 17 are currently operating. Another climatological station was maintained by the Department of Agriculture, Province of British Columbia, in the portion of the basin extending into Canada. It has been inactive since 1955. The elevations of these stations vary from 14 feet at Mount Vernon to 4,150 feet at Mount Baker Lodge, with 15 of the 24 stations below 1,000 feet and five above 3,000 feet. Three stations in the latter group have been activated since 1961 and hence do not have representative data for their locale. The location of these stations, together with their periods of record, are shown on plate B-1. A summary of precipitation and temperature data for 12 representative stations will be found in table B-1.

7. TEMPERATURE

The mean annual temperature for stations in or near the basin varies from 40.1° F. at Mount Baker Lodge to 51.5° F. at Concrete. Mean monthly temperatures vary from 27.3° F. at Mount Baker to 39.7° F. at Anacortes in January, and from 56.3° F. at Mount Baker Lodge to 65.4° F. at Newhalem in August. The temperature extremes recorded in the basin are 109° F. at Newhalem and -14° F. at the Darrington Ranger Station. Mean monthly temperature data for nine representative stations are presented in table B-2.

8. PRECIPITATION

Precipitation over the basin normally varies greatly, with a range of approximately 150 inches in annual amounts. A normal annual amount of 40

Table B-1

SUMMARY OF CLIMATOLOGICAL DATA 3/

Station	Elev	Precipitation					Snowfall		Temperature			
		Yrs of Rec	Mean	52-Yr. Norm	Max	Min.	Yrs of Rec	Mean Ann	Yrs of Rec	Mean Ann	Max	Min
Anacortes	30	70	25.79	26.7	37.82	15.89	61	5.9	46	51.4	95	6
Baker Lake 1/	670	8	102.88	114.3	133.39	69.26	7	58.1	2/	2/	2/	2/
Burlington 1/	50	8	34.66	2/	36.92	24.49	2/	2/	2/	2/	2/	2/
Concrete	270	48	64.40	65.0	82.94	43.45	43	31.4	35	51.5	106	-1
Darrington R. S.	550	46	80.38	82.4	104.89	51.33	36	43.5	31 1/	48.6	105	-14
Diablo Dam 1/	891	32	69.95	84.1	94.72	45.86	20	63.2	32	48.3	106	-10
Marblemount R.S. 1/	330	21	77.23	73.8	99.59	50.36	2/	2/	2/	2/	2/	2/
Mount Baker Lodge 1/	4150	22	107.66	147.4	141.97	74.13	14	530	10	40.1	91	-12
Mount Vernon 1/	14	6	32.28	2/	38.69	24.09	2/	2/	6	50.5	98	-4
Newhalem	505	41	77.66	79.8	102.85	48.40	31	51.7	32	50.1	109	-6
Sedro Woolley	56	65	45.31	48.2	64.60	18.36	56	10.2	51	50.6	99	-2
Silverton 1/	1500	31	112.61	89.4	151.27	77.03	11	88.0	11	46.7	103	0

1/ Computed by Corps of Engineers.

2/ No data.

3/ Climatological standard normals based on the period 1931-1955 (unless otherwise noted).

Table B-2

MEAN MONTHLY DATA 3/

Station	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
	Temperature												
Anacortes	39.7	42.2	45.5	50.6	55.5	59.4	62.2	62.1	58.8	52.8	45.7	42.4	51.4
Concrete	36.6	40.1	44.5	51.2	57.0	60.8	64.9	65.3	61.4	53.4	43.8	39.0	51.5
Darrington R.S. 1/	33.4	37.0	41.4	48.4	54.2	58.7	63.2	62.9	58.1	49.9	40.8	35.5	48.6
Diablo Dam 2/	31.2	35.1	40.0	47.1	54.6	59.1	65.0	64.6	59.4	49.6	39.3	35.0	48.3
Mt. Baker Lodge 2/	27.3	29.3	31.7	36.1	42.5	48.0	53.8	56.3	50.2	43.2	34.2	28.0	40.1
Mount Vernon 1/	39.4	41.4	44.4	49.3	55.5	59.7	63.1	61.9	57.1	50.6	42.6	41.4	50.5
Newhalem	33.8	37.5	42.1	49.6	56.2	60.4	65.1	65.4	60.8	51.7	42.1	36.7	50.1
Sedro Woolley	38.0	41.1	44.8	50.1	55.2	59.0	62.2	62.3	58.4	52.0	44.3	40.2	50.6
Silverton 4/	33.0	36.0	41.0	45.4	51.6	57.0	61.2	60.2	54.8	47.2	39.6	33.4	46.7
	Precipitation												
Anacortes	3.43	2.60	2.43	1.52	1.32	1.49	0.88	0.82	1.43	2.57	3.48	3.82	25.79
Baker Lake 4/	15.60	10.88	12.66	5.91	4.96	3.56	1.93	1.43	6.10	11.16	12.02	16.67	102.88
Concrete	8.77	6.91	6.67	4.09	2.93	2.66	1.40	1.36	3.46	6.78	8.85	10.52	64.40
Darrington R. S.	11.78	9.38	8.07	5.18	3.51	3.23	1.49	1.43	3.70	8.03	11.10	13.48	80.38
Diablo Dam 2/	10.00	8.57	6.86	4.28	2.49	2.12	1.22	1.20	3.30	8.14	9.82	11.95	69.95
Marblemount R.S. 2/	10.98	9.19	7.06	5.17	3.20	3.05	1.57	2.21	4.33	8.61	10.25	11.61	77.23
Mt. Baker Lodge 2/	12.39	11.55	11.52	8.12	5.81	4.25	2.83	3.17	7.08	11.32	13.30	16.32	107.66
Newhalem	11.11	8.97	7.49	4.44	3.07	2.64	1.57	1.61	3.85	8.81	10.76	13.34	77.66
Sedro Woolley	5.39	4.23	4.74	3.28	2.52	2.87	1.44	1.22	2.94	4.70	5.61	6.37	45.31
Silverton 2/	15.40	12.69	10.73	7.39	5.59	4.59	1.99	2.94	6.79	12.82	15.85	15.83	112.61

1/ Computed by Corps of Engineers, through 1960.
2/ Computed by Corps of Engineers, through 1961.
3/ Climatological standard normals based on the period 1931-1955 (unless otherwise noted).
4/ Inactive.

inches or less falls in the vicinity of the mouth of the river and that portion of the basin in Canada which lies in a topographic rain shadow. A normal amount of 180 inches or more falls on the higher elevations of the Cascade Range in the southern end of the basin and over the higher slopes of Mt. Baker. The normal annual precipitation over the basin above Mount Vernon is 92.2 inches, approximately 75 percent of this amount falling during the 6-month period October through March. The mean monthly precipitation at stations in or near the basin varies from 0.82 inches in August at Anacortes to 16.67 inches in December at Baker Lake. The maximum recorded precipitation for 1 month is 41.95 inches at Silverton in January 1953. Storm studies indicate that 5 to 6 inches of rainfall in 24 hours have occurred over much of the basin. Mean monthly precipitation data for nine representative stations are presented in table B-2.

9. SNOW

Snowfall in the Skagit River basin is dependent upon elevation and proximity to the moisture supply of the ocean. The mean annual snowfall varies from 5.9 inches at Anacortes to 530 inches at Mt. Baker Lodge, with a maximum annual of 694 inches recorded at the latter. Snow surveys have been made near the Skagit basin since 1927 and within the Skagit basin since 1943. In 1958 a more recent network of snow courses was established in the Baker River basin. The location of these snow courses is shown on plate B-1. The maximum snow depth and water equivalent for each course are tabulated on this plate also.

10. STORMS

All major floods in the Skagit Valley are produced by severe storms which occur chiefly during November, December, and January. The magnitude and intensity of a storm cannot always be used as an index to the resulting flood. Other factors such as temperature sequence, groundwater recharge, snowpack, etc., largely influence the rate of runoff as well as total runoff. Antecedent conditions may have been such that only a moderate storm may provide the required impetus to set in motion the related factors that collectively result in a flood. On the other hand, a combination of factors may be such that a very severe storm results in only minor high water. The following storms are described to illustrate the relationship between storm characteristics and the resulting flood.

The month of November 1909 was one of above normal precipitation over the Pacific Northwest with a period of moderate to heavy rains occurring during the last two weeks. Measurable amounts of precipitation occurred over the basin an average of 24 days during the month and approximately two-thirds of the monthly totals occurred after the 16th of the month. This period of heavy precipitation was the result of a series of low pressure systems which

moved through the Pacific Northwest. The fastest moving storm was the last one of the series which moved into the region on the 26th of the month, causing copious amounts of precipitation on the 28th and 29th. The storm period which produced the flood of November 1909, the largest of record, had a 66-hour duration beginning at 6:00 a.m. on the 27th and ending at midnight on the 29th. Total storm precipitations for this period were 9.2 inches at Goat Lake, 8.3 inches at Skagit Power Plant, 5.9 inches at Concrete and 2.5 inches at Sedro Woolley. Maximum 24-hour amounts were 5.6 inches, 5.8 inches, 3.8 inches, and 1.3 inches at these respective stations. Temperature sequences and the record at Goat Lake indicate that the precipitation fell as snow above 2,500 feet on the 26th and 27th, and mixed rain and snow fell on the 28th. On the 29th of the month, precipitation fell as rain up to elevations of 6,000 feet and melted off all snow to approximately 4,000 feet. The advent of a high pressure system brought a rapid decrease in storm activity by the 30th. The mean basin precipitation for this storm period was 6.69 inches and the mean basin maximum 24-hour fall, 3.60 inches.

Temperatures during the month of November 1921 were below normal but the precipitation was decidedly in excess. Mild weather with little or no precipitation prevailed until the 18th, when a sharp cold spell set in. Heavy snow fell on the 19th, 20th, and 21st to a depth up to 10 inches or more at stations west of the Cascades, being much heavier on high mountain slopes. It was the deepest snow on record for this early in the season with the exception of the extremely cold November of 1896. Mild weather with abundant rain marked the remainder of the month.

December, while cold, had less than the average amount of snowfall, and much of what fell was melted off by the excessive rains of the 10th to 12th. The storm period from 6:00 p.m. on the 9th to 12:00 p.m. on the 12th was the most critical in producing the flood peak of the 13th, the second highest flood of record. During this period, 14.2 inches of precipitation fell at Silverton, 10.2 inches at Davis Ranch, and 3.4 inches at Sedro Woolley. Maximum 24-hour amounts were 5.9 inches, 5.0 inches and 2.0 inches, respectively, at these stations.

The storms which produced the two largest floods of record have been analyzed above. The storm of December 1933 is an outstanding example of a major storm which did not cause a flood of damaging magnitude on Skagit River below Sedro Woolley; however, it did produce the largest flood in the last 40 years on several of the other streams in western Washington. The month of December 1933 was one of unprecedented rainfall over western Washington, including the entire Cascade Mountains. The total monthly precipitation was greater than for any month in previous years of record at the majority of stations. The average number of days recording measurable amounts of precipitation during the month was 28 for western Washington. The same average

conditions prevailed over the Skagit basin. The precipitation was unusually heavy during a number of periods within the month, the 6-day period from the 17th through the 22nd being the most critical. The storm period studied was from 7:00 a.m. on the 17th to 1:00 p.m. on the 22nd, a total of 126 hours. Total storm precipitations recorded in the basin varied from 2.50 inches at Anacortes to 11.41 inches at Darrington. It is estimated that nearly 25 inches fell over the high elevations in the southern portion of the basin. The maximum recorded 24-hour amounts were 3.55 inches at Darrington and 0.77 inches at Anacortes.

While precipitation was much higher than normal for December 1933, none of the individual 2- to 5-day storms produced severe flooding in the basin. Station precipitation records indicate that 24-hour amounts were less than for the November 1909 and December 1921 storms. Much of the precipitation occurred as snow at the mountain stations, which reduced direct runoff and also served to retard runoff from precipitation occurring as rain. These factors combined to produce high but non-damaging discharges throughout the basin.

11. EVAPORATION

The evaporation rate has never been recorded at any station within the Skagit River basin, but measurements have been made at the Seattle Maple Leaf Reservoir, some 60 miles south of the basin. These data are representative of the Skagit valley west of Sedro Woolley. Although no data are available for the area east of Sedro Woolley, evaporation is less because of lower average temperatures and less percent of sunshine. The monthly distribution in inches for Seattle is as follows:

Station	Years of Record	Elev Ft.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Seattle: M. L. Reservoir	*18	422	0.70	0.85	1.74	3.12	4.60	5.13	6.68	5.28	3.57	1.68	0.71	0.52

Records through 1960

* April through September, 18 years of record; others, 7-16 years.

12. DISCHARGE RECORDS

Stream gaging in the Skagit River basin began in 1908 at stations near Newhalem and Sedro Woolley. Since then, the U. S. Geological Survey has operated and published records for 72 gages, including lake and reservoir

stations, of which 32 are currently operating. The location and pertinent data for these stations are shown on plate B-2.

13. STREAMFLOW CHARACTERISTICS

Mean annual flows in the Skagit River range from 10,000 to 20,000 c.f.s. at Mount Vernon. The maximum recorded discharge was 144,000 c.f.s. in 1951 and the minimum was 2,740 c.f.s. in 1942. A summary of discharge data and mean monthly discharges for representative stations is presented in table B-3. Base flow is normally low from August through March. During April or May, base flow increases due to the melting snowpack and normally crests in early June. Winter flows are characterized by frequent sharp rises resulting from concentrated 2- to 5-day storms or series of storms. All major floods of record on the Skagit River have occurred during the period November through February and have been caused by high rates of precipitation with accompanying snowmelt. This type of flood has a crest which is normally higher and of shorter duration than the annual spring snowmelt high water. Occasionally, two or more floods follow in close succession. Plates B-3 through B-7 show daily discharge hydrographs at 3 key stations, together with the annual maximum instantaneous discharge when available.

The flood of November 1949 is a good example of the flattening of a flood crest as it moves downstream. Channel storage had a marked effect on the sharpness of the peak between Concrete and Mount Vernon. The peak discharge of 154,000 c.f.s. near Concrete was reduced to 114,000 c.f.s. near Mount Vernon. Precipitation records in the basin at the time of this flood partly explain the reduction in crest in the lower reaches of the channel. The Sedro Woolley gage indicates that very little rain fell in the lower part of the basin. The flood of February 1951 is a good example of a flood crest of long duration. The peak near Concrete lasted many hours longer than the peak of November 1949, although it did not have as great a discharge. The peak of the November 1949 flood remained above 120,000 c.f.s. for 14 hours whereas the peak of the February 1951 flood remained above the same point for 22 hours. The duration of the peak reduced the effect of channel storage and the peak downstream was increased by a large contribution of runoff from the lower elevations. The peak discharge near Concrete was 139,000 c.f.s. increasing to 150,000 c.f.s. near Mount Vernon. Table 6 in the report lists pertinent flood data for three gaging stations for both recorded and historical floods.

14. RUNOFF

Runoff varies widely among tributaries within the Skagit River basin. The Baker River, which receives the effect of the initial lifting of Pacific air over the Cascade Range, has an annual runoff of 120 inches at Concrete. The Skagit River above Newhalem is in the rain shadow of these same mountains

Table B-3

SUMMARY OF STREAM FLOW DATA
(THROUGH WATER YEAR 1960)

Stream	Station	Drainage Area in Square Miles	Period of Record	Annual runoff (cubic feet per second)				Extreme discharge in (cubic feet per second)		
				Mean	52-year Normal	Annual Max.	Annual Min.	Instant Max.	Daily Max.	Daily Min.
Skagit River	At Newhalem	1,175	1908-14, 1920-	4,339	4,555	6,300	2,650	63,500	42,400	136
Skagit River	Near Concrete	2,737	1924-	14,806	15,080	19,740	9,629	154,000	129,000	2,610
Skagit River	Near Sedro Woolley	3,015	1908-1924-	16,200	16,150	19,600	10,700	220,000	176,000	2,830
Skagit River	Near Mount Vernon	3,093	1940-	16,332	Miss.	21,440	10,510	144,000	138,000	2,740
Sauk River	Near Sauk	714	1910-12, 1928-	4,304	4,655	5,950	2,887	82,400	55,800	572
Baker River	Below Anderson Cr. near Concrete	210	1910-25, 1928-31	2,011	2,073	2,600	1,540	36,800	27,400	219

MEAN MONTHLY STREAMFLOW DATA (IN CUBIC FEET PER SECOND THROUGH WATER YEAR 1960)

Stream	Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Annual
Skagit River	At Newhalem	2,665	3,049	2,973	2,285	2,135	2,133	4,502	9,656	10,996	6,878	3,462	2,339	4,339
Skagit River	Near Concrete	11,627	13,769	14,860	12,653	11,779	10,700	14,660	23,597	26,383	19,054	10,177	8,303	14,806
Skagit River	Near Sedro Woolley	10,700	16,400	16,300	13,500	12,000	10,300	13,900	23,900	31,600	23,200	12,200	9,160	16,200
Skagit River	Near Mount Vernon	13,818	16,587	17,653	14,637	14,676	11,974	15,130	23,484	26,160	20,882	11,138	9,482	16,332
Sauk River	Near Sauk	3,071	4,151	4,500	3,678	3,443	3,092	4,255	6,933	7,976	5,669	2,723	2,104	4,304
Baker River	Below Anderson Cr. near Concrete	1,916	1,788	1,870	1,527	1,430	1,093	1,747	2,915	3,579	2,949	1,747	1,540	2,011
Baker River	At Concrete	2,433	2,835	2,498	2,065	1,986	1,566	2,308	3,937	4,441	2,422	1,998	1,763	2,619

and has an annual runoff of 50 inches. The runoff for the entire basin is about 71 inches per year. Extremes in annual runoff at Mount Vernon have been 15,520,000 acre-feet and 7,628,000 acre-feet, or 94.1 inches and 46.2 inches over the basin, respectively.

15. FLOOD CHARACTERISTICS

Because of its geographic location, the Skagit River basin is subject to winter rain floods and an annual high water due to snowmelt runoff. The annual high water is expected during the spring or early summer, caused by the seasonal rise in temperatures, with resultant melting of the accumulated snowpack. These high discharges may have a minor contribution from warm rains, but are caused predominantly by snowmelt. The spring snowmelt is characterized by its relatively slow rise and long duration. While this high water occurs annually, it has never reached a damaging stage. It is during this annual spring or early summer high water that power reservoirs are filling, and as a result the spring peak discharges are frequently reduced.

Rain-type floods occur usually in November or December, but may occur as early as October or as late as February. Antecendent precipitation serves to build up groundwater reserves and saturate the ground. Frequently, a light snowpack is then formed over most of, or the entire basin. A heavy rainfall accompanied by warm winds completes the sequence which produces major floods. The heavy rainfall and accompanying snowmelt result in a high rate of runoff as the ground is already nearly saturated from earlier precipitation. Two or more crests may be experienced within a period of a week or two when a series of storms moved across the basin from the west. The winter floods have a considerably higher magnitude than the average annual spring high water. Since 1920 these floods have been reduced varying amounts by incidental control at the power reservoirs. However, the location of these reservoirs is such that they cannot effect any great amount of flood control because of the contribution from large uncontrolled tributary areas, of which Sauk River is the largest and most important.

16. FLOOD HISTORY

In 1923, Mr. J. E. Stewart, of the U. S. Geological Survey, collected data for, and partially completed, a report on floods in the Skagit River basin. The data he collected and conclusions reaches, together with information concerning floods of record through 1957, are published in U.S.G.S. Water Supply Paper 1527. After careful study and analysis of all data available to him, Mr. Stewart reached the conclusion that two great floods occurred prior to the arrival of white settlers, and that the earlier and greater of these two floods probably was as large or nearly as large as the greatest flood that has occurred here within the last several hundred years. These floods are estimated to have

occurred about 1815 and 1856. Flood discharges as determined by Mr. Stewart for a number of historical floods, together with those of record, are presented in table 6 of the report.

17. FLOOD FREQUENCY

The records at the gaging stations on the Skagit River near Concrete, near Sedro Woolley, and near Mount Vernon, are used in the flood frequency study. Records are available since 1908; however, they are not continuous at any single site for the entire period. Peak discharges at these three sites have been subject to some degree of regulation since completion of Lower Baker Dam in 1927, making it necessary to adjust reported annual peak discharges for change of storage and travel time from appropriate storage projects to estimated natural peak discharges since 1927. To compute the frequency curve of maximum annual natural discharge at the gaging station near Concrete, historical floods in 1897, 1909, 1917, and 1921, based on high-water marks, and the period of record 1925, 1928 through 1960, were used. The historical floods are the largest floods since 1878 when settlers first arrived in the Skagit Valley. Because of the short period of record at the gaging station near Sedro Woolley, the frequency curve of maximum annual discharge at Sedro Woolley was derived from the frequency curve at Concrete and the relationship between recorded peak discharges at Concrete and Sedro Woolley. Due to the short period of record and the effect of regulation, the frequency curve of maximum annual discharge at the gaging station near Mount Vernon was derived from the frequency curve at Sedro Woolley and the relationship between reported discharges at Sedro Woolley and Mount Vernon.

Frequency curves for maximum annual regulated peak discharges at Concrete and Mount Vernon, for operation of Ross Reservoir alone, and Ross Reservoir plus potential Sauk Reservoir (see paragraph 23) were obtained by routing the 10-, 50-, 100-, and 200-year floods through the basin. Frequency curves showing the maximum annual regulated peak discharges near Sedro Woolley for the operation of Ross Dam alone were derived from a correlation of the relative discharges near Concrete and Sedro Woolley. These frequency curves are presented on plates B-8, B-9, and B-10.

18. CHANNEL CAPACITIES

The river channels downstream of Sedro Woolley, including the distributary channels, are mostly leveed. The capacities of the channels vary from slightly less than 91,000 c.f.s. in some areas of the distributaries downstream of Mile 10 to about 143,000 c.f.s. in some diking districts below Burlington as shown in table 2 of the report.

19. CHANNEL VELOCITIES

Average channel velocities during flood flows are between 10 and 12 feet per second in the vicinity of Concrete, Washington, 6 to 8 feet per second in the vicinity of Sedro Woolley, and 4 to 7 feet per second in the Mount Vernon area.

20. DISTRIBUTION OF FLOW IN DELTA

The numerous channels available for distribution of flow in the delta complicate the hydraulic analysis. Measurements of flow by U. S. Geological Survey and backwater computations of observed profiles indicate that distribution of flow at Mile 9.4 is 59 percent in North Fork and 41 percent in South Fork at approximately bankfull stage. Future distribution of the South Fork flow occurs at Freshwater, Steamboat, and Tom Moore Sloughs. Flow at these distributaries is not well defined by was estimated from backwater computations. No distribution occurs in the North Fork except in the tide-flats area downstream of Mile 4.0. Channel enlargements previously discussed for the North Fork and Freshwater Slough will change the distribution of flow between the North and South Forks, resulting in approximately a 3 percent increase in the North Fork and a corresponding decrease in the South Fork. These enlargements reduce the river stage in the area of the enlargement, and, as determined by backwater computations, the reduction in stage gradually decreases upstream. At the distribution point, Mile 9.40, the reduction is approximately 0.6 feet for a flow of 120,000 c.f.s. in the main river.

21. SEDIMENTATION

Bedload movement and bank erosion cause channels to shift with each flood flow in the river reach upstream from Sedro Woolley. The Skagit River carries large quantities of bedload sediment, estimated at more than 500,000 cubic yards annually.

Although channel depths are quite stable, there is evidence that sediment movement is considerable, especially bedload. Channel design must, therefore, recognize that unless the channel section is self-maintaining, the required maintenance dredging would be very great.

SECTION 3 - STORAGE POTENTIAL IN BASIN

22. RESERVOIR CAPACITIES

There are five storage reservoirs on the Skagit River and tributaries. Their primary function is to maintain adequate head and discharge for the production of hyroelectric power. The Ross Reservoir is the only one with a reservation for flood control storage. Upper Baker maintains 16,000 acre-feet of storage but only to replace natural channel storage lost to the impoundment of the present reservoir. Incidental flood control will result if the pools have been drawn down for power production and are refilled during flood runoff. This drawdown will generally be more pronounced after January first than in the critical months of November and December. Table B-4 lists pertinent data on existing reservoirs:

Table B-4

STORAGE CHARACTERISTICS OF EXISTING RESERVOIRS

Reservoir	Flood Control Storage	Maximum Storage	Maximum Usable Storage *
	Acre-feet	Acre-feet	Acre-feet
Ross	120,000	1,405,300	1,022,800
Diablo	-	90,140	76,220
Gorge	-	8,485	6,700
Upper Baker	16,000	285,470	220,630
Lake Shannon	-	Unknown	142,600

* Above minimum pool for power production.

Seattle City Light plans ultimately to raise Ross Dam another 125 feet, but construction is not definitely scheduled. This raise would increase the reservoir capacity to 3,450,000 acre-feet.

The present limiting channel capacity of the lower Skagit River is approximately 91,000 c.f.s. Flows at Concrete must be controlled to 90,000 c.f.s. in order to keep the lower Skagit River from exceeding its present capacity. Additional storage of approximately 500,000 acre-feet on other basin tributaries would be required to control the 100-year frequency flood to 90,000 c.f.s. at Concrete under present day conditions of development. Table B-5 lists three unregulated tributaries and one main stem storage site and their flood control potential:

Table B-5

STORAGE CAPABILITY OF POTENTIAL UPSTREAM STORAGE

River Basin	100-Year Peak Flow at Site c.f.s.	Maximum 3-Day Volume acre-feet
Sauk River	110,000	342,000
Cascade River	22,000	70,000
Thunder Creek near Newhalem	12,700	40,000
Skagit River (Copper Creek site *)	45,000*	140,000*

* On the Skagit River and controls about two-thirds of the inflow between Ross Dam and Marblemount; i.e., about 40 percent of the unregulated "Skagit at Marblemount" hydrograph.

The lower Sauk River site would be the most effective of these potential flood control reservoirs because it has control over one-third of the runoff from the Skagit basin above Mount Vernon. The effect of the Sauk River storage in conjunction with the Ross Reservoir will be discussed in the following section. The other three sites have not been studied to any degree beyond an estimate of peak discharge and maximum 3-day runoff volume.

A combination of flood control storage and increased channel capacity is a possibility. An increase of channel capacity in the lower reach of the Skagit River would reduce the volume needed for upstream storage.

23. FLOOD REGULATION AND FLOOD ROUTING

The existing channel with levees in the lower Skagit River has a governing capacity of about 91,000 c.f.s. This discharge will be exceeded once in 3 years on the average, taking advantage of the flood control storage in Ross Reservoir. The 100-year frequency flood would discharge 223,000 c.f.s. at Mount Vernon, provided there was no overflow into the Samish Basin (near Burlington).

Observed flood discharge hydrographs were studied and a routing procedure was adapted to route these floods, regulated to varying degrees by Ross, Diablo, and Lower Baker Reservoirs, along the Skagit River. When the routing procedure gave satisfactory results in reproducing the regulated floods, as shown on plate B-11, it was used to route the storage increments of each reservoir to obtain the natural hydrograph of these floods. Subsequently, 50- , 100- , and 200-year frequency hypothetical floods were produced to satisfy the peak

discharge and runoff volume relationships of the Skagit River and its tributaries. These floods also were routed using storage in Ross Reservoir and the potential Sauk Reservoir as illustrated on plate B-12.

The lower Sauk Reservoir, with 250,000 acre-feet of flood control storage, and the Ross Reservoir, with the present regulation schedule, could reduce the peak of the 100-year frequency flood at Concrete to 170,000 c.f.s. and at Mount Vernon to 163,000 c.f.s. The Avon Bypass and lower Skagit levee improvements now under consideration would increase the capacity of the lower reach to 180,000 c.f.s. The Avon Bypass and downstream levee improvements plus Sauk River dam would therefore result in complete protection against a 100-year flood for the flood plain west of Sedro Woolley. Plates B-8 and B-10 show the effect of Ross Dam and the additional effect of the potential Sauk Dam. The levee between the Skagit and Samish basins would, under present day conditions, be overtopped when the Skagit River discharge reaches approximately 150,000 c.f.s. at Mount Vernon. This discharge, which is limited to the flow in the main channel of the Skagit, would remain relatively constant, while the discharge at Concrete continues to increase.

24. NOOKACHAMPS CREEK AREA

This area of approximately 5,000 acres has no flood control protection of any kind and is a factor in reducing the flood discharges at Mount Vernon. When the Skagit River discharge exceeds 90,000 c.f.s., the water begins flooding the Nookachamps Creek area, which acts as a natural flood control reservoir. This results in about a 10-percent decrease in discharge at Mount Vernon. During the February 1951 flood, approximately 34,000 acre-feet of natural storage reduced the peak an estimated 6,000 c.f.s. This particular flood was unnaturally long and the effectiveness of the Nookachamps storage was reduced. In the event that levees are built along Nookachamps Creek in the future, loss of the natural overbank flood storage would have to be compensated for by upstream storage or higher downstream levees.

25. STANDARD PROJECT FLOOD

A standard project flood of 440,000 c.f.s. was derived for the site of the U. S. Geological Survey stream-gaging station on Skagit River near Sedro Woolley. It was derived by the application of accepted methods and was approved in March 1950 by the Office, Chief of Engineers. Precipitation data for this flood were taken from the "Preliminary Estimate Maximum Possible Precipitation Skagit River Basin," by the Hydrometeorological Section of the U. S. Weather Bureau, 29 July 1946. This flood will be reviewed using precipitation data from a publication of the Weather Bureau, "Probable Maximum Precipitation in the Northwestern United States West of the Continental Divide," to be released in 1965.

26. SPILLWAY DESIGN FLOOD

A detailed study has not been made of a spillway design flood at the Lower Sauk project. An estimated peak discharge of 573,000 c.f.s. was derived from a comparison of the Sauk with the Green River near Palmer where a relatively large basin was studied. This peak discharge may change as a result of future investigations, but is presented to indicate its general magnitude.

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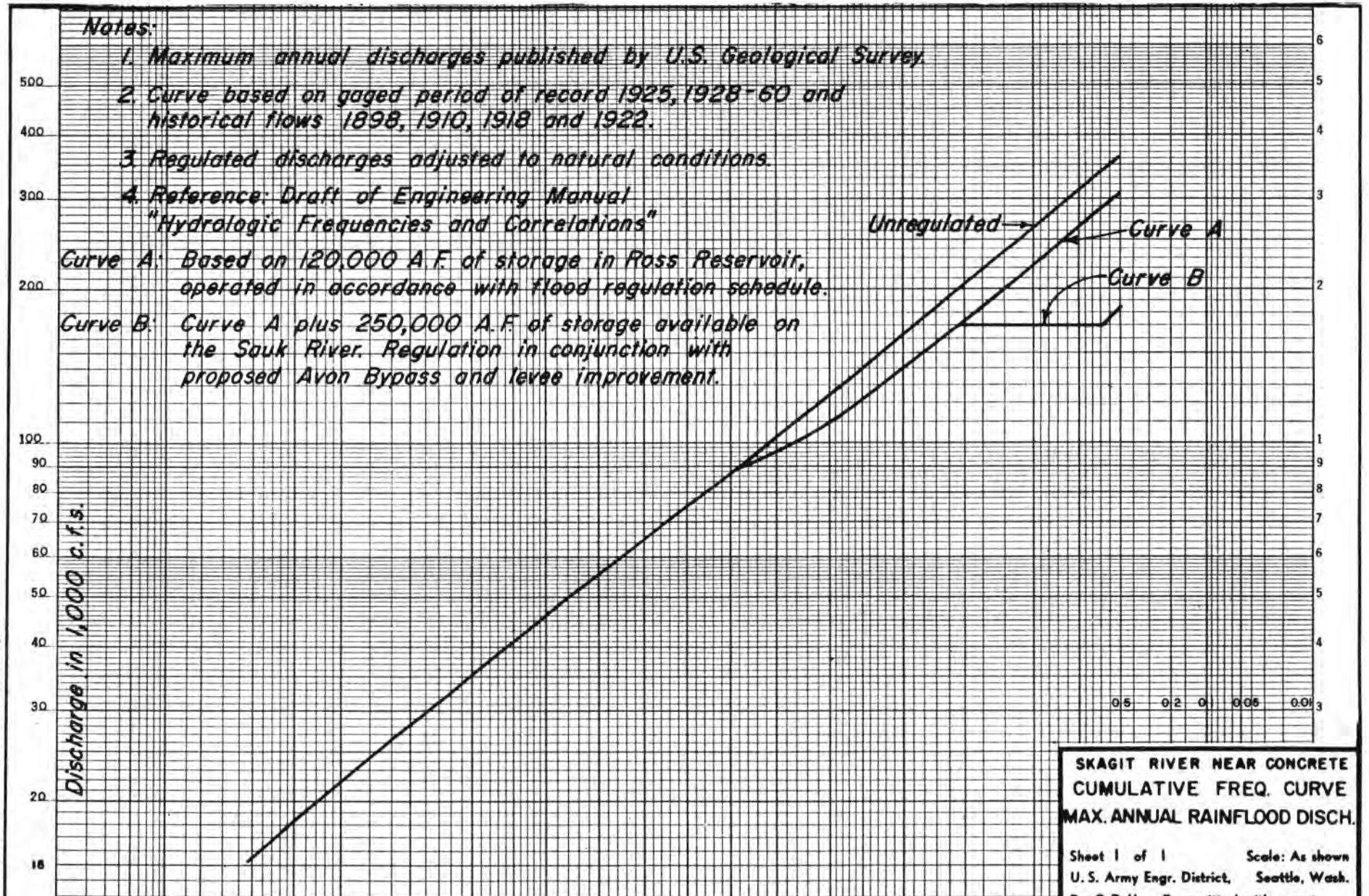

SKAGIT RIVER NEAR CONCRETE
CUMULATIVE FREQ. CURVE
MAX. ANNUAL RAINFLOOD DISCH.

Sheet 1 of 1 Scale: As shown
U. S. Army Engr. District, Seattle, Wash.
Dr: G.D.H. Transmitted with report
Tr.: B.E.J. dated SEPT. 1963
Ck: J.W.S.-N.J.M. File No. E-6-6-228

APPENDIX PLATE B-8

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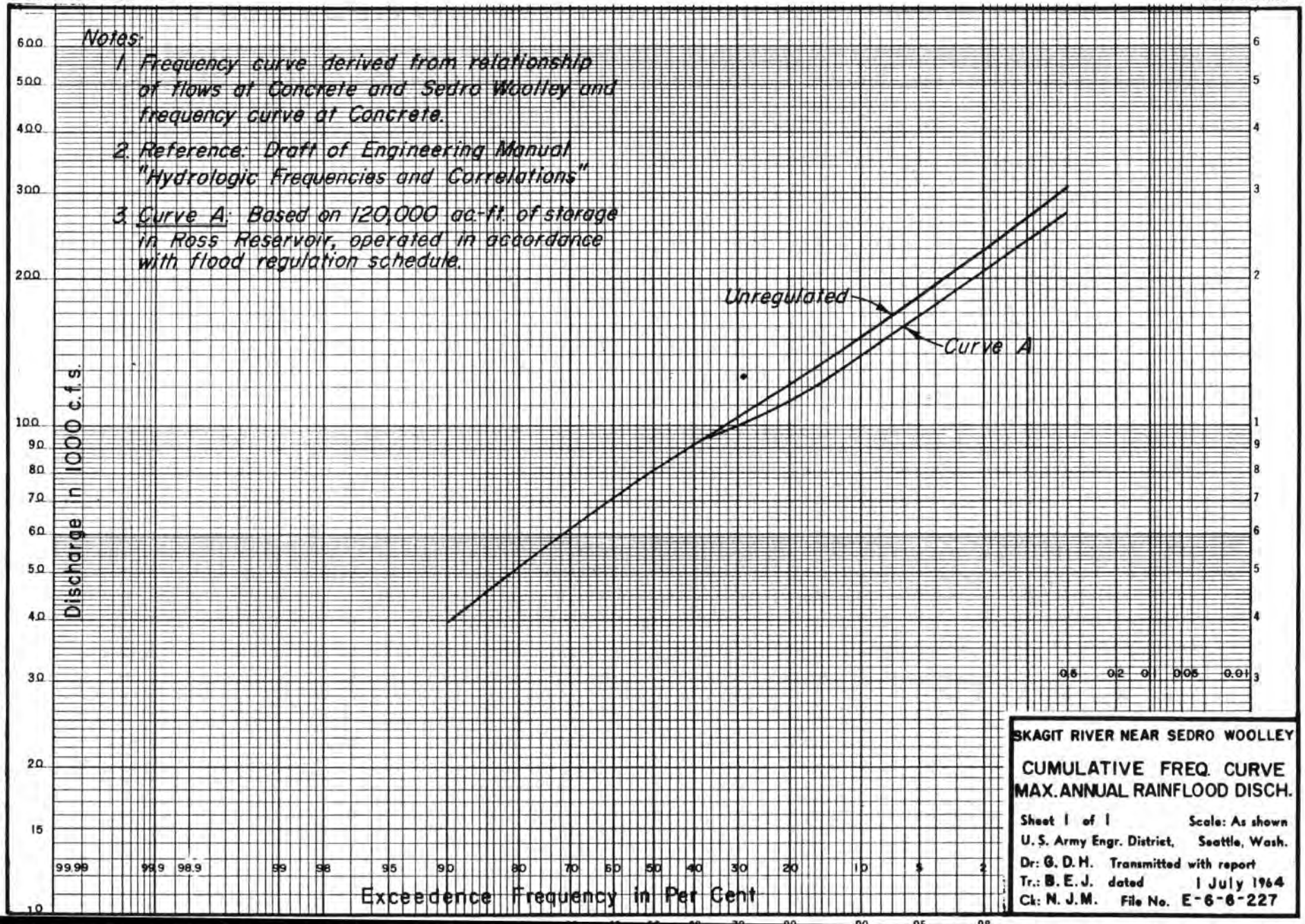

SKAGIT RIVER NEAR SEDRO WOOLLEY

CUMULATIVE FREQ. CURVE
MAX. ANNUAL RAINFLOOD DISCH.

Sheet 1 of 1 Scale: As shown
U. S. Army Engr. District, Seattle, Wash.
Dr: G. D. H. Transmitted with report
Tr.: B. E. J. dated 1 July 1964
Ck: N. J. M. File No. E-6-6-227

APPENDIX PLATE B-9

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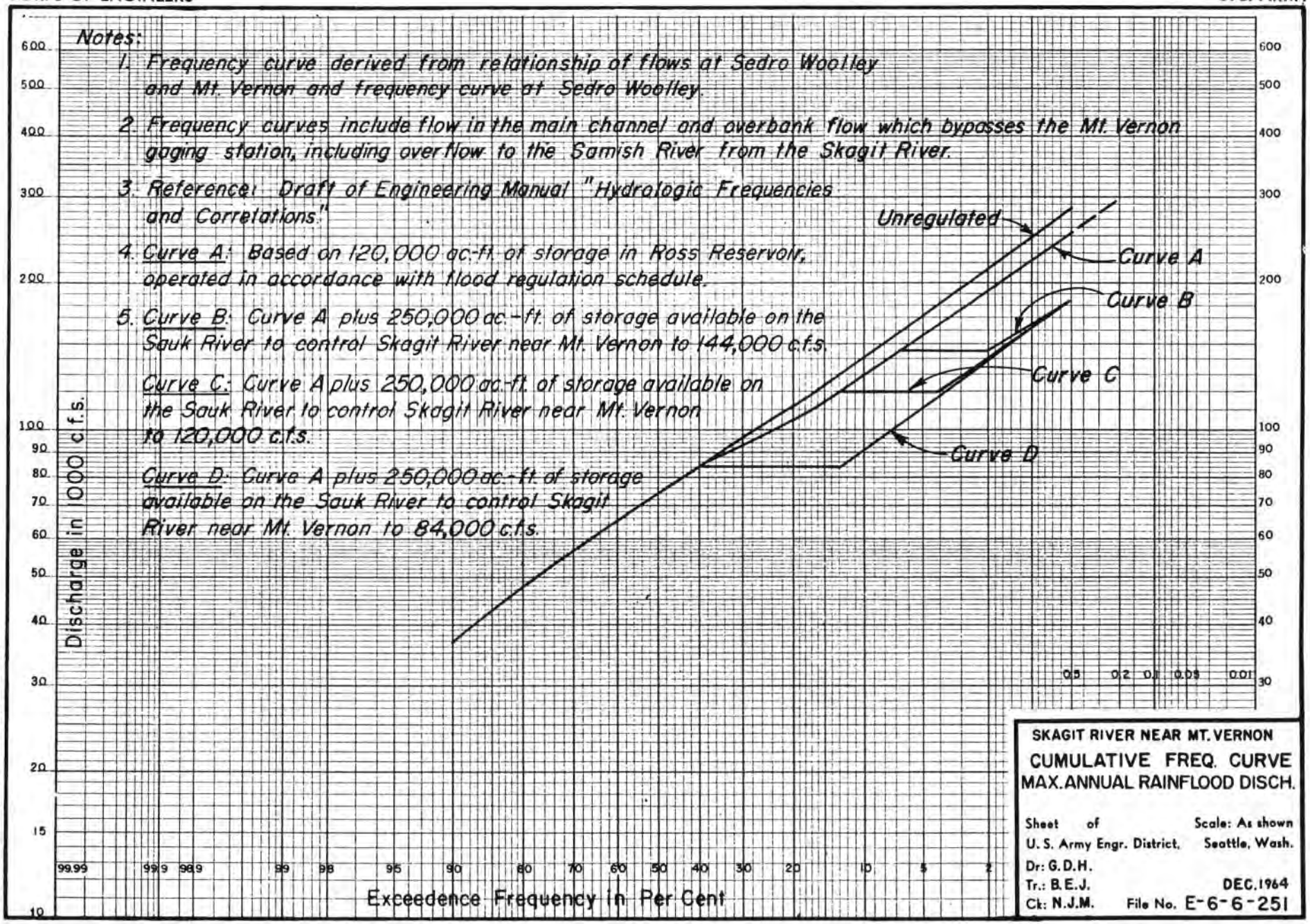

SKAGIT RIVER NEAR MT. VERNON

CUMULATIVE FREQ. CURVE

MAX. ANNUAL RAINFLOOD DISCH.

Sheet of

Scale: As shown

U. S. Army Engr. District, Seattle, Wash.

Dr: G.D.H.

Tr.: B.E.J.

DEC. 1964

Ck: N.J.M.

File No. E-6-6-251

APPENDIX PLATE B-10

APPENDIX C

PLANNING DETAILS AND COST ESTIMATES

APPENDIX C
PLANNING DETAILS AND COST ESTIMATES

CONTENTS

TABLES

PLATES

APPENDIX C
PLANNING DETAILS AND COST ESTIMATES

1. QUANTITIES

Embankment and excavation limits were dictated by project dimensions and soils reconnaissance. Original ground lines were established from current topographic maps and a 1960 field survey. The survey data included profiles of the existing river bank levees, and cross sections of the levees and river channel at one-quarter mile intervals. Average levee top widths and heights for the reaches between successive cross sections were estimated in the field. In determining the contingency for the project estimate, substantial allowance was made for the effect on quantities of the limited soils and survey data available.

2. UNIT PRICES

Unit and lump sum prices used herein were determined by consideration of location and accessibility of the project, remoteness of borrow areas, the prices of recent contract jobs for similar items, length of construction period, availability of labor, the dispersed nature of the construction, etc., which might affect the cost. Easements and rights-of-way costs were determined by real estate personnel from field appraisals. Consideration was given to the sale of similar property in the vicinity, and characteristic of the land being evaluated, such as type of soil, productivity, location, size, etc. Costs were based on July 1964 price levels.

The unit price used for levee embankment quantities is based upon an average of two alternative borrow sources. It appears that a certain amount of the embankment material can be obtained from benches along the riverward side of the existing levees at various locations. However, the quantity of acceptable borrow material available in these areas will have to be determined during more detailed design studies. For the purpose of this report, it has been assumed that about 50% of the required embankment material can be obtained from riverside borrow. The remaining material would be excavated from borrow areas along the lower foothills adjacent to the flood plain.

3. DETAILS

Existing and proposed levee profiles, and the locations of proposed levee and channel improvements with typical sections, are shown on Appendix plates C-1 to C-7. In addition, these plates illustrate the present proposed water surface profiles for the design flow of 120,000 c.f.s. The location and log of foundation explorations are shown on Appendix plates C-8 and C-9.

4. COSTS

An overall cost estimate for the levee and channel improvements is shown in table C-1. Incremental cost estimates for the levee and channel improvements are shown in tables C-2, C-3 and C-4. Cost estimates for the resident fishery, and for access to Padilla Bay are shown in tables C-5 and C-6.

Table C-1

LEVEE AND CHANNEL IMPROVEMENTS
COST ESTIMATE

Feature	Unit	Quantity	Unit Price	Item Cost	Feature Cost
FEDERAL COSTS					
09 CHANNEL IMPROVEMENT					
Stripping & Clearing	Acre	99	950.	$ 94,000	
Excavation & Disposal	CY	1,446,600	0.50	723,300	
Seeding	Acre	99	300.00	29,700	
					$ 847,000
11 LEVEE IMPROVEMENT					
Stripping & Clearing	Acre	200	950.	190,000	
Removal & Replacement of Existing Riprap	CY	4,500	3.00	13,500	
Filter Blanket	CY	24,428	3.50	85,500	
Riprap	CY	44,000	6.00	264,000	
Embankment	CY	1,365,000	1.75	2,390,000	
Seeding	Acre	200	300.00	60,000	
					$3,003,000
CONTINGENCIES (25%)					961,000
30 ENGINEERING AND DESIGN					540,000[1/]
31 SUPERVISION AND ADMINISTRATION					419,000
	TOTAL FEDERAL COST				$5,770,000
NON-FEDERAL COSTS					
Easements	Acre	181	24.00	4,340	
Rights-of-way	Acre	153	769.00	117,660	
Relocate or raze buildings	L.S.			60,000	
Relocate fences	L.S.			25,000	
Relocate electric utilities	L.S.			10,000	
Relocate roads	Mile	1	20,000.	20,000	
	TOTAL NON-FEDERAL COST				$237,000
TOTAL, LEVEE AND CHANNEL IMPROVEMENTS					$6,007,000

1/ Does not include pre-authorization survey costs of $169,000

Table C-2

LEVEE AND CHANNEL IMPROVEMENTS
AREA 1 - LEFT BANK MAIN RIVER AND SOUTH FORK
COST ESTIMATE

Feature	Unit	Quantity	Unit Price	Item Cost	Feature Cost
FEDERAL COSTS					
11 LEVEE IMPROVEMENT					
Stripping & Clearing	Acre	78	950.	74,100	
Filter Blanket	C.Y.	9,200	3.50	32,200	
Riprap	C.Y.	18,400	6.00	110,400	
Embankment	C.Y.	545,000	1.75	954,500	
Seeding	Acre	78	300.	23,400	
					$1,194,600
CONTINGENCIES (25%)					297,900
30 ENGINEERING AND DESIGN					167,400
31 SUPERVISION AND ADMINISTRATION					129,900
	TOTAL FEDERAL COST				$1,789,800
NON-FEDERAL COSTS					
Easements	Acre	56	24.00	1,340	
Rights-of-way	Acre	47	769.	36,160	
Relocate or Raze Buildings	L.S.			18,600	
Relocate Fences	L.S.			7,750	
Relocate Elec. Utilities	L.S.			3,100	
Relocate Roads	L.S.			6,450	
	TOTAL NON-FEDERAL COST				$73,400
TOTAL AREA 1					$1,863,200

Table C-3

LEVEE AND CHANNEL IMPROVEMENTS
AREA 2 - RIGHT BANK SOUTH FORK AND LEFT BANK NORTH FORK
COST ESTIMATE

Feature	Unit	Quantity	Unit Price	Item Cost	Feature Cost
FEDERAL COSTS					
09 CHANNEL IMPROVEMENT					
Stripping & Clearing	Acre	1,213,950	950.	82,650	
Excavation & Disposal	C.Y.	1,213,950	0.50	606,975	
Seeding	Acre	87	300.	26,100	$715,725
11 LEVEE IMPROVEMENT					
Stripping & Clearing	Acre	55	950.	52,250	
Removal & Replacement of Existing Riprap	C.Y.	2,242	3.00	6,700	
Filter Blanket	C.Y.	7,828	3.50	27,400	
Riprap	C.Y.	13,400	6.00	80,400	
Embankment	C.Y.	387,000	1.75	677,250	
Seeding	Acre	55	300	16,500	
					$860,500
CONTINGENCIES (25%)					$394,000
30 ENGINEERING AND DESIGN					$221,400
31 SUPERVISION AND ADMINISTRATION					$171,800
TOTAL FEDERAL COST					$2,363,425
NON-FEDERAL COSTS					
Easements	Acre	74	24.00	1,780	
Rights-of-Way	Acre	63	769.00	48,400	
Relocate or Raze Buildings	L.S.			24,600	
Relocate Fences	L.S.			10,250	
Relocate Elec. Utilities	L.S.			4,100	
Relocate Roads	L.S.			8,070	
	TOTAL NON-FEDERAL COST				$97,200
TOTAL AREA 2					$2,460,625

Table C-4

LEVEE AND CHANNEL IMPROVEMENTS
AREA 3 - RIGHT BANK MAIN RIVER AND NORTH FORK
COST ESTIMATE

Feature	Unit	Quantity	Unit Price	Item Cost	Feature Cost
FEDERAL COSTS					
09 CHANNEL IMPROVEMENTS					
Stripping & Clearing	Acre	12	950.	11,400	
Excavation & Disposal	C.Y.	232,650	0.50	116,300	
Seeding	Acre	12	300.	3,600	
					$131,300
11 LEVEE IMPROVEMENT					
Stripping & Clearing	Acre	67	950.	63,650	
Removal & Replacement of Existing Riprap	C.Y.	2,258	3.00	6,775	
Filter Blanket	C.Y.	7,400	3.50	25,900	
Riprap	C.Y.	12,200	6.00	73,200	
Embankment	C.Y.	433,000	1.75	758,250	
Seeding	Acre	67	300.	20,100	
					$947,875
CONTINGENCIES (25%)					$269,100
30 ENGINEERING & DESIGN					$151,200
31 SUPERVISION & ADMINISTRATION					$117,300
	TOTAL FEDERAL COST				$1,616,775
NON-FEDERAL COSTS					
Easements	Acre	51	24.00	1,220	
Rights-of-Way	Acre	43	769.00	33,100	
Relocate or Raze Buildings	L.S.			16,800	
Relocate Fences	L.S.			7,000	
Relocate Elec. Utilities	L.S.			2,800	
Relocate Roads	L.S.			5,480	
	TOTAL NON-FEDERAL COST				$66,400
TOTAL AREA 3					$1,683,175

Table C-5

ADDED PURPOSES FOR AVON BYPASS
RESIDENT FISHERY

Feature	Unit	Quantity	Unit Price	Item Cost	Feature Cost
CONSTRUCTION COSTS					
14 BOAT LAUNCHING FACILITIES (5)					
Right-of-way	Acre	4	$250.00	$1,000	
Concrete Launching Ramp	L.F.	300	50.00	15,000	
Gravel Approach	S.Y.	7,075	.80	5,660	
Gravel Parking Area	S.Y.	2,550	.80	2,040	
					$23,700
CONTINGENCIES (25%)					5,700
30 ENGINEERING AND DESIGN					5,700 1/
31 SUPERVISION AND ADMINISTRATION					3,000
	TOTAL				$38,100
	ROUND TO				$38,000

1/ Does not include pre-authorization survey costs of $8,000

Table C-6

ADDED PURPOSES FOR AVON BYPASS
ACCESS TO PADILLA BAY AND LOWER PROJECT WATERS
COST ESTIMATE

Feature	Unit	Quantity	Unit Price	Item Cost	Feature Cost
14 BOAT LAUNCHING FACILITIES					
Rights-of-way	Acre	5	$800.00	$4,000	
Site Preparation	L.S.			2,500	
Concrete Launching Ramp	L.F.	60	65.00	3,900	
Gravel Approach	S.Y.	1,000	2.00	2,000	
Gravel Parking Area	S.Y.	5,200	1.50	7,800	
Miscellaneous Appurtenances	L.S.			1,500	
					$21,700
CONTINGENCIES (25%)					4,400
30 ENGINEERING AND DESIGN					3,200 1/
31 SUPERVISION AND ADMINISTRATION					2,000
	TOTAL				$31,300
	ROUND TO				$31,000

1/ Does not include pre-authorization survey costs of $2,000

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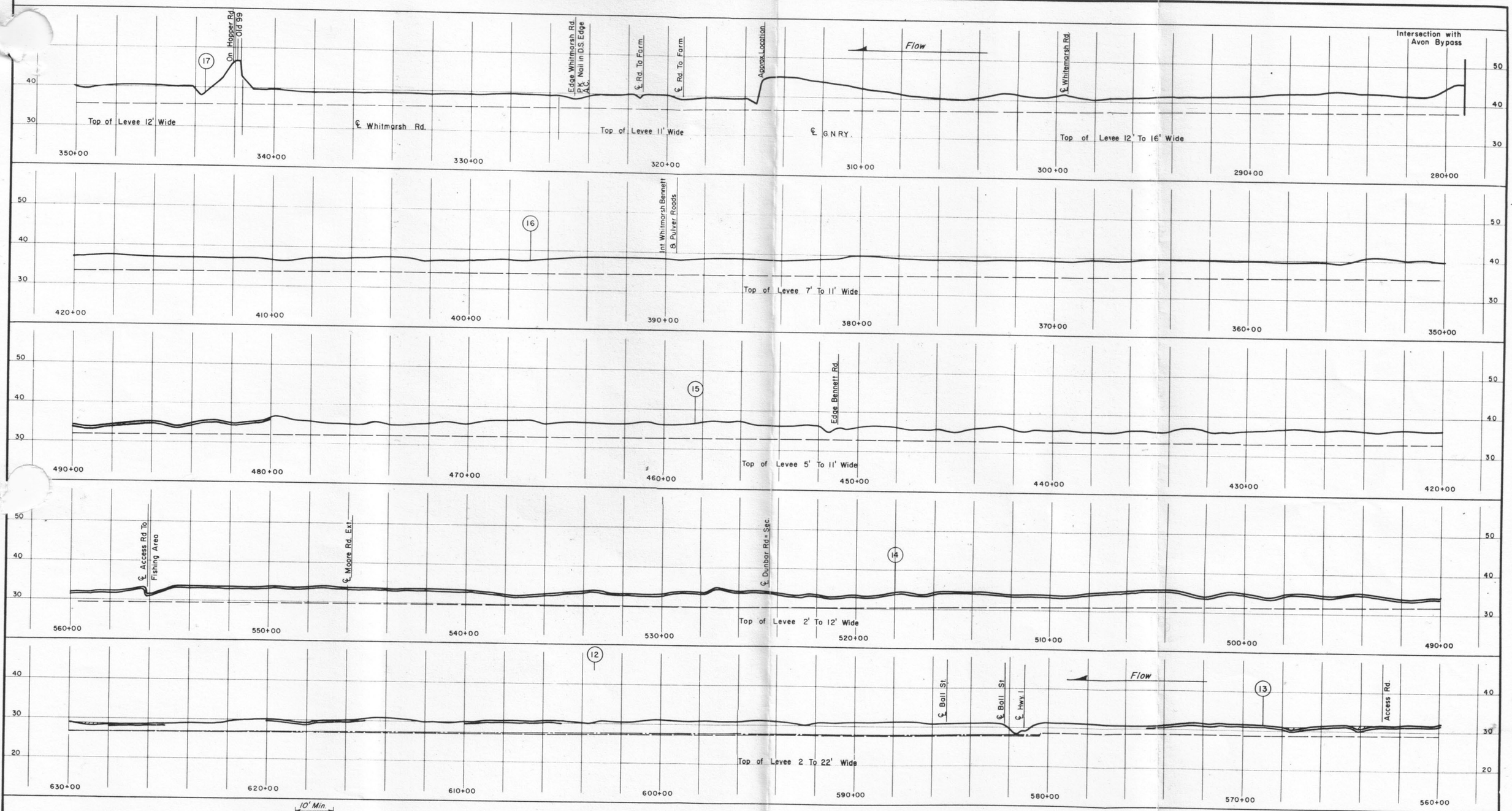
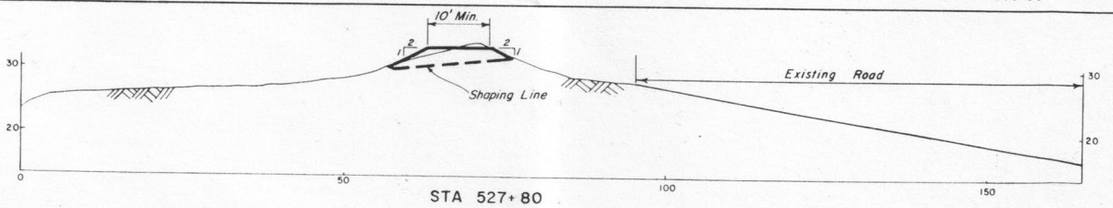




STA 527+80

TYPICAL LEVEE IMPROVEMENT SECTIONS

Scale: 1" = 10' Horizontal & Vertical

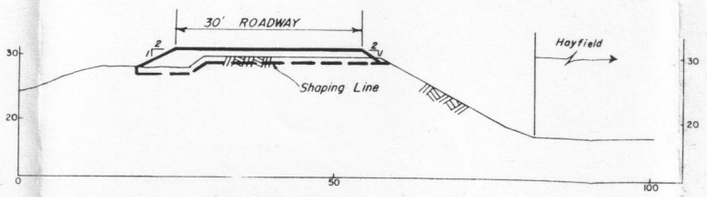
RIVER PROFILE SCALE:

Horiz. 1" = 200'

Vert. 1" = 10'

NOTES:

1. Datum is M.S.L.
2. River miles run upstream and stationing downstream.
3. Stripped matericl to be bladed back over rebuilt levee.



STA 645+00

LEGEND

- Water Surface Improved Channel
- Water Surface Natural Channel
- Levee Raising
- (12) River Mile
- Levee Widening and Strengthening

THIS DRAWING HAS BEEN REDUCED

SKAGIT RIVER WASHINGTON

RIGHT BANK MAIN RIVER

LEVEE PROFILE - 120,000 C.F.S. WATER SURFACE PROFILES & TYPICAL SECTIONS

In 7 sheets Sheet No. 1 Scale: As shown

U. S. Army Engineer District, Seattle, Wash. Jan. 1964

Prepared: John F. Scelly, Project Engineer

Recommended: R. H. Gedney, Chief, Basin Planning Branch

Submitted: Raymond A. Skinner, Chief, Puget Sound Section

Approved: Sydney Steinberg, Chief, Engineering Division

Drawn by: C.D.B.

Traced by: I.E.C.

Checked by: R.W.E.

File No. E-6-6-215

APPENDIX PLATE C-1

CORPS OF ENGINEERS

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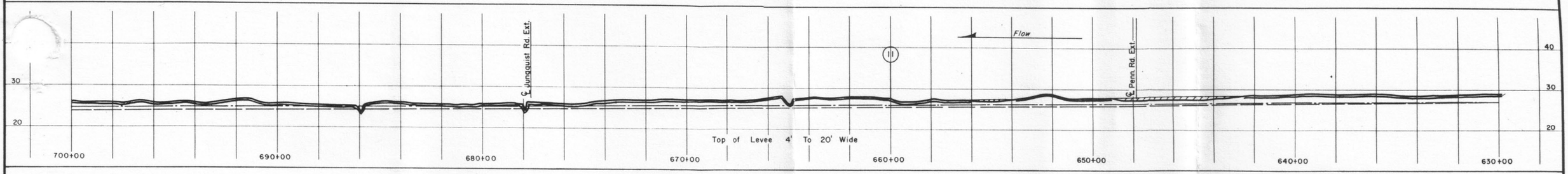
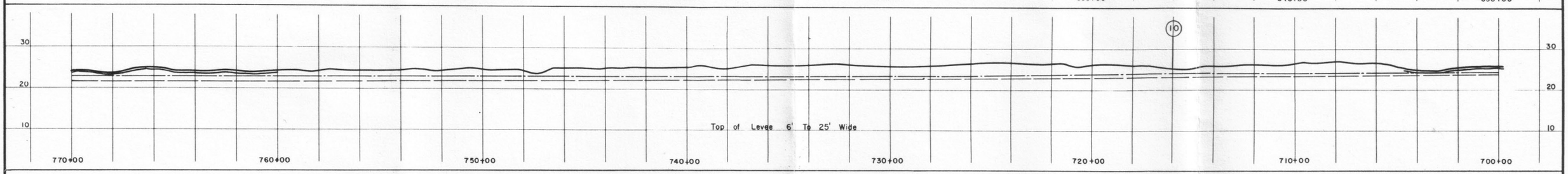
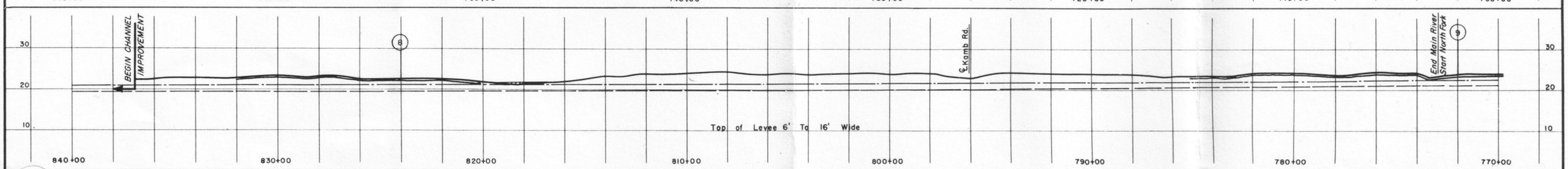
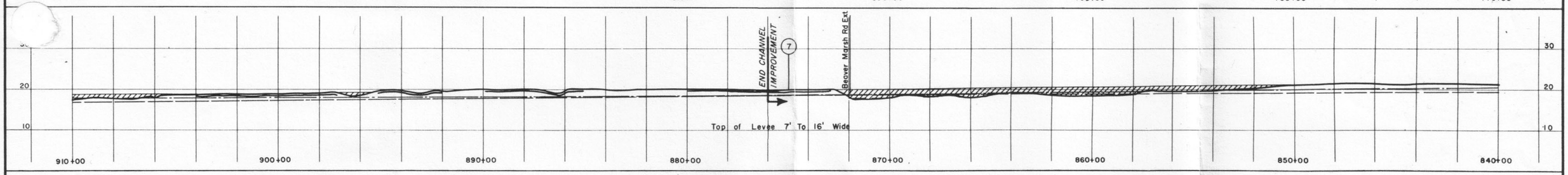
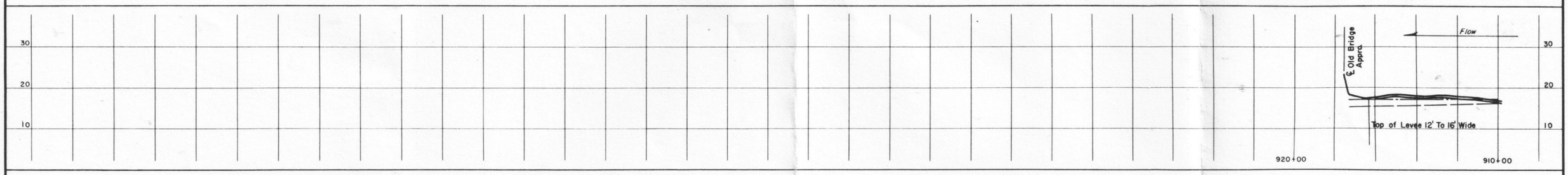
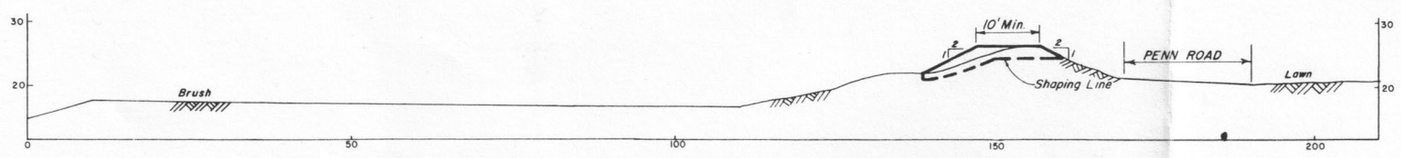




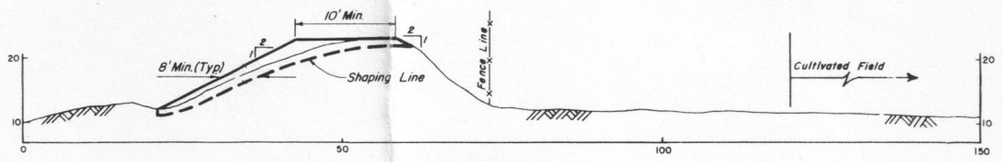








STA. 678+30



STA. 831+10

TYPICAL LEVEE IMPROVEMENT SECTIONS

SCALE: 1" = 10' Horizontal & Vertical

RIVER PROFILE SCALE
1" = 200' Horizontal
1" = 10' Vertical

NOTE:

See Sheet 1 for legend and notes.

THIS DRAWING HAS BEEN REDUCED

SKAGIT RIVER, WASHINGTON

RIGHT BANK MAIN RIVER & NORTH FORK

LEVEE PROFILE - 120,000 C.F.S. WATER SURFACE PROFILES & TYPICAL SECTIONS

In 7 sheets Sheet No. 2 Scale: As shown

U. S. Army Engineer District, Seattle, Wash. Jan. 1964

Prepared: Julian F. Buckley, Project Engineer

Recommended: R. H. Gedney, Chief, Basin Planning Branch

Submitted: Raymond A. Skinner, Chief, Puget Sound Section

Approved: Sydney Steinberg, Chief, Engineering Division

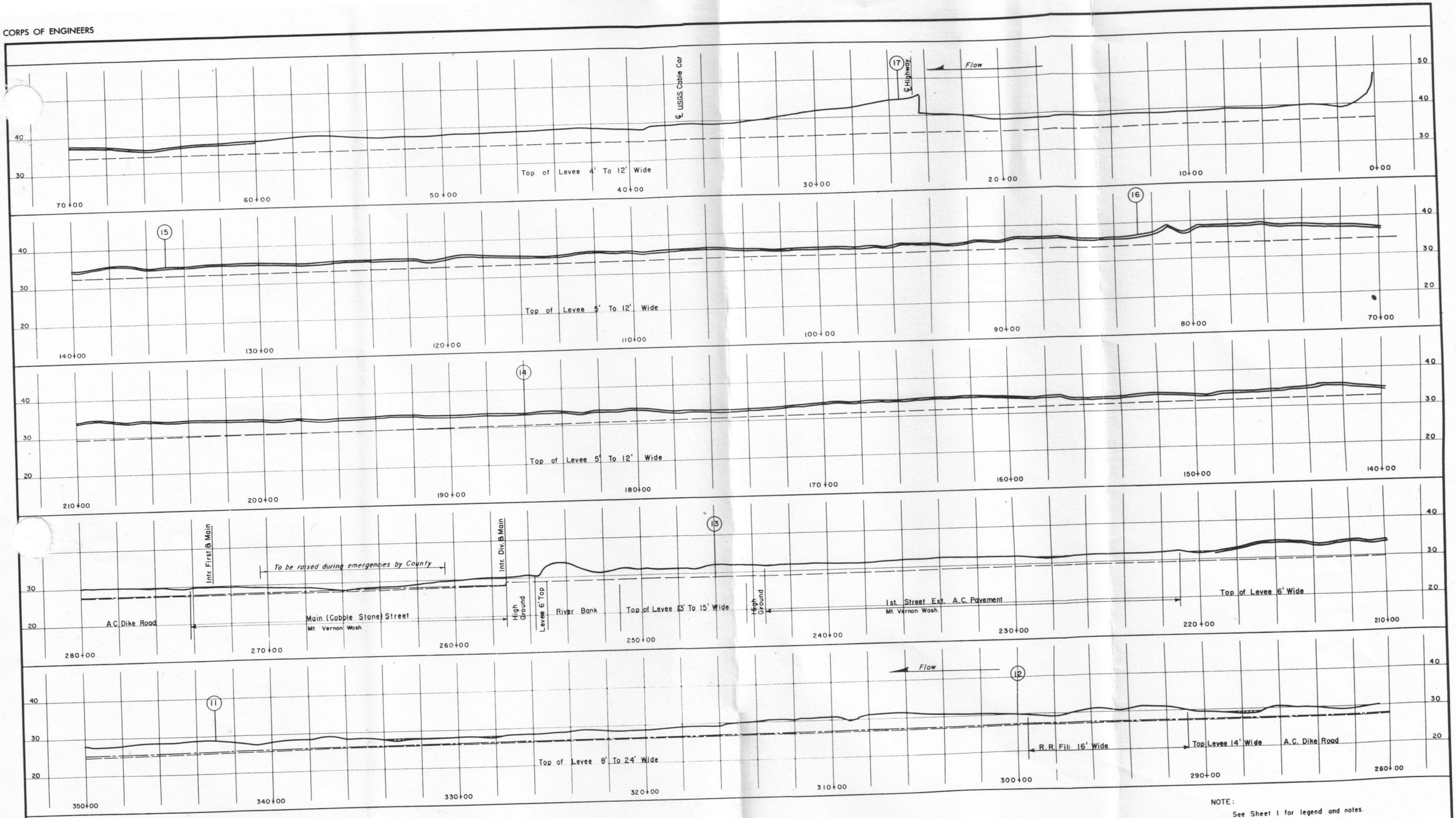
Drawn by: C. D. B.
Traced by: L. E. C.
Checked by: R. W. E.

File No. E-6-6-215

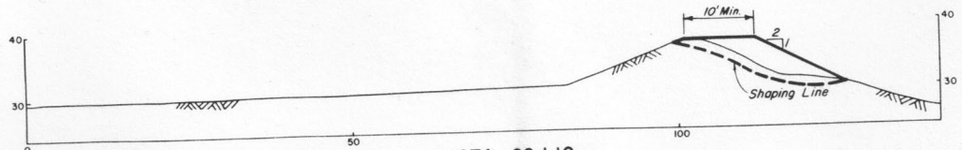
APPENDIX PLATE C-2

CORPS OF ENGINEERS

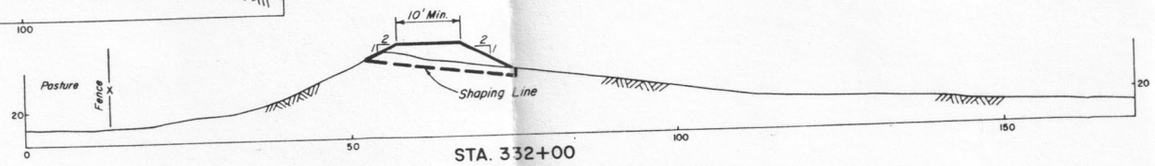
U. S. ARMY



NOTE:
See Sheet 1 for legend and notes.



STA. 69+10



STA. 332+00

TYPICAL LEVEE IMPROVEMENT SECTIONS

SCALE: 1" = 10' Horizontal & Vertical

RIVER PROFILE SCALE
1" = 200' Horizontal
1" = 10' Vertical

THIS DRAWING HAS BEEN REDUCED

SKAGIT RIVER, WASHINGTON
LEFT BANK MAIN RIVER

LEVEE PROFILE - 120,000 C.F.S. WATER SURFACE PROFILES & TYPICAL SECTIONS

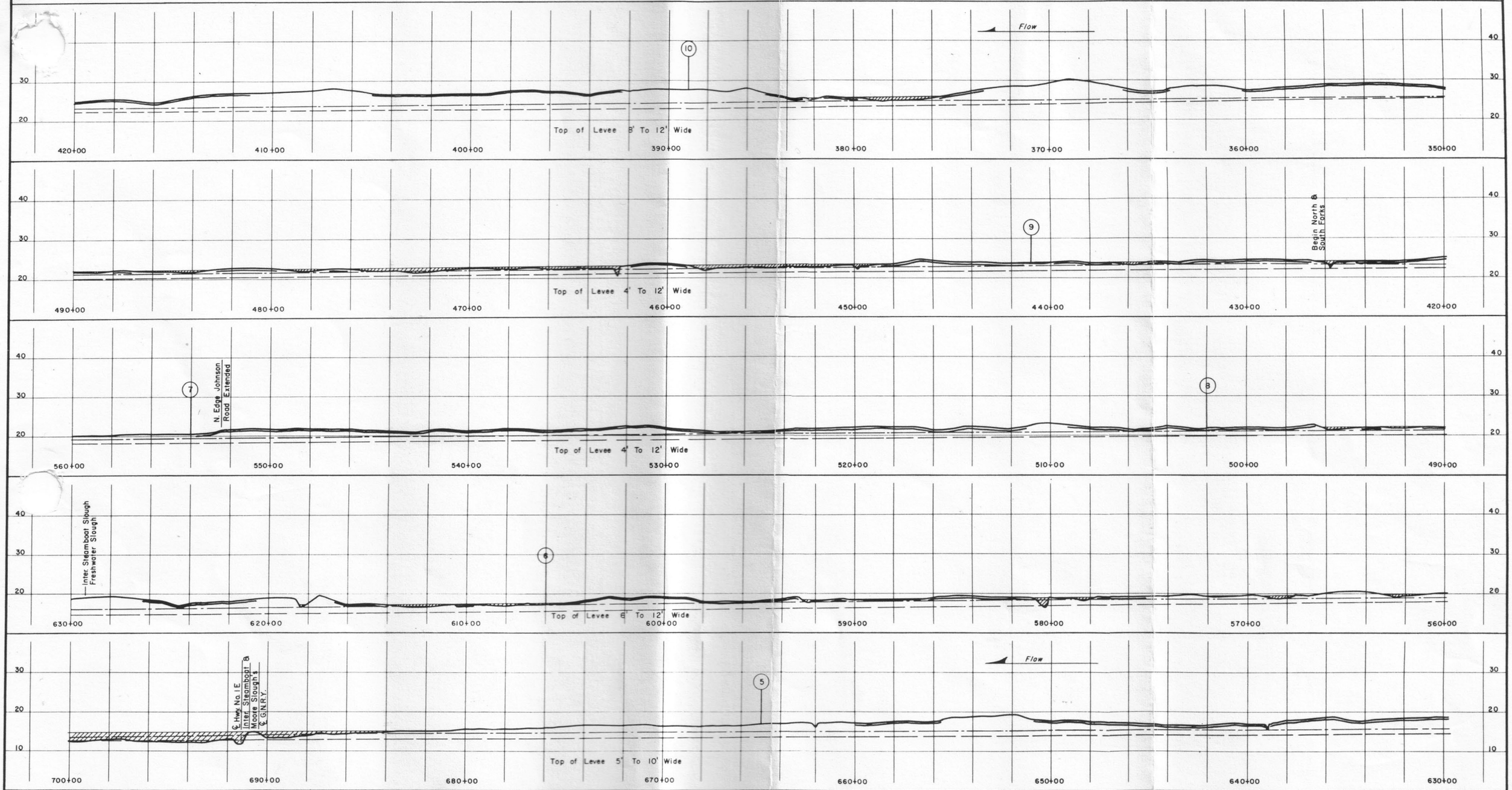
In 7 sheets Sheet No. 3
U. S. Army Engineer District, Seattle, Wash.
Scale: As shown
Jan. 1964

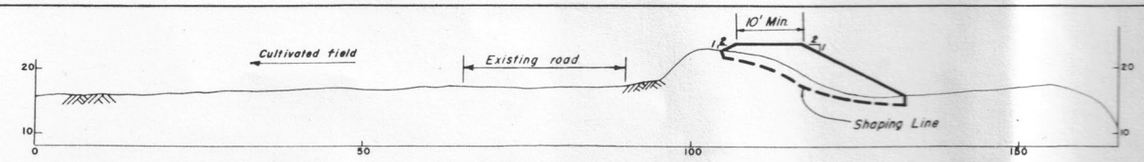
Prepared: Julius F. Buckley, Project Engineer
Recommended: R.A. LeSourd, Chief, Basin Planning Branch
Drawn by: C.D.B.
Traced by: B.E.J.
Checked by: R.W.E.
Submitted: Edmund A. Steimle, Chief, Puget Sound Section
Approved: Sydney Steinbora, Chief, Engineering Division
File No. E-6-6-215

APPENDIX PLATE C-3

CORPS OF ENGINEERS

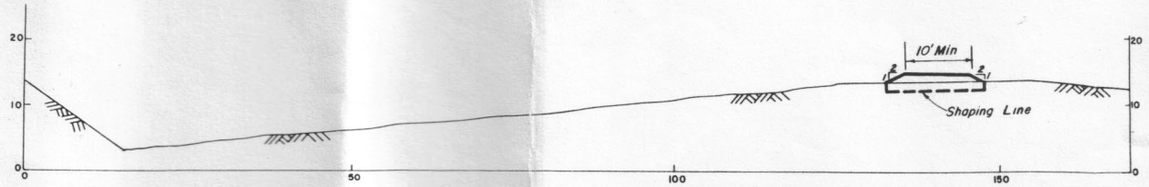
U. S. ARMY





TYPICAL LEVEE IMPROVEMENT SECTIONS

SCALE: 1" = 10' Horizontal & Vertical



RIVER PROFILE SCALE
1" = 200' Horizontal
1" = 10' Vertical

NOTE:

See Sheet 1 for legend and notes.

THIS DRAWING HAS BEEN REDUCED

SKAGIT RIVER, WASHINGTON
LEFT BANK MAIN RIVER & SOUTH FORK
LEVEE PROFILE - 120,000 C.F.S. WATER SURFACE PROFILES & TYPICAL SECTIONS

In 7 sheets Sheet No. 4 Scale: As shown

U. S. Army Engineer District, Seattle, Wash. Jan. 1964

Prepared: Julius F. Buckley, Project Engineer
Recommended: R. A. Gobray, Chief, Basin Planning Branch
Drawn by: C.D.B.
Traced by: L.E.C.
Checked by: R.W.E.

Submitted: Raymond A. Skinner, Chief, Puget Sound Section
Approved: Sydney Steinbach, Chief, Engineering Division

File No. E-6-6-215

APPENDIX PLATE C-4

APPENDIX D

RECREATION

APPENDIX D
RECREATION

CONTENTS

FIGURES

EXHIBITS
(Bound at end of Appendix)

APPENDIX D - RECREATION

1. GENERAL

Supplemental information on fish, wildlife and general recreation at the Avon Bypass project are given in this appendix.

2. STUDIES AND COORDINATION

The Washington State Department of Fisheries and Game, together with the Bureau of Sport Fisheries and Wildlife and the U. S. Fish and Wildlife Service, investigated the fishery and wildlife aspects of the project. Their findings are contained in the report and supplemental letter attached to this appendix as Exhibit D-1. General purpose recreation was studied by the Corps of Engineers in cooperation with the Bureau of Outdoor Recreation and the Washington State Park Commission. A letter from the Washington State Park Commission is attached as Exhibit 4 to the main report. There was also a review by the Bureau of Outdoor Recreation, as shown in a letter dated 24 February 1964 from Mr. Fred Overly, Regional Director, attached to this appendix as Exhibit D-2.

3. FISH AND WILDLIFE

The resident trout fishery and access to the lower project and Padilla Bay have been included in the plan for the Avon Bypass project. These features have been incorporated essentially as recommended by the U. S. Fish and Wildlife Service as only minor modification of the project features is involved and the benefits derived therefrom are greater than the cost. The U. S. Fish and Wildlife Service has recommended that Federal funds be used to obtain easements along the Bypass channel and to install foot stiles on fence lines along the channel for hunters to retrieve waterfowl and pheasants. They have also recommended that Federal funds be used to acquire 180 acres of land along Padilla Bay adjacent to the Bypass channel for waterfowl hunting. Boat access to the Skagit River has been deleted from the project because it is not project oriented. Benefits attributable to the boat access were not credited to the Bypass project. Recommendations made for management are detailed in the following paragraph.

4. MANAGEMENT OF AVON BYPASS FOR FISH AND WILDLIFE

The U. S. Fish and Wildlife Service has recommended that:

a. a zoning plan for the regulation of recreational use, to avoid conflicts and to control boat operation, be part of a joint management

agreement. This agreement would be developed at the time the project is turned over to local interests for operation and management.

b. a cooperative agreement be entered into between the Washington Departments of Fisheries and Game, the Bureau of Sport Fisheries and Wildlife, the Corps of Engineers and Skagit County to delegate management and development of the fish and wildlife resources of the project area to the Washington Department of Game, except that management of the channel between the outlet works and the section line between sections 10 and 11 be reserved for the propagation and management of anadromous fish by the Washington Department of Fisheries if that agency so desires.

c. additional detailed studies of fish and wildlife resources be conducted, as necessary and that such reasonable modifications be made in the authorized project facilities as may be agreed upon between the U. S. Fish and Wildlife Service and the Corps of Engineers.

d. all project lands be open to the public for hunting and fishing, except sections reserved for the conservation and development of fish and wildlife, safety, efficient operation or protection of public property.

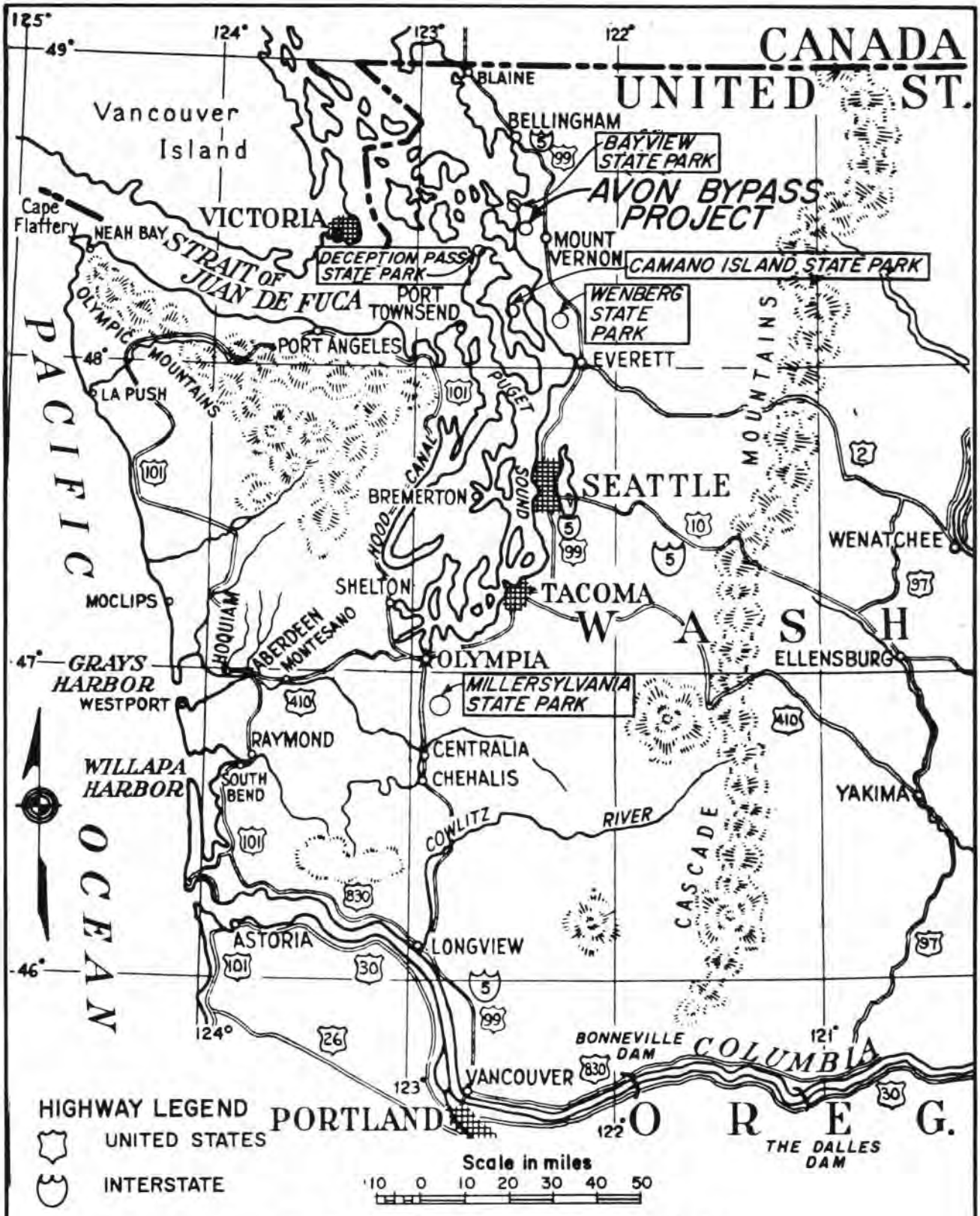
e. leases for all project land reserve the right of public use for hunting and fishing.

The Avon Bypass would be constructed as a local cooperation flood control project. The project sponsor, Skagit County, would be responsible for the acquisition of lands, easements and rights-of-way, as well as for operation and administration of the project after construction. The Corps of Engineers will bring recommendations of the U. S. Fish and Wildlife Service to the attention of the appropriate State and County sponsors, and will assist in developing working agreements and arrangements satisfactory to both the U. S. Fish and Wildlife Service and the project sponsor.

5. GENERAL RECREATION FOR AVON BYPASS PROJECT

All-purpose recreation facilities can be developed on a gently sloping, timber covered area about 230 acres in size, near the midpoint of the Avon Bypass channel. These facilities would be of State- or County-type park, the construction of which is normally a local responsibility.

With development, this recreation area would be similar to a number of parks maintained by the State of Washington. Pertinent data on these parks are given below.



LOCATION OF STATE PARKS
USED IN FORECASTING
AVON BYPASS POTENTIAL USAGE

E-6-6-234 FIGURE D-1

Name	Area Acres	Attendance 1950	1958	1962
Bayview	19	3,412	60,292	45,300
Camano Island	175	4,580	120,338	123,873
Deception Pass	1,763	157,879	645,314	678,530
Millersylvania	835	68,942	247,773	335,021
Wenberg	55	18,518	189,702	206,161

Locations of these parks with respect to the Bypass are shown on figure D-1.

For the purpose of estimating public usage of the Avon Bypass recreation areas, Millersylvania and Wenberg State Parks were chosen as the most comparable on the basis of location, available facilities and topography. Millersylvania State Park is in a different locale, but is very similar to the proposed Avon Bypass recreational area. Located just south of Olympia, the Millersylvania State Park is about the same distance from Seattle as the Avon Bypass project. The park offers picnicking, camping, swimming, fishing and boat launching facilities on a small, fresh water lake. The park lies just east of U. S. Highway 99 with an average daily traffic count of 9,700 which compares favorably with the average daily traffic count of 8,000 on U. S. Highway 99 just north of Mount Vernon. The growth in attendance approximates 9.5 percent annually since 1958.

The Wenberg State Park is located 45 miles north of Seattle on a small, natural lake, and has facilities for picnicking, camping, swimming, boating, and fresh water fishing. The park now operates at capacity during the recreational season and receives heavy usage from tourists travelling on U. S. Highway 99. Public attendance has increased about 1.1 percent annually since 1958. This park is overloaded during the summer recreation season.

Use of the recreation facilities developed along the Avon Bypass project should closely parallel that experienced at Wenberg and Millersylvania. Initial impact is expected to approximate the attendance of Millersylvania in 1960 of about 60,000 persons. Growth for the first 10-year period can be expected to be rapid. Visitation during the first three to five years of operation of recreation facilities is expected to average about 200,000 visitor days annually. A growth rate of 3 percent per year is forecast. This rate is only slightly greater than that experienced at Wenberg State Park and about one-third the rate at Millersylvania. The ultimate capacity is estimated to be 750,000 visitor days without undue overcrowding. A value of $1.00 per visitor day has been accepted. This value is in general use for projects having large diversified opportunities for general recreation. Using this value and discounting by present-worth procedures at 3-1/8% interest, the average annual recreation benefits are $300,000.

The cost of acquiring land for the recreational area is estimated to be $94,000, which includes the purchase of 200 acres of forest land at $350 an acre and 30 acres of cropland at $800 an acre. The estimated cost of initial construction during the first three years of project life is $588,000. The cost of future construction to meet public demand extending over a 40-year period is estimated to total $840,000, having a present-worth value at 3-1/8% interest of $454,000. Annual charges over the project life, including interest and amortization, annual operation and maintenance, and annual interim replacements, are $59,000 for initial construction and $35,000 for future construction, giving a total annual charge of $94,000. The work is well justified by the resulting benefits of $300,000 annually.

The studies were reviewed by the Bureau of Outdoor Recreation, U. S. Department of the Interior, and the results were shown in the inclosed letter, Exhibit D-2, dated 24 February 1964. This letter indicates general concurrence with the findings of the Corps of Engineers on general recreation and with the conclusions of the fish and wildlife agencies on fish and wildlife.

STATE OF
WASHINGTON
ALBERT D. ROSELLINI
GOVERNOR

DEPARTMENT OF
FISHERIES
GEORGE C. STARLUND
DIRECTOR

ROOM 115, GENERAL ADMINISTRATION BUILDING
OLYMPIA, WASHINGTON 98502

AIR MAIL

May 4, 1964

Bureau of Sport Fish & Wildlife
P. O. Box 3737
1002 N.E. Holladay
Portland 8, Oregon 97208

RE: Interim Report - Skagit Basin

Gentlemen:

The Department of Fisheries will concur in the "Interim Report on Fish and Wildlife Resources Affected by Proposed Corps of Engineer Projects in the Skagit River Basin".

This concurrence is on the basis that the suggestions made in our letter of March 26, 1964 are incorporated in the text of the report.

Very truly yours,

George C. Starlund

George C. Starlund
Director

GCS-RBA:lj

cc: Department of Game

State of Washington

DEPARTMENT OF GAME

600 North Capitol Way / Olympia, Washington 98502

February 24, 1964

Regional Director
Bureau of Sport Fisheries and Wildlife
P. O. Box 3737
Portland, Oregon 97208

ATTN: Harry A. Goodwin, Chief, Division of Technical Services

Dear Sir:

We have reviewed the draft of the interim report on the Skagit River Basin. This draft of the interim report meets with our approval.

Very truly yours,

THE DEPARTMENT OF GAME

John A. Biggs

John A. Biggs, Director

RWL/mjb

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF OUTDOOR RECREATION

Pacific Northwest Region
U. S. Court House
Seattle, Washington 98104

FEB 24 1964

District Engineer
Seattle District
Corps of Engineers
1519 Alaskan Way South
Seattle, Washington 98134

Dear Sir:

In accordance with your request for comments we have reviewed the preliminary recreation plan you furnished to us for the Avon Bypass project for the Skagit River. Our comments are based on a field examination of the project area and also from a review of the report on the project prepared by the Fish and Wildlife Service. We have also taken into account recent information you have given us relative to the lack of authority for the Corps to purchase lands for recreation purposes for this type of a project and also the contemplated changes in the fishery management program to emphasize initial use of the bypass for a trout fishery rather than an anadromous fishery program.

We also note the Washington State Parks and Recreation Commission has endorsed the project as having "a great recreational potential."

We concur in general with the opinions indicated in your preliminary report, the Fish and Wildlife Service report, and the Washington State Parks and Recreation Commission relative to the high potential recreational value of the project proposal. There is no question but that it will contribute important and needed recreation opportunities for the residents of the State of Washington. Because of its proximity to the heavily populated Seattle metropolitan area it will receive heavy public use especially for trout fishing.

The District Engineer's preliminary plan indicates the bypass canal would be constructed and operated to maintain a depth of approximately ten feet throughout with a minimum flow through it of 100 c.f.s. to prevent stagnation. These operating details would be desirable from a scenic and recreation standpoint.

The proposed locations of the six boat ramps were apparently selected on the basis of land suitabilities, prospective public use areas and access factors. Our information does not reveal any factors in conflict with the locations shown on the preliminary plan.

Under the present preliminary recreation plan we understand acquisition and development of lands for recreation would be the responsibility of State, county or local interests, which would not include boat launching ramps, water control structures or fish control facilities but would include campgrounds, picnic areas, water and sanitary systems, parking areas, etc. Because of the anticipated heavy public use and the indicated interest of the State Parks and Recreation Commission, we believe that agency would be the logical one to administer the recreation aspects of the projects. Also, as there are other State Park areas in the general vicinity, administration and use of the Avon Bypass could be correlated with these other areas with commensurate public benefits.

It is noted the visitation estimates are 60,000 visitor days initially and 750,000 ultimately, based on the original preliminary planned land acquisition and development program by the Corps. We assume these estimates would still be considered valid although land acquisition and development would not now be undertaken by the Corps. Although we have not made an intensive study of this question and recognizing public use will be influenced to a great extent by the timing, extent and type of development, we believe the estimate of initial visitation may be low. This opinion is on the basis that public facilities such as boat ramps, parking areas, water and sanitation would be available and that recreation fishing and hunting are included. We also assume this estimate refers to a three or five-year average and not necessarily to the first year of project operation. Under these conditons we believe we can assume visitation during the first three to five years operation would average approximately 200,000 visitor days annually. If the 60,000 estimate, however, does not include angler days it would appear reasonable.

The estimate of 750,000 visitor days ultimately seems to be quite conservative but the presently unknown factors of land acquisition and development together with other unknown factors make a reasonably accurate estimate difficult. However, assuming full development and continuation of an intensive recreational fishery, visitations could be expected to double the present estimate within the next 25-year period.

In reviewing the preliminary draft of the proposed Fish and Wildlife Service report several recommendations which would affect general recreation have been made. We believe these recommendations are good and we concur in general with them.

We concur that the bypass will be a very popular and valuable trout fishing area and that the estimate of 160,000 angler days with a monetary benefit of $240,000 annually is reasonable.

We agree with the conclusion that acquisition of the E½ Section 6, T.34N., R.3E. would be desirable from a recreation standpoint. We also are in agreement that zoning of the water area would be desirable from a recreation standpoint. Thisis particularly necessary if swimming, fishing and boating would all take place on the bypass. We are not entirely convinced that motor boats should be prohibited on the water but we do agree they should be adequately controlled. We believe zoning and an enforced speed limit would be adequate to control motor boating at least initially or until a need is demonstrated justifying prohibition.

Because we have made some comments on the Fish and Wildlife preliminary plan in connection with the over-all recreational evaluation of the project, we are furnishing the Regional Director, Bureau of Sport Fisheries and Wildlife with a copy of this letter.

Sincerely yours,

Fred J. Overly
Regional Director

cc: Regional Director, BSFW

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
Branch of River Basin Studies (1-RB)
Portland Area Office
208 S. W. 5th Avenue
Portland, Oregon 97204

January 20, 1965

District Engineer
Seattle District, Corps of Engineers
1519 Alaskan Way South
Seattle, Washington 98134

Attention: Pete Denny

Dear Sir:

This is in response to your telephone call of January 18, 1965, requesting reevaluation of certain fish and wildlife benefits from Avon Bypass project, Skagit Basin, Washington. The reevaluation is made necessary by a decision to evaluate the project on the basis of a 50-year project life rather than on the 100-year period considered in our Interim Report on Skagit Basin.

Values assigned to the boat ramps and to the outlet channel will be the same as indicated in our Interim Report. Hunter-use values will also remain as reported except for benefits associated with the proposed 180-acre public shooting area. Fisherman use and value of the bypass channel will be reduced from 159,000 angler-days valued at $238,000 annually to 129,000 angler-days valued at $195,000 annually. Cost of stocking for the 50-year period of analysis will be $7,500 annually. Management cost will not change.

Please call us if additional information is required.

Sincerely yours,

Ralph H. Imler

Ralph H. Imler
Field Supervisor

Supplemental Letter to
Exhibit D-1
(Exhibit D-1 follows)

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
1002 N. E. HOLLADAY STREET
P. O. BOX 3737
PORTLAND 8, OREGON

ADDRESS ONLY THE
REGIONAL DIRECTOR

PACIFIC REGION
(REGION 1)
CALIFORNIA
IDAHO
MONTANA
NEVADA
OREGON
WASHINGTON

Reference: RBS

May 20, 1964

Your file: NPSGW
NPSGW-R
NPSEN-BP
NPSEN-PP-R

District Engineer
Seattle District, Corps of Engineers
1519 South Alaskan Way
Seattle, Washington 98134

Dear Sir:

This is the interim report of the Bureau of Sport Fisheries and Wildlife on effects on fish and wildlife of proposed Corps of Engineers projects in Skagit River basin, Skagit and Whatcom Counties, Washington. With the exception of statements pertaining to various physical features, the portion of the basin lying in British Columbia, Canada, is not discussed. This report supersedes our preliminary comments on water development projects within this basin which were transmitted to you in previous correspondence. Our comprehensive report on Skagit River basin fish and wildlife is scheduled for release in 1969. The comprehensive report will present a detailed summation of the effects of these contemplated projects on the abundance, distribution, and utilization of these resources and recommend a plan for their conservation and development.

This report has been prepared under the authority and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and is based on information supplied to us by your staff prior to September 1963. All use and value estimates contained herein are preliminary and will be subject to revision in our detailed report.

The Washington Departments of Fisheries and Game have reviewed and concur with this report as indicated by the attached copies of letters from Director George C. Starlund, dated May 4, 1964, and Director John A. Biggs, dated February 24, 1964. These agencies furnished basic estimates of potential fisherman and hunter use employed in evaluating the projects. They also proposed development and management measures recommended herein

for conservation and improvement of fish and wildlife resources. The suggestions referred to in Mr. Starlund's letter have also been incorporated in our report. The Bureau of Commercial Fisheries has reviewed the fishery sections of this report and endorsed the fishery recommendations.

Your staff has furnished definite plans for the Avon Bypass project, to be located between Skagit River near Burlington, and Padilla Bay, an arm of Puget Sound, and for channel and levee improvement on North Fork Skagit River and Skagit River downstream from the bypass inlet site. Plans for channel dredging in a 40-mile reach of Skagit River from the bypass inlet site upstream to Concrete, a dam on lower Sauk River, and diversion of water from Sauk River to Stillaguamish River are under study and will be reported on at a later date. Effects of the Avon Bypass development and the associated channel and levee improvement work on fish and wildlife resources are analyzed in detail in this report. A tentative plan for fish and wildlife improvement in the Avon Bypass project area also is outlined. Discussion of the other proposals described above will of necessity be confined to statements of a preliminary nature.

DESCRIPTION OF THE BASIN

Physical Features

Skagit River basin lies on the west slope of the Cascade Range, and contains approximately 3,140 square miles, much of which is rough timbered land. A portion of the upper basin, approximately 400 square miles, lies in British Columbia, Canada. About two-thirds of the basin is in Mount Baker National Forest. Basin elevations vary from sea level to over 10,000 1/, and there are active glaciers and several peaks with perennial snow cover including Mount Baker, Mount Shuksan, and Glacier Peak. Much of the basin is so topographically rough and heavily vegetated that it is inaccessible except for trails or roads up the principal tributaries and to the major lakes, mountains, and glaciers. Over one-fifth of the North Cascade Primitive Area and approximately one-half of the Glacier Peak Wilderness Area lie within the basin.

Skagit River is the largest stream entering Puget Sound. It originates in Canada and flows 135 miles south and west to Skagit Bay. About seven miles upstream from the bay, the river divides into the North and South Forks which in turn branch into several subsidiary channels. The major tributaries of Skagit River are Sauk, Cascade and Baker Rivers. Sauk River is a large glacier-fed stream that enters Skagit River a few miles upstream from Concrete. Cascade River, also glacier-fed, heads at the

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1/ All elevations are in feet and refer to mean sea level datum.

summit of the Cascade Range and joins Skagit River at Marblemount. Upper Skagit River is impounded near river mile 97 by City of Seattle's High Gorge Dam. The City's Diablo and Ross Dams are located upstream, and Ross Lake Reservoir extends into Canada. All of these projects are for hydroelectric power production. Baker River is blocked near its mouth by Baker Dam and upstream by Upper Baker Dam. Both are Puget Sound Power and Light Company installations. Padilla Bay is a large, shallow arm of Puget Sound. The east and south portions of the bay are very shallow except in slough channels. Extensive mud flats are exposed in these portions of the bay at low tide.

Skagit River has a broad, fertile flood plain varying in width from one mile at Concrete to 13 miles on Puget Sound. Area soils are mostly alluvial fine sandy, silt, and silty clay loams. Above the flood plain, soils are mostly of glacial derivation.

The climate of Skagit River basin and vicinity is mild, varying with elevation and distance from Puget Sound. Anacortes, to the northwest, has an average growing season of about 227 days, recorded maximum and minimum temperatures are 95° F. and 6° F., and average annual precipitation is about 26 inches. At Concrete the average growing season is 194 days, maximum and minimum temperatures are 106° F. and -1° F., and annual precipitation averages 61 inches.

Skagit Game Range, a 12,192-acre area located on the Skagit Delta, is the largest and most important public hunting ground in the Puget Sound area. It ranks first in annual waterfowl harvest among the management units administered by the Washington Department of Game. The Department also maintains Barnaby Slough for steelhead rearing. This 27-acre impoundment located near Rockport produces over 100,000 steelhead migrants each year for release into the Skagit River. It also owns or administers a number of fisherman-access areas on Skagit River and scattered tideland acreages of the Sound. The Washington Department of Fisheries maintains Skagit Hatchery, a salmon production facility located on Skagit River near Marblemount. It has a capacity of 6.5 million fry. The Department also maintains Newhalem Pond, a 30-acre rearing area planted annually with approximately 150,000 coho salmon.

Commercial Features

About 80 percent of Skagit River basin's human population of 50,000 are concentrated in the lower Skagit Valley. Principal towns are Mount Vernon, population 7,921 1/; Burlington, population 2,968; and Sedro Woolley, population 3,795. Mount Vernon is the county seat of Skagit County. Seattle, a Puget Sound metropolis with a population exceeding one-half

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1/ 1960 Federal Census.

million, lies about 50 miles to the south. United States Highway 99 crosses Avon Bypass project site in the Mount Vernon-Burlington area. North-south State Highway 1A crosses Skagit River near Sedro Woolley, and State Highways 1F, 17A, and 17 follow the Skagit Valley for about 100 miles. The North Cascades Highway, now under construction, will connect these roads with the eastern Washington highway system. Secondary roads parallel Baker River upstream to Baker Lake, Cascade and Sauk Rivers throughout most of their lengths, and Suiattle River for about 25 miles upstream from its confluence with Sauk River. The Great Northern Railroad serves the Skagit Valley upstream to Concrete and connects Mount Vernon, Burlington, and Anacortes, a Fidalgo Island city to the northwest. The Northern Pacific Railway crosses the basin in the vicinity of Sedro Woolley. Skagit River is navigable to Marblemount, about 78 stream miles from Puget Sound, but river traffic upstream from Mount Vernon is composed principally of tug-towed log rafts.

Principal industries in the area are agriculture, lumbering, hydroelectric power production, mining, commercial fishing, and catering to outdoor recreationists and sportsmen. The U. S. Forest Service has developed numerous camp grounds, shelters, trails, and other recreational facilities in the basin, and private interests have constructed similar public facilities near the major power developments. The portion of Skagit River downstream from High Gorge Dam, including Sauk River and tributaries, has been selected for study by a joint U. S. Department of the Interior-U. S. Department of Agriculture team as one of twelve regions in the United States having outstanding recreational potential. The Skagit River flood plains are intensively farmed and are noted for production of vegetables, vegetable seeds, and other specialty crops. Dairying is an important industry. Basin uplands contribute forest products. There are a number of mineral deposits in the basin, but the only significant production is from a quarry near Concrete where limestone deposits support a local cement industry.

PLAN OF DEVELOPMENT

Avon Bypass

The flood control provisions of the project plan for Avon Bypass were authorized by the Flood Control Act of 1936, and are being recommended for reactivation. Flood control plans for the Skagit River downstream from Mount Vernon, and addition of fisheries and recreation as project purposes of Avon Bypass project, are being considered for authorization.

Avon Bypass project will be essentially a large canal designed to divert flood waters from Skagit River to Padilla Bay. The canal will be approximately 8 miles long and equipped with intake and downstram control structures and one intermediate control structure.

The intake structure will have six 48-foot by 19-5-foot tainter gates, a debris deflector, and a controlled 3-foot by 3-foot sluice. The sluice will permit introduction of fresh water to the channel as necessary to maintain proper temperature and flow for fish life.

The intermediate weir will, under the flood control plan, be a water inflated, rubber fabric dam on a concrete sill. It will be placed approximately midway in the channel to control drawdown of the groundwater table during nonflood periods.

The downstream control structure will be near the outlet about 7 miles below the intake. It will be an uncontrolled concrete weir with a sill elevation of 11.0. It will be provided with a 5-foot by 6-foot sluice equipped with a tide gate and control gate. The sluice will control introduction of brackish water to the channel at certain tidal flows.

Between the outlet and inlet works, the channel will have a bottom width of 340 feet, and a width between levee crests of about 600 feet. Downstream from the downstream control structure, the channel will have a bottom width of 460 feet and a crest-to-crest width of about 700 feet. The channel will have 1 on 2 gravel-blanketed side slopes from the bottom to 2 feet above low water level, and 1 on 3 slopes for the remainder. It will have a design velocity of 5 feet per second and will be capable of passing flood flow ranging to 60,000 second-feet.

The sluices will be equipped with fish barriers to insure against contamination by rough fish and to exclude anadromous fish, except during periods of migration. Crest elevation proposed for the downstream control structure is 11.3, and of the downstream sluice, -2.3. For the intake structure, these elevations are 21.0 and 9.0 respectively. The elevation of the channel bottom immediately below the intake will be approximately 4.8, and at the outlet structure, -2.3. Low-water pool level of the lower pool will be 5.0, and of the upper pool, 13.0. At these elevations the depth of the lower pool will be 7.3 feet to approximately 2.0 feet, and of the upper pool, approximately 13.0 to 9.0 feet.

Channel and levee improvement on lower Skagit River and North Fork Skagit River, downstream from the bypass inlet, will be necessary to provide freeboard for flows of approximately 120,000 second-feet. Addition of this capacity to that of Avon Bypass will control floods of 180,000 second-foot magnitude. Construction will consist of raising and strengthening existing levees and widening the streambed at three locations for uniform channel capacity.

Other Projects Under Study

The navigation improvement project between the bypass inlet and Concrete would provide for yearlong barge and log raft transportation on that reach of Skagit River. It would consist of excavating a channel 6 feet deep and 100 feet wide to accommodate a flow of 9,000 second-feet. Channel side slopes would be 1 on 6. The channel would be in the deepest part of the stream, and channel shortening is not planned.

Spoil would be deposited within the banks of the high water channel. The original project would entail removal of an estimated 1,520,000 cubic yards of material from the channel, and maintenance dredging would involve removal of 380,000 cubic yards annually.

Several damsites on Sauk River have been investigated. The most feasible is the Lower Sauk River site near Rockport. The project would be constructed for flood control and hydroelectric power production. Diversion of Sauk River flows to Stillaguamish River, through the divide near Darrington, is one of the features of this plan.

Detailed reports analyzing the impacts on fish and wildlife resources of projects under study will be issued as plans are formulated. These reports will recommend the most feasible means to conserve and develop these resources prior to the time that any such projects are authorized.

FISH

Without Proposed Skagit River Basin Projects

Skagit River produces large numbers of pink, coho, chinook, chum, and sockeye salmon that support a significant sport and commercial fishery extending over a wide area. About 46,000 angler-days annually are expended in Skagit River to catch about 17,000 salmon. The average annual commercial salmon harvest in the Skagit Bay-Deception Pass area during the past 29-year period is 23,000 chinook, 32,000 coho, 59,000 chum, and 1,000 sockeye. The 15-year average annual catch of pink salmon is 165,000. However, peak annual catches over the past years have produced as many as 52,000 chinook, 3,500,000 pink, 73,000 coho, 366,000 chum, and 4,000 sockeye salmon from the Skagit River and closely adjoining areas. Contribution of Skagit River salmon to commercial catch and sport fisherman harvest in other areas is very significant.

Skagit River is nationally famous for winter run steelhead trout and usually furnishes more of these fish to the creel than any other stream in the state. The river and many of its tributaries provide excellent angling for searun and resident cutthroat trout. There is also good fishing for whitefish and rainbow, brook, brown, and Dolly Varden trout.

High Gorge Dam on Skagit River is a block to anadromous fish. Diablo and Ross Lake Reservoirs provide excellent fishing for rainbow and Dolly Varden trout, as well as brook and cutthroat trout. High Gorge Reservoir provides little fishing.

Baker River was one of Washington's finest anadromous fish spawning streams before its runs were barred by completion of Baker Dam in 1925. The Washington Department of Fisheries, in cooperation with Puget Sound Power and Light Company, has successfully passed adult coho and sockeye salmon upstream and juveniles downstream around this barrier and Upper Baker Dam, completed in 1959. Other anadromous fish runs have not been maintained or have been reduced in numbers. Lake Shannon and Baker Lake Reservoirs, behind Baker and Upper Baker Dams, respectively, furnish good fishing for resident cutthroat, rainbow, Dolly Varden, brown, and brook trout, and young sockeye salmon.

Sauk River supports moderate to heavy runs of steelhead trout and coho, chum, spring chinook, and pink salmon. It is an excellent spawning stream and is readily accessible to fishermen. Suiattle and Whitechuck Rivers, main tributaries to Sauk River, are also important spawning streams and are noted producers of large steelhead trout and spring chinook salmon.

Cascade River has moderate to heavy runs of the same species of fish as Skagit River. It is considered a good late-season fishing stream for cutthroat, rainbow, and Dolly Varden trout.

Runs of anadromous fish are known to pass through Padilla Bay. These fish move through Swinomish Channel, which joins Padilla Bay with North Fork Skagit River.

There is a commercial crab fishery in the deeper portions of Padilla Bay. The bay once supported commercial oyster farms, but production has virtually ceased. There are fairly extensive but little utilized beds of jackknife clams and bay clams in some areas.

With Proposed Skagit River Basin Projects

Avon Bypass

Avon Bypass operated solely for flood control would have little hunter and fisherman use value and would probably result in major losses of anadromous fish. The Washington Departments of Fisheries and Game and our Bureau have worked closely with your staff and local sponsors to determine a plan for development, operation, and management of the area to assure optimum fish and wildlife values and to avoid possible losses. Certain problems remain, but changes in project design or management are not expected to be so major as to radically affect its value for fish.

There is a strong possibility that anadromous fish would be attracted by the minimum and flood flows released from the bypass, and be entrapped in the outlet channel and the bypass proper. This could result in significant losses of fish. Entrapment and possible losses of downstream migrants could be expected in the bypass following flood flow periods. During flood flow periods, which would have a 1- to 3-day duration period with a frequency of once in seven years, it would be possible for both juvenile and adult anadromous fish to enter the channel via the intake and downstream control structures. Drainage and flushing of the channel may serve to remove downstream migrant fish remaining after flood flows have receded. During normal flow periods, fish could be excluded from the channel by using gravel filters or some other type of screen at the low-level intake and outlet sluices, except during periods when anadromous fish are migrating.

Influx of fresh water into Padilla Bay during flood flow periods may kill shellfish. This possible loss has not been evaluated but, because of the small shellfish populations present, would not be expected to be monetarily significant.

Some fishing will occur in Avon Bypass outlet channel. Fish from Padilla Bay may occupy this area, and anadromous fish species could be attracted by flows through the channel. It is estimated that the outlet section will provide 1,400 fisherman-days annually, valued at $1,400.

Tentative plans are to manage Avon Bypass as a trout fishing lake. This would require water of sufficient depth in the bypass to raise trout, exclusion of other fish from the channel, and low-level sluices designed so that the bypass can be drained and refilled with both fresh and brackish water for cooling and enrichment. Public access to the area would be required for fishing. Sanitary facilities, parking areas, and boat launching ramps should also be provided.

Trout fishing in bypass waters is expected to draw people from adjacent metropolitan areas. No other trout angling site in the Puget Sound region will be more accessible. A local organization would administer the area, but management of the fishery resource will be a responsibility of the Washington Departments of Fisheries and Game. Department of Game will manage the game fish fishery while the Department of Fisheries will have authority to drawdown the bypass in order to obtain egress for any anadromous fish that may be trapped in the bypass. Avon Bypass, constructed with controls and safeguards as recommended in this report, will yield annual fishing benefits in Skagit River basin amounting to an estimated 159,000 angler-days valued at $238,000.

Boat launching ramps and parking facilities near both ends of the bypass channel have been proposed by your agency. The west end ramp will permit access to Padilla Bay. It will receive some use by fishermen, and encourage harvest of shellfish. Estimated annual use of this facility is 500 fisherman-days valued at $1,000. The ramp and parking lot proposed

for the east end of the channel is expected to receive considerable use because of restricted access to Skagit River. Only a small portion of this utilization will represent actual increases in river use by fishermen. With facilities, estimated fisherman use of Skagit River is expected to increase 700 fisherman-days annually valued at $3,500.

Channel and levee improvements proposed in North Fork Skagit and Skagit Rivers downstream from Avon Bypass inlet would have little effect on the fish or fisheries of the river if standard precautions are taken to avoid unnecessary turbidity and siltation in the stream, and to minimize interference with anadromous fish movement.

Other Projects Under Study

We have not received definite proposals resulting from your feasibility study of barge channel construction from the bypass inlet upstream to Concrete. However, preliminary information indicates that such a project would be extremely damaging to fish populations and fishing in Skagit River. It would be particularly disasterous to pink and chum salmon, since the 40-mile reach of the project encompasses a significant portion of the chum and pink spawning and rearing area of the Skagit River, along with about one-third of the chinook salmon habitat. This project would also be very detrimental to sockeye salmon and searun cutthroat and steelhead trout. The damage to fish resources would not only occur in the project vicinity but also in upstream areas. Fisherman-use of the river downstream from Concrete would be greatly reduced.

The dam on Lower Sauk River would prove very damaging to anadromous fish, even though passage for adults is provided. Spawning beds would be inundated, and migrant losses would occur through residualism and delay in the reservoir. Reservoir losses to downstream migrants might be alleviated by collecting these fish at the heads of the impoundment and transporting them to the stream below the dam. However, there are no presently known methods of successfully collecting downstream migrants at the head end of a reservoir; therefore, a dam constructed at this time could destroy Sauk River fish runs.

The suggested diversion from Sauk River to Stillaguamish River would require much further study by fish conservation agencies before its effect on fish resources could be determined.

WILDLIFE

Without Proposed Skagit River Basin Projects

Virgin forests in Skagit River basin were composed almost entirely of large coniferous trees, principally Douglas fir, western hemlock, Sitka spruce, and western red cedar. Rocky Mountain juniper and lodgepole pine grew on more arid sites, and several deciduous species such as red alder, vine maple, and willow flourished in low, moist areas and on the flood plains. Most of the merchantable timber in the basin's western sector has been harvested. However, extensive stands of mature western and mountain hemlock, and balsam fir, remain in the basin's eastern and northern sectors. Many logged areas have revegetated with the harvested species. However, subclimax plants, including red alder, willow, and bigleaf maple, predominate in fire-damaged areas.

Skagit River basin contains black-tailed deer, mule deer, black and grizzly bear, and mountain goat. Black-tailed deer occur throughout the basin, particularly in cut-over areas and brushy stream valleys. There are a few mule deer in the northeastern corner of the basin. Deer hunting pressure is moderate. Black bear are most plentiful on National forest land. Few are harvested. Small numbers of mountain goats and grizzly bears inhabit the high mountain areas. Mountain goats are hunted on a permit basis, and a few of these animals are harvested each year.

Cottontails are numerous in lands adjacent to cultivated valley areas, but they are not heavily hunted. Blue, spruce, and ruffed grouse, which are widely distributed over the basin, are hunted quite extensively. Lower Skagit Valley contains low populations of wild ring-necked pheasants, but most of the harvest is from stocked birds.

Muskrats, mink, opossums, skunks, raccoons, beavers, martens, river otters, red foxes, and weasels inhabit Skagit River basin. However, fur harvest is of little significance to the local economy.

Skagit Game Range is favored hunting area for snow geese and many species of ducks. Skagit and Stillaguamish Deltas are major wintering grounds for snow geese, and Padilla Bay accommodates the largest concentrations of black brants north of Baja California, as well as significant numbers of other waterfowl. Waterfowl feeding flights from the bay commonly cross the proposed bypass area.

Some marshland will be destroyed by construction of Avon Bypass, and a small amount of additional marsh may be formed in Padilla Bay by influx of fresh water from the bypass. Cultivated field and wasteland vegetation within the right-of-way will be lost with the project. The proposed navigation improvement projects would have little effect on wildlife habitat. A reservoir on Sauk River, however, would inundate fields, brushlands, and timberlands which support wildlife populations of importance.

The area that would be lost with construction of a dam and reservoir on Lower Sauk River is yearlong deer habitat of particular value as winter range. Other project proposals described in this report would have little effect on big-game resources.

The Washington Department of Game, in cooperation with the local sponsoring agency, plans to develop upland-game habitat along Avon Bypass right-of-way. The area will be managed for pheasant production and public hunting. With adequate stocking and development as proposed by the Department, the average annual increase in pheasant hunter use for the life of the project is forecast at 2,500 hunter-days valued at $7,500. Proposed channelization and levee projects would have little effect on upland game. A reservoir on Lower Sauk River would flood ring-necked pheasant and grouse range.

Some aquatic and semi-aquatic fur-animal habitat in small sloughs and drains will be destroyed by Avon Bypass project. However, the loss of this environment will be compensated for by the habitat that will develop along the channel dikes. There will be no economic increase in fur-animal populations or harvest with the project. Channel construction and levee improvement would only temporarily affect fur-animal populations and habitat. Such habitatwould be destroyed by inundation if a dam were to be constructed on lower Sauk River.

Good waterfowl pass shooting is expected to develop along Avon Bypass right-of-way between Padilla Bay and feeding areas to the east and southeast, and in the right-of-way southeast of Bay View Ridge. During the project life, we estimate that annual waterfowl hunter use of this area will average 6,200 hunter-days valued at $28,000. The boat-launching ramp proposed by the Corps of Engineers for the west end of the bypass will increase waterfowl hunter use of the bay about 760 days, valued at $3,400 annually. Channel and levee improvement projects would have slight effect on waterfowl populations and habitat. A reservoir on lower Sauk River would be expected to increase waterfowl values slightly.

DISCUSSION

The Avon Bypass project, as proposed for reactivation, does not include detailed plans for exclusion of fish from the channel area. However, rock crib filters at inlet and downstream control structures, or some other fish barriers, are proposed, and an allowance for fish barriers is included in cost estimates for the project.

During flood flow periods, it is not considered feasible to exclude fish from the channel. It is possible that immature fish remaining after flood flows have receded may be removed by draining and flushing the channel.

To eliminate losses to adult anadromous fish attracted to or entrapped in the bypass, fish-passage facilities would have to be provided at each water control structure. Washington Department of Fisheries personnel believe that relatively inexpensive Denil fish ladders would suffice because of the minor elevations involved. The project water-control structures should be so designed that these fish ladders can be easily and rapidly installed and removed. Ease of installation is essential in order that complete protection will be provided to anadromous fish species during migration. At other times of the year, the ladders could be removed to reduce the possibility of contaminating bypass waters with undesirable fishes. Close cooperation between Washington Departments of Fisheries and Game, your agency, and our Bureau will be necessary in final design stages.

Washington Department of Fisheries is interested in the possibility of salmon propagation either in the lower section of the bypass channel, or in ponds connected to the channel. They have indicated that further study will be necessary to determine whether or not such a project would be feasible.

Annual cost of stocking Avon Bypass channel with fish is estimated at $9,000, and associated management costs are estimated at $4,000 annually. These costs will be the responsibility of the Washington Department of Game.

Further detailed studies of the effect on fish and wildlife of Avon Bypass project will be necessary, as well as on other proposed Skagit River basin projects. Among these, studies to determine the feasibility of operating the west portion of the channel for salmon propagation will be necessary. Other project-associated problems affecting fish and wildlife resources may occur following bypass construction.

Substantial recreational use of the bypass channel is expected. Motorboat operation in the comparatively narrow channel between the inlet and outlet structures would be hazardous. It would increase water turbidity and wave erosion, and conflict with swimming and fishing from shore. A zoning plan would be necessary to insure that this area would be available

for various fish and wildlife purposes without undue conflict with general recreational activities. The plan should be developed cooperatively by the agency expected to administer the area, the Corps of Engineers, the Washington Departments of Fisheries and Game, and our Bureau.

Washington Department of Game personnel have suggested purchase of approximately 180 acres of land above mean high water adjoining the bypass right-of-way and the proposed west end automobile parking site. This tract would constitute an excellent public waterfowl pass-shooting area. It is in the flight lane from Padilla Bay to inland feeding areas, and we anticipate that bay waterfowl will be attracted to bypass waters. It would also serve as a hunter and fisherman access point to Padilla Bay. Ultimate area development would consist of construction of shooting pits, office, sanitary facilities, a foot bridge, fence, and other essential structures to facilitate intensive management of the unit as a public shooting ground. Such comprehensive development would probably not be required for some time. Average hunter use of the proposed acquisition area for a 100-year project life is estimated at 7,000 hunter-days annually valued at $31,000. Purchase price of the requested 180-acre land area is estimated at $180,000. This cost should be a nonreimbursable project cost. Cost of improvements, which would be largely deferred until hunting demand warranted the expenditure, is estimated at $50,000. Operation and maintenance costs, most of which would also be deferred, are estimated at $4,000 annually. Development and operation and maintenance costs would be the responsibility of the Washington Department of Game.

No land is proposed for Federal acquisition on Avon Bypass project except the 180-acre tract referred to above. Right-of-way and other project area tracts will be acquired by local sponsors. Some public access restrictions will be required for public safety and conservation and development of fish and wildlife.

Avon Bypass right-of-way will be comparatively narrow; therefore, entry to adjacent land to retrieve birds killed from the right-of-way would be essential if indicated hunter-use values are to be realized. This would require access easements. Easements should include access during the hunting season to 1/4-mile-wide strips on each side of the right-of-way where hunting is permitted. Crossing stiles would then be necessary along right-of-way fences. Easement provisions and other shooting-ground rules would probably require enforcement personnel. Cost of easements is estimated at $8,800 annually. Operation and maintenance costs are estimated at $3,000 annually. Stile construction cost is estimated at $2,000. Easement costs should be nonreimbursable project costs. Cost of stiles should be borne by the sponsoring agency, as stiles would be integral parts of the fence. Operation and maintenance costs would be the responsibility of the Washington Department of Game.

A few ring-necked pheasants will be produced along the bypass right-of-way, but most of the harvest will result from stocking by the Washington Department of Game. Stocking costs are estimated at $3,500 annually. The success of any pheasant stocking program and natural production of

upland game will depend on the type and amount of cover that would be developed through planting or otherwise.

Since fish and wildlife conservation, improvement, and development are proposed as a purpose of the bypass project, right-of-way portions not reserved for other uses should be managed by the Washington Department of Game. This should include the west section of the channel until it may be utilized for salmon propagation by the Washington Department of Fisheries. The Department of Game agrees to assume some operation and maintenance costs for resource development, but budgetary limitations will dictate the extent of such expenditures.

Under the flood control plan the lower pool section will be about three miles long, and too shallow through most of its length to assure fish survival. An additional intermediate weir installed approximately one mile above the downstream control structure would make it possible to produce fish in this channel section. With this weir installed, water depth in the lower pool would range from about 7 feet to about 5 feet. In the second pool, depth would range from about 10 feet to about 8 feet, and in the upper pool from about 13 feet to about 9 feet. Additional studies will be necessary to determine more precisely the best location for weir installations for fish production. Cost of the additional weir should be a nonreimbursable project cost.

Right-of-way fencing is essential to control access to adjoining private lands and to protect upland-game habitat proposed for development by the Washington Department of Game on right-of-way lands. Fencing and the associated maintenance should be the responsibility of the local sposoring agency except on areas purchased exclusively for fish and wildlife.

Skagit River is a vital spawning and rearing area for anadromous fish. So, extreme care must be used in timing and mode of project construction involving the streambed to minimize interference with upstream or downstream movements of fish. Consequently, channel work should be accomplished only from June 1 to August 15. Increasing the silt load in the stream would have undesirable effects on fish and fishing at any time.

RECOMMENDATIONS

It is recommended:

1. That the reports of the District Engineer, Corps of Engineers, include the conservation, improvement, and development of fish and wildlife resources among the purposes for which the projects are to be authorized or reauthorized.

2. That the report of the District Engineer, Corps of Engineers, on the Avon Bypass project, recommend that a zoning plan be developed in connection with overall planning to insure that the channel area between the intake and outlet structures will be available for various fish and wildlife purposes without conflicting uses for general recreation. It is further recommended that such plan include a stipulation prohibiting public use of motorboats in the area specified above. The zoning plan should be developed cooperatively by the agency expected to administer the area, the Washington Departments of Fisheries and Game, the Corps of Engineers, and the Bureau of Sport Fisheries and Wildlife.

3. That the report of the District Engineer, Corps of Engineers, on Avon Bypass project, recommend that all land in the east 1/2 of Sec. 6, T. 34 N., R. 3 E., W.M., not required for flood control purposes, be acquired for public access to tidal waters and for public hunting and fishing; and that cost of acquisition of this area, which contains approximately 180 acres above mean high water, be a nonreimbursable project cost. Estimated cost of acquisition is $180,000.

4. That the report of the District Engineer, Corps of Engineers, on Avon Bypass project, recommend that easements granting the right of ingress and egress for the purpose of retrieving game birds shot on project land during the hunting season be acquired on 1/4-mile-wide strips on each side of the right-of-way where hunting is to be permitted. This area would include approximately 1,750 acres. Annual cost of easements, estimated at $8,800, should be a nonreimbursable project cost. Operation and maintenance costs, estimated at $3,000 annually, would be borne by Washington Department of Game.

5. That the report of the District Engineer, Corps of Engineers, on Avon Bypass project, recommend that one additional intermediate weir be installed in the bypass channel in order to facilitate water control for fishery management. Cost of this weir should be nonreimbursable.

6. That the report of the District Engineer, Corps of Engineers, on Avon Bypass project, recommend that a cooperative agreement be formulated among Washington Departments of Fisheries and Game, Bureau of Sport Fisheries and Wildlife, Corps of Engineers, and the administering agency, to delegate management and development of the fish and wildlife resources of the project area to Washington Department of Game, except management of the channel area between the outlet works and the section line between Secs. 10 and 11, T. 34 N., R. 3 E., W.M., which should be reserved for the propagation and management of anadromous fish by Washington Department of Fisheries, if that agency so desires. Management of bypass drawdown to allow egress of entrapped immature anadromous fish should also be a prerogative of Washington Department of Fisheries.

7. That the report of the District Engineer, Corps of Engineers, on Avon Bypass project, recommend that final design of water control facilities incorporate Denil fish ladders at each water control structure. Design criteria should be developed in cooperation with Washington Departments of Fisheries and Game and the Bureau of Sport Fisheries and Wildlife.

8. That the report of the District Engineer, Corps of Engineers, on Avon Bypass project, recommend that, with the exception of areas purchased exclusively for purposes other than flood control, the right-of-way be fenced by the local sponsoring agency, and that stiles permitting access to lands proposed for access easement be included in fences. Stiles should be rendered inoperative except during the hunting season for upland game birds and waterfowl. Cost of stiles, which should be a nonreimbursable project cost, is estimated at $2,000.

9. That the report of the District Engineer, Corps of Engineers, on the channel work proposed for Skagit River and North Fork Skagit River downstream from the Avon Bypass inlet, recommend that such work be restricted to the period June 1 to August 15, and that silting of the stream be prevented to the greatest extent that is reasonably possible.

10. That the following language be incorporated in the recommendations of the report of the District Engineer, Corps of Engineers:

a. "That additional detailed studies of fish and wildlife resources be conducted, as necessary, after the projects are authorized or reauthorized in accordance with Section 2 of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); and that such reasonable modifications be made in the authorized project facilities and operation as may be agreed upon by the Director of the Bureau of Sport Fisheries and Wildlife and the Chief of Engineers for the conservation, improvement, and development of these resources.

b. "That all project lands and waters in the project areas be open to public use for hunting and fishing except for sections reserved for conservation and development of fish and wildlife, safety, efficient operation, or protection of public property.

c. "That leases of project land in the project areas reserve the right of public use of such land for hunting and fishing."

Please advise us of any subsequent revisions or refinements in your engineering plans so that we may have the opportunity to make such comments as may be necessary.

Sincerely yours,

Regional Director

Attachments