COUNTY OF SKAGIT
State of Washington
Office of County Engineer

Mount Vernon, Washington
November 26th, 1924.

W. J. Barden, Colonel,
Corps of Engineers
War Department
Seattle, Washington.

Sir:

In compliance with the request of Mr. H. L. Willis, Chairman of the Skagit River Improvement Committee, I have prepared a brief outline covering two of the subjects upon which you desired information for your hearing Wednesday, November 26th, on the question of flood control of the Skagit River system.

The two subjects upon which I have been requested to prepare data are: First, the frequency, duration and heights of floods, including area subject to floods of different heights, and Second, suggestions as to the methods considered most desirable for flood protection or prevention.

Before taking up these two subjects in detail, I wish to present a brief resume of the work which has been carried on through my office along the lines of solving the problem of flood control in this valley.

In the winter of 1922, immediately following the flood of 1921, a mass meeting was held in Mount Vernon at which was formed a citizens committee on flood investigation. To this committee in a large extent, must go the credit for instigating and promoting the work which has already been done. They appeared before the Board of County Commissioners and urged that a levy of one mill be placed on the assessed valuation of Skagit County to provide a fund in accordance with law, known as the River Improvement Fund. It was stipulated at the time that this fund was to be used for the purpose of an investigation by competent engineers, into the past record of the floods in this valley, a geological examination of the valley itself, and to gather such hydrographic data as was possible, in order that some comprehensive and practical development could be undertaken to as far as possible meet and successfully cope with future floods and minimize their damage.

In accordance with the wishes of this Citizens Committee above mentioned, a hydraulic engineer of wide reputation, Mr. James E. Stewart, was employed and in the fall of 1922 and the winter of 1923, he made a thorough preliminary examination of the valley and river system, and his exhaustive report is now on file in my office.

He has recommended, first that a flood warning system be installed; second, that the diking off of the Nookachamps be delayed; third, that certain danger spots be protected; fourth, obtain additional hydrographic data; and fifth, form a conservancy district.

The first recommendation has not as yet been carried out. Chiefly because of the limited funds at hand. The second recommendation has been carried out. The third recommendation has to some extent been carried out. Drift barriers have been built near Lyman, and a jetty built some little distance below Lyman. The fourth recommendation we have been very active in fulfilling because it is in direct line with the original wishes of the Citizens Committee on flood control.

I will give you a brief outline of such work as we have done in gathering additional hydrographic data. Because of the limited funds available in time past, such technical data as has been gathered in this vicinity, has been very meager and calculations of stream flow are at best only an estimate and accurate to within only 10 to 20%. The technical data so far gathered, has been done entirely by the U. S. G. S. Department of Water Resources, and they have had to rely upon intermittent gage readings, observations and recollections of residents, and more or less disconnected precipitation records.

Consequently, in order to secure definite and accurate stream flow records, it is necessary to install good reliable equipment and take measurements in a systematic manner. For this purpose and acting upon the recommendation of Mr. Stewart, the Board of County Commissioners in the spring of 1924, instructed the county engineer to proceed with the construction of a suitable installation for the purpose of gathering accurate stream flow records. With a certain degree of collaboration with the District Engineer, U. S. G. S. a site for the installation was selected at what is known as "The Dalles" on the Skagit River near Concrete. Two units were necessary in this installation. A continuous automatic stage recorder was placed directly in the gorge known as "The Dalles" and the second unit, a current metering and sounding station, about one-half mile down stream from the first unit. Convenience of operation would make it desirable that the two units be located in close proximity, but a location which would best serve the purpose of the two units, could not be found any closer together.

In the case of the sounding and metering unit, it is necessary that the measurements be taken on a section of the river where the cross-section of the river is nearly uniform and the thread of the current as nearly straight as possible so that the flow will be even and uniform at all stages of the river. On the other hand, it is desirable in locating a stage recorder unit, that it be placed in a constricted opening so that the fluctuations of the river will be exaggerated as much as possible. Perhaps this can be more clearly stated by saing that the more constricted the opening, the greater will be the gage height for a given discharge. Consequently the record of the automatic recorder will be more susceptible of accurate calculations from the rating curve as developed at the metering station.

Construction of the metering unit consists of two timber towers resting on concrete foundations, one on either side of the river and slightly over 800 feet apart. These towers are about 46 feet high and over them is suspended a one inch galvanized steel cable with the proper working stress and at the proper navigable clearance as dictated by the War Department, U. S. Army.

The cable is graduated in five and ten foot lengths and permanently marked and from it is suspended a small car in which the engineer making the river measurements, raises and lowers his current meter and sounds and measures the depth and velocity of the stream. The meter used is a Gurley, Penta Head, Type #623 and has been callabrated by the United States Department of Weights and Measures.

At this station will be made from time to time, depending upon the stage of the river, complete measurements of stream flow. It will take approximately a day to make a complete measurement of the river and such measurement will disclose the stream flow for that given gage height.

In the course of time when measurements have been made on all of the various gage heights of the river, the stream flow of the various gage heights can be platted and connected together by a graph and will then make what is known as a rating curve. With this rating curve, it is a simple matter to determine the stream flow or discharge in second feet for any gage height of the river. And with the record of the automatic stage recorder, the yearly discharge or average discharge for any day, week, or month, can be readily computed. A Stevens Type A continuous recorder is a simple instrument which is operated by a clock and a counter balanced float. The clock moves a graduated sheet of paper at a given speed and the float operated a pencil which records the gage height.

The automatic recorder is mounted over a concrete stilling well built in a niche blasted out of solid rock on the North bank of the Skagit River at "The Dalles" and is inclosed in a concrete house which practically insures the instrument against meddling and tampering. Proper gages are provided inside and outside of the well for checking the level of the water in the well and outside of the well, as the intake pipes sometimes become blocked with silt and it is advisable to frequently check up on the instrument.

It is our intention to determine the stream flow of the river at intervals of about two weeks on ordinary stages of the river and more frequently during flood periods so that in the course of a few years, we will have absolute accurate data upon which to base calculations and estimates for a flood control system, whether the system be built entirely by the County or with the aid of the Federal Government. It would be very foolish indeed to begin the expenditure of any considerable sum of money in the construction of flood control systems without a thorough knowledge of the conditions which would have to be met, and when the time comes to design and construct an adequate flood control system, we feel sure that we will have all the necessary data upon which to base designs and estimates.

As to the frequency, duration and height of floods, I might say that practically every year brings a high stage of water which would, but for a system of dikes now in existence, undoubtedly cover the valley with flood waters. Extreme heights have been reached in the following years as nearly as can be determined: 1815, 1856, 1879, 1880, 1882, 1883, 1887, 1894, 1896, 1897, 1909, 1917, 1921, and 1924.

No. in order of magnitude	Date	Gage height in feet (up per Dalles gage)	Discharge in second feet	Discharge in sec.ft. per sq.mi.	Accuracy in Percent
1	1815	56.6	500,000	189	10
2	1856	44.6	350,000	135	10
3	Nov. 19, 1897	38.4	275,000	106	20
4	Nov. 30, 1909	36.4	260,000	98	10
5	Dec. 13, 1921	34.9	240,000	91	5
6	Dec. 30, 1917	33.0	220,000	81	10

It is impossible to gather sufficient data to determine the discharge of some of these floods. However, high water marks of a few of the floods have been determined and an approximate estimate of their discharge in second feet has been made. The above table will give such data as we have so far been able to collect.

As to the frequency of extreme high waters, there seems to be no regularity of time elapsing between flood stages. The problem of climatic changes is still being investigated for it is a well substantiated fact that climatic conditions control the stage heights of the river.

As to the duration of floods, no definite knowledge is at hand and will not be obtainable until a flood crest or two has passed our stilling well at "The Dalles" and been recorded by the automatic stage recorder. The heights of the various floods is given in the table above.

Accompanying this report is a map upon which has been sketched a proximate flood area of the Skagit Valley. This as we have computed, is approximately 76,500 acres.

Under the head of suggestions as to the methods considered most desirable for flood protection or prevention, I would say that the first step would be Mr. Stewart's fifth suggestion--to form a conservancy district.

This would place all of the area of the valley subjected to floods, under the supervision and control of one Board of Commissioners so that whatever was done, would be done for the benefit of all, and not for the benefit of one small district as against the interest of another small district.

I believe it is as yet, too early to formulate any definite plans as to the best method of constructing a flood control system. Sufficient data is not at hand upon which to base any design and whatever is undertaken should be undertaken with great caution and thoroughly prepared. A move in the wrong direction might bring disaster, for in dealing with the flood waters of the Skagit River we have a mighty force to control and to a great extent, an unknown quantity.

Many plans have been suggested. Most of them very costly. I will enumerate a few.

It has been suggested that a spillway might be built from what is known as the Avon Bend or the Sterling Bend out to the deep water in Padilla Bay. There are several objections to this plan.

First, it would necessitate the expenditure of a great sum of money. Second, it might prove disastrous because the gradient of the river would be greatly increased and great erosion would take place. According to certain physical and mechanical laws, stream carrying capacity varies approximately as the sixth power of the velocity, i.e., if the velocity is doubled, the carrying power will be 64 times as great. Consequently by increasing the gradient, there would be an extended period erosion in this cut-off and the final result would be hard to estimate.

Unless extensive bank protection was provided, great bars would be built and the main channel of the river would flow into Padilla Bay. The river would undoubtedly swing back and forth across the valley floor before it finally reached its approximate stationary course.

A Second Plan suggested has been the widening and straightening of the present course of the river. This plan has many merits. The widening and straightening could take place gradually and the action of the river controlled to a great extent. However, it would be very expensive and could not be undertaken by this County without substantial assistance from the United States Government.

Another plan suggested is that dams be built in the upper reaches of the Skagit River system. These dams to be built at suitable locations where sufficient storage will be provided to hold back peak loads for lower discharge periods. This plan has many merits. Undoubtedly the stream flow of the Skagit River could be regulated by this manner in such a way that we would no longer have extreme high waters in the lower river.

The City of Seattle is at present constructing a aystem of power dams on the upper Skagit and the firm of Stone & Webster is constructing a power dam on the Baker River. At a comparatively small cost the City of Seattle and the firm of Stone & Webster, could be induced to add ten or fifteen feet to the top of their dams and hold this storage capacity in readiness for flood emergencies.

It would of course be very desirable that in connection with this plan, the lower river be to some extent improved and kept from silting up.

Another plan which has occured to me, but upon which I have not had an opportunity to study sufficiently, and which might possibly prove the most inexpensive method, would be, first to lower the existing river dikes so that they would just take care of spring freshets with a good degree of safety. Then to drop back from the river two or three thousand feet and construct a second dike somewhat higher than the first, and back of the second dike, to construct a third dike somewhat higher than the second dike. Over-flow points could be provided at such places as were naturally high, and little erosion would take place.

This method would permit the gradual spreading out over the land of all flood waters and while the land would be inundated for a period, yet no serious damage from swift water would occur. And the deposit of silt which would result from the flood waters standing over the land, would be beneficial to the farm land.

As I have said, I have not had time to give this plan much thought, but there are possibilities in it which might prove very desirable. At all events there should be no relaxation in the effort to solve the flood problem which we have in this valley. Two or three floods will cost the County more in property loss and damage than an adequate flood control system, and should a maximum flood occur, such as occurred in this valley approximately in the year of 1815, there will be a serious loss of life as well as loss of property, It would seem from the natural cycle of climatic changes, that we are due in the next few years for some of the worst floods. However, the theory of climatic cycle is not as yet fully understood. But should a series of floods approaching those of 1815 and 1856 occur, this valley would be financially ruined and practically destroyed, and for this reason it behooves us to spare no efforts in the study and solution of our flood problem.

Respectfully,

Robt. E. L. Knapp
County Engineer, Skagit County,
Washington.

Mount Vernon, Washington
November 26th, 1924.

FOLLOWING is a complete account of the expenditures from the River Improvement Fund to date:

Survey by Mr. Stewart, November & December, 1922, also for January & February, 1923;

Engineering	$1,661.77	
General Expenses	269.32	
Car Expenses	86.75	
Total		$2,017.84

March to December, Inclusive, 1923

Engineering & labor, for Jetty	$604.99	
Contract for Jetty	1,395.07	
Total		2,000.06

1924 - Installation of Metering & Gaging Stations.

Engineering	$ 749.29	
Expenses	92.39	
Instruments	737.60	
Car Hire	23.90	
Gas & Oil	209.42	
Pay-roll for labor	2,369.08	
Supplies	759.12	
Right of Way	351.29	
Total		$9,292.09

Drift Barrier at Lyman:

Engineering	$ 76.71	
Pay-roll for labor	26.61	
		103.37

TOTAL COST $9,413.36