C O P Y

Seattle, Wash., Sept. 26, 1922

Mr. A. H. Hogeland,
Chief Engineer,
St. Paul, Minn.

Dear Sir:-

Concerning high water trouble vicinity bridge #36 Coast Line:

There has been considerable time and study devoted to this matter and Mr. Herzog has been supervising the work for a considerable time past. I am enclosing Mr. Herzog's report, together with two blue prints referred to in the report.

You will note that we have a very serious condition to contend with, much more serious than I had anticipated, especially as to the large quantity of water. The breaking of the dykes during extreme water conditions has always relieved the situation at our bridge #36 and I never realized the total discharge to be as great as it is. The information given in Mr. Herzog's report indicates that our bridge has a maximum capacity of only about half the high water flow of the stream. It is perfectly evident, therefore, that whatever improvements may ever be carried out in this vicinity, the Railway Company will, in any event, have to provide an opening, being an extension of the present opening, or an entirely new opening, of approximately the capacity of the present bridge.

I believe the conditions here are so serious that the Railway Co. cannot handle this proposition alone. If the present dykes should be raised and strengthened so that they would hold against flood waters, there is not room between the dykes to pass the water under our present bridge. The bridge would have to be raised considerably if we should construct another long opening near Burlington for the passing of flood waters, this would assume the breaking

of the dykes and if the dykes should break, such an arrangement would take care of the railway. We can hardly assume, however, that such a condition will always exist. Sooner or later a very radical improvement must be made to take care of the flood waters of the Skagit River, to relieve the farmers and the towns from the present hazard.

The County Commissioners are very much interested in the work we have been doing and I think it would be a good idea to give them a copy of Mr. Herzog's report. The Government, through their local Engineering Department, is also just now making investigation as to losses which have occurred account floods in the different rivers and I think copy of this report should go to Colonel Schultz. It seems to me that the County, with the assistance of the State and some Federal aid, may want to embark on a scheme for positive improvement if they can be convinced as to the actual conditions confronting them.

I will hold an additional copy of this report and prints for you at Seattle, in case you should leave St. Paul before this letter reaches you.

Yours truly,

(Signed) Oscar S. Bowen,

Assistant Chief Engineer.

CC-L. C. Gilman,
J. H. O'Neill,
with copy of report.

C O P Y

P R O P O S E D F L O O D C O N T R O L

S K A G I T R I V E R

The flood discharges of the Skagit River at the Northern Pacific Bridge, near Sedro Woolley, measured by the U. S. G. S. are as follows:

November,	1908	68,800 sec. ft.	
"	1909	96,100 "	" (claimed too low dyke broke.)
"	1910	75,400 "	"
"	1911	61,300 "	"
"	1912	48,000 "	"
June	1913	57,600 "	"
January	1914	75,000 "	"
April	1915	57,300 "	"
June	1916	63,300 "	"
December	1917	151,000 "	" (dyke broke.)
November	1918	65,400 "	"
December	1921	in excess of 151,000 sec. ft.	(dyke broke.)

The gagings show that the peak discharge is reached very suddenly, that it is of short duration, not more than one day and that it falls as rapidly as it came up. It is claimed that the discharge of 96,100 sec. ft. for November 1909 is too low.

The gaging station was discontinued during 1919, but from information at hand, the flood discharge during 1921 must have been in excess of the discharge of 1917 of 151,000 sec. ft. because the stations ahead of Sedro Woolley registered higher than during 1917.

There is additional drainage coming into the Skagit River between the Northern Pacific Railway bridge and Great Northern Railway bridge #36, such as Nooka Champ Creek. It would therefore appear that for to be on the safe side, the extreme high water discharge of the Skagit River at bridge #36 should be taken as 200,000 sec. ft.

The dyke upstream from the bridge broke and the Great Northern Railway track was washed out between bridge #36 and Burlington during the floods of 1909, 1917 and 1921.

The flood discharge at the Northern Pacific Railway bridge for these three years ranged from upwards of 96,100 sec. ft. during 1909, to more than 151,000 sec. ft. during 1921.

The next highest discharge at the Northern Pacific bridge for which the dyke ahead of bridge #36 did not break, was 75,400 sec. ft. during 1910.

The drop in the river between the Northern Pacific bridge and the Great Northern bridge during high water discharge of December, 1921, was 7.43 ft. in a distance of 39,300 ft. Calculating by Kutters formula the discharge of the river through the piers of bridge #36 for the corresponding high water elevation of 134.7 we obtain plus or minus 85,000 sec. ft.

The conclusion is therefore that under the conditions of cross section and slope prevailing up to December, 1921, bridge #36 was able to pass and the dyke ahead of the bridge, as well as the Great Northern Railway track between Mr. Vernon and Burlington, was safe for a discharge of from 75,000 to 85,000 cu. ft. of water per second between the piers.

This does not mean that as soon as the Skagit brings down more than 85,000 sec. ft. at the Northern Pacific bridge, the danger point has been reached, as will be seen by the following considerations.

At the time when the levels for water surfaces were taken August 21st to August 24th, 1922, the discharge of the river at the Northern Pacific bridge was about 3400 sec. ft. and the drop in water surface between Northern Pacific and Great Northern bridges was 14.14 ft.

On July 6, 1922, the river discharge at Northern Pacific bridge was 23,300 sec. ft. and the drop in water surface between Northern Pacific and Great Northern bridges was 11.5 ft.

During the flood of December, 1921, the difference between high water marks at Northern Pacific and Great Northern bridges was 7.43 ft. corresponding to a discharge at the Great Northern bridge of plus or minus 85,000 sec. ft. while the discharge at the Northern Pacific bridge was probably at its maximum of upwards of 150,000 sec. ft.

This shows that the hydraulic grade of the river between Northern Pacific bridge and bridge #36, decreases rapidly with increasing discharge of the river at the Northern Pacific bridge, in fact, there is a choke at, or slightly ahead of bridge #36, and the discharge capacity at and below bridge #36 during extreme high water, is not more than one half of the water delivered at the Northern Pacific bridge. There are about ten square miles of land adjacent to the river upstream from bridge #36, colored in red on blue print, bounded by the dyke to the west, by high ground to the south and east and by the Rockport Branch of the Great Northern Railway and some high ground to the north. During flood discharge of the river, this area becomes covered with

water from five feet to fifteen feet deep, forming a large storage basin capable of absorbing the discharge of 150,000 sec. ft. for five hours, if no water were drawn out at bridge #36. As the discharge of the river at the Northern Pacific bridge increases, the river channel proper and bridge #36 and beyond becomes less and less capable to take care of it, the ten square miles of land become flooded, the hydraulic grade decreases, decreasing the discharge, the stage of the water at bridge #36 rises until it reaches the heretofore critical elevation of 134.7, when up to 1921 at least, the dykes upstream from bridge #36 broke discharging the stored water, thereby relieving the situation at the bridge proper.

The testimony of the Bridge Tender at Bridge #36, and other people, is to the effect that as soon as the dykes have broken, the water at the bridge begins to fall, but the tracks of the Great Northern Railway between bridge #36 and Burlington, opposite the break, are washed out.

The general level of the land to the west and north is from 10 to 15 ft. lower than the high water mark of the Skagit upstream from bridge #36, while the Great Northern Railway track between 36 and Burlington is nearly four feet lower than high water at the bridge, while going north from Burlington, the grade of the track falls still more at the rate of 0.2% until sub-grade elevation of 123.6 is reached, being 11.1 ft. lower than 134.7 H.W. at bridge #36. Going west from Burlington to Anacortes sub-grade falls from 130 to 100.3 this side of draw bridge, over Swinomish slough.

Taking the general elevations of the streets of Burlington as equal to Great Northern track elevation through the town, or about 131.0 and remembering that H. W. at Northern Pacific bridge only three and one half miles due east is 142.1 and H. W. of Great Northern bridge #36 only 2 miles south is 134.7, the dangerous position of the town and the Great Northern tracks will be appreciated.

The above elevations of the country to the west and north from the Skagit River upstream from bridge #36 will explain why the discharge through the breaks in the dykes from 800 ft. to 1200 ft. long, until such time as the elevation of water surface in the previously described storage lake and H. W. at bridge #36 has been considerably lowered, will be equal to, if not greatly in excess of, the discharge of the regular river channel through bridge #36 and beyond, because the hydraulic grade of the onrushing waters is considerable more than that of the river proper, but growing less and less as the

ccuntry to the west and north becomes flooded.

There have also been many breaks in the dykes downstream from bridge #36, although the river in that section carries considerably less water, with the same general result of relieving the situation in the channel proper, but, the breaks upstream are more disastrous to railroad property as well as to the lands to the west and north.

Before the dykes and the railroad were built, the country was covered with heavy timber and the floods spread slowly and more or less evenly over the whole area, depositing the silt which is the cause of the fertility of the lower Skagit Valley. The water receded in the same manner and the land was none the worse for it as long as the buildings were put above high water mark.

The problem of protecting the Great Northern property cannot be solved independently but must be treated in conjunction with and as part of the problem to take care of the flood waters of the Skagit River from the Northern Pacific bridge down to the outlet into Skagit Bay, because the Railway Company will get no relief if twice the waterway would be provided at bridge #36, if beyond this point the channel can only take care of one half of the flood discharge or even less.

There are, at present, a dozen or more different dyking districts between Sedro Wooley and Skagit Bay, some of them for salt water protection but all working independently of each other. Each member of each district naturally endeavors to place as much land as possible inside of the area protected by the dykes. The result is that the distance between dykes from one side of the river to the other varies from 600 ft. to 2000 ft. regardless of the amount of water to be carried, while the size, height and strength of the dykes have no uniformity.

Calculations show that for high water marks and hydraulic grades as given on the profile, the discharge capacity at the Northern Pacific bridge is upwards of 160,000 sec. ft. while bridges #36 and beyond have a capacity of plus or minus 85,000 sec. ft. The gagins show that more than 150,000 sec. ft. have passed the Northern Pacific bridge. The river channel and the bridges from the Northern Pacific bridge downstream should therefore be enlarged to take care of a total of 175,000 sec. ft. or more. The profile shows that the choking up of the water is somewhat upstream from bridge #36,

probably at, or near, the 90 degree bend; the greatest depths of water, or the greatest difference between high water and low water are near this point and within the area of the storage lake, shown in red on blue print.

From station 400 downstream, the hydraulic grade becomes steeper and is about parallel to low water grade. From station 600 downstream, the difference between high and low water decreases the nearer it gets to Skagit Bay, all of which points to increased velocity and better discharge capacity of the river, which, however, is illusory, because numerous breaks in the dykes all along from bridge #36 down to the Bay allow the water confined between the dykes, to spread out and to flood the whole country down to within one mile north of Stanwood in spite of the fact which must be borne in mind that from bridge 36, downstream, the discharge of the river proper is only about one half of the amount of water passing the Northern Pacific bridge.

To relieve the situation it is evident that more than two times the present discharge capacity of the river must be provided. This can be accomplished in two ways, each of which should be investigated.

First. The present river bed can be straightened, widened and improved from the Northern Pacific bridge to Skagit Bay. This would mean that most all of the present dykes would have to be removed and new ones built with sufficient distance between them to provide uniform waterway for a discharge of from 175,000 to 200,000 sec. ft. This would call for lengthening of all bridges from and including bridge #36 to the Bay.

Second. A high water Relief Channel can be built from above bridge #36 to Padilla Bay capable of carrying 100,000 sec. ft. This will require a water area of 20,000 sq. ft. with a velocity of flow of 5 ft. per second, or a cross section of 2000 ft. width with a depth of water of 10 ft. Such a high water channel would leave the land within the dykes in the same condition for farming purposes as it is at present but would effectively remove the danger of floods because, as soon as the discharge gets above a maximum of plus or minus 70,000 sec. ft. the surplus water will flow into the high water relief channel to Padilla Bay.

As mentioned before, the waters flowing through the breaks in the dyke ahead of bridge #36 flow west to Swinomish Slough and Padilla Bay; they follow the Anacortes Branch of the Great Northern Railway. The relief channel should therefore follow approximately the same course which would call for the

relocation of some five miles of railroad. As the country traversed by the high water channel is of low elevation, there would be practically no excavation required, except what is wanted for the building of the dykes. The channel would have an apron at inlet and outlet which would determine the hydraulic grade or the velocity of flow which, of necessity, would be kept at or below five ft. per second, so as to prevent scouring. The outlet apron will also act as a dyke against salt water. The apron at the entrance to the high water channel will have a shear boom or an effective barrier against drift wood so that only water would pass and that roots, logs and trees would have to follow the old course down the river.

The table of flood discharges shows that it would only be every three or four years that the high water channel would carry any water, that this would be during the winter months, not during the growing season, and of short duration. The land within the dykes of the high water channel could therefore be farmed under the same or better conditions than at present because it would not be covered by gravel and other debris, nor would it be scoured away, as is the case when the present dykes break. There are a good many instances where the lands between the present dykes and the river channel are now cultivated.

Bridge #38, the P. N. T. bridge and the State Highway Bridge will have to be lengthened with truss spans.

On account of the location of the choke in the river somewhat upstream from bridge #38, it may be preferable to tap the river with the high water channel in the position shown on blueprint by dotted lines; this would give a better location for the shear boom and drift barrier, it would also eliminate the necessity of lengthening the three bridges by truss spans because the crossing would be made by trestles.

The present location of bridge #38 is in a very unfavorable position on account of the right angle bend; the highwater mark is dangerously near the bottom chord, should the dykes ahead hold so that a high water mark one or two feet in excess of the present one be reached, the bridge is almost sure to go out, in which case the two bridges below would very likely go also. The proposition might therefore be considered of changing the location of bridge #38 and combining the three bridges into one, situated at, or near, the present P. N. T. bridge. This would simplify the crossing of the high

water channel and reduce operation cost.

By tapping the Skagit River in place shown by dotted lines, will lower H. W. at bridge 36 and below more effectively than by tapping in place shown in full lines.

The course of the river between bridge 36 and the Northern Pacific bridge should be straightened, especially in sections 34 and 35, T. 35, N.R. 4 E. as shown on blue print. If this is not done artificially, the river will probably do it at the time of the next high water. In this case, the new dykes on either side of the improved river channel should follow the same to the east line of section 25 of the above named township, thereby reclaiming much valuable land.

The correction of the White River has been accomplished by providing sufficient waterway, straightening the channel and protecting the banks by reinforced concrete mats. The result was that the river channel has been scoured out by the high water.

A similar solution of the problem may be desirable for the Skagit River. It should, however, be borne in mind that the White River Valley has no elaborate dyking system like the Skagit Valley and that the flood discharge of the White River is only 50,000 sec. ft.

The statement has been made that the building of the high dam of the City of Seattle Power development on the upper Skagit will greatly improve the flood conditions in the lower valley.

The drainage area tributary to the proposed power development, is about one third of the total drainage area, discharging at bridge 36 and the high water discharge at the City's dam is given as 50,000 sec. ft. Even if this were held back by the dam at the time of the flood crest, which is by no means certain, there would still be left a balance of nearly 150,000 sec. ft. if the figures of the U. S. G. S. are to govern, to be taken care of below the Northern Pacific bridge.

The flood discharge of the Skagit River will increase in magnitude as the years pass, the demand for a solution of the problem cannot be delayed much longer, and all the parties interested should combine for common action.

The interested parties are:

1st - The owners of the land.
2nd - The different towns.
3rd - The Great Northern Railway.
4th - The P. N. T. Co.
5th - The State of Washington and Skagit County.
6th - The United States Government.

An idea of the magnitude of the undertaking may be obtained by considering that King and Pierce Counties together have corrected the White River, etc., to take care of a flood discharge of 50,000 sec. ft. They have, up to date, expended $1,500,000 and propose to spend $1,000,000 more. The problem to correct the Skagit River, the biggest stream emptying into Puget Sound, will be to take care of 200,000 sec. ft. It is, however, believed that the cost of this will be considerable less than a direct proportion between the two.

(Signed) Robert Herzog,

Assistant Engineer - G. N. Ry. Co.