DEPARTMENT OF LANDS, FORESTS AND WATER RESOURCES
VICTORIA, B.C.
R.G. Williston, Minister

WATER RESOURCES SERVICE
A.F. Paget, Deputy Minister

WATER INVESTIGATIONS BRANCH
V. Raudsepp, Chief Engineer

PRELIMINARY REPORT ON PEMBERTON VALLEY DYKING DISTRICT DRAINAGE PROPOSALS

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J. Wester, P.Eng.
Senior Hydraulic Engineer

SYNOPSIS

This report deals with the drainage problem which exists in the area south and east of the Village of Pemberton.

Two alternatives to solve this problem have been investigated:

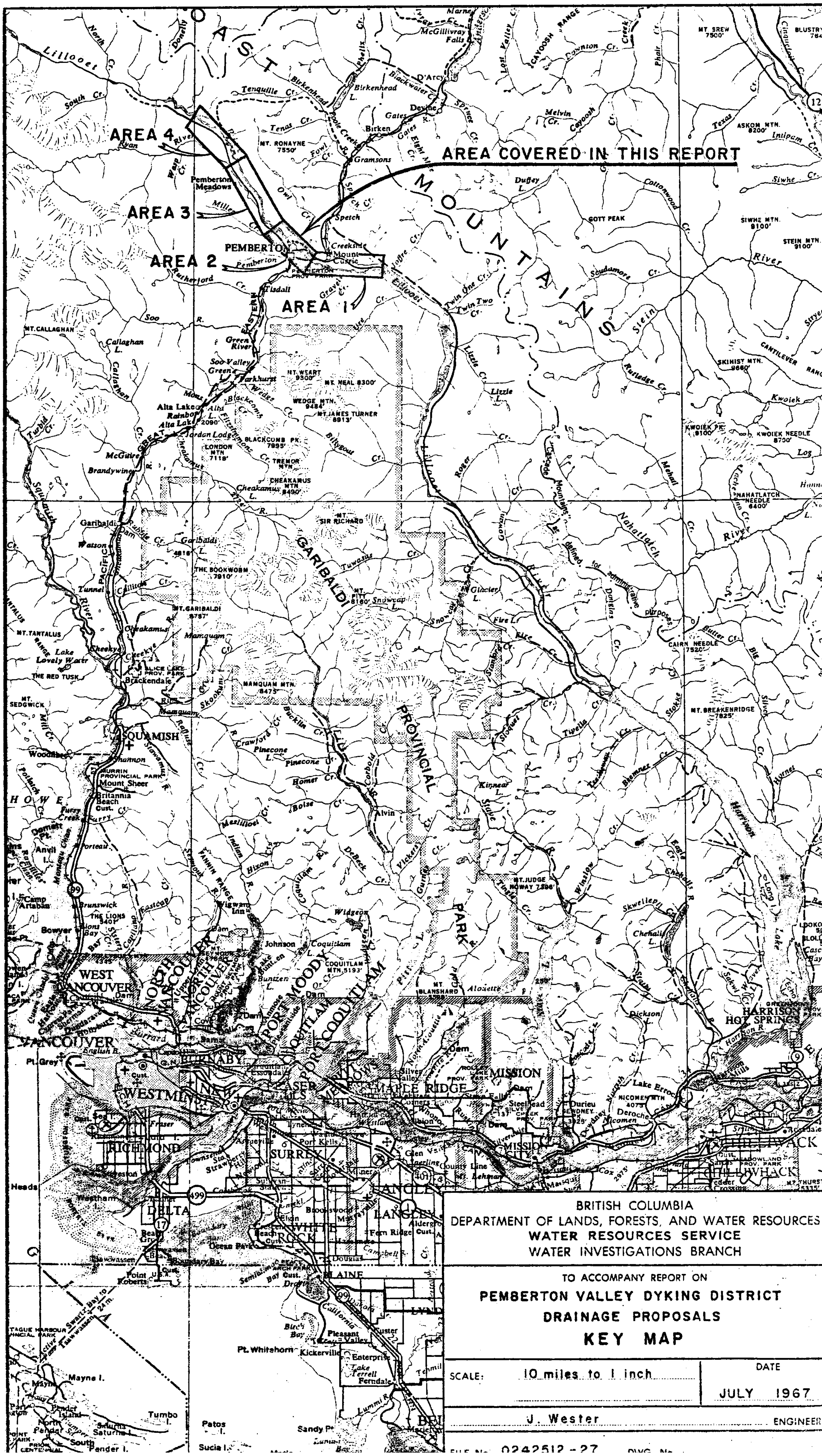
A. Drainage by gravity.
B. Drainage by pumping.

Alternative A involves the diversion of One Mile Creek into the Green River, while Alternative B considers a pumping station at the confluence of the drainage canal and One Mile Creek.

The capital costs of the alternatives are estimated at $119,000 and $103,000 respectively.

Although the estimated annual cost to the District of the pumping scheme is slightly more than the annual cost of the gravity scheme, $ 5,604 against $5,483, the pumping scheme is recommended because it will afford better protection against flooding.

The cost estimates and designs for the various works are subject to adjustments when final designs are prepared. Before final designs are undertaken, additional surveys will be required and drainage requirements should be reviewed by agriculture and soil experts.



BRITISH COLUMBIA
DEPARTMENT OF LANDS, FORESTS, AND WATER RESOURCES
WATER RESOURCES SERVICE
WATER INVESTIGATIONS BRANCH

TO ACCOMPANY REPORT ON

PEMBERTON VALLEY DYKING DISTRICT
DRAINAGE PROPOSALS
KEY MAP

SCALE: 10 miles to 1 inch

DATE: JULY 1967

J. Wester — ENGINEER

FILE No. 0242512 - 27 DWG. No.

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ACKNOWLEDGEMENTS

Field surveys were carried out by personnel of the Water Investigations Branch under the supervision of Mr. R.G. Fernyhough, Technician.

Topographic information was obtained from mapping of the area being prepared by personnel of the Surveys and Mapping Branch, Department of Lands, Forests and Water Resources.

Drawings and air photo mosaics were prepared by Mr. F.W. Danks, Draughtsman, under the supervision of Mr. B. Varcoe, Chief Draughtsman.

The manuscript was typed by Mrs. L. Stalker.

Preparation of this report was carried out under the general supervision of Mr. R.G. Harris, Chief, Water Supply and Investigations Division of the Water Investigations Branch.

The study was authorized by Mr. V. Raudsepp, Chief Engineer.

WATER INVESTIGATIONS BRANCH
B. C. WATER RESOURCES SERVICE
DEPT. OF LANDS, FORESTS & WATER RESOURCES
PARLIAMENT BUILDINGS
VICTORIA, B.C.

PRELIMINARY REPORT ON

PEMBERTON VALLEY DYKING DISTRICT DRAINAGE PROPOSALS

1. PREFACE

Following representations made by the Pemberton Valley Dyking District and the Pemberton Board of Trade, the drainage problem near the Village of Pemberton was investigated on the instructions of the Chief Engineer of the Water Investigations Branch. Field surveys were carried out in 1965 and 1966 by the Water Investigations Branch.

2. HISTORY

Under the triparte agreement between the Pemberton Dyking District, the Federal Government and the Provincial Government, the Prairie Farm Rehabilitation Administration (P.F.R.A.), Canada Department of Agriculture, carried out certain dyking and drainage works in the Pemberton Valley from 1946 to 1953. As a result of these works, some 12,000 acres of fertile land were reclaimed or protected from flooding.

The engineering proposals carried out at that time called for:

a. the lowering of Lillooet Lake by deepening the channel between Lillooet and Tennasse Lakes;

b. the straightening of meanders in the Lillooet River;

c. diversion of the Green River;

d. channel improvement of Ryan River and Miller Creek;

e. the construction of drainage canals;

f. the construction of a system of dykes.

The lowering of Lillooet Lake by some eight feet proved successful and the bed of the Lillooet River has degraded considerably. Various meanders of the Lillooet River were straightened by excavating a pilot channel after which the river scoured out the present channels. The largest of these cutoffs, the so-called McKenzie cutoff, has a length of 2.7 miles.

The Green River, which used to enter the Lillooet at a right angle (where at present One Mile Creek enters the Lillooet River) was diverted along the foot of the mountain and now joins the Lillooet River some two miles below the old point of confluence. This channel was initiated by excavating a pilot channel approximately 20 feet wide and six feet deep and has continued to develop by natural flows, particularly in high water, and now carries all the Green River flow.

The channels of Ryan River and Miller Creek were improved by clearing and excavating and the banks were protected with rip-rap, where needed.

Throughout the valley, drainage canals were constructed to which private owners could drain their lands by lateral ditches. Existing dykes were reinforced and new dykes constructed where necessary along the Lillooet River, Ryan River and One Mile Creek together with bank protection at places where erosion was occurring.

For reference, the Pemberton Valley was divided into four areas as follows:

Area No. 1: From Lillooet Lake to Green River
Area No. 2: From Green River to Miller Creek
Area No. 3: From Miller Creek to Ryan River
Area No. 4: Above Ryan River.

The lowering of Lillooet Lake and the consequent lowering of the lower reaches of the Lillooet River was of immediate benefit to Area No. 1, mainly consisting of Indian Reserve land.

The reclamation of Areas 3 and 4 was also successful and apart from regular maintenance, the works in these areas are completed. Area No. 2, however, in which the Village of Pemberton is located, still has problems with high water during certain times of the year and our investigation is centered on the problem in Area No. 2 to find ways of improving this situation.

3. DESCRIPTION OF EXISTING PROBLEM

The principal works so far constructed in Area 2 are a dyke along the south bank of the Lillooet River, the north side of the old Green River and the east side of the One Mile (Pemberton) Creek. A drainage canal starting in Area No. 3 runs through Area No. 2 and carries water to One Mile Creek. These works are shown on the attached mosaic of aerial photographs, Drawing No. 4690-1.

Although the constructed works were of great benefit to the area, which formerly was mostly swamp land, there is still room for improvement because the area does not drain satisfactorily during spring runoff and during high flows in the Lillooet River. The Trustees of the Dyking District are anxious to bring Area No. 2 on a par with Areas No. 3 and 4, especially since it appears that Area No. 2 will develop into the industrial and commercial center of the valley.

The area involved is located around the Village of Pemberton and is bounded on the south and west by the One Mile Creek, on the east by the Lillooet River and on the north by the Pemberton Meadows Road and amounts to a total of approximately 1,300 acres. About 500 acres are presently cultivated while another 50 acres might be classified as industrial and residential area (i.e. sawmill, railroad, bulk plant, school, etc.) It is estimated that 500 acres more could be brought into production within the area.

From our investigations and studies, it appears that there are two basic reasons for the existing drainage problem, namely:

a. The cross-section of the drainage canal is inadequate to handle the flow during spring runoff and during periods of heavy rainfall.

b. During high stages of the Lillooet River which normally occur in June and July because of snowmelt, or in October and November due to heavy rains, water backs up in One Mile Creek as far as the confluence with the drainage canal, thus preventing the drainage by the canal.

4. PROPOSED REMEDIAL MEASURES

To overcome these problems, two alternative schemes have been investigated:

A. Drainage by gravity.
B. Drainage by pumping.

Under Alternative A, the following works are proposed to be carried out:

a. Widening of the drainage canal from the Pemberton Meadows Road bridge to the confluence with One Mile Creek (Drawing No. 4690-8).

b. Diversion of One Mile Creek along the route shown on Drawing No. 4690-1 into the Green River.

c. Construction of a dam at the outlet of One Mile Creek where it now enters the Lillooet River.

d. Construction of a dam on the south fork of the Lillooet River to prevent the Lillooet River from breaking through to the New Green River.

e. Construction of a dyke between the dams mentioned under (c) and (d).

f. Removal of the logging bridge over the Green River and the log jam at this location.

Alternative B would involve widening of the drainage canal to such dimensions that the maximum expected flow can be handled, together with the construction of flood gates and a pumping station at the confluence of the canal and One Mile Creek.

The above-mentioned proposals will be discussed in detail later in this report.

5. HYDROLOGY

The following streamflow records are available for the general area:

1.	Lillooet River at Pemberton	1914 - date	(Sta. 8MG-5)
2.	Green River below Nairn Falls	1913 - 1952	(Sta. 8MG-3)
3.	Soo River	1925 - 1947	(Sta. 8MG-7)
4.	Six Mile (Rutherford) Creek	1924 - 1947	(Sta. 8MG-6)

From these records, it is apparent that the peak flows usually occur during the months of June and July due to snowmelt. It is significant to note, however, that the two highest recorded flows in the Lillooet River occurred in October of 1940 and 1957 respectively. These flows were due to extreme rainfall over the whole area. The other three rivers on record also recorded maximum flows in October, 1940.

Generally speaking, the peak flows during spring freshet, although occurring annually, are not as damaging as the peak flows due to rainfall for the area under consideration because the peak flows from rainfall occur simultaneously on all watercourses in the area while during spring freshet the river-peaks do not coincide, depending on the area and elevation of the respective watersheds.

A temperature and precipitation station has been operated since 1921 at Pemberton Meadows. Following is a table showing the average monthly precipitation and temperatures for this station:

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Precip:	4.91"	3.73"	2.68"	1.44"	1.45"	1.36"	1.04"	1.26"	2.17"	4.82"	5.56"	6.67"
Temp:	23°	28°	37°	47°	56°	60°	65°	63°	56°	46°	35°	27°

The average annual precipitation is 37.09" of which 10.5" (105.2" of snow) occurs as winter showfall. The average annual temperature is 45°F.

6. DESIGN FLOWS

To arrive at design discharges for the various works to be constructed, it has to be kept in mind that we are dealing with two entirely different problems. One is the protection of the area against flooding from the rivers outside the dyking system and the other one is the protection against internal flooding caused by local runoff.

For the protection against flooding from the rivers, a design flood with a probability of 1:100 has been selected. This may also be stated as the design flood having a chance of occurrence of once in a hundred years. Chance of occurrence or recurrence interval is the average length of time in years between floods of a certain magnitude over a very long period of time.

This selection was made because the existing dykes around the area protect against such a flood and it would be unwise to construct new works with a lower safety. Appendices C, D, E and F show calculations or probable peak flows for the Lillooet River, Green River, Soo River and Six Mile Creek. The results of these calculations have been used as a basis for the calculation of expected peak flows in One Mile Creek as shown on Appendix G.

The watersheds of the Soo River and Six Mile Creek are adjacent to the watershed of One Mile Creek and as the area-elevation curves for the three watersheds are quite similar, it is considered that the results of the calculations for the peak flows in One Mile Creek are quite accurate.

From the appendices, it can be seen that the flows to be considered in our study are as follows:

		Drainage Area sq. mi.	cfs/sq.mi.
One Mile Creek	1,430 c.f.s.	14.5	99
Green River	15,800 c.f.s.	307	51.5
Lillooet River	31,200 c.f.s.	791	39.5

It must be mentioned here that the recorded peak flows used are annual peaks, and can be due to either snowmelt or rainfall or both. Separate calculations for peaks due to snowmelt and for peaks due to rain show that the frequency curves for annual peaks and rainfall, coincide above the five percent chance of occurrence point. The values calculated for peak flows due to snowmelt are of a smaller magnitude.

Since our design floods are above the five percent chance of occurrence point, the design flows as stated above, are considered satisfactory. For the drainage of the area within the dykes, a different approach to find peak flows has to be employed.

There are no streamflow records available for the drainage canal and existing streamflow records on the other streams in the area cannot be used as a basis for the calculation of peak flows in the drainage canal because 55 percent of the drainage area of the canal at its mouth (1,500 acres), is valley floor and 45 percent (1,600 acres) is mountainside and the average elevation is considerably lower than the watersheds of the other streams. It is, therefore, not possible to compare the canal with these mountain streams.

As previously stated, the rainfall in the fall of the year has produced greater peak flows in the rivers in the area than the snowmelt in the spring of the year. Assuming that this holds true for the canal, we can base the expected flows on the rainfall records at Pemberton Meadows.

It is not considered necessary to design for a probability of 1:100 in this case since damage due to flooding by local rainfall is much smaller than flooding from the rivers as for instance occurs if a dyke should break or be overtopped.

For the calculation of the drainage canal and pump capacity, it is assumed that the expected volume of water during a maximum of six successive 24-hour periods will have to be discharged during this same six-day period. Inspection of the rainfall records show that the recorded maximum six-day rainfall is 6.75 inches in November, 1949. The expected maximum six-day rainfall with a chance of occurrence of 1:25 is calculated to be six inches. (A few higher precipitation records, up to eight inches in six days have been recorded but this was in the form of snow and these figures have not been used in our calculations.)

The capacity of the drainage canal and pumping plant will therefore be designed for six inches in six days or one inch per day for six days over the entire drainage area of 3,100 acres. This amounts to 130 cubic feet per second.

7. ALTERNATIVE A, DRAINAGE BY GRAVITY

7.1 General

Because of the backwater effect of the Lillooet River in One Mile Creek, the water levels in One Mile Creek are too high during certain times of the year for satisfactory drainage by the drainage canal. Since it is not possible to lower the outlet of One Mile Creek at its present confluence with the Lillooet River, it is proposed to divert One Mile Creek into the Green River along the route shown on Drawing No. 4690-1.

Although this proposed scheme would be of some benefit to Area No. 2, our studies show that the capacity of the Green River is not sufficient as yet to carry flows larger than 8,000 cubic feet per second. Appendix F-2 shows that the chance of such a flow to occur is once in every five years. (The present channel of the Green River was made by excavating a pilot channel after which the river scoured out its present new channel).

During flows of greater magnitude, the surrounding lands will be flooded and the backwater effect in One Mile Creek will be such that satisfactory drainage by the canal will be prevented. In other words, the annual flooding now experienced in Area No. 2 will still happen but on a frequency of an average of once every five years until the Green River has eroded a channel large enough to carry peak flows. It is, of course, impossible to predict when this will be accomplished. It is not considered feasible to excavate the Green River to the required dimensions because of the cost involved.

For design purposes, it will be assumed that the maximum water level of the Green River at the point of confluence with the proposed diversion will be 668.0 feet (Geodetic). This is the elevation of the existing river for a flow of 8,000 cubic feet per second, and is also the expected elevation when the Green River has fully developed and carries the maximum 100-year flow of 15,800 cubic feet per second.

7.2 Design of Drainage Canal

As stated in Section 6, the design flow for the drainage canal is 130 cubic feet per second. From local information, it appears that the canal presents no problem above the Pemberton Meadows Road bridge since the grade above this bridge is considerably steeper than the grade below. Improvements to the canal are therefore only necessary below this bridge.

From the profile shown on Drawing No. 4690-3A and B, it can be seen that the grade of the canal is very flat and the only way to increase the capacity of the canal is by widening. From the Pemberton Meadows Road bridge to the Pacific Great Eastern Railway bridge, a grade of 0.00083 can be maintained and from the railway bridge to the confluence with One Mile Creek, the proposed grade is 0.00022. Although the grade above the railway bridge is steeper than below the bridge, it is proposed to keep the cross-section of the canal constant throughout because the adjacent land in the upper part is relatively lower than the land below the bridge. By keeping the design section constant, the freeboard during maximum flows will be the same for both parts.

The pond at the railway bridge which is the remains of a lake, will provide a natural transition between the two parts. A canal with a bottom width of 20 feet and side slopes of 1½:1 is proposed as shown on Drawing No. 4690-3A and B.

For a roughness factor n = 0.040, the capacity of the upper part of the canal which has a slope of 0.00083, at a depth of three feet is 135 cubic feet per second. The capacity of the lower part of the canal which has a slope of 0.00022 at a depth of four feet is 125 cubic feet per second. In both cases, the freeboard during maximum flows is one foot which is considered necessary for satisfactory drainage of the area.

7.3 Design of One Mile Creek Diversion

The bottom at the confluence of the drainage canal and One Mile Creek is at an elevation of 670.0 feet (Geodetic). As shown on the profile (Drawing No. 4690-4) a constant grade of 0.0012 is proposed for the diversion. This will involve dredging of One Mile Creek for some 3,100 feet. The length of the new diversion is 5,100 feet.

For the design of the diversion, we have to take into account that on the one hand the velocities will not be so high as to cause erosion in the new channel and on the other hand that the velocities be high enough to carry sand and silt that is in suspension during high flows to prevent deposits in the new channel. At present, the critical point of deposits is at the confluence of the drainage canal and One Mile Creek as is clearly visible on the mosaic of aerial photographs (Drawing No. 4690-1).

To prevent scour in the new channel which will be cut through mainly sandy silt a maximum velocity of four feet per second should not be exceeded. This velocity may be too high in the freshly cut channel but it is expected that the banks will soon be covered with vegetation which would reduce the chance of scour considerably. To keep sand in suspension, a minimum velocity of two feet per second will have to be maintained.

Drawing No. 4690-4 shows the proposed section and the discharge curve. An 80-foot bottom width with 3:1 side slopes is proposed. From the table on Drawing No. 4690-4 it can be seen that for a maximum discharge of 1,450 cubic feet per second, the depth of water will be four feet and the velocity 3.94 feet per second. At a depth of one foot, the discharge is 140 cubic feet per second and the velocity 1.67 feet per second. At a discharge of 140 cubic feet per second no sediment deposition or erosion has been observed and the section as described, has been adopted for further investigation.

Drawing No. 4690-4 shows the backwater curve with the Green River at elevation 668.0 feet and a discharge of 1,430 cubic feet per second in One Mile Creek. It is recommended that the excavated material be placed on the south side of the diversion to form a dyke to prevent water from the Green River entering the new diversion. To obtain maximum benefit from the diversion, it is essential that the logging bridge and log jam at the confluence of the diversion and Green River be removed. Removal of the log jam only will not be sufficient since in a short time the jam will form again because the Green River carries quite an amount of debris during freshet flows.

There is also a large log jam about 1½ miles upstream from the bridge and it is recommended that this should also be given attention by the District, for should this log jam break loose and lodge further downstream, serious damage may be the result. Another reason for removing the bridge and log jam is that the river now bypasses the main channel through an overflow channel. This impedes the degrading process which is still taking place in the present Green River which has been in existence since 1951. The logging bridge with its short spans on pile bents is a certain trap for any floating debris. It is realized that the bridge is occasionally being used to check a water intake for the Indian Reserve, but only for pedestrian traffic since the bridge is in such a state of disrepair that it is unsafe for any vehicular traffic. It is therefore recommended that the bridge be removed. Access to the water intake should not be a major problem if a small boat would be located at the present bridge site.

7.4 Dam at Mouth of One Mile Creek

The diversion as described above would be of little benefit if the Lillooet River was allowed to back up the water in One Mile Creek. It is therefore proposed to build a dam at the mouth of One Mile Creek. A dam with a 12-foot crest width and side slopes of 3:1 is proposed at this point. The elevation of the crest of the dam is designed at 679.3 feet. From Drawing No. 4690-8 it can be seen that the difference in water elevation between the location of the proposed dam and the location of the federal gauge is quite constant at 13 feet at various discharges. On August 4th, 1965, the river discharge was 10,900 cubic feet per second. The design flow for the Lillooet River is 31,200 cubic feet per second. The rating curve shows that the gauge reading for 10,900 cubic feet per second is 6.5 feet and for 31,200 cubic feet per second, 12.4 feet, a difference of 5.9 feet. The water elevation at the mouth of One Mile Creek was 671.39 feet on August 4th, 1965, and if it is assumed that the rise in river level is the same as the rise at the gauge, the expected water level for 31,200 cubic feet per second at the mouth is 671.4 + 5.9 = 677.3 feet. Allowing two feet freeboard, the dam crest would be at an elevation of 679.3 feet. This elevation compares favourable with the crest of the existing dyke near this point which is 679.5 feet (see Drawing No. 4690-1 and Drawing No. 4690-6).

7.5 Dam on South Fork of Lillooet River

Approximately 2,000 feet below the mouth of One Mile Creek, the Lillooet River splits. The main channel flows easterly towards Lillooet Lake while the other smaller channel flows southerly into the Green River. This fork should be blocked off because it is quite possible and probable that the whole flow of the Lillooet River will eventually follow this course because of a better grade. What prevents the river from doing this at present is an obstruction some 1,000 feet below the fork, probably consisting of peat, which is hard to erode. At low water, there is a fall of two feet at this point. Should this obstruction erode, practically the full flow of the Lillooet River would follow this channel, thus nullifying all the work done to date on the Green River and the proposed works.

A dam similar to the one proposed at Section 7.4 is proposed at the head of the south fork of the Lillooet River with a crest elevation of 678.5 feet, having a freeboard of two feet. (See Drawing No. 4690-1 and Drawing No. 4690-6).

7.6 Dyke Between the Two Dams

From the profile along the south bank of the Lillooet River, it is evident that the bank is below the design flood levels and in order to prevent the river to flow southwards towards the proposed One Mile Creek diversion, it is proposed to construct a dyke between the two dams as shown on Drawings No. 4690-1 and 4690-6. A dyke with a 12-foot crest and slopes of 2:1 is proposed for this section, following the existing logging road. The crest elevation will be 679.3 at the northwest end and 678.5 at the southeast end, having a freeboard of two feet.

7.7 Limitations

The proposed works, as discussed, do not give full protection against design floods. As mentioned before, the Green River has not yet reached its final capacity to carry maximum flood flows and this may cause some backwater in the One Mile Creek. The south bank of the Lillooet River below the Fork is also below flood levels. At flood stages, water can overflow the Lillooet River bank and raise water levels in the Green River and One Mile Creek, especially then when these water courses also have extreme flows at the same time. To protect against such a possibility, a dyke would have to be constructed along the south bank of the Lillooet River from the Fork to the confluence of the Lillooet River with the Green River. At this point, flood levels are low enough and backwater will have little or no effect upon the levels of the Green River where the proposed diversion enters.

The construction of such a dyke is not recommended to be undertaken at the present time because of the high cost and limited benefits.

8. ALTERNATIVE B, DRAINAGE BY PUMPING

8.1 General

This alternative involves improvements to the existing drainage canal, construction of flood boxes and a pumping station at the confluence of the canal and One Mile Creek.

8.2 Design of Drainage Canal

The same cross-section and grades are proposed as discussed in Section 7.2. In this case, it is proposed to widen the canal at the lower end to form a pumping bay for a better delivery of water to the pumps. The excavated material from the canal should be deposited on the right or southwest bank of the canal to be used for the construction of a dyke from the proposed pumphouse to the road to Mount Currie. The crest elevation of this dyke should be at 681.0 to prevent the One Mile Creek from spilling into the canal during extreme flows.

8.3 Design of Pumps and Flood Boxes

Drawing No. 4690-7 shows a suggested layout for the pumps and floodboxes. This is only meant to be a sketch plan and was made for estimating purposes only and should not be considered as a final design drawing. The capacity of the pumps, as stated before, should be 130 cubic feet per second. With a maximum expected water elevation of 679.0 feet in One Mile Creek and a water level of 674.0 feet in the canal, the static head for the pumps is five feet. Assuming two feet for velocity head and elbow losses, the total dynamic head amounts to seven feet. To pump 130 cubic feet per second or 58,500 U.S. gallons per minute, the brake horsepower required at 80 percent efficiency is

$$\frac{58,500 \times 7}{3,960 \times 0.80} = 130 \text{ horsepower}$$

For cost estimating purposes, it is assumed that two pumps will be installed, one for 80 horsepower and one for 50 horsepower and that these pumps will be automatically controlled.

Due to the variation in elevations in One Mile Creek and the variation in discharges of the canal, it is not possible to set any standards for the design of the flood boxes. A check on existing flood boxes in the Fraser Valley shows a great variation from one dyking district to the next.

It is proposed to install the maximum number possible in the available space under the pumphouse, which means four flood boxes, each four feet high by four feet wide, equipped with gates as shown on Drawing No. 4690-7. The maximum discharge of these flood boxes is estimated to be 60 cubic feet per second.

Because of the poor foundation material in the area, it is assumed that the structure will have to be founded on piles and the cost estimates are based on this assumption.

8.4 Other Considerations

The Clover Road area which is presently drained by a culvert with flapgate through the dyke just opposite the mouth of the old Green River (See Drawing No. 4690-1) will not benefit from this scheme. It is possible, however, to drain part of this area towards the main drainage canal and pumps by means of the ditch on the south side of the Mount Currie road. An existing ditch which now discharges its water through a culvert into One Mile Creek just east of the canal outlet can be diverted into the canal to carry the excess water from the Clover Road area.

There still remains the area south of the Mount Currie road to be drained during high water in One Mile Creek at which time the flapgate closes. To drain this small area, it is proposed that the Dyking District purchase a portable pump which can be put into service when and if required, at the location of the present outlet. The area to be drained is 300 acres and the estimated runoff is 13 cubic feet per second requiring a pump of 20 horsepower.

9. ADDITIONAL WORKS REQUIRED

The inset on Drawing No. 4690-8 shows the invert elevation of culverts draining the area south of the Village of Pemberton near the school grounds. The drainage problem in this area can, to a great extent be overcome by deepening the ditches and the lowering of some of the culverts. This will be possible since the maximum water levels in the canal to where this area drains will be lower if either of the Alternatives A or B is implemented.

The Clover Road area (Drawing No. 4690-1) has already been discussed for Alternative B. If Alternative A is chosen, this area will benefit since water levels in One Mile Creek will be lower than at present. For proper drainage, it may be necessary to dredge a small ditch in the bed of One Mile Creek from the culvert to the proposed point of diversion in order to reverse the flow in that section of the One Mile Creek channel. Cost of the above works are not included in the estimates since these problems are considered local and not part of the main scheme.

It should also be noted that the Cost Estimates for Alternative B do not include removal of the logging bridge and log jam nor the blocking off of the south fork of the Lillooet River. Although this work is desirable in either case, they do not form a necessary part of Alternative B, as is the case for Alternative A.

10. COST ESTIMATES

Appendices H and I show the cost estimates for Alternatives A and B. The prices for excavation are based on the assumption that the dragline owned by the Dyking District will do part of the work. The widening of the canal will have to be done by dragline. The excavated material may be placed on the banks and spread out by bulldozer or grader. The dredging of One Mile Creek can, to a great extent, be done by bulldozer at low water. The Creek has sufficient width at this section and the cut averages about two feet.

The excavation for the One Mile Creek diversion can partly be done by bulldozer down to the groundwater table after which it will be necessary to employ a dragline.

The material for the dams and dykes is assumed to come from waste material of the diversion cut. Dump trucks can be loaded by the dragline and haul material for about one mile to the sites of the dams and dyke, provided that this work is carried out in the dry season when ground conditions permit such hauling.

An item has been included in the estimates for modification of the bridge over the drainage canal at the Mount Currie road, because another span will be needed for the extra channel width. Also included in the estimates for Alternative A is an item for the removal of the logging bridge and log jam. Care should be taken that the material is not carried down the river to form a log jam elsewhere. This material should be pulled on shore and burned or otherwise disposed of.

11. ANNUAL COSTS

Should this project qualify under the Agricultural Rehabilitation and Development Act (ARDA), the senior governments will participate in the cost of the project up to two-thirds of the capital cost. The share to be paid by the Dyking District would thus be one-third of the capital cost.

If it is assumed that the District will borrow the full amount of their share at six percent and amortize this loan over 25 years, the annual cost of the project would be as follows:

Alternative A, Drainage by Gravity

Loan Repayment $\frac{\$119,000}{3} = \$39,666$

@ 6% over 25 years = 0.07823 x 39,666 =	$ 3,103
Maintenance and Operation @ 2% of Capital Cost	$ 2,380
Total Annual Cost	$ 5,483.

Alternative B, Drainage by Pumping

Loan Repayment	$\frac{\$103,000}{3}$ = $34,333		
@ 6% over 25 years = 0.07823 x 34,333		=	$ 2,686
Maintenance and Operation @ 2% of Capital Cost			$ 2,060
Power Charges @ $6.60 per horsepower		=	$ 858
	Total Annual Cost		$ 5,604

The annual cost may be reduced considerably if the District should be in a position to finance their share of the project cost out of their accumulated reserve fund.

12. REMARKS AND RECOMMENDATIONS

From the foregoing, it is noted that the annual cost of Alternative B is slightly higher than the annual cost of Alternative A. The protection obtained from Alternative B (pumping) is, however, better than the protection obtained by Alternative A (gravity).

While on the average minor flooding could theoretically occur once every 25 years with the pumping scheme, this figure may be reduced to once every five years for the gravity scheme, due to backwater effect from the Green River caused by the lack of capacity of the Green River and by the Lillooet River overflow below the south fork of the Lillooet River.

It is possible that the effect of the gravity scheme improves over the years as the new Green River develops but this cannot be predicted with any degree of accuracy. The pumping scheme would, therefore, appear to be the best alternative.

There is no reliable information available as to what effect the lowering of the Lillooet Lake has had so far on the Lillooet River. It is recommended that a study be undertaken to investigate if further retrogression of the riverbed can be expected and to what extent. The accretion of the delta at the outlet of the Lillooet River into Lillooet Lake should also be included in this study. From observations and from comparison of aerial photographs, it is evident that the delta has extended considerably into the lake and some local residents have suggested that the delta has also built up in elevation, thus raising the river levels above what they have been in the past. Should this be the case, it might be possible to dredge a channel in the delta and thus gain a drop in river levels. This would also be of benefit to the Green River and degrading might continue at a more rapid rate.

13. CONCLUSIONS

The capital cost of providing improved drainage for Area No. 2 is estimated at $119,000 for a gravity system and at $103,000 for a pumping system. The annual costs to the District are estimated at $5,483 and $5,604 respectively.

Alternative A, the gravity system, would involve widening of the present drainage canal, dredging of a section of One Mile Creek and a diversion of One Mile Creek into the Green River. Other works required would be dams at the outlet of the present One Mile Creek and at the south fork of the Lillooet River and a dyke between these two dams. The proposed works for Alternative B, the pumping system, includes the widening of the drainage canal and the construction of a pump station at the confluence of the canal with One Mile Creek.

The cost estimates and engineering data are subject to adjustments when final designs are prepared. Before final designs are undertaken, drainage requirements should be reviewd by agriculture and soil experts.

Although the annual cost of Alternative B is somewhat higher than the annual cost for Alternative A, the pumping scheme is recommended because of the greater protection and reliability.

J. Wester, P.Eng.
Senior Hydraulic Engineer

JW/ls

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