

PORTLAND, OREGON

REPORT

on the

COLLECTION AND DISPOSAL

of

SEWAGE

August 19, 1939
Portland, Oregon

BOARD OF REVIEW

R. H. Corey
Wellington Donaldson
Carl E. Green
Abel Wolman

203877

TO THE MAYOR and COMMISSIONERS
of the City of Portland, Oregon:

The Board of Review convened by you on August
6, 1939, has reviewed the sewage collection and disposal
problem of Portland, Oregon.

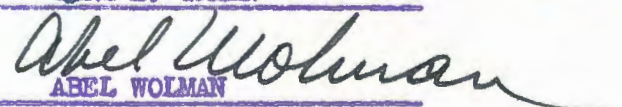
It submits the enclosed report for your considera-
tion. The report represents the unanimous judgment of
the Board.

Very truly yours,


R. H. COREY


WELLINGTON DONALDSON


CARL E. GREEN


ABEL WOLMAN

LETTER OF ASSIGNMENT
BY MAYOR AND COUNCIL

CITY OF PORTLAND
OREGON

August 14, 1939

To the Board of Review for the
proposed sewage treatment system
for Portland, Oregon:

Mr. Abel Wolman
Mr. Wellington Donaldson
Mr. R. H. Corey
Mr. Carl E. Green

Gentlemen:

In your investigations and report on a sewage treatment system for Portland, Oregon, the undersigned members of the City Council request that you include the following specific items:

- (a). A discussion on character of the water of the Willamette River as it is now and will be after treatment.
- (b). The type of treatment of sewage recommended.
- (c). The preferred location of treatment plant or plants.
- (d). An estimated cost of construction of main collection system.
- (e). An estimated cost of construction of treatment plant or plants.
- (f). Annual operating and maintenance cost for collection, pumping and treatment.
- (g). Recommended method of financing.
- (h). Recommended immediate steps for detailed design.
- (i). Technical type, character, number of personnel and estimate of cost of such detailed design.

Yours truly,

(Signed) Joseph K. Carson, Jr.
Mayor

(Signed) Wm. A. Bowes
Commissioner of Public Works

(Signed) R. E. Riley
Commissioner of Finance

(Signed) Ralph C. Clyde
Commissioner of Public Utilities

Commissioner of Public Affairs

SUMMARY OF FINDINGS

The Board of Review records the following conclusions and recommendations:

1. The Willamette River during periods of low flow, normally during the summer months, is heavily polluted, unsafe for bathing, unsuitable for recreation purposes and impossible for sustained fish and aquatic life.
2. The City of Portland, through its various sewer outlets and the sewage resulting therefrom, is primarily responsible for this condition.
3. The Willamette River reaches the city limits in none too good condition. It should undoubtedly be relieved of a large part of its domestic and industrial waste load, discharged into it before it reaches the city.
4. The Columbia Slough is in worse condition than the Willamette River.
5. The unsatisfactory conditions on the Willamette and the Columbia Slough can be eliminated almost entirely by collection and by treatment processes. It is recommended that the sewage discharge from all of the outlets on the Willamette River and the Columbia Slough from the City of Portland and its immediate environs be collected and transported to a site in the vicinity of Columbia Slough, there to be treated by sedimentation, and then discharged into the Columbia River through multiple outlets.
6. Such a plan of collection and treatment will eliminate the objectionable conditions already noted and will create no detectable deleterious effects on the Columbia River.
7. The cost of the main intercepting system will be approximately \$7,900,000.
8. The cost of the treatment plant will be approximately \$2,387,000.
9. The cost of pumping, of operation, and of fixed charges will be annually approximately \$794,000.
10. The program should be financed by a general obligation bond issue of approximately \$7,500,000, by a pay-as-you-go revenue from sewer service charges and by an increase in the general tax rate.
11. Approximately \$150,000 should be made available at once for detailed field and office surveys and for design for the proposed program.

REPORT OF BOARD OF REVIEW
ON
THE COLLECTION AND DISPOSAL OF SEWAGE OF PORTLAND, OREGON
(August 19, 1939)

The sewage disposal problem of Portland, Oregon, has had a long and varied history. The discussions of various aspects of the local situation have covered a period of probably over twenty-five years. Since 1933, however, much more detailed attention has been given officially and publicly to the problem.

In the spring of 1933, a group of unemployed began a campaign looking toward the correction of the sewage disposal problem. This group prevailed upon the City Council to authorize the preparation of plans, estimates and specifications for this purpose. In six weeks such a plan was prepared and submitted to the Council on June 8, 1933. A special election was called for July 21, 1933.

The plans prepared in this interval were necessarily incomplete and rested upon no sound basis or estimate of sewage flow, size or location of main sewers, or adequate review of the local necessities for various degrees of treatment.

This preliminary and indefinite plan was hurriedly revised by the then City Engineer and re-submitted to the Council on July 12. The Council in receiving the revised program declared it to be "tentative only and would have to be changed, revised, added to as further study developed the need."

On July 21, 1933, a \$6,000,000 self-liquidating bond issue was passed by the people by a vote of 47,029 to 23,395.

During the campaign, statements were made as to service charges and sale of fertilizer. The record indicates that the people felt the bonds would be self-liquidating, either from service charges, or from revenues derived from sludge fertilizer sale, or both. Work relief features of the undertaking, however, probably supplied the principal motives for the passage of the bonds.

On August 4, 1933, an application for a loan of \$6,000,000 and a grant of \$2,000,000 was made to the Federal Emergency Public Works Administration on the basis of the still inadequate plans submitted to the Council on June 8 and July 12.

The application was immediately returned to the City by the P.W.A.

with the statement that "plans, estimates and specifications were insufficient to afford a proper checking of the application."

The Council attempted to obtain various amounts of money from different federal and state agencies with which to carry out the preparation of such plans, estimates and specifications. The cost of such preparation was estimated by the P.W.A. at approximately \$50,000.

The City succeeded in raising through its own auspices some \$10,000 in September, 1933. This fund, together with a small amount of money supplied by the Oregon State Reconstruction Advisory Board, provided limited funds for further study.

In July, 1934, a grant of \$2,240,000 was obtained from P.W.A., contingent on the sale of the \$6,000,000 bonds. No purchaser of these bonds could be found.

On September 15, 1933, Mr. Harrison P. Eddy, of Boston, was retained as consultant. He submitted his report on October 3, 1933. On October 25, 1933, Messrs. Koon, Cunningham and Dieck, local consulting engineers, were retained for further studies.

In November, 1933, the City submitted an application for \$50,000 for preparation of complete plans and a further application for a southeast unit of the intercepting sewer, at an approximate cost of \$461,000. The application was formally submitted on December 4, 1933, and immediately denied.

A complete application for the entire project, at a total cost of \$8,240,000 was submitted to P.W.A. on February 22, 1934.

Although it was accepted, no money was available because Oregon had at that time exceeded its allotment.

On November 6, 1934, a charter amendment was placed before the voters, adding a provision to the \$6,000,000 of self-liquidating bonds to the effect that the bonds would be supported out of the general tax funds in case of default in total service charges. This charter amendment was defeated.

During the latter part of 1935 and the early part of 1936, the Council proceeded through various steps to test the legality of the bonds. These steps were terminated on March 31, 1936, when the State Supreme Court handed down an opinion which in effect permitted the city to issue bonds and proceed upon the project as submitted to the Council on June 8, 1933. The opinion, however, carried several conditions, of which the most important were: (a) that all sewage except of Linnton shall be treated, and (b) that the activated sludge treatment be used for the entire sewage except of Linnton.

In order to clarify the various financial and legal complications, the Council submitted to the voters in the November, 1936 election, a pay-as-you-go amendment. It was defeated.

A charter amendment on a similar pay-as-you-go plan was again submitted to the Portland voters on November 8, 1938. On this occasion the voters accepted the enterprise with an assumed probable cost of approximately \$9,000,000.

This brief summary of the discussions during the past six years indicates that the assumed cost of the sewage collection and treatment program has risen from \$6,000,000 to approximately \$9,000,000, that at no time during this period has a detailed study of the enterprise been accomplished, and that apparently local understanding of the engineering plan and of the methods of financing is not yet completely clarified.

PRESSENT CONDITIONS OF WILLAMETTE RIVER AND COLUMBIA SLOUGH.

The Willamette River and the Columbia Slough receive virtually all of the domestic and industrial waste of the City of Portland and of the territory immediately adjacent to the city limits. We have had an opportunity to review a number of the past investigations of the condition of these bodies of water. One or more field inspections have been made of each of the areas as well as of a considerable portion of the Columbia River above, at, and below the City of Portland. The records of field investigations, the field inspections by the present Board of Review and the calculations of the capacities of these various bodies of water for the reception of domestic and industrial waste make it perfectly clear that the pollution of the Willamette River by domestic sewage and industrial waste has converted it and the Columbia Slough into objectionable open sewers.

The most sensitive and perhaps the most important index to the character of these waters from a sanitary standpoint is their dissolved oxygen content. All of the investigations disclose the fact that the Willamette River and the Columbia Slough in the vicinity of the City of Portland have reached such a state of organic degradation as to prevent the existence of any except the most hardy forms of fish life, as to produce objectionable odors at many times during the summer, as to create objectionable sludge deposits and floating materials of obvious sewage origin, and as to interfere with the normal uses of the river for navigation, fish life, recreation, or bathing.

In other words, the character of the Willamette River and the Columbia Slough during a large part of the summer months leaves no doubt as to the objectionable and deleterious effects of the discharges of Portland domestic sewage and industrial waste. These waters are in bad condition and immediate steps for removing the major part of the contributing sewage and industrial waste from both areas is an obvious task for the community.

These conclusions of the present Board of Review are so amply and completely supported by prior investigations and by the findings and conclusions of all previous consultants or consulting boards that it is not felt that this point need be further labored. The Board assumes that the river is bad, that the Columbia Slough is worse and that corrective measures are essential in each.

MEASURES NECESSARY TO CORRECT UNSATISFACTORY STREAM
POLLUTION CONDITIONS.

(a) Practice elsewhere in the United States.

The problems confronting the City of Portland in respect to sewage disposal are not peculiar to Portland. This problem has vexed thousands of communities and millions of people in the United States. Considerable progress in treatment has, of course, been made in various areas in this country, even though the rate of correction may have been slow in this as well as in other communities. In 1938 approximately 41,000,000 people, or 52% of the urban population of the United States, were supplied with sewage treatment plants.

Almost 5,000 communities in 47 states had undertaken and were carrying on the treatment of sewage from their populations.

In New York State alone, the sewage of almost 6,000,000 people was being treated in 1938.

More than half of the communities treating their sewage provided treatment by sedimentation only. So-called complete or oxidation treatment has been used by 44% of the communities. Several hundred of the cities have been using activated sludge plants.

Disinfection of effluents prior to discharge into receiving bodies of water was employed in 1938 in only 20% of all the plants of the United States.

Literally thousands of plants had been equipped for sludge disposal through by-product utilization of one form or another. Of these thousands, more than 150 communities have been disposing of sludge, from either plain sedimentation tanks, activated sludge plants or chemical treatment plants for fertilizer use.

This brief summary of current sewage disposal practice in the United States shows that the problem is not new and that actual construction and operating data are available on a vast scale. It is equally important to emphasize the fact that data on costs, whether fixed or operating, are abundant in number and variety, so that there is no excuse for viewing the problems of the City of Portland on the basis of fantastic and fanciful figures lifted largely out of the imagination and rarely, if ever, checked against known principles, design data, or actual costs of construction and operation. The fund of experience on all of the elements necessary for reaching a decision for the City of Portland is tremendous in scope and character elsewhere in the United States. It is perhaps unsurpassed in availability of data anywhere else in the world.

It should be further pointed out, in reviewing the current practice in this country, that the methods of treatment adopted in the past have not been the result of chance or of whim. In thousands of instances, the degree of treatment in each local situation has been determined upon the basis of the character

and quantity of the sewage in question as balanced against the character, use and volume of the receiving body of water. In addition, the relative merits of the conclusions reached by this method have been balanced against the first cost and the annual operation and maintenance charges involved in the different types of treatment. In other words, the variation in method of treatment adopted in the different communities of the United States reflects the efforts of engineers and public officials to select for each community that most economical form of treatment most satisfactory for the protection of the sanitary, esthetic and biological necessities of the receiving body of water. Only upon such a basis can and should a decision be rendered.

(b). Controlling Criteria for selection of type of treatment.

What are the criteria which should be applied to any river in order to determine what degree of treatment is necessary and desirable to improve the quality of the river water receiving the untreated or treated discharges of domestic and industrial waste? Obviously, the most important consideration rests upon hygienic standards. In other words, a receiving body of water which is used for private or public supply intakes, for the production of natural ice, for the growing of shell fish, for the protection of migratory fish, or for the use of bathing beaches or recreational facilities, represents the highest uses to be protected in a treatment program.

Perhaps the second important consideration rests upon the avoidance of conditions affecting the public comfort, offensive either to the eye or to the sense of smell.

A third consideration, frequently of equal importance to those listed under hygienic values, involves the uses of the receiving body of water for economic values, such as industrial water supplies, the watering of live stock, the propagation of fish and other useful aquatic life, the protection of real estate values, and the safeguarding of private and public river and harbor improvements and navigation, so as to avoid the costly and objectionable effects of silting and sludge deposits.

A similar set of considerations must be borne in mind in relation to the law, with particular reference to the rights of lower riparian owners and users and to compliance and conformity with existing legal requirements of local, state and federal agencies.

All of these considerations must be reviewed in determining upon the logical method of collecting and treating the sewage of any important metropolitan population.

A generalization of these considerations would lead us to state that the choice of type and location of a treatment plant will be determined primarily by which of two groups of waters the community uses for the discharge of sewage. If it falls into a designated water area which is or is to be expected to be used primarily for water supply, for recreational purposes, for shell fish culture or for the development of fish life, it will require that degree of treatment which will not be detrimental to these uses. If, on the other hand, it is located

upon a designated water area which is not or is not expected to be used primarily for recreational purposes, shell fish culture, or the development of fish life, or for water supply intakes, a lower degree of treatment will be required, which will produce conditions in the water area unobjectionable for those uses of less importance.

The Board of Review has examined with care all of the considerations listed above and considers that the Willamette River, the Columbia Slough and the Columbia River fall within the first designated class. These water areas have important uses, which will be specified further below, which will require the discharge of effluents which will not disturb the uses already enumerated for a first class receiving body of water.

Experience throughout the country has indicated that the waters of such first class areas may be preserved in satisfactory condition when all floating solids and at least 60% of suspended solids have been removed from the sewage; when organisms of the B. coli group (bacteria of intestinal origin) have been so reduced as to not exceed one per cubic centimeter in more than 50% of the samples of sewage effluent during the bathing season; and when the average dissolved oxygen content in the waters does not fall below 50% saturation in any week during the year.

(c). Application to the conditions in Portland.

With these preliminary observations as to the controlling criteria for selection of type of treatment for any given community, the Board is now prepared to consider the local conditions of the City of Portland, and to develop on the basis of those conditions quantitative findings which should lead to a decision as to most desirable type of treatment process for the local area. For this purpose, the Board has made the following assumptions, based upon previous studies by the municipality and its consultants, and upon adjustments considered wise by the present Board:

- (1). The population of Portland and environs will reach 450,000 in 1950.
- (2). The average sewage flow in 1950 will be 95.3 million gallons per day.
- (3). The sewage treatment plant should be designed for the 1950 population and average sewage flow.
- (4). The plant should be so designed as to provide for a reasonable amount of storm water flows in addition to sanitary sewage and industrial waste.
- (5). The characteristics of the sewage resulting from the Portland population would be represented by the following assumed values: a bio-chemical oxygen demand of 200 parts per million; suspended solids of 210 parts per million; and a B.coli content of 800,000 per cubic centimeter. (These assumptions rest upon comparable sewage analyses in many other communities "spot-checked" by laboratory tests of Portland sewage.)

(6). The Willamette River and the Columbia Slough are or will be used at or near Portland for the propagation and migration of fish, for bathing and recreation, for industrial water supplies, for the watering of livestock and for various private and public river and harbor improvements. Similar uses are assumed for the main Columbia River.

For the preservation of these bodies of water for fisheries purposes, it is assumed that the dissolved oxygen content of these waters should not at any time fall below 5 parts per million. This figure is intentionally placed at a high level, although some authorities in this field feel that a minimum dissolved oxygen content of 3 parts per million might suffice. The Board, however, considers the rivers of such importance in relation to fish life that it has assumed the figure of 5 parts per million for this purpose in its calculations.

In connection with the assumptions as to quantity of sewage flow and quality of sewage, insufficient studies have so far been made by the City of Portland to warrant completely final decisions as to these two important elements. It is reasonably safe, however, to use the figures which the Board has assumed for comparative purposes at this stage of the study. Their accuracy for final plant design should be determined at an early date and as herein later recommended.

The Board finds that the Willamette River reaches Sellwood Bridge in Portland with its dissolved oxygen content already seriously impaired, due to the discharge of important amounts of domestic and industrial waste on the Willamette and its tributaries above Portland. This critical situation in the River before it reaches Portland makes it important to call attention to the necessity of cleaning up the river above Portland at the same time as improvements in sewage treatment are undertaken by the City of Portland.

Until such cleaning of the upper river is accomplished, it is doubtful whether the Willamette River above Portland may be expected in the summer months to reach Portland with any more than 4 parts per million of dissolved oxygen. The Board does not retain its requirement of 5 p.p.m. residual oxygen for fish life in the Willamette River, because if it does so the calculations result in no available dilution waters during the low flow months.

It is, therefore, assumed that, of this 4 parts per million, 3 parts must be preserved for fish life. A residual of only 1 part per million is then available to assimilate and convert the treated or untreated sewage of the city. One part per million of residual oxygen in the river is the equivalent of 5,400 pounds of oxygen for each one thousand cubic feet per second of flow.

The Board has calculated the amount of dilution water required in the Willamette River to assimilate the sewage of the city with varying degrees of treatment. In this connection the Board has assumed that the combined sewage of the City of Portland represents an oxygen requirement for conversion of its organic constituents into stable inorganic material of 0.24 pound per person per day. In 1950, the population of 450,000 will therefore require 108,000 pounds of oxygen per day. This oxygen must be supplied either through the natural resources of the receiving bodies of water or through artificial treatment processes of varying degrees of efficiency.

The Board has assumed for purposes of calculation three commonly accepted degrees of treatment, viz: (a) no treatment except by dilution; (b) 25-1/2% of

removal of organic constituents; and (c) 90% removal of organic constituents. These degrees of treatment correspond in general to the following processes: No treatment, plain sedimentation, and activated sludge.

On the basis of these figures, the Board finds the results set forth in Table 1, showing the required diluting water in the Willamette River to provide for the safe disposal of the various effluents resulting from the three degrees of treatment. The quantitative evidence in Table 1 discloses at once that during a large part of the time the Willamette River is insufficient in flow to provide for adequate assimilation of the effluent from any of the treatment processes except the 90% one.

Table 1

WILLAMETTE RIVER

Calculations of Oxygen Balance on Discharge of Portland Sewage
with Various Degrees of Treatment

Degree of Treatment . : (On basis of bio- : chemical oxygen : demand) . . : : : : : : :	Oxygen : Required, : pounds : per day : : : : :	Minimum Flow : of River Re- : quired to : Satisfy Oxygen : demand, cubic : feet per : Second : : :	Percent of : Time Requir- : ed Flow is : Available : : :
None : : : : :	108,000 : : : : :	20,000 : : : : :	52 : : : : :
33-1/3% Treatment : : : : :	72,300 : : : : :	13,400 : : : : :	62 : : : : :
90% Treatment : : : : :	10,800 : : : : :	2,000 : : : : :	100 : : : : :

COMPUTATIONS

~~1000~~ cubic feet per second = 646,000 gallons per day

1 part per million of oxygen = $0.646 \times 1000 \times 8.33 = 5380$, say 5400 pounds
per day per 1000 C.F.S.

Assumed sewage load (combined sewers) = 0.24 pound per capita per day @
450,000 population = 108,000 pounds of oxygen
required per day for untreated sewage.

Dissolved Oxygen, P.P.M.

Willamette River at Sellwood Bridge	4
Minimum requirement for fish life	<u>3</u>
Available	1

1 p.p.m. available is the equivalent of 5400 pounds per day per 1000 c.f.s.

If it is further assumed that 5 parts per million of dissolved oxygen is to be retained in the Willamette River, the conclusion is reinforced.

If sewage is to be discharged with safety into the Willamette River, it must be subjected to at least 90% treatment. It should be emphasized that this would still leave for discharge into the Willamette River 10% of the organic content of the original sewage requiring reasonable diluting amounts of water in the Willamette during every summer. This is particularly true since velocity and holding conditions in the Willamette at low flow are decidedly unsatisfactory. It is an unusually sluggish body of water with delayed carrying off of discharged materials. Although in later years the minimum flows in the Willamette will be increased by regulated flow controls, the conclusions here noted will not be affected in any important degree at that time.

Similar calculations have been developed for discharge into the Columbia River. The results are set forth in Table 2.

Table 2

COLUMBIA RIVER

Calculations of Oxygen Balance on Discharge of Portland Sewage
with Various Degrees of Treatment

Degree of Treatment (On basis of bio- chemical oxygen demand)	Oxygen Required, pounds per day	Minimum Flow of River Re- quired to Satisfy Oxygen Demand, cubic feet per second		Percent of Time Required Flow is Available
		For 3ppm	For 5ppm	
None	108,000	4000	6700	100
33-1/3% Treatment	72,300	2700	4500	100
90% Treatment	10,800	400	670	100

COMPUTATIONS

SEE Table 1 for duplicate calculations

Dissolved Oxygen, p.p.m.

Columbia River above Portland 8

Minimum Requirement for fish life 3

Available 5

5 p.p.m. is the equivalent of 27,000 pounds per day per 1000 c.f.s.

From 60 year record, minimum flow of Columbia River, unregulated,
for a single day, in January, 1937, - 35,000 c.f.s.

Minimum flow with regulation will be ~ 80,000 c.f.s.

Reference to Table 2 indicates that Portland sewage in the amounts probably available in 1950 could be discharged into the Columbia River without any treatment whatever, with no deleterious effect in oxygen balance upon any of the present or potential uses of the Columbia River. This is the case not only upon the assumption that 3 parts per million of dissolved oxygen should be retained in the river for the preservation of fish and aquatic life, but also if it is assumed that 5 or 7 parts per million are so required. Our conferences with experts in the field of biological life, fisheries or otherwise, disclose that no experienced professional observer in this field suggests a residual oxygen of more than 5 parts per million. The Columbia River, therefore, can receive all of the Portland sewage untreated without detriment to its oxygen balance: It can do so because its mean monthly discharge has never fallen below 40,000 second feet in the period of record covering some sixty years.

It should be recalled and emphasized that the low flow on the Columbia occurs in midwinter, when the dilution necessities are at their lowest figure. In summer, when sewage assimilation proceeds at its greatest rate, the flow of the Columbia exceeds 100,000 c.f.s.

Within the next few years and no doubt before the Portland sewage treatment program has been consummated, the regulated flow of the Columbia River will result in a minimum flow of over 80,000 instead of 40,000 cubic feet per second. This future regulated flow would provide, without detriment to the river, for receiving the untreated sewage of approximately 1.5 million people.

In order to avoid, however, any conceivable evidence of sewage discharge into the Columbia River, the Board recommends that the sewage to be discharged into the Columbia River should be subject to plain sedimentation which will reduce the organic content of the sewage by at least 33-1/3%.

It has been suggested by some that carrying sewage to the location here proposed would result in a quality of sewage difficult to treat. Our Calculations show that the difference in time of transit of sewage to this location in contrast with any other proposed location is a matter of only hours. The time difference will not control the type or efficiency of treatment at any of the sites recommended.

Discharge into the Columbia Slough is not even desirable with 90% treatment, since its conditions of flow are decidedly inferior to those of the Willamette River.

In summary, therefore, the Board finds that if sewage is to be discharged into the Willamette River, it will require a minimum of 90% treatment; if it is to be discharged into the Columbia River a minimum of partial treatment will be required; and that preferably no sewage, no matter how well treated, should be discharged into the Columbia Slough.

On the basis of all considerations so far discussed, the Board recommends without qualification that the sewage of the City of Portland should be

collected and transported to the Columbia River, into which it should be discharged after treatment by plain sedimentation.

Discharge into the Oregon Slough (North Portland Harbor) is not recommended, since the flow in this area is only a fraction of that in the main Columbia River and since the discharge point is unnecessarily close to reasonably populated bathing beaches.

The plants on the Willamette River are not viewed with any great favor because of operating problems in connection with sludge handling, which experience elsewhere shows makes the placement of such plants in heavily populated areas unwise, if alternative sites equally cheap are available in more isolated sections. These conclusions are later reinforced by considerations of costs for the various processes reviewed.

The science and art of sewage treatment are sufficiently well advanced in this country to make it unnecessary to construct and operate in Portland experimental or small pilot plants, prior to design and construction of full scale units. Although such a procedure has been suggested, the Board recommends against it.

Chlorination of the effluent is not considered necessary in any of the projects, although it will no doubt be used from time to time for special plant purposes.

MAIN COLLECTION SYSTEM FOR PORTLAND.

The collection of sewage from the many outlets of the Portland sewerage system offers a more complicated and difficult set of problems than does the ultimate treatment of the collected material. This complex situation is brought about by the fact that practically all of the sewers in the City of Portland are of the combined type, namely, they are designed and constructed to carry storm water as well as sanitary sewage. Apparently none of them have been designed or constructed with reference to the ultimate problem of joining them at their outlets for the simplest and least expensive method of disposal of the sewage. As a result, a number of unsolved problems arise when a decision as to the best intercepting system is to be made. Existing data on normal and storm water flows are exceedingly meager. Estimates of cost at present available in the city engineer's office are equally preliminary in character and insufficient in extent or in exploration.

The preparation of an adequate plan for collection and the development of safe estimates of costs therefor will require many months and the expenditure of a reasonable amount of money. These facilities have not yet been accorded to the city engineer's office and, until they are, the exact method of design and construction and location of the main collection system cannot be definitely determined.

It still remains to be demonstrated, for example, whether all of the

sewage should be collected by low level interceptors, by high level interceptors, or by combinations thereof, which would carry the sewage by gravity and pumping to one or more of the assumed sites for treatment. Preliminary studies which the Board has undertaken since its arrival in Portland and similar studies by engineers concerned with the problem made prior to our arrival, give support to the hope that a combination of high level gravity and low level pumping interceptors will yield the greatest economy for the future. With these possibilities in mind, the Board has made comparative estimates of a number of projects for collecting the sewage and has compared undertakings on the low level interceptor basis with preliminary cost estimates for the combination of high level and low level methods.

In its evaluation of the main collection systems, the Board has reviewed a number of unit cost estimates. It believes that the figures are reasonably in accord with local costs for similar work, but it repeats its caution that the interceptor costs quoted in this document should be thoroughly checked by more detailed field and office studies. In its review of interceptor design and costs it has assumed that the intercepting sewers should be designed for a population of approximately 660,000 persons to be reached about the year 1970. It will be noted that this population is considerably in excess of the population of 450,000 assumed for the treatment plan design. This increase in population has been assumed in the design of the intercepting sewers because they are built deep in the ground, involve heavy and costly construction and cannot be readily enlarged or duplicated.

The relative costs of the various systems for intercepting sewers are shown in Table 3. The locations of these main collectors shown on the maps attached to this report are general and tentative in character, since adequate studies to determine their final and most economical location, for minimum construction as well as minimum permanent pumping costs, have not yet been made. The comparative costs will be discussed more fully below.

Table 3

PORTLAND, OREGON

Estimated Cost of Constructing and Operating Interceptors, Pumping Stations and Treatment Plants. (As of August 19, 1939)

Project Number*	Cost of Interceptor System	Cost of Treatment Plant	Total Cost of System	Annual Cost			
				Operation	Pumping	Interest and Amortization at 5%	Total
1	7,728,000		7,728,000		104,600	386,400	491,000
1A	8,601,100		8,601,100		62,400	430,100	492,500
2	7,900,000	2,387,500	10,287,500	174,300	104,600	514,400	793,200
2A	8,773,100	2,387,500	11,160,600	174,300	62,400	558,000	794,700
3	7,900,000	5,730,000	13,630,000	630,000	104,600	681,500	1,416,100
3A	8,773,100	5,730,000	14,503,100	630,000	62,400	725,200	1,417,600
4	7,345,200		7,345,200		104,600	387,300	471,800
4A	8,218,300		8,218,300		104,600	410,900	515,500
5	7,517,200	2,387,500	9,904,700	174,300	104,600	495,200	774,100
5A	8,390,300	2,387,500	10,777,800	174,300	62,400	538,900	775,600
6	7,517,200	5,730,000	13,247,200	630,000	104,600	662,600	1,397,000
6A	8,390,300	5,730,000	14,120,300	630,000	62,400	706,000	1,398,400
7	7,088,100	5,061,500	12,149,600	536,800	87,100	607,500	1,231,400
7A	7,530,100	5,061,500	12,591,600	536,800	52,100	629,600	1,218,500
8	6,723,300	5,067,500	11,790,815	540,800	87,100	589,500	1,217,500
8A	6,769,100	5,067,500	11,836,600	540,800	54,000	591,800	1,186,600

Note: Projects marked "A" represent the system with high level interceptors taking part of the sewage to plant by gravity flow and low level interceptors for the portion to be pumped.

* Project descriptions appear in text of Report on page 21

ESTIMATED COST OF CONSTRUCTING AND OPERATING SEWAGE TREATMENT
PROCESSES FOR VARIOUS PROJECTS.

In the design of sewage treatment plants for Portland, similar difficulties have been encountered as in the design of the collecting system. Virtually no detailed engineering design for treatment plants is available at this stage in the city engineer's office. No reliable data have so far been collected on the flows or quality of sewage. No authentic detailed cost figures are at hand.

In this situation, as in others already discussed, we have been confronted, therefore, with the task of making assumptions in the design and in the cost figures as the result of our experience with undertakings of similar nature in a number of places throughout the country. We consider the cost estimates to be reasonably accurate and generally useful for comparative purposes. It cannot be too strongly emphasized, however, that they are entirely preliminary in nature and should not be accepted as final figures for construction, bond issue, or pay-as-you-go purposes. The estimates and the designs from which they emanate still remain to be prepared. They are not in existence today.

In general, the assumptions as to unit costs, construction and operation, result in the following averages:

Plant Cost

33-1/3% Treatment:

\$5.00 per capita - \$25,000 per million gallons

90 percent treatment:

\$12.00 per capita - \$60,000 per million gallons.

Operation and Maintenance Charges

33-1/3 percent treatment:

\$5.00 per million gallons - \$0.40 per capita per year

90 percent treatment:

\$18.00 per million gallons - \$1.40 per capita per year (without sludge processing for fertilizer)

The Board has defined the various degrees of treatment upon which costs were determined as follows:

- (A) No treatment except by dilution - mechanical screening.
- (B) 33-1/3 percent treatment - mechanical screening, grit chambers, grease removal and plain sedimentation for two hours
- (C) 90 percent treatment - mechanical screening, grease removal, preliminary settling for one hour, aeration for six hours, and secondary settling for two hours.

It has further assumed in each treatment program that the large amounts of sludge resulting from any of the processes will be handled as follows:

33-1/3 percent treatment - Digestion and vacuum filtration.

Digestion tanks - covered and heated, capacity 3 cubic feet per capita.

90 percent treatment - Digestion and vacuum filtration.

Digestion tanks - covered and heated, capacity 5 cubic feet per capita.

The final sludge cake in either process will be disposed of in land fill or carted away by farmers, at little or no revenue.

The Board has reviewed eight separate projects (shown schematically on attached charts) as follows:

- Project (1) The collection and discharge of sewage to the Columbia River without treatment.
- Project (2) The collection and discharge of sewage to the Columbia River with 33-1/3% treatment.
- Project (3) The collection and discharge of sewage to the Columbia River with 90% treatment.
- Project (4) The collection and discharge of sewage to the Oregon Slough (North Portland Harbor) without treatment.
- Project (5) The collection and discharge of sewage to the Oregon Slough with 33-1/3% treatment.
- Project (6) The collection and discharge of sewage to the Oregon Slough with 90% treatment.
- Project (7) The collection and discharge of sewage into the Willamette River with a single plant of 90% treatment.
- Project (8) The collection and discharge of sewage into the Willamette River with five plants of 90% treatment and one plant of 33-1/3% treatment with discharge into the Columbia River.

The costs of construction, operation and maintenance, and carrying charges are shown in detail in table 3.

RECOMMENDATED LOCATION AND TYPE OF TREATMENT PLANT

The data already presented in Tables 1, 2 and 3 and hitherto discussed in some detail indicate without question that the most desirable plan for the collection and disposal of sewage for the City of Portland comprises carrying the sewage by a combination of high level and low level interceptors to a point beyond the Columbia Slough, where it would be subjected to partial treatment and then discharged by gravity through multiple outlets at a depth of not less than fifteen feet into the Columbia River. This plan will involve a construction cost of approximately \$10,000,000 and an annual fixed and operating cost of approximately \$794,000. This program is less costly than any of the other programs reviewed or submitted, which are capable of accomplishing the desired results. Further detailed studies as herein recommended will no doubt disclose that this project probably could be constructed at a cost in the neighborhood of \$10,000,000. It is cheaper in total annual cost by more than \$390,000 than any of the activated sludge proposals, since all of the 90% treatment plan programs involve heavy operating and fixed charges.

The plan (Project 2 or 2A) herein recommended will produce a better condition in the Willamette River than any of the proposals for activated sludge treatment, since the latter must of necessity leave a 10% residual of organic materials for continuous discharge into the Willamette River. In other words, the most complete method of removing the sewage from the Willamette River is offered by the plan herein proposed. It is likewise the cheapest in first cost and in annual operation.

In reviewing these comparative costs, the reader must bear in mind that annual operating costs may have as much as or more significance than first cost. Hitherto, as far as the Board is aware, no previous report or discussion has concerned itself with the important element of operating costs. These cannot be indefinitely ignored.

The adoption of Project 2 or 2A will result in no detrimental effect on the Columbia River, possible of detection by any of our known physical, chemical or biological tests. It will remain for many decades a completely satisfactory method of providing for the local sewage situation. When the population of Portland and its environs has grown to over a million and a half, then the time for discussion of more complete treatment will be at hand. Until then, any other method of handling the situation merely calls for expenditures large in amount and completely unnecessary in character.

Before closing the discussion on sewage treatment processes and costs, the Board wishes to record the fact that it has reviewed proposals for treating the sewage of Portland in writing and in conversation with a variety of proponents of various plans. Without exception, not one of these proposals rests upon engineering data or cost figures of more than a highly preliminary kind. No proposal, even including those hitherto used by the city, rests upon any detailed or reasonably complete engineering or cost information. The city engineer's

office has been aware of this deficiency since April 7, 1933, when Mr. C. H. Smith recorded the lack of such studies and the necessity for providing time and money for making them. Funds have never been provided to the city engineer's office for such purposes. None of the previous consultants have been provided with sufficient data, therefore, to make final decisions.

We do not believe that this is the place to comment critically, beyond the above statements, upon some of the alternative schemes hitherto discussed by the public. Sufficient evidence is available, however, to show that in many of them the cost estimates are neither logical nor representative of the conditions which would be encountered in the Portland project.

One proposal submitted to the city, for example, calls for plants costing approximately \$2,720,000 for 320,000 people. Nowhere in the proposal does any estimate of operating costs appear. As a matter of fact, these operating costs for the plants proposed, notwithstanding that their capacity would be inadequate for the 450,000 population, would exceed \$30,000 a month. With sufficient plant capacity, these charges would exceed \$45,000 a month, taking no account of other discrepancies and omissions in the proposal.

RECOVERY AND SALE OF SEWAGE SLUDGE.

The citizens of Portland have been led to believe that the sewage treatment costs would be met by an income to be derived from the sale of sewage sludge for fertilizer and from the sale of treated liquor for industrial water or irrigation purposes. It has even been stated that the cost of construction would likewise be amortized through such revenues.

Throughout the entire history of sewage treatment, this search for profitable use of the liquid and solids in municipal sewage has proceeded apace. Today the solution is almost as far away as it was fifty years ago.

It is true that the organic values and inorganic constituents of sewage materials have varying degrees of fertilizer value. The difficulty in realizing these values lies in the fact that it costs money both for plant structures and operation. The sludge from plain settling tanks, properly processed to avoid nuisance, has a reasonable fertilizer value. The sludge from activated sludge treatment plants, likewise adequately processed, has a greater fertilizer value. Both of these materials are being used for fertilizer purposes throughout the United States, but nowhere at a net profit to the community. There are one or two minor instances, under very unusual local circumstances, where such operations have resulted in no loss. The number of these latter is insignificant and their application to Portland is unwarranted.

In the two or three important plants in the United States in which activated sludge has been recovered on a commercial scale, at no time has the income from the sales of fertilizer resulted in a net profit or a breaking-even in operating costs. Nowhere have such incomes reached the level of assisting in amortizing the cost of the plant.

If the Milwaukee, Wisconsin, experience, for example, in this field were applied to Portland, with a present population of 320,000 persons, the loss upon sludge conditioning and processing alone would exceed \$125,000 per year.

The availability of mineral phosphates in the Pacific Northwest and the necessity for increased fertilizer use in the same region, may some day warrant the City of Portland's entrance into the commercial fertilizer field, under the guise of sewage treatment. When that time arrives, the recommended plan of treatment can be extended without loss of structure or investment to provide for sludge processing. The treatment proposed on the Columbia River can always be extended to provide for more treatment, such as activated sludge, or for sludge processing. When firm contracts for such fertilizer are at hand, reasonably guaranteed by reliable companies, the city may profitably re-open the discussion.

Until that time, the City of Portland would be warranted in undertaking the production of fertilizer only because it has determined to do so as an independent commercial enterprise and not because it is compelled to do so or finds it profitable to do so as an integral part of the correction of its stream pollution conditions.

METHODS OF FINANCING PROPOSED PROJECT.

It is the understanding of the Board of Review that up to the present moment the plan of meeting the costs of construction and ultimate operation of the sewage collection and treatment program was on a "pay-as-you-go" basis. This program provided originally for sewer service charges which were expected to yield an estimated yearly revenue of between \$400,000 and \$500,000. The Sewer Charge Equalization Board has recently indicated, however, that its proposals will produce a gross annual revenue of only approximately \$275,000.

It should be clear that with the original estimated revenue of \$400,000 annually, a construction program of approximately \$10,000,000 would take 25 years to complete, provided, of course, no federal subsidies or grants were included or supplied in the interval. With the present anticipated revenue of \$275,000 a year, the \$10,000,000 construction program will stretch over a period of over 35 years. Even if federal grants to the extent hitherto provided are assumed, the program will not be completed in less than 20 years.

The Board considers a construction program of this character and of the amount herein recommended as wholly impractical of accomplishment by the pay-as-you-go procedure, at least with the current anticipated revenues.

Although it is true that certain portions of the program might be undertaken and finished independently of others, particularly in the case of the Columbia Slough portion, even these would require five or six years for unit completion. In the meantime, the Willamette River would not be materially improved. As a matter of fact, until the Willamette River intercepting system is completed, the objectionable conditions of that river will remain approximately the same.

It does not appear to the Board that the program as herein recommended can be adequately accomplished to the advantage of the public on a strictly pay-as-you-go piece-meal basis.

It is likewise doubtful whether a rigid pay-as-you-go principle is sound for the entire construction costs, particularly in view of the fact that both the collection system and the treatment plant are designed for populations to be reached from 15 to 35 years from now. There is no real basis in equity for the present user to bear the full construction load for the ultimate user. Even assuming that current annual revenues were much larger than the anticipated ones, it is our judgment that the equities of the financial scheme would be even more seriously disturbed.

It is our belief that a sounder principle of financing would rest upon a bond issue for the greater part of construction and sewer service charges for operation and maintenance.

The fixed charges on the bond issue, aggregating in our estimate approximately \$550,000, should more properly rest at least in part upon the assessed valuation.

Any combination in modification of this proposal might be used. For example, the Columbia Slough undertaking might be carried out by a bond issue, to be followed by additional construction from year to year out of accumulated annual sewer service charge revenues. The procedure, however, would be long and time consuming.

The more reasonable proposal would be to finance the entire intercepting sewer undertaking through a bond issue of approximately \$7,500,000. By the time it is studied, designed and constructed, sufficient money will have accumulated from the sewer service charges to undertake an important portion of the necessary sewage treatment plant. By this process the entire program could be completed no later than 1948. It rests, however, upon a bond issue of the general obligation type, upon sewer service charges for operation and maintenance and upon an increased tax rate for the fixed charges on the construction bond issue. The method is intended to facilitate cleaning up the Willamette River and the Columbia Slough. By any other method this desired result would be postponed a quarter of a century. The citizens of Portland and the Mayor and Council must, of course, decide upon the alternative choice.

RECOMMENDED IMMEDIATE STEPS.

The City of Portland is not provided at this time with a sufficiently authoritative and detailed program of stream pollution correction to warrant the expenditure of funds on any important steps in the construction program. A number of months will be required to place it in such a position of preparedness. Because of this, the Board of Review makes the following suggestions:

1. The City should provide the personnel and equipment sufficient to carry forward investigations on the following important details:

- (a) The determination of flows in all the trunk sewers, with particular reference to minimum rates of flow and maximum rates.

(b) A detailed investigation of the present and ultimate population and industrial densities in each of the main interceptor areas.

(c) An evaluation of present and future population and industrial densities in outlying areas within and without the city limits.

(d) Field and laboratory investigation of the character and quantity of industrial and domestic wastes contiguous to the sewers.

(e) The study of the possibility and practicability of constructing sewers of the separate type in critical areas so as to reduce continuous and recurring pumping charges and to make greater use of high level gravity interceptors.

(f) The investigation of the detailed hydraulics of high level gravity and low level pumping interceptors.

(g) The investigation of the number, location and type of storm water diversion regulators and screens.

(h) The investigation of the existing sewerage system in order to prepare a schedule of replacements of portions of the system, obsolescent either because of physical condition or inadequate size.

(i) A comprehensive study of the engineering design and of the estimates of cost for a sewage treatment plant on the Columbia River.

(j) Adequate borings for interceptor tunnel locations, sites of pumping stations and treatment plant, and river crossings.

The personnel necessary for such an undertaking as outlined above will consist of approximately 40 men, of whom 20 should be individuals of highly specialized hydraulic and sanitary engineering experience. The principal or project engineer herein suggested should be a man of unusual and mature technical experience, equipped to assume complete charge of the investigations and designs, under the general direction of the city engineer. The following staff is suggested for consideration and discussion:

- 1 Principal or Project Engineer
- 3 Field Parties of 4 men each
- 10 Designers and Draftsmen
- 2 Computers of flow and population data
- 5 Subsurface survey men
- 3 Right-of-way men
- 2 Specification men
- 3 Clerks and typists
- 2 Designers - Treatment Plant
- 1 Chemist - Biologist
- 1 Assistant Chemist

Total 34

	Salaries \$ 97,200
3 Consultants and Expenses	10,000
Equipment, materials, rent, transportation, etc.	22,800
Subsurface explorations, borings, etc.	<u>20,000</u>
Grand Total	\$150,000

The work here outlined will take approximately a year and the costs will approach \$150,000.00.

The plan of action for this purpose and the operations thereunder should be currently reviewed and agreed upon by a Board of Consultants, of approximately three men, convened for this important purpose.

2. Following these investigations, the city engineer's office should be provided with sufficient funds to proceed at once with the preparation of detailed engineering plans and specifications, which could be used for advertisement for contract, if and when this latter step is taken. The additional amount of funds for this purpose would be in the neighborhood of \$25,000.

3. The Mayor and Council should request in the immediate future a formal ruling from the State Board of Health, the State Engineer, the State Sanitary Authority, the United States Army, the United States Bureau of Fisheries, and any other local, State or Federal agency having jurisdiction, as to their respective decisions upon the City of Portland's intention to discharge a sewage effluent from a sedimentation treatment plant into the Columbia River

SUMMARY

The Board of Review records the following conclusions and recommendations:

1. The Willamette River during periods of low flow, normally during the summer months, is heavily polluted, unsafe for bathing, unsuitable for recreation purposes and impossible for sustained fish and aquatic life.

2. The City of Portland, through its various sewer outlets and the sewage resulting therefrom, is primarily responsible for this condition.

3. The Willamette River reaches the City limits in none too good condition. It should undoubtedly be relieved of a large part of its domestic and industrial waste load, discharged into it before it reaches the City.

4. The Columbia Slough is in worse condition than the Willamette River.

5. The unsatisfactory conditions on the Willamette and the Columbia Slough can be eliminated almost entirely by collection and by treatment processes. It is recommended that the sewage discharge from all of the outlets on the Willamette River and the Columbia Slough from the City of Portland and its immediate environs be collected and transported to a site in the vicinity of Columbia Slough, there to be treated by sedimentation, and then discharged into the Columbia River through multiple outlets.

6. Such a plan of collection and treatment will eliminate the objectionable conditions already noted and will create no detectable deleterious effects on the Columbia River.

7. The cost of the main intercepting system will be approximately \$7,900,000.

8. The cost of the treatment plant will be approximately \$2,387,000.

9. The cost of pumping, of operation, and of fixed charges will be annually approximately \$794,000.

10. The program should be financed by a general obligation bond issue of approximately \$7,500,000, by a pay-as-you-go revenue from sewer service charges and by an increase in the general tax rate.

11. Approximately \$150,000 should be made available at once for detailed field and office surveys and for design for the proposed program.

ACKNOWLEDGEMENTS

The Board of Review has had the complete and gracious cooperation of all the members of the municipal staff, upon whom it has called for information. It wishes to acknowledge at this point their whole hearted cooperation and support and intelligent participation in review and in revision of the many complicated features of the problem. Although it is impossible to enumerate the names of all who have thus cooperated, the Board does wish to make particular mention of the efforts of the following individuals:

Mayor Joseph K. Carson, Jr.
Commissioner Wm. A. Bowes
Commissioner R. E. Riley
City Engineer Ben S. Morrow
City Health Officer Adolph Weinzirl
City Planning Commission
City Park Department
Dr. Frederick D. Stricker, State Health Officer
Dr. D. B. Charlton
Harlan B. Holmes.

In addition, the Board has held a number of hearings at which complete cooperation has been afforded by a number of persons, who were interested in presenting points of view, programs of actions, and estimates of cost. It is particularly indebted to the following individuals and the groups they represent:

Persons who appeared before the Board:

O. R. Bean
R. E. Koon
R. G. Dieck
J. W. Cunningham
John H. Lewis
A. C. Forrester
F. W. McQueen
F. W. Allen
W. W. Wolff)
Arthur Day) Federation of Community Clubs
Paul Sayre)
Dr. V. M. Wirtz)
F. E. Coulter
Mrs. Louise Palmer Webber
Monroe Sweetland

The efficient and intelligent handling of the general typing and preparation of this document by Mrs. Ruth Hannaford, should not go unmentioned. She has saved the Board of Review a great many hours of preparation of material by her successful and prompt handling of the body of the report.

Respectfully submitted,

R. H. COREY

WELLINGTON DONALDSON

CARL E. GREEN

ABEL WOLMAN

