REPORT ON PROPOSED IMPROVEMENT AND EXTENSION OF HEMLOCK LAKE WATER SUPPLY SYSTEM, ROCHESTER, NY

BY

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INDEX

INTRODUCTION

The writer was engaged in August 1942 to investigate and report to the City Manager and Council in relation to various matters in connection with the Rochester water supply. All of these matters are directed toward putting the present supply in first-class condition and developing its resources to the fullest extent to meet both existing wartime demands and as far as practicable to provide for future water requirements of the City.

It was recognized that the work must be planned in such a manner that it could be carried out step by step under war conditions, without requiring either an excessive use of critical war materials or involving demands for labor and equipment at any one time beyond those available under the restrictions imposed by war conditions.

This report presents a plan for improvement and extension of the Hemlock water system not only to meet present requirements but capable of extension to meet future requirements up to 50 mgd. This plan may be considered as comprising:

1. The present project or First stage.
2. The future program, including the second and third stages of the general plan.

The present project or First stage of the general plan, and which is intended for immediate construction, has the following characteristics:

1. It utilizes only water from areas now partially utilized but utilizes the yield of these areas to the fullest possible extent.
2. The characteristics and hardness of the water will remain substantially unchanged, as it will be water from the same sources now utilized.
3. Construction of the present project substantially as planned is desirable if Hemlock Lake system is to be retained for future use, and is essential to any future economic development of a water supply program for Rochester.
4. The construction of the present project will provide a total dependable water supply of 40 mgd. This is enough for present needs under war conditions and for a period economic readjustment following the war. Post-war conditions and requirements cannot now be accurately seen.

It is always desirable for a city such as Rochester to have a dependable water supply developed and available considerably and in excess of its current requirements.

The present sources of supply used in the manner subsequently outlined can be developed to provide a dependable supply of about 40 mgd. This is not sufficiently in excess of present water consumption to adequately provide for future requirements for any long period of time. Study has therefore been given to the possibility of bringing additional water from adjacent areas into Hemlock Lake to augment the supply, and a project has been formulated, as subsequently described, which will provide an ultimate supply of 50 mgd.

THE PRESENT WATER SUPPLY SYSTEM

The Hemlock Lake water supply system has been in use for 68 years. Originally built to supply 7,5000,000 gallons of water per day, increased conduit capacity and the raising of the Hemlock Lake dam in 1927 has supplied Rochester with adequate and excellent water up to the present time.

The original cost of the system was low, measured in terms of accepted standards, and the City of Rochester has been exceedingly fortunate in having so excellent a water supply available at so low a cost over such a long period of time. This low cost of water has, however, been to some extent subject to the penalty of deferred maintenance and expansion.

Waterworks structures, such as dams and conduits, are relatively permanent, yet they are subject to gradual deterioration. It is impracticable to maintain such structures, particularly those underground, in strictly first-class condition at all times. The alternative is to permit deferred maintenance to occur until some condition arises which either permits or requires major repairs or replacement of structures, the most usual occasion for such repair or replacement being the need for increased supply. One essential feature of this investigation has been to determine the condition of the existing structures and their suitability for continued or future use.

The present Hemlock Lake system as it stands now, with relatively minor repairs, has heretofore been estimated to be capable of yielding a dependable supply of 31 mgd, and with new construction to provide for the complete regulation of Canadice Lake, it has been estimated that a supply of 34.5 mgd can be obtained. There would still be a considerable quantity of water wasted from the drainage basin of Hemlock Lake because the storage in the lake as now developed is inadequate to impound and regulate all of the runoff from the tributary area at the time it occurs.

With the exception of 1890, when a water shortage occurred in Rochester resulting from the fact that the then conduit capacity was less than the demand, the present Hemlock Lake system, with some purchased water, has supplied Rochester with adequate water from 1876 to the present time. There were threatened water shortages in 1930, 1934-1935, and 1941-1942, indicating that the present supply is inadequate to meet either increased demand or more severe droughts than those of recent years.

The water consumption in Rochester during the five pre-war years, 1935-1939 and subsequent years compares as follows, in million gallons per day a), including purchased water, if any.

mgd

1935	27.66
1936	27.82
1937	26.57
1938	25.88
1939	28.84
Average, 1935-1939	27.35
1940	30.02
1941	31.40
1942	32.80
1943 (to end of Nov.)	34.16

The water consumption increased progressively in 1940-1942, and in 1942 it was 5.45 mgd or 20% greater than the 5-year average, 1935-1939.

The average water consumption for the four war years 1940 to 1943 was 32.10 mgd or 2 mgd in excess of the dependable supply from the present sources as now developed, and within 2 mgd of the heretofore estimated dependable supply from the present sources with increased storage in Canadice Lake. Records of the City Water Department show that increased water consumption during the past four years has been chiefly due to increase of industrial use under war conditions.

The question may naturally be asked whether normal conditions will not be restored after the present war and the water consumption then drop back to 28 or 30 mgd, making necessary only the provision of a temporary increase of supply.

Water consumption, unlike most things, tends to go up more easily than it goes down. This is especially true in a city like Rochester, where in the past the per capita water consumption has been below the average in cities of corresponding size, in spite of the high rank of Rochester as an industrial center. Furthermore, water consumption tends to increase as the distribution system grows older. Some increase of normal per capita water consumption in Rochester in the future is therefore to be expected for various reasons.

Rochester industries must be permitted to continue their normal growth after the war. Rochester presents a somewhat unusual situation because of the restriction of its boundaries by adjacent incorporated suburbs and the present highly developed state of its industries. The desideratum of expansion is increased production.

This can be obtained by either enlarging the plants at their present sites when needed or in the same manner as now, i.e., by plant operation with more than one daily shift of labor.

Barring the effect of financial depressions, only a partial rather than a complete return to normal pre-war water consumption can reasonably be presumed for post-war conditions. Some definite, permanent steps to increase the water supply for post-war conditions should be taken, and means provided to meet war demands should as far as practicable fit in with a longer range water supply program.

Some of the structures connected with the present Hemlock water system require either renewal, replacement or repair if they are to continue much longer in service. This results partly from increased water demands and enhanced conditions as compared with those existing when the structures were built, and in part from deferred maintenance.

Additional flexibility is needed to provide alternative methods of operation in case of emergency. This is particularly true of the 6-foot diameter brick supply tunnel, built in 1893, leading from Gatehouse No. 2 at Hemlock Lake to Overflow No. 1, 1 ½ miles to the north, at which point it supplies conduits II and III. Increased storage is also needed to better regulate and more completely utilize the available yield of the tributary drainage areas.

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a) Corrected for meter under-registration.

LEAKAGE, DIVERSION AND WASTE FROM PRESENT HEMLOCK SYSTEM

The dependable yield of the present Hemlock system has previously been estimated at 31 mgd, assuming, however, that the entire Hemlock Lake drainage area of 48.0 square miles is tributary to the lake and that no leakage losses occur.

There is a stream, Yohon Creek, at the head or south end of the drainage basin of Springwater Creek near Wayland, draining an area of 2.20 square miles, shown on the U.S. Geological Survey map as tributary to Springwater Creek and thence to Hemlock Lake. This stream has been diverted at a point just north of the village of Wayland at some time in the past and its runoff now passes into Canaseraga Creek. The runoff from this area is over 1 mgd.

There is also a not inconsiderable amount of leakage or seepage through the present Hemlock Lake dam, particularly near the west end of the dam.

In 1913, a diversion dam was constructed on Canadice Outlet at the location of the former Beam mill dam, together with a 5-foot (inside) diameter diversion conduit, 3,800 feet long, leading from the intake dam to an inlet weir in Hemlock Lake. The conduit is of reinforced concrete, with 9-inch wall thickness, and throughout a portion of its length the invert is below the normal level of Hemlock Lake. Under certain conditions water can flow back from Hemlock Lake into the conduit. According to the record plans of the conduit, poor foundation material was encountered in places, particularly about 300 feet from Hemlock Lake, where peat and other woody material occurred at the bottom of the trench and hand-mixed concrete was used.

This conduit was not put into use until 1919 and apparently has been entered and some repairs made to leaky joints on one occasion.

In August 1942, the writer noticed that the soil was saturated and water standing on the ground on the conduit route about 300 feet from Hemlock Lake, where the poor foundation material was encountered. Following up the conduit another location was found where the grass was killed and the soil surface washed, and the writer was informed that earlier in the season, when the water in Hemlock Lake was higher, water had flowed out above the conduit and flowed over the ground until it was absorbed at a little distance from the conduit. On a later visit, with Hemlock Lake at a lower level saturation of the soil at sta. 35.00, nearest Hemlock Lake, had disappeared. Similar conditions occurred in 1943.

The 36-inch section of conduit I from Hemlock dam to air valve no. 45 was abandoned in 1934 and the conduit blocked off at the dam and also just north of Hemlock village. About 100 feet south of the highway at Hemlock village, a large stream of clear water was found entering Hemlock Outlet from the east and excavation showed that it came from the rock trench in which Conduit 1 is laid. It appears that considerable leakage takes place from the Canadice diversion conduit under two conditions:

1. As a result of back-water and upward pressure from Hemlock Lake, particularly when Hemlock Lake is at a high level, and only at times when Hemlock Lake is above the lip of the inlet weir of the Canadice diversion conduit, elevation 392.00. The leakage occurs mostly near the Hemlock Lake end of the conduit and is mostly Hemlock Lake water.

2. Much larger leakage occurs for shorter intervals near the head of the diversion conduit at times when diversion from Canadice Outlet is taking place and the conduit is flowing full, and particularly if Hemlock Lake is than at a high level. This water is mostly Canadice Lake water. The abandoned portion of Conduit I crosses underneath the Canadice diversion conduit not far from the point where the heaviest leakage occurs. This abandoned portion of Conduit I apparently contains numerous openings through the pipe walls or joints and acts as an interception gallery, so that a considerable part of the leakage from the Canadice diversion conduit enters Conduit I and is carried downstream to Hemlock village, where the flow is blocked off and the grade of the conduit creates a sufficient pressure to force the water out of leaks in Conduit I and it enters

Hemlock Outlet. Because of its variability and the fact that Hemlock Outlet also receives a certain amount of ground-water, a precise determination of the amount of this leakage loss, which has certainly taken place since 1934, has not been made. It is, however, that the total loss of water from Yohon Creek diversion and from leakages as above described has averages at least 2 mgd running back at least to 1935 and part of it much longer. As a check on this estimate a balance-sheet for the present Hemlock Lake system for the 10-year period 1933-1942, has been made up as follows:

WATER BALANCE, PRESENT HEMLOCK SYSTEM, 1933-1942

Water used, from corrected meter discharge............	29.97
Wasted at Canadice intake spillway	2.30
Wasted at Hemlock Lake spillway............................	1.74
Gain of storage	0.60
Leakage, (Canadice conduit) and diversion	2.00
Total	36.61
Total computed yield	36.66

The last two figures giving totals were made up independently from different data, the last being from the runoff records of Canadice weir and Conesus Lake and the rainfall and evaporation records on the different areas. These figures show an average of 2.0 mgd yield of the drainage basins which is unaccounted for excepting as leakage and as a result of Yohon Creek diversion.

The figures in the preceding table show an average waste from Hemlock Lake spillway for the ten-year period, 1933-1942, of 1.74 mgd and from Canadice intake spillway a waste of 2.30 mgd, or a total waste of roundly 4.00 mgd. This waste is in addition to the leakage and diversion losses and results from inadequate storage. Part of the water wasted from Hemlock Lake is water previously brought in from Canadice Lake and Outlet but which could not be retained because of inadequate storage.

Owing to heavy rainfall in the winter and spring of 1942-1943 the runoff from the drainage areas tributary to Hemlock and Canadice Lakes was unusually large. Because of increased water demands, minor repairs were made to both Hemlock Lake and Canadice Lake dams to permit water to be impounded and held at somewhat higher levels than previously. In spite of this increased storage and in spite of increased use of water, the runoff was so great that a large amount of unavoidable waste occurred at both Hemlock Lake and Canadice intake. The figures for individual months, in millions of gallons of water wasted, are shown in the subjoined table.

Waste over spillways during winter and spring of 1943

Month	Rainfall at Hemlock	Waste over spillways Hemlock Lake	Canadice Lake	Total
(1)	(2)	(3)	(4)	(5)
	inches	mill. gals.	mill. galls.	mill. galls.
Dec. 1942	4.15	181.04	- -	181.04
Jan. 1943	1.65	1,103.15	488.26	1,591.41
Feb. 1943	1.42	312.48	426.51	738.99
Mar. 1943	2.23	69.52	159.94	229.46
Apr. 1943	4.53	1,638.46	537.92	2,176.38
May 1943	5.91	2,474.53	1,352.76	3,827.29
June 1943	3.14	295.93	238.11	534.04
Total	23.03	6,075.11	3,203.50	9,278.61

The total amount of waste in the winter and spring of 1942-43 was 9,278 million gallons. This, with present average use of 35 mgd, would, if it could have been impounded, supply the entire requirements of the City for 265 days. These figures strongly emphasize the need for additional storage in order to develop the full water-yielding capabilities of the present system.

The item of 2 mgd leakage and diversion would be wholly eliminated in conjunction with the project described in this report. The area at the head of Springwater Creek, the runoff from which is now diverted into Canaseraga Creek, would be restored to Springwater Creek, the present Hemlock Lake dam would be replaced by the new dam near Hemlock village, on a better foundation, and the use of the Canadice intake and diversion conduit would be discontinued inasmuch as it would no longer be needed, since the entire yield of the Canadice Lake and Canadice Outlet drainage basin would flow directly into the lower basin of the new reservoir.

PRESENT OUTLINE OF PROJECT

The surveys and investigations have resulted in the formulation of a project which retains the present Hemlock system and provides increased storage and tributary drainage area sufficient to maintain a dependable supply of at least 50 mgd.

The project contains various items which have hereto been considered separately but the result differs from that of previous studies by bringing together all of the salient points requiring consideration in a single coordinated project, fitted into the existing Hemlock supply system. Such a program is necessary at this time since some steps must be taken immediately to relieve the situation created by war conditions, and the steps to be taken depend to a considerable degree on the longer range project to be adopted.

The investigations have been carried far enough so that the controlling features of the main project for increased supply can be definitely outlined. Field surveys are still in progress and much further work is required before detailed plans can be prepared for some of the structures required. In particular, consideration of the question of relining or replacement of Conduit II must be deferred until the relining of Conduit I (now in progress) and other conditions permit un-watering of Conduit II section by section.

Various figures given in this report, particularly as to elevations, flow lines etc., are derived from existing maps and reports, and while believed to be substantially correct, they are subject to revision upon completion of field surveys and detailed studies.

For purposes of comparison a brief outline of salient features of some other projects heretofore considered is given later.

The main features of the project are shown on Figs. 1 and 2.
F1,2)

Referring to fig.1, a new dam would be constructed about one-quarter mile upstream from the highway crossing Hemlock Lake Outlet at the village of Hemlock. This dam would have a fixed spillway at crest elevation 403.00 and would provide additional storage in two ways:

1. By increasing the depth of flowage in Hemlock Lake from elevation 397.5, the present maximum, to 403.00.

2. By creating an additional storage basin, designated the "Lower Basin," between the present Hemlock Lake and the new dam. This would provide about 1.53 billion gallons additional storage.

The present Hemlock Lake dam would be raised and retained as a partition wall between Hemlock Lake proper and the lower basin, so that water could if desired be drawn from either basin.

The present Gatehouse No. 2 at Hemlock Lake would be retained, together with the 6-foot diameter brick main supply tunnel leading therefrom to overflow No. 1.

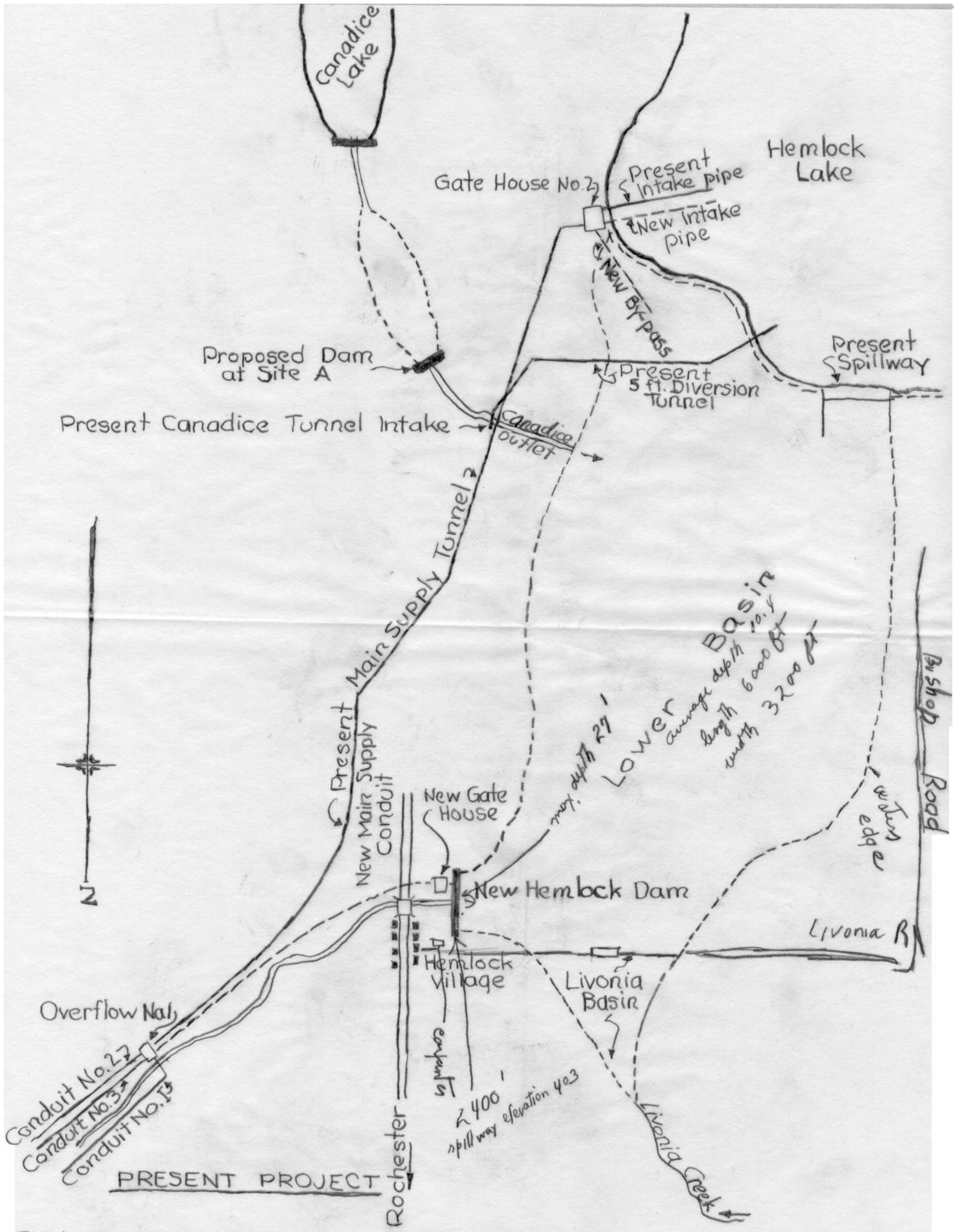


FIG.1 - PRESENT AND PROPOSED STRUCTURES—HEMLOCK LAKE WATER SUPPLY
ROBERT E. HORTON, Consulting Engineer

In addition, a new Gatehouse would be constructed at the new dam and a new main supply conduit would be built therefrom to Overflow No. 1, providing increased flexibility of supply to the present and future conduits leading from Overflow No. 1 to the City. The new main supply conduit would have a capacity to deliver about 65 mgd at Overflow No. 1. The supply could be drawn through either main supply conduit as long as the demand did not exceed 40 mgd. The new supply conduit would have a capacity to take care of fluctuations in demand, with an ultimate water consumption of 45 mgd.

Detailed topographical surveys have been made of the site of the lower basin and topographic surveys and underground explorations have been made at the dam site. The higher portion of the dam and the foundation of the new gatehouse would be on rock and a fixed spillway would be provided of sufficient length to avoid the use of manually controlled stop-logs or flashboards. The increased storage provided by the new dam would be used in part to impound waters now wasted and thereby increase the supply from the present Hemlock drainage basin. It would be used to provide regulation for additional water brought in from adjacent areas.

Excluding Canadice Outlet, there is a natural drainage area of 9.25 square miles tributary to Hemlock Outlet between Hemlock Lake and the proposed new dam and this additional area would become directly tributary to the lower basin.

Canadice Lake dam would be reconstructed and a new fixed spillway provided at the west end, avoiding manual operation during floods. The flow line would be raised 3 feet or from elevation 1096.00 (USGS) to elevation 1099.00 (USGS).

Provision would also be made to draw Canadice Lake down to elevation 1081.00 (USGS), providing a total storage draft of 18 feet as compared with the present use of 6 feet of storage in Canadice Lake. This would provide complete regulation of the runoff from 12.6 square miles of area tributary to Canadice Lake and avoid the use of storage in Hemlock Lake to regulate Canadice Lake yield, as has been done heretofore.

Outflow from Canadice Lake would flow down from Canadice Outlet into the lower basin of Hemlock Reservoir. Use of the present diversion dam and conduit leading from the diversion weir at Beams dam on Canadice Outlet to Hemlock Lake would be discontinued. These are the only structures appurtenant to the present Hemlock system which would not serve a useful purpose in conjunction with the enlarged Hemlock supply system.

Regulation of the runoff of the 5.8 square miles of area tributary to Canadice Outlet below Canadice Lake would be accomplished at present through the use of part of the additional storage provided by the lower Hemlock basin.

STRUCTURES APPURTENANT TO PRESENT PROJECT

ITEM 1 - CANADICE LAKE DAM

This is a low earth dam without corswall, and, aside from minor items of depreciation and the growth of trees on the easterly portion of the embankment, the structure is in good condition.

The top elevation of the embankment is 1100.00 (USGS) and in 1936-37 a new spillway was constructed, 24 feet long with stop-logs and by-pass, permitting the lake level to be regulated between 1096.00 and 1090.00 (USGS). Floods have been controlled in the past chiefly by impounding the water in Canadice Lake, with manual operation of the stop-logs during floods. The 40-year record of lake levels and outflow kept by the City shows that it is necessary to provide for a flood runoff equivalent to 5 feet depth on the lake, with a maximum inflow rate of 2400 cfs, with the reservoir initially full. Heavy floods occur usually in late fall or in the spring months, more commonly the latter, after the reservoir has been filled. The flood requirements can be met by construction of a new spillway with 100-foot crest length at the west end of the present dam, where better foundation conditions are available than in the valley bottom. The combined spillways will take care of a flood such as described, with a rise in the lake of less than 2 feet above spillway crest and without removing the manually controlled stop-logs in the present spillway.

To provide increased storage the new spillway crest would be at elevation 1099.00 (USGS) and the present spillway would be raised from elevation 1096.00 to 1099.00 (USGS), the embankment would be raised to top elevation 1105.00 (USGS), with side slopes 1 on 2.5 and 1 on 3 on the land and water sides, respectively, and with top width 12 feet, the top being used as a roadway from the east to the spillway.

Surveys, borings and plans for the main features of the work have been completed. Reconstruction of Canadice dam requires practically no metal or defense material, as it will be constructed wholly of earth, cement and stone.

The City now has the right to regulate water levels in Canadice Lake between any desirable limits, and owns the land on which the reconstruction would take place. There is certain preliminary work which can be carried out this fall and winter, including clearing of lands to be flooded at the head of the lake, certain highway improvements and acquisition of cottages adjoining the head of the lake. The construction of the dam could then be carried out in 1944.

Raising the Canadice dam to flow line elevation 1099.00 (USGS) will provide 740 million gallons of additional storage and will provide a total of 2,000 million gallons storage which can be drawn by gravity through the present outlets in the dam.

To completely regulate Canadice Lake and avoid waste of water requires a much large volume of storage and greater depth of draft. To obtain this additional storage will require provision for drawing Canadice Lake down to elevation 1080.5 (USGS) or 9.5 feet below the present minimum draft level. This additional storage can be obtained either by low-lift pumping from the lake into the present Canadice Lake channel below the dam or by the construction of a new low-level outlet, which will permit this additional storage to be drawn by gravity. The flat bottom of Canadice valley is at elevation 1091.00 (USGS) just below the dam and slopes gradually to 1080.3 near the Canadice town line, 8,000 feet to the north. Provision for drawing the lake to the required level by gravity could be made either by construction of an open channel or a concrete conduit throughout this length or by construction of an open channel for emergency use during the war period, to be followed later by laying of a conduit in the channel as a post-war project. Neither of these two methods would require defense material and most of the land through which the drain conduit would be laid is now owned by the City. In either case a diversion conduit would be constructed from deep water in Canadice Lake, around the east or right-hand end of the dam (looking downstream), leading into the new drain channel or conduit. Surveys have been made and underground explorations are in progress along the route of this proposed conduit and it is intended to complete plans so that provision for complete regulation of Canadice Lake can be made at the same time that the reconstruction of the dam is carried out. This increased use of Canadice Lake storage will provide an increase of available supply of roundly 2.3 mgd.

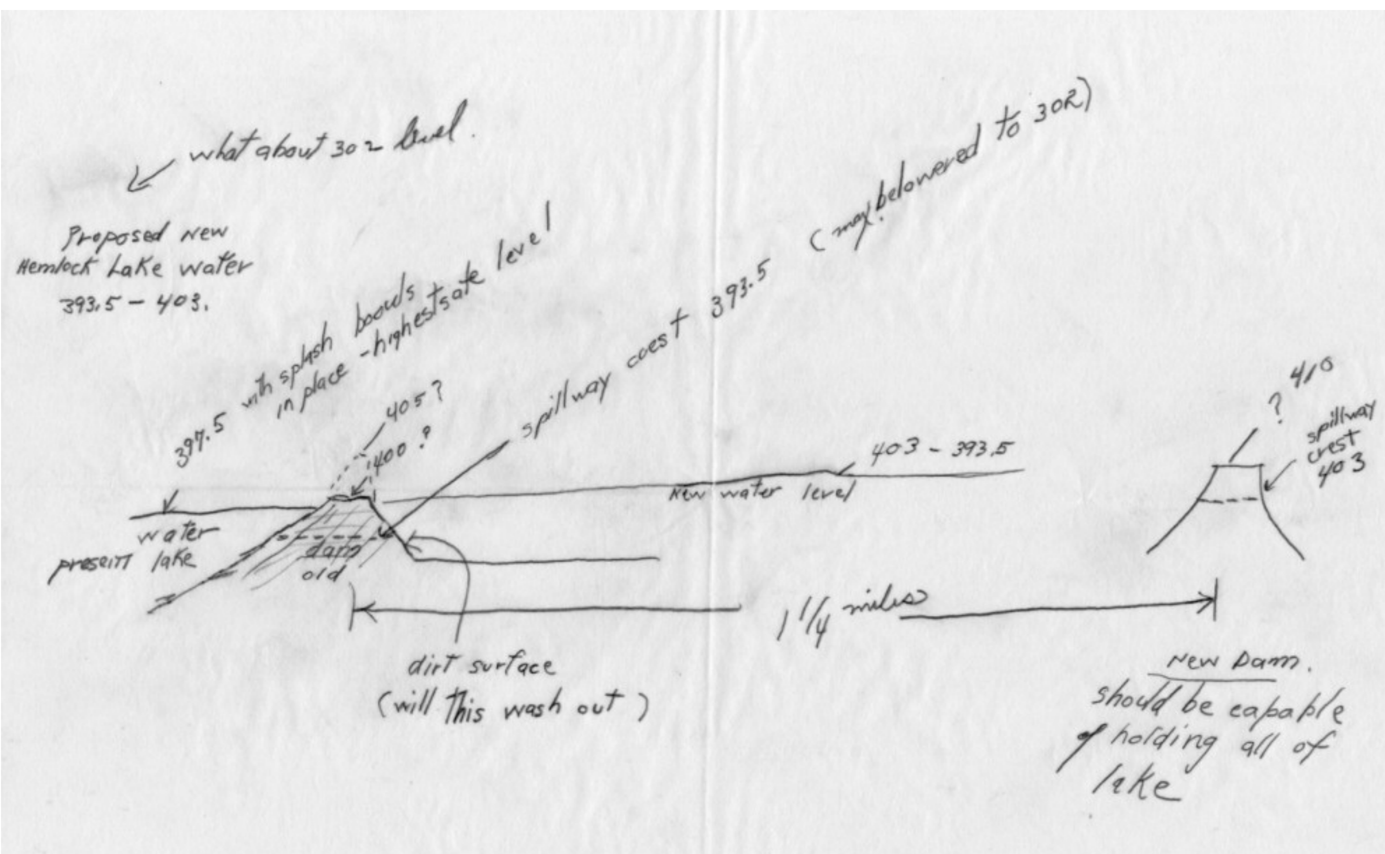
Pending construction of the new Hemlock dam, water derived from Canadice Lake and Outlet must be diverted into Hemlock Lake through the present Canadice intake and diversion conduit. Recently the lip of the Canadice Outlet conduit in Hemlock Lake was raised and gates provided to prevent back-flow from Hemlock Lake into the conduit and reduce loss by leakage. These gates will also permit the conduit and making temporary repairs. In addition, they will prevent the loss of a large volume of storage from Hemlock Lake which would occur in the event of a break or blow-out of the roof of the conduit.

ITEM 2 - NEW HEMLOCK DAM AND LOWER BASIN

The new Hemlock Reservoir will be formed and controlled by the dam located one-fourth mile upstream from the village of Hemlock. The dam will have a fixed spillway at elevation 403.00, with a crest length of at least 300 feet. The overall length of the dam will be 2,400 feet. The dam will consist of heavy earth embankment with a reinforced concrete core wall extending from the top down either to rock or to a depth below the natural ground surface at least equal to the depth of water at the same location, thus insuring water-tightness.

The natural stream bed at the location of the dam is at elevation 378.00 and 376.00 at the sight of old Hoppaugh dam. The maximum height of dam from stream bed to top of embankment would be 30 feet. This is a relatively small dam and would be constructed of earth, cement and stone, and it would require no considerable amount of defense material of any kind, the principal items being steel for the core wall etc., and the valves and pipe fittings in the Gatehouse.

The reservoir formed by this dam will comprise two basins, the lower basin extending from the new dam to the present Hemlock Lake dam, the upper basin covering Hemlock Lake as at present but with normal flow line from elevation 397.5 to elevation 403.00.



The spillway weir crest at the present Hemlock Lake dam is at elevation 393.5. The drop timbers in the spillway would be removed and the present Hemlock Lake dam retained, but with water at elevation between 393.5 and 403.00, water would stand at the same elevation above and below the dam, and the present spillway would no longer be used as a spillway but merely as an outlet channel.

The elevation of Hemlock Lake Outlet just downstream from the present spillway is 386.00 and the elevation of the floor of the apron of the spillway is 386.8. With the water drawn below elevation 393.5 the upper and lower basins of the reservoir would be separated and they could of course be kept entirely separate at any time by replacing the drop timbers in the spillway. With present Gatehouse No. 2 retained and in operation, the lake could be drawn down to 381.0.

With water in the present lake at elevation 393.5 or lower, there would be a slight difference of elevation of water in the two basins of the reservoir. The lower basin reservoir would be nearly rectangular in form and would have an area at elevation 403.0 of 450 acres or 0.7 square mile, and a useable volume between elevation 403.0 and 381.0 of 1530 mg. The maximum depth of the reservoir at the dam site would be 27 feet, (leaving 3 feet to top of dam) its average depth of 10.4 feet, its length 6,000 feet or 1.14 miles and its average width 3,200 feet. It is therefore, considered by itself, neither a small nor a shallow reservoir.

Under normal operating conditions, drawing the entire supply from the Gatehouse at the new dam, a large portion of the water used would come from Hemlock Lake and would flow down through the lower basin of the reservoir, thus maintaining continuous circulation. With, for example, a draft of 40 mgd, and without bringing in other areas, the part of supply drawn, respectively, from the upper and lower basins of the reservoir would be approximately or 27 mgd from Hemlock Lake through the lower reservoir and or 13 mgd directly from the lower reservoir. The proportions drawn from the upper and lower basins of the reservoir will be little changed when the Calabogue and Cohocton areas are brought in.

The bottom of the lower basin reservoir, between Hemlock village and Hemlock Lake, is mostly clean cultivated soil, with areas of timber and low ground along the stream. The trees and stumps would be removed and the vegetal matter, roots, humus etc. remaining in the ground on these areas would be covered with a layer of clean mineral soil taken from the new channel or elsewhere within the reservoir basin.

Some organic matter of vegetal origin invariably remains in the bottom of such a reservoir when first put in use. This material is changed chemically and gradually absorbed by the water when the reservoir is first put into use and may produce color, odor and taste for a time if the water is allowed to remain too long in the bottom of the reservoir. This is a condition common to new reservoirs created by flooding lands and would also occur if the City went to some other stream instead of building a new dam at Hemlock. The occurrence of water of poor quality in the bottom of a reservoir is related to the depth of the reservoir and this condition is much more aggravated in deep reservoirs than in reservoirs of moderate depths, such as that proposed at Hemlock, where circulation of air, oxygen and sunlight can penetrate nearly to the bottom of the reservoir. There is nearly an ideal depth of reservoir, ranging from 25 to 35 feet, depending on conditions. The occurrence of undesirable water in the bottom of a new reservoir is not a dangerous condition. In this case, there is a simple remedy. During the first few years of operation of the project there would be an excess of available supply over water requirements of Rochester. Instead of wasting this excess over the spillway it should be drawn from the bottom of the reservoir at periodic intervals. In the meantime, water used from the Lower Basin should be drawn from near the surface and suitable intake openings at two or more levels in the gatehouse would be provided for this purpose. This practice has been used elsewhere with satisfactory results during the first few years of operation of a new reservoir while the bottom is undergoing a curing process.

The new dam would be upstream from the village of Hemlock. A portion of the lands flooded by the Lower Basin, comprising those within the flow line of the old Hoppaugh mill dam, are now owned by the City. No first-class highways would be interfered with. About one half-mile of second-class highway now running to the foot of Hemlock Lake would require abandonment or relocation. Livonia Creek would enter the Lower Basin from the west and a low portion of the highway along the west side of the Lower Basin would be raised and used as a dike to form a settling basin for the waters of Livonia Creek. A drain from this basin to a point on Hemlock Lake outlet below the new dam would permit low water flow from Livonia Creek to be discharged into Hemlock Lake Outlet. A spur of the Lehigh

R.R. leading to the canning factory at Hemlock would require relocation if continued in use, the relocated length being about three-fourths mile.

ITEM 3 - PRESENT HEMLOCK LAKE DAM

The original Hemlock Lake dam was completed in 1875 and was constructed over and on the site of a preexisting timber mill dam and embankment, with the crest of the dike or embankment at elevation 390.0 (898.3 USGS).

The following quotations are taken from the Annual Reports, Division of Engineering, Rochester 1928-1936, (p.69).

"Plans for increased storage in Hemlock Lake were first put in effect in 1909 by the construction of a concrete spillway having four openings each six feet wide. The crest of spillway was built to elevation 393.5' (H. D.). The construction of this original spillway was followed in 1913 by the raising of the dyke to elevation 395' (H. D.).

In November 1927, the dyke was again raised an additional five feet to elevation 400' (H. D.). A concrete spillway, similar in construction to the old one and having the same number of width of openings was constructed in the same location and on top of the old spillway. The new crest of the spillway was built to elevation 394.5' (H. D.) With flashboards provided for raising the water level in Hemlock Lake to a safe maximum storage elevation of 397' (H. D.)."

In 1936, a new spillway was constructed at the location of the old natural outlet of the lake, about 220 feet to the west of the existing channel.

"The new structure consists of a concrete spillway of the ogee type having eight openings, each with a clear width of eight feet, a total width of 64 feet. The spillway crest is at elevation 393.5' (H. D.) (901.8' USGS)."

"....... The whole structure, excepting the concrete floor of the channel, is built on timber piles ranging length from 40 to 60 feet. A cutoff wall consisting of sheet metal piling was driven under the main spillway wall and a steel toe wall driven under the downstream end of the concrete channel."

The construction of the new spillway the remains of the original mill dam were encountered in driving piling. There had been a slight settlement of the new spillway and it has not been considered safe to maintain the water at higher elevations than 397.0 to 397.5. The trouble is with the foundation rather than the superstructure and cannot certainly be easily remedied by repairs to the latter. The spillway is not automatic in operation but requires manual operation of the steel flashboards. The length and capacity of the spillway are less than is desirable.

The embankment constructed of earth and, so far as known, without any core wall or cutoff wall of any kind excepting at the spillway.

With the new dam at Hemlock village the water would stand at nearly the same elevation upstream as downstream from the present dam at all high stages of the stream and no question of safety would arise. The drop timbers will be removed from the spillway and the present Hemlock Lake spillway will operate as a discharge channel rather than a spillway. The crest of the earth embankment will be raised and paved on the water slopes to prevent over-wash by waves.

The spillway at the present Hemlock Lake dam has 8 bays, each 8 feet wide, separated by 2-foot piers, with a fixed crest at elevation 393.5. Stop-logs are kept in place in the spillway bays, usually to elevation 397.5 in the two end bays, and are manually operated as required during floods, in the six intermediate bays. With present maximum flow line 397.5 this spillway has a capacity of about 1800 cfs if all stop-logs were removed.

In comparison, it is proposed to provide a fixed spillway at Hemlock Lake in connection with the new project which will automatically take care of the maximum flood from the drainage area with a maximum outflow depth of about 3.5 feet above spillway crest level.

The spillway at the present Hemlock Lake dam will be used solely as a connecting channel between the upper and lower basins of the reservoir. Removing the stop-logs and lowering the fixed crest to elevation to 392.0 will provide a channel section of 704 feet square feet below elevation403.0. This will be capable of discharging a flow of 7,000 cfs at a permissible velocity of 10 feet per second with a head loss or drop of level between the two reservoir basins of about 2 feet.

Consideration was given to the construction of a new dam to flow line elevation 403.0 immediately downstream from the present dam. Because of the character of the foundation this would require a deep cut-off wall, preferably of steel sheet piling, which is not at present available. A new dam can be constructed at the site chosen near Hemlock, with better foundation conditions and at less cost and without the use of steel sheet piling. A dam at this location will also provide much needed additional drainage area and storage and greater flexibility of operation, by providing two storage basins, from either or which the supply can be drawn.

ITEM 4 - NEW GATEHOUSE AND MAIN SUPPLY CONDUIT

A new gatehouse, designated Gatehouse No. 3, on rock foundation, would be constructed at the new Hemlock Lake dam, together with a new supply conduit, about 5,500 feet in length, leading to Overflow No. 1. The length of the present 6-foot brick tunnel from Gatehouse No. 2 to Overflow No. 1 is 11,892 feet. Because of the shorter length, with water in the reservoir at the same elevation, the new main supply conduit, if of the same diameter, would deliver both a greater quantity of water at Overflow No. 1 and deliver it at a higher elevation.

Under present conditions it is necessary to pump water under a low head from Overflow No. 1 to feed to feed the restored portion of Conduit No. 1 to Rush Reservoir. This pumping is necessitated by the fact that the present brick tunnel does not deliver water at Overflow No. 1 at a sufficiently high level. This condition would be remedied upon completion of the new main supply conduit to Overflow No. 1. This conduit would enter a concrete standpipe located adjacent to the present building at Overflow No. 1, with outlets arranged so that the present

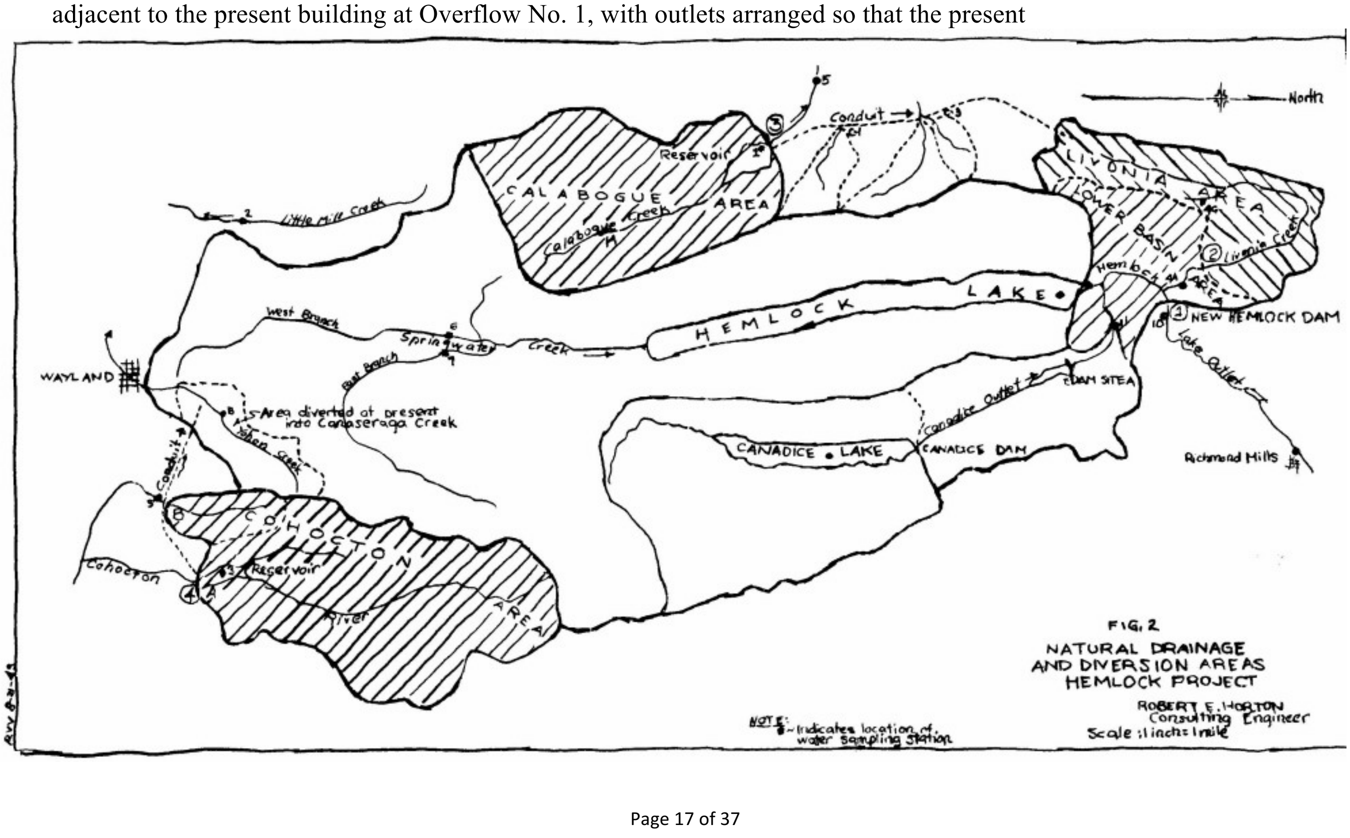


FIG. 2
NATURAL DRAINAGE AND DIVERSION AREAS
HEMLOCK PROJECT
ROBERT E. HORTON
Consulting Engineer
Scale: 1 inch = 1 mile

Conduits Nos. 2 and 3 could be fed either as at present from the 6-foot brick tunnel or from the new supply tunnel, while Conduit No. 1 and any future additional conduit constructed to convey water to the City would be fed ordinarily from the new supply tunnel but could be fed from the present 6-foot brick tunnel. This would provide increased flexibility of supply and would make it possible to continue the supply with the present 6-foot tunnel shut off for inspection or repairs.

The new main supply conduit would have a capacity of about 65 mgd, adequate to take care of fluctuations in demand as well as to maintain a continuous supply of 50 mgd. The present brick tunnel has a capacity to deliver 40 mgd at Overflow No. 1.

The construction of the gatehouse and new main supply conduit to Overflow No.1 could be carried out either in conjunction with or immediately following the construction of the new dam, while the reservoir is being filled. Upon completion of the new dam and main supply conduit, together with the complete regulation of Canadice Lake, the Hemlock system would provide a minimum dependable supply of 40 mgd, made up as follows:

From regulated Canadice Lake …...........	7.5 mgd
From the new Hemlock Reservoir	32.5 mgd
Total	40.0 mgd

These figures include the additional supply obtained from the restoration of the head-water tributary of Springwater Creek to the Hemlock Lake drainage basin, but not the Calabogue and Cohocton areas.

THE GENERAL PLAN

The above description comprises only work to be done in connection with the present project or first stage of the general plan. More detailed descriptions of the principal structures are given later.

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The general plan comprises also the bringing of water into the new Hemlock Reservoir from (1) Calabogue Creek - Second stage, and (2) Cohocton River, third stage, as subsequently described.

Data relative to drainage areas, storage and yield, both for the present project and the Second and Third stages of the general plan, are given in connection with the discussion of the Second and Third stages.

The location of the additional areas which would be made tributary to the Hemlock system are shown cross-sectioned on Figure 2. These include Calabogue Creek, Cohocton River Livonia Creek and other areas naturally tributary to Hemlock Outlet north of the present Hemlock Lake. Approximate locations of diversion conduits are shown by dotted lines.

Calabogue Creek lies west of Hemlock Lake and is naturally tributary to Conesus Lake. Its drainage basin contains an abandoned fingerlake bed, similar to that of Hemlock and Canadice Lakes but at a sufficiently high elevation so that water from this stream can be brought into the lower Hemlock basin by a gravity diversion conduit, which would convey the water into Livonia Creek drainage basin, from which it would flow naturally into the basin of the Hemlock Reservoir. A storage dam would be constructed on rock foundation at the north end of the Calabogue diversion area.

Aside from the main diversion area f 9.38 square miles on Calabogue Creek there are three additional small areas lying west of the Hemlock drainage basin, designated C-1, C-2 and C-3 on Fig. 2, from which water could be diverted into the Calabogue diversion conduit.

The head-waters of Cohocton River lie immediately south of the head-waters of the Springwater Creek, the main tributary of Hemlock Lake. A small reservoir would be constructed on Cohocton River at a suitable elevation so that the water could be diverted by gravity into Springwater Creek north of Wayland.

There is an additional small area from which water could be diverted into the supply conduit. This is designated "B" on Fig. 2.

In case of all these diversions a sufficient quantity of water would be released at all times during low water periods to provide for domestic and agricultural uses.

A stream having a drainage area of 2.20 square miles and forming the head-water tributary of Springwater Creek has at some time past been diverted from its natural course at a point just north of Wayland and is now tributary to Canaseraga Creek. Restoration of this stream to its natural course would be included in connection with the project.

If developed and extended in the manner described, the Hemlock supply system would be capable of providing a dependable yield of at least 50 mgd as compared with the present supply of 31 mgd.

The principal items and structures involved in the general plan are:

1. Restoration of Conduit I north of Overflow No. 1 (now in progress).
2. Provision of increased capacity to deliver water from Overflow No. 1 to the City, either by relining

Conduit II or by construction of a new conduit to supplement Conduits II and III. Consideration of this item is deferred pending restoration of Conduit I.
3. Reconstruction of Canadice Lake dam and the construction of a new low-level outlet therefrom.
4. Construction of a new dam near Hemlock village and of the Lower Basin Reservoir.
5. Raising present Hemlock Lake dam to serve as a partition wall between the upper and lower basins of the new Hemlock Reservoir and construction of by-pass from Gatehouse No. 2 to the Lower Basin Reservoir.
6. Construction of new gatehouse at the new Hemlock dam and new main supply conduit therefrom to Overflow No. 1.
7. Calabogue diversion. (Second stage.)
8. Cohocton diversion. (Third stage,)

The different steps or stages would be constructed about in the order named and in the manner as:

1. To provide a progressively increasing supply of water in the Hemlock system and increased ability to deliver water to the City.
2. To provide an adequate water supply during the war period and at the same time defer as much as possible of the construction until the war is over and permit it to be carried out as part of the post-war program.

Structures are planned in such a manner as to require the minimum use of metals and essential war materials in parts of the program which must be constructed during the war.

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In case of all these diversions a sufficient quantity of water would be released at all times during low water periods to provide for domestic and agricultural uses.

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Structures are planned in such a manner as to require the minimum use of metals and essential war materials in parts of the program which must be constructed during the war.

DRAINAGE AREAS IN SQUARE MILES

The following table shows the drainage areas tributary to the Hemlock system at different stages of development of the project. The total tributary area upon completion will be roundly 100 square miles, as compare with 66.40 square miles tributary to the present Hemlock-Canadice system.

DRAINAGE AREAS IN SQUARE MILES

I - PRESENT SYSTEM

	Square Miles	
Hemlock Lake - -		
Land	45.10	
Water (1828 acres)	2.86	
Total		48.00 a)
Canadice Lake - -		
Land	11.58	
Water (648 acres)	1.02	
Total		12.60
Canadice Outlet at present diversion		
Weir	5.80	
Total, Canadice Lake and Outlet		18.40
Total, present system		66.40

a) The head-water stream of Springwater Creek, draining about 2.2 square miles of this area, is now diverted into Canaseraga Creek at Wayland but would be restored to its natural course, leading into Hemlock Lake, in connection with this project.

II - AREA NATURALLY TRIBUTARY TO HEMLOCK NEW DAM

	Square Miles	
Area tributary to present Hemlock system		
(As above)		66.40
Additional areas:		
Lower Basin - -		
Land	2.88	
Water	0.70	
Total	3.58	
Livonia Creek	5.67	
Total additional areas		9.25
Total area at new dam		75.65

III - ADDITIONAL AREAS FROM WHICH RUNOFF WILL BE DIVERTED INTO NEW HEMLOCK RESERVOIR

Calabogue Creek:		
At diversion dam	9.38	
Three small areas tributary to Conesus Lake ...	2.67	
Total, Calabogue-Conesus Lake area	12.05	
Cohocton River:		
At diversion dam	11.16	
Area "B"	1.15	
Total Cohocton area	12.31	
Total, inverted areas		24.36
Area naturally tributary to project		75.65
Total supply area		100.01

AVAILABLE WATER YIELD

In view of the fact that the present water consumption of the City of Rochester exceeds the available yield of the existing sources of supply as now developed, the question of dependable yield of the present sources, if fully developed, and present sources augmented in the manner proposed in this project, is of prime importance. Fortunately, the determination of available yield can be made with more definiteness and certainty in this case than is usual in similar water supply projects, partly because of excellent and long-continued records of rainfall, runoff and evaporation, some of which were established by Emil Kuichling and Edwin A. Fisher in the early days of the Hemlock Lake system and which have been maintained by the City Engineer and Water Departments down to the present time. In particular, the weir record of outflow from Canadice Lake is continuous, accurate and homogeneous and covers a period of 40 years.

Gaging stations have been established to supplement existing data for determination of the yield of the Livonia and Calabogue drainage areas. Gaging stations have been maintained by the U. S. Geological Survey for several years on Cohocton River at Avoca and Campbell. These locations are farther downstream than the proposed diversion area on Cohocton River. They give the runoff from much larger areas and are not fully representative of conditions under which diversion would be made.

The Research Division of the Soil Conservation Service, U. S. Department of Agriculture, has cooperated with the City by turning over to the Consulting Engineer advanced copies of several years' records of rainfall and runoff from small drainage areas and test plats in the adjacent to the upper Cohocton drainage basin at Arnot, Hammondsport and Cohocton. These data not only save the City the expense of collecting similar data but also provide a basis for making a determination of the yield of the diversion areas on Cohocton River as soon as surveys are completed. Several years would be required to collect similar data if it had not already been done. Since the runoff from the Cohocton area may not be required for a few years it is desirable that arrangements be made to have at least the most important of these records continued and the data supplied to the City.

The extent to which natural runoff can be regulated as required for use, other things equal, depends on the volume of storage available per square mile of drainage area. For the Hemlock system it is as follows:

	Drainage area sq. mi.	Storage billion galls. Total	Storage billion galls. 90%	Storage mill. galls. per sq. mi.
Present system				
Hemlock Lake + Canadice Outlet	53.8	10.1	- -	188
Canadice Lake	12.6	1.26	- -	100
Total	66.4	11.36		171
Completed project (not including storage on Calabogue and Cohocton areas)				
New Hemlock Reservoir (el. 403.) ..	63.0	15.75	14.20	226
Canadice Reservoir	12.6	3.83	3.45	304
Total	75.6	19.58	17.65	239

The total storage at present available in the Hemlock and Canadice Lake is 11.36 billion gallons. This assumes a draft of Canadice Lake storage of 6 feet.

The total available storage in conjunction with this project would be 19.58 billion gallons, an increase of 8.22 billion gallons, or 72%. This would be made up as follows:

Increased storage in Canadice Lake	2.57 bill. galls.
Increased storage in new Hemlock Reservoir	5.65 bill. galls.

The increase of storage in Hemlock Lake Reservoir would in turn be made up of two items:

Increased storage in Hemlock Lake by raising flow line to elevation 403.00	4.12 bill. galls.
Available storage, Lower Basin	1.53 bill. galls.
Total	5.65 bill. galls.

These figures do not include storage which would be provided on Calabogue Creek and Cohocton River, the amount of which has not yet been precisely determined. The storage provided would, however, serve chiefly as temporary or detention storage. Most of the runoff from these streams occurs in larger stream rises at times when there is likely to be a large natural inflow into Hemlock Lake. The detention reservoirs would permit the runoff of the tributary streams to be held back until the runoff to Hemlock Lake from the same storm has been drawn and used, thus providing impounding space in Hemlock Reservoir without waste of water.

In addition a reservoir can be constructed on lower Canadice Outlet, with a dam on excellent rock foundation, about one-fourth mile upstream from the present Canadice diversion weir. This dam would provide storage needed for the regulation of the runoff from the 5.8 square miles of area tributary to Canadice Outlet. Raising the flow line of Hemlock Reservoir to elevation 403.00 and increasing the available storage at Canadice Lake will, however, provide adequate storage for regulation of the runoff for these areas and of most of the runoff from the areas diverted into Hemlock Reservoir. Construction of the reservoir on lower Canadice Outlet will not be needed until the runoff from these additional areas is brought in and then only if required to release storage in Hemlock Reservoir and so permit increased diversion from the Calabogue and Cohocton areas.

The dependable supply of water from a given drainage area or source depends not only on the quantity of runoff or water yield of the drainage area but also on the extent to which the water can be impounded or stored for use at time when required. A dependable supply of about 600,000 gallons per day per square mile can be adequate storage from Hemlock and Canadice areas. This figure cannot be applied to the other drainage areas involved in this project, partly because of differences of rainfall, geology and soil, which affect the runoff conditions, particularly on the Cohocton area south of the divide between the Great Lakes and Susquehanna River drainage basins. Another reason why they cannot be applied to other areas is because all runoff from Hemlock and Canadice drainage basins enters the reservoirs directly, while in case of Calabogue and Cohocton areas the proportion of the natural runoff which can be diverted is largely determined by reservoir and diversion conduit capacity. Precise figures for the amount of diversion from these areas will not be available until field surveys are completed and the economic sizes of reservoirs and conduits are determined. Preliminary field examinations and subsequent studies show that at least the quantities of dependable supply given in the subjoined table can be obtained from these areas and still permit an ample supply of water to be passed downstream for domestic and agricultural uses. In dry periods no diversion would be made from these streams.

FIRST STAGE OF PRESENT PROJECT

The following figures show the estimated minimum dependable supply from the various proposed sources with net useable storage as specified in the preceding table.

1st stage or Present Project	
Hemlock Lake Reservoir at new dam, excluding Canadice Lake but including Canadice Outlet, the area tributary to the Lower Basin, and Livonia Creek	32.5
Canadice Lake	7.5
Total from Hemlock areas	40.0
2nd stage	
Calabogue area added, including three smaller areas	45.00
3rd stage	
Cohocton areas added - Total net estimated supply	50.00

It is always desirable to provide some factor of safety in estimating the ultimate dependable yield from a water supply system dependent on storage. A factor of safety is best available in the form of reserve storage. This can easily be provided by adopting as the dependable yield of a given project a quantity of flow somewhat less than the computed yield, thereby providing a certain amount of reserve storage which will remain in the reservoir and still be available at the end of the longest dry period.

These estimates have been made up in such a manner as to allow 10 % reserve storage in the new Hemlock Reservoir. This is equivalent to roundly 1,500,000,000 gallons of storage, which would not be used even in the driest years but would be held in reserve or emergencies.

All structures would be designed to permit draft of the Hemlock Reservoir to elevation 381.00. The minimum draft level, barring such unforeseen conditions, would be elevation 384.00. The reserve storage lies between elevations 381.00 and 384.00.

The figures show a dependable yield on completion of the first stage of the project of 40 mgd, as compared with 31 mgd estimated yield from the Hemlock-Canadice system as now developed. This increase arises in three ways:

1. From additional storage of 4.12 billion gallons storage in new Hemlock Lake proper.

2. From additional storage of 1.53 billion gallons in the new Hemlock Lake Reservoir.

3. By bringing into the new reservoir the flood and melting snow runoff from 9.25 square miles of additional area.

The figures on yield given in this report are based on the use of much more complete and extensive data of runoff etc. than have been either available or used in any previous estimates of yield of this system. The results, however, check closely previous estimates as to the yield of the present system and they are therefore chiefly due to the above named three causes rather than to differences in the data or computations.

The figures given for the new dependable yield at the end of the second and third stages of development, i.e. with the Calabogue and Cohocton areas added, are necessarily tentative as the surveys not completed.

SECOND STAGE OF PROJECT - CALABOGUE AREA

Calabogue Creek is naturally tributary to Conesus Lake. An excellent dam site with rock foundation exists at a location upstream from the village of Conesus and a dam at this site could be built of sufficient size to impound the entire flow of ordinary floods. The drainage basin is clean countryside, with only one hamlet - Webster Crossing - and this is located about one-quarter mile away from the stream. There is an old mill and dam still in existence on Calabogue Creek at Conesus but no other developments or use of the stream. The Rochester Division of the Erie R.R. follows the east side of the Calabogue Creek valley in the vicinity of the reservoir site but at a sufficiently high elevation so that it would not be interfered with by the proposed reservoir. There is one third-class earth road crossing the reservoir site which would require relocation.

Water diverted from Calabogue Creek would be conveyed through a gravity conduit, i.e., without pumping, into the drainage basin of Livonia Creek and would thence follow the natural drainage channel of Livonia Creek into a retention basin adjoining the new Hemlock Reservoir.

In addition to Calabogue Creek there are three small streams naturally tributary to Conesus Lake which cross the route of the diversion conduit. Small intake dams would be constructed on these streams to divert their flow into the Calabogue diversion conduit.

The total area from which diversion from Conesus Creek drainage basin would take place is as follows:

Calabogue Creek	9.38 square miles
Other areas directly tributary to Conesus Lake	2.67 square miles
Total	12.05 square miles

Conesus Lake serves as a source of water supply for the villages of Avon and Geneseo. The total drainage area at Lakeville, near the foot of the lake, is 72 square miles. The natural runoff from the 60 square miles remaining tributary to Conesus Lake after the proposed diversion will be many times the amount required for these villages.

As pointed out in conjunction with the discussion of water analyses, the mixture of the water from the Calabogue and Livonia areas in the manner described would provide water from these areas of quality and hardness similar to and comparable with that of the present effluent from Hemlock-Canadice Lakes.

Upon completion of the second stage of the project, i.e., after the Calabogue-Conesus areas are developed, the total drainage area supplying water will be 87.7 square miles and the net dependable yield 45 mgd.

THIRD STAGE - COHOCTON RIVER

This area, at the extreme head of Cohocton River, is naturally tributary to Chemung and Susquehanna Rivers.

An excellent site for a diversion dam and reservoir exists on this area at a suitable elevation to permit water to be diverted to be conveyed into Springwater Creek drainage basin by gravity.

A covered concrete conduit would lead from the reservoir, following approximately between 1300 and 1400 foot contours, into the head of Springwater Creek north of Wayland. This would provide an area of 11.16 square miles in area "A", and an additional area, "B", of 1.15 square miles, from which water could be diverted into the same conduit (Fig. 2). The drainage basin is clean rural area, containing only one small hamlet.

This project would, however, involve diversion from the drainage basin of an interstate stream.

It may be noted that there is already a similar diversion of most of the water from an area of 45 square miles from Mud Creek, naturally tributary to Cohocton River near Bath. This diversion, by the Lamoka Power Corporation, into Keuka Lake, began about 1929. The natural low water flow is, I understand, released to the stream.

In this connection a precedent is established for diversion by the decision of the U. S. Supreme Court in the so-called Delaware River case (Master's Report and decision of the U. S. Supreme Court, State of N. J. vs State and City of N. Y., case of original jurisdiction No. 17, U. S. Supreme Court.) In this case the writer represented the State of New Jersey as Chief Engineer.

In this case New York City proposed to divert 600 mgd from Delaware River in New York State, and action for injunction was brought by the State of New Jersey but permanent injunction was denied, although the permissible diversion was reduced to 440 mgd.

In the present instance argument might be made that this diversion of the Cohocton area is unnecessary, as Rochester already has another approved source of supply on Honeoye Creek. A similar situation existed in the Delaware River Case, New York City having previously reported favorably on a supply of equal volume from sources east of Hudson River and lying wholly within New York State, but afterwards, by official action, the City adopted the Delaware River source. The Special Master held that the question of necessity could not be entered into as the City had the right to determine the most advantageous and desirable source of its water supply.

While, of course, the Cohocton diversion would represent a technical invasion of property rights, the court held in the New Jersey case that before an injunction could be granted, something more than trivial damage must be shown. Also it was held by the Supreme Court in that case that the question of use of an interstate stream rested primarily on a reasonable and equitable diversion and use of the stream rather than on the ordinary principles of common law.

There are important waterpower developments on lower Susquehanna River. However, the area to be diverted, namely, 12.3 square miles, is so small compared with the total area of over 25,000 square miles at the location of the principal power developments that this question, if it arises, should be capable of ready adjustment.

The principal developments are:

	Head, feet		Drainage area, square miles
Conowingo	89	....	27,000
Safe Harbor	53	....	26,000
Holtwood	53	....	25,000

If the entire flow was diverted and if it could all be used for power, the loss of power would be roundly 200 hp.

The Cohocton diversion would turn water into Springwater Creek. There would be some increase in flood discharge of that stream but never in excess of the capacity of the diversion conduit. Some flood channel improvement on Springwater Creek should be made.

Pending completion of surveys, determination of the available sizes of intake reservoirs and the economic sizes of diversion conduits cannot be made.

The suggestion naturally occurs that since at least 10 mgd additional supply can be obtained from Calabogue and Cohocton drainage basins, outside the Hemlock Lake Basin, why not bring these sources in at once, making this the first step in the program? The answer is, of course, that storage for regulation of this added inflow is not at present available and the first step therefore be to provide additional storage space.

Upon completion of the project, with the bringing in of the Cohocton area, the drainage area tributary to the Hemlock system will be roundly 100 square miles and the net dependable supply at least 50 mgd, after allowing a reserve storage in Hemlock Reservoir of 10% for Emergency use.

QUALITY OF WATER

Arrangements were made in 1943 to have water samples taken and analyzed frequently from each of the proposed drainage areas or sources of supply. The results of the analyses thus far and reported are given in a supplement to this report. Considering the results of these analyses with respect to quality, aside from hardness, the waters to be used are all of a relatively high degree of purity and are comparable to the present supply from Hemlock and Canadice Lakes. The pronounced bactericidal section of prolonged storage of natural waters in reservoirs is well established. The extensive storage in Hemlock and Canadice Lakes is one of the outstanding reasons for the high degree of purity of the present supply of water to the City of Rochester. Under the proposed program of extension of the system the quantity of storage per unit of supply would remain substantially the same as at present.

There is one characteristic of the water, namely, hardness, which is not materially affected by prolonged storage. Particular attention has therefore been given to the hardness of the water in securing samples for analysis, and the total hardness of the different samples as determined by the soap method, together with the estimated flow in the stream at the time of sampling, has been determined for several hundred samples from the different sources. (These results are given in the Supplement on Water Analysis.)

Unfortunately the analyses thus far made and reported are from samples taken at times when the flow in the streams generally less than 1 csm, whereas most of the water diverted would be at times of much higher flows - 5 to 10 or up to 100 csm or more. Many of the analyses made are therefore more nearly representative of the part of the water from the tributary areas which would be released to the stream than of the water to be diverted and used. The water diverted and used would be mainly from flood flows and melting snow, particularly the latter.

Rainwater and water from melting snow are nearly pure water, with little hardness. It is well known that flood and melting snow runoff consists mostly of surface rather than ground-water and usually contain much less hardness than summer and fall derived chiefly from ground-water. For some drainage basins in New York State the hardness varies inversely as the quantity of flow, while for other areas the hardness decreases about one-half in higher flows.

The hardness of water in Hemlock and Canadice Lakes represents mostly the hardness of stored waters derived from flood and spring runoff. A comparison of this hardness as of a given date with that of other streams at the same date, but without storage, has little meaning. For example, the hardness of Springwater Creek at Springwater at times of low water runs up to 100 ppm or more, while the hardness from the effluent from Hemlock Lake at the same time is commonly about 70 ppm. The difference is the result of mixing of hard water from low or summer flows with previously stored soft water from flood flows and melting snow. With the exception of Livonia Creek, waters derived from the proposed additional areas are relatively soft, often softer, in fact, than the effluent from Hemlock Lake, even under summer conditions. Livonia Creek water is objectionably hard in low water but the low flow of this stream, like that of the others, would be released and not used. As already noted, the soft water from Calabogue Creek would be brought into the Livonia Creek drainage basin in connection with the second stage of the project. The water from the two streams would be thoroughly mixed en route into the Hemlock Reservoir, providing an in fluent to the reservoir from these sources having a hardness comparable to that of the present Hemlock Lake supply.

It so happens that the softest and best water available to the present system is the flood water from Canadice Lake Outlet. As already shown, a large portion of this flood water is at present wasted. With the proposed new project all this water will be impounded and stored. This will insure water of about the same hardness as at the present upon completion of the First stage of the project, with somewhat softer water when the Second and Third stages of the plan are carried out. The present hardness of the water used at about 70 ppm, that of Lake Ontario about 140 ppm, and hardness exceeding 100 ppm is generally considered undesirable because of the increased amount of soap required to soften it.

There is only one industrial use of water within the entire area from which the new supply will be derived. This is a milk station at Webster Crossing, located about one-fourth mile from Calabogue Creek. Some treatment of waste from this milk station may be required.

FLEXIBILITY

Flexibility in relation to waterworks practice means the ability to maintain the supply with one unit out of service. As applied to the Hemlock Lake system there is at present a single 5-foot diameter pipe 1,550 feet long extending from Gatehouse No. 2, at Hemlock Lake, into the lake. All the water used from Hemlock Lake must under present conditions pass through this pipe. Also there is a single 6-foot diameter brick tunnel, extending from Gatehouse No. 2, at Hemlock Lake dam, to Overflow No. 1, through which the entire supply must at present pass. The intake pipe and tunnel were constructed in 1893 and have been in continuous service since that date. There is no practicable way to examine the interior of either the pip or tunnel or to make repairs excepting by wholly or at least partially shutting off the draft of water from Hemlock Lake during the period of examination or repair, using water from Rush Reservoir and the distributing reservoirs or from other sources. This does not provide desirable flexibility.

With the new project in operation it would be possible to entirely shut off the flow through either the intake pipe in Hemlock Lake or the tunnel extending from the lake to Overflow No. 1 for a period of several months at a time, to make examination or repairs. In either case the flexibility of the system would be greatly increased since water could be drawn at any time by either route, i.e., through the present tunnel or from the new dam and gatehouse and the new conduit leading therefrom to Overflow No. 1.

Much more attention will probably be paid to flexibility and alternative methods of drawing and routing water in connection with supply systems in the future than in the past. The writer is not sufficiently optimistic to believe that the menace of aerial bombardment will and forever end forever with the termination of the present war. Furthermore, with the possibility of aircraft becoming as numerous as gnats, malicious injury to a water supply system will be much more readily possible than at present unless aerial policing is developed far beyond its present stage.

As at present operated, the supply, whether originating in Hemlock or Canadice Lakes, must be drawn directly from Hemlock Lake. With this project in operation the entire supply from Canadice Lake Outlet would pass into the lower basin of the new Hemlock Reservoir. Hemlock Lake proper could be shut off entirely and the entire supply drawn from Canadice Lake through the Lower Basin for a period of several weeks or even months.

In addition to providing greatly increased flexibility of operation the new project fits in well with the increase of conduit capacity for delivery or water to the City of Rochester. In addition to the construction of a new mains supply conduit from Hemlock Reservoir to overflow No. 1, provision will be made for additional conduits in the future. An additional supply conduit to Rochester when built can be extended through to the new Hemlock Lake dam, so that in the event that the use of the present brick tunnel from Gatehouse No. 2 to Overflow No. 1 is ultimately abandoned, there will still be two main supply lines leading out of the new Hemlock Lake Reservoir.

COST

The structures are all relatively simple and a fair indication of their cost can be obtained by comparison with pre-war cost of more or less similar structures. To these figures must, however, from 50 to 100% to cover uncertainties as to labor and material costs under war conditions and during the post-war period. In this way the following figures have been obtained.

STRUCTURAL COST

First Stage (Present Project)

Reconstruction of Canadice Dam and Outlet conduit and construction of new Hemlock Lake Dam and main supply conduit ....$1,500,000 to $2,500,000

Second Stage

Calabogue Conesus diversion .... $1,000,000 to $1,500,000

Third Stage

Cohocton diversion .... $1,500,000 to $2,000,000

Total .... $4,000,000 to $6,000,000

The figures given above include a low-level outlet conduit at Canadice Lake. Pumping to supply the restored portion of Conduit No. 1 would no longer be necessary after the completion of the first stage of the project. The entire supply would then be delivered by gravity, as at present.

These figures do not include the cost of lands and water rights nor the cost of repair or replacement of Conduit No. 2.

The structural cost for gravity supply water systems under pre-war conditions, for cities comparable in size with Rochester, is commonly $250,000 to $350,000 per million gallons of dependable supply. The proposed project will increase the dependable supply to Rochester by roundly 20 mgd and the estimated cost per million gallons comes within these limits even after allowing for greatly increased costs to be expected under conditions now and in the near future.

COMPARISON WITH OTHER PROJECTS

RICHMOND MILLS

The taking of water from Hemlock Lake Outlet at Richmond Mills was considered as early as 1890 as a source of increased supply. Richmond Mills is located three miles downstream from Hemlock village. The drainage area is 81.8 square miles or 6.2 square miles greater than at Hemlock village, and a dam at Richmond Mills if built at elevation 911.3 (USGS) or to the same elevation as proposed for Hemlock Lake in conjunction with the Hemlock project, would provide 2 billion gallons additional storage, would eliminate the 6-foot brick tunnel and shorten the conduit lengths from Overflow No. 1 to Rochester by about 10,000 feet, and would provide a reservoir with two basins, as in connection with the proposed Hemlock project.

An inspection was made to determine the possibility of finding a suitable dam site at Richmond Mills. The bottom of the stream valley is flat and at about elevation 316.7 (825.0, USGS). No evidence was found of rock either in the stream bed or in the sides of the valley. The valley side banks are abrupt and are composed entirely of coarse sand and gravel interspersed with cobblestone. These conditions are highly unfavorable for construction of a water-tight dam.

A dam at this location with flow line elevation 403.0, as proposed in connection with the Hemlock project, would have a height from stream bed to spillway of about 86 feet, and even if rock foundation was available it would cost several times as much as a new dam at Hemlock village. In addition the drainage from the village of Hemlock would pass directly into the head of the lower basin of the reservoir, while in conjunction of the Hemlock project this drainage all passes into Hemlock Outlet downstream from the reservoir.

In spite of its attractiveness in other respects, further consideration has not been given to this project because of poor foundation and bank condition, lack of rock for spillway and danger of pollution.

HONEOYE LAKE

Honeoye Lake is at elevation roundly 100 lower than Hemlock Lake. It has been proposed to construct a dam on Honeoye Creek about 8.5 miles downstream from Hemlock Lake. The elevation of Honeoye Creek valley bottom at this location is about 275.0. Conduits nos. 2 and 3 follow this valley and the elevation of the top of Conduit No. 2 at air valve no. 57, near the proposed location of the dam, is 364.3 and the hydraulic grade line 386.4. The highest dam proposed at this location has flow line elevation 322.0 and no rock was found by borings at the proposed dam site.

A lower dam of course could be constructed, and was later proposed, but it would obviously be necessary either to pump the water or else to build entirely new supply conduits leading from this point to Rush Reservoir. In addition it has been suggested that the water should be filtered. The construction would involve the use of much larger quantities of defense materials than the Hemlock project and, furthermore, if this site is to be used to supplement the Hemlock supply, then various steps must be carried out to put the Hemlock system in condition for continued use.

The City of Rochester now has permission to use water from Honeoye Creek. If used to supplement the Hemlock Lake supply, then some of the steps involved in the first stage of the Hemlock project must be taken in any event to restore the Hemlock system to first-class condition. Since an adequate supply for the present and near future can be obtained from Hemlock Lake in conjunction with diversion from adjacent areas, it seems advisable that the Hemlock project should be developed first and that the taking of water from Honeoye Outlet should be deferred until some future time, if and when needed.

GROUND-WATER

The ground-water supply per square mile of area tributary to an aquifer is limited in three ways:

1. It cannot exceed the fraction of rain which enters the soil surface as infiltration during rain.

2. The soil can hold part of the water entering it as capillary moisture. This water does not pass downward to the water-table but is mostly absorbed by vegetation and returned to the air. Hence the ground-water supply cannot exceed the residue of infiltration after evaporation and transpiration by vegetation have taken their toll.

3. Water proceeds downward through the soil to a water-table only during rain occurring at times when the soil is filled with moisture to capillary saturation. Replenishment of aquifer occurs at irregular intervals and in limited amount.

Viewed in another way, total runoff is made up of surface runoff and ground-water outflow. The ground-water outflow represents the fraction of the total runoff available as ground-water supply. It is seldom that it can all be utilized. In the region around Hemlock Lake, for example, the total runoff is equivalent to about 12 inches depth of water per year, of which at least two-thirds to three-fourths is surface runoff, leaving the equivalent of only 3 to 4 inches depth to supply aquifers. In the immediate vicinity of Rochester there are local sandy areas where nearly the entire rainfall enters the soil as infiltration and nearly the entire runoff of streams like Irondequoit Creek is derived from ground-water flow. An aquifer consisting, for example, of buried deposits of sand or gravel fed by a tributary area of the first type, would require three to four times as many square miles of tributary area to yield 1 mgd as an area of the second type with the underground aquifer precisely the same in both cases, while the latter would require a drainage area tributary to the aquifer about the same as that required to provide an equal supply from natural runoff.

A ground-water supply to be adequate and dependable requires the concurrent conditions of suitable underground beds of porous material, which act as a storage reservoir, and a sufficiently permeable surface and sufficiently large tributary drainage area to replenish the aquifer. This combination of conditions is relatively infrequent.

In addition, ground-water, as a rule, is harder than surface water, although a high degree of purity from a bacteriological viewpoint.

There is a not uncommon misunderstanding regarding ground-water arising from the failure to recognize the fact that an aquifer to provide a given ground-water supply requires a surface area drainage area of at least equal to and sometime greater than that which would be required for the same supply derived from natural surface runoff. Lacking this, an aquifer may provide abundant supply for a time bur gradually fails through lack of replenishment. While there are areas from which limited ground-water supplies can be obtained in the vicinity of Rochester, there is apparently none having the requisite underground storage capacity and surface intake area for so large a supply as is required. Even if ground-water of adequate quantity and suitable quality was obtainable, it would require pumping, whereas an adequate supply can be obtained from the Hemlock system without pumping.

SUMMARY

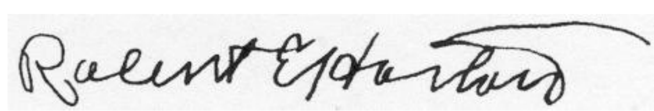
The plan here considered will increase the drainage area tributary to the Hemlock water system from 66.4 square miles to 100 square miles by bringing in water from additional areas adjacent to Hemlock Lake. It will increase the available storage from 11.36 billion gallons to 17.65 billion gallons and still provide 10% reserve storage as a factor of safety. It will provide a net ultimate supply of 50 mgd or an increase of supply of 19 mgd at a total structural cost of between $4,000,000 and $6,000,000. The project will provide water of substantially the same quality and softness as the present Hemlock Lake supply, delivered by gravity and with increased flexibility of operation.

The areas tributary to the proposed new sources of supply are exceptionally free from pollution.

The development of the project will be carried out in three stages, giving net dependable supplies as follows:

Present project or First stage	Hemlock-Canadice areas with additional area north of Hemlock Lake .... 40 mgd
Second stage	With Calabogue-Conesus areas added .... 45 mgd
Third stage	Completion of project, with Cohocton areas added .... 50 mgd

The present project, comprising the First stage of the general plan, will provide a dependable yield of 40 mgd of water of the same quality as that now available. It will provide greatly increased flexibility of the system and involve work which should be carried out in any event if the present Hemlock system is to be retained as a part of any economic plan of future development for the City of Rochester.



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