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GENESEE VALLEY HYDROGRAPHY AND DRAINAGE

BY

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Introduction

The river and valley Genesee have held great interest for the historian, the economist and the geologist. The glacial phenomena and deposits are in handsome display, and have been the chief subject of the more recent scientific literature. The physiographic and hydrographic features are remarkable and require description.

The problem of supplementary water supply for the City of Rochester has brought into question the quantity and quality of water carried in the drift-filled portions of the ancient, preglacial valley. This subject has interest and importance not only to the city and villages situated in or near the old valley but also to the hydraulic engineers and to the students of glacial, physiographic and applied geology. And this scientific interest in the available artesian water justifies publication of this writing in the Proceedings of the Rochester Academy, especially because the description and proper discussion of the matter involves the entire geologic history of the Genesee drainage area and its present physiography and hydrography.

In this Genesee water problem are four general topics:—The form and features of the ancient river and its valleys; the disruption of the drainage system by the overriding glacier, which left the valleys filled with deposits; the volume and composition of the valley fillings; and the quantity and character of the water that is passing through the buried valleys.

A list of former papers by the writer which have relation to the underground water problem is appended.

Tertiary, Preglacial, Drainage

Map of the Ancient Rivers

Central and Western New York had a long and eventful drainage history before the Genesee River came into existence. With that far-back stream-flow the present study has no concern. It is briefly considered in numbers 5–9 of the appended list of writings.

During the millions of years of the later division of geologic time, the Tertiary Period, the drainage was diverted into northward flow, tributary to the great river which was producing the deep Ontario Valley. The map, figure 1, shows the course of the old Genesee drainage system before it was changed and dissected by the Canadian ice sheet. It will be noted that the preglacial Genesee had two main branches. The West Branch is yet represented by the present river above (south of) Portageville. The East Branch, which produced the Canandaigua Valley, has been filled with drift and detritus and quite obscured. This branch carved the wide valley now buried beneath Naples, North Cohocton, Wayland and Dansville. The two branches united in the neighborhood of Sonyea (see figures 1, 5).

The united branches, as the main trunk of the Genesee, passed northward to about four miles north of Avon and then turned east in a depression, produced by the outcrop of the weak Salina Shales, for about 13 miles, to the vicinity of Fishers. Resuming its northward flow the river excavated the Irondequoit Valley and continued to junction with its master river, the great Ontarian. The drift-filled and abandoned stretches of the ancient valley are indicated in the map, figure 5, by the heavy lines.

The reader will note especially that all of the East Branch valley, and the main valley from Naples around to the Irondequoit Valley, are deeply filled with glacial, lake and stream deposits. The present river is lazily meandering on the surface of the deep filling from near Mount Morris to the bend in the old valley north of Avon, a right-line distance of nearly 20 miles. Except for that short stretch the present Genesee is cutting new, postglacial, channel for its flow north of Portageville.

It should also be noted that all of the drainage of central New York was concentrated in two river systems, the predecessor of the Genesee and the Susqueseneca. The only trenches or valleys cut across the east-west ridge of Niagara strata were made by these two rivers, now marked by Irondequoit and Sodus bays.

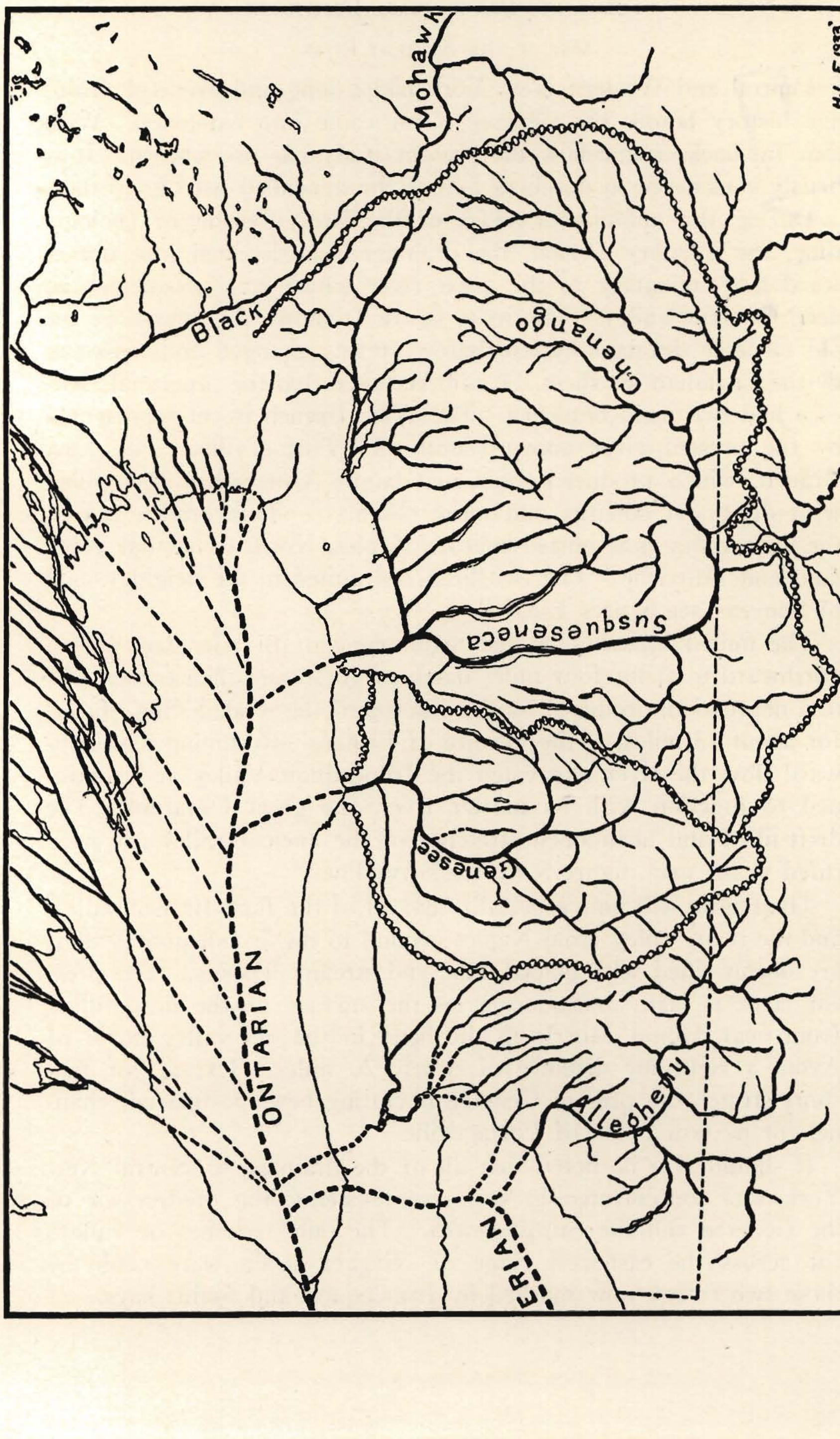

Figure 1. PREGLACIAL DRAINAGE OF WESTERN AND CENTRAL NEW YORK

River Terminology

The Genesee river has slight resemblance to its long-ago predecessor. The only portion that is similar to the ancient flow is the headward stretch above Portageville; and even there it is not flowing in the ancient rock channel but is meandering on the surface of glacial-time deposits. From Mount Morris to four miles north of Avon, a distance of eighteen miles in direct line, its sluggish flow in idle curves is double that mileage, and on the surface of glacial filling many hundreds of feet in depth. The relation of the river to the ancient valleys is shown in figure 5.

To make clear distinction and to save repetition in description it is desirable to have a name for the ancient river. The unlikeness of the two streams, and the time space between them make a distinctive name appropriate as well as convenient.

The lower stretch of the old river was in the course of the valley and bay Irondequoit. It is proposed to combine the two names, Genesee and Irondequoit into Irondogenesee. That name, retaining the music of the two Indian names, will be used hereafter.

The eastern branch of the Irondogenesee with another Indian name, Canandaigua, deserves recognition in the new appellation, but must be slighted.

The old river may thus have a name in rivalry with the original Indian name of the young river, Casconchiagon.[1]

Map of Existing Drainage

Figure 2 shows the river systems of western and central New York as they exist today, following the interference and disruption by the Canadian ice sheet. The southward drainage forced by the glacier is shown in figure 3, and those forced lines of flow are yet retained.

Instead of all the drainage being to the north, as in preglacial time, (figure 1) it now has several directions with far-spread destinations. The Genesee River is unique in retaining its ancient northward direction. Along with the singular drainage of the Finger Lakes area the Genesee water contributes to the St. Lawrence and north Atlantic.

The Allegheny goes to the Ohio and Gulf of Mexico; the Susquehanna to Chesapeake Bay; and the Mohawk to the Hudson

[1] Rochester Democrat & Chronicle, July 18, 1926. Rochester Historical Society. Pub. Fund Series. Volume 5. 1926, pages 141–145.

estuary. These inconsistent and anomalous lines of river flow are largely an effect of glaciation.

The Niagara and Oswego rivers are in new, or postglacial, courses with rock ravines.

Physical Principles Involved

The ancient rivers have left their records in the existing gross topography, the greater valleys and hills. To translate those drainage inscriptions and to appreciate the following descriptions and inferences some physical principles in earth science must be recognized. These are:

1. The fact of vast up-and-down movements of great continental land areas, carrying the land down, to perhaps far below ocean level, or to high above. The Genesee region has experienced such changes in elevation.

2. Rivers are the valley-makers. All of the valleys in this part of the world, and everywhere in approximately horizontal strata, have been carved by running water. The great hills are only the unremoved portions, or remnants, of the original rock strata.

3. The ancient, long-lived rivers, like the older rivers of today, had well-graded channels, or paths of uniform slope, with no obstructions. Given great length of time rivers wear away all barriers, obliterating all cataracts and rapids in their primitive courses.

The map, figure 1, of preglacial stream-flow in New York, is a product of the use of these fundamental principles.

Elevation of the Land Area

During the latter part of the Tertiary Period, preceding the "Age of Ice," this northeastern part of the continent stood some thousands of feet higher than at present. One clear proof is the simple fact that the bottom of Lake Ontario, in a river-carved valley, is toward 500 feet below ocean level. And probably there are hundreds of feet depth of glacial deposits beneath the water.

The deep bays along the coasts, like the Delaware, Chesapeake and the Maine fjords, are the drowned portions of the Tertiary river valleys. Recent survey of the Atlantic sea bottom off New England coast has mapped a series of stream valleys down to the depth of 8,000 feet.

Because of the high elevation of the land in preglacial time the rivers had farther drop to reach the sea, with consequent rapid flow, steeper gradient, and great work of erosion. In consequence the Genesee and other rivers in central New York carved deep valleys. When the Canadian ice sheet overwhelmed the region the rivers were flowing in relatively steep-walled, canyon-like valleys. The deeper portions of all these valleys are now filled with glacial deposits, and only the drill can prove the depths.

At Watkins, many years ago, in search for salt, drilling to depth of 1,200 feet did not reach bed rock. The plain is little above Seneca Lake, with elevation 444 feet above tide. At Ithaca the drill did not reach the rock at depth of 1,250 feet; starting near the level of Cayuga Lake, 381 feet A. T.[2]

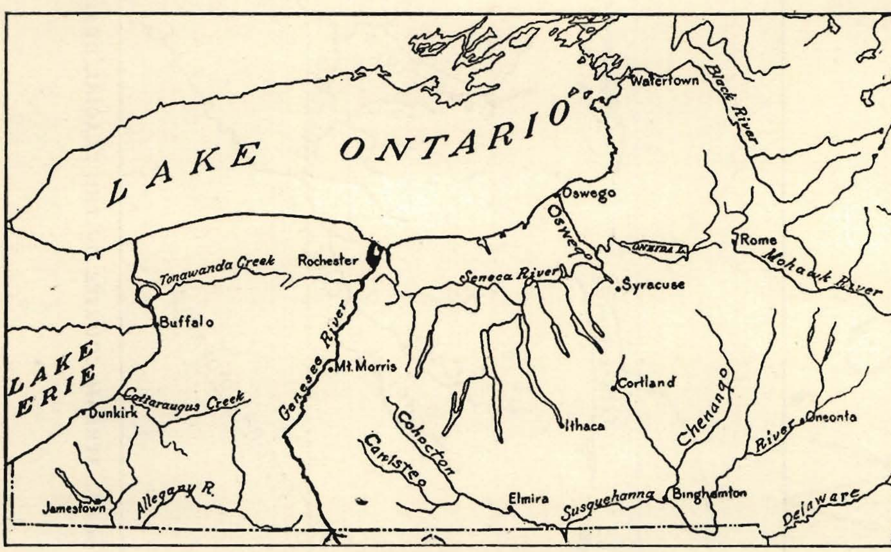

Figure 2. EXISTING RIVER SYSTEMS

Unfortunately for our present study the buried Genesee Valley has not been probed to its rock bottom. To this date the deepest drilling is the Leighton well, three miles north of Dansville, in the East Branch of the Genesee, to depth of only 450 feet. The wide plain has there elevation of 600 feet; hence the bottom of the well is 150 feet above sea-level (figure 8). The curvature of the walls of the old valley projected downward suggests a depth to rock of over 1,000 feet.

[2] Seneca Valley physiographic and glacial history. Geol. Soc. Amer., Bull. 45, 1934, 1073–1110.

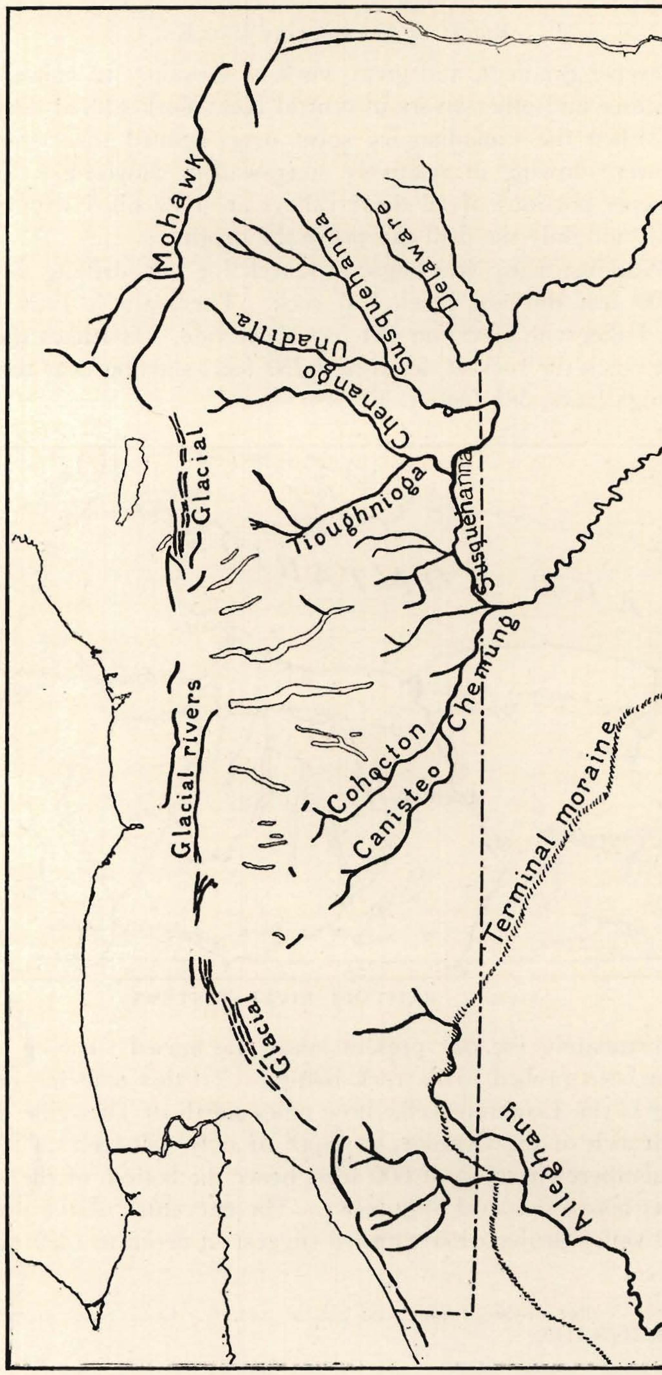

Figure 3. STREAM COURSES OF THE GLACIAL DRAINAGE

Glacial Interference

Ice-Sheet Invasion and Overriding

The extreme altitude of northeastern America at the close of Tertiary time resulted in snow caps on the mountain tracts, that eventually coalesced into the Quebec continental glacier. The expanding ice sheet spread over all of New England and New York. With the oncoming of the ice sheet the north-flowing rivers were blocked, producing ice-dammed lakes. In further advance the ice occupied the valleys, and eventually buried the State under thousands of feet of moving ice, a condition comparable to that of Greenland of today.

The advancing ice sheet eventually forced all the waters into southward flow. The receding ice front, during the removal of the glacier, repeated the process in reverse order, and the lines of forced glacial flow are shown in figure 3.

Valley Drift Fillings

The depositional work of the ice sheet filled large portions of the ancient valleys, and radically changed the Irondogenesee drainage system. The eastern branch, which headed in the Canandaigua Valley, has been wholly obscured. The traveller going south from Naples to North Cohocton and west to Wayland and Perkinsville and then northwest to Dansville would not realize that he was passing over a deep, buried valley. Yet the high hills on either side are the upper slopes of the ancient valley.

The wide smooth plain from Dansville to north Avon is the surface of the deep valley filling (figure 7). From Mount Morris to below Avon the present river is idly coursing on lake-smoothed filling of the ancient valley.

Below, north of Avon the old valley curved east to the present Irondequoit Valley which was its northward course to the Ontario Valley. The villages of West Rush, East Rush, Mendon, Fishers and East Rochester are on the valley drift filling, that entirely conceals the ancient canyon.

The portion of the West Branch Valley northwest from Portageville to Sonyea, south of Mount Morris, was also filled, forcing the present river to cut the Portage canyon and Mount Morris High Banks. The new path of the river north from Avon includes the handsome Rochester ravine.

Mapping by the Monroe County Planning Board of the subsurface conditions has clearly defined the rim of the old valley from north of Avon to Irondequoit Bay, as shown in figure 7.

The drift-filled portions of the preglacial valley are indicated in the map, figure 5.

Depth of the Drift Fillings

The depth or thickness of the glacial deposits in the old valleys depends, of course, upon the depth of the preglacial valleys.

The Genesee canyon should have been similar to those of the Seneca and Cayuga valleys, minimum depths of which have been stated above. A rough approximation is made by downward continuation of the curves of the exposed valley walls, where these have good display, as shown in figure 8. Under the atmospheric erosion of the valley walls, while the river was intrenching at the valley bottom, the downward slope, or pitch, of the walls steepened toward the river.

The Tertiary Irondogenesee probably was actively at work in its intrenching when the advancing ice sheet invaded the State and blocked the river, and the width of the valley bottom probably was not much wider than the width of the stream. Figure 8 is drawn with such conception.

The rock bottoms of Canandaigua Lake and Lake Ontario are, of course, the maximum depths of the valley. But these basins hold glacial deposits of unknown depth, hence those datum points are not available. However, the great depth of the valley fillings can be proven by using minimum data. We have three points of elevation known; the bottom of Canandaigua Lake, the bottom of the Dansville (Leighton) well and the bottom of Lake Ontario. Making use of the fact that old rivers have channels with uniform or graded slope, a principle stated above, we may calculate the minimum depth of drift filling for all localities of the East Branch and of the Main Valley.

In the following tables the figures indicate feet, and the figures for elevations are heights above ocean level, except those in heavy-face type which are for distance below ocean.

Recognizing the uniform slope of the line, or plane, connecting the three datum points, we can, with the distances and gradient calculate the elevation for any location along the line. Then, with the elevation of the ground surface (see the U. S. Geological Survey topographic maps) the depth of the valley filling is found. But these are only positive *minimum* depths; the actual depths of the valley deposits are probably hundreds of feet more.

TABLE 1

Elevations of Three Datum Points

	Surface	*Depth*	*Bottom*
Canandaigua Lake	686	262	424
Dansville Well	600	450	150
Lake Ontario	246	721	**475**

TABLE 2

Approximate Distances and Gradients

Stations		*Fall*	*Miles*	*Gradient*
Canandaigua Lake to Dansville Well				
424	150	274	34	8.0
Dansville Well to Lake Ontario				
150	**475**	625	85	7.35
Canandaigua Lake to Lake Ontario				
424	**475**	899	120	7.5

Following are the approximate minimum depths for several localities along the line of the buried Genesee Valley.

TABLE 3

Bottom, at middle, of Canandaigua Lake	elevation	424
On the moraine south of Naples	depth of drift	1.100
At Wayland	" " "	1.140
Dansville well	bottom elevation	150
By Geneseo	depth of drift	530
By Avon	" " "	574
At Rush	" " "	650
At Rochester Junction	" " "	685
At Fishers	" " "	715
At East Rochester	" " "	620
Bottom of middle of Lake Ontario	elevation	**475**

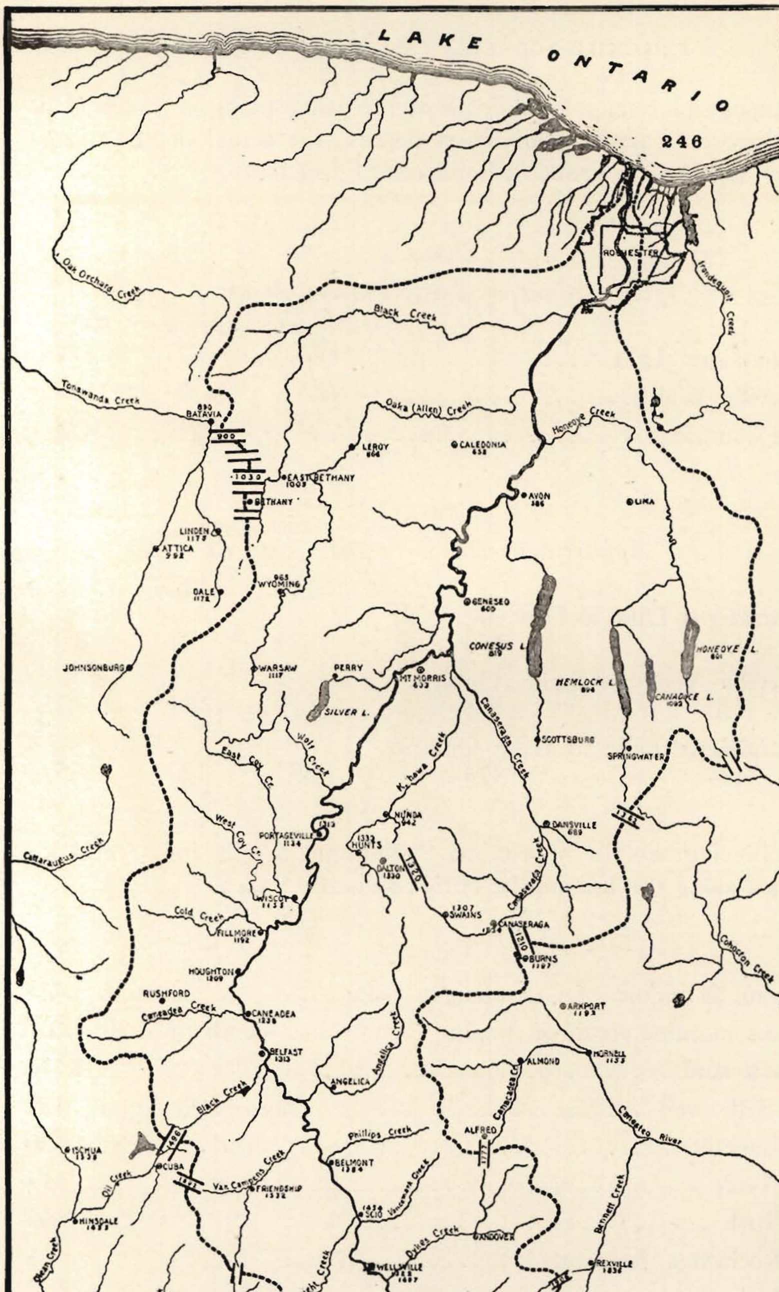

Figure 4. HYDROGRAPHY OF THE GENESEE VALLEY

The figures that cross the line of water parting show elevations above ocean, and locate the channels of escape of glacial waters

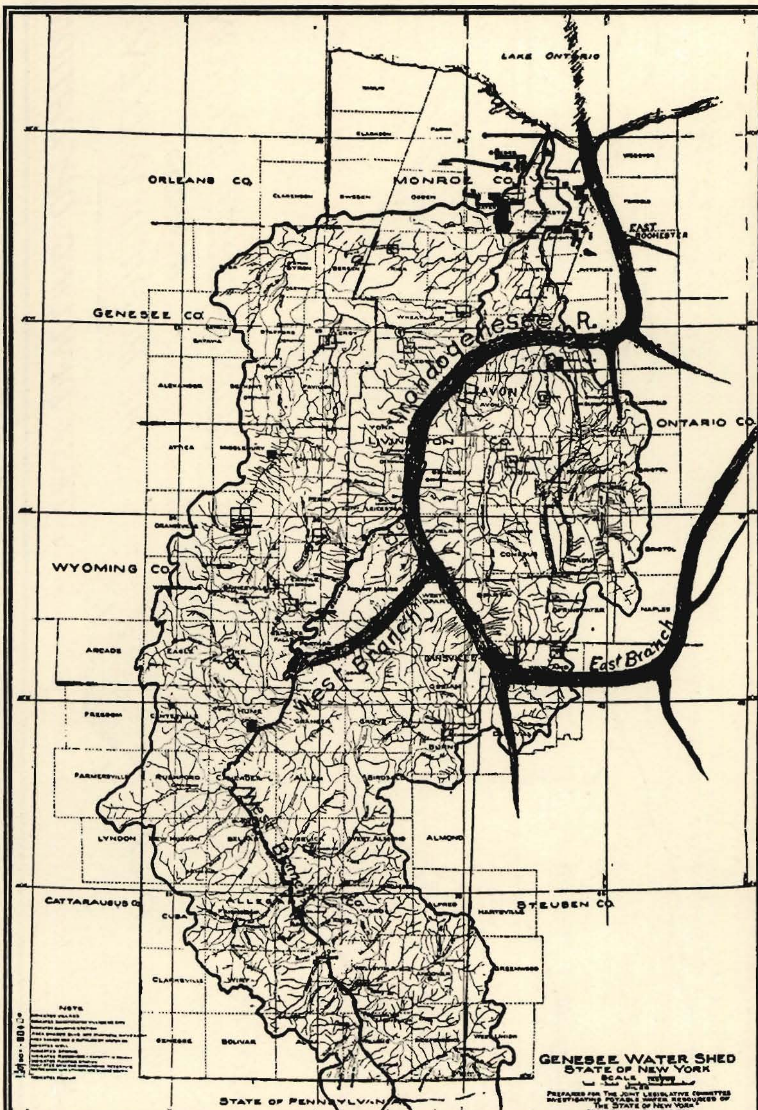

Figure 5. DRIFT-FILLED PORTION OF THE IRONDOGENESEE VALLEY

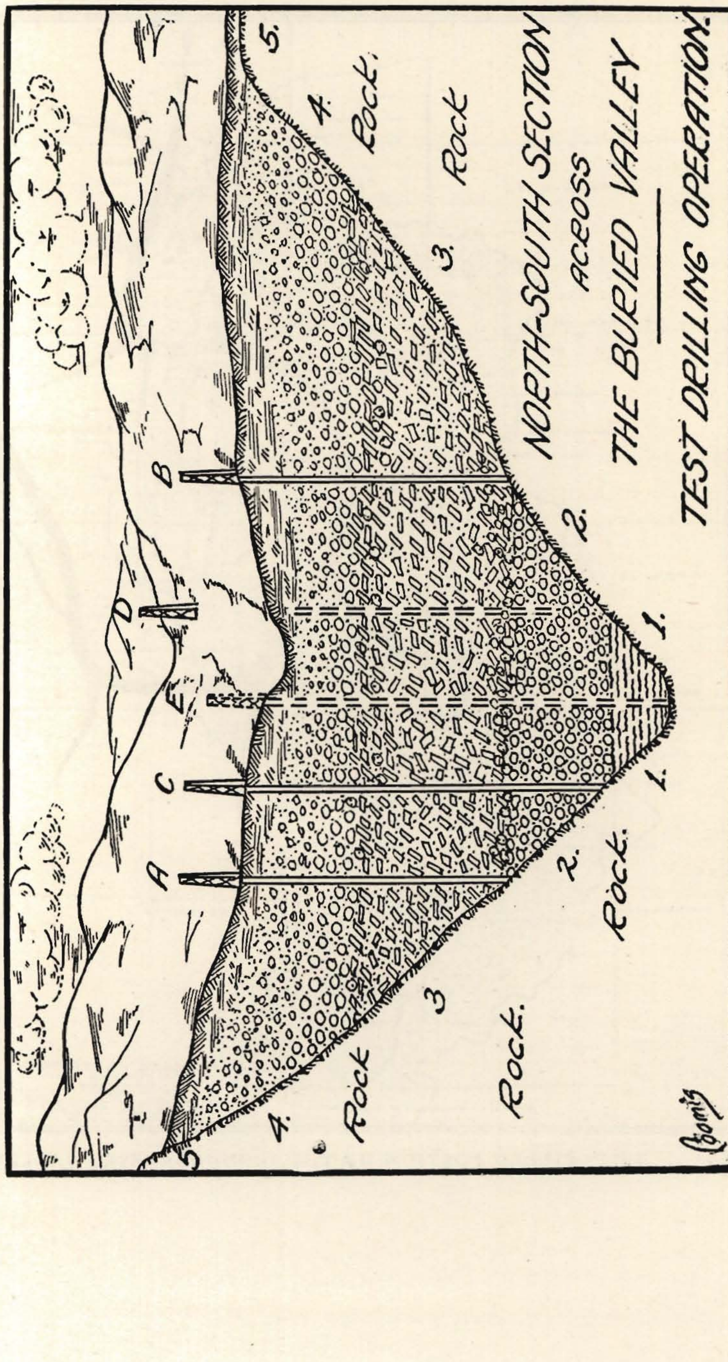

Figure 6. THEORETIC SUCCESSION OF THE GLACIAL VALLEY FILLING

Composition of the Valley Fillings

This factor in the problem is important because of its bearing on the storage and transmission of underground water.

The typical glacial drift is the ice-laid material, the "hardpan" of the farmer, or the "till" and "ground-moraine" of the geologist. This can hold relatively small amount of water. But this compact material is the minor portion of the visible deposits. The moraines, hills and ranges of glacial origin, in central New York are largely water-laid, gravel and sand, dropped by the loaded streams which drained the ice sheet, and by the lakes held in the ice-dammed valleys. The invisible deposits in the valleys are doubtless similar to the deposits open to view.

Four classes of earth materials contributed to the deposits in the old valley. (1.) The materials pushed and rubbed into the valley by direct action of the ice sheet. This is the rock-rubbish, boulders and stony clay, similar to the "till" and "soil" of upland surfaces. (2.) Gravel and sand, washed in by the streams which flowed from the melting ice. (3.) Sand and silt deposited by the lakes that fronted the ice border during both the advance and the recession of the ice front. (4.) Sand and silt washed in by the streams from the uplands. Some suggestion in order of deposition is given below, and in figure 6.

The nature and proportions of these materials must vary from place to place, and in cross sections of the valleys. No drilling has yet penetrated the full depth of the filling. The deepest well is the one three miles north of Dansville, to depth of 450 feet, the record of which is not available.

A general succession of the deposits is suggested by the theoretic physical processes in the glacial history. Students of the history in the valley of the Mississippi River find evidences of more than one advance and removal of ice sheets. Such multiple glaciation has not been proven for New York, and for the present study only one stage of glaciation will be recognized.

We have to do with the effects and phenomena of the oncoming ice sheet; the effects of the overriding ice; and the effects and phenomena of the ice removal, the backing away, northward, of the border of the waning glacier. These changing conditions produced variation in the deposits, with, it is supposed, some difference in the succession from the bottom upward. This is suggested in figure 6.

The earliest, and hence the bottom deposit in the filled valleys, must have been the clay, silt and sand laid down in the lakes that occupied the valleys as the advancing ice front blocked the north-

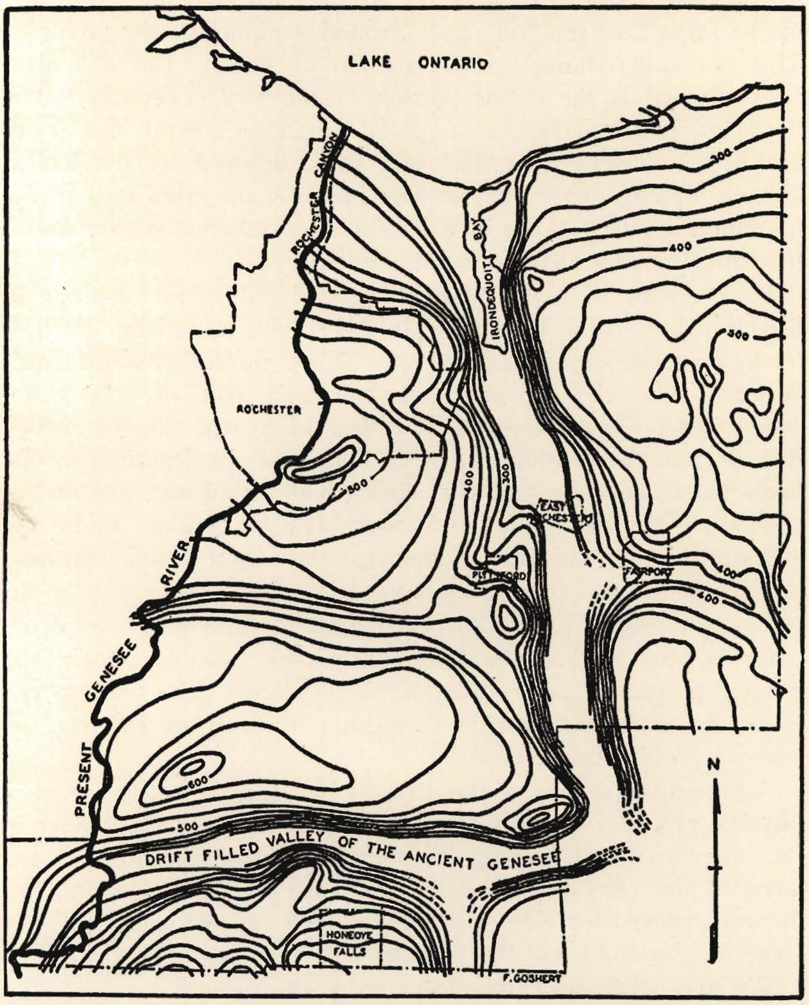

Figure 7. **THE BURIED CANYON OF THE IRONDOGENESEE RIVER**
Preliminary mapping by the Monroe County Regional Planning Board

flowing rivers. On the lake silts would be laid as the next deposit the gravel and sand supplied in quantity by the loaded streams that drained the melting ice sheet as it advanced; for it should be under-stood that the margin of the ice sheet was melting during the on-coming of the glacier as well as during its removal. The ice sheet expanded only because the push exceeded the melting.

The copious outwash of the coarse stream detritus derived from the ice sheet was the more abundant early deposit. Its depth can be learned only by deep probing to the rock bottom of the old valleys.

During the time, probably hundreds of thousands of years, that the continental glacier held New York in cold storage some amount of ice-laid material, stony clay-like stuff, rock-rubbish and boulders were rubbed into the valleys.

During the removal of the ice sheet the physical process was, in a general way, the reverse of that during the ice advance. Gravel and sand from the glacial outwash, capped the ice-laid drift, and in turn this was covered by the lake deposits, with included boulders rafted in by floating ice blocks. Such boulders are sometimes cause of trouble and delay in drilling.[3]

The lakes held in the valleys during the ice-front recession, probably for centuries, were responsible for most of the surface deposits in the old valleys; of finer and compact material, which largely serves as the cover for the artesian water.

The theoretical vertical succession of the valley deposits is summarized as follows. The time succession is the numerical order, as in figure 6.

6. Sand and silt from existing streams, especially in flood.
5. Glacial lake deposits, silt and sand, during the ice sheet removal; with ice-rafted boulders. (Similar to No. 3.)
4. Gravel and sand, outwash from the ice sheet by the glacial streams. (Similar to No. 2.)
3. Ice-laid drift, unassorted material, stony clay, boulders, etc.
2. Gravel and sand, outwash from the ice sheet during its advance.
1. Glacial lake sand and silt, during the ice advance.

Hydrography of the Genesee Valley

Precipitation on the Drainage Area

Reports of the U. S. Weather Bureau give the records of twelve stations in the Genesee Valley, tabulated below in geographic order

[3] Working in glacial deposits the drillers are liable to report "bed-rock" when they have merely encountered a boulder or rafted block of stone, or perhaps only cemented gravel. Records of "depth to rock" should be verified.

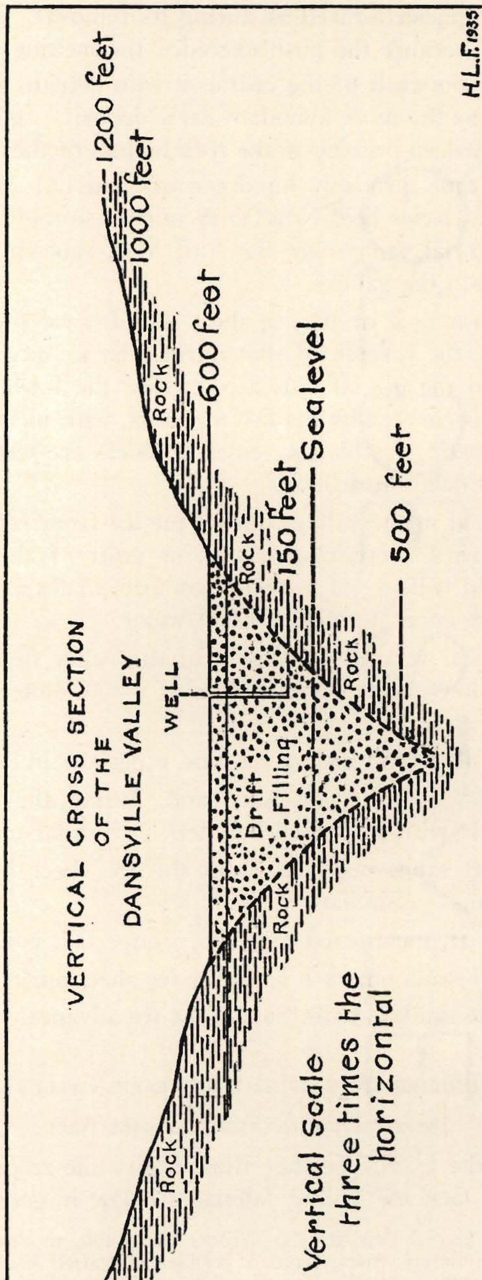

Figure 8. **CROSS SECTION OF THE DANSVILLE BURIED VALLEY**
At the site of the flowing artesian well

from south to north. The discrepancies between near-by stations suggest probable deficiency in measurement (table 4).

TABLE 4

Genesee Valley Precipitation—Annual Average: in inches

Stations	*Record*	*Feet over Ocean*	*Years*	*Period*
Andover	32.20	1,650	8	1922–1930
Friendship	36.23	1,550	9	1877–1896
Angelica	36.29	1,420	39	1889–1930
Hunt	33.59	1,150	15	1902–1919
Letchworth Park	28.08	1,260	16	1913–1930
Dansville	26.65	703	12	1919–1930
Mount Morris	28.14	640	5	1890–1900
Hemlock	29.43	920	32	1899–1930
York	29.87	700	14	1912–1925
LeRoy	36.45	900	15	1885–1911
Avon	28.42	585	38	1891–1930
Brockport	33.26	537	31	1900–1930
Average for the valley	31.55			

It will be seen that stations on the south with higher altitude have heavier precipitation, five stations averaging 33.48 inches; while seven stations on lower ground average 30.32 inches. Stations either side of the Genesee area have high records, up to over 50 inches on the west. With the high borders of the valley poorly represented it appears that the figure for the whole drainage area should be more than 31.55 inches. Rochester, with accurate observation, has a 60-year average of 33.23 inches. For reasons stated below Rochester is not here included. However, in order to keep within conservative limitations, and also for easier computation, the figure of 32 inches will be adopted. It should be noted that any larger figure would increase the estimates for evaporation and for ultimate removal by the deep-seepage.

A complication now appears which has to be considered in all the estimates and calculations to follow. Two areas of precipitation and drainage must be recognized. One is the present surface drainage area of the river, the "watershed," taken as 2,476 square miles. The other is the area which was drained by the Irondogenesee (figures 1.5), estimated as 300 square miles greater than the existing Genesee drainage. The deep ground water of this greater area even now finds ultimate escape through the drift-filled valley into Lake Ontario.

For the subsequent calculations the area of Genesee surface drainage to be used is that of the Elmwood Avenue gaging station, 2.450 square miles. The area of precipitation and deep-seepage is 2.750 square miles.

Removal of the Water; Three Factors

The removal of the atmospheric water, taken as 32 inches every year, is carried away from the 2.750 square miles in three processes. (1.) By the run-off, the surface flow, concentrated in the Genesee River. (2.) By evaporation, including the transpiration through vegetation, the fly-off. (3.) Deep-seepage, the underground flow of the water that is absorbed by the ground and which does not reappear at the surface. Some of the ground water does reappear as springs, but this becomes part of the river flow and is included in the run-off. In very dry season the river is wholly supplied from the ground water. The deep-seepage in the Genesee drainage province finds escape through the drift-filled, abandoned valley into the depths of Lake Ontario.

Two of the factors involved are measurable, in approximation, the precipitation and the run-off. The difference in volume between those two is the combined volume of both the fly-off and the deep-seepage. As these cannot be directly measured they must be estimated. The volume of water escaping through the old buried valley is the special quest of this quantitative study.

Constants and Quantities

In order to save from repetition and to enable the reader to verify the calculations, the quantitative elements used in the following pages are here given.

One gallon of water has weight, $8\frac{1}{3}$ pounds.

One cubic foot of water has weight, 62.32 pounds.

One inch of water on one acre, 113 tons.

One inch of water on one square mile, 72,320 tons.

One gallon of water is 231 cubic inches.

One cubic foot of water is 1,728 cubic inches.

One cubic foot of water is 7.48 gallons.

On one square foot 32 inches depth of water is 19.95 gallons.

One acre is 43,560 square feet.

One square mile is 27,878,400 square feet.

One square mile with 32 inches of water carries 556,174,080 gallons.

Total drainage by Genesee River, 2,476 square miles.

Preglacial drainage, Irondogenesee River (estimated) 2,776 square miles.

Run-off of the Genesee River

In volume and regimen of flow the Genesee River is affected by a complex of physical factors; change in land elevation and climate, varying precipitation, radical difference in channel conditions, and the unusual factor of permanent ground absorption in large amount of the precipitation.

Heading in Pennsylvania, in the elevated Allegheny Plateau, its northward course is in the old intrenched valley through the highland, and later on the Ontario lowland (figure 9). Precipitation is heavier on the highland. The permanent ground absorption, the deep-seepage, is partly effective in the upper valley, above Portageville, and largely over the abandoned East Branch Valley (figure 5). North of Portageville the river is not directly affected by the deep-seepage, and north of the old valley through Rush, Mendon, Fishers, there is no loss of water by ground absorption.

We have run-off records of five river-gaging stations. On the map, figure 5, the locations are marked by heavy bars across the line of the river. The Scio station checks on the headwaters flow.

The St. Helena station is in the post glacial course of the river, between the Portage and the Mount Morris canyons. The Jones Bridge station is a few miles north of Mount Morris, on the wide plain of filling in the ancient trunk valley. Elmwood Avenue station, at the south edge of Rochester, was abandoned in 1918 when the Rochester harbor of the Barge Canal was created. Its record, however, is sufficient to serve for the following calculations on the three elements, run-off, fly-off and deep-seepage.

Driving Park Avenue station, in the north part of Rochester, includes in the gaging the surplus Barge Canal water from Lake Erie. This matter is discussed below.

The following tabulations certainly give an approximation to the truth. The run-off data are from the U. S. Geological survey, courtesy of Arthur W. Harrington, District Engineer. The precipitation data are from reports of the U. S. Weather Bureau.

TABLE 5

Precipitation and Run-off

	Stations			
	Scio	*St. Helena*	*Jones Bridge*	*Average*
Estimated precipitation, in inches	34.72	35.18	32.59	34.16
Measured run-off, in inches ...	17.78	16.70	15.48	16.65
Remainder, in inches	16.94	18.48	17.11	17.51
Run-off, percentage of total ...	51	47.5	47	48.5
Remainder, in percentage, includes evaporation and the deep-seepage	49	52.5	53	51.5

TABLE 6

Precipitation and Run-off in Daily Gallons

Gaging Stations, and years	*Drainage area, in square miles*	*Daily Precipitation*	*Daily Run-off*	*Percentage in Run-off*
Scio .... (1919–1934)	309	470,843,262	226,841,472	48.18
St. Helena ...... (1918–1933)	1,017	1,549,668,601	740,627,712	47.79
Jones Bridge .... (1917–1933)	1,419	2,162,221,971	1,053,423,360	48.72
Elmwood Ave. .. (1908–1918)	2,450	3,733,223,277	1,635,068,160	43.80
Driving Park Ave. (1926–1933)	2,467	3,759,127,275	1,421,798,400	37.82

In the above table, No. 6, the estimates for the Driving Park Avenue Station are inserted for comparison, but require some explanation. As previously stated, the river through Rochester carries surplus Lake Erie water from the Barge Canal.

With close estimate of that extra water deducted the actual river flow for the last eight years is taken as 2,200 second feet, and that figure is the basis of the calculation.

But a climatic factor enters here. The last eight years include exceptionally dry years. The Rochester Weather Bureau record of precipitation for 62 years averages 33.19 inches, but for the last eight years only 30.43. The Rochester figures are significant for comparison, and in illustration of variable hydrographic conditions. The figures for the first three stations include the dry years to 1934.

Evaporation; the Fly-off

This factor in removal of the precipitation is indefinite and uncertain. Complex and variable conditions of the precipitation, in amount, character and distribution in time; character of the land surface, in composition and attitude; character of the vegetation and forest cover; soil cultivation and drainage; and especially temperature and winds following storms. These variables make any large area individual and distinctive.

Test measurements in the field are manifestly impractical. Experimental tests in laboratory and under artificial conditions are poor suggestion.

In regions where there is no ultimate removal by underground flow the evaporation, or the total fly-off must account along with the run-off for all the atmospheric supply. The Genesee area is somewhat exceptional. In cloudiness it ranks high. Most of the area is in cultivation, only the head district retaining much forest cover. The glacial mantle on the uplands is normal in volume and composition, but the wide valleys are loaded with absorbant drift.

These conditions suggest that the evaporation factor may be less than the average for the climatic province. However, the concession is made that the evaporation exceeds the deep-seepage removal. Assuming that the run-off may be fifty per cent of the total precipitation, we may allow thirty per cent for evaporation and twenty per cent for the invisible, underground removal, available for artesian water supply. The volumes, in daily gallons, will be stated below.

Deep-Seepage; the Underground Flow

In this study the term deep-seepage is applied to the volume of water which sinks into the ground and does not reappear. Of course some reappears at the surface as springs, but that in the Genesee drainage area is included in the run-off. A large volume of water is gushing up on the flats and contributing to the river flow. The flowing Dansville well is a fine example. Honeoye and Irondequoit creeks are partly supplied from the underground water. And probably the river between Avon and Mount Morris and above Portageville is also nourished from the subterranean supply. This all implies that the capacious valley fillings are unable to transmit all of the water which seeps into the ground.

In ancient, preglacial, time the Irondogenesee and its tributaries were flowing in rock-walled canyons and there was no deep-seepage, because all of the water which sank into the shallow earth mantle eventually found its way into the open streams. The same condition is true today of the streams and valleys outside the glaciated territory.

Today the Genesee below Mount Morris to Avon is idly swinging on the surface of the deep drift filling, while below Avon the ancient valley is buried and abandoned by the river. This gives the underground water a great invisible filtration conduit passing through the Irondequoit basin into the depth of Lake Ontario. It is only this invisible escape of the ground seepage that is included in the "deep-seepage." However, any water which pours up from deep in the valley filling and counts as run-off is yet available as pure, filtered water.

Volume of the Underground Water

Estimates of the Deep-Seepage

The quantity of water transmitted by the buried valley of the ancient Genesee has both scientific and economic interest. As a source of artesian supply it may be practically inexhaustible, but the volume should be approximately determined.

Theoretically the volume is the balance of the precipitation over 2,750 square miles after the run-off and the fly-off have been deducted. In a preceding chapter it has been concluded that the deep-seepage may be estimated as twenty per cent of the precipitation. That proportion must now be found as expressed in daily gallons. For this calculation the areas of the present and the ancient rivers will be compared, using the areas south of Elmwood Avenue gaging station.

Comparison with Evaporation and Run-off

In the following table the annual precicpitation is taken as 32 inches. The comparison, for gallons, is between the area of underground drainage in the ancient valley (figure 5) and the Genesee surface drainage area above Elmwood Avenue station, at Rochester.

Table 7

Water Disposal, in Daily Gallons

	On 2,750 square miles	*On 2,450 square miles*
Precipitation yearly	1,529,478,720,000	1,362,626,496,000
Daily precipitation	4,190,352,657	3,733,223,277
River run-off, 50%	2,095,176,329	1,866,611,638
Evaporation, 30%	1,257,105,797	1,119,966,983
Deep-Seepage, 20%	838,070,532	746,644,655

Capacity of the Ground Conduit

In view of the surprising volume of water escaping through the drift filling in the valley abandoned by the river, approaching a billion daily gallons, it is desirable to question the capacity of the filter conduit. This involves the cross-section area of the filling and the character of the filling materials, as related to the transmission of the fluid.

The depth of the filling at Rochester Junction is certainly more than 680 feet. Estimating from geologic considerations the depth is probably more than 1,000 feet.

The width of the buried valley is obscured, at Rochester Junction, by hills of glacial deposition. But, judging from the open stretches above Avon, it may be taken as one mile. Then the cross-section area is a triangle, with base 5,280 feet and height (inverted) of 1,000 feet. The area is, therefore, 2,640,000 square feet. But as the walls of the buried canyon are not straight, but convex, some reduction in that area must be made. Suppose that we use only 2,000,000 square feet.

To pass the daily flow, as given in the table above, would require that each square foot of the cross-section, on the average, must pass 419 gallons in 24 hours; or 17.5 gallons per hour. Of course the seepage is under pressure of the hydraulic head of the water upstream, and especially of the water in the tall hills of porous drift which border the valley, particularly at and above Dansville, about Portageville and in the region southeast and east of Rochester Junction.

The theoretic succession and composition of the valley-filling materials have been given in an earlier chapter. It is a fact that the material deposited directly by the mechanical action of the ice sheet has relatively small porosity and function of fluid transmission. The quantitative proportion of the ice-laid drift to the porous, water-laid material can not be known. One half the total is thought to be a generous estimate. So, if we reduce the transmission or seepage capacity of the drift filling to one half the above figures for cross-section, then the aquifers or water-bearing portions must average per square foot 838 daily gallons, and 35 gallons per hour. Hydraulic engineers may check these figures.

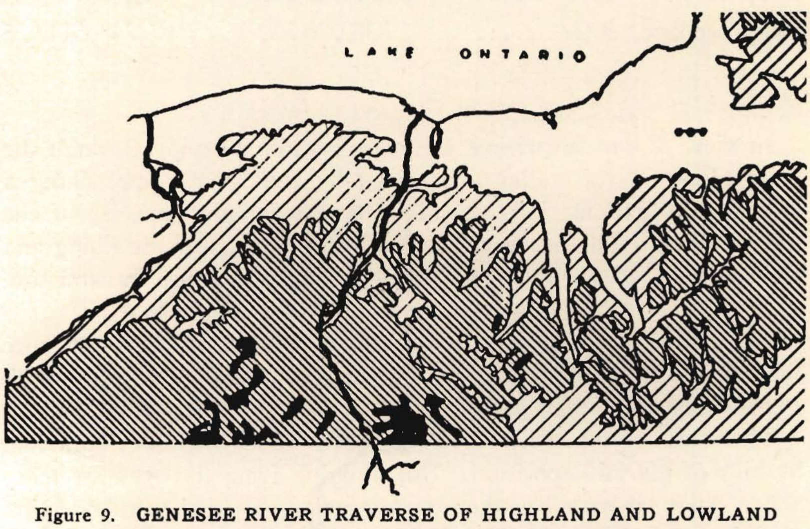

Figure 9. GENESEE RIVER TRAVERSE OF HIGHLAND AND LOWLAND

It is evident that the valley filling at least below Avon, through Rush, Mendon and Fishers, is fully loaded and transmitting all the volume of water of which it is capable. Numerous copious springs are pouring up on the flats continuously. The Honeoye and Irondequoit creeks are supplied in part from the underground water. And it is probable that the river between Avon and Mount Morris, and above Portageville is supplied in dry seasons from upwelling, ground water. And in very dry seasons all the flow of the river is derived from ground water.

Many examples of the springs gushing on the surface of the valley filling could be given. The most notable in the Leighton well, three miles northwest of Dansville (figure 8). This is a genuine artesian well, opened to the depth of 450 feet, in the year 1924, in the search for gas. It was stated that the pressure was 75 pounds per square inch. The 10-inch pipe was capped, but a large volume of water has been continuously escaping from and around the pipe, as a contribution to Canaseraga Creek. The flow is entirely indifferent to climatic changes.

A group of heavy-flow springs, southeast of Pittsford, on the west edge of the filled Irondequoit Valley has, from immemorial time, contributed heavily to Irondequoit Creek.

Near Sibleyville, in the Honeoye Valley the copious Jenner spring has long supplied a salable mineral water.

At the crossing of the Lehigh Valley R. R. by Clover Road a living spring was brought into life when a 5-inch pipe was withdrawn from a depth of 50 feet.

Many other examples could be given.

Quality of the Artesian Water

The ground water in the valley filling reflects in mineral content the composition of the drift filter and the nature of the enclosing rock strata.

Except for the short east and west stretch of the buried valley the drainage areas of both the existing and the ancient rivers are practically devoid of soluble minerals. South of the parallel of Avon the strata are sandstone and shale with only negligible limestone. Close north of Avon is the outcrop of the Onondaga limestone, extending east and west, passing through Honeoye Falls. This is underlain by the thick Salina shales, which, because of their nonresistance to atmospheric agencies, caused the development of the east and west valley at Rush, Mendon, Fishers.

The upper beds of the Salina contain sulphates (anhydrite and gypsum). The rock salt (halite) in the strata, reached by shaft-mining north of Mount Morris, lies below the ancient valley bottom.

The surface waters in the enclosing belt of Salina strata carry carbonates and sulphates, and some of the springs yield mineral water, derived from the leaching of the exposed and surficial rocks. Yet, at no great distance down the valley (northward) at East

Rochester the wells, with depth less than 200 feet, produce water with hardness of about 200 parts per million.

The important fact in this connection is that the water from some depth in the valley filling is not affected by the soluble content of the rocks in the Salina belt. The surface and mineralized waters in that belt cannot mingle with the deeper water but are kept surficial and are drained off into Irondequoit and Honeoye creeks. The deeper water is mainly derived from up-state, and from the East Branch filling. It is under considerable, but as yet unmeasured, pressure from its hydraulic head. The drift filling in the lower stretch of the valley is not competent to transmit all of the ground water, in consequence of which there is flowage toward the surface; and the surface water, from the local land drainage, including the mineralized Salina water, is compelled to remain in surface flow.

Artesian water supply for domestic and heavy service taken from the old valley filling should come from depths of more than 200 feet. At the greater depths the water will probably have hardness less than 200 p. p. m., and be comparable to, or better, than the Dansville Well water. In all respects except the hardness the artesian water is superior to any surface supply.

Excessive hardness is readily removed by softening processes that are chemically and economically successful; but that is beyond the scope of this article.

Utilization of the Underground Water

Until the present time no use has been made of the available artesian supply. In this geographic province of sufficient precipitation, of topographic relief and upland lakes, only surface water has been in mind.

Three shallow wells are now installed. The village of East Rochester has one well completed and another nearly finished. The No. 1 well, to depth of 160 feet, is planned to yield 700 gallons per minute; but it is tested to 1,600,000 daily gallons, and is believed capable of yielding over 4,000,000 daily gallons. The second well is of equal capacity.

South of East Rochester, on the Marsh Road, the Monroe Golf Club has a well on the eastern rim of the buried ravine, with depth to rock of 158 feet, intended to yield 500 gallons per minute.

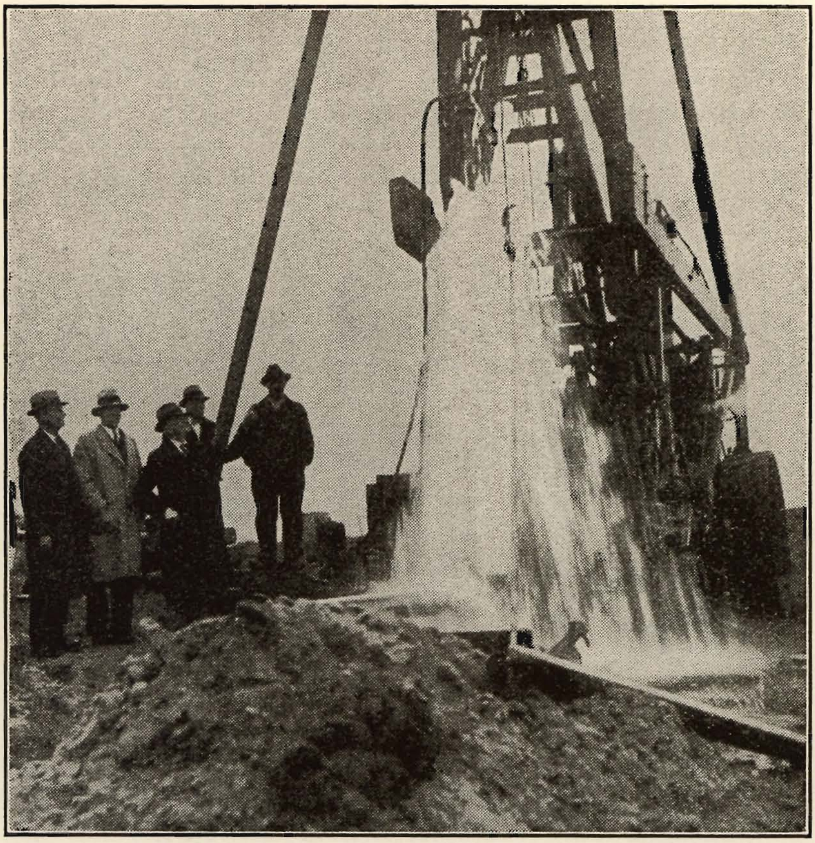

Figure 10. **EAST ROCHESTER ARTESIAN WELL, NO. 1**
Preliminary test, November 8, 1934

SUMMARY; ECONOMIC

Two elements in the Genesee hydrography have an economic bearing; the run-off, as a source of energy and the deep-seepage as an available supply of pure, filtered artesian water.

The ancient, preglacial, drainage of western and central New York, with its high elevation and deep valleys, was dismembered by the overriding ice sheet, the Quebec continental glacier. The east branch of the Irondogenesee, the Canandaigua—Dansville branch, was deeply filled with glacial, lake and stream deposits that supplanted the river. The upper portion of the west branch, above Portageville, was only partially filled, but the stretch between

Portageville and the junction with the east branch was blocked by the drift filling and abandoned by the river.

The famous Portage Canyon and High Banks, in the Letchworth State Park, and the Mount Morris High Banks represent the recent postglacial diversion of the river. And another diversion is the final stretch from Avon northward to Lake Ontario that includes the Rochester ravine.

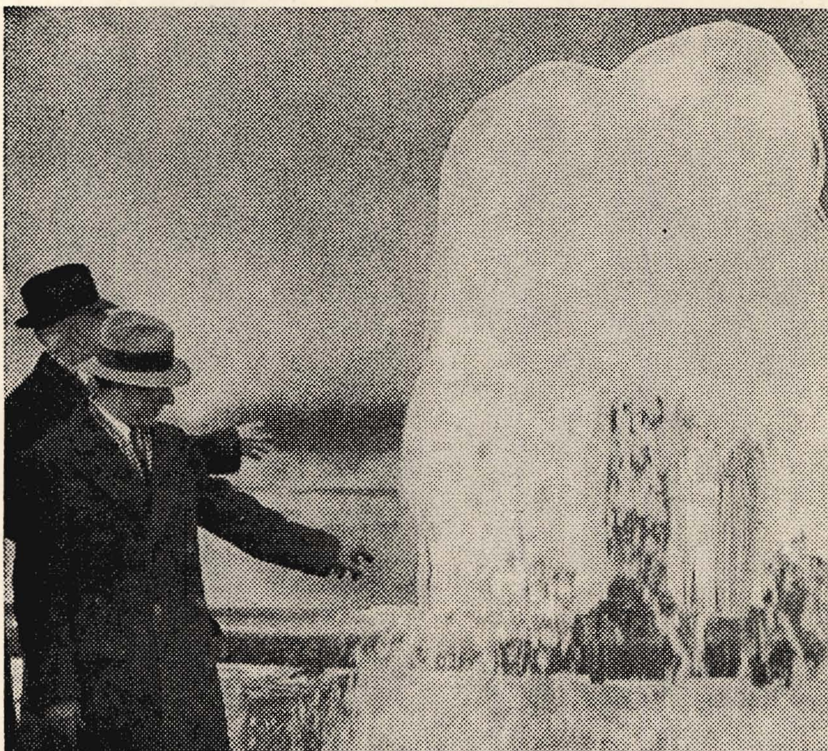

Figure 11. **EAST ROCHESTER ARTESIAN WELL, NO. 1**
Final test, February 13, 1935

From Mount Morris to four miles below (north of) Avon the river is now meandering on the wide plain, the lake-smoothed surface of the deep glacial filling in the trunk valley. This filling continues eastward in the abandoned valley and then northward by Irondequoit Valley to Lake Ontario. The existing river, with its young ravines, is a weak descendent of its preglacial ancestor with wide valleys and deep canyons.

For many years the flow of the Genesee has been gaged by the U. S. Geological Survey and the Rochester Gas & Electric Corporation. The records show that somewhat less than one half of the thirty-odd inches of annual precipitation over the drainage area is carried away by surface run-off. Fifty per cent, or more, of the atmospheric water is removed by two agencies, evaporation, the fly off, and underground escape through the old, buried valley, the "deep-seepage." The precipitation data are on record in the publications of the U. S. Weather Bureau.

The water that sinks into the ground beyond reach of the vegetation follows the sloping rock surfaces and the drift-filled channels and concentrates in the old buried rock-walled valley, similar to the flow in the ancient valleys, open to the sky, in preglacial time. A large proportion of the ground-absorption water never emerges as springs, but as the deep-seepage it escapes invisibly into the depths of Lake Ontario. And the deep-seepage is not merely of the present river watershed but of the greater area that was drained by the ancient river.

With conservative estimates and minimum proportions it is calculated that the ultimate underground removal, the deep-seepage, is not less than twenty per cent of the precipitation, or 838 million gallons daily.

In the east-west stretch of the buried valley, beneath Rush, Mendon, Fishers, the drift filling is over 680 feet in depth, and probably is over 1,000 feet. The cross-section of the drift filling is roughly estimated at about two million square feet. To pass the deep-seepage required that each square foot should transmit, on an average, about 419 gallons daily, or 17.5 gallons per hour.

Regardless of any and all estimates and computations it is certain that the drift filling is transmitting, under pressure, all the water of which it is capable. This is proven by the numerous copious springs that are upwelling on the valley plain. Honeoye and Irondequoit creeks are well supplied from the underground surplus. The high-pressure flow of the Dansville well shows the abundance of artesian water, under hydraulic head, in the old east branch valley.

The chemistry of the artesian water has interesting variation due to the rock relations. The surficial water in east-west stretch of the valley is highly mineralized from contact with the Salina shales. But the wells at East Rochester, with depth less than 200 feet in the filling have hardness of only about 200 parts per million. The flowing Dansville well, depth 450 feet, and similar hardness indicates that the deeper water, from up-state on the south has only the moderate hardness characteristic of pure, spring water from nature's filter.

Test wells in the old valley are not required to prove abundance and quality of the artesian water, although necessary for location of service wells. Deep drilling is desirable to determine the water pressure at varying depths, and to learn the probability of artesian flow; also to find the depth and dimensions of the old valley as a matter of geologic interest.

Bibliography

From an extended list of writings on the geology and physiography of the Genesee Valley the following titles are selected as relating to the changes in drainage and to the surface and subsurface waters.

1. Glacial Genesee lakes. Geol. Soc. Amer., Bull. 7, 1896, 423–452.
2. Direction of preglacial stream-flow in New York. Amer. Geologist, 33, 1904, 43–45.
3. Pleistocene history of the Genesee Valley in the Portage district. N. Y. State Museum, Bull. 118, 1908, 70–84.
4. Drainage evolution in central New York. (abstract). Science 29, 1909, 632, 633. Geol. Soc. Amer., Bull. 20, 1010, 668–670.
5. Geologic history of the Genesee Valley. In "History of the Genesee Country." Chicago, 1925, pages 15–110, 37 plates.
6. The Dansville Valley and drainage history of western New York. Rochester Acad. Sci., Proc. 6, 1926, 217–242, 8 plates.
7. Evolution of the Genesee River. Rochester Gas & Electric News. 15, 1927, 113–122.
8. Geologic story of the Genesee and western New York. Rochester 1928, pages 105–136.
9. Artesian water in the Genesee Valley. The Rochester Engineer. 8, 1930, 236–243.
10. Artesian water available for the City of Rochester. Rochester Democrat & Chronicle. July 27, 1934.
11. The Dansville artesian well. Rochester Democrat & Chronicle. August 19, 1934.

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