With the Compliments of

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REPORT OF A COMMISSION

APPOINTED TO CONSIDER

A GENERAL SYSTEM OF DRAINAGE

FOR THE

VALLEYS

OF

MYSTIC, BLACKSTONE, AND CHARLES RIVERS,

Hale.

MASSACHUSETTS, U. S. A.

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CONSIDER A GENERAL SYSTEM OF DRAINAGE FOR THE VALLEYS OF THE MYSTIC, BLACKSTONE AND CHARLES RIVERS.

To His Excellency the Governor of the Commonwealth of Massachusetts.

SIR: — The undersigned commissioners appointed to consider and report systems of drainage for the Mystic, Blackstone and Charles rivers, and for some other purposes recited in a resolve of the legislature, which received your official approval on the twenty-eighth day of May, 1884, beg leave to state that they have attended to the duty assigned them, and desire to submit the following report: —

The resolve under which they acted directed them to consider and report a general system of drainage for the relief of the valleys of the Mystic, Blackstone and Charles rivers, and for the protection of the public water supplies of the cities and towns situated within the basins of said rivers; also to consider the various methods of disposal of sewage, and the application of such methods to any portion of the territory mentioned in the resolve. They may further consider and report upon the needs of any other portion of the Commonwealth as to the disposal of sewage and the protection of the public water supplies therein. The commissioners were empowered to employ such engineering and other assistance as might be necessary to carry out the designated objects, and were directed to include in their report suitable maps and plans of the territory to be drained. They were empowered to expend, for all the purposes of the commission, such a sum, not exceeding twenty thousand dollars, as might be found necessary.

The commissioners first met and organized July 9, 1884, and immediately set themselves to study in person the localities especially indicated by the legislature. The water supply and sewerage systems of Boston were carefully inspected, and the valleys of the Mystic and Charles visited and traversed with minute fidelity. The Blackstone River was followed down from the outfall of the Worcester sewer to the town of Blackstone, and its condition noted. The commission also gave a hearing at Millbury, at which the people inhabiting the valley were invited and encouraged to present their views. The city of Worcester was also requested to send representatives, and was, in fact, present by its mayor and corporation counsel. The commissioners have visited and examined the State Prison at Concord, the Woman's Prison at Sherborn, the State Lunatic Asylum at Danvers, and many other localities where they deemed a personal inspection advisable, or where interesting experiments in sewerage were known to be on trial. They caused circulars to be addressed to all the cities and towns in the Commonwealth which they thought might be in any way interested in the subjects of investigation, explaining the object of the commission and inviting correspondence or suggestion. Being well aware how largely the value and weight of their recommendations would depend on the character of the professional assistance upon which they must rely for a great part of their facts, the commissioners devoted their early and earnest attention to the organization of an engineering staff. They were fortunate in securing as head of that department an engineer whose previous experience had peculiarly fitted him for their purpose. Mr. Eliot C. Clarke was just closing a prolonged engagement as Assistant Engineer of the Improved Sewerage Works of the city of Boston. In that employment it had been his business to study the whole subject of sewerage and water supply, and to familiarize himself with all practical details of such works. His services have proved of the highest value to the commission, and his thorough and exhaustive report, which is printed herewith, supplies with minute precision all the specific information which may be found necessary to sustain and illustrate the more condensed conclusions of this report. Mr. Clarke has spared no pains to obtain the latest information, to observe the most recent experiments, and to collect a mass of reliable engineering data which adds great force and validity to his conclusions. One of the doubtful points in the sewage problem being the possibility of disposing of sewage upon land during the protracted severe frosts of our climate, he visited Pullman, at the request of the commission, to observe the actual operation in progress during cold more extreme than that of a New England winter. In the summer of 1885 he crossed over to England, in order to verify, by personal inspection, the accuracy of the printed statements regarding a great number of sewerage experiments which are undergoing practical trial in that country. There, he had a good opportunity to estimate by actual observation the amount and kind of injury, if any, which the establishment of a sewage farm, or filter-bed, inflicts upon persons or property in its vicinity, and especially during the periods of highest temperature. No labor has been spared, and a large sum of money has been spent, to obtain a thorough comprehension of the subject given us in charge, and to ensure a patient search for the most economical and effective remedies.

From the fact that previous commissions had reported heretofore upon the more important parts of the districts mentioned in the resolve establishing this board, we were forced to infer that the legislature required something more or something different from the information already at their disposal. The Metropolitan Drainage Commission, for example, made a very valuable report upon the Mystic Valley, with an estimate of cost, in 1882, and in the same year the State Board of Health, Lunacy and Charity made a careful and elaborate report upon the Worcester sewage and the Blackstone River. In the former of them, the commission say that "it would be impossible to decide satisfactorily upon the details of plans for the drainage of so extensive a district, without a mass of information much more costly to obtain than we have felt justified in procuring." They felt obliged, therefore, to assume the total cost at a lump sum, which was not arrived at by any specific and accurate investigation. Presuming that it was in part this lack of precise detail which the present commission was appointed to supply, we early set ourselves to ascertain the cost of a complete collection of engineering information, sufficient to enable us to fix with approximate certainty the actual cost of works which we might recommend. We found that the sum of twenty thousand dollars, which had been thought to be enough, would prove too little for the kind of investigation which we conceived to be essential for our report. We decided, accordingly, to apply to the legislature of 1885 for more money than had been originally appropriated. We based this fresh call expressly upon the ground that it was necessary to make this report exceedingly minute and detailed, in order that the practicability and cost of the plans recommended might be assured and precisely defined. The legislature, concurring in this view of the undertaking, authorized a further expenditure of thirteen thousand dollars, if required. Of this sum it was thought that about five thousand dollars would be necessary for a careful survey of the Neponset river and valley, in the prosecution of which the Joint Standing Committee of the Legislature expressed much interest and to which they urgently directed our attention. And the commissioners desire to to say that the quality of the lands and waters, the nature of their surroundings, and the adaptability or otherwise of the various situations for sewerage operations of different kinds, together with all the engineering facts upon which the practicability or expediency of such difficult and expensive works depend, have been in each case accurately ascertained and considered. It has been our aim to prepare the estimates of cost with such care that they may be used for framing contracts for actual construction, and we think they may be relied upon as safe and conservative.

In addition to the observation of contemporary experiment and attention to practical detail, the commissioners have endeavored to master the theoretical and historical literature of the subject, and to become familiar with the results of previous investigations here and elsewhere, as well as the reports upon cognate matters which have been called for by the legislature, or obtained by public boards or municipal authorities in this State. These publications, not less than independent inquiry, strongly impressed upon us the extreme costliness of such extensive drainage works as the Resolve seems to contemplate, and we may as well preface what we have to say by admitting frankly the great importance which we have invariably attached to the relative expense of different plans. We felt that the necessity of strict economy should not be lost sight of for a moment. Sewerage at its cheapest is very dear, and it must always be remembered that the communities which will be called upon to pay for this improved sewerage are already heavily taxed and often deeply in debt, and it may well be that a project for their relief might be so admirable that it would be ruinous. People can hardly be blamed if they prefer enduring a good deal of discomfort and considerable jeopardy to health rather than face possible bankruptcy and certain impoverishment. Nor were we unmindful of the many other importunate demands for needful municipal outlay besides this. We felt obliged, therefore, to approach all proposals from the pecuniary point of view, feeling that it would be futile to recommend anything which would be, in a money sense, impracticable, no matter how brilliant might be its theoretical promise. In submitting our conclusions, therefore, we feel justified in claiming to have given careful consideration to every bearing of each case which our experience or that of our expert assistants could suggest, and the course finally adopted has been the one which, upon weighing every contingency, seemed to us, upon the whole, obnoxious to the fewest objections. In order to lessen as far as possible the liability to error or oversight, we thought it best to submit our conclusions, when they had reached a certain degree of maturity and assumed a sufficiently definite form, to the revisal and criticism of high professional authority. Messrs. Joseph P. Davis of New York, and Rudolph Hering of Philadelphia, were accordingly called in as consulting engineers, to scrutinize and review the facts, figures and proposals which the engineer of the commission had submitted in a preliminary report to us and which had been by us provisionally accepted. The reputation of these gentlemen is such, and the personal experience and special knowledge of the former, in respect to these particular problems, so well known, that we felt sure that we might confidently accept their judgment as final, in case they should be able to agree. By their report, which may be found annexed, it will be seen that, after careful study and inspection, they concur in the views of Mr. Clarke in all essential particulars, and unite in the opinion that his plans and recommendations are well considered, and the best attainable under the circumstances.

We interpreted the language used in the resolve which directed us to report measures for the relief of certain districts, to relieve us of the burden of proving the need of relief. We construed the terms chosen to import an assumption by the legislature that a condition of things existed now, or was likely soon to exist, which called for some remedial measures, and it was the character of these measures, and not the question of their necessity, which it was given us in charge to determine. We have accordingly expended comparatively little energy or funds in estimating the precise amount of evil which the lack of drainage has inflicted or is likely to inflict upon the lands and waters specified in the resolve. We have concerned ourselves in the main with elaborating complete plans in each case for removing any such evil, assuming it to exist. And irrespective of the precise text of our commission, we should have been forced to this conclusion by consulting the reports of our predecessors in the same fields of labor.

And in this connection it seems appropriate to indicate the sources from which we have derived much information bearing upon the subjects of this inquiry, and to which we are greatly indebted for examples of careful examination and able treatment of both the special and general investigations upon which we have been engaged. In 1871, a special report on the pollution of Mystic Pond water, by George Derby and Prof. W. R. Nichols, was printed in the second annual report of the State Board of Health. The next year the legislature resolved, that "the Board of Health be requested to consider the general subject of the disposition of the sewage of towns and cities, having in view, first, its utilization as a fertilizer; second, sanitary effects of draining the same into the waters of the Commonwealth; third, the increasing joint use of water courses for sewers and as sources of supply for domestic use by the people of the Commonwealth." In compliance with this direction, that board, in the following year, made a special, very interesting, comprehensive and instructive report on sewage and sewerage; the pollution of streams; and the water supply of towns; which may be found in their fourth annual report. In the year 1874 a report was made to the Boston city government by the Mystic Water Board, with plan of Engineer Doane for building sewers in Mystic basin to protect the water supply. Again, the fifth annual report of the State Board of Health contained a special report on the present condition of certain rivers of Massachusetts, together with considerations touching the water supply of towns.

The seventh annual report of the same board contains another special report on the pollution of rivers; the water supply, drainage and sewerage of the State from a sanitary point of view, and the disposal of sewage. And in the very next year it followed this with a further special report on pollution of streams and disposal of sewage, etc.

In 1878, their ninth annual report had a special report on drainage and health, sewerage and pollution of streams.

The legislature of 1881 (chapter 67, General Statutes) requested the State Board of Health to report on the pollution of Blackstone River by Worcester.

In the year 1881 the legislature authorized a commission to consider the drainage of Mystic and Charles River valleys, with the estimate of cost; and the following year that commission made a report of their findings to the legislature, which, with plans, may be found in House Document, No. 4, of the year 1882. During the same year appeared a report of the State Board of Health on the pollution of the Blackstone River. In February and March, 1884, the Joint Standing Committee on Health had a very long and elaborate series of hearings in regard to the pollution of Blackstone River by Worcester. And the same committee for the year 1884 took a large amount of evidence in relation to preventing the pollution of water supplies of cities and towns, which was printed for the use of the legislature.

It will be seen from this catalogue how thoroughly the ground had been gone over by competent workmen, before we were ordered to resume the inquiry, and how much difficulty the legislature has found in dealing with evils which are admitted to exist, are known to be increasing, and which seem to possess enormous vitality.

Before proceeding to define exactly what we think the most expedient thing to do to remove these stubborn and threatening abuses, and to relieve the Mystic, the Charles and the Blackstone, it may serve to prepare the way for the discussion of those cases, and to indicate more clearly the motives which urged us in the direction we have taken in each instance, to attempt to describe here as curtly as may be the present attitude of what may fairly be entitled the science of sewerage. Some such task is especially assigned us in the resolve under which we act: "The commission shall consider the various methods of disposal of sewage, and the application of such methods to any portion of the territory herein mentioned."

Sewerage may be defined as the removal of what is popularly called filth, by water. For the purposes of this report it has been found convenient to consider household sewage, and the pollution of bodies of water by manufactories, separately. Confining ourselves then more particularly to domestic sewerage, it may be said to be largely an outgrowth of the modern systems of water supply. So long as people live thinly scattered over the country, no difficulty arises about the removal of the offensive refuse of living. It is sufficiently solid to be retained in suitable temporary receptacles for a season, and readily taken away from time to time to land where it is valuable as manure. As long as the natural supply of clean water sufficed for the community, so long the simple natural channels of absorption and diffusion were able to carry it away when made dirty by use. Even after the inhabitants in towns became closely packed together, the same methods could be made to answer by enlarging the vaults into cesspools. It is still retained in many large places, but it requires great care in management, and considerable expense to prevent nuisance. Speaking generally, it is found easiest and cheapest to use water as a vehicle for entire removal. Especially is this accepted as almost inevitable when the use of water becomes as lavish as it generally does in our towns when once a public water supply is introduced. Systematic water supply turns "night soil" into mere dirty water, which can hardly be carried away in carts, or permitted to leach away through the ground. It calls for a channel of discharge as swift and capacious as its source of supply. Sewerage works are, so to speak, the corollary of water works, and, in our opinion, should immediately follow their adoption everywhere. Take the city of Boston for an example, on a large scale, of what is done in miniature in half the larger towns in the State. The Mystic and the Sudbury are turned through the city at the rate of thirty million gallons a day. This enormous flood is used, and turned to sewage in the using. It must then be got rid of; but how? To answer this question in each case is the science of sewerage. The simple and obvious way is to let it run into the nearest water. This is the practice of the earliest time, and it is still admitted to be the best where it is entirely practicable. For, earnest as has been the protest of many noted theorists against this apparent waste, yet a great preponderance of evidence has convinced the best modern authorities that the loss is not a real injury. Not that any one denies that human excrement is a good manure. Nor can we controvert the chemist when he offers to prove that every ton of Boston sewage contains two cents' worth of fertilizing matter. Admitting it all, the difficulty of extracting it remains. Practically, no one would take the sewage of Boston as a gift, although in theory it may be a mine of wealth. The truth is, that the excreta and other valuable ingredients are so mixed with heterogeneous and often injurious matters, so altered by chemical changes and so drowned in water, that they are of little or no value. It costs more to get them out than they are worth when saved. Taking all the accessible evidence into account, the very able and distinguished royal commission which lately discussed the whole question of sewage disposal in connection with the great problem of the London sewage, came at last to the conclusion, that "in some very favorable cases a profit may be made without purification, and very frequently the purification may be made without profit; but the two cannot apparently be combined."

Still, though it may be true that the simplest and easiest may yet be the best way of getting rid of sewage, it is not always suitable or safe. For, though diluted so much as to be valueless, it is not diluted enough to be harmless. It retains a facility for decay which makes it an offensive and a dangerous neighbor, and that, too, whether we cast it into the sea, or into estuaries or rivers or brooks. The defilement is often such as to cause alarming mischief. It may answer very well for New York to discharge her sewers directly into the Hudson and East River on either hand, or for St. Louis to drain straight down into the Mississippi at her feet, or for Chicago to lead her sewers into the lake under her very nose; but Boston found that it would not do to use her harbor, spacious as it is, for a cesspool; and London, after having spent twenty millions to empty her sewers ten miles below her on the Thames, now finds even that remote outlet so intolerably offensive, that it must either be pushed on to the open sea, or some means of purification before discharge must be resorted to. Nevertheless, if it can be done effectually and finally, it is undoubtedly cheapest and best to cast the foul water entirely away into a body of clean water so large and so free that all trace of the contamination speedily disappears.

But when the situation does not admit of this disposition, — and this condition may result from a lack of a good outlet as well as from mere distance from the water itself, — we are brought to the discussion of the other systems of disposal of sewage which have obtained the greatest degree of acceptance among professional experts and practical engineers.

First among these are two plans for using earth in much the same way as we have above described water to be frequently used. One of these schemes insists more upon the manurial value of sewage, the other looks only to its purification. The former is known as Broad Irrigation. By this process, the sewage being conducted to land prepared for the purpose, is suffered to flow over it and be taken up in part by the crops raised upon it. In short it is an attempt to extract the element of value from the sewage by using it as a fertilizer in farming. The noxious and offensive elements are thus either beneficially appropriated by crops, or are detained in the soil by mechanical filtration, or by long and repeated exposure to the air are decomposed, oxidized and changed into harmless matters, so that the water which runs off is comparatively pure. More than one hundred towns in England employ this system, and it proves eminently satisfactory where conditions favor its adoption. Its great drawback is the vast area of land required for its successful operation on a large scale. It is stated for example, in our engineer's report, that Boston would require a farm about as large as the entire township of Brookline, if it wished to realize the whole farming value of its sewage. The best English authorities estimate that one acre of land must be set aside for each one hundred persons. When it is remembered that this land must all be tolerably level and fairly dry, some appreciation is reached of the obstacle which this incident presents to the general adoption of this system. There are subsidiary difficulties which will naturally occur to all. It suggests alarming possibilities of farming on a large scale, by municipal corporations. This prospect may well damp the enthusiasm of many who would eagerly welcome such a solution of the sewage problem, if sufficient private farming enterprise were available upon tracts of land convenient and adapted to the purpose. If only the farmers stood ready to take all that might come in every hour of the year, the case were simple enough; but here lies the difficulty. This system proper does not contemplate running to waste any part of the sewage. And this circumstance is important because any elasticity just at this point would materially accelerate its welcome in New England. For weeks and sometimes months of our summer droughts this dirty water charged with stimulating substances might be invaluable to men who had learned how to use it to best advantage. But that is not the proffer which we have to make when we lay out an irrigation farm. Dry or wet, night and day, summer and winter, the same quantity must be taken, or if there be any variation it is likely to be most when the crop needs it least. And it is this obligation which we fancy would dismay our farmers. But in the absence of such a private demand, it is difficult to see how the work can be carried out without the direct intervention of the municipality. Now there are manifest and weighty objections to superadding such delicate functions to the already onerous duties imposed upon our town and city governments. Even apart from the consideration that they seem already sufficiently burdened, it is not probable that such management could be made tolerably economical in the long run, to say nothing of any profit. But it may be said that such a farm ought to command a rent if there is really value in sewage. Possibly this may turn out on trial to be the case. The farm at Pullman is asserted to have more than paid expenses at times. But we have no evidence as yet that private capital is convinced of the practicability of making a profit from such a contract, and even if it were, tenants of such farms would require vigilant watching lest they turn away unwelcome sewage into the nearest water course.

In fine, we believe this system to be admirable, if only a number of somewhat intractable conditions, some of which we have indicated, can be controlled. Where all things can be made to work together in harmony, it offers a reasonable probability of at least reducing the expense of getting rid of sewage to a minimum. Where an arrangement can be made to operate it in combination with filtration, so that private agriculturists may take the sewage in such quantities, and at such times, as they may find best for their crops, and when not desired can turn it upon filter-beds, we think there would be a fair prospect of attaining the largest measure of utilization with the least possible complication and expense.

The second of these plans is known as Intermittent Downward Filtration through porous land. Intermittent filtration, pure and simple, is the converse of irrigation. The latter is the minimum quantity of sewage applied to the maximum area of land, and permits utilization as well as purification to the greatest degree. The former is the application of the maximum quantity of sewage upon the minimum area of land. It permits of only partial utilization, but in our opinion of more perfect purification. It frankly abandons all dreams of profit, and in so doing it gets rid of the two greatest drawbacks to the system of irrigation. Having no crop to consider, much less land will suffice, as it is found that the ground will filter ten times as much sewage as any crop upon it can profitably absorb. Having no farming ventures at stake we are relieved of all the machinery of trade and difficulties of management. Purification, not profit, is the paramount idea. Not that it is impossible, in certain cases, to combine some profitable use with this primary intention, but if so it is a purely secondary consideration. This system is in effect nothing but turning certain tracts of suitable land by skilful preparation into monstrous filters. There is properly no attempt to save any matters held in suspension or solution in the sewage. The object is to get clear of them utterly, whether they be good or bad, precious or worthless, and restore the water to its first estate, pure and undefiled as it bubbled from the spring. And this wonderful transformation is confidently asserted to be brought about by a faithful application of the filtration process. Its advocates maintain that sewage passed through ten feet of prepared earth is good enough for any purpose, and they claim it to be nature's process, and intimate that after all it is a mere question of a little more or less remoteness and every drop of water on earth to-day was sewage not long ago. However that may be, it is sufficient for the present purpose to say that if properly managed it does afford a practicable, economical and efficient means of cleansing sewage. The objections to it are fivefold. It is charged to be wasteful in that it feeds no crop. There is a dread lest so much sewage on so little land should cause offence, especially in midsummer. Doubters are confident that the land must eventually clog. And finally it is thought that the cost of the preparation of the land will be excessive, or that the carelessness to be bargained for with ordinary management on a large scale would render its success utterly problematical. The final arbiter of all such questionings is experience, and that infallible test has decided that these fears are for the most part groundless. The first cost of preparing the land is doubtless likely to be considerable, but as so much less land will answer the purpose, there is found to be a large saving on this head over broad irrigation. If thoroughly prepared the filter will not clog, provided it be used intermittently. And finally, as to management, it has been found possible to insure care enough to avoid all offence in many places in England for many years. To the impeachment of waste it pleads guilty, urging only in mitigation, firstly, that it is entirely susceptible of modification, with a view to partial utilization; and secondly, that it can easily and advantageously be used in combination with farming enterprise, and is indeed an indispensable safety valve of that system in almost all cases. Finally, we ought to notice the prophecies of disaster which have been widely disseminated hereabouts founded upon the alleged utter incompatibility of either of these systems with the violent extremes of the New England climate.

It is urged with great force, that Old England and New England differ too diametrically in their climates to admit of safe comparison. The sceptics point out that England's atmosphere is moist and equable while our heats are tropical and our cold arctic; that one-half the year our land is frozen solid and the other half baked hard; that in summer the sewage will stink insufferably, while in winter it will freeze into dirty icebergs, which spring will convert into torrents of sludge and filth. Once more we fall back upon experience. At Pullman, where it is colder than in most parts of Massachusetts, the frost never prevents the flow and absorption of the sewage; and in the hottest days of July and August the primitive filter-field at Concord is never a nuisance, nor the lawn at the Worcester Hospital an annoyance. The sewage is warm, and melts its own way into the earth when the frost is hardest; and no matter how hot the air, the earth has a wonderful power of deodorizing and destroying the harmful elements in sewage. This property has been so abundantly manifested in a multitude of instances, here and elsewhere, that we feel that we take no undue risk in dismissing the climatic bugbear as a chimera. We have then no hesitation in recommending the adoption of this system where for any reasons broad irrigation is impracticable or undesirable and the ocean unattainable, and we think it likely to prove always a valuable auxiliary, in combination with irrigation, where the surroundings admit of its introduction.

Processes of Deposition or Precipitation.

There remain to be noticed a number of operations with sewage which are all based upon some application of the principles of deposition or precipitation. By allowing the suspended matter to settle naturally, or by intercepting it by artificial strainers, it is possible to extract a certain percentage of it. But neither of these processes has been yet proved to work well in practice with large quantities of sewage. They are now usually supplemented by chemical treatment. The addition of lime is most generally approved for this purpose, but a multiplicity of other substances has been tried with various success. As a business venture purely, we doubt whether any scheme has proved lucrative. The resultant sludge, however manipulated, does not seem to make a highly-prized fertilizer. But a complete review of the attempts to extract the treasure from sewage would exceed our limits. Our concern is merely to make up our minds whether we ought to advise the trial of any such device upon any part of our territory. Waiving all claims which may be made in favor of these processes, as profitable or at least inexpensive, let us inquire exactly what can be expected from them, and at what cost. And here we can do no better than to condense and adopt the conclusions of the royal commission upon this head, to whose voluminous and exhaustive report reference has been made before. They tell us that "a chemical precipitating process does two things; it effects improvement in the liquid flowing away, and it leaves behind a precipitated deposit which has to be disposed of."

"The main object of a chemical process being to purify the effluent, the first point of inquiry is, to what extent does it answer this end?"

"No one denies that the suspended matters may be almost entirely removed, and therefore the clarification must effect a great improvement." It is also the general opinion that chemical processes in their best form will have some effect in removing noxious matter in solution, but all agree that a considerable amount must be left in the effluent. This, however, may be safely discharged into a running stream, if its proportion to the supply of pure water does not exceed five per cent. But we have still to deal with the precipitate, — about fifty grains, we will say, to the gallon. It is very offensive, and not valuable. By subjecting the sludge to methods of pressure, however, most of the water has been expressed without offence and its weight reduced to about one ton to one hundred and sixty-five thousand gallons of sewage. It is possible that some market value might attach to this residuum in some localities, but we dare not count upon anything better than gratuitous removal. Finally, the cost of the operation in England is estimated to be just about one shilling per head, or say, twenty-five cents here for each person yearly. This does not include interest on the capital invested in the works, land, and so on. By itself, therefore, it does not appear to be financially attractive.

The processes of precipitation can, like the other methods of disposal w we have briefly discussed, be combined to advantage with some one or more of those others when the circumstances favor or require it. For instance, precipitation may be supplemented to advantage by application to land. The clarified but imperfectly purified water can be used for irrigation, or passed through a ground filter, which effectually and finally removes all trace of taint or stain. By this means all desirable results can be accomplished. In case of towns on tidal rivers this plan may be resorted to with advantage to clarify the sewage before ultimate discharge. It was somewhat considered in connection with a part of the Mystic system, but it was more expensive than the plan finally adopted, and we have not thought it expedient, upon the whole, to try any of these methods in any case with which we have been called to deal. But it may very possibly prove of service in the hands of the authorities of some towns, who may be searching for a combination which may permit the discharge of a comparatively small amount of partially clarified sewage into estuaries, creeks or small streams.

To sum up, we are of opinion, upon the whole —

1st. That when it can be done unobjectionably, it is best to throw sewage into great quantities of free water.

2d. That filtration on land, either alone or in combination with one or more of the other processes, ranks next.

3d. That when irrigation is especially favored by circumstances, it is better than either of the preceding; but that it is so seldom that these circumstances can be controlled to advantage, that we assign to it a third place only in practical usefulness.

4th. That precipitation and chemical treatment may be advisable in connection with either of the first, second or third of these devices, but in our present state of knowledge ought not to be preferred to either of them.

Although we have preferred to treat of these fundamental propositions of the science in connection with one branch only of the subject, it is not to be inferred that we are inclined to admit any inherent distinction between household sewage and the pollution of water by other instrumentalities. Chief among these is the contamination caused by the use of water in manufacturing processes, and the incidental damage to the purity of water resulting from the establishment of great industrial activities upon streams and rivers. But while the injury done is not essentially different, there are some peculiar considerations bearing upon this part of our problem which should not be overlooked.

Manufacturing.

Manufacturing industry has from the earliest days been greatly favored by the law-makers of Massachusetts. To foster and encourage it they long ago substantially dedicated the unnavigable running waters of the land to its use. Believing its prosperity essential to the common welfare, the legislature has not hesitated to step to the very verge of its constitutional power to stimulate and maintain it. For more than half a century persons have been authorized by law to dam up streams, and flood lands of others, for their own private manufacturing ends. This taking of one man's property against his will for the individual benefit of another has been justified as a proper exercise of the prerogative of eminent domain, on the ground of the advantage inuring to the public from the improvement of water power, and the importance of encouraging manufactures.

It has been supported, also, upon the principle which permits the State to compel the several possessors of a common interest, which they cannot beneficially enjoy in severalty, to submit to measures essential to secure a full and profitable use of their property.

As a general proposition of law it is laid down that the owners of the bed and banks of a stream have the right to use the running water in common from its source to its outlet. Each one has an equal right to its reasonable use as it flows by his land. This right of each is limited by the like right of every other. But this special qualified property of the individual in the water does not seem to exclude a general paramount interest which the public retains. Consequently, while no one can justly diminish his neighbor's enjoyment by greatly vitiating the water during his own short-lived tenure of it, neither may he destroy or gravely impair the public property in it. The factory or the mill may temporarily monopolize the flow, but they do so under an implied agreement not to spoil the water for the ordinary uses of the people in general. If they pollute the stream unduly they violate their license, and may be compelled to abate the nuisance they have made. But while it is easy to lay down the principle, it is not easy to insist upon its rigid application, without danger of working injustice and of frustrating the immemorial policy of the Commonwealth. An inflexible enforcement of a rule forbidding any defilement whatever might ruin many mill-owners and stop half the water wheels of the State. Some diminution of purity is inevitable, and tolerable, while other contamination is unnecessary or excessive. The difficulty lies in distinguishing the legitimate from the destructive usage. A satisfactory definition is impracticable. Each case differs a little from the next. The circumstances may be utterly unlike. All will agree that some kinds of corruption may reasonably be sharply dealt with. No one, for example, pretends that he can rightfully pour human excrement and household filth into the water below his dam. Neither can he justify dumping into the river waste and refuse and garbage. On the other hand, the most exacting purist might not care to complain of the sediment washed from some bleachings or scourings, the slight taint of certain kinds of harmless chemicals, or the evanescent stain of dyes which are not unwholesome. The task is to discriminate the variety of shades of impurity which occur between these extremes.

Then there is a class of cases where it may be an open question whether it is not for the public interest to abandon a stream or sheet of water to the customary pollution of industry, so long as it does not imperil the public health. Unless this be admitted, the alternative may be to drive away thriving communities, and destroy the work of years of patient labor and active enterprise, undertaken under a presumed security of tenure. In such a dilemma, if the water is not required for drinking purposes, a considerable contamination may be suffered without inordinate inconvenience. No doubt the State cannot entirely escape responsibility even by such a relinquishment as this. The public have a right not to be poisoned by the air they breathe any more than by the water they drink. There is a foulness which is inadmissible even in a factory stream, which may embitter the life and undermine the health of the dweller upon its banks. In such cases the State is bound to intervene peremptorily if the riparian owners remain obstinately deaf to the public protest. Generally, however, before this stage is reached, the dirt of the earlier usage has so impaired the value of the water for some subsequent taker that he insists upon an abatement of the abuse above him. Complaints frequently reached the commission that this mill or that workshop so befouled a stream that fabrics which formerly could be washed white, now came out stained and damaged. Time was, they told us, when the river water was pure enough to drink, and served perfectly well all the manufacturer's purposes. Now, the sediment it carried clogged and corroded tubes, ruined boilers, caused constant foaming in making steam, and was a perennial source of annoyance and injury in their business. And upon inspection we would find that probably the next man below our informants would echo the same complaints, attributing his troubles perhaps to the very persons who had called us in. And so on, sometimes for many miles down the stream, each successive proprietor would bewail the wretched usage which it had suffered before it reached his dam, and then proceed forthwith to give cause for more lamentation to his neighbor below. Still, they cannot entirely disregard such remonstrances. Generally, the moral as well as the legal obligation of abstaining from all avoidable vitiation of the water was frankly admitted, and the practice was usually deplored as inevitable rather than defended as right in itself. We are sanguine that a co-operation of water owners might be brought about, in most cases, by any board charged with the duty of mitigating the pollution of rivers, provided some practicable plan be proposed and presented to them. And we are inclined to look upon this interaction and mutual concession as likely to promise better results than a sharpening of the edge of the law. At all events, we should like to see the experiment tried before resorting to harsher measures. We prefer to encourage the individual to voluntarily improve his own and his neighbor's property, and thus subserve the public interest at the same time, before we invoke the heavy hand of the General Court to coerce him.

We think it will be enough for the present to require that water for dwellings must be protected from every avoidable taint, while water for business must not be offensive or dangerous. All wanton ill usage, such as privies over the stream or cesspools draining into it, may well be put a stop to; and where the incidental injury characteristic of an industry is detrimental to the next user or to the public, it should be scrupulously restricted to absolutely unavoidable dimensions by the adoption of the most approved methods of remedial treatment.

But even if it should be thought expedient to impose some such restrictions as we have indicated, there is still room for much difference of opinion as to the best method of enforcing whatever regulation is adopted.

There are several ways which naturally suggest themselves. We may leave the land owners, the water owners and the community at large to the ordinary courts and to the common law to define and protect their various interests, or we may erect a special tribunal and prescribe by statute the scope and method of its oversight and jurisdiction, or the legislature may pass upon each case as it arises. For reasons which we state in another place, we are inclined to recommend that the supervision of matters pertaining to water supply, sewerage, and the pollution of waters generally, be assigned to some board which shall be clothed with powers analogous to those of the Railroad Commissioners and Harbor Commissioners, to enable it to introduce system and method in these important departments of the common welfare.

As we have extended our reasons for this provision somewhat at length in a subsequent portion of this document, we do not deem it worth while to enlarge further upon it in this place, except to point out that the function of such a board should be supplementary and not subversive of the processes, jurisdiction and rules of the common law, and the ordinary courts of justice.

After so tedious a disquisition upon the more abstract and theoretical side of the task assigned us, we recognize the obligation to hasten to present some concrete results. But before entering upon the practical application of the general principles of sewerage science which we have very inadequately sketched, it will tend to simplify the body of this report if we can dispose of three preliminary matters at the outset. Naturally, during the long period that this question of sewerage has been impending, many projects of more or less value have been propounded, and more or less debated in the daily papers and elsewhere. There is only one of these which we deem it advisable to try to dispose of here, in order to clear the way for any really useful discussion of measures of relief. It has been suggested that the State should build a trunk sewer from Worcester to the sea, at Boston, and thus furnish the whole intervening territory with complete facilities at a blow. This scheme we consider to be entirely visionary and impracticable, for various reasons. In the first place the engineering difficulties are very great, although not absolutely insuperable. As the heights of land between Worcester and Boston run north and south, separating the valleys of the Blackstone, Sudbury and Charles, several long and deep tunnels would be necessary, but it is possible to bore them. Then, as a sewer once let down cannot be got up again without pumping the sewage, it becomes necessary, in covering so great a distance, to maintain a steady downward grade of a very slight and regular inclination for each mile. This aggravates excessively the difficulties of location and by consequence greatly stretches out the length of the route. It is not probable that a line could be found less than fifty miles in length. But even this does not put it beyond the bounds of possibility. Then, in consequence of its meandering course, which must be governed by topographical considerations and could not be modified to meet requirements of population, it cannot be carried from town to town like a railway, but must wind from hillside to hillside. This might and probably would compel towns not actually touched by the main sewer to spend more money merely to reach it, than they would have to pay to treat their own sewage for themselves near at hand. Still it would be possible. All these objections are serious but not absolutely conclusive. What we do consider, however, ought to be entirely conclusive, is the enormous cost of such a work. We do not believe that it could be completed and put in operation for less than eight million of dollars. And when it was done we should have a piece of machinery which could do no more and no better work than can be obtained from simpler mechanism for one-eighth of the money.

A second preliminary of an explanatory character may be excused in this connection. We found, after many trials, that it was impracticable to equalize the accessibility of our trunk sewer to the various communities it was intended to serve. For example, take Medford and Malden, in the Mystic system, and compare or contrast their relations to the main sewer, as respects convenience of contact, with the position of Stoneham or Woburn. In the former, the main trunk runs its whole length through the most crowded population, and in streets where it actually supersedes the necessity of building town sewers, while in the latter, only one not very convenient point of access is furnished, and that so placed as to rather increase than diminish the length of local drainage. But inequitable as this may seem, it was manifest, upon a full comprehension of all the surrounding circumstances, that it was one of the inherent and essential infelicities of our problem. And we were forced to come to a distinct understanding that we could not undertake to do more in any case than to furnish one suitable mouth or sink in each town, where it could empty its town sewers into the district sewer. One only could be granted as of right, more must be attributed to fortune of situation.

A third obvious but prudent warning may also find a place here. In none of our sewer plans has any provision been made for storm water. We do not provide for surface drainage. Situated as we were, it was found to involve a scale of cost which seemed to us entirely inadmissible. It may answer very well when sewage flows freely away into large bodies of water, but if it requires pumping, treating or handling in any form, the accession of rainfall swells the discharge at times to utterly unmanageable proportions and in any aspect is very costly and cumbrous. We think that the figures which we have to present will be sufficiently imposing without one dollar of needless expenditure. In our view the treatment of street scour as sewage is a luxury rather than a necessity of municipal life, and it seems to us that most of our towns and cities find that their necessities will probably absorb all the funds which they are quite ready to spare.

Without further preface we pass now to the particular territory to which we are directed to apply the general conclusions which we have attempted to deduce from the experience of the world up to this time, and we come to the valley of the Mystic.

The Mystic Valley.

The first in order of the specific duties prescribed by the resolve under which the commission is acting is the preparation of a plan of drainage for the relief of the Mystic Valley. The streams which combine to form the Mystic Ponds in Medford rise among the hills of Winchester, Woburn and Stoneham, about six miles only above the dam of the Boston Water Works at the foot of the upper of the ponds. From the outlet of the lower pond to the mouth of the river between Charlestown and East Boston, about six miles more, it is a tidal stream. Its valley may therefore be considered to include parts or the whole of the towns of Stoneham, Winchester, Woburn, Medford, Belmont, Arlington, Cambridge, Somerville, Melrose, Malden, Everett, Chelsea, Revere and East Boston. Charlestown might properly be included in this list but may be more conveniently classed with the Charles River towns. The area of the valley is about seventy square miles, of which twenty-seven constitute the drainage area tributary to Mystic Pond. The number of people who will be served by the sewers which it is proposed to build may be stated at one hundred and thirty thousand. The population of the valley has increased very rapidly, and may not improbably double in number in the next quarter of a century. Careful investigation has convinced us that considerable contamination from the large and industrious communities living upon the tributaries of the Mystic Pond affects the water which is drawn thence for the use of Somerville, Chelsea, Everett and Charlestown. To reduce, as far as possible, this evil, Boston has built a sewer from Woburn to Mystic Pond, where the refuse from ten of the largest tanneries is treated, and the partially cleaned water is then allowed to flow into the lower pond below the dam of the water works. There it is charged with causing a nauseating stench at times quite offensive. The whole facts in full detail need not be repeated here, as they may be found in the engineer's report. And it is perhaps proper to add that we feel less called upon to dwell upon this aspect of the case for the general reason which is alluded to in another part of this report. This whole matter has been very ably and carefully examined heretofore by public servants, and their information submitted to the Legislature. We consider that our charge is rather to find a remedy than to prove a need of one. That, the General Court seems to have assumed to exist, and it would appear to be enough for us merely to add that our investigations entirely confirm that assumption. Nor would the utter abandonment of Mystic Ponds as a source of water supply obviate the necessity, in our opinion, of providing betimes some other outlet for the sewage of the valley. On the contrary, it might not improbably precipitate the crisis. No one doubts that sooner or later the ponds, if left to themselves, will become offensive if not dangerous neighbors. All the towns thereabout recognize the peril, and are anxious to prepare an adequate safeguard. Their own need of town sewers is pressing, and the convenience and economy of a common channel of discharge is admitted. Spot Pond in Stoneham furnishes water to Malden, Melrose and Stoneham, but there is no evidence that any measures for its protection are called for at present. Woburn draws its water from a gallery about sixty feet removed from the shore of Horn Pond, but we are not prepared to declare that it is jeopardized by the dirty drainage which directly and indirectly finds its way into that sheet.

There are various methods of dealing with the Mystic problem which suggested themselves to the commission or were furnished by the labors of former boards. That recommended by the commission of 1881 attracted our especial attention and was subjected to minute analysis. Its prominent feature was a main sewer running the whole length of the valley, passing through Chelsea across to Winthrop, under Shirley Gut, and thence to a discharge in the deep-water tide current at the southeastern extremity of Deer Island. This solution is thorough and probably the best of which the case admits. But it seemed to us, on subjecting it to searching scrutiny, to be likely to be extremely expensive. It is probable that the site which would be required for storage reservoirs may be needed by the Federal Government for works of harbor defence. But apart from that, to reach a satisfactory point of discharge the mouth of the sewer must be built out nearly half a mile from the shore. For nearly all the distance it would be at times exposed to the almost unbroken sweep of the Atlantic swell, which nothing short of the most massive and securely fastened masonry could be relied upon to withstand. This would cost a very large sum in itself, and, combined with other considerations, constrained us to search for some more accessible outlet if it might be discoverable. For a time we hoped that we had found it at Point Shirley. But a series of experiments with floats and a careful study of the currents at that point compelled us to abandon that hope. Our investigations satisfied us that to throw such a large quantity of crude sewage into the sea thereabout would only be shifting not abating the present evil. The currents and eddies would soon strand much of the suspended filth upon the neighboring shores. Sooner or later the mouth would have to be carried to Deer Island or moved elsewhere. It was somewhat debated whether it would be tolerable to adopt the simple and cheap but obviously temporary expedient of prolonging the sewer already built from Woburn to Medford to a point just below the bridge at Somerville. Such a device would leave the lower towns and cities to drain into Boston Harbor as they do now. But the reasons against seriously propounding such a mere palliative for a remedy were so manifest and weighty that it was only not overlooked. To be sure, it is entirely practicable to clarify the sewage chemically at that point before it is let into the river, but it was estimated to cost more to clean it there than it would to carry it further away and filter it. It was also doubted whether it might not be preferable to treat the sewage of each town separately on land, or to combine one or more in such a plan upon tracts as near as might be to the population which was to use them. But practical knowledge of the ground and the levels settled the question in the negative. It was found that it would be more troublesome, less satisfactory, and not so economical as the plan which it was finally decided to advise. This plan contemplates adopting the present sewer of the city of Boston from Woburn to Mystic Pond and carrying it, increasing in size as it receives the contributions of the various places requiring relief, through Medford, Malden and Revere to Saugus. In the southeastern part of Saugus there is a wide tract of sandy plain, remote from any considerable number of dwellings, which borings prove to be well adapted for the purposes of filtration. The plans and other description requisite to a complete knowledge of the chosen site may be found in the engineer's report. It is sufficient for this commission to heartily commend this disposition of the sewage. It is settled by ample experience that it is entirely feasible, upon ground like this, to treat the whole sewage of the district tributary to the proposed main sewer for the next fifty years without causing any serious annoyance. If any person finds it difficult to accept this statement, it is only necessary to look into the material which we have collected to be convinced of its reliability. Not only can the water be delivered from the bottom of the filter practically pure and sweet so that its mixture with the sea water can never be detected, but not even any seriously annoying effluvia need be apprehended from the surface of the ground upon which the dirty stream is poured. Sewage farms and filter-beds are common in England close by thickly-peopled towns, and excellent houses are built and inhabited quite near to them, as may be seen by the photographs printed in the engineer's report, but no evil consequences are observed to follow from the proximity. It almost seems as if earth by a touch took every baleful element out of sewage. We wish to emphasize this immunity from all essential pollution to air or water in the neighborhood of such lands, because it is probable that such an apprehension may be aroused at the outset, and it is possible that such baseless fears may be instrumental in prejudicing a feature of the scheme which seems to us to offer a singularly fortunate escape from a very perplexing dilemma. For between Deer Island and Nahant one may look in vain for any point where it would be safe to discharge such a volume of crude sewage as that we have to deal with here. But even were we compelled to admit that the proposition was objectionable, we might still urge with unanswerable force that it was the least objectionable plan possible; if some one must be inconvenienced, that at least this way disturbed the fewest and disturbed them the least. In this connection some value may be attributed to the facility which this situation will afford, if ever desired, for trying the value of sewage for raising grass or other crops, and for furnishing a field for experiments looking to a profitable development in this direction in future.

These reasons, among others, were satisfactory to us apart from a final consideration which has been declared to have been ever present at our deliberations and to have greatly influenced our determinations. That consideration is the very important one of cost. The most careful estimates satisfy us that this system can be put in operation for but little over a million of dollars. The Deer Island plan would certainly cost more than twice as much, and might run up to three or four times that amount before it could be entirely completed. The yearly burden for pumping, care, management, and running expenses generally, will not at first exceed about twenty thousand dollars.

It will be observed, however, that the proposed line of sewer makes no provision for some of the communities which seem to fall within the bounds of this system. For engineering and economical reasons, Charlestown and Somerville, excepting a small portion of the latter, are recommended to discharge with the Charles River system, which is described hereafter, while a small part of Cambridge, which mainly belongs to the Charles, is for like reasons included in the Mystic system. Chelsea and Revere will be obliged by the lay of the land to build a separate sewer of their own when it is required, which will, however, discharge into the common receptacle at Saugus. One city alone we think it desirable to detach entirely from its natural connection and to treat in a radically different manner. East Boston, from certain peculiarities of position, presented such a tempting opportunity for simple and effective treatment, at a small cost, that it seemed like wilful extravagance to ask it to pump its sewage across an arm of the sea into either the Boston or the Mystic sewer. We think it may be disposed of quite safely with much less outlay and machinery. The quantity is small and can never be much greater, and it can readily be poured into a large body of constantly changing salt water.

We deem it entirely unobjectionable to turn it into the strong tidal current in Boston harbor at a point in the channel on the southerly side of Bird Island flats. We are confident that no serious inconvenience is likely to result to any one if this method is adopted. The commission recommends the city of Boston to make, therefore, such an arrangement whenever the present discharge of sewers in the docks shall require to be discontinued.

The Charles River Valley.

The second matter with which the commission was charged by the terms of the Resolve is to report a general system of sewerage for the relief of the valley of the Charles. This river rises in the extreme southwestern part of Norfolk County, and its watershed includes the whole, or a part, of the towns of Bellingham, Franklin, Medway, Norfolk, Medfield, Sherborn, Natick, Dover, Needham, Dedham, Newton, Weston, Milford, Wrentham, Holliston, Lincoln, Lexington and Waltham. It empties into Boston harbor, and, as a tidal stream, ebbs and flows between Watertown, Cambridge and Charlestown on the one hand, and Brighton, Brookline and Boston on the other. At the upper part of its course there are many mills upon its banks, and from South Natick to the tide there is a succession of dams which, as the river has no very considerable fall, causes the water to set back for some distance. After it becomes a tidal stream, it receives a large amount of sewage from the cities on its banks.

From the extreme southwestern crest of its watershed to Charlestown bridges is about twenty-seven miles as the crow flies, or fifty or more if you follow the windings of the stream. The census of the present year finds three hundred and seventy thousand people dwelling upon the area it drains, and it may not be extravagant to anticipate that the enumerators of 1910 will reckon up seven hundred thousand souls within the same limits. The population that would naturally sewer into the river or its branches may be roughly divided by a line at Waltham into a country and a city community. The former district may number some forty thousand souls; the latter, not counting the portion whose drainage has been carried elsewhere, may reach to about one hundred and sixty thousand. Twelve of its towns have public water supplies. It boasts of several hundred manufacturing establishments. It is not surprising that the stream has lost its pristine purity. The report of Mr. Clarke corroborates the evidence heretofore accumulated by the Board of Health and other investigators, and fully justifies the judgment of the Legislature that the time had come to apply some measure of relief. It is the duty of this commission to suggest that which they deem the best under all the circumstances of the case.

In order to secure the most satisfactory results, it is desirable to divide the district into two unequal parts which require very different treatment. The section below Waltham, which we have ventured to distinguish as the metropolitan portion, can be disposed of without serious complications. Disposition on land, whether for farming or filtration, is unadvisable on account of the absence of suitable and sufficient tracts below Waltham where it might be carried by gravity. To pump it back far enough to reach a fitting site for such works would be very expensive, and might be objected to on the score of danger from the returning effluent to the water supplies of Waltham and Watertown. This expedient is of course possible were there no alternative; but, fortunately, it can be avoided. An outlet to the ocean is not only possible, but it has been already provided. By a wise foresight the whole main drainage works of Boston were designed with special reference to taking the sewage of this very territory. Nothing, therefore, remains to be done but to connect a main sewer to be built down the valley from Waltham with the upper section of the Boston main sewer at Huntington Avenue. This plan, therefore, contemplates a trunk line of sewer, starting at Waltham, following down the southern bank of the Charles to Brookline, and thence striking southeasterly across the park to Camden Street at Huntington Avenue. The sewage of most of Cambridge, a great part of Somerville, and the whole of Charlestown, is to be brought by branch lines of conduit to a pumping station to be placed not far from the northerly end of the Brookline bridge in Cambridge. There it will be raised sufficiently to flow through a siphon under the river to the main sewer on the opposite bank in Brookline. From Waltham to the junction at Huntington Avenue the proposed main line is eight miles long, and is estimated to cost to-day eight hundred and fifty-seven thousand dollars. The East Cambridge and Charlestown branch will add less than three miles more of sewer and three hundred and twenty-four thousand dollars to the cost. The East Somerville branch will require eighty-nine thousand dollars to build to its junction with the last named line, and the south side of Cambridge branch will cost one hundred and forty thousand dollars more. Add to these sums the amount which the pumps and pumping station are estimated to cost, which is not less than one hundred and fifty thousand dollars, and we reach a grand total of a little more than a million and a half for this portion of the plan. This is, undoubtedly, a large outlay, but we do not see how the same work can be done in any other way for nearly so little. And, indeed, although the price is large, the service rendered is not small. This money will furnish an outlet to the sewerage of forty-six square miles of territory and to one hundred and eighty thousand people. On the other hand the impost can be equitably shared among one hundred and eighty-three millions of taxable property. Assuming that the required amount may now be borrowed at a rate of interest not exceeding three and one-half per cent., that would require an annual charge of fifty-two thousand five hundred dollars, to which add say forty-two thousand dollars, which should cover compensation for the use of the city sewer and plant, as well as pumping and cost of maintenance of those sections which are recommended to be built. We thus have a total yearly tax of ninety-four thousand five hundred dollars for this accommodation.

If this provision should be held to be adequate, it will furnish an outlet for by far the greater part of the population of the valley by a combined effort of all the municipalities which will be benefited by the undertaking. The more distinctively rural district, which embraces the upper part of the valley and the head waters of its main stream, contains several places which call for separate attention and individual treatment in each case.

Milford.—Among the most pressing cases of this group of towns is Milford. It is situated upon one of the higher affluents of the Charles. It has a public water supply of about three hundred thousand gallons daily, which for the most part goes into vaults and cesspools. There are two main drains in the two principal thoroughfares, which together measure about four thousand feet. One of these pours its contents directly into the stream. It is proposed to sewer the whole town directly into the river; but we regard such a disposition as threatening the towns below, and quite inadmissible. All things considered, and having due regard to economy, we recommend that the sewage be carried by gravitation to a field about three-quarters of a mile south of the village and east of Vernon Grove Cemetery, where it might be treated by intermittent downward filtration, the purified effluent leaching away towards the Charles. We believe this disposition would prove entirely effectual and satisfactory. Full detailed descriptions and plans may be consulted in the engineer's report. The total cost would reach about $40,000.

Franklin. — Franklin has a water supply, but its consumption is comparatively trifling as yet. We are not prepared to say that it should be required to put in a complete system of sewerage at once, but it is evidently expedient to lay down the lines now, upon which it can be eventually and gradually built. Some part of the sewers, however, ought to be set about soon. The focal point of collection might be near the corner of Union and Cottage streets. The present town sewer and the drain from the Dean Academy should be brought there, along the railroad location. Thence, as it cannot be carried out of the basin of the Charles, it must be purified before it reaches the river, which is used for domestic supply below. We should look forward to possibly two hundred thousand gallons a day in the near future. This amount can be thoroughly filtered on five or ten acres of porous land by the downward intermittent process. The most available grounds for this purpose are to be found on the Beet Sugar Company's grounds, southwest of the village and north of the railroad. The necessary outlay for entire lines of main sewer, land and grading, we should not put at much less than $25,000.

Wellesley. — We hardly consider Wellesley to fall within our cognizance, so remote is its probable necessity. Still it has a water supply, and upon a principle which we have stated, we consider that fact to portend sewerage in the not distant future. The land falls to the southwest and northeast, towards different parts of the Charles. There is a brook which nearly cuts in two the denser part of the village, and any main sewer would naturally follow its direction. From the corner of Walnut and Washington streets, down to near the river, may be three miles or thereabout. A million and a half gallons daily could flow there, through a fifteen-inch pipe. There it must be purified. And again, in this emergency, we propose to rely upon intermittent filtration. It may be possible to find suitable land near the lower end of the sewer, upon which it can deliver without forcing; but if not, the sewage must be pumped up to a good filter-bed, whence its purified effluent may percolate harmlessly into the river.

The Sudbury and Cochituate Basins.

In addition to the relief of the valleys of the Mystic and Charles, the commission was directed to report a system of drainage for the protection of the public water supplies of the cities and towns situated within the basins of those rivers. Boston derives most of its water supply from the basins of the Sudbury River and Cochituate Lake, and it therefore becomes necessary to extend our examination over those regions also.

The city of Boston has secured the right to take water from a tract of country nearly one hundred square miles in extent and divided amongst the towns of Marlborough, Southborough, Westborough, Hopkinton, Ashland, Framingham, Sherborn, Wayland and Natick, in different proportions. This large area is far from thickly peopled, but yet some twenty-three thousand people have their homes there. Many thriving industries and some large and closely built towns are within its borders. With some of these it is not necessary to interfere at all. But in respect to Natick and South Framingham, the present need of sewerage relief is crying, while Marlborough and Westborough ought by rights to be supplied with suitable facilities without any great delay. We propose to deal with these towns in one general way. The distance precludes access to salt water, for economical reasons which we have explained elsewhere, and the law, no less than sound policy, forbids a discharge into any fresh water which could be reached. Nothing remains, then, but the land. Of good land for our purpose admirable specimens have been found. It was desirable that any sewage field which might be fixed upon should not even filter in the direction of streams which supply water for drinking. This is certainly reasonable, if only on sentimental grounds. Imagination is altogether too potent a factor in the conduct of mankind to be neglected, even if it be sometimes unreasonable, which, in this case, it is by no means safe to assume. For reasons which we have endeavored to vindicate in another part of this report, we are not prepared to urge upon towns at present to undertake sewage farming. It is doubtful whether it would be well to add to our municipal functions the business of running a milk farm, if it can be avoided. Consequently we prefer decidedly the plan of intermittent downward filtration through porous land for these towns. The relative position of South Framingham and Natick is such that a sewer connecting their more thickly built portions would carry their drainage nearly in a straight line to a point about half way between the two, where a low lift and a short line of pipe would deliver it upon a tract of land very well adapted for the end in view. This ground slopes away from the Cochituate basin and drains towards the Sudbury below the intake of city water. The situation has the additional attraction that it affords an opportunity of trying irrigation by crude sewage in our climate in the way which seems to us at present the most promising. The pipes here can readily be so arranged as to provide for furnishing such a flow as may be from time to time desired to the crops upon a considerable stretch of fair farming land, the superfluity only reaching the prepared beds. Here we can make actual trial of the probable money return which may be obtained from this agent as a fertilizer under our ordinary climatic conditions. Our plan provides further for taking the discharge from the sewer of the Women's Prison, which is not now deemed unobjectionable, and for a connection with Ashland if required. The entire cost of this scheme would be about one hundred and thirty-five thousand dollars. There yet remain two considerable places in this group which are unprovided for. And for Westborough and Marlborough we design that each shall have a system of its own.

Marlborough. — There is a lot of land about two miles from the centre of the village of Marlborough, containing forty acres, which is well adapted for a filtration field. It can be reached by gravitation, and its effluent cannot mingle with any existing water supply. It will cost, however, about twenty-two thousand dollars more to reach this ground than it would to reach another equally acceptable, were it not for the fact that the effluent from the nearer of the two might affect the Boston water supply. This circumstance, as it concerns both this town and that which we have next to consider, will call for some remark when we have to deal with the whole question of the distribution of the cost of the works which are recommended in this report. It is enough here to merely state that the cost of the plan which we recommend is calculated to be about sixty-two thousand dollars.

Westborough — For reasons already abundantly detailed, we urge afresh that in Westborough, as in Marlborough, some additional expense should be faced, rather than to run the risk of mixing the results of a possibly imperfect filtration with the drinking water of any community. The excess of cost is small, while the sense of added security is great. We propose a sewer from the centre of the most thickly settled part of the town to a tract of gravelly land situated within the meadow bordering Assabet River. Here a filter-bed from ten to fifteen acres in extent can be prepared, which will probably suffice for all future needs of the town in this regard. We think that the entire outlay for this scheme, including the land, need not exceed forty-five thousand dollars.

Hopkinton. — Hopkinton may succeed in averting the adoption of a sewerage system for ten years or more, but when the time comes, we should advise an outlet sewer from the junction of Main and Cedar streets, following near the brook to the west of Cedar Street to the bottom of the hill. There we find a tract of land remarkably well adapted for broad irrigation. If twenty-five or thirty acres are taken, very little sewage need be applied per acre, and good crops might be raised on the land. It is one of the best opportunities that is presented to save the entire worth of sewage, and we should anticipate interesting and instructive results from a sewage farm at this point. The crops might be sold standing or the land let yearly by auction. In spite of the general objections to which such operations are obnoxious, which we have adverted to elsewhere, we should regard a trial of this nature for the public interest. The amount adventured would not be oppressive. Its first cost would not exceed $10,000, and returns might be realized from the crops.

The Blackstone.

The condition of the Blackstone River has been the subject of such minute and exhaustive investigation that we do not feel justified in retracing in this report ground which has been so often and so thoroughly explored. Although we have not felt at liberty to rely upon material already provided without very careful verification, yet we have been unable to detect any error which seems to us material in the work of an earlier commission or to suggest any important amendment to its conclusions. The main facts are familiar and may be briefly reviewed in this place. The evidence may be found in detail in Report of the Board of Health for the year 1882, and in the printed volume of Hearings before the Joint Standing Committee on Public Health of the Legislature, held in February and March of the same year, as well as in the report of the engineer of this commission. Briefly, then, we may say that the Blackstone River begins at the city of Worcester, it being near there that several brooks converge to swell its upper waters to the dignity of a river. For some distance below Worcester it is not a large stream, and in ordinary summer drought it is quite small. Growing larger as it goes, from the influx of strong brooks, it runs on about southeasterly, passing into Rhode Island at Blackstone, and emptying at last into the head of Narragansett Bay. Naturally a rapid stream, its fall has been taken advantage of for manufacturing, and a succession of dams has formed a chain of slack-water pools thoughout its entire course. Upon the main stream and its tributaries combined, there are nearly one hundred mills of various kinds, making use of the water in some fashion. Around these centres of industry clusters of population have gathered, rising in some instances to the proportions of large villages and busy towns. The whole valley in this Commonwealth comprises about two hundred and fifty square miles of drainage area and its population numbers about one hundred thousand. Near seventy thousand of these live in Worcester. The increase in population in twenty years has been about forty per cent., all in Worcester itself. As a whole, the rest of the territory has decreased in numbers. Neither the river nor its affluents are used for public water supply, nor have any of its towns, save Worcester, any systematic sewerage. A water company at Uxbridge furnishes about seventy-five families with excellent water from springs on the hill behind the village. The ordinary receptacles for domestic sewage are provided of about the usual character. Many houses upon the river bank and most of the factories use the river as a sewer. One of the tributaries of the Blackstone is a brook known as Mill Brook, which runs directly through the city of Worcester. Pretty much all the land upon which the city has grown up naturally drains into this brook. Of course a great and steadily greater quantity of dirty drainage must have inevitably drifted into such a stream from time to time as a large city grew steadily closer and closer along its edges. At last the Legislature authorized the city of Worcester to turn the brook outright into a sewer. At the present time, therefore, it receives a large part of the sewage of sixty-eight thousand people. This contribution, of course, adds very largely to the pollution of the river itself, and for several miles below the mouth of the sewer its agency is unmistakably evident. But, as has been intimated above, it is not necessary for us to reproduce at length the scientific and other data which have been accumulated upon the subject of the actual composition of the waters of the Blackstone at various points. To the casual observer it seems very dirty, as has been said, at Millbury, and, apparently working itself clear as it runs, it presents at Uxbridge and Blackstone very much the aspect of ordinary manufacturing streams. The problem, in this river basin, therefore, presents but two features of interest; namely, the pollution caused by the sewage of Worcester, and that caused by the manufactories within the different towns.

As to the first part, assuming, as we do, that the General Court looks to this Commission for a remedy of a state of things which is admitted to call for some relief, we are constrained to admit that our best efforts have failed to discover any material improvement to suggest to the plan very ably and elaborately described and defended in a report of Messrs. Folsom, Davis and Walcott, as experts, to the Board of Health, dated Nov. 17, 1881.

For the convenience of persons who may not be able to refer readily to that document, we will adopt and embody the recommendations of that Board, which may be briefly epitomized as follows: —

To intercept the sewage of Mill Brook Valley before it is discharged into the brook, as the natural flow of the brook is too large to be handled. To conduct the sewage proper, thus kept out of the brook, to a tract of land about a mile below Cambridge Street, and dispose of it there by intermittent downward filtration through so large an area of land as to admit raising some crops. Provision to be made to afford farmers in the vicinity a chance to try the sewage for irrigation. It will be necessary to pump a part of the sewage to reach this land, and the total cost, including the pumping station, was then estimated to be $408,000. The pumping will impose a further yearly burden of $3,500.

This disposition of the city sewage seems to us to be entirely feasible, and we believe that it will effectually remedy the great and growing nuisance which results from the existing method of discharge. It is further recommended to us by the hope which the surroundings permit us to indulge, that some convenient methods may be devised in connection with it for trying to make a profitable use of a considerable part of the sewage at certain seasons, at least, in irrigation for raising fodder crops or for market gardening. The first cost is large it is true, but it does not seem to be excessive considering the present condition and future prospects of Worcester, and the certainty that its rapid growth must soon make some change absolutely imperative unless the Blackstone River is to be permanently condemned for a common sewer. Be the cost great or small, however, we have been unable to find any alternative which promises better results at an equal or less expense. We therefore recommend that the city of Worcester be enjoined to supplement its present sewerage system by some method of purification, before the effluent finds its way into the Blackstone. As to the matter of the factory pollution of the Blackstone, we propose to deal with that question in connection with the subject of manufacturing pollution in general.

The Neponset Valley.

In addition to the districts particularized by the Legislature, our attention was urgently called to the condition of the Neponset river and valley by the Committee on Drainage of the Legislature of 1884. The brooks which unite to form the Neponset spring from the hilly country embraced in the townships of Sharon, Walpole and Canton. The river itself, flowing northeasterly for some fifteen miles, meets the tide at Milton, and thence, as an estuary, broadens down to its mouth in Dorchester Bay, four miles below. Its upper waters are rapid and are thriftily husbanded for mechanical uses, but further down it meanders without check through the great plain at the foot of the Blue Hill in Dedham. There it drags sluggishly along for six miles, through nearly level meadows, with a barely perceptible current. A little above Hyde Park it regains enough vitality to be put to work again, and thence to salt water it is but a string of mill ponds, the flow of the dam below backing up to the foot of the raceway of the mill above. The Neponset meadows effectually divide the valley for our purposes into districts of radically different sewerage characteristics. From Hyde Park downwards the population can, and eventually must, drain into the ocean at or near the present outlet of the Boston sewer. From the head of the meadows upward it is impracticable to reach the sea, and we must, therefore, use the land. Eventually we believe that the intercepting sewer of Boston through the Dorchester district to Mattapan will be available to connect with a sewer for Dedham and Hyde Park. Meanwhile, these places cannot be permitted to turn their crude sewage into the river above the dams without gross injustice to the people living upon the banks and to the manufacturers, who already complain bitterly of the increasing foulness of the water. Possibly the people of Milton and Dorchester, Neponset and Quincy, might tolerate, for a time, an outlet somewhere about Granite Bridge; but, we think, having regard to the wide-spreading flats bordering the narrow channel on both sides, that it would not be a safe or proper experiment to permit. The only alternative left us is either to call to our aid the land once more, or to effect a temporary junction with some part of the Boston system of sewers until such time as the main Neponset branch sewer be extended within reach of Hyde Park. But below Hyde Park we cannot find any lands to our liking. Above there were attractive gravel plains to be had, but only at the price of pumping. In fine, when all possible expedients had been sifted and tried by the final test of comparative economy and aptness, we agreed that the following plan was much the most promising. Bearing always in mind that we have established it as a general rule to regard our duty as done if we afford to each community which seems to us likely to need it, one, and only one, convenient opportunity of access to the trunk lines of sewer which we propose, we will begin with the town of Dedham. Here we should wish to fix this point of contact near the low spot where Wigwam Brook crosses High Street. Thence the line of sewer should follow High Street eastward, as far as a way which lies next east of Harvard Street, along which it might run for a short distance, passing thence into the meadow and running along a little north of High Street to Mother Brook, near the upper mill of the Merchants' Woollen Company. From this place it may follow the south side of the brook as a general line to Hyde Park, where it could unite with the sewer of that town, and the combined sewerage be brought to Arlington Street. That would be a proper place to set the pumps necessary to force the sewage over a ridge and nearly three miles to the Boston sewer in Washington Street at Roslindale. On economical grounds solely, we are inclined to commend this course to Dedham, in preference to going to the tempting lot of gravel land between the Dedham branch of the Boston & Providence Railroad and the New York & New England

Railroad, which is fully described in Mr. Clarke's report. No better filter-bed could be desired, but it could not be got at without pumping, and the mile of sewer, which would be the only compensating saving, would have to be built at some future day, as a necessary link in the main river system. The above described scheme when completed would cost the two towns, as we reckon, about $136,000. As Dedham, with the exception of its county jail, seems not to feel greatly in need of a sewer system at present, it may be deemed wisest for Hyde Park, which feels an exigency now, to proceed at once and alone to build its part of the works we have indicated, leaving Dedham to come in later, upon such terms as might then be thought equitable.

The Upper Neponset.

When we turn to consider the towns lying above the meadows, we find it difficult to single out any one of them as now suffering materially from lack of systematic sewerage. Still, in view of our general declaration that a public water supply almost invariably entails a speedy demand for sewers, we felt bound to indicate, at least to such of them as have already put in water works, how they can best get rid of their sewage when vaults and cesspools have to be superseded. There are three towns falling within this category,— Sharon, Stoughton and Norwood,— and one isolated case of an exigency irrespective of water supply, which we have decided to consider in connection with them. Canton, however, is not unlikely to join the class itself at any time, inasmuch as a movement in favor of introducing a public water supply has been defeated in town meeting more than once by very narrow majorities.

Sharon. — The main village of Sharon, roundabout the junction of Main and Lake streets, seems to be the only section of that town which can be at all suspected to call for present relief, or be likely to need any sewerage for a long time to come. This region can be accommodated by a pipe, starting from the schoolhouse in Main Street and running down that street to the Unitarian meeting-house. Thence, by Lake Street, it goes to Tolman Street, and follows that to the brook which feeds the Knife Works pond. Turning southerly along the brook side, it may be filtered upon land now owned by H. L. Sheppard, north of Ames Street and east of Lake Street. Five or ten acres here would be ample, and unless managed with gross carelessness it will not occasion annoyance. We should certainly prefer to discharge near the market gardens at Sharon Heights, if they could be reached without pumping, as a good part of the sewage might be beneficially used upon them, but the additional expense would more than countervail that advantage. We should estimate the cost of such a system at about eighty-five hundred dollars.

Stoughton. — The only sewage which need be considered at Stoughton could, by means of two intercepting sewers, one for each side of the town, be concentrated at the corner of School and Water streets. Thence, it must follow the slope of the land westward, and must be purified on fields lower than the point at which it is collected. Our engineer reports that he has been able to find but one suitable tract which can be reached by gravitation. Of the land selected, only about six acres can be arranged conveniently for filtration. Although this area, if suitably prepared, will be large enough for some time to come, yet, to allow for future growth of the town, we would have preferred a more extensive filtration area. Plenty of land could be selected on the other side of the brook; unfortunately, it is so high that the sewage would have to be forced to it by pumping, which would double the cost of the system. In the interest of present economy, and bearing in mind that the alternative scheme can at any time be adopted if necessary, we recommend that the small area selected by our engineer be secured at first, and the sewage disposed of upon it. The cost of the system we recommend, which includes a large portion of the more expensive town sewers, is somewhat under twenty thousand dollars.

Norwood. — Like its sister towns, Norwood can practically drain nowhere except into the Neponset or its tributaries. Certainly this commission could not justify turning crude household sewage into the rivulets and ponds which form a network among the hills at the sources of the Neponset. Purification is, in our judgment, an indispensable pre-requisite to admitting any sewage into waters like these. More fortunate than Stoughton, an ample filtering field lies very conveniently accessible by gravitation from every part of the village proper. It may be found marked upon the engineer's plan, which accompanies his report, between Dean and Pleasant streets, south of the brook. But as it is very uncertain that any earnest call for such a convenience will be heard for years to come, and as a more thorough search may suggest some amendments in the detail of this plan, we do not present it as a finality. It is enough to declare it entirely practicable, and though costly not excessively so, if it can be effected, as we believe, for twenty thousand dollars.

Canton. — In order to bring the drainage of Canton village to the low point where the Neponset flows under Washington Street, we think the preferable course would prove to be a line along the low land near the brook, to serve the southerly part of Washington Street, which would probably be the region calling for the earliest attention. This sewer could take all the foul drainage from the factories on the brook, and intercept, as they might require to be built, branches in several streets on the east as well as the west sides of the brook. That part of Washington and its connected streets north of the river could be brought in by a sewer along Washington Street. The region of Pequid Brook must be reached by a sewer along the north bank of the brook. As we have repeatedly explained, we have no alternative but purification on land to propose for the accumulation which we have thus made near the intersection of the river with Washington Street. We incline to think that the best location for this purpose can be reached most easily by a main sewer upon the north side of the river down to the railway viaduct. Thence, through private land, to an area of coarse sand and gravel about half a mile beyond. It is parcel of the farms of Daniel Fuller and S. M. White, and is well suited to the purpose, though requiring a good deal of grading. Of course we cannot predict exactly the quantity of sewage to be provided for, but we consider that we allow an ample margin for error if we prepare ten acres at the outset. As grading forms in this instance one of the main elements of cost, any diminution in this area would tell largely in reducing our estimate of the total cost. But even though we may hope for some abatement in that direction, we are concerned to find that it can in any event hardly be brought much below forty thousand dollars.

Before closing this part of our report, we wish to add one other remark respecting the estimates of cost which we have felt bound to submit in detail for each undertaking. They must be understood to be predicated, so far as labor and material are concerned, upon prices as they run to-day. They may be entirely changed, it is almost needless to say, in a year or even less. And again it is only fair to point out an inherent flaw in the reliability of our estimates which we have deplored without being able to exclude. We refer to the head of land damage. Here we were confronted with a veritable Scylla and Charybdis. If we tried to escape the reef on one hand we struck upon the ledge on the other. If we appraised the lands at what we thought them actually worth, we were in peril of condemnation if it should turn out, when the public came to take them for municipal uses, that they had suddenly acquired a value three or four times greater than we could possibly have imagined them to possess. If, on the contrary, in order to shun the fault of under-estimation, we fixed a value which disinterested judges would consider an outside price, we were pretty sure to establish that rate as the going rate when the land must be had. In this dilemma, we have, to the best of our ability, endeavored to steer a midway course, but we do not pretend that our valuations are always reliable. Indeed, we ought to say frankly, that as a general thing we have felt that the way of safety for a board like ours was to resist the temptation to arouse flattering anticipations which sober experience might rudely dissipate. We suspect, therefore, that our land damages are for the most part liberal, perhaps sometimes excessive.

Manufacturing Pollution of the Neponset.

Excepting the case of Hyde Park, it is probable that the relations of the owners of the various mill privileges upon both the upper and lower waters of the Neponset, in respect to river pollution, require more immediate attention than do the towns. The long stretch of meadows acts as a settling basin for the higher section of the stream as it ramifies upwards into numerous affluents, and at Paul's Bridge in Dedham the water was found fairly clean. The condition of things, however, among the mill owners upon the head waters was eminently unsatisfactory, and it seemed hardly better below Hyde Park and the mouth of Mother Brook. Down there the water was very foul and was declared to be rapidly growing intolerable. Amid such a variety of uses, which almost without exception contribute something of contamination to the water, it would be invidious to denounce individuals, but is is worth while to pick out one or two instances, as examples of offence which seemed to stir up a good deal of mutual irritation. Wool scouring, as usually pursued, requires a great deal of water and releases a vast proportion of sand, dung and grease from the dirty fleece. If the water flows from such an establishment direct to a paper mill, the consequences are likely to be highly distasteful to its proprietor. And conversely, if the paper maker discharges great volumes of lime-impregnated waste water from his rag washings upon the wool scourer who happens to hold the pond below, the recipient finds his business sorely disturbed and deranged. Of course, the moral of a single observation of this kind is applicable to almost all the other streams of the Commonwealth, and with some variation or other may be brought home to half the manufacturers in the State. We held a conference with such of these Neponset gentlemen as were willing to meet us, and we visited and inspected their places of business, to realize more vividly, upon the ground, the exact state of things. The upshot of our action in both instances was to confirm an opinion which we had already entertained, that much of the pollution was readily remediable by due care, that more could be eliminated by improved methods of using the water, while probably almost all could eventually be kept from the river by well considered scientific precautions. The tendency of opinion among these manufacturers themselves seemed to be in this direction and to incline towards the tentative policy which we have decided to advise the General Court to adopt in regard to this description of water pollution.

It is unnecessary for us to dilate upon this point in this connection, as we have fully developed our views upon the whole subject of rivers pollution by industrial and other similar agencies, together with our conception of the most available machinery for alleviating the mischief, in the concluding pages of this report.

Apportionment.

It will be readily appreciated that fixing the rate of apportionment proved to be an exceedingly perplexing job. In approaching the task, we naturally sought for some guiding principle to direct us amid the multifarious and conflicting elements of the problem. The analogies of highways and bridges, the ratio of valuations, the relative convenience, the proportion of numbers or areas, the probable amount of contribution, the comparative difficulty of access, the length of line used and some other considerations, all required to be weighed and measured. No one of these various constituents seemed by itself to furnish the required standard. In each there seemed something lacking to the accurate adjustment of the competing claims. In fact we failed to find any absolutely sure and unerring criterion upon which to base a judgment in these cases. There must necessarily be a certain something of arbitrariness, a seeming absence of exact principle and lack of scientific precision about such apportionments. It is difficult to defend them by purely logical arguments. They partake of the nature of compromises, which must seek for justification upon grounds of an all things considered fairness and honesty. Feeling thus, and despairing of discovering a perfect test, we were forced to accept as a measure of liability which, if not perfect, seemed to us to be the best attainable, a careful estimate of the approximate worth of the service rendered. No better gauge of this value received occurred to us, upon the whole, than the number of people served. Taking this, then, for our basis of computation, we have generally followed pretty steadily where it led us. In some cases where there seemed to be manifest equity in deviating from our usual course, we have not hesitated to do so. The most noticeable instance of this kind, perhaps, is the apportionment of the sum of three hundred thousand dollars of the cost of the Mystic sewer to the city of Boston. Boston is not directly served by this sewer.

No part of its population drains into it. And yet the commission thought it reasonable that Boston should contribute something to build it. They justify this anomaly partly on the ground of benefit derived, if not as a sewer, at least as a safeguard to water supply. Partly upon the fact that the city has derived and is receiving to-day large returns from the sale of Mystic water. And in part they were influenced by the apparent admission by the city of some sort of moral, if not legal obligation, to assist the upper valley towns to do their duty in keeping foul matters out of the tributaries to the Mystic. Some such sensibility may fairly be presumed to have influenced the policy which built a conduit from Woburn to Medford, at a cost of more than one hundred thousand dollars, to divert the tannery sewage, and erected and maintained pumping and cleansing works at the Mystic dam to clarify the refuse which that sewer brings. For this work the city is now paying not less than six thousand dollars a year. These operations, however, are not satisfactory, and already occasion much annoyance to the people of Medford and give rise to much complaint. Probably they must soon be removed at a considerable further outlay. Regard being had to all these considerations, we thought it reasonable that Boston should be asked to pay for a superior service to that which she now furnishes an equivalent to her present outlay. We propose to take the existing sewer, allowing a credit for it of one hundred thousand dollars. The two hundred thousand dollars in addition represent the present yearly outlay of six thousand dollars at Medford, capitalized at three per cent. If within a few years the Mystic Lake should be entirely abandoned as a water supply, it will be for the Legislature to consider what modifications of this apportionment should be made.

Similar departures from our guiding line will be observed in the apportionments settled between South Framingham, Natick, the State and the city, in the case of the joint sewer between the two towns. There the share of the Commonwealth could not fairly be rated by population served, and we were compelled to fix it at a lump sum, which seemed to us to be fair and reasonable, all things considered. The city here again is called upon to assist, upon the ground of a direct benefit received at the price of increased cost to the towns paying for the sewer. Land fairly well suited for their filtration area could be had, which was nearer than that selected, and could be reached at less expense. But it was within the Cochituate watershed, and albeit we think it exceedingly probable that the result of perfect filtration may be delivered harmlessly at any spot somewhat detached from an actual water intake, yet we are ready to defer to delicate susceptibilities, or even to pure prejudice in such a matter. And particularly in view of the chance of carelessness and the risk of accident it is no mere squeamishness which insists on making assurance doubly sure by paying a premium for a consciousness of complete security. We think, then, that the city should defray the extra cost of lifting the sewage across the crest of the Cochituate basin so that it may percolate slowly away from the water which the city drinks. We have appraised this accommodation at twenty thousand dollars.

Somewhat similar considerations influenced the action of the commission in dividing the cost of the Marlborough sewer. The town will be put to a considerable expense if it carries its outlet and filtration works beyond the limits of the basin which contributes to the supply of water for the city of Boston. It can doubtless secure a sufficiently unobjectionable site within the Cochituate watershed for much less money. We have adjudged it fair, therefore, that in the event of the town exhibiting such deference to the rights or apprehensions of the city, that the latter ought to bear a proportion of the cost bearing some relation to the extra expense, which we fix at twenty thousand dollars.

There remains yet one more case of special features calling for particular notice in this connection. Westborough resembles Marlborough in all essential conditions. Like her, she can carry the purified effluent of her filters away over a ridge of land which will effectually preclude all possibility of its ever in any form mingling with the city water; but this perfect precaution will cost the town more than it might otherwise secure an outlet for. For this extra insurance from all possible harm we think the city may be fairly called upon to pay the sum of fifteen thousand dollars.

Subject to these exceptions, we apportion the cost of building and maintaining the main sewers, which we recommend, according to the following schedules, based upon population: —

Mystic Valley system. — The engineer's estimate of the cost of this system (p. 154) is in round numbers one million five hundred and twenty thousand dollars. To this we add one hundred thousand dollars to represent the value of the Boston sewer already built for the Mystic Water Works. We then deduct four hundred and one thousand five hundred and twenty-seven dollars, which is the estimated cost of the branch to Chelsea and Revere, assuming that that city and town can hardly afford to incur such an expenditure at present; nor is the immediate need for this branch so urgent as that for the others. For somewhat similar reasons, we deduct the sixteen thousand two hundred and ninety-one dollars, and twenty-two thousand four hundred and eighty-four dollars which represent, respectively, the cost of the Belmont and Arlington branches. Possibly these towns may prefer to join the system at once, in which case the apportionment can be modified to meet that contingency. We have made provisions in the draft of an Act herewith submitted, by which they can join the system later, by building their own branches and paying an equitable share of the cost of the main system. The deductions indicated above reduce the estimate to one million one hundred and eighty thousand dollars. Of course, should the work be constructed, the total expenditure may be greater or less than the estimate. Be it more or less, we apportion it in the following ratios: —

Boston, ...	$300,000

with $100,000 of this allowed for the sewer already built, and of the remainder, —

Stoneham, ...	8.5	per cent.
Woburn, ...	17.5	"
Winchester, ...	6.5	"
Medford, ...	14.0	"
Cambridge, ...	10.5	"

Somerville,	1.0	per cent.
Melrose,	9.0	"
Malden,	25.0	"
Everett,	8.0	"
	100.0	per cent.

Charles River system. — The engineer's estimate for this system is about one million five hundred and sixty-one thousand dollars. Be the final cost more or less, we apportion it in the following ratios: —

Waltham,			8.0	per cent.
Newton,			11.0	"
Watertown,			3.5	"
Brookline,			5.0	"
Cambridge,			29.0	"
Somerville,			16.0	"
Brighton,	5.	Boston,	27.5	"
Charlestown,	21.			
Boston proper,	1.5			
			100.0	per cent.

Natick and Framingham system. — The engineer's estimate for this system is about one hundred and thirty-five thousand dollars. Be the cost more or less, we apportion it in the following ratios: —

Boston,	$20,000
The Commonwealth,	15,000

and for the remainder, —

Natick,	50	per cent.
Framingham,	50	"
	100	per cent.

Marlborough. — The estimate of cost for Marlborough is about sixty-two thousand dollars. Be the actual cost more or less, we apportion it thus: —

Boston,	$20,000
Marlborough,	the remainder.

Westborough. — The estimate of cost for Westborough is about forty-five thousand dollars. Be the cost more or less, we apportion it thus: —

Boston,	$15,000
Westborough,	the remainder.

In all other cases the cities or towns building any of the systems recommended will pay the cost of said systems.

We append here a brief summary of the expenditures of the commission for the most considerable amounts. Most of these expenditures have been already incurred; a small part is based on estimates.

Salary of chief engineer,	$5,000
Other salaries and wages,	17,000
Transportation and subsistence of field parties,	2,500
Supplies and repairs,	2,000
Office rent,	800
Consulting engineers and other experts,	1,750
Printing and other expenses, final report,	3,000
Miscellaneous,	500
	$32,550

No part of the above expenditures was received by the commissioners themselves. They have drawn no compensation whatever.

Having finished the work assigned to them up to this point, the commissioners were in some doubt as to their further conduct in the premises. A strict construction of the resolve under which they were acting absolved them from further responsibility for the fate of their recommendations. They were clearly ordered to report systems of drainage, but it is not clear that they were also expected to furnish models of machinery to build and operate them. They were undoubtedly directed to supply plans of land, but no mention is made of forms of law. They are to estimate and apportion the cost of the schemes which meet their approval, but they do not appear to be required to suggest a financial programme. And although empowered in general terms to consider the needs of any portion of the Commonwealth in regard to its sewerage and water supply, it is questionable if they were designed to report a statute providing for the protection of all water supplies and the conservation of all waters. But, upon mature deliberation, we have deemed it better to take a comprehensive view of our obligations, and to err on the side of liberality rather than narrowness in interpreting the legislative intent. Even if it should be considered officious it can do no harm, and it may prove useful to the Legislature to have before it some forms to serve at least as frames for more acceptable construction.

It is evident that the recommendations upon which we have agreed will require executive agencies of different characters. There are two great main lines of sewer to be built and some minor systems to be built or superintended on the one part, and on the other there is the establishment of a protective supervision over the lakes and rivers of the entire State. As respects the first class of operations we are well aware that it has been the policy of this Commonwealth to leave to the different municipalities the inception and completion of all that pertains to sewerage, water supply and like matters of local interest; and in the wisdom of that policy we heartily concur. Nor in urging a different procedure in the present instance are we advising an infraction of that general rule. The Mystic sewer and the Charles River sewer are neither of them of a local or municipal character. They partake, on the contrary, pre-eminently of the nature of great arterial channels for the benefit of wide metropolitan districts. They must be established and managed, if at all, by some central agency and authority, which can for this special purpose override town boundaries and disregard local susceptibilities. It would be futile, in our judgment, to leave the difficult and perplexing questions which are necessarily involved in building and operating such works to the chances of securing practical unanimity in a council composed of representatives of ten or fifteen independent corporate bodies. There would be much debate but we fancy not much action. We, and others before us, disinterested and impartial, have found so much difficulty in settling upon any satisfactory principle of adjusting the burden of such imposts, that we should despair of an agreement between adverse and hostile interests. There is, in fact, as we have declared, no absolutely unassailable principle to follow in this regard, and a certain arbitrary element will of necessity enter into any scheme of apportionment. It must be accepted as a compromise, and as the least illogical of a number of possible contrivances, or it must be abandoned. It is possible to dispute forever upon the delicate degrees of inequity or the fine shades of inequality which can easily be detected in any conceivable contrivance for fixing precisely the exact share which each community should in pure and abstract justice be called upon to pay. If anything is to be done, and done seasonably, we think that the State itself must take the matter in hand. Unless the work of this commission is to go for nothing, it is a vigorous executive mainly which is now needed. For this purpose we suggest the establishment of a Board, of one or more persons, who shall be empowered to proceed to contract for the immediate construction of the Mystic Valley sewer and the Charles River sewer, in substantial accordance with the general plans submitted herewith, and the detailed drawings and other engineering material which we have prepared, and which should be transferred to the custody of the Board. The Natick and South Framingham sewer should be assigned to the same Board, if those towns neglect or decline to proceed with it themselves within a reasonable time.

Our first impression was to favor a plan which contemplated asking the Commonwealth to advance to this Board, from any funds in the treasury, the necessary payments from time to time as the work went on. They in turn to assess them upon the various municipal corporations concerned, in the ratio recommended by us. We thought of offering to these municipalities the option of paying these levies in cash, or in town and city obligations of such denomination, period of payment and rate of interest, as the Legislature might determine. These promissory notes were to be taken into the sinking funds of the State. But some legal difficulties being apprehended, we finally determined to draft forms of acts establishing districts and empowering these special corporations to issue obligations of their own in like manner as towns and cities may do, the principal and interest of which to be paid by a levy upon each constituent municipality in proportion to the apportionment fixed by this act. As it will be remembered that all of these sewers involve an annual outlay for running expenses and maintenance, it will devolve upon the same authority to fix and assess, from time to time, the fair proportion of these which each participant should pay, and attend to all incidental business of a like nature. In case the Legislature approves and adopts such a scheme, we should think that the works might be expected to be expeditiously and economically constructed and operated. Where the works proposed, however, are purely local, as in the cases of Westborough and Marlborough and some others, we see no objection whatever to leaving the execution of some such plans as ours to the towns themselves. At the same time, we think it very desirable that there should be some expert authority to consult with towns and cities looking for pure and adequate water supplies, or searching for unobjectionable methods of sewerage.

The difficulties in these directions are becoming greater each year and the resultant confusion and complication more embarrassing. In the two years eighty-three and eighty-four alone, some fifty or sixty towns came up to the State House for leave to take or increase a water supply, and more than two score of private companies obtained similar privileges, and the indications are that these applications will show little diminution for many years to come. Each one of these towns, and many others in like case will, in no long time, find that water supply and sewerage are for the most part inseparable companions. Then, instead of a carefully pre-arranged plan of sewers, a piecemeal, hand to mouth sort of a makeshift device is likely to be improvised from day to day, entailing unnecessary expense and danger, and finally total loss. And again the scramble for the best and most accessible waters is responsible for a good deal of avoidable contention and imperfectly matured legislation. There is water enough for all if it be equitably shared. But the Legislature is annually besieged by importunate suitors who are bound to disregard all claims but the needs of their own constituents. It would be far better, in our opinion, if there were some competent board where all these jostling demands could be calmly considered and systematically adjusted. We have accordingly inserted a section in one of the subjoined forms of statute conferring such discretion upon a board as we think will tend to promote scientific sewerage and a fair and judicious distribution of pure water. Once more disclaiming any design on our part to attribute any especial propriety to the forms of legislation which we submit and which we wish to be regarded as auxiliary suggestions rather than settled conclusions, we approach the end of these observations.

Coming to the final division of our report, we have again preferred to enlarge rather than restrict the scope of the jurisdiction which can be strictly derived from the bare text of the resolve. We "may consider and report upon the needs of any other portion of the Commonwealth as to the disposal of sewage and the protection of the public water supplies therein." We have determined to regard the whole remaining body of the State, and not any particular division, as the "other portion" as to which we are at liberty to submit our views upon the propriety of throwing further safeguards about its supplies of drinking water and attempting greater system in the disposal of its sewage. This interpretation brings within the purview of our commission the whole subject of water pollution and its restriction or prevention within the State.

We take it that no one will controvert the general proposition of law that every holder of property, however absolute and unqualified be his title, holds it under the implied liability that his use of it may be so regulated that it shall not be injurious to the rights of the community.

In the exercise of its undoubted prerogative to watch over the general welfare and to guard the public rights by the ample police powers with which it is armed, the Legislature may make exactly such rules respecting the pollution of streams and ponds or other inland waters as it may judge requisite and necessary for the public welfare. It may absolutely prohibit, under suitable penalty, any contamination of any water within the borders of the Commonwealth, if it so please. It is a question always of expediency what degree of interference with individual liberty is required by the circumstances. Thus far the Legislature has been content to forbid any pollution of waters used directly or indirectly for a water supply by any city or town within twenty miles above the point of taking, provided this prohibition be not held to impair rights granted by statute before July 1, 1878, or prescriptive rights of drainage, to the extent to which they lawfully existed on that date. The Merrimack and Connecticut rivers and so much of the Concord as lies within the city of Lowell are also exempt from this rule. Nor can any person save those employed in getting ice or hauling lumber drive a horse on any pond used as a water supply for domestic purposes by a city or town. Neither is bathing permitted in any such pond. The Legislature seems to have drawn the line at drinking water. Water dedicated to household uses is protected, within certain limits and to a certain degree, by a speedy, peremptory and effectual process. Municipal authorities may obtain an injunction at any time, from any justice of the supreme or superior court, to restrain any person from violating the 80th chapter of the General Statutes, which we have recited above. But all other waters are left to the ordinary rules of the common law. We think that a comprehensive knowledge of all the facts will satisfy any unbiased inquirer that under this kind of customary guardianship of no one in particular, the general condition of our waters has suffered a steady degradation, or, to borrow the language of the State Board as long ago as 1876, "any defence against the impurities which so conveniently flow into our waters from the settlements and works on their banks has thus far been merely nominal; that is, the law *can* be used to prevent a nuisance from continuing to be poured into the river, but it is *not* used, because the process is too slow, cumbersome and expensive." The lapse of nine years has only served to point and emphasize this commentary. The growth of population, the spread of modern refinements of living, the increase in industrial establishments, and all the indefinite multiplication of incidents appertaining to a prosperous and progressive community, must naturally and perhaps inevitably tend to vitiate the water of its rivers and lakes. But even if a certain degree of taint be unavoidable, there is a vast amount which is wanton and preventable. A cursory glance at the report of Mr. Clarke will convince any one that there is no necessity whatever for a large part of the abuse to which our water courses are subjected. It is a question of time only, and that not a long time either, when, if we hold to the path we are travelling, we shall find ourselves face to face with a state of things as intolerable as that of England twenty-five years ago, when the Sewage of Towns Commission denounced it as an "evil of national urgency requiring the earliest and most serious attention." The condition of many of its important and frequented streams had become so filthy and disgusting, that a universal protest arose, and large sums of money had to be expended in haste to mitigate the extremity of the offence. Meanwhile untold misery and mischief had been inflicted. Now preventive measures are far less costly and much more effective than remedial expedients. We think it is high time that some steps should be taken here to arrest the progress of rivers pollution at the point it has reached to-day in Massachusetts, and gradually to retrieve some portion, at least, of the ground we have carelessly yielded. Impressed with this conviction, we yet consider it impracticable to ask for a summary enforcement of the extreme right of the community in its waters now for the first time. Apart from technical points of law, and taking it upon broad, equitable grounds, it would be felt to be unfair for the community suddenly to insist upon a rigid exaction of its abstract right to clean waters after so many years of license and neglect. Even if it be law that no one can prescribe for a public nuisance, it does not necessarily follow that it is policy to abate all nuisances forthwith. And supposing such a project of law to have been enacted, we do not believe that the statute could or would be enforced. Certainly the existing law is not, then why should one so much more severe? We therefore cast about a good deal to hit upon some principle of classification, some scheme of discrimination, or even a mere frame of fixed regulations to guide the steps of a guardian of public waters. It was suggested that schedules might be made of streams which could be allowed a certain kind and amount of pollution, to be carefully defined, either in general or for each individual case. Certain others might be set apart and reserved for the standard purity expected for drinking water. While possibly a few might be left to take care of themselves, at least for the present. It was held to be reasonable to forbid certain more dangerous or offensive trades from seating themselves in future at or near the fountain heads of rivers or brooks. It was urged that there would be no hardship in compelling a new comer, whose labors must grievously deteriorate the quality of the water, to go below the industries which already depended upon the water as they were getting it, and could not endure without suffering any additional impairment of its purity. These expedients and many like them were canvassed and weighed in turn, but to all there seemed to be grave objections. After much consideration it was decided to propound a plan of action which seemed to fit the exigency as well or better than any which occurred to us. It had besides the strong recommendation of shaping itself in exact conformity with precedents which have stood the test of time and have proved themselves to be valuable working agencies. In the year 1879 the Legislature intrusted the care of "the lands, flats, shores and rights in tide-waters belonging to the Commonwealth," and the supervision of "all its tide-waters and all the flats and lands flowed thereby," to a Board whom it empowered "to prevent and remove unauthorized encroachments" or whatever "in any way injures their channels." Every work done within tide-water, not sanctioned by them or authorized by the General Court, where a license is required, is declared to be a nuisance, and the Board may order suits on behalf of the Commonwealth to prevent it or stop the removal of material from any bar or breakwater of any harbor. This legislation is strictly in line with that we offer. It is, indeed, almost identical with it. Alter its wording but a little and it would suit our purpose exactly. Precisely the same principle which enjoins a watchful care over the exterior waters of the State would seem to call for at least an equal solicitude concerning the abuse of its interior waters. But mindful of the tenderness with which Massachusetts has always treated her industrial classes, we think it would be wise to embrace in the enactment one peculiarly characteristic feature borrowed from the act establishing a Railroad Commission, and which has proved strong enough to enforce amply all the rights of the public in that class of highways called railroads. This distinctive trait is the use of advisory as distinguished from mandatory power. We think it would be well, then, for the Legislature to designate some one or more persons to look after the public interests in this direction. Let these guardians of inland waters be charged to acquaint themselves with the actual condition of all waters within the State as respects their pollution or purity, and to inform themselves particularly as to the relation which that condition bears to the health and well-being of any part of the people of the Commonwealth. Let them do away, as far as possible, with all remediable pollution, and use every means in their power to prevent further vitiation. Let them make it their business to advise and assist cities or towns desiring a supply of water or a system of sewerage. They shall put themselves at the disposal of manufactories and others using rivers, streams or ponds, or in any way misusing them, to suggest the best means of minimizing the amount of dirt in their effluent, and to experiment upon methods of reducing or avoiding pollution. They shall warn the persistent violator of all reasonable regulation in the management of water, of the consequences of his acts. In a word, it shall be their especial function to guard the public interest and the public health in its relation with water, whether pure or defiled, with the ultimate hope, which must never be abandoned, that sooner or later ways may be found to redeem and preserve all the waters of the State. We propose to clothe the Board with no other power than the power to examine, advise and report, except in cases of violation of the statutes. Such cases, if persisted in after notice, are to be referred to the Attorney-General for action. Other than this, its decisions must look for their sanction to their own intrinsic sense and soundness. Its last protest against wilful and obstinate defilement will be to the General Court. To that tribunal it shall report all the facts, leaving to its supreme discretion the final disposition of such offenders. If such a Board be able to commend itself by its conduct to the approval of the great court of public opinion, it will have no difficulty, we think, in materially reducing the disorders and abuses which are threatening to give great trouble in future if not speedily checked. If, however, we err in this expectation, and more drastic measures prove indispensable, the mandate of the State can always be invoked to re-enforce its advice.

In conclusion, it may be well to explain, in order to avoid misconception, that we do not regard the form which we suggest as very material. We wish it understood that although we propose a fresh commission to build the Mystic or the Charles River sewer, we do not deny that they can very possibly be as well done by the Governor and Council, by the city of Boston, or some other agency, if the Legislature prefer, and when we recommend that the prevention of rivers pollution be assigned to a Board, we do not intend to prejudge the question whether that Board shall be an existing Board or a fresh creation. It seems to us comparatively immaterial by what instruments our ends are wrought, provided only the work be done economically and speedily, and above all, be done well.

JOHN Q. ADAMS.
SOLOMON B. STEBBINS.
EDMUND W. CONVERSE.
EDWARD D. HAYDEN.
LEVERETT S. TUCKERMAN.

DECEMBER 24, 1885.

DRAFT OF AN ACT ESTABLISHING CERTAIN HEALTH DISTRICTS.

Section 1. For the purpose of protecting the health of the people resident and being within the limits of the territories hereinafter described, and especially to carry out such purpose by the acquisition, construction and maintenance of three or more systems of main sewers, the territory comprehended within the limits of the towns of Stoneham, Woburn, Winchester, Medford, Melrose and Everett, the city of Malden, that part of the city of Cambridge lying northwestwardly from the following described line: — Beginning at Town Bound No. 15, on the line between the cities of Cambridge and Somerville, thence running in a straight line to the intersection of the centre lines of Appleton and Brattle streets, thence following the centre lines of Brattle, Mount Auburn and Belmont streets to the boundary line between the city of Cambridge and the town of Belmont, and that part of the city of Somerville lying northwestwardly from the following described line: — Beginning at a point on the boundary line between the city of Somerville and the town of Medford, at the intersection therewith of the centre line of Cedar Street in said Somerville, produced, thence following the centre line of Cedar Street to its intersection with the centre line of Clyde Street, thence running in a straight line to the intersection of the centre lines of Holland and Newbury streets, thence following the centre line of Newbury Street to the boundary line between the cities of Cambridge and Somerville, is hereby incorporated as the Mystic River Health District; and the territory comprehended within the limits of the towns of Watertown and Brookline and the cities of Waltham, Newton, the city of Cambridge, except such part of said city as is above incorporated in the Mystic River Health District, the city of Somerville, except such part of said city as is above incorporated in the Mystic River Health District, and those parts of the city of Boston which formerly constituted the town of Brighton and the city of Charlestown, is hereby incorporated as the Charles

River Health District; and the territory comprehended within the limits of the towns of Natick and Framingham is hereby incorporated as the Natick and Framingham Health District. Each of said districts, respectively, for the purpose of carrying out the provisions of this act, shall have full power to sue and be sued, to purchase, take and hold real and personal estate, and to make necessary contracts and do necessary acts in relation to its property and concerns.

SECT. 2. The management, direction and control of the property affairs and concerns of said districts shall be vested in a Board of

The governor, with the advice and consent of the council, shall, before the first day of July next, appoint competent persons, who shall constitute said board of

, and who shall hold their offices from the dates of their respective appointments, and for the terms of years, respectively, from the first day of July next. The governor shall in like manner, before the first day of July in each year thereafter, appoint a member of said board, to continue in office for the term of years from said day; and, in case of any vacancy occurring in the board by resignation or otherwise, he shall in like manner appoint a member for the residue of the term, and may in like manner remove any member of said board. And the compensation of each of said members shall be

. Said board shall annually elect a clerk and treasurer for each of said districts, who may be the same person, and may appoint such agents, officers and servants as it may find necessary to carry out the purposes of this act, and may determine their duties and compensation. Said board shall be furnished with an office in some suitable place, in which the maps, plans and documents relating to its business and to the sewers, land and other property in its charge, and records of all its doings shall be kept. The salaries of the members of said board and such general expenses as shall not be incurred for the separate account of either of said districts, shall be equitably apportioned among and paid by said districts from time to time, as the board may determine, having regard to the services rendered to each and to the amounts expended for each. Except as hereinafter provided, no contracts or other acts which involve the payment of money from the treasury of the Commonwealth shall be made or done without an appropriation expressly made therefor by the general court. Said board shall annually, on or before the tenth day of January, report to the general court its doings in the preceding year, and shall recommend such legislation as it may deem necessary for the preservation, extension and improvement of the systems of main sewers hereinafter provided for and for the promotion of the interests connected therewith. It shall bring instances of neglect or of omission to comply with the provisions of this act to the knowledge of the attorney-general, for the enforcement thereof.

SECT. 3. As soon as may be practicable after the passage of this act, said board shall proceed to construct systems of sewage disposal for said districts, the main features of which shall be in substantial accordance with the plans reported and recommended to this legislature by the commission appointed under chapter sixty-three of the resolves of the year eighteen hundred and eighty-four, and for that purpose may make all contracts necessary for the construction of the sewers and works aforesaid, or may where deemed advisable carry on such construction by days' labor.

SECT. 4. Said board, acting on behalf of said districts respectively, may take by purchase or otherwise any lands, water-courses, rights of way, or easements, or any existing sewers or parts of sewers, necessary for the carrying out of the provisions of this act. When any lands, water-courses, rights of way, or easements, or any sewers or parts of sewers are so taken in any manner other than by purchase, said board shall, within thirty days after said taking, file in the registry of deeds for the county or district in which said lands, water-courses, rights of way, or easements, or sewers or parts of sewers lie, and cause to be recorded a description of the same, as certain as is required in a common conveyance of land, with a statement of the purpose and the district for which it is taken; which description and statement shall be signed by said board, or a majority thereof, and the fee of the lands, water-courses, rights of way, or easements, or sewers or parts of sewers so taken or purchased shall vest in such district. Such district shall pay in the manner hereinafter described all damages that shall be sustained by any person by reason of such taking as aforesaid. Such damages to be ascertained and determined in the manner provided for ascertaining and determining damages in the case of laying out, altering, or discontinuing ways.

SECT. 5. Said board may, for the purposes aforesaid, carry and conduct any sewer by it to be made and constructed under or over any water-course or any street, turnpike-road, railroad, highway, or other way, in such manner as not unnecessarily to obstruct or impede travel thereon; and may enter upon and dig up any such road, street, or way for the purpose of laying down sewers beneath the surface thereof, and for maintaining and repairing the same;

and, in general, may do any other acts and things necessary or convenient and proper for the purposes of this act. In entering upon and digging up any such road, street, or way of public travel, it shall be subject to such reasonable regulations as may be made by the mayor and aldermen or selectmen of the cities and towns respectively wherein such works shall be performed.

SECT. 6. Whenever said board shall dig up any road, street, or way, as aforesaid, it shall so far as practicable restore the same to as good order and condition as the same was in when such digging commenced. And the district, in behalf of which such work was prosecuted, shall at all times indemnify and save harmless the several cities and towns within which such roads, streets, or ways may be, against all damages which may be recovered against them respectively, and shall reimburse to them all expenses which they shall incur by reason of any defect or want of repair in any road, street, or way, caused by the construction of any of said sewers, or by the maintaining or repairing the same: *provided*, that said board shall have due and reasonable notice of all claims for such damages or injury and opportunity to make a legal defence thereto.

SECT. 7. Said board may also, with the consent of the respective county commissioners, alter and change the course or direction of any water-course, or may alter and change the location or grade of any highway, and may, with the consent of the mayor and aldermen or selectmen of the respective cities and towns, alter or change the location or grade of any townway, public street, or way of travel, crossed by any sewers constructed under the provisions of this act, or in which such sewers may be located, subject to such reasonable regulations as may be made by the county commissioners, mayor and aldermen, or selectmen respectively.

SECT. 8. Whenever the system of sewers to be constructed under the provisions of this act for the Charles River Health District shall be so far completed as to conduct sewage from the whole or any part of said district to a connection with the main drainage works of the city of Boston, the city of Boston shall allow the same to be connected with said main drainage works, and such sewage to flow into and through the same, and shall dispose thereof in the same manner as it disposes of the sewage from its own sewers; and for such service it shall receive from said district such annual compensation as may be agreed on by it and said board, based on the value and cost of maintenance of that part of said main drainage works which may be used in such service, the amount of sewage discharged from said Charles River system, and its proportion to the whole amount discharged through said main drainage works. In case said city and said board fail to agree on the amount of such compensation, the same shall be determined by three commissioners, or a majority thereof, to be appointed by the supreme judicial court on application of either party and notice to the other, whose award, when accepted by said court, shall be binding on the parties for the term of years.

SECT. 9. For the purpose of meeting the expenditures authorized and required by this act, except as otherwise provided herein, the board shall, from time to time, subject to the direction and approval of the governor and council, issue scrip or certificates of indebtedness of each of said districts respectively, for such times, in such amounts, and at such rates of interest, as the governor and council shall approve.

The sinking funds of any loans of the Commonwealth, or of any city or town in the Commonwealth, or funds of any savings banks or other corporations whose investments are regulated by statute, may be invested in said scrip or certificates.

SECT. 10. For the amounts so raised, and for the interest thereon, and for the annual cost of maintenance and repairs of the systems of sewers, for which provision is herein made, and for the other expenditures in relation thereto, authorized by this act, the corporations hereby created shall be severally liable in the same manner as towns and counties are liable for debts lawfully created. The amounts required to meet said indebtedness and all other charges, shall, from time to time, be apportioned and assessed by said board in the amounts and proportions hereinafter provided, and shall be certified to and paid over to the respective district treasurers by the several cities and towns, in the same manner and under the same provisions of law as are applicable to the assessment and collection of county taxes, for the time being, and shall be added to and collected with the city and town taxes.

SECT. 11. All sums so to be raised for said Mystic River Health District shall be assessed as follows: To the city of Boston, the sum of two hundred thousand dollars, and also, in addition thereto, whatever may be the value of the sewer already built and now owned by said city within the towns of Woburn, Winchester and Medford, if the same shall be purchased or taken by said board for the use of said district, *provided*, that not more than thousand dollars of said two hundred thousand dollars shall be assessed to said city in any one year; and the remainder in the following proportions: To the town of Stoneham, eight and one-half per cent.; to the town of Woburn, seventeen and one-half per cent.; to the town of Winchester, six and one-half per cent.;

to the town of Medford, fourteen per cent.; to the city of Cambridge, ten and one-half per cent.; to the city of Somerville, one per cent.; to the town of Melrose, nine per cent.; to the city of Malden, twenty-five per cent.; to the town of Everett, eight per cent.

SECT. 12. All sums so to be raised for said Charles River Health District shall be assessed as follows: To the city of Waltham, eight per cent.; to the city of Newton, eleven per cent.; to the town of Watertown, three and one-half per cent.; to the town of Brookline, five per cent.; to the city of Somerville, sixteen per cent.; to the city of Cambridge, twenty-nine per cent.; to the city of Boston, twenty-seven and one-half per cent.

SECT. 13. All sums so to be raised for said Natick and Framingham Health District shall be assessed as follows: To the city of Boston, the sum of twenty thousand dollars, *provided*, that not more than thousand dollars of said sum shall be assessed to said city in any one year; to the Commonwealth, the sum of fifteen thousand dollars, and also the annual sum of dollars after the completion of said works, so long as the sewage of the reformatory prison for women at Sherborn shall be disposed of thereby; and the remainder in the following proportions: To the town of Natick, fifty per cent.; to the town of Framingham, fifty per cent. Such sums as shall be assessed to the Commonwealth under the provisions of this section shall be paid out of the treasury of the Commonwealth to the treasurer of said district.

SECT. 14. At any time after years from the passage of this act, the apportionments provided in the preceding three sections, so far as they apply to the annual expense of maintaining and operating said systems of sewers, may be changed or altered by the General Court, in such manner as to provide for assessing such annual expense on the several cities and towns in proportion to the respective amounts of sewage contributed by each.

SECT. 15. Said board shall at all times keep full, accurate and separate accounts of the receipts, expenditures, disbursements, assets and liabilities of each of said health districts, and shall include an abstract of the same in its annual report to the general court.

SECT. 16. From and after the completion of the systems of main sewers, under the provisions of this act, the management, control and power to make repairs thereof shall remain vested in said Board of hereinbefore created, and said board may make any reasonable regulations in regard to the use of the same.

SECT. 17. Said board may, from time to time, contract with any city or town not included in either of the districts hereby incorporated, for the extension thereto of either of said systems of sewage disposal, and for the reception of sewage therefrom: *provided*, that the indebtedness of the district shall not be increased thereby, and that such compensation shall be made by such city or town as said board shall deem reasonable.

SECT. 18. Any city or town, within whose limits any main sewer shall have been constructed, under the provisions of this act, shall connect its local sewers with such main sewer, subject to the direction and control of said board. And any person, firm or corporation may, subject to the direction and control of said board, and subject to such regulations as each city or town may prescribe, connect private drains with said main sewer.

SECT. 19. Any person or persons who shall wantonly or maliciously destroy or injure any sewer, or other property held, owned, or used by said board, or by either of said districts, by the authority and for the purposes of this act, shall forfeit and pay to said board or district three times the amount of the damages that shall be assessed therefor to be recovered by any proper action. And every such person or persons may, moreover, on indictment and conviction of either of the wanton or malicious acts aforesaid, be punished by fine not exceeding one thousand dollars and imprisonment not exceeding one year.

SECT. 20. The supreme judicial court and the superior court shall have full powers in equity to enforce the provisions of this act.

SECT. 21. The commissioners appointed under chapter sixty-three of the resolves of the year one thousand eight hundred and eighty-four shall, on the organization of the board created by this act, transfer and deliver over to said board all books, plans, maps, engineers' reports, instruments, and other property, acquired during the surveys and investigations for which said commission was appointed.

DRAFT OF ACTS FOR MARLBOROUGH AND FOR WESTBOROUGH.

SECTION 1. The town of   is authorized to construct a system of sewage disposal for said town, the main features of which shall be in substantial accordance with the plans submitted to this legislature by the commission appointed under chapter sixty-three of the resolves of the year eighteen hundred and eighty-four.

SECT. 2. Said town may take, by purchase or otherwise, any lands, rights of way or easements necessary for the carrying out of the purposes of this act. When any lands, rights of way or easements are so taken, in any manner other than by purchase, said town shall, within thirty days after such taking, file in the registry of deeds for the district in which said lands, rights of way or easements lie, and cause to be recorded, a description of the same as certain as is required in a common conveyance of land, with a statement of the purpose for which the same is taken, and the fee of the lands, rights of way or easements, so taken or purchased, shall vest in said town. Said town shall pay all damages that shall be sustained by any person by reason of such taking, the same to be ascertained and determined in the manner provided for ascertaining and determining damages in the case of laying out, altering or discontinuing highways.

SECT. 3. Whenever within   years said town shall have completed said system of sewage disposal, in such manner that the final effluent therefrom, or from any irrigation field or filtration area connected therewith, shall flow outside of that part of any watershed which contributes to the water supply of the city of Boston, and shall adopt and enforce proper means and regulations for disposing thereby of such sewage of the town as would otherwise enter said watershed, said city of Boston shall pay to said town the sum of

SECT. 4. Said town is hereby authorized to raise and appropriate, in such manner as it shall determine, such sums of money as shall be required by it to carry out the provisions of this act.

DRAFT OF AN ACT FOR WORCESTER.

SECTION 1. The city of Worcester is hereby directed, within years after the passage of this act, to purify from all offensive, noxious and polluting properties the waters or substances that may thereafter be discharged from its sewers into Blackstone River, or any of its tributaries, so that said waters and substances shall not of themselves, or in connection with other matters, create a nuisance or endanger the public health; and said city thereafter shall cease to empty from its sewers into Blackstone River, or any of its tributaries, any waters or substances containing said properties until the same shall have been first so purified.

SECT 2. Said city may take, by purchase or otherwise, any lands, rights of way or easements necessary for the carrying out of the purposes of this act. When any lands, rights of way or easements are so taken, in any manner other than by purchase, said city shall, within thirty days after such taking, file in the registry of deeds for the district in which said lands, rights of way or easements lie, and cause to be recorded, a description of the same as certain as is required in a common conveyance of land, with a statement of the purpose for which the same is taken, and the fee of the lands, rights of way or easements, so taken or purchased, shall vest in said city. Said city shall pay all damages that shall be sustained by any person by reason of such taking, the same to be ascertained and determined in the manner provided for ascertaining and determining damages in the case of laying out, altering or discontinuing highways.

SECT. 3. Said city is hereby authorized to raise and appropriate, in such manner as its city government shall determine, such sums of money as shall be required by said city to carry out the provisions of this act.

SECT. 4. The supreme judicial court, or any justice thereof, in term time or vacation, sitting in equity for either of the counties of Suffolk or Worcester, shall have jurisdiction in equity to enforce the provisions of this act, by injunction or by any other appropriate equitable remedy, on complaint of the selectmen of any town in the county of Worcester situate on the Blackstone River.

DRAFT OF AN ACT TO PROTECT THE PURITY OF INLAND WATERS.

Section 1. For the purpose of providing for the care of the inland waters of the Commonwealth, and preserving the purity thereof, the governor, with the advice and consent of the council, shall, before the first day of July next, appoint competent persons, who shall constitute a Board of Guardians of Inland Waters, and who shall hold their offices from the dates of their respective appointments, and for the terms of years, respectively, from the first day of July next. The governor shall in like manner, before the first day of July in each year thereafter, appoint a member of said board, to continue in office for the term of years from said day; and, in case of any vacancy occurring in the board by resignation or otherwise, he shall in like manner appoint a member for the residue of the term, and may in like manner remove any member of said board. And the compensation of each of said members shall be , which together with the other expenses of said board shall be paid out of the treasury of the Commonwealth.

Sect. 2. Said board shall be furnished with an office in some suitable place, in which the maps, plans and documents relating to matters in its charge, and records of all its doings shall be kept. It may employ such engineers and clerks and other assistants as it may deem necessary; provided that no contracts or other acts which involve the payment of money from the treasury of the Commonwealth shall be made or done without an appropriation expressly made therefor by the general court. It shall annually, on or before the tenth day of January, report to the general court its doings in the preceding year, and at the same time submit estimates of the sums required to meet the expenses of said board during the ensuing year, and it shall also recommend legislation and suitable plans for such systems of main sewers as it may deem necessary for the preservation of the public health and for the purification and prevention of pollution of the ponds, streams and inland waters of the Commonwealth.

Sect. 3. Said board shall have the general oversight and care of all inland waters with reference to the purity thereof, and shall from time to time, as it may deem expedient, cause examinations of the said waters to be made for the purpose of ascertaining whether the same are adapted for use as sources of domestic water supplies, or are in a condition likely to impair the interests of the public or persons lawfully using the same, or imperil the public health. It shall recommend measures for prevention of the pollution of such waters and for removal of substances and causes of every kind which may be liable to cause pollution thereof, in order to protect and develop the rights and property of the Commonwealth therein and to protect the public health. It shall have authority to conduct experiments to determine the best practicable methods of purification of drainage or disposal of refuse arising from manufacturing and other industrial establishments. For the purposes aforesaid it may employ such expert assistance as may be necessary.

Sect. 4. It shall from time to time consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby. It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or refuse from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or refuse: *provided*, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act.

All such authorities, corporations, firms and individuals are hereby required to give notice to said board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and refuse. Said board shall bring to the notice of the attorney-general all instances which may come to its knowledge, of omission to comply with existing laws respecting the pollution of water supplies and inland waters, and shall annually report to the legislature any specific cases not covered by the provisions of existing laws, which in its opinion call for further legislation.

REPORT OF CONSULTING ENGINEERS.

To the Massachusetts Drainage Commission, Hon. JOHN Q. ADAMS, *Chairman.*

GENTLEMEN :—In compliance with the instructions received from you in a letter as follows —

BOSTON, Oct. 14, 1885.

JOS. P. DAVIS, Esq., *and* RUDOLPH HERING, Esq.

DEAR SIRS : — The Massachusetts Drainage Commission hereby requests you to act as consulting engineers in regard to the various schemes for the collection and disposal of sewage designed by its engineer, Mr. Clarke. You are requested to confer with Mr. Clarke, to make yourselves familiar with the plans proposed by him, and to inspect, so far as you may think necessary, the places affected by said plans. You will please report to the commission your opinion as to the merits of the general statements and the specific recommendations contained in Mr. Clarke's report, giving any suggestions which may be useful to the commission in its considerations of the matters referred to it by the State Legislature.

Yours respectfully,

J. Q. ADAMS,
Chairman,

— we respectfully present the following report :

On October 15th, we met at the office of your engineer, Mr. E. C. Clarke, and after acquainting ourselves with the general features of the work in question, proceeded with him to the localities which it was most important for us to inspect. On the same day we visited the towns and cities of the lower Charles River basin as far up as Waltham, examining the line of the sewer proposed to connect those places with the Main Drainage System of Boston. The next day we devoted to the Mystic Valley Scheme, for the purpose of inspecting both the suggested sewer lines and filtration areas. During the following week South Framingham, Natick, Westborough, Marlborough, Dedham and Hyde Park were visited for the same purpose. A trip was made to the pumping station and outfall of the Boston Main Drainage Works and also through the intercepting sewer from Falmouth Street to Albany Street. Finally a day was spent in Worcester and Millbury, to inspect the proposed line for the outfall sewer and the filtration area, also the condition of the Blackstone River and the effluent water from numerous mills draining into it.

We did not visit the upper Charles River and upper Neponset basins, partly because the engineering questions involved were simple and the solution independent of the requirements of other sections, but mainly because the general features they presented were the same as those of some of the towns which we did visit.

The problem which is before you is one of magnitude because of the great diversity of conditions which obtain, and which preclude its being solved either in a simple or in a uniform manner. These conditions vary not only with the general location of each town, with its proximity to the drainage system of Boston, with the available neighboring grounds for purifying sewage, but also with the character of the water-courses into which the sewage, purified or not, would finally make its way, and with the uses to which they may thereafter be put, whether serving for domestic water supplies or for manufacturing purposes only.

The completeness with which Mr. Clarke has collected and compiled the data relating to this complex question is to be highly commended, permitting no doubt as to the precise conditions which it presents, and leaving nothing for us to add in that direction. He states in a clear manner the problem in its general and detailed features, and what it was proper and necessary for him to investigate for intelligent discussion of the same. He gives an account of all the elements which contribute to the stream pollution in each town, the manner and present expense of dealing with a part or all of the objectionable matters, and also refers to what actions have been taken, or what opinions have been held by the local authorities on the subject.

The second part of the report presents the general conclusions arrived at in England and elsewhere, as to the best methods of sewage disposal under conditions similar to those of eastern Massachusetts. A third part applies them to each particular locality, and the last one refers to certain general considerations having a bearing upon the question.

The particular manner in which sewage should be treated after leaving the sewers, depends upon the use to be made of the brooks, rivers or other bodies of water into which it will ultimately find its way either by direct discharge, flowing over the surface, or by percolating through the soil.

If they are to furnish water for general domestic purposes, a high standard of purity is required; the sewage must be very thoroughly treated before entering them, to guard against the transmission of disease, liable to be produced by specific poisons or infectious germs. It is not possible to set up an absolute standard for this purpose. Although the water may be clear and chemical analysis may show it to be of a good quality, it can still hold a virulent poison from a previous sewage pollution. Mr. R. Pumpelly has shown by experiments on the filtering capacity of soils, that otherwise pure water readily carries bacterial infection along with it when percolating through sand and other common materials of the ground.

While there is some evidence which tends to show that such germs may retain their dangerous qualities for a considerable length of time, yet our experience with water supplies proves that sewage which has been made clear by a thorough land filtration, before it is discharged into a relatively large body of water, is rendered comparatively harmless, particularly after a subsequent flow of several miles. This may be accounted for in part by the aeration of the water and the thorough dilution and dispersion of the sewage.

Notwithstanding this fact, it will be more prudent to exclude sewage entirely, even after filtering through land, from a water course that is used for a domestic supply, and especially so when this can be done as readily as in the case of South Framingham, Marlborough and Westborough.

Whenever a stream will not be required to furnish potable water but will serve only manufactories, a high sanitary standard may be neglected and only a chemical one substituted, thereby in many cases rendering the purification less expensive.

Finally, when sewage is to be discharged into streams which furnish water neither for domestic nor for industrial consumption, or when it is to be discharged into a bay or the sea, the standard of purity may be safely still further lowered, because the only requirement remaining is that it shall not become offensive either to sight or smell. Under the above conditions, a direct discharge of the crude sewage into a large body of flowing water or into a strong tidal current will usually be all that is required.

Different standards then should be adopted for different conditions, and advantage be taken of the fact, pretty generally true, that the less sewage requires to be purified the less will be the necessary expenditure of money.

We will now briefly consider the different modes by which purification may be effected :

The highest standard can be obtained by application on cultivated land. Dr. Alfred Carpenter of Croydon, England, attempted to arrive at perfection in the sewage farms with which he was connected, by altogether avoiding filtration through the soil and using only as much sewage on the ground as could be evaporated and absorbed by the vegetation. It is obvious that this principle must fail in accomplishing its purpose in winter, even if it were always possible to acquire the large area of land that becomes necessary.

The filtering property of soils will therefore have to be made use of, at least to some extent, and it is evident that the greater the amount of land, per million gallons of sewage, the greater will be the purity of the effluent. Its purity will be governed also by the character of the soil ; a sandy loam giving the best result.

To obtain effective filtration it is quite essential that the sewage should be applied intermittently, that the pores of the soil may, from time to time, fill with air, and thus ventilate the ground, oxidize the filth and prevent clogging. To insure this aëration the ground-water level should be kept at least six feet below the surface, which usually requires artificial underdrainage.

When favorable conditions can be secured, therefore, there is no practical difficulty in satisfactorily purifying the sewage, and a long experience abroad shows that when the land has been carefully prepared and the work attending the distribution of the sewage intelligently managed, no concomitant evils will appear. Mr. Clarke has collected photographs showing how closely dwellings have been built to some of the English sewage farms. As far as we know no authenticated case exists tracing disease to any effects from well conducted works. In fact, in the midst of the fields irrigated by the waste waters of Paris, the village of Gennevilliers has grown up from a few isolated buildings, and its death-rate does not differ from that of villages in apparently more favorable locations.

From our personal examination of many well managed works, we can also state that not even a nuisance need be caused. The odors from high manuring, as carried on in ordinary farming, as well as those common about farmhouses and barns, are often more offensive.

The natural fear that frost might seriously interfere with the filtering action of the soil, is likewise dispelled by the results of experience. The extensive sewage farms at Berlin and Dantzig, which were visited by us during the winter months, and which are both under a more severe climate than that of Massachusetts, do not have their efficiency much impaired, and Mr. Clarke states that at Pullman, Ill., when the thermometer was below zero, he found the same to be true. The inherent warmth of sewage is sufficient to prevent freezing of the ground upon which it flows.

Mr. Bailey Denton of London, who has done more to develop the sewage disposal by "intermittent filtration" than any one else, says: "No instance of failure can be pointed out where careful underdrainage and careful preparation of surface, with proper periods of rest (regulated by the character of the soil), have been adopted."

Where land of proper quality and sufficient extent cannot be had, sewage is frequently treated by what is known as chemical precipitation. To obtain by it a purity equal to that produced by irrigation is, however, not practicable. If the effluent sewage is to be discharged into a stream used for drinking, filtration through at least a comparatively small amount of land should be carried on in connection with it.

Where a moderate degree of clarification is required, sufficient only to prevent a nuisance along the shores of a watercourse or the sea, precipitation might, in some instances, accomplish the result with less expense than land treatment, but where the effluent enters a water supply, the required standard of purification necessitates a very large expenditure by this method. In the territory covered by this investigation, comparatively inexpensive and suitable lands for filtration can be found, and in view of this fact the much greater cost of the chemical method precludes it from consideration where a water supply is concerned.

As the expense of purifying sewage is proportionate to its quantity, it is evident that this should be reduced to a minimum. It becomes a matter of economy, then, to adopt measures of preventing undue waste in the use of water, and to so plan and build the sewers that neither rain nor subsoil water can enter them.

Mr. Clarke has divided the territory into sewerage districts and we are of opinion that the dividing lines have been judiciously located.

Mystic Valley District.

Feasible schemes for disposing of the sewage of this district by either of the aforementioned methods may be devised.

The only points where the crude sewage can be safely turned into water are Shirley Gut and the southeast end of Deer Island, and here it must be emptied on the ebb tide only. The objections to utilizing the latter point are clearly stated by Mr. Clarke; the necessary expense throws it out of consideration. A discharge at Shirley Gut would cost much less, but on account of the rapid spreading of the current after leaving the Gut, and on account of its feebleness, deposits would unquestionably occur along the beach to the north of it, and to a certain extent also along the northeasterly shore of Deer Island.

The precipitation method of disposal requires a large annual expenditure for labor and chemicals. To bring the cost of the works needed for it within a reasonable limit, will require the sewage to be treated near the lower reaches of the Mystic River, in the vicinity of a large and growing population. The sewage sludge, which is produced in large quantities by this process, would either accumulate at the works or must be gotten rid of at a large expense by carrying it well out into the sea in scows. Whenever the sewage from the entire surrounding country should be delivered to the works for treatment, even if the operation of clarification is carefully conducted, a nuisance to persons living within short distances would undoubtedly be created. We are therefore of the opinion that the adoption of this method is not advisable in this case.

We concur with Mr. Clarke in the recommendation that the proper disposal of the sewage from the Mystic Valley is by means of filtration. The land in the vicinity of Pines River selected by him is not in all respects as favorable for the purpose as could be desired. It lies rather low with reference to tide level, and a portion of it is covered with a layer of peat from three to four feet thick. However, it can all be made available by diking out the tide and by proper preparation of the peat surface. A large portion of it, much more than will be needed for some years to come, is directly available and consists of sand varying from coarse to fine, overlaid by a thin layer of loam or peat. We know of no instance where land situated as this is has been adopted for sewage irrigation or filtration, but we feel confident that if the methods of sub-drainage, diking and pumping of the effluent, suggested by Mr. Clarke, are followed, the result will prove satisfactory.

While the waste liquids from the Mystic Valley can thus be carried away through a separate system of sewers and properly disposed of, the surface drainage from roads and lands would still run into the river, and owing to the large and growing population and the probable increase of manufactories in this district, the water therefrom will, no doubt, eventually become too impure for domestic use.

We fully agree with Mr. Clarke, that the comparatively small amount of sewage which can be collected from East Boston will not cause any ill effects, if discharged continuously into the current at the point which he has designated.

Lower Charles River System.

In this valley, we may consider that there are two feasible schemes. Filtration on land is out of the question, there being no suitable territory available for the purpose. The method of precipitation at a point below Watertown could be made sufficiently effective, as the river is not further used for a water supply. But the possibility of discharging the sewage from this district into the Boston Main Drainage System, and thus finally disposing of it at a very much smaller cost, leaves no doubt of the superiority of the latter scheme.

At first sight the carrying of the sewage from Charlestown and Somerville up-stream, might appear injudicious, but a more careful study shows that it is the least costly route by which any suitable point of the Boston Main Drainage System can be reached.

As the main sewer along the Charles River, for the greater portion of its length, will be placed below the water-table of the country through which it passes, it should be built with every precaution to exclude the subsoil water. On account of the expense of pumping and handling the sewage, any unnecessary addition to it should be avoided; and, therefore, it may prove advisable to adopt some method of assessment for paying the cost of operation and maintenance, based upon the actual amount of sewage furnished by each town or city, thereby giving an incentive to a careful construction of their sewerage systems, and the adoption of some method of keeping the amount of sewage at the lowest practicable limit.

Natick, South Framingham, Marlborough and Westborough.

The principle recommended by Mr. Clarke for these towns, of delivering the sewage upon lands situated at points outside of the Sudbury and Cochituate watersheds, is one which we fully endorse. The lands selected by him for the disposal of the sewage of Natick, South Framingham, the State Prison at Sherborn, and Ashland, also of Marlborough, are of a character well suited for the purpose. The tract of land selected for the disposal of the sewage of Westborough, is the only one which is both outside the Sudbury River watershed and upon which the sewage can be delivered without pumping. While of good character for filtration, its surface requires considerable grading to prepare it for use, the cost of which, however, will not be large.

The details of the system of works proposed by Mr. Clarke for those towns are simple, and require no comment from us further than that they meet with our approval.

Dedham and Hyde Park.

Undoubtedly, at some future day, an intercepting sewer connected with the Boston system will be built along the Neponset River, into which the sewage of Dedham and Hyde Park will be emptied. The comparatively small population to be provided for at present, will hardly warrant the expenditure, at this time, of so large a sum of money as this sewer would cost. Therefore, Mr. Clarke has, we think wisely, recommended a temporary method of disposal through a line of sewer already built in West Roxbury, by pumping it over a divide into another valley. He has also considered a scheme for disposing of the sewage of Dedham by pumping it upon land which is very suitable for filtration. He gives reasons, however, for not recommending it, and also for not recommending any system of precipitation for either Dedham or Hyde Park, which reasons we consider decisive.

Worcester.

Although a report on the disposal of the sewage of Worcester was made to the State Board of Health in 1881 by a Commission of Experts, we have carefully reconsidered the entire subject, but are unable to suggest any better system than that recommended by the above-mentioned commission. The scheme proposed is one of land filtration, and the soil is well adapted for the purpose. With careful management the result cannot be other than satisfactory.

It has been suggested that the sewage of Worcester might be carried to the coast and emptied into the sea, at the same time utilizing the sewer for the reception of the sewage from towns lying along its course.

The great distance of the city from the seaboard and the necessarily high cost of the sewer per mile renders this scheme, in our opinion, utterly impracticable.

In conclusion we wish to say that the general location of the lines of the sewers, proposed by Mr. Clarke for collecting the sewage from the various towns under consideration, have been well chosen with reference to economy, and, from our cursory examination, seem to be the proper ones, requiring only unimportant modifications, if any, when built. Their capacity seems to be well proportioned for the work they have to do, and their gradients are as favorable as the topography will admit. In some cases, flushing will be required at first, when the amount of sewage will be too small to produce the currents necessary for self-cleaning.

We have not had the data by which to revise the estimates of cost presented by Mr. Clarke, but we have tested with some care the cost of the units of work used by him in the same, and find them as a rule large rather than small.

Respectfully submitted.

JOS. P. DAVIS.
RUDOLPH HERING.

December 12, 1885.

ENGINEER'S REPORT.

LETTER OF TRANSMITTAL.

Hon. John Q. Adams,

Chairman Massachusetts Drainage Commission.

Sir: — I was appointed engineer to your Commission, and assumed that position Sept. 1, 1884. I was instructed to consider, investigate and report upon the matters referred to you by the following resolve of the State Legislature of 1884: —

Resolved, That the governor, with the advice and consent of the council, be authorized to appoint a Commission of five persons, no two of whom shall be residents of one municipality, for the purpose of considering and reporting a general system of drainage for the relief of the valleys of the Mystic, Blackstone and Charles rivers, and for the protection of the public water supplies of the cities and towns situated within the basins of said rivers. Said commission shall have power to employ such engineering and other assistance as may be necessary for carrying out the objects of this resolve. The Commission shall consider the various methods of disposal of sewage, and the application of such methods to any portion of the territory herein mentioned, and shall report its conclusions, in print, to the legislature of the year eighteen hundred and eighty-six, or to that of the year eighteen hundred and eighty-five, if practicable, for a portion or the whole of said territory; and may consider and report upon the needs of any other portion of the Commonwealth as to the disposal of sewage and the protection of the public water supplies therein. Said Commission shall include in its report suitable maps and plans of the territory to be drained, an estimate of the cost of the work, and a recommendation as to the methods of apportioning said cost. They shall receive such compensation for their services as the governor and council may determine, provided that the whole amount expended shall not exceed twenty thousand dollars; and the term of office of said commissioners shall not extend beyond the thirty-first day of January in the year eighteen hundred and eighty-six. [*Approved May 28, 1884.*

The Committee on Drainage of the Legislature of 1885 having requested that your Commission should also consider the Neponset River basin, I was instructed to investigate and report upon that district as well as those specially mentioned in the resolve.

Soon after assuming my position as your engineer I was obliged to report to you that the money then available for the investigation was insufficient to carry it on with the thoroughness that the problems involved demanded and which seemed to be required by the terms of the resolve. An additional sum of $13,000 was asked for, and was granted April 14, 1885. Until that time it was uncertain what the total appropriation would be, and with what degree of fulness and exactness the surveys and other investigations could be made. Consequently, little beyond certain preliminary general examinations and the collection of plans and statistics was attempted until May, 1885.

Since that date, a force including five assistant engineers and from 20 to 30 other assistants, comprising transitmen, levellers, rodmen, chainmen, laborers, etc., has been constantly employed. The towns covered by the resolve, 83 in all, have been visited, and their needs in respect to sewage disposal or relief from nuisances have been examined. Surveys have been made over about 56 miles, on lines where it was supposed that it might prove advisable to recommend the construction of sewers. Most of these surveys have been plotted on a scale of 40 feet to an inch. A large number of other plans have been made, including those embodied in the report herewith submitted. From two to three parties, consisting of a foreman and five laborers each, have been engaged in making light rod borings, to develop the nature of the ground on the lines of proposed work. In all 1,263 such borings and test pits have been made, aggregating 16,693 feet in all, at a total cost of $5,268.76. Nearly all of the above investigations, surveys and other work, have been made and done within the past seven months.

A longer time would have been desirable, and would have ensured greater thoroughness; but the facts and statements contained in the report are believed to be as full as are required, and to represent accurately the conditions existing at the time the examinations were made.

The investigations and surveys in the Mystic and Sudbury basins were made by Mr. W. M. Brown, Jr.; those in the lower Charles River basin by Mr. Sidney Smith; those in the upper Charles and Neponset basins by Mr. C. W. Folsom, and those in the Blackstone basin by Mr. S. C. Heald of Worcester. I desire to express my appreciation of the conscientious and intelligent services of these gentlemen and their assistants.

As directed by your Commission, I visited England to investigate methods of sewage disposal in practice there. I conversed with the leading authorities on sewerage in that country, and examined characteristic methods of disposal as practised at 27 cities and towns. During the past winter I visited the Pullman sewage farm, to observe the effect of severe and prolonged freezing weather upon land irrigation.

I request instructions from your Commission as to the disposal of the office furniture, instruments, plans, profiles, field books, etc., collected during the present survey. The furniture and instruments if sold would realize from $100 to $200, or about half their cost value. The plans and books probably only could be sold by the pound at the market rates for waste paper. The information contained by them would be of great value in case of future construction, and could not be reproduced for less than $10,000.

Up to Dec. 1, 1885, the expenses incurred have amounted to $26,894.74, which may be roughly divided as follows: —

ENGINEERING:	
Salary of Chief Engineer,	$4,333 33
Other salaries and wages,	10,084 80
Transportation and subsistence of field parties,	1,908 35
Supplies and repairs;	171 71
Miscellaneous,	55 37
BORINGS:	
Salaries and wages,	3,748 11
Transportation and subsistence,	556 85
Supplies and repairs,	882 92
Miscellaneous,	80 88

OFFICE EXPENSES:	
Salaries,	$1,646 75
Rent,	435 42
Supplies and repairs,	561 04
Maps and plans,	84 57
Miscellaneous,	28 15
EXPENSES OF COMMISSIONERS,	185 65
PRINTING,	283 04
CONSULTING ENGINEERS,	1,500 00
OTHER EXPERTS,	255 00
MISCELLANEOUS,	92 80
	$26,894 74

Further payments from the appropriation to the amount of about $3,000 will be made on account of salaries, office expenses, finishing of plans, preparing and indexing plans, etc., for filing, and about $3,000 for printing and distributing two thousand copies of your report.

As the result of the above described surveys and investigations, the following report is respectfully submitted.

ELIOT C. CLARKE,
Engineer.

November, 1885.

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DEFINITION OF TERMS USED.

Sewerage. — The removal of certain kinds of filth by water carriage.

Sewer. — A conduit through which filth is removed by flowing water.

Main sewer. — The largest sewer of a connected system for draining a limited district.

Lateral sewer. — Also called branch, or sub-main sewer; one which receives the flow from pipe sewers, and itself empties into a main.

Pipe sewer. — One made of clay or cement pipe.

Intercepting sewer. — A large sewer which conveys to a remote outlet the sewage from several main sewers.

Sewage. — The combined water and waste matters found in sewers.

Crude sewage. — Sewage as it comes from houses, unchanged by any treatment.

Clarified sewage. — Sewage from which all the solid particles have been eliminated.

Effluent. — The sewage water which flows away after any mode of treatment.

Sewer gas. — The atmosphere of sewers, principally pure air, with a varying admixture of gases and vapors, some well known and some obscure, the products of decomposition. The presence of vegetable germs and spores is suspected.

Sludge. — Solid organic and inorganic matters deposited by sewage, existing in the form of black, putrescent mud.

Flushing. — Passing a large volume of water through a sewer, in order to wash away deposits.

Man-hole. — A structure connecting a sewer with the surface of the ground, through which it can be entered.

Catch basin. — A receptacle through which water flows to a sewer, and by which sand and other solids are intercepted.

Tide gates. — Gates or valves at the outlets of sewers, which close as the tide rises, and exclude it.

Watershed. — An area of land from all parts of which water naturally flows into the same stream. When furnishing a water supply it is sometimes called the *catchment area* of that supply.

Divide. — The ridge between two contiguous watersheds.

Intake. — The channel through which a water supply is taken from a stream.

Datum plane. — An assumed horizontal plane under a district, to which all elevations are referred.

Plant. — The tools and apparatus by which a business or work is carried on.

PART I.—THE PROBLEM.

SECTION 1. *Advantage of defining the problem.*—What are the evils from which relief is needed in the districts referred to? To what dangers are the water supplies subjected, from which they must be protected?

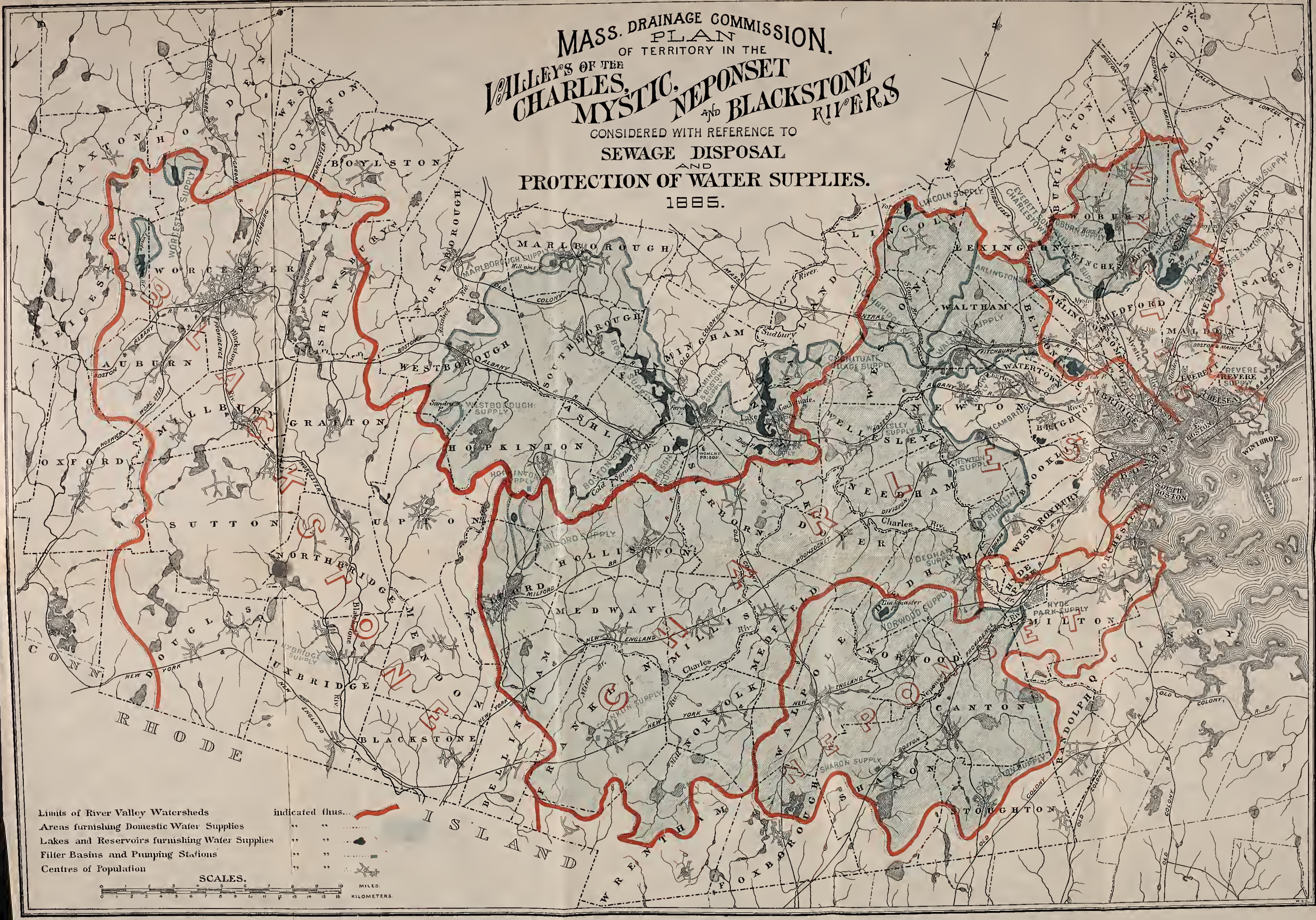
At the outset of the inquiry it is necessary to ascertain these facts clearly. Having decided what we have to accomplish the solution of the problem will be easier.

SECT. 2. *The problem in general terms.*—A necessary concomitant of human existence is the production of matters noxious to that existence. In ordinary domestic operations and in many of the common branches of industry there are produced waste matters either at first noxious or liable to become so. To preserve health or even life, it is necessary to remove such matters from the vicinity of habitations to places where they can decompose and putrefy without causing harm. Solids can be collected and removed with comparative ease, although the difficulty of doing so increases with the density of population. Human excrement, from its nature and consistency, is more difficult to handle, and it has been found that the easiest method of getting rid of it expeditiously, before it begins to decompose (that is within 24 hours), is to wash it away to a distance through pipes by the aid of flowing water. Most of it dissolves or disintegrates in the water during this process. The same method has been found convenient for removing other kinds of household refuse, and is almost universal in the case of fine residences everywhere, and dwellings of every class in thickly settled communities where there is a public water supply. By this method, called sewerage, it is easy to move the water and its contained filth away from the houses where it originates. It is not at all easy, however, to find places to put it where it can do no harm. It always goes, and must go, into some neighboring body of water — stream, river, lake or sea. This will be so as long as the attraction of gravitation causes water to run down hill. Sewage may be raised temporarily by pumping, a limited amount of it may be stored for a time in reservoirs, it may be made to filter through land in its downward course, or chemicals may be added to it as it flows. The solid particles may be precipitated or arrested; in summer a portion of the liquid may be taken up by growing plants, and another portion may evaporate; but sooner or later the greater part of the waste water from any town or city must find its way into a neighboring water course or body of water. It is almost impossible to find places where crude sewage can be continuously emptied without doing harm. Its mere proximity may be injurious, and in water used for domestic purposes it is a source of the greatest danger. The contamination of drinking water by the dejections from a sick person may, under conditions favorable to it, cause widespread fatality. All this has been abundantly proven and is generally recognized.

If the danger from an improper disposal of filth affected only the person or community making such disposition of it, and it were always possible safely to dispose of it within the territory where it originates, the instinct of self-preservation might perhaps be trusted to prevent serious evils; but on account of the temptation to get rid of sewage by putting it where it only affects other persons or communities, the regulation of such matters becomes a legitimate subject for legislation.

The problem is, therefore, How can the sewage and other filth now or hereafter produced in the districts under consideration be disposed of without doing harm?

SECT. 3. *Investigations necessary for a discussion of the problem in the specific cases under consideration.* — In order to discuss understandingly the problem in the specific cases under consideration, it is necessary to examine the several districts, note their extent and physical characteristics, the populations living in them, the industries carried on


MASS. DRAINAGE COMMISSION.
PLAN
OF TERRITORY IN THE
VALLEYS OF THE CHARLES, MYSTIC, NEPONSET AND BLACKSTONE RIVERS
CONSIDERED WITH REFERENCE TO
SEWAGE DISPOSAL
AND
PROTECTION OF WATER SUPPLIES.
1885.
Limits of River Valley Watersheds indicated thus...
Areas furnishing Domestic Water Supplies " "
Lakes and Reservoirs furnishing Water Supplies " "
Filter Basins and Pumping Stations " "
Centres of Population " "
SCALES.
MILES.
KILOMETERS.

there, the present and prospective sources of filth pollution, its kind and extent, and the evils already engendered or likely to arise in the future.

Such investigations have been made, and the information derived from them is given in Part I of this report. As the time which was available for this branch of the inquiry was very limited, it is probable that a good many facts bearing upon the subject have been overlooked. Statements made concerning industries and special cases of pollution represent the conditions existing at the time the places were visited. Even if it is not entirely complete and accurate, this part of the report should give a fair idea of the problem in the several river valleys, as regards nuisances and the pollution of streams. Following in natural sequence, and as required by the Resolve, Part II considers the various methods of disposing of sewage which have been put in practice. Part III endeavors to show which of these methods will prove most efficacious and inexpensive in every case, and also gives estimates of the cost of applying said remedies. Part IV contains certain general information and suggestions.

The Mystic Basin.

Sect. 4. *The basin as a whole.* — Mystic River with its tributaries drains an area of about 70 square miles. The population of this area at present is about 130,000. The rate of increase in population for the last twenty years has been about 80 per cent., and assuming that the same rate will be maintained in the future, the population in 1905 will be about 234,000, and in 1925 about 421,000. The area embraces the whole or considerable portions of sixteen cities and towns. Fourteen of these have public water supplies. The daily aggregate of such supply is about 5,000,000 gallons. There are also many private water supplies, derived from brooks, springs and artesian wells.

Only three cities, in the lower part of the basin, have sewerage systems. Just above Mystic Lake, water for domestic purposes is taken from the river, and consequently the towns lying within the basin above that point, comprising an area of 27.25 square miles, are prohibited by the General Statutes (chap. 80, sect. 96) from turning water-closet sewage directly into the river or its tributaries. In such towns polluted water is commonly disposed of by emptying it into holes in the ground; i. e., cesspools. The liquid contents of these cesspools mixes with the adjacent ground water and flows underground to the river or its branches. Where cesspools are remote from any stream, and, to reach one, the water passes through much ground, it is clarified and more or less purified by the journey.

Within the basin are a large number of manufacturing establishments. These include tanneries, currying shops, shoe shops, India-rubber works, chemical works, dye houses, steam laundries, etc., etc.

The drainage from these establishments, with few exceptions, passes directly into the nearest water course.

Many of these manufactories are situated on streams which furnish a supply to the Mystic water works. To lessen the pollution of this supply the city of Boston has built a sewer which intercepts the foul drainage from ten of the largest tanneries and conveys it to the Lower Mystic Lake, below the intake of the water works. A portion of the suspended solid impurities in this intercepted drainage are removed in settling tanks, but all of the filth in solution and a considerable part of that in suspension remain in the effluent, which causes a continual nuisance in the lower lake and the river below, especially in the winter months.

Up to and including the lower lake, the river and its banks are somewhat foul and offensive. Alewife Brook, one of the tributaries, receives filth from three Cambridge sewers, and at times stinks badly. Malden River, another tributary, is polluted in places. Abajona River is dirty at points where it receives refuse from factories.

After this brief consideration of the drainage area as a whole, it remains to examine in detail the condition and needs of each town within the basin, beginning with those nearest its head waters.

SECT. 5. *Reading.* — Not more than a quarter part of Reading is situated within the Mystic basin. The land is high and rocky, and sparsely settled, there being but a few dozen farms in this part of the town. Reading contemplates obtaining a public water supply from driven wells, to be located near the town line, and within the Mystic basin. This source of supply will be exposed to little or no danger of pollution. The town presents no special subjects for consideration in connection with the present inquiry.

SECT. 6. *Burlington and Lexington.* — Parts of these towns also are included within the Mystic basin, but it is not known that any conditions exist in such portions which would call for investigation or comment.

SECT. 7. *Stoneham.* — Nearly the whole of this town lies within the Mystic basin. About half its area drains through Melrose into Malden River, and the other half into Abajona River, through Woburn and Winchester. The last-named half contains nearly all the thickly settled portion of the town, and about nine-tenths of the total population, or about 5,000 souls. Stoneham has a public water supply, amounting at present to 250,000 gallons daily. This supply comes from Crystal Lake, in Wakefield, which is subject to the inevitable slight contamination caused by its being fed by surface and ground water coming from an inhabited district where cesspools are commonly used. One brook feeding the lake runs through the more thickly settled portion of the village of Wakefield, and in the nature of things cannot be kept perfectly clean. No noticeable pollution exists, however, and no apprehensions on this account are expressed by those in charge of the water supply or by the citizens generally. Stoneham also contains Spot Pond, which furnishes water for Malden, Melrose and Medford. Part of the reservoir which supplies water to Winchester is also within the limits of Stoneham. It stands in a very thinly settled part of the town, and is not liable to pollution. The drainage area of Spot Pond contains very few inhabitants, and the pollution caused by them, if any, must be extremely slight. At times the quality of the water in this pond seems to be much vitiated by decaying vegetable matter. This evil can be remedied by the towns interested, and its consideration does not come within the scope of the present enquiry.

After its use, the contaminated water supply of Stoneham is disposed of by running it into loose cesspools, whence the water soaks away, and much of it probably finds its way eventually into the Abajona River. Privy vaults are also common. There are supposed to be about 1,000 of these, and about 800 cesspools in the town. The solids from these are cleaned out about once a year, at an estimated cost of about $5 each, making a total expenditure of $8,000 or $9,000 a year, which is the interest on about $200,000, or more than enough to provide the thickly settled portion of the town with sewers.

The principal manufacturing establishments in Stoneham are thirty boot and shoe factories, two currying shops, and one tannery. These all drain into cesspools. For about 200 feet around the cesspool at the tannery the ground seems to be saturated with foul drainage, and in warm weather smells badly.

The town Board of Health, in its report dated Feb. 29, 1884, speaks thus of the needs of the town in respect to sewerage: —

"Owing to the introduction and greatly increased use of water, the question of drainage is brought to your attention with redoubled force. A system of drainage for the thickly settled portions of the town will soon be a necessity. The sanitary condition of some localities is such as to excite apprehension, if not alarm, and although we have escaped any serious amount of disease proceeding from these causes, we cannot expect further exemption unless these causes are removed."

No matter how much Stoneham may need a sewerage system, it will be difficult for the town to build one by itself. The natural and necessary direction of drainage is into Abajona River, which is itself a source of domestic water supply, so that the disposal of sewage there is prohibited by Public Statutes. To convey the sewage to any point so remote that it would not be a source of nuisance and subject the town to injunctions would be so expensive as to make it impracticable.

SECT. 8. *Woburn.* — The town of Woburn is almost wholly within the Mystic River basin. About 100 acres in its northwest corner drain through Burlington to the Shawsheen River. All the rest of the town drains into various brooks which furnish water to the Mystic water supply.

Woburn has a population of about 12,000, grouped at four principal centres: namely, Woburn Centre, about 8,000; East Woburn, about 1,000; North Woburn, about 1,500; Cummingsville, about 500; and an outlying scattered population of about 1,000. The town has a public water supply from a filter gallery about 80 feet long, situated in a stratum of gravel on the south side of Horn Pond, 60 feet from the edge of the pond. The water-works officials think that this gallery is not fed from Horn Pond, but by ground water moving towards the pond. The water in the gallery is sometimes high when that in the pond is low, and *vice versâ*. Analyses of the two waters vary considerably. There is, however, a direct connection between the pond and the gallery, to be used in case of necessity. Horn Pond has a somewhat large catchment area, and parts of it are quite thickly settled and abound in cesspools, from which foul waters are continually leaching into the ground. Town Meadow Brook, which feeds the pond, is the natural outlet for drainage from about half of Woburn Centre. Another brook drains the village of Cummingsville and carries to the pond the refuse from two large currying and tanning establishments. This brook looks very dirty.

The daily public water supply of the town is estimated at 700,000 gallons. After use, this water with its contained filth is put into privy vaults and cesspools, or upon the surface of the land. The character of the ground being gravelly and porous, and the vaults and cesspools constructed with loose walls, their liquid contents leach away freely into the ground water. It is estimated that there are about 1,200 such structures, which are cleaned out about once a year, at an average cost of about $5 each. This makes in the aggregate an annual tax of $6,000.

Besides household drainage, a large number of factories contribute more or less refuse to foul the streams and ground water. The principal of these are referred to below. There are eight large tanneries (one of them, White & Co.'s, being vacant), near the Woburn Branch of the Boston & Lowell Railroad. Drainage from these tanneries, amounting to 400,000 gallons per day, is intercepted by the Mystic Valley sewer, built by the Boston Water Board, and is discharged into Lower Mystic Lake, where it causes a considerable nuisance. The tanneries turn into the sewer not only their waste liquids, but a large amount of spent tan bark, hair and scrapings from hides, and other solid refuse, which will not flow, but clogs the sewer and has to be flushed and scraped to man-holes, whence it is removed by hand.

Russell's Brook has its source in about the middle of Woburn Centre, and flows through the thickly settled portion of the town into Wedge Pond, and thence into Abajona River and Upper Mystic Lake, to which it contributes a portion of the Mystic water supply. A portion of this brook looks very foul and stinks. The principal sources which could be found of the pollution of this brook are as follows: —

N. J. Simons' shoe-stock factory on Main Street, next the depot; 140 hands; 4 water closets; uses about 1,000 gallons of town water per day; drainage goes into cesspool which overflows into a ditch along the railroad, thence to the brook.

Steam Laundry on Main Street; 30 hands; 3 water closets; uses about 900 gallons of town water daily; drains into an open ditch, thence to the brook.

Seven estates, one of them a stable, on Main Street, below the laundry; privies overflow into a ditch, thence to the brook.

Boston & Lowell Railroad roundhouse drains into the brook.

Cummings & Symonds' shoe-stock factory uses about 600 gallons of water per day for washing leather; this goes direct to the brook. Privies of this establishment are 100 feet from the brook.

Two cottages on Prospect Street turn sink water into an open ditch, thence into the brook.

Skinner & Co.'s tannery turns a large quantity of very black drainage directly into the brook.

The Woburn Gas Company turns ammonia water and some tar directly into the brook.

Two estates near Conn Street have privies which overflow into a ditch, and thence into the brook.

Within Woburn Centre, but not in the immediate vicinity of the brook, are four currying establishments and two shoe shops, employing in the aggregate about 270 hands and using about 3,000 gallons of town water per day. The drainage from these establishments is disposed of in privy vaults and cesspools and upon the surface of the ground.

Town Meadow Brook which runs from Woburn Centre into Horn Pond is covered over until reaching Centre Street, so that that part of it could not be examined. From Centre to Winn Street, it runs through back yards and under houses, is much choked with rubbish of all kinds and looks very badly. This part of it receives the overflow from four privies and the sewage from four sink drains. After running some distance farther the water becomes clarified, although the bottom looks discolored.

Stephen Dow's tannery, near this brook, employs 100 hands and has dry privies; uses 15,000 gallons of town water per day, and 3,000 cords of bark per year; handles 1,200 sides of leather per week. Foul water is now pumped about one-eighth of a mile to four settling basins on a gravel hill near the brook. The brook water below the tannery is clear.

The brook which runs through Cummingsville into Horn Pond and thence into Mystic Lake is polluted by the following establishments: —

Cummings' tannery and currying shop; employs 150 hands; handles 1,200 hides a week; uses 30,000 gallons of brook water per day and 5,000 cords of bark per year; privies over an open ditch five or six feet from the brook; refuse tan and lime water passes into two settling basins close to the brook, thence by a 10-inch iron pipe to a meadow, corner of Willow and Locust streets; the brook below this establishment is very foul.

Bishop's tannery and currying shop; employs 130 hands; uses 50 to 60 barrels of extract and handles 2,500 to 3,000 calfskins per week; drainage goes to two settling basins, whence it soaks into the brook; privies 30 feet from the brook.

In North Woburn are three currying shops, employing about 130 hands in all. The drainage from two of these goes directly into Willow Brook, and thence into Mystic Lake. The Merrimac Chemical Works, situated on a tributary of Willow Brook, employ 50 men, and use about 1,000 gallons of water per day, which goes back into the brook. There are two privies, one of which is directly over the brook.

In East Woburn, on Willow Brook, or Abajona River, are three manufactories. Baeder, Adams & Co.'s glue works employ 80 hands; use about 50,000 gallons of brook water per day; refuse drainage is pumped at considerable expense into settling basins, whence it soaks away; the basins cause a very bad smell, which is complained of in Stoneham. Whitten's currying shop; 45 men; privies on edge of the brook; handles six tons of splits a week; uses 400 gallons of water per day, which goes over surface of the ground back to the brook.

The selectmen of this town, in their report issued in 1884, speak thus of the needs of Woburn in respect to a system of sewerage: —

"Without repeating what has been previously said by other boards, the matter of a system of drainage will ere long be a matter which the town must look in the face, with this end in view; and as the best and most proper solution of a question which has been harassing the suburban towns and cities within a radius of twenty miles from Boston, after mature consideration in the hearings before the committee on drainage and public health, we have conceded that for our town a metropolitan system of drainage, for the conveyance of sewage and other polluting elements through and beyond other neighboring towns to the sea, is the proper plan. . . . ."

SECT. 9. *Winchester.* — This town is wholly within the watershed which feeds the Mystic water supply. Of the total population of about 4,400, 2,400 live in the thickly settled part of the town, in the immediate neighborhood of Wedge Pond and Abajona River. It has a water supply amounting to about 250,000 gallons per day, derived from a reservoir situated partly in Winchester and partly in Stoneham, and which is apparently not subject to pollution. After use, this water, with its contained filth, is disposed of in cesspools. Within the town are three large tanneries. The drainage from two of these is intercepted by the Mystic Valley sewer, built by the city of Boston to protect the Mystic water supply, and is discharged into the Lower Mystic Lake, where it causes considerable nuisance. From these tanneries much solid refuse matter goes into the sewer, which tends to clog it, and is only kept from doing so by continual labor and expense. The third tannery is situated immediately on the banks of Abajona River, into which it drains through settling basins and a coarse filter, which arrest a portion of the filth. This establishment employs about 125 men, handles about 200 hides a day, and discharges from 15,000 to 20,000 gallons of foul water into the river daily. The village of Winchester contains about 400 houses, an equal number of privies and about 300 cesspools. The soil is gravelly, the ground water low, and the liquid leaches away freely from the cesspools. The solids are cleaned from the cesspools and privy vaults about once a year, at an estimated cost of $4 each, or a total cost of about $2,800 yearly.

The town Board of Health, in its report for 1885, says:

"In view of the certainty that at no very distant day our town must provide for the disposal of its sewage, the Board suggest the advisability of setting some competent person, or persons, to inquire into the possibility of safely disposing of such sewage within our own territory."

It may be possible that areas of land within the town can be found where sewage can be satisfactorily disposed of, although I have failed to find any such area which seemed suitable to the purpose. Should such a filtration area be adopted, the effluent from it must of necessity go into the Mystic water supply, and should the purification at any time prove incomplete, the works might be subjected to injunction, and the money expended on them prove to be wasted. Any scheme by which the sewage of the town should be conveyed to a point where it could be discharged in a crude state without doing harm, would be too expensive for the town to carry out by itself.

SECT. 10. *Medford.*—The population of Medford is about

9,000, grouped at two principal centres, Medford Centre and West Medford, both in the immediate vicinity of Mystic River. The average daily water supply of the town is 210,000 gallons, coming from Spot Pond in Stoneham, whose liability to pollution is referred to in section 7. Most of the water supply after use is disposed of in cesspools, although a considerable portion is turned directly into the river. It is estimated that there are about 1,600 privy vaults and 800 cesspools within the town. These are cleaned out about once a year by a licensed contractor, at an expense of from $4 to $5 each, or an aggregate of upwards of $10,000 a year, which would be the interest on nearly $300,000.

Medford contains several manufactories. The Mystic Printing and Carpet Weaving Company, situated on the marsh west of Wellington, employs 250 hands, and discharges about 30,000 gallons of waste water per day. This goes through an open ditch about half a mile long to the river. Privies for 135 employés are over this ditch. The water is very dirty on leaving this factory, but loses much of its color before entering the river.

The Brunswick Antimony Company, also situated on the marsh, when in operation discharges 20,000 gallons of waste water through a ditch to the river. Its privies, used by about 10 employés, are over the ditch.

Near the corner of Main Street and Mystic Avenue are several small manufactories, employing about 70 hands. The drainage from these goes directly into the river. The water closets in the West Medford station drain to the river, as also do five estates on High Street, and the Lawrence distillery on Riverside Street, near the square.

The principal source of nuisance in Medford is the Mystic Valley sewer, constructed by the Boston Water Board, which discharges sewage from tanneries in Winchester and Woburn into the Lower Mystic Lake. This lake and the river below are made very foul, and stink badly at all seasons of the year, but especially in winter. The gases arising from the river discolor houses in its vicinity and at times are perceived over a large part of the town. The town Board of Health for 1884 speak thus of one source of complaint: —

"Many of the smaller streams running through various parts of the town have become more or less obstructed in their course, from natural and other causes, whereby their velocity is diminished, resulting at certain times and under certain circumstances in conditions offensive both to the senses of sight and smell."

Medford has long contemplated the building of a sewerage system. As early as 1873 an excellent report on the subject was made by the selectmen. This included one from Mr. Clemens Herschel, civil engineer, who had been engaged to design a system of sewers for the town. The system as devised by Mr. Herschel provided for nearly all the settled portions of the town, and the estimated cost of that part of it north of the river was about $200,000. Two main outlets were provided, one on either bank of the river, near the easterly limits of the town. It may be questioned whether any considerable quantity of sewage could be continuously discharged at these points without creating a serious nuisance, or whether any point of the river could be found where such discharge could be properly made.

SECT. 11. *Belmont.* — Four-fifths of this town is within the Mystic River watershed. The remaining portion, which drains into Clematis Brook and so into Charles River, is comparatively unoccupied land. The population of Belmont is about 1,600, and is somewhat concentrated in the two villages of Waverly and Belmont, the principal increase in population at present being at the latter point. The natural direction of drainage of the town is into Wellington Brook, a tributary of Alewife Brook, which in turn runs into Mystic River. The town has no public water supply, but has contemplated taking one from one of the adjoining towns, Waltham, Watertown or Arlington. The present water supply is derived from wells and natural springs. These are liable to the usual sources of contamination in inhabited districts, although no special cases of impurity have been heard of. After use, the waste water is commonly disposed of in cesspools or privy vaults, whence it filters into the surrounding soil or overflows into the brook. Wellington Brook receives a considerable amount of impure water in this way. About fifty such cases were observed, where foul drainage passed directly or indirectly into the stream. In some of these the drainage came from handsome residences, and in others from a very cheap class of dwellings. This brook has been used by Cambridge as a source of water supply in the winter time, to supplement that derived from Fresh Pond. To do away with the pollution from privies in the immediate neighborhood of the brook, Cambridge at her own expense replaced some of them with brick vaults. On examining these structures last year, some of them were found to be overflowing into the brook. Such pollution of a water course is clearly illegal, but it will probably be impossible to prevent it except by providing a sewer into which the houses can drain. As Cambridge has taken a new source of supply from Stony Brook, in Weston, Wellington Brook, which is evidently unfit for the purpose, will doubtless be abandoned. It is estimated that there are in Belmont about 285 dwellings, and about an equal number of cesspools or privy vaults. The cost of cleaning these is probably about $1,000 yearly. In the case of two fine estates, waste water is disposed of by systems of sub-surface irrigation. In one case the system is said to have cost $2,000, a sum sufficient to build about a third of a mile of town sewers. The McLean Insane Asylum contemplates moving its establishment to Waverly. One obstacle in the way of this is the difficulty which would be experienced in finding an outlet for its drainage, which would amount to 30,000 gallons per day.

It will be seen from the above that Belmont needs a sewerage system, although she does not feel ready to incur the expense of building one. With any considerable increase in population and in the use of water, sewers would doubtless become a necessity for the centres of population. There appears, however, to be no accessible place where the sewage could be put without doing harm. The natural drainage is into Wellington and Alewife brooks. The former is much too small to serve as an outlet for sewage, and the latter is already polluted in this way to an extent which makes it offensive.

SECT. 12. *Arlington.*— This town lies entirely within the Mystic watershed. It has a population of about 4,600, pretty well distributed, being most concentrated along

Arlington Avenue, which traverses the town. It has a public water supply of about 300,000 gallons per day, derived from Great Meadow Swamp in Lexington. This supply is thought not to be subject to pollution, though occasionally made offensive by the decay of vegetable matter. At times in the summer, 500,000 or more gallons a day, in addition to the regular domestic supply, are taken from the town pipes by market gardeners, for use in irrigating their crops. The charge made for this water is one and a half cents per hundred gallons. The domestic supply is chiefly disposed of in cesspools and privy vaults, of which it is estimated there are 700 in the town. These are cleaned out about once a year, at an average cost of $3.50, or an aggregate of $2,450 yearly. Sucker Brook and its mill ponds receive a certain amount of waste drainage, but not enough to render the water noticeably polluted. There are six small manufactories upon this brook, and some of them have their privies over it. In the case of the largest establishment, employing 25 hands, the privies are over the manure heap in the stable.

The principal nuisance complained of in Arlington is the foul odor from Alewife Brook on its eastern boundary. The smell comes from sewage emptied into the brook by Cambridge, and formal complaints have been made to Cambridge about the matter.

The town does not feel the need of a sewerage system nor desire to build one. There seems to be no place within or near the town where crude sewage could be emptied without causing a nuisance, and no tract of land within the town especially suitable for sewage filtration.

SECT. 13. *Cambridge.* — A portion of Cambridge, embracing 1,600 acres, is within the Mystic watershed, draining into Mystic River through Alewife Brook. Two-thirds of this area is sparsely settled; on the remaining third live about 7,000 persons, and this population is rapidly increasing, especially in Wards 1 and 5.

The principal source of water supply for Cambridge at present is Fresh Pond, having a catchment area of 569 acres, and situated within the limits of the city and of the Mystic watershed. The supply of this pond has heretofore been augmented at times by diverting to it the waters of Wellington Brook (referred to in section 11), which are manifestly polluted and unfit for the purpose. The city has decided to abandon this brook and is constructing works to introduce into Fresh Pond a supply from Stony Brook in Weston. A sanitary survey of that brook, made at the joint expense of Cambridge and this Commission, revealed no liability to pollution which could not be done away with.

Fresh Pond itself is somewhat liable to pollution. This danger has been well stated by a committee on water supply appointed by the city: —

"Fresh Pond is exposed to certain dangers to which all ponds in the midst of rapidly growing centres of population are subject; and these dangers are to a great extent inevitable. That our pond must at no very distant day fail to be an acceptable source of supply for this reason is, in our opinion, to be expected. This danger, believed to be inseparable from the covering of the surface of the ground with houses, will be even more menacing to the purity of running streams. . . . ."

"We cannot keep the underground currents from going into the pond. They must be kept pure from polluted matter in solution, because once polluted it is beyond our power to prevent that pollution from reaching the pond. The protection therefore needed is not only to the pond as seen to the eye, but to the underground currents leading to the pond, wherever they may be."

The most practicable way of preventing the pollution of ground waters is to remove, by means of sewers, the filth which causes the pollution. Sewers for the area about Fresh Pond would naturally drain into Alewife Brook. But this brook itself is already dangerously contaminated, and when it overflows the meadows on either bank its waters may return underground to the pond. Sewage from a part of Cambridge is emptied into the brook at three main outlets, and makes it a source of nuisance and danger not only to Cambridge itself, but also to the adjoining towns of Arlington and Somerville.

This evil is continually alluded to by the city Board of Health in its annual reports. It said in 1881: —

"The filthy condition of Alewife Brook has greatly increased in the past year, so that it is now little else than an open sewer, the rank odor of which is distinguishable for a long distance from its banks."

And again in 1883: —

"Complaints have been made by the town of Arlington, and others, in relation to the nuisance in Alewife Brook. The authorities of Cambridge are as desirous as any one of abating it, but have been met by serious opposition in their efforts to do so. There is, also, so much uncertainty in the matter of the final disposition of the sewage as to render the adoption of any plan of magnitude exceedingly difficult as well as of doubtful propriety."

Cambridge is apparently ready and anxious to build sewers to carry off the filth which threatens the purity of its water supply and also causes serious nuisances. It realizes, however, that this can only be done in combination with other towns by a metropolitan system of sewerage established by legislative action.

SECT. 14. *Somerville.* — About half of this city is within the Mystic watershed, naturally draining into Alewife Brook or Mystic River. A portion of this area is already sewered, and the sewage is discharged at three outlets into ditches which run to the river. Considerable nuisances exist at these points, and they are likely to increase with the growth of population. In the unsewered portions of the city about 500 cesspools remain. The objection to these structures as stated by the city Board of Health is worth quoting on account of its general applicability: —

"The result of the use of cesspools in porous soil was forcibly illustrated last season during the excavation for the sewer in Park Street. The stench emitted from the earth as it was removed from the trench proved conclusively that the filth from cesspools not only saturates the soil in close proximity to them, but is liable to render the whole neighborhood unfit for the location of dwellings."

The principal nuisances from which Somerville requires relief are the pollution of Alewife Brook by sewage, referred to in the preceding section, and a similar pollution of

Mystic River. The former of these evils is thus spoken of by the city Board of Health in its report submitted in 1881 : —

"This nuisance on the westerly border of our city has increased during the year. It is caused by the contents of three main sewers (which drain an area of 864 acres), and the sewers from Niles Brothers' hog-slaughtering establishment, Muller's tannery and currying shop, and two other currying shops, all in the city of Cambridge, flowing into this brook and its tributaries.

"Several cases of sickness have occurred in West Somerville, which have been caused, in the opinion of the attending physician, by this nuisance. Its odor, even in the coldest weather of the present winter, has been very offensive."

The same Board said in 1882 : —

"The nuisance occasioned by the condition of this brook has received the attention of the board ever since its organization. We have repeatedly called the attention of the Cambridge author ities to the dangers to which the residents of this city, living in that vicinity, were exposed, and requested them to abate the nuisance. There being no material change in the condition of the brook, we, on the 25th of January, 1881, sent a communication to the Senate and House of Representatives, in which, after referring to the filthy condition of the brook and its being a probable cause of sickness in that vicinity, we prayed for such legislation as would compel Cambridge, within a reasonable time, to divert its house drainage and sewage from business establishments from the brook and its tributaries. As a result of that communication, a bill was passed on the 6th of May, 1881, which provided for the purification of the brook. The bill met the approval of the board. It is true that there were some objectionable features in it; but when we consider that it was only a temporary measure, and that pending the formation of a metropolitan system of sewerage, which must eventually come, our people would be relieved from this nuisance, and our city would receive $1,000 annually from Cambridge for the use of a portion of our sewers, we think a great mistake was made in not accepting the act. . . ."

The act above referred to authorized Cambridge, by agreement with Somerville, to build an intercepting sewer along the line of Alewife Brook and pump the sewage into the Somerville system, paying for the privilege such sum as should be agreed upon. The two cities failed to agree as to terms.

The water supply of Somerville comes from Mystic Lake and its tributaries. The pollution to which this water is subjected has been referred to in the sections describing the towns forming its watershed. The feeling of Somerville in regard to this matter is thus expressed by its Board of Health: —

"The selection, for a source of water supply, of a lake whose watershed is in many parts thickly settled, and which is occupied by a large number of manufactories and other establishments where objectionable classes of business are conducted, was unfortunate.

"We are of the opinion that the following measures should be carried out in order to make Mystic Lake a proper source of water supply: —

"Divert all sewage matter from the lake and its tributaries; provide a proper system of sewerage for the towns of Winchester, Woburn and Stoneham.

"Remove the filth and decayed vegetable matter from the lake and its tributaries.

"Improve the shores of the lakes and ponds, and take such measures as may be necessary to prevent the growth of vegetable matter."

SECT. 15. *Melrose.* — Melrose has a population of about 6,100, consisting largely of well-to-do persons occupying good houses. Most of these houses are grouped about the Boston & Maine Railroad, near the centre of the town. There is a public water supply, amounting to 180,000 gallons daily, taken from Spot Pond, referred to in section 7. The water is disposed of in cesspools, and, the soil being porous, the liquid contents of the cesspools leach away freely into the ground water, and probably finally flow away into Malden River or its tributaries. It is estimated that there are about 1,200 privies in the town, and about 600 cesspools. These are cleaned once a year, at an average cost of $3.50 each, or a total annual cost of $6,300. The upper portion of Malden River runs through the town, and the stream in places is made a dumping-place for rubbish of various kinds. The privies from eleven estates were observed to overflow into the stream. That at the Wyoming station is directly over the river. The stream is therefore somewhat polluted by sewage, but not sufficiently so to make it offensive.

The Rubber Works, near the Malden line, employ 1,000 operatives, and have a private water supply from artesian wells amounting to 200,000 gallons per day. The waste water from this establishment, which is considerably discolored but not particularly offensive, runs into a filter basin, and thence, but slightly clarified, enters the river. It seems to cause no appreciable nuisance. The water closets for the operatives discharge into tight vaults, which are cleaned out at regular intervals.

One small tannery on Grove Street, employing nine men, drains its manufacturing refuse and the sewage from its privies directly into the river, which is discolored for several hundred feet below this point.

A large shoe shop, on the corner of Waverly and Grove streets, employs 80 hands, and drains into a cesspool on its own estate.

So far as could be learned, there is no disposition on the part of the town to build sewers. The increase in population during the last five years was about 37 per cent.; should this rate be maintained in the future, there is little doubt that the need of some disposition of domestic filth, other than storing it in the soil about habitations, will be felt. The difficulty in the way of establishing a sewerage system for Melrose is that the natural line of drainage being through Malden, there is no easily accessible place where the sewage could be put without causing a nuisance.

SECT. 16. *Malden.* — The population of Malden is about 16,400. The older and more thickly settled parts of the city are situated on the slopes of steep hills, which incline towards the Malden River and its tributary brooks. The city has had a public water supply since 1870. The water comes from Spot Pond, referred to in section 7. The supply amounts at present to 700,000 gallons per day. The water board state that "there can be no doubt that the supply of water from Spot Pond is totally inadequate to the needs of Malden, Melrose and Medford." An additional supply for Malden is contemplated, to be derived from driven wells located on the low land near the centre of the city just south of Eastern Avenue. At this point the gravel, which is overlaid by clay, forms a natural reservoir into which drains soil water from the upper portions of the city. Chemical analysis does not reveal any impurity in this supply, but it doubtless contains a large part of the waste water from the higher portions of the town, which reaches it through the cesspools. Whether such water is perfectly purified by its journey through the ground it is impossible to say. There are about 3,000 feet of small drains in Malden, used solely to convey surface water to the streams, but there are no town sewers for sewage proper. Nearly the whole of the contaminated water supply is disposed of in cesspools. These are usually loosely built structures, and the earth about them being gravel, their liquid contents escape freely into the ground water below. The rules of the Board of Health require that when a cesspool is located within 15 feet of a cellar it shall be made water-tight. But as it would take a very large cesspool to contain a week's supply, and it would be very troublesome and expensive to have it emptied fifty times a year, it is doubtful if in practice any water-tight cesspools are built. It is estimated that there are 3,000 privy vaults and 2,000 cesspools in the city. These are cleaned, under a contract, by a licensed night-soil remover, who uses an odorless excavating apparatus. This is done about once a year, at an expense of $3 for each privy and $5 for each cesspool. This represents an annual tax of $20,000, which would be the interest on about $500,000.

Malden River and nearly all its tributaries in this city are very dirty, except when washed clean by freshets. The brooks have a good deal of rubbish thrown into them, and, with the river, receive much domestic drainage and foul liquids from manufactories. The principal brook running through Edgeworth is polluted by the overflow from a number of privies and cesspools. Another neighboring brook which empties into the river near the Rubber Works is very foul, and has been referred to by the city Board of Health as a nuisance. At Middlesex Street 12 privies, used by about 75 people, are directly over Malden River. Where Pleasant Street crosses the river, four or five blocks of houses are supposed to drain into it. The brook on the north side of the Saugus Branch Railroad receives the overflow from the privies and sinks of six estates east of Cross Street.

The Gas Company discharges a good deal of waste tar and ammonia water through a 2 ft. × 2 ft. box drain into an open ditch on the marsh. This drainage looks foul and smells very badly.

The Boston Rubber Shoe Company's mill No. 1 employs 1,300 men, and has a private supply of water amounting to 250,000 gallons per day, derived from artesian wells. The drainage from its water closets, privies and rubber washing passes directly into the river. The water looks black, but does not smell very badly.

The Glue and Sandpaper Company employs 30 men, and has a private water supply from three artesian wells amounting to 30,000 gallons per day. They use lime water in washing glue stock, consuming about 200 casks of lime per season of six months. The refuse lime water is discharged through privies into the river.

Webster's tannery employs 200 hands, handles 200 to 250 hides per day, and uses 5,000 cords of bark per year. It has a private water supply of 50,000 gallons per day from ten artesian wells. The drainage from privies, water closets and vats goes directly into the river through two 8-inch drains. At low water the river back of the tannery looks very foul and stinks badly.

Cochran's indigo dye house discharges about 500 gallons of liquid refuse directly into the river. The privies at this place are over tight vaults.

Cochran's Turkey-red dye house employs 160 men. The privies are over tight vaults. About 1½ tons of chemicals are used monthly in dyeing yarns and fabrics. The waste dye water goes into the river, and turns it a bright red color noticeable a mile below the dye house. When the brook is low, everything that flows in it below this point consists of waste water from the dye works.

The National Laundry and Dye House employs from 60 to 70 hands, and uses about 2,000 gallons of city water per day. All the drainage from their water closets and washtubs is discharged through an 8-inch box drain into the brook on the south side of the Saugus Branch Railroad. In the same group of buildings with the laundry are several small manufactories, employing about 50 hands. All their water-closet and other drainage goes into the same brook.

The need of a sewerage system for Malden has been generally felt, and is becoming more pressing as population increases and becomes more crowded. A system of sewers for the city was devised a year ago by Mr. Page, an engineer residing in Malden. The scheme embraced nearly 40 miles of sewers, with an outlet into the Pines River near Linden. His estimate of cost of the system was $172,750. This estimate seems to be a remarkably low one, and it seems at least doubtful whether any large amount of sewage could be continuously emptied at the point indicated without causing a serious nuisance, and furnishing sufficient grounds for lawsuits or injunctions. It would be, however, extremely difficult to find any other accessible point for discharge which would not be liable to the same objection.

SECT. 17. *Everett.* — This town is largely a town of residences, having comparatively few factories. The population is about 5,400, and is chiefly located on the sides of gravelly hills, which slope down to marshes about Malden and Mystic rivers. It has a public water supply from Mystic Lake in common with Somerville, Chelsea and Charlestown. The average daily supply is supposed to be 150,000 gallons. After use the polluted water is run into privy vaults and cesspools, whence it soaks through the porous ground and joins the ground water. A private supply, of which about 50,000 gallons a week are sold for drinking, is derived from a well sunk in the ground near the base of one of the hills. It is estimated that there are about 1,100 vaults and 500 cesspools in the town. About two-thirds of these are cleaned yearly by a licensed night-soil remover, at a charge of $3 each. The aggregate yearly cost of this service is therefore more than $3,000. The only large manufacturing establishment in this town is Cochran's chemical works, near the Charlestown line. It employs 100 workmen, and privies for them are placed directly over Mystic River. A small dye house on Spring Street, employing four men and using about 500 gallons of water per day, discharges refuse from its dye vats and water closets into an open ditch, and thence into the river. The Board of Health of this town, in their report for 1884, say: "The question of sewerage is one which will engage the attention of our citizens in the early future."

SECT. 18. *Chelsea.* — The population of Chelsea is about 25,700. The city is supplied with Mystic water by an arrangement with the Boston Water Board. The average daily consumption is estimated to be about 1,500,000 gallons. The city has a system of sewerage, including 18 miles of sewers which admit rain as well as house sewage, and which cost to Jan. 1, 1885, $344,000, or over $19,000 per mile. The district called Prattville is sewered on the separate system by two miles of sewers which do not admit rain, and which cost $16,000, or $8,000 per mile. The sewage is discharged at thirteen outlets on the margins of the city. The Spruce Street sewer, discharging into Island End River, back of the Marine Hospital grounds, has caused a nuisance which has been complained of by the hospital authorities and by the Board of Health. The Highland Street outlet is also a source of offence.

Speaking generally, it may be said that the disposal of sewage by Chelsea on its shores is not satisfactory and is liable to create nuisances. Considering the financial state of the city, it is doubtful if any costly remedial measures would be deemed expedient at present.

SECT. 19. *Revere.* — About one-half of Revere, including all the thickly settled portion of it, drains into Chelsea Creek and thence into Mystic River. The population is about 3,600, partly made up of summer residents. The town, in common with Winthrop, has a small water supply furnished by the Revere Water Company, amounting to about 50,000 gallons per day. The water is disposed of in vaults and cesspools, of which structures there are about 700 in the town. A portion of these are cleaned out and the contents carted away at an average cost of $4 each. The larger part are cleaned out in the spring, for perhaps $2 each, and the contents spread over the cultivated ground of the premises.

The population is too scattered to make the need of a sewerage system a pressing one at present.

SECT. 20. *East Boston.* — East Boston is an island bounded on one side by Mystic River and its tributary, Chelsea Creek. It has a population of 31,400, and uses about 1,500,000 gallons of water per day, derived from Lake Cochituate and the Sudbury River. The sewage, which is of about equal amount, is discharged at seventeen outlets on the margins of the city. Four of these, on the south side of the city, empty into the heads of docks, making them very offensive and causing a continual nuisance to the steamships and other vessels using them. The outlets on the east side of the city discharge upon large areas of flats, which are much polluted and are a continual subject of complaint by the Board of Health. There seems to be no remedy for this state of affairs except to collect all the sewage by means of intercepting sewers and convey it to some point where it can be discharged without causing a nuisance.

THE CHARLES RIVER BASIN.

SECT. 21. *The basin as a whole.* — The Charles River Basin contains about 290 square miles, and includes the whole or considerable portions of twenty-eight cities and towns, with an aggregate population of 370,000. Of this total population, 42,000 are found in what may be called the rural district, comprising towns in the upper portion of the river basin above Waltham, and 328,000 are in the metropolitan district about the lower part of the river. By a reasonable inference from the rate of increase during the past fifteen years, it may be assumed that twenty years hence the population of the two districts will be 50,000 and 500,000 respectively, and after forty years will be 70,000 and 800,000. Excluding those portions of Boston whose drainage has been diverted from Charles River, the population of that part of the metropolitan district which still naturally drains into the river is 158,000, and in successive periods of twenty years may increase to 275,000 and 450,000. It should be understood that the latter figures are little more than guesses.

Twelve cities or towns have public water supplies. Six take their water from filter galleries or basins constructed on the banks of the main or lower river. The lowest down is that at Watertown, eleven miles from the river's mouth; and the highest up is that at Dedham, about twenty-seven miles from the mouth. Two towns take from filter basins near principal branches of the upper river, and four from sources outside of the Charles River valley.

The statute (chap. 80, sect. 96) which prohibits the putting of excrement into any stream within twenty miles above the point where it is used as a source of public water supply, affects most of the towns and streams in this district. The law is not strictly complied with or enforced, and many cases of this kind of pollution are to be found; but the amount is rarely sufficient to affect noticeably the purity of the water supplies.

The common mode of disposing of foul drainage is to put it into cesspools, from which the liquid portion soaks away, and the more solid part is periodically removed. In sparsely settled regions this method answers fairly well; but it is far from satisfactory at centres of population, where the buildings are in blocks or near together. In such cases the filth is retained in the soil about, and even under, dwellings, and the cesspools are so close to each other that the ground, unless very porous, becomes sodden and probably unhealthful. Several towns in this district would be glad to build sewers to convey their foul drainage to a distance, if they only knew where to put it without violating the statute.

Within the district are several hundred manufacturing establishments of various kinds. Most of the large ones are situated immediately on the banks of the main river or its branches. Many of them use large quantities of water and discharge more or less polluting refuse into the streams. The law prohibiting such pollution within twenty miles of a water supply is, as yet, practically inoperative. Much of the refuse from such establishments is more objectionable on account of its appearance than because it is known to make the water actually unwholesome.

In places, near the outlets of sewers and drains, the water-courses of this basin are polluted and sometimes offensive. Throughout the greater part of their extent, however, evidences of serious contamination are not as yet apparent to the senses.

In the following sections the different towns will be considered in detail.

SECT. 22. *Milford.* — About two-thirds of this town, including the village proper and three-fourths of the total population, is situated within the Charles River valley, on the head waters of the river. The western third, containing the village of Hopedale, is in the valley of Blackstone River. The two valleys are separated by a marked ridge, on the easterly slope of which is situated the village proper. There is a public water supply furnished by a private company, pumped from a well about a mile above the town, on the bank of the river, here about twenty feet wide. A storage reservoir has been constructed about three miles further up the stream, within the town of Hopkinton. The supply is taken from a sparsely settled region and is therefore subject to very little liability to pollution. The daily average amount of water pumped is about 275,000 gallons. There has been no increase of population at this place during the past ten years. After use, the fouled water is chiefly disposed of in privy vaults and cesspools. There are, however, two sewers, aggregating about 4,000 feet in length, situated in Main Street and in Central Street, within the limits of the village. The sewage from the Main Street sewer fouls the stream badly and causes a great nuisance. The Board of Health in its report for 1884 refers to this outlet in these terms: —

"The greatest nuisance in the town, however, still exists almost unattended to; a nuisance which is probably the cause of a very large share of the sickness and very many of the deaths in our town. We refer to the uncovered and undrained outlet of the Main Street sewer, in rear of Pond Street. Undoubtedly much disease-producing filth is emptied from the sewer, and, slowly carried along the sluggish brook, poisons, not the air alone, but permeates the soil, so that persons using water which has percolated through such soil, are very apt to be imbibing not pure water, as it appears, but liquid death. The very severe epidemic of typhoid fever, which prevailed during last summer and fall, and which was especially violent below the outlet of the sewer, can undoubtedly, in a good measure, be traced to this source."

The direct pollution of streams in Milford, due to manufacturing, is not very great in amount. A few cases, however, may be noted.

The shoe factory of Jones & Shippee, on Central Street, is built directly over Charles River. Water closets used by from 300 to 350 operatives discharge direct into the stream. A little dry refuse, including dust, scrapings and shavings of leather from the cutters and wheels used in shaping and polishing soles, heels, etc., is blown by fans into the stream.

Green Brothers, heel manufacturers and renderers of scrap leather, employ about 200 hands, who use dry privies. The vats in which scrap leather is boiled are drawn off to a drain which enters the river north of the railroad depot. There is not much of this liquid, but it is highly colored, and would probably become offensive in summer.

There are about half a dozen other large factories in the town, employing in the aggregate about 1,200 hands. They are most of them remote from the stream and have dry privies. It could not be ascertained that any considerable pollution is caused by their processes.

A bad nuisance exists in the brook back of Eastman's box factory, due either to drainage from the factory or to that from vaults on estates fronting on Depot Street, or both. In summer the odor from this brook is quite offensive.

The annual expenditure on account of cleaning out vaults at Milford is estimated to be about $1,200.

An elaborate plan of sewerage has been prepared for the town by D. L. Wilkinson, C. E. By this the sewage is to be discharged at about eight outlets into the river and its tributary brooks, all of which are liable to be nearly or quite dry during a portion of the summer. The town has taken no action towards carrying out this scheme. There is an evident need and desire on the part of the citizens of the town to provide a system of sewerage for the thickly settled portions of it. As the town is more than twenty miles above any point where water is taken from the river for public water supply, it is not restrained by public statutes from discharging its sewage into the river. There being however at times so little water in the river, it is probable that, should any large amount of crude sewage be turned into it, not only would a nuisance be created near the outlet, but the river would be fouled to an extent which would be injurious to the towns below, and would be opposed by them.

SECT. 23. *Bellingham.* — About half of Bellingham is within the Charles River valley. It is in the main a thinly settled rural district, with no public water supply nor any probability of needing one. The river, which passes through the town, is not noticeably polluted before reaching North Bellingham. At this point are situated the mills of the Ray Woollen Company, which turn out about 1,000,000 yards of satinets, and wash 200,000 lbs. of wool per year. Privies for about 120 hands discharge directly into the river. Water used in wool scouring, and a certain amount of spent dye liquors, also contribute to the pollution of the river at this place.

At Caryville, half a mile below, is the satinet mill of Taft, McKean & Co. It scours from 150,000 to 200,000 lbs. of wool per year and employs 90 hands, privies for whom discharge into the river. The drainage at these places as it flows to the river looks very foul, but its effect in polluting the large amount of water in the river is not noticed by the eye for any great distance. It is said that cattle will drink the water if taken at a considerable distance below the mills. Some nuisance does at times exist, and more cases of typhoid fever and malaria are said to occur in the vicinity of the river than elsewhere.

SECT. 24. *Franklin.* — Franklin lies almost wholly within the Charles River valley. The population is about 4,000, of which three-fourths are in the village proper on a hill near the centre of the town. There is a public water supply which went into operation in the spring of 1885. This is furnished by a private company, and the water is taken from a well southwest from the village, with a supply pipe also from Beaver Pond. At present (July, 1885) only about 100 services have been connected, and the average amount pumped is about 30,000 gallons per day. Privies and cesspools are common in the town, and there is also a sewer and one or two drains which discharge directly into the stream. A drain from Dean Academy, where there are usually about

100 pupils, connects with the sewer which drains through Mill River, in Norfolk, into Charles River. There are several large mills in Franklin which discharge water-closet and manufacturing refuse through Mine Brook into Charles River. This brook is made very dirty for a long distance below the town. The well from which the water supply is taken is about 100 yards from the brook.

The following is a list of the principal manufacturing establishments in the town: —

Shoddy mill of J. P. & J. G. Ray, just southeast of the Union Street railroad crossing; employs 15 men, and has a dry privy that is cleaned out occasionally.

Belt knife factory of A. M. Cummings; employs 8 hands; has a dry privy; apparently causes no pollution.

Ray's cassimere mill, on Cottage Street; employs 20 hands; has a dry privy; causes little or no pollution.

Felting mill of A. D. Thayer; employs 25 to 30 hands; privy empties into the stream. No scouring is done at this mill, but there is more or less dyeing, and the waste liquor from dye vats goes into the stream.

Satinet mill of C. J. McKenzie; employs 32 hands; privy discharges into the stream. Some dyeing is done, but no scouring.

Cassimere mill of J. F. & L. P. Ray; employs 90 to 100 hands; privies discharge into stream. Both scouring and dyeing are carried on.

All the foregoing mills are situated on a small branch of Mine Brook. In summer this branch has very little water in it, and what there is looks very foul where it joins the main brook, although Mine Brook itself looks clear at that point. During rains, a good deal of dirt is probably washed into the brook from this branch.

The Franklin Rubber Company's mill employs about 200 hands. Earth closets are used, to which earth is supplied once a day, and the closets are cleaned out every week by the Sunday watchman. A large amount of water is used at this mill, principally for cooling the rolls, and also for washing the crude gum, which is very foul smelling. After use, the water is run off upon porous, gravelly soil, whence it soaks away, and makes little or no nuisance.

At Unionville, on Mine Brook, is the felting mill of J. B. Ray, employing 30 to 40 hands, with a privy discharging into the stream. About 24,000 lbs. of wool are scoured and about 140,000 lbs. dyed yearly. It is estimated that only about 3 lbs. of dye per day run into the stream. Although this amount seems small, its effect in discoloring the water is quite marked, and the stream is made very red as far as the mill-pond below.

A small shoddy mill, and a cotton mill, also at Unionville, cause no noticeable pollution.

In the village of Franklin is the straw factory of D. Thayer, Jr. There are 300 hands, who use dry privies, cleaned three times a year. The drainage from the bleachery, dyehouse, and sinks used to cause a nuisance, and is now carried in a drain more than 500 feet long, and emptied upon gravelly land.

Waitt's felting mill, in the main village, employs 20 hands, and has a dry privy, which is cleaned out occasionally, and the contents utilized on land. Some scouring is done, and also dyeing. The refuse from the dyehouse goes through a pipe to the town sewer at the railroad.

This sewer does not seem to cause any special nuisance, because nobody lives near its immediate outlet; but the stream into which it empties has very little water, and its bed for a considerable distance below the sewer looks black and foul.

There is no talk as yet, at Franklin, about building any *system* of sewerage; and the topography of the town is such as would make any system by which the sewage should be brought to a single outlet, somewhat expensive. Different portions of the town drain naturally in different directions, into different branches of Charles River. It is stated that little cash is ever paid at Franklin for cleaning vaults and cesspools. Householders either clean their own or find farmers who will do it for nothing.

SECT. 25. *Wrentham.* — About one-third of Wrentham, in the northerly part, drains to Charles River through Mill River. Two large natural reservoirs exist on this area, and store water for the use of the mills below. The water of these reservoirs is supposed to be very pure, and they are fenced in and stocked with fish. Just below them, on Mill River, are two small shoddy mills which cause little pollution. There is no talk of artificial water supply or sewerage at this town.

SECT. 26. *Medway.* — The town of Medway lies on the north side of Charles River, from which it rises by gentle slopes. A manufacturing district extends along the river, and back of that and at a distance from the river are farms. The total population is about 2,800. There is no public water supply and no probability that one will be needed for a long time, as the village is scattered along the river and is not increasing in population. For the same reason there is no likelihood of any sewers being built. There are several mills in the town, one of which scours 200,000 lbs. of wool annually. The effect of drainage from this mill is sometimes noticed for about a quarter of a mile below it.

SECT. 27. *Holliston.* — All of Holliston drains into Charles River through several brooks. The population at present is about 2,900, and has diminished slightly during the last ten years. The town is very thinly settled, except at villages near its centre, which contain about two-thirds of the total population. There is no public water supply, although one is talked of, to be taken from wells near some of the smaller water-courses. To accomplish this the "Holliston Water Company" has been incorporated under an act (ch. 106, 1884), approved March 26, 1884. The only noticeable case of pollution in this town is at the Holliston Mills at East Holliston. Here fine blankets are made, and 300,000 pounds of greasy wool are washed annually. Seventy to eighty operatives are employed and the privies are over the stream.

SECT. 28. *Norfolk.* — This is an upland town, with a scattered population of less than 1,000. The whole of it naturally drains through brooks into Charles River. There is no talk of adopting any artificial water supply or system of sewerage, and none will probably ever be needed. There are a few cases in this town where the water in the streams is somewhat contaminated by refuse from manufacturing establishments.

Three-quarters of a mile south of Norfolk Centre, on Stony Brook, is a shoddy mill employing 12 hands. The privy is so arranged that its contents get into the stream. About 250 carboys of vitriol are used every year for washing the cotton warp out of woollen rags. The waste from this operation does not cause a marked pollution, and is noticeable only where it passes into the stream.

At City Mills village, near the westerly border of the town, are the felting mills of the City Mills Company, who use both cotton and wool. About 150,000 pounds of the latter material are scoured annually. The goods are dyed in a great number of different colors, and the spent dye liquors and scour go directly into Mill River, which is somewhat discolored. Privies for about 75 men discharge directly into the stream, but that for the women is over a vault on land.

A paper mill on the east side of the town makes about 10 tons per week of Manila wrapping paper and dark carpet lining. Old newspapers and Manila stock are used. There is no bleaching, but some logwood and copperas are used for dyeing. A privy for 10 or 12 hands discharges into Stop River, but there is no sensible discoloration.

SECT. 29. *Millis.* — This is essentially a farming town. It has no public water supply or system of sewerage, nor is there a probability of any being needed. No cases of pollution of the river are known to exist.

SECT. 30. *Sherborn.* — Sherborn has a sparse population, which is not increasing. A small part of the town at the north drains toward Lake Cochituate and Sudbury River, and is referred to in section 53. The part within the Charles River valley consists mainly of farming lands. There is no public water supply or sewerage, and no occasions of pollution worth noting are known to exist.

SECT. 31. *Medfield.* — Medfield lies principally in the valley of Charles River, which borders it on the western side. The land is high and rolling, and the principal village contains a population of about 1,000. The only water supply is from wells, and none other is talked of. As is always the case, some of the wells are of doubtful purity, being exposed to pollution from vaults and cesspools. This can only be guarded against by the personal care of the owners.

There is one case of marked pollution in Medfield, which is at the straw factory of D. D. Curtis & Co. This establishment employs from 600 to 700 hands in busy times. It has a liberal supply of water from an artesian well 140 feet deep. At this place straw braid brought from Europe is bleached or dyed, and sewn and shaped into hats. All waste from the bleachery, and also from the water closets, is emptied into a cesspool, whence it overflows by a 6-inch pipe into Vine Brook near by. A hotel with from 40 to 50 boarders drains its water closets at the same place from another cesspool. The brook, which is in the centre of the village, is more or less dammed near by, and is said to be very offensive in hot weather. Three years ago there was much complaint on account of this, and the attention of the State Board of Health has been called to it. Water was formerly taken from the brook below this point and forced, by means of rams, to houses for domestic use. The water, however, became so foul that such use of it had to be abandoned. There has been no talk of building sewers at Medfield.

SECT. 32. *Dover.* — This is a thinly settled farming town in which there are no dense settlements. Water is derived from wells, which are presumably as pure as those in other towns, any contamination being the result of carelessness. There is one small paper mill in the town, and as this makes only brown paper, the wash water which runs into the river is not specially foul.

SECT. 33. *Natick.* — The easterly half of this town, including South Natick village, is in the valley of Charles River. The population of South Natick is about 500. It has its share of the general town water supply, which comes from Dug Pond in the Cochituate valley. This water is somewhat polluted by drainage from the village of Natick, and is referred to in sect. 51. Most of the water which is fouled at South Natick is put into cesspools. Farmers can generally be found who will clean these out for the privilege of using their contents. It is said that only two families in the village pay for this service. Sewage from Bailey's hotel is discharged directly into the river. This is less than twenty miles above points where water is taken from the river through filter basins for domestic supply.

There has been no talk at South Natick of building a sewerage system, except that some people have supposed that the sewage of Natick would eventually be brought across the town to Charles River, in which case South Natick would join the system. Crude sewage could not, however, be discharged at this point without violating the public statutes.

SECT. 34. *Dedham.* — About two-fifths of this town, including the whole of the main village, is within the Charles River valley; the remainder, including the villages in the vicinity of Muddy Brook, drains naturally into the Neponset. The population of the whole town is about 6,600, and is increasing at a moderate rate. The town has had for five years a water supply furnished by a private company. The water is taken from a well in the immediate vicinity of Charles River, a little above the village. It is assumed by the water company that most of the water pumped comes from the landward side. The average daily supply is somewhat less than 150,000 gallons. After use, the fouled water is put back into the ground through cesspools. This method of disposal is not considered wholly satisfactory, but there has been no action as yet looking to the establishment of a sewerage system. As in some parts of the village the houses are close together, it will probably not be long before the need of sewers to remove their filth will be felt. The public statutes would prohibit the discharge of any sewage into Charles River.

One marked case of nuisance and pollution exists within the village proper. This is caused by sewage from the county jail, which is discharged into a brook passing through swampy land a few hundred feet distant. This makes a bad stink at times, and it is reported that during the past year several cases of typhoid fever have occurred in its vicinity. In October, 1885, a petition signed by over 50 taxpayers was presented to the selectmen, praying that body to carry into effect some adequate system of drainage by which this nuisance might be abated.

There has been some talk at Dedham of digging a canal to drain the swampy land in the vicinity of Wigwam Brook into the Neponset near Green Lodge. It was thought that if this were done, a sewer to serve the town could be built in the same excavation, with an outlet into Neponset River. To discharge crude sewage at that point would, however, be contrary to the public statutes, since Hyde Park takes its water supply from a filter basin less than three miles below. Such a scheme would not serve the portion of the town situated near Mother Brook, referred to hereafter in section 68.

SECT. 35. *West Roxbury.* — West Roxbury constitutes Ward 23 of Boston. About 2,000 acres of this territory, including the villages of West Roxbury and Spring Street, drain in a westerly direction into the neighboring upper part of Charles River. Being near the city proper, on a line of railroad, and provided with city water, the population at these points is increasing rapidly. There are no sewers built, and it would be illegal to discharge crude sewage into Charles River or its tributary brooks. The filter gallery from which Brookline takes its water supply is within this territory near Charles River.

SECT. 36. *Needham.* — This was formerly a large town, containing 12,000 acres, with a population of over 5,000. In 1881 Wellesley, containing about half the population, was set off as a separate town. Needham contains large grassy plains, which slope gradually to Charles River. The centre of the town is divided into somewhat large estates, bordered near the river by a farming region. There is no public water supply, although there has been talk of taking one from Newton, whose pumping well is near Charles River, within the territory of Needham. Some informal negotiations of committees, looking to that end, were held before Needham was divided. The division of the town will probably tend to defer the procuring of a water supply, and until one is obtained there will be no need of a sewerage system. There are a few cases of pollution from manufacturing establishments in this town.

The Waban Mills, which make about one hundred and seventy-five tons of leather board per year, have two outlets which discharge dirty water into the river for two or three hours daily. A privy for eight employés overhangs the stream.

The Keeler Manufacturing Company, which manufactures under-garments and hosiery, employs 108 hands, who use water closets emptying into Rosemary Brook.

The sewage from Hotel Wellesley, which contains in summer about 600 boarders, is discharged into two cesspools which retain the solids and permit the liquid to overflow to Charles River. This has been spoken of as a nuisance by neighboring residents.

SECT. 37. *Wellesley.* — This town consists of the northwest half of Needham, from which it was set off in the spring of 1881. It drains into Charles River in two opposite directions, towards the two sides of the town. The population is about 3,000. The town is highly cultivated and improved, with a large valuation for its size. There is a public water supply, introduced during the present year. The water is pumped from a well near the river, below Newton Lower Falls. The pumps have a capacity of 1,000,000 gallons per day, although only about two hundred services are at present connected. After use the fouled water is disposed of in cesspools.

Not much manufacturing is done at Wellesley, and little pollution is caused in this way. The principal establishments in the town are as follows: —

Paint and color works just north of Lake Waban, on the stream running into it. Thirty-five to forty hands are employed, who use a dry privy. The wash water from the colors runs into the stream. From one and a half to two tons of paints, chiefly house paints, are made daily.

The shoe factory on Washington Street, corner of Cottage Street, employs 125 hands. The privy is cleaned out four times a year and its contents utilized on a farm. Water used for soaking leather is turned into a cesspool.

On the main river at Newton Lower Falls are several mills.

The Thomas Rice Paper Company; employs 25 hands; privy discharges into the river. At this mill about 3,500 pounds daily of white newspaper are made. About one and a half tons per month of bleaching chemicals, such as chloride of lime, vitriol, etc., are used in bleaching colored rags. River water is used in manufacturing, and is considered clean enough for that purpose.

Dudley hosiery mills; employ 125 to 130 hands; privies discharge into the river. All-wool and cotton-mixed underwear is chiefly made, sometimes dyed and sometimes not. No wool is scoured; waste dye liquor and soapy water from washing finished goods are discharged into the stream.

Chemical works of Billings, Clapp & Co.; make chemicals for druggists' use; employ 10 hands; privy over a vault on land. All refuse is thrown in a pile on a vacant lot near the river, but none is put directly into the stream.

The four mills above mentioned are about four miles up the river from the Waltham filter basin.

The wool scouring establishment of George W. Hollis is on Longfellow Brook, about a mile above the pump well of the Wellesley water works, which is located at the confluence of this brook with Charles River. On the day it was visited, this mill was not in operation, but it is said to do a large business in scouring the wool from sheepskins coming from Brighton Abattoir. Considerable apprehension has been manifested as to the extent to which the foul drainage from these works may affect the Wellesley water supply.

At Wellesley College, with about 600 inmates, the sewage is disposed of by passing it through filtering media in chambers constructed for the purpose. The chambers are divided into compartments, eight or ten in all, each 12 by 15 feet. The sewage is received on a bed of dry muck or peat 15 inches thick, resting on a floor of 2-inch plank with open joints. Below the plank are three inches of gravel, underdrained by tile drain-pipe. These tiles unite in larger drains which discharge into Waban Pond and Waban Brook below the pond. It is said that the sewage is clarified and does not smell; but it is unlikely that it would be thoroughly purified by such filtration. The chambers when visited during vacation time were found to be entirely inoffensive.

At present there is no talk of adopting a sewerage system in this town, although with a free use of water, one will be needed before many years.

SECT. 38. *Weston.* — This town is happy in having no history of sewerage nor any likelihood of one in the near future.

SECT. 39. *Lincoln.* — About two-thirds of this town drains into Charles River through Stony Brook and its branches. A sanitary survey of this brook, made during 1885, revealed no marked cases of pollution, and the town offers no subjects for consideration in connection with the present inquiry.

SECT. 40. *Lexington.* — About one-third of this town is within the Charles River valley, but it includes none of the more thickly settled portions, and so far as known contains nothing needing special investigation.

SECT. 41. *Waltham.* — Waltham lies entirely within the Charles River basin. The river flows through the southerly portion of the town for a distance of two and a half miles. The present population is about 14,600, and if the rate of increase during the last fifteen years should be maintained to the end of the century, the population at that time will approximate 30,000. Seven-eighths of this population is concentrated within the city proper, occupying an area of about two square miles on both banks of the river. Waltham has a public water supply amounting to about 600,000 gallons per day. This supply is taken from a basin dug in the gravel at the edge of the river; one bank of the basin extends into the river, but is thought to be water tight. It is supposed by the water works officials that nearly all of the water now pumped is land water, intercepted on its way to the river, and that little, if any, of the river water itself enters the basin. Pumping is done only during the daytime, and when it ceases in the evening the surface of water in the basin is usually about two feet lower than that of the river. Some experiments were made by us in the spring of 1885 to determine the probable amount of filtration from the river at that time. At one time, about half a ton of rock salt was distributed on the river bottom near the bank above the basin. Samples of water taken from the basin before putting in the salt and for twenty-four hours afterward, were analyzed by Dr. Wood of the Harvard Medical School. An increase in the amount of chlorine was found in only one sample, and this was not supposed to be significant. At the time of the experiment it is probable that nearly or quite all of the water entering the basin came from the land.

It is impossible to say to what extent, if at all, this water is liable to be polluted by the privies, cesspools and foul drainage due to the population living on the area whence the water comes. The cattle quarantine station, in which as many as 1,800 head of cattle have been detained for 70 days each during one year, is about 900 feet from the water-works basin. The manure from these cattle is collected and sold, but the urine soaks into the gravelly ground. That it pollutes the water cannot be proven, but for sentimental reasons, if no more, such a station should not be permitted to exist so near to a source of water supply. A large cemetery, about forty acres in extent, is also in the immediate vicinity of the pumping station. Chemical analysis has not detected any evidences of pollution in the Waltham water supply.

After being used and fouled the water is put back into the ground through cesspools and privy vaults. That this disposal of it may in some cases be a source of danger is realized by many persons in the city. The Board of Health said in 1883, "No well water in the village can longer be used with safety." In 1885, the inspector to the Board of Health recommended that dry earth or ash closets should be substituted for loose vaults. The consulting engineer to the city sewerage commission said in 1884: —

"In the meantime it may be worth while for your community to consider the risks that are now incurred by a continuance of the present methods of disposal, or rather methods of *hoarding* their filth, for there is but a very small part of it really *disposed of* at present."

It is estimated that there are 1,900 cesspools and 2,150 vaults in the city, and that only about 16 per cent. of the former and 25 per cent. of the latter are cleaned out each year. It is also estimated that three-fourths of the excrement entering the vaults is never removed, but finds it way into the surrounding soil. The average yearly amount paid for cleaning these structures is $1,300.

In addition to any indirect pollution of the river at Waltham due to the ground-water being polluted by cesspools, there are several cases of more direct and evident pollution. The most apparent of these are noted below. About a dozen house-drains discharge sewage into the river through pipes laid by the town for removing surface water. About five miles of such conduits have been built by the town at a cost of about $45,000.

The American Watch Company, employing on the average nearly 2,500 hands, discharges its sewage into five cesspools, from which solids are cleaned out about once in two weeks and liquid overflows into the river.

The American Watch Tool Company, with 85 employés, discharges its sewage through an eight-inch drain into the river.

The Parmenter Crayon Company, employing 40 hands, discharges about 600 gallons of sewage daily into a cesspool, whence it leaches away into the river.

The Waltham Gas Works discharge daily about 100 gallons of waste ammonia water into the river.

The Thorpe & Rogers Steam Laundry turns from 300 to 400 gallons of sewage daily into a loose stone cesspool near the river. The sewage from 45 employés, together with that from a neighboring block of stores, also enters this cesspool.

Roberts' Paper Mill uses from 250,000 to 300,000 gallons of water per day in the manufacture of roofing and other paper. The dirty water which contains lime and has been used in washing rags, is discharged into a large basin about twenty feet from Stony Brook.

The Boston Manufacturing Company employs about 1,500 hands. A constant stream of water is pumped through twelve water closets, whence it passes directly into the river.

The Waltham bleachery bleaches and dyes the cotton goods made by the Boston Manufacturing Company referred to above. The cloth is washed by passing it through wooden rolls submerged in a canal leading from the river. This mill pumps every day 700,000 gallons of water. Only 150,000 gallons of this is much fouled by use. The polluting substances are spent dye liquors, chloride of lime, soda ash and oil of vitriol. Privies at the mill hang over the river bank; those at tenement houses are over vaults, which are cleaned twice a year.

Waltham has long considered the desirability of building a sewerage system, and the necessity for one is now considered urgent. In their report for 1880, the Board of Health say: —

"The Board are not prepared at present to make any specific recommendation as to the establishment of any system of sewerage. It is a very important question and growing more so every day as the town becomes more thickly settled and the ground more and more saturated from the leakage of open-walled cesspools."

And again, in the report for 1883: —

"In our opinion, the time has fully come when the town (soon to be city) of Waltham, should take the first step toward the settlement of the sewerage question."

A sewerage commission has been appointed by the town and has employed an engineer to consider its needs in this respect. The conclusions arrived at seem to be that the only practicable method of disposing of the sewage of Waltham, will be by adopting some scheme in combination with other towns in the Charles River valley, and before taking action the recommendations from the State commission are awaited.

SECT. 42. *Newton.* — This city covers 11,600 acres, and is bounded on three sides by Charles River. Part of the territory is from 150 to 200 feet above the water of the river. Chestnut Hill, Newton Centre, Newton Highlands and Newton Upper Falls are situated upon highlands, from which the ground slopes to plains and valleys. In these are other villages, grouped about the line of the Boston and Albany Railroad, at an elevation of about 60 or 70 feet above the river. The most elevated points are rocky or have a retentive soil, but the larger part of the town is underlaid by sand and gravel. The northern slopes of the higher lands are swampy and abound in springs. On the lower lands the ground water stands from 5 to 10 feet below the surface.

The population of Newton is 19,800, and is concentrated in twelve villages situated along the railroad lines and at the falls of the river. The increase is somewhat uniform over the whole territory. Of the present population, 75 per cent. reside upon slopes naturally draining towards the north. Should the growth for the next 15 years equal that of the past, the population in 1900 will be about 30,000. The city uses 600,000 gallons of water daily, which is pumped from a filtering basin resembling a canal 1,600 feet long with closed ends, parallel to the river bank on the Needham side, and about 75 feet distant from it. The bottom of the canal is about 10 feet below the ordinary level of the river. It is thought that most of what is pumped from the basin is ground water, derived from the wooded and sparsely settled district extending from the river towards Needham Plains. Such water could be but slightly contaminated and no noticeable cases of pollution of it are known to exist. When the basin is drawn down, water is seen to enter it from both of the exposed slopes. The water which comes from the river is exposed to the causes of pollution referred to in previous sections. After use, the fouled water is generally disposed of in cesspools, of which it is estimated that there are 2,705 in the town. Of these it is known that 2,309 are loosely built, so that their liquid contents at once unite with the ground water. Of privy vaults within the town, 882 are supposed to be reasonably tight, and 781 are known to be loosely built. The cesspools and vaults are cleaned from time to time. In the report to the Committee on Sewerage, made by the city engineer in June, 1884, he says: —

"The cost of the present method of removing the house sewage during the past year was, according to the returns, $11,153, although this must be very considerably below the real cost, for there were many instances wherein the cost could not be ascertained, either from forgetfulness on the part of the owner or lack of inclination to look up the facts.

"From six hundred and eleven estates there was no removal of sewage during the year, which would be necessary in most cases the coming year, and thus largely add to the cost. In many cases estates were draining directly into the brooks or city drains, thus relieving the owners of any expense for removal, but gradually making the brooks foul with the sewage.

"During the inspection voluntary expressions were made favorable to a system of sewerage by the owners of eighty-seven estates and against any system by the owners of five estates." . . . . .

"A casual examination of the tables will show that the greatest need for a system of sewerage or drainage exists in the 'Newton District,' where the population is the most dense, the estates smaller in area and the ground becoming so saturated with the house sewage as to have greatly diminished its absorbing capacity; thus largely increasing the expense of the removal of the sewage or house filth, and in many cases becoming a great burden upon the property owner.

"The present cost of removal of this district would probably pay a fair interest on the probable cost of construction of a system of sewerage designed to take the house sewage only, with the additional benefit of its constant removal from the premises, and undoubtedly to the greatly improved sanitary condition of the district." . . . .

There are several large manufacturing establishments in Newton, some of which cause more or less pollution to neighboring water courses. The special cases worth mentioning in this connection are as follows: —

Pettee's machine works, at Newton Upper Falls; employ 200 to 300 hands. Privies are over vaults; dry ashes and loam are added to these, and once a year the contents are removed, composted, and finally used on Mr. Pettee's estate. About 150 carboys of sulphuric acid are used annually in cleaning castings; some of this gets into the river.

The Newton cotton mills, at Upper Falls, have been closed for a year. When running they employed 175 hands. Seven privies discharge directly into the river.

About forty years ago, owing to an epidemic of sickness, drains were laid to the river from nearly all the houses at the Upper Falls. These drains were designed to take surface and subsoil waters and the wastes from kitchen sinks. The outlet for these drains is on the south side of Elliot Street bridge. The flow is slight and looks soapy, but is not very offensive.

Paper mills of C. P. Clark, Jr., at Upper Falls; make tissue, water closet and wrapping papers; have not been running since July 1st; usually employed 25 hands; one privy over raceway. Gunny bags and old ropes were worked up into 2,400 lbs. of paper daily.

Collins' glue factory at Upper Falls; usually runs during cold weather; 5 employés; privy over river; uses about 100 casks of lime and 100 carboys of acid yearly. The waste water, which is large in quantity and contains much organic matter, goes directly into the river.

Crehore's paper mill, at Newton Lower Falls; makes card and press papers for mills; works up annually from 300 to 400 tons of domestic rags and old rope, and in the process employs (say) 350 bbls. of lime, 15 carboys of vitriol, 10 tons of copperas and 5 casks of chloride of lime. All refuse goes into the river. Twelve hands are employed; one water closet over the river.

Cordingly shoddy mills, at Lower Falls, were employing only 25 hands when visited, which was less than the usual number; one privy over river; work up and dye woollen and cotton rags and some waste; 25 to 30 per cent. of material is refuse. Dyes used are logwood, fustic, cam and other woods; capacity is 1,200,000 lbs. per year, although last year but 300,000 lbs. were handled. When running full handed would use yearly 1,200 lbs. of potash, 4 tons of sal soda and 400 carboys of sulphuric acid.

Wiswall's paper mill, at Lower Falls; makes wrapping and carpet papers; 12 men; one privy over flume; works up daily 2½ tons of bagging, domestic rags, old ropes, etc.; about 15 per cent. of this is waste; uses several mineral and vegetable dyes, also sulphuric acid, lime, alum and soda ash; water is used at the rate of 500 gallons per minute; the waste water as it goes into the river looks dark and turbid.

The quality of the water at Newton Lower Falls is said to have deteriorated greatly within the last ten or fifteen years. No paper better than newspaper can now be made with it. The water itself cannot exactly be called offensive, but it is sometimes unsightly, owing to its color and floating refuse, and it causes objectionable deposits on its bottom and shores.

The Silver Lake Company, near Silver Lake; employs 80 hands, and makes braided cotton cord, cordage and steam packing. Water is used only for closets and lavatories. There are 13 water closets and urinals. Sewage is conveyed to a large cesspool, in which solids are retained and liquids overflow to a second cesspool. From the latter the sewage is pumped daily upon the surface of the land near the factory. The ground is gravelly, and the sewage soaks away in a few minutes.

Nonantum Worsted Company; makes yarns and noils; uses about 10,000,000 gallons of water yearly; there are 50 hands and eight water closets; all waste drainage flows into settling tanks, in which solids are intercepted and cleaned out daily. These solids are composted and are finally sold. The cost to the mill of this process is $150 yearly, and the return from sales $100. From the settling tank the fluid overflows through a 6-inch pipe with an outlet into Charles River, near the foot of Dolby Street. The flow from this drain is considerable, and as it does not mix readily with the river water, may be traced by its color for about a thousand feet below the outlet.

The Newton Theological Institute has about 60 inmates; the drainage goes into two cesspools, and overflowing, runs down the hill into some woodlands. Most of it finally gets into a branch of Cold Spring Brook, but is pretty thoroughly clarified before doing so.

The Lasell seminary has about 150 inmates; uses city water to the extent of 500,000 gallons annually. For the past eight years, all drainage has run into a large cesspool which was never cleaned. During last summer this cesspool was opened, and about 25,000 gallons of liquid and 100 barrels of solid refuse were removed from it. A second cesspool has been built, which it is stated will probably be sufficient for five years to come.

The need for sewerage at Newton is felt to be urgent, and growing more so yearly. A commission to consider this subject was appointed in 1876. The commissioners spent $3,000. They considered the practicability of disposing of their sewage on land and decided against it, endorsing instead a plan devised by their engineer, Mr. Sawyer, by which the sewage from the more thickly settled portions of the town was to be collected and carried to an outlet into Charles River opposite the arsenal. The system was considered a rather expensive one, the principal lines of sewers alone being estimated to cost $465,000. The chief objection to the scheme, as stated in the mayor's annual address for 1882-3, was that it

"Provides for the discharge of sewage into Charles River opposite the arsenal. . . . The most serious objection to this plan, in my opinion, is the possibility of creating a public nuisance by so doing. . . . Should it prove so the city would have expended a large sum of money in constructing sewers, and no outlet would exist for them." . . .

Newton has at present a committee on sewerage, but as no practicable outlet for the sewage can be found, the committee can do little but await the report of this Commission, which it is hoped will be followed by such legislative action as will lead to the adoption of a comprehensive system for the towns in the lower Charles River valley.

SECT. 43. *Watertown.* — This town is wholly within the Charles River basin. It extends along the north side of the river, and its surface is rolling and elevated. A small tract, containing about 100 acres, lies on the south side of the river. The population is about 6,200, and at the present rate of increase will be 9,000 at the beginning of the next century. The population is grouped at several centres, of which the principal is the main village, on the river near the centre of the town. Within the last year Watertown has acquired a public water supply, furnished by a private company. The total pumping capacity of the works is 1,500,000 gallons daily, but only about 150,000 gallons a day are at present taken. The supply is taken from two filter galleries, situated near the river in the southwesterly corner of the town. It is commonly supposed that most of the water pumped comes from the land, but there is reason to doubt whether any considerable amount could be drawn from the galleries without their being fed from the river. The ground water has the indeterminate liability to pollution incident to the condition of the district from which it is drawn, and the river water is subject to the contamination referred to in previous sections. The water has been analyzed and is reported to be unobjectionable so far as chemical analysis can determine. After use, the water and the filth which goes with it is returned to the soil.

The town contains about 1,100 houses, and somewhat more than that number of privies and cesspools. It is estimated that about 740 of these are cleaned in a year, at an annual outlay of about $2,200. The town has expended about $16,000 in building drains, from 6 to 18 inches in diameter, for removing surface water. A good many house-pipes connect directly with these drains, and thus discharge their sewage into the river. There are a number of manufacturing establishments on the banks of the river, some of which discharge their waste water into it.

The Ætna Woollen Mills employ 220 hands and wash 12,000 pounds of wool per week; 60 per cent. of this, or 7,200 pounds, is dirt, which goes into the river, as do also spent dye liquors and water-closet sewage.

The Wheat Starch Company discharges 700 gallons a day of sour water containing gluten.

Parker's starch factory discharges about 9,000 gallons per day of the same kind of waste. Closets for sixteen hands are over the river bank, which at this point is very foul. This factory obtains its water supply from six springs or wells within 100 feet of the river.

Elliott's machine shop employs thirteen hands; the water-closet empties into the river.

The Newton and Watertown Gas Light Company discharges 200 gallons of waste ammonia water into the river daily, and also drainage from two closets.

The Warren Soap Manufacturing Company has a privy over the river. The sewage of ten families in a block on the south side of the river west of the bridge is emptied through a 12-inch pipe into the river.

The Hollingsworth & Whitney Company employs 112 hands, who use privies directly over the river. This company discharges about 600,000 gallons of dirty water into the river daily. They make wrapping papers, and state that the water of the river at that point is too dirty to permit the manufacture of white paper.

Lewando's dye house employs 90 hands, and the water closets empty into the river. There is also discharged from the establishment about 30,000 gallons per day of highly-colored waste dye liquors. Near this point the domestic sewage from a brick block, occupied by about thirty people, also enters the river.

The Walker & Pratt Manufacturing Company have privies for 125 hands over the river bank.

On Main Street, east of the square, a block occupied by forty people turns the waste from eight water closets into the river. Treadaway Brook, which consists of two branches, each running through thickly settled portions of the town, receives sewage from a number of house drains which enter it, and also from privies which are built directly over it. In dry weather very little water flows in this brook, and it stinks badly. Heavy rains or freshets wash it comparatively clean.

Charles River opposite Watertown is manifestly polluted, and in time of drought the water is apt to be offensive. The evil is one which is increasing yearly with the increase of population. As early as 1874, Watertown appointed a committee instructed to employ an engineer and "to report to the town as early as practicable a comprehensive and proper system of sewerage, which shall protect us from the bad effects which an improper system might subject us to from our own sewage, and also a plan or system to protect us from the bad effects of drainage by other towns and cities above and below us." The committee and its engineer, Mr. Crafts, spent several years and $3,000 in very thorough surveys and investigations in respect to a sewerage system at Watertown. An excellent and voluminous report by the engineer was made in 1878. This included a design for a sewerage system with outlets at the river. It was stated, however, that such permanent disposal of the sewage would not be satisfactory, but that it would be necessary for the neighboring towns to unite in building an intercepting sewer which should connect with the Boston system, or else convey the sewage to some other remote place of disposal. No action was taken at that time. The town is desirous and ready to build sewers whenever any practicable method of disposing of the sewage can be discovered.

SECT. 44. *Brighton.* — Brighton, which constitutes Ward 25 of Boston, is increasing rapidly in population, and already contains about 8,500 inhabitants. Having a bountiful supply of water from the Boston Water Works, all the more thickly settled portions of the ward require sewerage. About five miles of sewers have already been constructed, and an equal amount will doubtless be required before long. The sewers already built discharge at three outlets into streams or ditches connecting with Charles River. The sewage helps to pollute the river, and this method of disposal is not satisfactory; but the Boston main drainage system was designed to extend ultimately to Brighton, to divert the sewage from the river to the harbor at Moon Island. A considerable amount of drainage is turned into the river at this place from private drains and from manufacturing establishments. Much foul water also comes from operations carried on at the abattoir.

SECT. 45. *Brookline.* — This town has a present population of about 9,200. It has a public water supply amounting to about 500,000 gallons per day, taken from a filter basin in the immediate vicinity of Charles River, opposite Dedham. A portion of the water pumped comes from the land, but probably the larger part of it is derived indirectly from the river. A direct connection, to be used in case of necessity, unites the basin with the river. This river water is subject to the pollution spoken of in the previous sections.

A large part of the town is sewered, and the sewage is collected in an intercepting sewer which follows the line of Muddy River to an outlet at the channel of Charles River. A part of the sewage accumulates on the flats in the vicinity of the outlet and causes some nuisance, which will increase from year to year. The town officials realize that the discharge of their sewage at this point is objectionable and cannot continue permanently. It is expected that when the Boston main drainage system is extended to Brighton, the Brookline sewage will be diverted to it and discharged at Moon Island. The town is ready to pay any reasonable charge for such accommodation.

SECT. 46. *Cambridge.* — As stated in section 13, a small part of Cambridge drains into Mystic River through Alewife Brook. The greater part of it, however, drains into Charles River at fifteen sewer outlets. The present population contributing to these sewers is about 57,000, which is liable to increase to 100,000 in the next 20 years. The disposal of sewage is far from satisfactory. Large deposits occur on the flats in the vicinity of the outlets and cause serious nuisances. As much as $3,000 a year has been expended in dredging and removing the sludge which accumulates at the outlet of the Bridge Street sewer, used jointly by Cambridge and Somerville. The necessity for the adoption of some other method of disposal is fully appreciated, and the state of feeling on the subject is shown by the following extracts from late municipal reports : —

"The sanitary condition of that part of the Charles River basin near Craigie's Bridge requires no description at the hands of this Board, as it is familiar to all who have occasion to visit the locality. The dredging about the mouth of the Bridge Street sewer, for which the cities of Cambridge and Somerville have lately made an appropriation, can only afford a temporary and partial relief for the evil, if indeed any benefit may be thus obtained. We believe the time has fully arrived for action by this city and adjoining municipalities in the direction of effective and permanent relief from these growing nuisances." — *Report for 1880.*

"The filthy condition of that part of Charles River basin within our limits is increasing from year to year. We know of no other plan for obtaining relief from this nuisance than that recommended by the commission authorized under the resolve of the Legislature of 1881 to investigate the subject of drainage in Boston and vicinity. This will, of course, require a concert of action of all the cities and towns draining into this basin. We recommend the consideration of this matter." — *Report for 1882.*

"The Bridge Street sewer nuisance is not only a very serious and disgusting annoyance to those passing over or near Craigie's Bridge, but, in the opinion of this Board, is a constant danger to people living and employed in that part of the city. As the abatement of these nuisances not only interests the city of Cambridge, but adjoining cities and towns, we earnestly recommend the city council to take such action as will lead to a consultation of the authorities of the different cities and towns interested, and a thorough consideration of the whole matter, or such other action as may be thought proper, looking to the permanent abatement of these nuisances. This Board makes this recommendation, fully appreciating the magnitude of these matters, and the great expense that must be incurred and the difficulty to be met in permanently ridding ourselves of these more than serious nuisances." — *Report for 1883.*

"The flats of the Charles River basin are growing more and more offensive ; and even now the odor arising from this source, when they are not covered by the tide water, is not only very annoying to the people living in this vicinity, but it also very seriously threatens the health of all coming within its influence. The serious nuisance caused by the discharge of the contents of the Bridge Street sewer into that part of the basin near the Cambridge end of Craigie's Bridge still continues, although, by reason of the thorough cleaning by washing and dredging the accumulated filth in the vicinity of the sewer outlet last spring, it has been less serious and annoying than last year; still, the sickening and disgusting odor arising from this source is almost intolerable, and this cleaning should again be done in the early spring. We renew our recommendation of last year, that the city government at once take such steps as it may think proper, looking to the permanent abatement of the Alewife Brook and Charles River basin nuisances." — *Report for 1884.*

SECT. 47. *Somerville.*—The needs of that part of Somerville which drains into Mystic River have been referred to in section 14. Sewage from about half the city is discharged into Charles River at the Waverley Street and Bridge Street outlets, the latter being used in connection with Cambridge. Both of these outlets cause continual nuisances, and add to the pollution of the river. In his annual report for 1882 the city engineer says: "It is important to Somerville that the plan for a metropolitan sewage should be adopted, and then our new work could be laid out with a view of connecting therewith."

SECT. 48. *Charlestown.* — Charlestown comprises Wards 3, 4 and 5 of Boston. It has a population of about 37,800. The water supply, amounting to about 2,000,000 gallons per day, is derived from the Mystic Water Works before referred to. Sewage is discharged at thirteen outlets, principally into Charles River. The sewage causes continual nuisances, which are annually made the subject of complaint by the Board of Health, which states that the only remedy for them is to be found in the adoption of a combined intercepting system for districts north of Charles River, with an outlet extended to deep water in the sea. The Board speaks thus in its report for 1883–4: —

"The Board would respectfully suggest that our city is vitally interested in the abatement and prevention of this nuisance, and ought to be the foremost in the effort to remedy the evil. The Legislature, at its present session, passed a bill providing for the appointment, by the governor, of five persons to act as a commission to consider and report a plan for sewering the metropolitan district, and we trust that there will be a strong concurrent action of the cities and towns interested to bring about this great public improvement."

SECT. 49. *Boston Proper.* — Previous to Jan. 1, 1884, about 10,000,000 gallons of sewage were daily emptied into Charles River from Boston proper. At that date the new intercepting system went into operation, and all of the sewage from the city sewers has since been diverted to the harbor at Moon Island. On an average about twice a month, during rainstorms or thaws, when the amount of water flowing in the sewers is greater than can be taken by the intercepting sewer or controlled by the pumps, a portion of it overflows at the old outlets. Such occasional and temporary discharge of very dilute sewage into the river does not seem to cause any nuisance. Although the sewage flowing in the sewers is thus intercepted and disposed of, there are a large number of houses on the margins of the river, situated on the water sides of Beacon, Brimmer and Charles streets, which turn their house sewage through private drains directly into the river. The amount of water in the river at this point is so great that such sewage does not cause any special nuisance, although it is offensive to the sight. Since the city has spent $5,000,000 in order to divert its sewage, it seems a pity that the improvement should not be thoroughly accomplished. To do so would only require the building of a few small pipe sewers with which the house drains before referred to could connect. In a number of cases such sewers already exist, and house owners might properly be required to change the directions of their house pipes so as to connect with them.

THE SUDBURY AND COCHITUATE BASINS.

SECT. 50. *The basin as a whole.* — In 1846, Boston was granted the right to take the waters of Lake Cochituate and its tributaries as its water supply. The catchment area which feeds this supply is nearly 20 square miles in extent, and includes parts of the towns of Wayland, Natick, Sherborn, Ashland and Framingham. At that time the population on this area was about 4,000; now it has increased to about 13,000. As Boston increased in population this supply proved insufficient in quantity, and the city was granted the right to the water of Sudbury River and its tributaries above a point in Framingham. The watershed of this district is nearly 75 square miles in extent, includes the whole or parts of four other towns, and has a present population of 23,000, which is liable to increase in the future. Although the district may seem to be an immense one, it is not too large for the purpose to which it is dedicated. The increase in the population of the city and in the consumption of water is so rapid that it is possible that still further extensions of its system of supply may be needed. These districts were selected after a careful investigation by competent experts from all those which were practically available for the purpose, and were found to be the best and the least liable to pollution.

In order that the water may be wholesome, it must be kept as pure as possible. Some of the streams from which it is derived flow through thickly-settled communities, and it is impossible, in the nature of things, that they should remain absolutely pure. Absolute purity could only be attained by deporting all population from the districts and keeping the whole 100 square miles uninhabited. The efforts of the water works officials to prevent pollution by keeping out of the streams all drainage and manufacturing refuse, has caused considerable contention between the city and the towns within the districts. On the one side, it is said that any foul drainage entering the water might endanger the health of 400,000 persons and cause an epidemic. On the other side, it is claimed that drainage must naturally, of necessity, go into the streams; that a prohibition of such drainage is practically a prohibition of water supply and manufacturing industry, and that without these population cannot increase, and can barely maintain itself.

SECT. 51. *Natick.* — About half of Natick is within the watershed which furnishes the Boston water supply. This district includes the villages of Natick and Felchville, with populations of 5,500 and 1,000 respectively. There is a public water supply amounting to 208,000 gallons per day, derived from Dug Pond within the town. Dug Pond is subject to considerable pollution from the south branch of Pegan Brook, which is the natural outlet of drainage from the south part of Natick village. The town has no public sewers. Some 500 feet of 18-inch brick and 12-inch pipe drain, in connection with the covered channel of the north branch of Pegan Brook, have until recently received sewage from about 90 private drains from buildings on the main streets of Natick village. These drains conveyed to Lake Cochituate the sewage from a population variously estimated at from 1,000 to 2,500. About March 1st, 1885, a decision based on the Cochituate water act was rendered by the supreme court declaring such disposal of sewage to be illegal. In compliance with that decision and under pressure from the Boston Water Board, the use of these drains has been discontinued, and cesspools to receive the sewage have been constructed instead. Some of these cesspools were built under the public streets; others were located in back yards within a few feet of dwellings. One or two thousand dollars were spent in making the change, and so far as the town itself is concerned, the new arrangement is far more objectionable and probably more dangerous to health than the old one. The liquid which leaches from the cesspools certainly in many and probably in most cases still reaches Lake Cochituate through Pegan Brook, but is clarified and more or less purified by its filtration through the ground. It is estimated that there are about 1,200 privies and about 200 cesspools in the villages of Natick proper and Felchville; also that about 1,000 of these structures are cleaned out every year at an aggregate cost of about $3,000. Within Natick are six large shoe shops, employing in the aggregate about 1,150 hands, and using 4,300 gallons of town water per day. All of these now have privy vaults for their employés, and run their manufacturing waste over the surface of the ground. There are also some smaller manufacturing establishments which do not call for special notice. The Natick Gas Company is reported to discharge some ammonia water and tar into Pegan Brook.

The urgent necessity for a system of sewerage at Natick is fully appreciated. The state of feeling on the subject may be illustrated by a few quotations from late town reports: —

"We would warn the people that unless decided steps are taken in the near future for getting rid of our sewage and drainage we shall some day bitterly regret it. The need of some system of sewerage increases each year, and sickness and death are certain to ensue unless some practical measure is soon devised for that purpose." — *Report for 1882.*

"Last July we inspected the south arm of Pegan Brook, from its termination in Dug Pond to where it crosses the South Natick road. We found seven sink drains emptying into the brook; one cesspool with a covered overflow into the brook; one privy within two feet of the brook; one pig-pen, the wash from which must go into the brook during high water; one barn cellar used as a receptacle for manure and also as a privy vault, which is flooded by the brook during high water. These facts, with the names of the parties permitting the nuisances, were given in detail in a report made by us to the water commissioners. Since making said report we have learned that a sewer, connected with several dwelling-houses, empties directly into the brook. The distance, in a straight line, from the mouth of this brook to the pumping station, is 980 feet. The direct pollution of our water supply from these sources of filth must be evident to all. We see no other way to preserve the purity of our water supply than by acquiring and maintaining permanent control of the brook and its banks." — *Report for 1883.*

"The committee appointed by the town, and whose duty it is by vote of the town to defend the rights of Natick and its citizens against all suits pending, or that might be brought by the avaricious and aggressive policy of the city of Boston, in striving to prevent the town and its citizens from the exercise of their inalienable, natural and prescriptive rights and privileges, employed gentlemen of high legal attainments as counsel for the defence. The selectmen feel highly satisfied with the work of the committee, and can bear testimony to their ability and good judgment in carrying out their instructions with zeal and vigor." — *Report for 1884.*

Natick would doubtless build a sewerage system if it could find some place at which to discharge the sewage. The feeling seems to be that as Boston, by acquiring a right to all of the water within the Cochituate basin, has deprived the town of its natural outlet for drainage, the city ought in equity to be at the expense of providing another outlet. It may be said, however, that even if Lake Cochituate did not furnish a water supply, it would not be a suitable place in which to put sewage; since there is no current there, a nuisance would surely arise.

Sect. 52. *Wayland.* — About one-fifth of Wayland, including the village of Cochituate, naturally drains into Lake Cochituate. This village has a population of about 1,200. It has a public water supply built by the town at an expense of about $30,000. Water is taken from a filter gallery located on the bank of the mill pond near the head waters of Snake Brook. The watershed feeding the pond is small and contains few houses, so that there is little liability to pollution. Snake Brook, throughout its whole extent, from its head waters to the lake, looks clear, and no pollution of it is known to exist. There is no talk of sewerage and no place where sewage could be put without its getting into the lake.

Sect. 53. *Sherborn.* — About one-fifth of this town drains towards Lake Cochituate. This area is thinly settled, and the only danger of pollution comes from the State's Prison for Women, situated on it. This institution has a capacity for 300 inmates. There is a water supply amounting to 30,000 gallons a day, taken from a neighboring pond. After use for water-closets, laundries, baths, etc., this water runs to a cesspool which is emptied intermittently into about 20,000 feet of drain tile, distributed 6 inches below the surface over about three acres of land. Passing through the joints of these pipes, the water filters downward about 3 feet, and escapes through other pipes laid at that depth. The pipes empty into a ditch which connects with Course Brook, a tributary of Lake Cochituate. The effluent from the under-drains looks perfectly clear; but chemical analysis has shown that it often contains a large proportion of its original soluble impurities. The imperfect purification is probably due to the fact that the sewage passes through only three feet of soil, consisting of fine silt, which looks somewhat like clay and contains very few air spaces. A disagreeable smell from the field is often noticed.

Sect. 54. *Framingham.* — About a third of this town is within the watershed of the Boston water supply. Included in this area is South Framingham, which is the principal village, with a population of about 4,500, and drains naturally *via* Beaver Dam Brook to Lake Cochituate. This village has a public water supply derived from Farm Pond and the Boston conduit. The supply is furnished by the Framingham Water Company, and was first put in operation about Aug. 1, 1885. The pumps have a capacity of about 1,000,000 gallons per day. The town built in South Framingham in 1882–3, at a cost of $5,300, about 2,000 feet of public sewers. These consist of 12-inch and 15-inch pipe, and are located in streets about the Pará Rubber Works. These sewers receive sewage from part of the rubber works, and from a boarding-house and two blocks of tenements belonging to the company. The total population contributing the sewage is said to be about 800. The sewage, which is very foul, is discharged by way of an open ditch into Beaver Dam Brook, whence it flows to Lake Cochituate. The bulk of the town drains into privy vaults and cesspools, which disposition of its filth is far from satisfactory. There are a number of manufactories in South Framingham. The only ones which manifestly pollute the water courses are the following: —

Pará Rubber Works — use from 200,000 to 300,000 gallons of water per day; employ 1,000 hands; have about 20 water closets, and discharge their sewage into Beaver Dam Brook, partly through the town sewers and partly through an open ditch.

Richardson's Straw Factory — employs 200 hands for a season of seven months; uses 6,000 to 8,000 gallons of water per day; discharges foul drainage over the surface of the ground to an open ditch, thence to Beaver Dam Brook.

Barber's Straw Factory — employs 300 hands for the season of eight months; uses 8,000 gallons of water per day; foul drainage goes into a settling basin, from which much of it leaches into a stone drain leading to Farm Pond.

An extension of the sewerage system of this town is much needed, and would be made if it were not for the apprehension that the discharge of sewage at the present outlets may prove to be illegal. A suit against the town on this account has already been brought by the city of Boston. The following quotations show the public sentiment in regard to this matter: —

"Drainage. This is a serious and very important matter, and cannot be brought before the town too soon or too strongly. Our villages are growing rapidly, and the wants of proper drainage are being severely felt. The village of South Framingham, in particular, should be attended to at once. The demand is imperative. Something must be done. What, or in what manner, your commissioners do not feel like saying at this time. One thing, however, we will say, that is, the town should authorize some *plan* and *system* for the benefit of the *whole* village of South Framingham, rather than put off from year to year by ordering drains and sewers for special localities and individuals. Let us have a full survey and plan for the whole to work from, and then build as necessity requires. We would respectfully suggest that the town, under article in the warrant for the annual March meeting 'To choose any committees of the town,' choose a committee of three to consider and report to the town at a future meeting some plan for the proper drainage of Framingham, or that portion of it called South Framingham, with authority to employ competent engineer and counsel, and that a suitable appropriation be made therefor." *Report of Road Commissioners, 1884.*

"The Legislature of 1884 created a State commission on drainage, giving them two years in which to thoroughly investigate the matter and make extended surveys in eastern Massachusetts, Framingham coming within their jurisdiction. This commission is to make its report to the next Legislature.

"By a recent decision in the Pegan Brook controversy, one of the abutters, being the defendant, has been debarred from allowing any sewage to enter that stream which flows into Lake Cochituate.

"By special legislative enactments in favor of the city of Boston, that gigantic corporation has levied tribute on the waters of the Mystic valley, on the waters of the Sudbury valley, Farm Pond and Lake Cochituate, also all streams tributary to those waters.

"The inhabitants of all towns bordering on these rivers, ponds and streams, have been mercilessly robbed of their prescriptive rights, and now demand redress. Undoubtedly the wisdom of future legislators will remedy this evil; if not, the towns will certainly establish the fact that they *do* have rights which cities must respect.

"Therefore, before making further expenditures for works that may be but temporary, we advise that further action on this article be for the present postponed." — *Report of Committee on Drainage, 1885.*

At various times from 1872 to 1878, propositions were made by Boston in regard to combined action by the city and towns in carrying out comprehensive systems of sewerage. Nothing resulted from this; but about six years ago the Boston Water Board had surveys and investigations made to ascertain the practicability of building a sewerage system to divert the drainage then going into Boston's water supply. The scheme, as designed, included a large main sewer following the Sudbury River from the village of Ashland through Framingham to Saxonville, with two smaller branches, one on each side of Farm Pond. The sewage was to be disposed of by filtration on elevated land near Saxonville. The estimated cost of these works to serve Ashland and Framingham, which were expected to build their own connecting systems, was about $600,000. The scheme was very costly, and was never seriously considered.

SECT. 55. *Ashland.* — The whole of this town is within the district furnishing the Boston water supply. Of the total population of about 2,600, Ashland village, near the centre of the town, on Sudbury River and Cold Spring Brook, contains somewhat over 2,000, the remainder being scattered. There is no public water supply or system of sewerage, and no talk of adopting any. Water is obtained from wells, and drainage is disposed of in vaults and cesspools, of which there are about 500 in the town. The annual expense for cleaning these is about $1,000. Sudbury River is somewhat contaminated at this place by the overflow from privies of seven estates directly on the river bank in the centre of the town. Two houses drain directly into a brook running through the centre of the village. There are a few factories in the town, two of which discharge foul waste water.

Tilton's shoe factory employs 300 hands; privies have tight vaults; foul water goes to loose cesspool near brook, through which it reaches the river.

Aldrich's shoddy mill, on the river bank near Southborough, employs 50 to 100 men; manufacturing waste goes directly into the river; privies are over tight vaults.

SECT. 56. *Marlborough.* — About half of this town, including the main village and the more thickly settled areas, with a total population of about 10,000, is within the Sudbury basin. The remaining half, with a scattered population of about 1,000, drains through six brooks to Assabet River. There is a public water supply, introduced in 1873, from Williams Pond. This pond is situated just beyond the Sudbury divide, and having a small, sparsely settled catchment area is little liable to pollution. The consumption of water averages 200,000 gallons per day. There are no town sewers, and the water and its contained filth are disposed of in privy vaults and cesspools. It is estimated that there are about 1,570 of the former and 200 of the latter structures in the town, also that about 1,300 privies are cleaned annually at a cost of $2 each, and 200 cesspools at an expense of $4 each. This makes an aggregate yearly tax of $3,400. The principal industry of Marlborough is shoemaking. There are eleven large shoe factories in the town, employing in the aggregate about 5,000 hands, and using about 9,000 gallons of town water a day. As the village proper is quite thickly settled, and the buildings are near each other or often in blocks, the cesspools and vaults are in many cases situated very near to or even under houses, and the ground in such cases is presumably saturated with water and filth. The brooks flowing through the thickly settled parts of the village evidently receive drainage from the cesspools and look very dirty. A few cases of manifest pollution were noted.

The Marlborough Gas Company, making about 60,000 feet of gas per week, turns waste ammonia and tar water into a basin on their lot, whence it overflows through a box drain and open ditch to the brook.

The Central House, with four water closets, drains into the cellar of a neighboring barn. This drainage overflows through the gas company's drain into the brook.

Burke's Block on Main Street, occupied by about 200 persons, drains directly into the brook by a 12-inch pipe.

A dyehouse on Liberty Street drains into a loose cesspool ten feet from the brook. Near the dyehouse two privies and one hog-pen also overflow into the brook.

There is a manifest need of sewerage at Marlborough, and a committee to consider the subject was appointed in 1884. This committee employed as engineer Mr. E. S. Philbrick of Boston, who made a general design of a sewerage system for the town. This comprised a system of sewers for the removal of sewage proper, and the approximate estimate of its cost was $135,371. The main sewer, which was to be 15 inches in diameter, extended through Main Street and down Maple Street to an outlet on land in the immediate neighborhood of the Marlborough Junction Station. In the estimate of cost was included the purchase of 100 acres of land at $100 per acre, and the preparation of 50 acres of it for immediate use. In examining the tract referred to, I failed to find more than 25 acres which seemed suitable for the purpose, although 10 additional acres north of the railroad also might be utilized. The 25 acre tract seemed to be well adapted for purifying sewage, since it is porous, reasonably level, and the ground water under it is low. The effluent, however, would be discharged within four miles of Basin No. 3 of Boston's water supply, which it would reach through Angle Brook and Stony Brook. Moreover, before many years the Boston Water Board expect to build three additional storage basins. These are all designed to be located on Stony Brook. Basin No. 7, which will be the upper and larger of the three, will extend to within a few hundred feet of the proposed filtration area for Marlborough's sewage, so that the effluent would flow directly into the basin. Under such conditions it would be very necessary that the purification of the sewage should always be complete, without the slightest possibility of failure; a thing difficult to ensure even under the most favorable circumstances.

An engineer is at present employed by the town in making surveys and detail plans for a sewerage system in general accordance with the design submitted by Mr. Philbrick, and it is expected that work will begin upon it early in 1886.

SECT. 57. *Southborough.*—Southborough is wholly within the watershed of the Boston supply. It has a population of about 2,100, four-fifths of which are about equally divided between the villages of Southville, Cordaville, Fayville and Southborough Centre. There is no public water supply or system of sewerage, nor a likelihood of either being needed. Few cases of manifest pollution exist in this town. The Cordaville Woollen Mill, employing 100 operatives, turns some wool scour and dyestuffs into the river. A shoe shop at Fayville, with about 250 hands, empties its refuse into a vault and cesspool, which are liable to overflow into Stony Brook, which feeds Basin III. of Boston's supply.

SECT. 58. *Westborough.* — About two-thirds of the area of this town is within the Sudbury basin. This includes the village of Westborough and all the thickly settled part of the town, with a population of about 4,000. The remaining third has a scattered population of less than 900, and drains by three brooks into Assabet River. There is a public water supply from Sandra Pond in the southeast corner of the town, at the head of a brook tributary to Sudbury River. The catchment area of the pond is small and contains but about a dozen farmhouses, so that there is little liability to pollution. This water was introduced in 1874, and the average daily amount of it used is about 125,000 gallons. There are no town sewers, and after use, the water with its contained filth is disposed of in privy vaults and cesspools. It is estimated that about 400 vaults and 200 cesspools are cleaned out once a year at an aggregate cost of $1,800; the others are cleaned out by the farmers without charge. There are a few manufactories in the town, and of these one or two have some difficulty in disposing of their refuse.

The National Straw Works, on East Main Street, employ 600 to 800 hands and use 20,000 gallons of town water per day. They have twelve water closets. The manufacturing waste water and that from the closets, constituting quite foul drainage, go by an open ditch to Cedar Swamp, and thence by a brook to Sudbury River and Basin No. 2 of Boston's water supply.

A straw shop on South Street employs 100 hands and uses 3,000 to 5,000 gallons of water daily. The privies are over vaults at the rear of the lot, and the manufacturing waste goes into a basin near the same place. This looks badly, and makes a local nuisance.

At three shoe shops, the waste water is turned on to the surface of the ground and soaks away.

Two privies used by the employés of three small carriage shops are over a brook running through Cedar Swamp into Sudbury River.

The State Homœopathic Asylum, which is now building near the northerly limits of the town, will have a capacity for 500 inmates. A water supply amounting to about 100,000 gallons daily, will be taken from Chauncy Pond. The foul water is to be disposed of by irrigation on a neighboring tract of land about 30 acres in extent. Any effluent from this tract would naturally go into Stony Brook.

Westborough needs a sewerage system and has long considered the building of one.

"At the annual March meeting in 1875, the town authorized the then Board of Road Commissioners to cause surveys and estimates to be made with a view to the introduction of a system of sewerage for the village. That board procured the services of Messrs. Buttrick & Wheeler, Civil Engineers, of Worcester, Mass., who made surveys and estimates, proposing a main drain or sewer from the east side of the Common, through Brigham Street to Cedar Swamp Brook, a distance of about 3,400 feet, at an estimated cost, exclusive of land damage, of five thousand one hundred and eleven dollars ($5,111). But no action resulted from that inquiry." — *Report of Committee on Sewerage, 1881.*

In 1881 a committee on sewerage was appointed who employed as engineers Messrs. Ball & Heald of Worcester. They designed a system, including sewers for sewage proper and drains for surface water, both discharging through Ruggles Brook into Cedar Swamp, and thus into Sudbury River. The estimated cost was $22,774. Some exceptions being taken to this scheme, Col. George E. Waring, Jr., of Newport, was called into consultation and prepared a plan of sewers to cost $30,000. The system was intended to remove only the sewage proper from the whole of the settled portion of the village, and consisted entirely of small pipes, the largest main sewer being 10 inches in diameter. In explanation of the plan, Mr. Waring said: —

"I have assumed that, as the drainage runs to the Sudbury River, you will not be permitted to discharge the effluent into the brook without first purifying it. The circumstances are favorable to its purification on the flat bounded by the brook and Sudbury River, the course of the brook being slightly changed. The matter of purification will be simple and of little cost, being effected by a combination of an osier bed and an irrigation field. The osier bed is about one acre in area, and is simply a series of level ditches running back and forth between banks (made by excavating the ditches) the banks being planted with osier willows. The sluggish flow secured by this means will cause a deposit of solid matter, and, as experience has amply shown, the effect of the growth of the willows in purifying the sewage will be almost, if not quite, complete. To make the purification absolute, the two outlets of the osier bed discharge on the surface of an irrigation field of about four (4) acres, over which it will flow to surrounding ditches, discharging into the brook."

The committee recommended that this plan should be adopted, but that a part of it only should be then constructed, leaving the remainder to be built from time to time as needed. No action was taken at that time, but the town has always considered that whenever sewers are built a method of disposal somewhat similar to that recommended by Mr. Waring should be adopted. A committee on sewerage is now in existence, and the town voted to make a start in constructing its sewerage system in the autumn of 1885. It was afterwards decided to postpone work until the spring of 1886, in order first to consider any recommendations which should be made by your Commission.

In my opinion there may be a reasonable doubt whether the scheme as proposed would prove satisfactory. The surface of the land on which it is proposed to discharge the sewage is so little elevated above that of the water in the neighboring swamp that the ground water is little if at all below the surface. The sewage which would be put on each acre would not therefore filter through aerated soil, so that the effluent which would escape into Boston's water supply would not be purified, or even entirely clarified. Turning imperfectly purified sewage into Boston's water supply probably would be considered a violation of the public statutes, and would almost certainly lead to litigation and injunctions on the part of the city. Should the discharge at this point prove to be illegal and be prohibited, the town would have a sewerage system without an outlet, or, at least, would be put to very great expense in altering the system so as to obtain a new outlet.

SECT. 59. *Hopkinton.* — The greater part of Hopkinton is within the Sudbury basin; two smaller portions drain respectively into the Charles and Blackstone rivers. Of the total population of 4,000, over 3,000 are in the first-named district. The town has a public water supply derived from three 6-inch driven wells, located on a very lofty piece of meadow land to the west of Hayden Row. This supply was introduced late in the season of 1884, so that the present consumption is only about 15,000 gallons per day. The sewage of the town is disposed of in shallow loose privies, of which there are about 700 in the town. These are commonly cleaned out at no expense to the owners by neigboring farmers, who use the contents on their fields. The following cases of pollution occurring in this town are worth noting: —

The privies of eleven estates on the edge of Whitehall Pond, which is the head waters of Sudbury River, overflow into the pond.

A shoe shop in Woodville, employing 100 men, has its privies directly over the river, into which it also discharges its waste water.

A shoe shop on the corner of Main and Grove streets, employing about same number of hands, drains by an 8-inch pipe into a tributary of Indian Brook, which feeds Sudbury River and Dam No. 2 of the Boston water supply.

There has been no consideration of sewerage by the authorities of this town.

THE NEPONSET BASIN.

SECT. 60. *The basin as a whole.* — The Neponset River basin comprises about 100 square miles, and includes the whole or portions of twelve cities and towns. In addition to Boston, five towns have public systems of water supply, and in all but one of the remaining towns there is more or less talk of obtaining such a supply. Sewers are found at present only in Boston, but will soon be needed at Hyde Park, probably at Dedham, and possibly at three or four other towns. The present population in this basin is about 33,000, of which about 19,000 are found in the lower portion below Dedham. Within forty years the population will probably exceed 60,000, the greatest increase occurring along the lower river. A large number of manufacturing establishments are situated within the basin on the main river and its tributary brooks. These pollute the water considerably, the largest amount of foul drainage coming from wool-scouring mills, tanneries and dye works. The lower portion of the river shows the effect of such pollution and is noticeably dirty.

SECT. 61. *Foxborough.* — This town has a population of about 2,800, and most of it naturally drains into Taunton River. About one-fifth of the town, however, in its northerly part, including outskirts of the main village and a total population of about 400, drains towards the Neponset. No action has been taken by the town with reference to obtaining a public water supply, and consequently there has been no consideration of artificial drainage. On this area there are no cases of marked pollution of water courses which call for notice.

SECT. 62. *Sharon.* — This town has a total population of 1,300, and is situated on high land along the divide between the Neponset and Taunton River valleys. About two-thirds in area of the town, with four-fifths of the population, is within the Neponset basin. As the soil is very porous and wells deep, water has hitherto been chiefly obtained by means of rain-water cisterns. Works to furnish a public supply of water have just been built by a private company chartered in 1883. The water is taken from a well 250 feet above tide level, near Sharon station. This is in the vicinity of Beaver Hole Meadow Brook, a tributary of the Neponset. For the first year or two this supply will probably be furnished to only about 100 houses. The well can easily be kept free from danger of pollution. The building of a sewerage system is not at present contemplated; and probably it will not be for several years, or until the use of water has largely increased, that the need of one will be realized. Waste water is now put into the ground. No marked cases of pollution of streams in this town have been noticed.

SECT. 63. *Walpole.*—Nearly the whole of Walpole is within the Neponset River basin; a small corner at the west end of the town, with a population of about 200, is in the Charles River valley. The total population is about 2,430. The surface of this town is gently rolling, and well watered by various streams forming the head waters of Neponset River. Owing to an even distribution of population, which is not dense at any part, water is obtained from wells, and there is no especial talk of an artificial supply. For the same reason the subject of sewerage has not been considered. There are a number of manufacturing establishments in Walpole, some of which considerably pollute the streams on which they are situated.

The wool-scouring establishment of E. F. Lewis is on the brook fed by Morey's mill pond, and from 10,000 to 25,000 lbs. of wool per day, or an aggregate of 6,000,000 lbs. per year, are scoured there. This comes from Oregon, Texas, Nevada and other places, and contains a variable amount of earth, alkali, dung and grease. The amount of dirt removed by scouring varies from 18 to 67 per cent., and therefore over 1,000 tons of it are yearly discharged with the wash water. This affects the river water for a distance of two or three miles below. It is claimed that this causes a floating scum, disagreeable to the eye, to accumulate in the mill pond opposite Stetson's card factory, and in that of Bird's paper mill at East Walpole. At these places the water is said at times to smell badly. Suits have been brought against the owner of the scouring mills by manufacturers on the river below, who claim that the pollution of the water injures it for their uses and also makes it offensive and unhealthful. It is noteworthy that one complaint comes from a man who himself wishes to carry on wool-scouring at a point about four miles below Lewis's mill, and claims that the water is rendered too dirty to use for that business. Mr. Lewis would like to avoid polluting the water, if he knew any practicable means of doing so. Until recently he scoured all of his wool by means of repeated washings with very large volumes of water, and still uses that process for three fifths of his product. He has lately put in, at a cost of $18,000, new machinery of sufficient capacity to handle two-fifths of his material. By this, the wool is first beaten while dry, so that a considerable part of the dirt and short wool fibre is extracted from it. It is then carried automatically in a series of tanks and rolls, where it is washed clean by the application of very much less water than is used under the old process. The soap suds and wash water, although containing the same amount of dirt as in the old process, are very much less in quantity, and would therefore be easier to treat by any method of purification. An attempt is made to precipitate some of the dirt by passing the wash water through basins before permitting it to enter the stream; but not much is effected in this way. Mr. Lewis has contemplated pumping the waste water from his new machines to chemical works about half a mile distant, in the hopes that by some method of treatment the water may be purified and a valuable product extracted. He has also commissioned a chemist travelling in Europe to ascertain methods of purification used there in similar cases, and intends to adopt any which has been found to be practicable.

A short distance below this establishment is a mill for cleaning cotton waste. The waste as received contains from 20 to 30 per cent. of dirt and oil, principally petroleum. About a ton of waste is cleaned daily. The wash water, containing soap, oil and dirt, flows through four large settling basins, in which much of the dirt is precipitated and the oil accumulates on the surface. The effluent from these basins into the river looks like dirty soap suds. From 25 to 30 men at this place use water closets which discharge direct into the river.

Near by is the paper mill of H. N. Lewis & Co. This mill makes a dark binder's-board, which does not require any bleaching. The polluting matter added to the stream at this place is chiefly dirt washed from the stock, which escapes with the wash water from the tubs. At this place water closets used by 17 hands discharge into the brook.

The Walpole Dye and Color Works drain into Mill Brook. They make about 375 tons a year of products, chiefly dyes for calico printers. The drainage from this place contains some sulphuric acid, aniline dyes, logwood, etc. This causes considerable discoloration, but the drainage does not seem to smell badly. About 18 hands are employed here, who use a dry privy.

On Spring Street, near the Common, is a mill for making batting and carpet lining from cotton waste. No manufacturing waste is sent into the stream. About 100 hands are employed. For these there is one water closet discharging into the stream, and one privy in which the excrement is kept dry by the addition of the short, dusty fibre extracted from the waste. The resulting compost is used as a manure, and is said to be valuable.

At the bleachery and dye house of S. Gray & Co., on Main Street, 2,000 lbs. of yarn are dyed daily. Vegetable dyes are used, and the refuse goes through a ditch to the river. The drainage looks black, but has no special odor.

The Norton Manufacturing Company manufactures seersuckers. They employ about 75 hands, and claim to discharge no refuse into the stream. The privies, however, are in the immediate neighborhood of the brook.

The Union Mill Company makes batting and carpet lining, and discharges no manufacturing waste into the stream. The water closet, used by twenty or thirty hands, empties into the river through the raceway.

There is a small hat factory at Stetson's dam on the river. This discharges but little waste product. The manufacturer complains that the water is too dirty to allow him to make light-colored hats.

Near Stetson's dam and mill pond is Stetson's card clothing manufactory, employing 11 hands. The privy is over a dry brick vault more than 50 feet from the mill pond. Mr. Stetson complains of the offensive condition of the water which comes into his pond. An unsightly scum often accumulates on the surface of the pond, and its bottom appears to be covered with a dirty deposit. On throwing a stone into the pond, or stirring the mud with a pole, an oily film arises and spreads upon the surface of the water. The amount of smell noticed from the water depends largely on barometric and thermometric conditions. At three separate visits, made during the months of June, August and September, respectively, a decided smell was noticed only on the last occasion. Probably the smell comes largely from decomposition, in summer, of the scum just mentioned. This consists chiefly of certain kinds of algæ mixed with dirt collected from the water. The polluted condition of the water favors the growth of the algæ, which thrive on the quiet surface of the mill ponds. As the slimy growths become loaded with dirt they sink to the bottom, where they begin to decompose. The resulting gases cause the decomposed slime to rise to the surface again.

At East Walpole is the paper mill of F. W. Bird & Son, employing 60 hands. Prior to April, 1885, the privies at this mill discharged into the river; now they are over vaults, and the contents are utilized on land. They work up old paper stock into hardware wrapping papers. Some of the paper is dyed, and the pollution added to the river at this point consists of waste dyestuffs, such as Venetian red, yellow ochre, etc., lime used in bleaching, and the dirt washed from the old stock. At this mill there is much complaint concerning the polluted condition of the water which reaches it. River water is used in the boilers, and much trouble is experienced from foaming.

On the river a little below Bird's mill is the paper mill of Hollingsworth & Vose; 21 hands are employed, some of whom use a privy discharging into the river. About three tons a day are made of Manila paper for flour sacks, and also paper for sanding; *i. e.*, to make sand-paper of. The stock worked up is old rope. For softening and bleaching there are used each week about 1,000 lbs. of chemicals, consisting of 400 lbs. of chloride of lime, 600 lbs. of quicklime and 20 lbs. of soda ash. A portion of this finally escapes into the river, the water of which is made noticeably "hard" by the lime added to it by this mill and Bird's mill above. At this mill there is great complaint of the foulness of the river water. It is said that much scum accumulates on the mill pond, and is very offensive. A well 20 feet in diameter and 30 feet deep has been dug at this mill, about 50 feet from the river, in order to get from it purer water for manufacturing purposes. The water filters to this well from the river, but is still too dirty to be satisfactory. The boilers give a great deal of trouble by foaming, and the mill has sometimes shut down three hours on that account.

At South Walpole are the Walpole Emery Mills; 20 hands are employed, who use a closet discharging into the stream. About 1,000 tons of iron ore are ground yearly, and some of the fine powder escapes into the stream. Its effect in discoloring the water and staining submerged objects is noticed for a long distance below.

SECT. 64. *Stoughton.* — The total population of Stoughton is about 5,200. The northwesterly third of the town, containing the principal village of Stoughton Centre, with a population of 2,500, drains through Canton into the Neponset. No action has been taken by the town towards procuring an artificial water supply, but a private company called the Stoughton Aqueduct Company has been organized with a view to furnishing water for public purposes and to individuals. The principal mover in this enterprise is Mr. Phinney, who during the summer of 1885 sunk a large well near the centre of the town from which to procure water to supply automatic sprinklers in his factory and storehouse, which would largely diminish his insurance. Finding the public interested in the matter, it is now proposed to make the works of sufficient capacity to furnish a supply for street hydrants and for such private individuals as desire to take water. The plan contemplates a pump with a capacity of 18,000 gallons per hour. The present well will furnish 2,500 gallons per hour, but it is thought that other wells can be added. The purity of the supply will be subject to the general conditions affecting ground water drawn from the vicinity of a somewhat numerous population.

Most of the pollution to streams in that part of Stoughton draining into the Neponset, occurs at West Stoughton, and is due to mills upon Muddy Brook, which runs from Stoughton into Canton and is a tributary of Steep Hill Brook.

The upper of these mills is the woollen mill of Consider Southworth; 14 hands are employed, who use a privy discharging into the stream. The proprietor expressed an intention of diverting this discharge from the brook, out of regard for the public welfare. About 100,000 lbs. of wool per year are scoured here, chiefly Eastern super, which is not very dirty, and shrinks only 15 per cent. It is washed with sal soda and soda ash, and the wash water and dirt go into the brook. This mill has been running for a year past on white goods, and has done no dyeing, although it has facilities for that work.

French & Ward's woollen mill employs about 150 hands. A dry privy is used, into which is put peat and sawdust, which farmers finally take away free of charge. This mill washes weekly about 5,000 pounds of domestic wool, shrinking on the average 25 per cent. The wool is washed by machinery, and the wash water, which contains salt, sal soda and soap, goes into the brook. Dyeing is carried on with aniline colors, logwood and cochineal. The refuse from dye vats also goes into the stream. Two or three years ago the proprietors of this mill dug out several hundred cart loads of deposit from the pond below their mill. This deposit proved to be too sandy to be of value as a fertilizer. The superintendent of this mill expressed the opinion that much of the dirt caused by such manufacturing processes *might* be intercepted in vats.

The cotton twine manufactory of A. Southworth & Co. comes next below on the stream. When visited, there was little doing at this mill, though sometimes there are eight hands employed. A privy discharges into the stream, but no other pollution is caused by this establishment. Much complaint is made of the polluted condition of the brook water which reaches this mill. It is said that the operatives were troubled with sore throat and nausea, which was attributed to the smell of the water.

There are several large boot factories, rubber works, etc., in Stoughton. As they are not situated in the vicinity of streams, they do not cause direct pollution to water courses.

SECT. 65. *Canton.* — Nearly the whole of this town is within the Neponset River basin. The total population is a little under 4,500, and of this about 3,000 are found in the main village. There is no water supply except from wells, some of which are thought to be of doubtful purity. Some of them are near streams which flow through the village. These streams are considerably polluted and may affect the wells. A part of the village is underlaid, near the surface, by ledge rock, along which liquids from cesspools might be guided in the direction of wells. For these and other reasons, especially on account of the need of better protection against fire, the inhabitants of the village are anxious that the town should accept a legislative act of 1885 authorizing it to procure a public supply of water from Beaver Hole Meadow Brook, just in the edge of Sharon. Many town meetings have been held to consider the subject, but the opposition of residents remote from the village, who would not be reached by the water pipes, has prevented the measure from receiving the necessary two-thirds vote. A survey for water works has been made by Mr. William Wheeler, C. E., who has prepared a plan, including fourteen miles of pipe, with pumps and stand-pipe having an ultimate capacity of 750,000 gallons daily and calculated to supply within two years a population of 4,000, at an estimated cost of $90,000. There is no system of sewers at Canton, and probably will be no disposition to build any until after water works have been put in. There will then be decided need of one for the removal of house sewage, and also to receive manufacturing refuse, which now makes the streams very dirty. The following is a list of the principal manufactories: —

The upper mill on Massapoag Brook makes cotton fishing lines. It was closed when visited, but was said to employ six or seven hands, and to have a privy discharging into the stream.

The American Net and Twine Company's mill employs 60 hands, who use a privy discharging into the stream.

The Eureka Silk Manufacturing Company has three mills on this brook. About 150 hands in the aggregate are employed, and the privies empty into the stream. Silk machine twist is made, amounting to about 95,000 lbs. per year. All their product is dyed with cutch, logwood, iron, dyewoods and aniline colors. Soap is used in cleansing, and the refuse from all manufacturing operations goes into the stream.

On Beaver Brook at Spring Dale is the Spring Dale mill, which makes woollen yarns; 15 hands are employed, and the privy empties into the stream. About 50 tons of wool a year are dyed, chiefly with krosine, said to be an aniline color. The stream, which at this point is small, is badly discolored by the refuse from this mill, but there is no very noticeable smell.

The shovel works of O. Ames & Son, on the brook formed by the union of Beaver and Steep Hill brooks, employ 25 hands when running full. A dry privy is used, and no noticeable pollution is caused.

The stove-polish works of Morse Bros., on Washington Street, employ about 40 hands, and apparently cause no pollution. The privies are over tight vaults, whose contents are deodorized with ashes and earth.

Near the centre of the town, at the head of the east branch of the Neponset, which is formed by the union of a number of tributaries, are the works of the Kinsley Iron and Machine Company; 225 to 250 hands are employed here. The privies for about half of them empty into the stream, and those for the other half are over vaults, the contents of which are emptied and used as manure. Complaint is made at this mill that the boilers corrode much more rapidly than formerly. This is attributed to the polluted condition of the river water, caused by the mills on its tributaries.

Below is the Revere Copper Company, employing 140 hands. The privies empty into the stream. Little other pollution is caused, except possibly by some dilute acid used in cleaning castings. At these works no trouble is experienced from corrosion of boilers.

At the stone mill of the old Neponset Cotton Factory, on the east branch of the Neponset, are two distinct though connected companies. The Canton Paint and Oil Company manufactures ship paints, black dressing for leather, axle grease, and a soap for bleaching purposes made from petroleum, mustard-seed oil, alkali, etc. The substances handled seem rather dirty, but it could not be learned that any of them got into the stream. A privy used by four operatives empties into the river. The Canton Manufacturing Company, in the same building, bleaches fine cotton goods by a new process, advertised as the "Canton bleach." The capacity of the works is about 30,000 yards per day. Refuse from the bleaching process is turned into the river. The proprietors claim that this refuse is antiseptic and harmless. A privy used by 22 hands empties into the river. The river water is not considered pure enough for use at this mill; the water used is brought through an 8-inch pipe from a pond over half a mile distant.

At Canton Corners is the cotton mill of Robert Draper, employing 50 hands. It is not near a stream, and seems to cause no pollution.

At Canton Corners is also the woollen mill of Draper Bros.; 80 hands are employed, who use privies over vaults. From 300,000 to 400,000 lbs. of wool a year are used, about half of which is scoured at the mill. A part of the product is dyed. The refuse from scouring and dyeing goes on to swampy land near by, where it makes a local nuisance and is said sometimes to smell badly.

SECT. 66. *Norwood.* — This town consists of what was formerly the southerly part of Dedham, and was set off in February, 1872. It lies wholly in the valley of the Neponset, and slopes gently towards that stream. Bordering that river and a tributary called Purgatory Brook are large areas of swamp or flowed meadow. The town has just put in a system of water works, the supply being taken from Buckmaster Pond in West Dedham. The present population is about 3,000, of whom 2,500 reside in the village. The capacity of the works is based upon a population of 5,000, using a total of 300,000 gallons daily. There is no sewerage system; and as population is nowhere dense it will probably be some time, even after the introduction of water, before one will be considered indispensable.

There are one or two marked cases of pollution of water courses in this town. On Hawes Brook is the paper mill of Isaac Ellis, employing 12 hands. From 450 to 500 tons of Manila wrapping paper are made here yearly. The stock worked up is old bagging, rope and paper. In treating this there are used about 300 barrels of lime, 16 of chloride of lime and some copperas. The water which reaches this mill is perfectly clear; below the mill the brook has a muddy yellow color.

Further down on Hawes Brook is the tannery of Winslow Bros., employing 125 men. About 1,000,000 sheepskins are tanned and dyed here yearly. About a quarter of these are "domestic slaughter" skins, and the rest are "foreign process" (*i. e.*, salted in the countries from which they are imported). The skins are "drenched" with salt and vitriol, "limed" with lime, tanned with bark or extract, and dyed with aniline colors and logwood. Refuse from all of these processes goes into the brook, the water of which is turned quite black. The black color is probably due to the combination of iron with tannin. The brook stinks very badly at times. The proprietors of the tannery claim that the discoloration of the brook before it reaches them, caused by the paper mill above, injures them by preventing the making of white sheepskins.

On the main river, not far below where Hawes Brook enters it, is the printing-ink factory of Geo. H. Morrill & Co.; 16 hands are employed, who use a privy emptying into the river. Little if any pollution is caused by the manufacturing processes. Complaint is made here of a "fearful stench" from the river water which reaches them. It is said to be specially noticeable in the morning, when their water-wheel is started, and the filth accumulated during the night at the head of the race is stirred up.

At the north end of Norwood village, opposite the Norwood station on the N. Y. & N. E. R. R., is the tannery of Lyman Smith's Sons. There are about 125 employés, who use privies over vaults, whose contents are sometimes utilized as manure and sometimes carried away by persons paid for that service. About 1,000,000 sheepskins are tanned and dyed yearly by processes similar to those employed at Winslow's tannery, as before described. At this place the refuse from the several processes passes first through a "settling pit," 50 feet long and 20 feet wide, by which some of the solids are intercepted. The pit is cleaned out occasionally by farmers, and the contents applied to land. The dirty effluent from the settling pit goes for about 500 feet through an open ditch, which is very foul. Fortunately there are only one or two dwelling-houses near it. The ditch connects with a plank drain eight inches square, which conveys the foul water to Neponset River. This drain is over a mile long and cost $3,000, of which the town contributed $800.

SECT. 67. *Randolph.* — About a sixth part of this town, including the farming neighborhood of Tower Hill and a population of about 200, drains into the Neponset; the rest of the town drains in an easterly direction into Weymouth River. No cases of marked pollution of water courses are known to exist on the Neponset side. The town has lately voted to accept an act which empowers it to take water from Great Pond, situated partly in the adjoining town of Braintree. The watershed of this pond is sparsely settled, and is therefore little liable to pollution. There is no probability of sewers being built at Tower Hill.

SECT. 68. *Dedham.* — The part of Dedham which naturally drains into Charles River has been considered in section 34. Of the remaining portion, the greater part consists of a hilly and sparsely settled farming region where there is nothing calling for comment. The somewhat populous villages of East Dedham and Oakdale drain towards Mother Brook, which, as before explained, diverts one-third of the waters of Charles River into the Neponset. These villages share in the general town water supply referred to in section 34. On Mother Brook are several marked cases of pollution due to manufacturing. At the upper mill of the Merchant's Woollen Company, about 200,000 lbs. of unwashed wool are sometimes scoured in a month. The resulting product of clean wool may be only 80,000 lbs., the other 120,000 lbs., consisting of dirt and grease, escaping into the brook. The water closets for 40 operatives discharge into the stream, as do also those for 460 hands in the spinning and weaving mills of the same company just below. At the Norfolk Mills, now owned by the Merchants' Company, about 50,000 lbs. of wool are scoured in a month. About 60 per cent. of this passes into the river in the shape of dirt and grease. At this mill there is no pollution from water closets. Dry wool waste is put into the privy vaults, and the resulting compound is used as a fertilizer. Mother Brook joins Neponset River a short distance below the point at which are situated the driven wells for Hyde Park's water works. The water between the two points, however, is slack on account of a dam below. It is a question whether putting excrement into Mother Brook would be held to be a violation of the Public Health Act.

SECT. 69. *West Roxbury.* — About 400 acres in the southerly corner of this part of Boston drain towards Mother Brook and Neponset River. This territory has a population of about 500, which is not increasing much at present, although it may do so in the future. There are no sewers here and none are contemplated. Should any ever be needed they could hardly connect with the sewerage systems in other parts of Boston, on account of a dividing ridge which it would be difficult to cut through. A connection with a Dedham system would be more practicable, and such a system will probably be built before sewers are needed for this part of West Roxbury. There are no noticeable cases of pollution in this district.

SECT. 70. *Hyde Park.* — This town has a population of nearly 8,500, which is increasing rapidly. About three-fifths of the area, including most of the main village and over four-fifths of the population, drain into Neponset River. Two-fifths of the town, on its northerly side, with a population of 1,500, naturally drain towards Stony Brook and Charles River. Up to this time water has been chiefly derived from wells. This source of supply is thus referred to by the Board of Health : —

"Where the houses are in such close proximity as in Hyde Park, the well water must necessarily become contaminated from the cesspools and privy vaults. Dr. Hammond, the distinguished authority in sanitary matters, says that a cesspool should be at least one hundred feet from the well. Here they are often less than ten feet. There is no doubt that both wells and cesspools are a nuisance in Hyde Park. We advise that filtered cistern water be used if it can possibly be obtained."

In accordance with the above advice, a number of citizens have abandoned their wells and have constructed rainwater cisterns instead. A system of public water works is now building by a private company. Water is to be taken from driven wells adjoining the river bank, about half a mile above where Mother Brook enters. The water of the river which flows past this point has been contaminated in the manner described in previous sections. The pollution is sufficiently marked to be noticeable to the eye. It is asserted by the water works officials that what reaches their wells will be land water intercepted on its way to the river. All the settled portion of the town is to be piped, and it is supposed that the average daily consumption will soon reach 400,000 gallons. There are no public sewers in Hyde Park, and sewage is disposed of in cesspools and privy vaults. The Board of Health estimates that there are about 1,250 privies and an equal number of cesspools in the town, and that they are all cleaned about once a year at an average cost of $4 each. This makes a total annual expense of $10,000, which at present rates for good municipal loans would be the interest on $300,000. Portions of the town are so densely settled that the use of cesspools is especially unsatisfactory. The Board of Health says of this: —

"In some parts of the town, where the ground is low and wet, it is quite difficult, without great expense to private parties, to keep the cesspools emptied. This trouble will continue until sewerage is introduced. Many parts of our town are thickly settled, and to prevent the accumulation of nuisances as the town becomes more populous is a question demanding consideration and action. It is to be hoped that water will soon be introduced, and then the demand for a system of sewerage will become more urgent, because more water will be used. Many think if we only obtain water we can wait some time before it will be necessary to have sewerage. It would be desirable and cheaper to have all the work done together."

It is known that a number of estates near the river have drains discharging directly into the stream. The number of these and the amount of sewerage contributed by them has not been exactly determined. A number of manufacturing establishments also contribute directly to the pollution of the river. The principal of these establishments are the following: —

The cotton mill of D. B. & R. Knight, on Mother Brook; employs from 275 to 300 hands; the privies discharge into the stream. No dyeing is done, and little if any manufacturing refuse gets into the stream.

The Boston Blower Company, on Mother Brook; employs at present 20 hands; has a privy discharging into the stream, but apparently causes no other pollution.

The Brainard Milling Machine Company; when visited employed 35 operatives, although, occasionally, it has double that number. The privy discharges into the stream, but no other pollution was noticed.

The American Tool and Machine Company, on Mother Brook; employs about 150 hands, of whom half use a privy over a vault, and the others closets discharging through an 8-inch pipe into Mother Brook.

The woollen mills of Robert Bleakie & Co.; employ about 275 operatives. All refuse from closets, wool scouring and dyeing goes into a settling basin from which the effluent goes into the stream. About 3,000 lbs. of wool are scoured daily with about 40 lbs. of soda ash, and are dyed chiefly with ground dyewoods. The wool shrinks in cleansing from 50 to 60 per cent., so that the refuse amounts to over 1,500 lbs. daily. The settling basin through which the waste water flows, as shown by the accompanying cut, Fig. 1, consists of a cemented structure 80 feet long by 10 feet

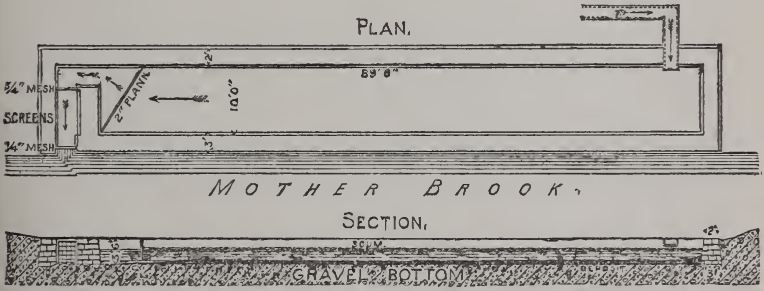


Fig. 1.

wide and 8 feet deep. A large amount of solid refuse is intercepted by this, the heavier portions being retained in the bottom of the basin, and the greasy scum floating on top. The effluent, however, is still very dirty. The proprietor cleans out the basin at intervals, and uses its contents to fertilize his land. He estimates its value for this purpose at several hundred dollars per year.

The Boston Gossamer Rubber Company, at Readville; was employing 50 operatives when visited. The privy at this place is over a vault, which is cleaned out periodically by the "odorless" process. The water which has been fouled by washing crude rubber is turned upon neighboring gravelly soil, where it soaks away.

The curled hair factory of Glover & Willcomb; employs about 130 hands, who use privies over the stream. From 50,000 to 60,000 lbs. of the hair handled by them yearly is dyed. It is first washed and bleached with soap and soda, and then dyed, chiefly with logwood and copperas. The refuse from these operations goes into the stream.

The wool scouring mill of John Scott, on Neponset River, employs from 15 to 20 hands. The privy is over a vault on the edge of the stream. Into this vault also goes the refuse from scouring, and the heavier portions settle there, while the rest overflows into the river. The vault is cleaned out two or three times a year, and its solid contents piled on waste ground near by. There seems to be no reason why it should not be as valuable as the refuse collected at Bleakie's mill before referred to, but in this case it is said that farmers will not take the trouble to cart it away. When visited, about 5,000 lbs. of wool per day were being scoured, the refuse from which would amount to a ton or more. When business is brisk the out-put is said to be larger.

On the Neponset near the above mill is the shoddy mill of T. H. Gray, employing 15 hands, with privies emptying into the stream. Not much pollution is caused by the manufacturing processes, any waste fibre being piled in heaps on the ground. There is no sale for this here, although at some places it is said that farmers will pay $8 per cord for it, to use as manure.

On the Neponset River, near the eastern or lower boundary of the town, is a paper mill of Tileston & Hollingsworth, which firm also runs two other similar mills, one in Dorchester and one in Milton. At this mill, called the Mattapan Mills, 54 hands are employed, who use privies emptying into the stream. White and colored rags are worked up into about four and a half tons per day of white book and plate papers. In bleaching the stock there is used weekly about 1,400 pounds of lime, 1,200 pounds chloride of lime and 200 pounds of vitriol. The waste water from the bleaching tubs goes into the river. There are ten beating engines and four washers. It is claimed that serious damage is occasioned at this mill and those below by the filthy condition of the water in the river. The pollution of the river is said to have increased steadily during the past seven years, which is attributed chiefly to domestic drainage from Hyde Park and to the wool scouring at Bleakie's and Scott's mills in that town. The "flocks" or loose fibres of wool waste sent down from these mills cause much trouble, and the grease and soap suds make the water greasy and slimy. Sometimes the river water is too filthy to use, and cleaner water is pumped from a well which has been sunk on the Milton side of the river. The river water smells, and is thought to be unhealthful for those living near it. Messrs. Tileston & Hollingsworth have had communications with the Board of Health of Hyde Park in regard to this pollution, and have threatened to bring a lawsuit against the town on account of it.

As soon as the public water supply is introduced a sewerage system will probably be found to be a necessity. As the river water below the town is not used for domestic purposes, sewage could be put into it without violating the Health Act. It would be sure, however, to cause nuisances in the mill ponds below, especially at Mattapan and Milton Lower Mills, and would probably lead to lawsuits and injunctions. To reach a satisfactory outlet at the sea would require the building of a larger and more expensive sewer than Hyde Park could afford.

SECT. 71. *Milton.* — Nearly the whole of this town, with a total population of 3,500, drains into Neponset River, which forms its northern boundary. The population is more evenly distributed here than in most other towns, and there are fewer thickly settled districts. Partly for this reason a system of public water supply has not yet been considered necessary. There has been some talk of taking one from Houghton's Pond, or of buying a supply from Quincy. Sewerage has hardly been thought of, and probably will not be considered until after the introduction of a water supply. A short piece of street drain has been built in Adams Street and along the railroad at the Lower Mills. It receives water-closet sewage from the railroad station, and, emptying into a ditch, causes some nuisance, which could be mitigated by extending the sewer to tidewater in the river.

On the river at Mattapan is the Fuller Paper Mill, belonging to Tileston & Hollingsworth; 36 hands are employed, and the privy discharges into the stream. Colored papers are made to the amount of about 1½ tons daily. About 2,800 lbs. of chemicals are used each week for bleaching and softening, principally quicklime and chloride of lime, with a little vitriol. After use, more or less of these escape into the stream. The dirty condition of the river water is complained of at this mill.

At Milton Lower Mills are the large chocolate mills of Walter Baker & Co. Some of the buildings are on the Milton side of the river and some on the Dorchester side. In the winter about 200 hands are employed, but in summer there are not nearly as many. Water-closets are provided, which discharge into the stream. It could not be learned that any other offensive refuse was turned into the water at these mills. The quality of the water in the river causes much complaint. It smells badly, and causes foaming in the boilers. It is said that the pollution has increased steadily during the past four or five years. Ten years ago the river water could be used for drinking, but not since that time. It is said that a noticeable increase in the pollution was caused by the removal of Scott's wool scouring mill from this place to Hyde Park.

SECT. 72. *Dorchester.* — Dorchester constitutes Ward 24 of Boston. It has a population of over 20,000. The southerly third of this ward, with a growing population of perhaps 5,000, drains into Neponset River. Most of this territory is unsewered at present, but what sewers there are discharge into the river. There are two outlets at the village of Neponset, also one at Milton Lower Mills and another into Davenport Brook, a small stream tributary to the Neponset.

A drain from the "Liversidge Institute of Industry" near Mattapan, empties into a cesspool 10 feet in diameter, which overflows by an open ditch to the river.

On the river near Mattapan is the Eagle Paper Mill, operated by Tileston & Hollingsworth. There are from 70 to 80 hands, who use a privy discharging into the stream. About five tons of paper are made daily, and about 3,100 lbs. of chemicals a week are used in the process, and a portion of them finally goes into the stream.

Below Mattapan on River Street is the starch factory of H. N. Glover. Seventy barrels of flour weekly are converted into starch. In this process the flour is "soured," then "washed," and a considerable amount of waste "sour water" escapes into the river.

The population in this part of Dorchester will be sure to increase largely in the near future, and will demand sewerage facilities. The river, as far up as Milton Lower Mills, is a tidal stream, with areas of mud flats exposed at low water, and it is evident that no large amount of crude sewage could be put into it without causing serious nuisances.

SECT. 73. *Quincy.* — About one-fifth of this town, along its northerly border, drains into Neponset River. With the exception of the village of Atlantic, this district is almost uninhabited. About 40 houses in this village take water from the company which furnishes a public supply to the town. This supply comes from driven wells near Quincy Adams Station, and is said to be pure. A portion of Atlantic is so thickly settled that sewerage would be desirable, but it is not contemplated. An outlet into the river might cause some nuisance.

THE BLACKSTONE BASIN.

SECT. 74. *The basin as a whole.* — The area drained by the Blackstone and its tributaries in the State of Massachusetts, not including Mill River, a tributary that unites with it below the State line, is about 260 square miles. The basin includes the city of Worcester, and the whole or considerable portions of fourteen towns. The total population living on this area is about 100,000. More than two-thirds of this number, or 68,500, are in Worcester, and the remainder is chiefly concentrated in manufacturing villages in the country towns. The increase in population for the last twenty years has been 40 per cent. The whole of this increase has occurred at Worcester, and as a whole, the rest of the territory has decreased in population. Neither the main river nor its tributaries are used as sources of public water supply. The only such supply or system of sewerage existing in the basin are those of Worcester. In some instances mill owners pump water to their own homes, and at Uxbridge a water company supplies about seventy-five families from springs on a hill west of the village. With these exceptions, the only water supply is from wells near houses. As is usual in such cases, some of the wells are of doubtful purity. After use in sinks, the water is discharged into cesspools built in the ordinary manner. Privies, when remote from the river or streams, have vaults which are cleaned out as often as necessary. There is no systematic cleaning of vaults, each householder caring for his own. The sewage from mills and houses near the river is commonly, but not always, turned into it. The whole sewage of Worcester also flows into the river through Mill Brook. The main river and its tributaries have considerable fall, and afford opportunities for many water privileges, which are used for manufacturing. There are nearly a hundred manufacturing establishments upon the different water courses, nearly all of which turn more or less refuse into the streams and thus pollute the water. The problem in this river basin, therefore, presents but two features of interest, namely, the pollution caused by the sewage of Worcester, and that caused by the manufactories within the different towns.

SECT. 75. *Worcester.*— Worcester is wholly within the Blackstone basin. The present population, by the census of 1885, is 68,383; and the growth of the city during the last twenty years is shown by the following figures: —

In 1865, its population was 30,047; in 1870, 41,105; in 1875, 49,317; in 1880, 58,291; and in 1885, 68,383.

Should population increase proportionally during the next twenty years, it will amount in 1905 to 155,000.

The city has a public water supply amounting to about 3,750,000 gallons per day, derived from two storage reservoirs. One of these, in Leicester, has an area of 140 acres and a storage capacity of 682,000,000 gallons, and the other, in Holden, has an area of 98½ acres and a storage capacity of

400,000,000 gallons. The watersheds about these basins consist of thinly settled farming regions, with little or no liability to pollution.

To dispose of the water after use, with its retained filth, the city has built an extensive system of sewerage. This comprises at present about forty miles of sewers, serving a population of about 45,000. Extensions of the system are contemplated or in process of construction, which will serve additional population, both present and prospective. All of these sewers empty into Mill Brook, a tributary of the Blackstone, which it joins within the limits of the city. Except in seasons of freshet, this brook has naturally a very slight flow, so that the sewage is not materially diluted until reaching the Blackstone. Mill Brook has been walled in and arched over for much of its length, so that it has become substantially a main sewer of the city. The use of the brook for this purpose was by authority of a special legislative enactment in 1867.

Worcester is essentially a manufacturing city. The manufacturing processes carried on there, which are very varied in character, contribute largely to the sewage. There are also a number of factories which are not reached by the city sewers, and probably will not be for a long time. These discharge their refuse into the streams on which they are situated. The following is a list of the principal ones: —

On Mill Brook, above Salisbury Pond, is a mill for manufacturing cotton yarn. It employs 15 operatives; privies over the stream.

On Tatnuck Brook is Thayer's mill, manufacturing satinets. It employs 30 operatives; privies over the stream.

Ashworth & Jones's mill, on Kettle Brook, is not running at present.

Darling satinet mill; 25 operatives; privies over the stream.

Hunt's satinet mills; 25 operatives; privies over the stream.

Jamesville satinet mills; 60 operatives; privies over the stream. No scouring or dyeing at present, but facilities for both.

Curtiss & Marble's mill, at New Worcester, manufactures cassimeres; 75 to 100 operatives. The privies at this mill, used also by 70 operatives of machine shop, discharge into the stream.

Hopeville satinet mill; employs 40 to 50 operatives; privies over the stream.

Whittall Carpet Company; 125 operatives; privies over vaults; dye wastes go to river.

Worcester Carpet Company; 300 operatives; drainage from water closets, sinks and dye vats goes into the stream. There are 8 dye tubs of 250 gallons capacity each, which are drawn off three or four times a day. About 1,250,000 lbs. of wool are scoured here yearly.

Hicks Manufacturing Company; makes worsted suitings; 150 to 200 operatives; privies and dye vats discharge into the stream.

In so far as the method of disposing of its sewage affects Worcester itself, it is satisfactory, except that Mill Brook smells, and will need covering. The sewage, however, is conveyed to a point so remote from the limits of population that it can thereafter cause no nuisance to the city. Unfortunately it often causes a very great nuisance to the people living on the banks of the Blackstone, below where the sewage enters it, and especially to those at Millbury, which is the nearest town below Worcester. During a large part of the year there is not enough water flowing in the river to dilute the sewage to a degree which will render it inoffensive. On some Sundays and holidays, when the river water is held back by the dams, almost nothing flows in the river between Worcester and Millbury except the city's sewage. On one such occasion the river water at Millbury, as observed by myself, seemed to resemble exactly the sewage in the Mill Brook sewer at Worcester. Complaints of the condition of the river have been growing more and more urgent during the past ten years, and have been brought to the notice of the legislature. The State Board of Health has referred to the evil as being dangerous to health. The physicians practising in towns through which the river flows, think that its condition produces much sickness.

Apart from the danger to health, the serious sewage contamination to which the river water is subjected is thought by the manufacturers who use the water to cause them much pecuniary damage. It is stated that light colored cloths cannot be made when river water is used, and that some mills have been obliged to give up making such goods. It is also asserted that the water is unfit to use in boilers, as it causes foaming and corrosion. Investigations below Worcester show that there is some foreign element in the water which tends to corrode the boilers. That this is due to the sewage seems probable, but has not been distinctly proven. It will be seen by statements made in the following sections, that this trouble is met with at all mills using in their boilers the water from the main river, while those using the water of tributary streams have not this cause for complaint. A large amount of acid used by iron manufacturers at Worcester is contributed to the sewage, which has an acid reaction.

So far as I could learn, the authorities and citizens of Worcester recognize fully that their present method of disposing of their sewage injures their neighbors, and must eventually be changed. There seems, however, to be a feeling that the Commonwealth, by sanctioning the use of Mill Brook as a sewer, and Blackstone River as a place of disposal, has rendered itself *particeps criminis*, and should bear part of the cost of making any change.

The Legislature of 1881 requested the State Board of Health to examine and consider the question of the disposition of the sewage of the city of Worcester, especially with a view to prevent the pollution of the Blackstone River and its tributaries, and to recommend a definite plan for the prevention of such pollution. The Board appointed a committee of experts, consisting of C. F. Folsom, M. D., and Jos. P. Davis, C. E. This committee, with Dr. Walcott, Health Officer of the Board, designed a plan by which the sewage should be diverted from Mill Brook, and conducted instead to a tract of land situated near the river midway between Worcester and Millbury. By intermittent filtration through this land, the sewage was to be purified before entering the river. The estimated total cost of this scheme was $408,-490. The city opposed the compulsory expenditure of this sum of money, and no action requiring it was taken by the Legislature.

SECT. 76. *Auburn.* — Nearly all of this town, with a population of about 1,300, is within the Blackstone basin. There are few factories and little pollution.

The Larnard mills employ from 60 to 100 operatives; privies discharge into boxes, the contents of which are removed and applied to land.

The Stoneville cotton mill employs about 75 hands when running, but has not been in operation for more than a year.

SECT. 77. *Shrewsbury.* — The portion of this town lying within the Blackstone basin is a farming district, and no noticeable cases of pollution to any tributary of the river are known to exist.

SECT. 78. *Millbury.* — Millbury is wholly within the Blackstone basin. Its population by the census of 1885 is 4,555. Of this number about 2,500 live in the main village of Millbury, and the remainder are chiefly concentrated at the several factory villages. There is no public water supply, although there has been some talk of taking one from Singletary Pond. The great nuisance complained of in Millbury is that arising from the polluted condition of the river, due to the sewage of Worcester. The physicians of the town state that statistics show that the ratio of deaths within half a mile of the river to the whole number of deaths in the town has increased considerably during the last five years. A smell from the river is often noticed at houses within a thousand feet of the stream. Some nuisance, though not much complained of, is caused by the dirty condition of Singletary Brook, which is polluted by refuse from factories situated on it, and also by the drainage from the sinks of several neighboring tenement houses. At times this brook is very much discolored, and, when water is held back by the mills above, a decided smell is observed. In time of drought the water is quite thick with refuse, principally dye stuffs from the factories. The smell does not seem to be quite so offensive as that due to sewage. There was no complaint of trouble caused by the use of this water in boilers, although at the lower mill the tubes of the boilers at times would be covered with a greasy substance resembling pork rind. This, when scraped off, left the tubes bright and clean.

The following are the principal manufacturing establishments in Millbury: —

Hoyle's scouring mill, on Ramshorn Brook; scours about 1,000 lbs. of wool in the grease per day. In scouring, the first wash is discharged into a cemented basin. Dust and refuse from the wool, extracted dry, is thrown into the basin, and a compost made. From 50 to 100 loads of manure are obtained in a year. A portion of this is used by Mr. Hoyle on his own land, and the remainder is sold at $2.50 per load.

The Millbury Scouring Company's mill, also on Ramshorn Brook; scours about 1,000 lbs. of wool in the grease per day. In scouring, the first wash is discharged into old tan vats. These vats are cleaned out occasionally, and their contents used as a fertilizer. The liquid portion is baled out into carts provided with suitable sprinklers to distribute it over the land. The first wash contains about five-sixths of the dirt extracted by scouring.

Wheeler cotton mills, on Singletary Brook; employ from 50 to 60 operatives in the manufacture of white goods. Privies do not discharge into the stream.

M. A. Lapham's cassimere mills, on Singletary Brook; employ 125 operatives; scour about 1,200 pounds of wool in the grease per day; refuse from scouring and dye tubs, also privies, discharges into the stream.

Rhodes's mill, on Singletary Brook; manufactures white cotton yarn; about 25 operatives; privies over stream.

Walling mill, on Singletary Brook; was not running when visited, but usually employs about the same number of operatives and manufactures the same class of goods as the Lapham mill.

Crane & Waters's hosiery mill, on Singletary Brook; employs about 150 operatives; privies used by about 120 discharge into the stream. At this mill about 1,000 pounds of wool are scoured per day. The dyes used are indigo, aniline colors and a small amount of wood dyes. The waste from dye vats goes into the stream.

There are two small establishments on Dority Brook, one an indigo works and the other a shoddy mill. Little pollution is caused by them, although privies used by about a dozen operatives discharge into the stream, and perhaps 1,000 lbs. of wool per year are scoured at the indigo works.

The sash and blind works of C. D. Morse, on the main river, employ about 60 operatives. These complain of smell from the river. Steam was put in in 1883, water for the boilers being taken from a well 70 feet from the river. No complaint on account of corrosion as yet. Mr. Morse has a suit pending against the city of Worcester on account of damage to his works occasioned by the foul condition of the river water. A demurrer by the city, founded on the right granted by the State to discharge sewage into the river, has been overruled. The privies at this mill discharge into the river.

Atlanta mills, on the main river, manufacture fancy cassimeres; employ about 100 operatives. It is stated that light colored woollens cannot be made here on account of the condition of the water. River water has been used in the boilers, and causes much trouble. It foams badly at times, and corrodes the iron. From 700 to 800 lbs. of wool are scoured here daily. The refuse from this and other operations, as well as that from the privies, is discharged into the stream.

Millbury cotton mill, on the main river, manufactures white goods; employs 150 operatives; privies over the stream. No special trouble is experienced on account of river water corroding the boiler tubes, but there is trouble from foaming during the summer months.

Cordis mills, on main river, manufacture tickings; employ 175 operatives; use a small amount of indigo dye; all waste products, also privies, discharge into the stream. Previous to November, 1884, the water used in the boilers was taken from the river; but the tubes blistered and corroded so rapidly that it was deemed advisable to obtain water from a spring a quarter of a mile from the river. While using river water it was found necessary to replace two or three tubes every week. From December, 1884, to July, 1885, while spring water was used, only one tube was replaced. No trouble from foaming was caused by using river water. Wells in the vicinity of this mill are found to be much polluted, although the water appears clear. Water for the tenements is now brought from the spring before referred to.

Simpson's satinet mills, on the main river; employ 70 operatives. All wastes, including that from privies, go into the stream. The manager of this mill states that he had to give up making light colored goods on account of the condition of the water, and that buyers complained that his goods had a disagreeable smell; also, that he had a difficulty in keeping operatives on account of the smell of the river. The river water corroded the boiler. Now, the water for the boilers is pumped from a well.

SECT. 79. *Grafton.* — This town is almost wholly within the Blackstone basin. The total population by the census of 1885 is 4,498, about 1,000 being in the village proper and the remainder grouped at the several factory villages in the town. There has been a little talk of getting a small water supply from a spring east of the town. What pollution is caused in this town comes chiefly from the manufactories, the principal of which are the following: —

Grafton flax mills, on Quinsigamond River; employ about 250 operatives; privies used by 150 of these discharge into the stream. The mills use from 1,000 to 1,200 lbs. of bleaching powder and about 2,000 lbs. of caustic lye per week.

Quaker Cottage mill, on Quinsigamond River; manufactures cotton yarn and sheetings and employs 150 operatives. Privies discharge into vaults, which are cleaned out twice every year. No trouble with boilers, either from corrosion or foaming.

Saundersonville mills, on Blackstone River; manufacture cotton sheeting and employ 150 operatives. Privies do not discharge into river. There has been considerable trouble from corrosion of boiler tubes and from foaming.

Fisher Manufacturing Company, also on Blackstone River; makes white cotton goods; employs 230 operatives; sewage from privies is discharged into a cesspool, from which liquids overflow into the river and solids are cleaned out and used as a fertilizer. There has been some trouble from corrosion of boiler tubes.

Farnumsville cotton mills, on Blackstone River; manufacture white goods; employ 135 operatives; privies at the mill and at tenement houses discharge into boxes, the contents of which are used as fertilizers. The waste from sinks goes through drains to the river. Trouble has been experienced at this mill from corrosion of boilers. It is stated that the polluted condition of the river at this place has increased noticeably within the last two or three years.

SECT. 80. *Northbridge.* — The whole of this town lies within the Blackstone basin. Its population by the census of 1885 is 3,785, of whom 2,500 are at the principal village of Whitinsville. There is no talk of water supply or sewerage. The principal manufactories in the town are as follows: —

Whitin's machine works, on Mumford River; manufacture cotton machinery, and employ about 800 operatives. There is a foundry, in which about 300 carboys of sulphuric acid are used yearly. The privies at the works and tenement houses discharge into vaults, the contents of which are taken out and utilized. At the works, the vaults are cleaned every week. The sinks at the tenement houses drain into cesspools, which overflow into the stream. No trouble is experienced here from corrosion of boiler tubes or foaming of water.

The cotton mill of Charles P. Whitin, on Mumford River; manufactures shirtings and sheetings, and employs 250 operatives. The privies at the mill and tenement houses discharge into vaults, the contents of which are utilized; the sinks drain into cesspools. No trouble from corrosion or foaming in boilers.

Linwood mill, on Mumford River; manufactures shirtings, and employs 200 operatives. Privies at the mill and tenement houses discharge into vaults, the contents of which are utilized; sinks drain into cesspools. No dyeing or bleaching is done at this mill. There is no trouble from foaming or corrosion in boilers.

The Rockdale mills, on Blackstone River; manufacture sheetings and shirtings, and employ about 150 operatives. Privies and sinks at the mills discharge into vaults, into which earth and ashes are occasionally thrown, and the resulting compound used as a fertilizer. Privies at the tenement houses discharge into vaults, and the kitchen sinks into boxes. These are cleaned out as occasion requires. Previous to 1883, not much trouble was experienced from using the river water. Since then, a hard, elastic scale has formed upon the boilers, and tubes have corroded and become perforated with small holes. Iron feed-pipes for the boilers would not last more than a year, and were replaced with brass. A new steel boiler, put in during 1880, required about as much repairing as did one which had been in use since 1872. A patch to this older boiler was covered with a white scale in one month. The boiler inspector considered that this white deposit was caused by lime and acid in the water. Soda ash and extract of oak bark, in equal quantities by weight, are now used in the boiler, and the trouble has been considerably abated. At this mill and the mill below there has been much trouble from the wheels clogging and the iron racks corroding.

The Riverdale mill, on Blackstone River; manufactures shirtings, and employs 100 operatives. The privies of the mill and tenement houses discharge into boxes, into which earth is occasionally thrown, and the contents are cleaned out once a week. Sinks at the tenement houses drain into ordinary cesspools; those at the mill drain into the river. The boilers at this mill were put in in 1873. Scales began to form; but, by the use of soda ash and oak bark, serious trouble was prevented.

Sect. 81. *Upton.* — Nearly the whole of this town, with a population of 2,265, is within the Blackstone basin. There is no probability of public systems of water supply or sewerage being needed. The principal manufacturing industry is the straw works at West Upton, near West River, which employ about 950 operatives. The sewage from the water-closets of the mill and boarding-house is conveyed, by a drain-pipe about a quarter of a mile long, to a basin into which earth and refuse are thrown, forming a compost heap. This is used as a fertilizer, and the manager says he could not afford to lose it. The wastes from gas works, bleachery and dye vats are discharged into a ditch, and eventually find their way into West River.

SECT. 82. *Douglas.* — More than half of this town, and all the more thickly settled portion of it, is within the Blackstone basin. The total population of the town, by the census of 1885, is 2,205. The village of East Douglas, with its manufacturing industries, is the only source of pollution worth considering. There are no sewers here, although several drains and culverts discharge street-wash into Mumford River.

The Douglas Axe Company, on Mumford River; employs 350 operatives. Privies used by 50 of these discharge into the stream. Other privies at the mill and at tenement houses, as well as sinks, discharge upon the ground. The company uses no acids or other chemicals, and makes little refuse. There is no trouble with the boilers.

The Douglas woollen mills, on Mumford River; manufacture satinets, and employ 70 operatives. The privies at the mill are over the stream; those at tenement houses are over vaults. Sinks drain upon the ground. The mill has facilities for scouring, but at present that operation is not carried on. There is no trouble with the boilers.

SECT. 83. *Uxbridge.* — About the whole of this town, with a population of 2,948, is within the Blackstone basin. The Uxbridge Water Company supplies, from springs west of the village, about 75 families living in the village of Uxbridge. There are no sewers, nor a likelihood of any being needed. The principal manufacturing industries of this town are as follows: —

Uxbridge cotton mills, on Mumford River; manufacture fine sheetings; no dyeing or bleaching; 130 operatives, half of whom use privies discharging into the stream. No trouble from corrosion of boiler tubes or foaming of water.

Rivulet woollen mill, on a tributary of Mumford River; manufactures satinets; employs 50 operatives; privies are over vaults into which earth is thrown from time to time. This mill scours from 100,000 to 150,000 lbs. of wool per year. No trouble with the boilers.

The Catron mill, on Mumford River; manufactures satinets; employs from 60 to 75 operatives; has facilities for scouring and dyeing; privies are over vaults.

The shoddy and yarn mill on Mumford River; employs 20 operatives; privies discharge into stream.

Taft's mill, on a tributary of Mumford River; manufactures union cassimeres; employs 25 operatives; privies do not discharge into stream; no trouble with the boiler.

Wheelock's woollen mill, on West River; manufactures cassimeres; employs 75 operatives; privies at mill discharge into stream, those at tenement houses into vaults. Wood dyes are mostly used, also some aniline colors. About 1,500 lbs. of wool in the grease are scoured per day; no trouble with the boiler.

Scott's mill, on West River; manufactures satinets; privies at mill discharge into river; those at tenement houses into vaults. No scouring or dyeing; no trouble with boiler.

Calumet Woollen Company, on Blackstone River; manufactures fancy cassimeres; employs 124 operatives; privies at mill discharge into river; those at tenement houses into vaults; wood dyes are principally used, also some aniline colors; 1,000 lbs. of wool per day are scoured and dyed; much trouble is caused by tubes of the boilers corroding and scales falling off; there is no foaming.

The Uxbridge woollen mill, on Blackstone River; when running, employs about 170 hands; it has not been in operation for several years.

SECT. 84. *Leicester.* — The greater part of this town, including the main village of Leicester, is beyond the Blackstone divide, and drains into French River. About one-third of the town, on its easterly side, drains into Kettle Brook, a tributary of the Blackstone. What pollution is caused to this brook is due chiefly to the manufacturing establishments noted below.

Mannville satinet mill; employs 40 operatives; does little scouring or dyeing; privies do not discharge into stream.

Kent's mill; manufactures satinets; employs about 30 operatives; no scouring or dyeing; privies discharge into stream.

Thayer's mill; manufactures cassimeres; employs from 70 to 100 operatives; a small amount of dye waste discharged; privies over the stream.

Smith's upper mill; manufactures skirtings; 30 operatives; privies over the stream.

Dickinson's mill; manufactures satinets; employs 19 operatives; privies over the stream.

Olney mill; manufactures white flannels; scours 300,000 or 400,000 lbs. of wool in the grease per year; waste discharges into the stream; privies for 80 operatives over the stream.

Smith's lower mill; manufactures skirtings; employs 60 operatives; privies over the stream; does the dyeing for Smith's upper mill, using about 150 lbs. of extract of logwood and 75 lbs. of blue vitriol per week; refuse goes into stream.

SECT. 85. *Sutton.* — This town is wholly within the Blackstone basin. Its population by the census of 1885 is 3,101. There is no likelihood of systems of water supply or sewerage being needed at any of the villages. Little pollution of the river is created at this town. What little there may be would be due to manufacturing establishments, the principal of which are given below.

On Cold Spring Brook are several shoddy mills and a satinet mill, but the pollution caused by them is too slight to require special notice.

Wilkinsonville cotton mill, on Blackstone River, manufactures prints and fancy dress goods, and employs from 175 to 200 operatives. The privies at the mill and at the tenements discharge into vaults, from which the contents are taken and used as a fertilizer. Considerable trouble has been experienced at the mill from the corrosion of the boiler tubes. Scales from $\frac{1}{8}$ to $\frac{1}{4}$ inch thick have been removed, which looked like dried wheel grease. In November, 1884, a well was sunk, water from which is used for the boilers alternately with that from the river, the supply from the well not being sufficient by itself. There has been no trouble from foaming here. The water from the river is conducted to this mill by a canal three-quarters of a mile long. This canal fills up rapidly and requires cleaning out. The substance removed is black and sticky, with a consistency like clay, though not so hard; eel grass grows very rapidly in it.

The Manchaug mill, on Mumford River, manufactures white cotton goods and employs about 650 operatives. The privies for about one-half the number discharge into the stream; those for the remainder and for the tenement houses are over vaults which are cleaned out from time to time. The waste water from three or four of the tenement houses is conveyed to the stream. The water of this river causes no corrosion or foaming of the boilers.

SECT. 86. *Blackstone.* — This town has no water supply or sewers, and the only noticeable pollution is that caused by the mills at the villages of Millville and Blackstone. All of these mills are upon the main river.

The Texas mill manufactures satinets; employs 50 operatives. A mill for manufacturing braids; employs 12 operatives. Privies from both discharge into stream.

Thayer's shoddy mill; 9 operatives; privies discharge into stream.

Wheelock's flock mill; 9 operatives; uses logwood dyes, and colors from 1,400 to 2,100 lbs. of material per day; refuse from dye vats and privies discharges into river.

Spring Brook mill has facilities for scouring and employs from 50 to 60 operatives when running, which it is not at present.

Lawrence felting mills; 150 operatives; privies discharge into river; use aniline and wood dyes, and color from 500 to 600 lbs. of stock per day; 10 or 12 carboys of muriatic acid and some oxalic acid are used. No trouble with boilers.

Woonsocket Rubber Company; employs 950 operatives; privies at the mill and wash from grinding rubber discharge into river; waste at tenement houses discharges into cesspools and vaults, which are occasionally cleaned. There has been much trouble with the boilers, owing to a hard scale forming on the tubes. Water for the boilers is obtained from a reservoir excavated in the mill yard. The bottom of the reservoir is lower than the bed of the river, and although partly fed by springs, also receives water from the river through a pipe. The pipes that convey steam and water for heating and cooling the rolls, corrode rapidly and have been replaced after two or three years' use. The company is now laying a pipe to take water from the pond above the mill, in hopes that it may cause less trouble.

Blackstone Manufacturing Company; manufactures white cotton goods and employs 800 operatives. Privies used by about half this number discharge into the river. Other privies at the mill and those at the tenement houses have vaults, whose contents are cleaned out and used as a fertilizer. Sink water from tenements discharges through pipes and stone drains into the river. There has been no trouble with the boilers.

Evans, Seagrave & Co. manufacture cassimeres and employ 225 operatives. They scour about 2,000 lbs. of wool in the grease per day. The waste from wool scouring and sewage from closets in the mill go into the river.

SECT. 87. *Paxton, Holden, Boylston and Mendon.*— Portions of these towns appertain to the Blackstone basin. Their areas are very sparsely settled, and afford nothing for consideration in connection with the present inquiry.

PART II.—METHODS OF SEWAGE DISPOSAL.

SECTION 88. *Preliminary.* — Sewage is dirty water. The water contains a variable small percentage of putrescible matter in suspension and another variable amount of similar matter in solution. As explained in sect. 2, a considerable portion of the water must finally flow into some natural water course or into the sea. All that human agency can accomplish is to guide the sewage by means of sewers as it flows, select the point or points for its discharge, or modify its character somewhat by treating it before it escapes. An account of methods of disposing of sewage is an account of methods by which it may be isolated and guided, and by which its character may be modified.

SECT. 89. *Sources of information.* — Information concerning methods of sewage disposal is gained by examining examples of the different methods as they exist in actual practice. Some information, but less complete and trustworthy, can be gained by reading reports and treatises on the subject. Detailed accounts of sewerage works built and operated, giving the results obtained, are valuable. There are many treatises on the subject, the later ones usually largely copied from the earlier, which treatises are less valuable because often not based on personal experience. The statements of mere theorists and of those pecuniarily interested in patent processes abound, but are to be accepted with great caution.

SECT. 90. *England the best place in which to gain information.* — Systems of sewerage are to be found in all civilized countries. In all of them the prevailing method of disposal is turning the crude sewage into the most accessible body of water. In England alone have other methods been much used; methods which aim to eliminate, more or less completely, the noxious elements from the water before permitting it to escape. Over two hundred examples of such methods of purification exist in England, and probably not much more than twenty in all other countries combined.

SECT. 91. *History of experiments and investigations in England concerning treatment of sewage.* — Up to about the middle of the present century, it was the universal custom in England, as in other countries, to turn crude sewage into the most accessible water courses. At about that time experiments were made in treating the sewage and purifying it more or less before permitting it to escape. The inducement to this course was mainly the prospect of mitigating the great nuisances caused by the discharge of crude sewage; but also a belief, which had become common, that the manurial elements might be saved and become a source of great profit. Companies, with large capital, were organized to carry this theory into practice, and hundreds of thousands of dollars were sunk in the attempt. At first efforts were made to extract solid portable manure from the sewage. It was easy enough to extract solid matter in great quantity, but it was found to have no manurial value; or if any, considerably less than the cost of extracting it. Hundreds of methods of making solid manure from sewage were invented, and not one of them has proved commercially profitable, nor by any of them has the sewage been so purified as to permit its being discharged into water courses without danger of causing a nuisance.

All idea of profit in this direction having been abandoned, a hope was entertained that the manurial elements in the sewage might be utilized by applying the whole of the sewage directly to the land. It was known by chemical analysis that each 100 gallons of average (English) town sewage contained about one cent's worth of manure, and it was believed that the soil would fix and retain this manure in condition to be taken up by vegetation. Experiment proved that growing plants would take up and assimilate sewage which reached their roots, but that, unless so intercepted, the manurial constituents of the sewage were not retained and stored up in the soil. By applying sewage to land the soil was not made more fertile, and the manure in the sewage could be utilized only by applying it directly to the plants. Unfortunately it was discovered that none of the commercially valuable vegetables would flourish when dosed with the great quantity of water in which the manure was dissolved. There is a limit to the size of farms which it is practicable to procure and prepare for the reception of sewage. To provide one acre for each one hundred persons contributing sewage, would require for a city of the size of Boston a farm as large as the whole town of Brookline. And even this large area would have to receive an amount of water equal to two and one-half times the annual rainfall in addition to the rain itself. Few crops, if any, would be benefited by such an amount of water, and it was found in practice that only a few coarse grasses and roots would grow readily under such conditions. The sewage comes in the night as well as in the day, requiring the services of an extra night gang to attend to it. It comes every day in the year, in rainy seasons when the crops are already suffering from too much water, as well as in dry weather when it is of service. It was found that farms which could be cultivated at a fair profit without sewage were operated at a loss when sewage was continuously applied to the land.

It was found, however, that the sewage could be purified by passing it through the land, and that by careful management some crops could be grown notwithstanding, whose value would partly offset the cost of distributing the sewage. Since the purification of the sewage, at whatever cost, was the main object to be attained, the fact that there is no profit in sewage farming has not prevented its being very commonly adopted.

The commercial failure of this method of treatment did not arise from any lack of scientific counsel and experiment. The subject was studied and reported on by many committees and commissions of experts. There has been a constant succession of such commissions appointed by the government. Thorough investigations and reports have also been made from time to time by experts appointed by the General Board of Health, the Metropolitan Board of Works, the British Association for the Advancement of Science, the Society of Arts, the Institution of Civil Engineers and the Royal Agricultural Society.

The conclusions at which all these different bodies arrived, and in which they all concurred, were about these: —

That it is imperatively necessary that sewage should be purified in some way before turning it into water courses;

That any method of doing this must be very expensive;

That purification by land is most efficient;

That under favorable conditions the land can be cultivated and will return something in abatement of the cost of purification.

SECT. 92. *Report of Royal Commission on Metropolitan Sewage Discharge.* — As has been stated, the report of one commission is very apt to be like those of all the others. One report, however, it may be useful to refer to here, because it is the latest one and therefore based on the largest experience, and also because of the peculiar fitness for the task of investigation of the members composing the commission, and the extreme thoroughness with which its work was done. This report is the second and final one of the Royal Commission on Metropolitan Sewage Discharge, and has been issued within the last year. At the head of the commission was Baron and Judge Bramwell; included in its membership were royal engineers, civil engineers, professors of chemistry and of medicine, all eminent in their respective professions.

The commission was issued to these gentlemen primarily that they should inquire into and report upon the pollution of the Thames River by London sewage, and upon the measures which could be applied to remedy said pollution. Incidental to this inquiry an investigation was made of all the existing methods of treating town sewage. To aid in this investigation the commissioners summoned and questioned twenty-seven of the leading scientists and sanitarians and engineers, including all the principal English experts in the matter of sewage disposal. The evidence thus adduced was weighed and compared, and the conclusions finally arrived at by the commission may be accepted as representing faithfully what is definitely known of the subject in England at the present time. Some brief quotations from the report will be useful: —

"... Although the most modern scientific knowledge and experience may be brought to bear on sewage disposal problems, their satisfactory solution is a matter of extreme difficulty." ...

"Having taken, *vivâ voce*, the opinions of the best living authorities, and compared them with the great mass of documentary information we have collected, we are compelled to express our regret at the obscurity in which, after so many years' study and discussion, and after the large experience that has been gained, the subject of the treatment of sewage appears to be involved." ...

"Looking now to the whole of the evidence we have obtained on the prospect of profit from the utilization of sewage, we are of opinion —

"That the most likely mode to obtain a profit from the utilization of sewage is by irrigation; but that, in the present state of knowledge of the subject, there is no hope of any town doing so consistently with the due attainment of the more important object, the purification of the sewage. In some very favourable cases (as in Edinburgh) a profit may be made without purification, and very frequently the purification may be effected without profit, but the two cannot, apparently, be combined." ...

"On the whole, therefore, with regard to broad irrigation, we are of opinion —

"1. That, generally speaking, it offers a satisfactory mode of disposal of town sewage, where circumstances admit of its application.

"2. That it offers the most likely means of realizing some portion of the value of the sewage.

"3. That when properly arranged and carefully conducted, the effluent will be effectually purified, but that under careless management the purification may be incomplete.

"4. That it need cause no danger to health.

"5. That with proper care, when applied on a moderate scale, it need cause no serious nuisance to the surrounding neighborhood, but that if improperly managed nuisance may arise, and may become considerable." ...

"With regard to filtration through land, we are of opinion —

"That the process has great scientific merit, and offers valuable practical advantages for the disposal of sewage in situations where broad irrigation is impracticable, and where land suitable for filtration can be obtained." ...

". . . No one denies that by chemical precipitation the *suspended* matters may be almost entirely removed, or in other words, the sewage may be practically clarified. . . . And as it is also admitted that the suspended matters are the worst cause of pollution and nuisance, it follows that the clarification must effect a great improvement. . . . All agree that with this mode of treatment a considerable amount of polluting matter must be left in the effluent." . . .

SECT. 93. *English law concerning pollution of streams, and its effect.* — The present law in England in regard to pollution is the Rivers Pollution Prevention Act, 1876. It is divided under four heads and deals with as many sources of pollution.

1. The law forbids the putting of any solid refuse matter whatever into water courses, or upon their banks in such manner as to interfere with the flow of the water. In case of violation of the law in this respect any person aggrieved may institute proceedings against the offender. This part of the law seems to be very generally enforced, and English streams are comparatively free from the dead animals, tinware, old boots and dumps of ashes and garbage which may be seen in and about most of the streams in Massachusetts. As there is not the least necessity for such disposal of refuse, the law prohibiting it seems to be a just and salutary one.

2. The law also prohibits the putting of sewage into streams unless the sewage has first been purified by the best practicable and available means. The law distinguishes between sewage from sewers already built and that from those built after the law went into effect. In the latter case it requires that the sewage shall be entirely purified. But as it never can be purified more thoroughly than by the best practicable means, the distinction seems to have little force in practice. As before, any person aggrieved may prosecute for violations of the law under this head.

As a result of this and previous laws, about 200 towns purify their sewage by different methods of greater or less effectiveness. In some cases the sewage is purified completely, or very nearly so; in others it is not even clarified. In fully 200 more cases, towns still turn crude sewage into streams without any attempt at complying with the law.

They can be compelled to purify their sewage, however, and they themselves expect to do so sooner or later. On the average, about one town a week, either voluntarily or by compulsion, adopts some mode of purifying its sewage, and there is no doubt that it is only a question of time when all of them will do so.

As before stated, the sewage often is not completely purified. This is not because it is *impossible* to do so, since it is always possible to purify sewage by means of land filtration. But sometimes the expense of procuring and preparing a sufficient area of land for the purpose, and of conveying the sewage to it, would be so excessive as to be thought impracticable. The constant effort is to combine efficiency with economy, and to an onlooker the attempt usually seems hopeless. It is quite common to find towns which have tried four or five methods of treatment in turn and found none of them satisfactory. The less effective methods have subjected them to lawsuits and injunctions and the better ones have been thought to be too costly.

The effect of this portion of the law has been greatly to improve the condition of many rivers and streams, and to abate nuisances which were probably injurious to health.

3. The law also forbids the discharge into water courses of any polluting liquids or refuse from manufactories. Proceedings against violators of the law under this head cannot be instituted by individuals, but must be made by the sanitary authorities where the violation occurs. The local authorities also can take no action in any case unless authorized to do so by the Local Government Board at London, which is the national authority. Moreover, the Local Government Board, in giving or withholding its consent to action being taken, must consider whether means of purification are reasonably available, having regard to the industrial interests involved in the case and to the circumstances and requirements of the locality.

It will be noticed that the manufacturers are carefully guarded against vexatious interference. In fact, the law, in so far as it affects pollution from manufacturing refuse, is practically inoperative. After considerable inquiry I failed to learn of a single case in which such pollution had been stopped by proceedings under the law. Where manufacturing establishments are able to discharge their foul liquids into town sewers, as they are in England more frequently than in this country, the town can be obliged to purify such liquids with the rest of its sewage; but where a factory stands by itself, remote from sewers, it is usually suffered to discharge its liquid refuse into any stream with impunity. Some of the rivers in manufacturing districts, notably in Yorkshire, are, without exaggeration, as black as ink. It is to be noted in this connection that most kinds of manufacturing refuse, although they make the water in a stream very unsightly, do not often cause it to stink badly as town sewage does.

4. The law also forbids the discharge into streams of polluting liquids from mines; but as this source of pollution is not of importance in Massachusetts it need not be considered here.

In concluding this section it may be said: —

That in England the streams are kept tolerably free from solid refuse, and also are, or soon will be, guarded against the most obnoxious and dangerous kind of pollution, that caused by domestic sewage.

That nothing has been accomplished towards lessening the pollution due to manufacturing, except indirectly where factories drain into town sewers.

It may be added that a new law, with more stringent provisions against the pollution of streams, has been introduced into Parliament.

SECT. 94. *Turning crude sewage into water.* — Until recently this method of disposal was universally adopted, and it is still the common one everywhere except in England. Its merits can be ascertained by observing how it has worked in a large number of cases, under different conditions.

Sewage is water containing putrescible matter in solution, and also solid putrescible particles in suspension. The solid particles are kept in suspension by the motion of the water flowing in the sewers. If the sewage is emptied into a current of water moving at the rate of about a mile an hour, or faster, most of the solid particles will remain in suspension until they reach places where the water is comparatively still, when they gradually settle to the bottom, the heaviest particles sinking first. If the particles as they settle are widely scattered over a very large area, their putrescible constituents will soon be oxidized * so that they will not create any nuisance. But if the particles settle in masses, the lower ones, being kept from contact with the oxygen in the water, will decompose slowly, giving off offensive gases.

Sewage water mixes readily with the clean water into which it is discharged, and the organic matter *in solution* is thereby diluted. If the dilution is very great, say twenty-fold or more, no subsequent putrefaction is noticed, and the organic matter is oxidized by the oxygen in the water with which it is diluted.

Two conditions are necessary, therefore, to insure that crude sewage when put into water shall not cause a nuisance: first, there must always be enough water to dilute very greatly the matter in solution, and second, there must be a constant current which shall carry away and widely disperse all of the suspended particles.

It is more rarely than might be supposed that these two conditions are found to exist. A stream may usually have amply enough water to dilute a sewage discharge, but during occasional droughts it may prove to be insufficient. The current of a river may be generally sufficiently rapid but have places where there is slack water, or eddies in which suspended particles deposit. A portion of the sewage is apt to work into the edges of a current, or near the shore where there is little motion.

A few examples of this method of disposal may be cited as illustrations.

Boston's sewage was formerly discharged on its shores and at the heads of docks, where the dilution was considerable, but where there was seldom any decided current to disperse the solid particles. These settled in masses and caused serious nuisances. At present the whole sewage of the city is discharged into a good current in the harbor. Nearly all of it is diluted and dispersed so that it is practically annihilated; but a little which gets into an eddy on the edge of the current near the shore causes a minor nuisance.

* The term "oxidize" is used for the sake of simplicity. In fact, the process is thought to be somewhat complex and to depend upon bacterial fermentation.

Providence sewage is discharged into water where there is little current, and a serious nuisance has been created. Worcester sewage is insufficiently diluted, and pollutes Blackstone River badly. Part of the sewage of Lawrence goes into Spicket River, where there is little water, and a great nuisance results. The bulk of the sewage goes into the Merrimac, where there is plenty of water and a good current, and no nuisance is caused by it. Philadelphia sewage is insufficiently diluted and pollutes the Schuylkill. Chicago River has little or no current, and is terribly polluted by the sewage it receives. Sewage at Buffalo is discharged into the midst of a good current and is no more heard of. Sewers which discharge well out into the Mississippi River cause no trouble.

Even if crude sewage can be discharged into water without causing any nuisance, it does not follow that it will be proper or safe to put it there if the water is used afterwards for domestic purposes. Not much is definitely known about the specific thing or things which may exist in sewage and may cause disease, or by what extent of dilution and exposure in water they may be destroyed. But after making all due abatement for exaggerated statements and unverified hypotheses concerning disease germs, enough remains which has been proven to show that drinking water should never be at all contaminated by human excrement.

When sewage can properly be emptied into water, such method of disposal is generally found to be the cheapest which can be adopted. This is evident, because the permanent structures and work required to carry out this method usually will not be more extensive than those needed for other methods, and the expense of treating the sewage will be avoided.

SECT. 95. *Sedimentation and coarse filtration.* — As stated in the preceding section, there are two distinct elements in sewage. Of these, the particles in suspension usually cause the most offence. There are many cases where, if these particles could be eliminated, the rest of the sewage, containing only impure matter in solution, could be disposed of without making any nuisance. Such a case would occur where the sewage could be discharged into a body of comparatively still water large enough to dilute it sufficiently, but where any particles would be apt to settle and form banks of foul-smelling sludge.

Under such circumstances attempts have been made to remove the particles by allowing them to subside in settling tanks, or by passing the sewage through coarse filters made with brush, straw, gravel, coke, or similar substances.

Such methods have rarely, if ever, proved satisfactory. It is true that by simple subsidence in a settling tank a considerable part of the solid particles will be arrested; but it is almost impossible thus to eliminate the whole of them. Much of the suspended matter is so finely comminuted and so light that the least agitation of the water keeps it from subsiding; and in any case, it will be many hours before it finally settles to the bottom. In practice, it is found that enough of it escapes to make trouble, although it may be longer in doing so.

The same difficulty exists in the case of filtration. If the filters are coarse, much of the suspended matter passes through them; if they are fine enough to arrest the smaller particles, they quickly become clogged and inoperative.

There is no doubt that nuisances may be somewhat mitigated by such processes, but there are disadvantages which offset the slight benefits. The settling tanks and filters themselves are apt to be offensive. The semi-fluid sludge which is intercepted is difficult to dispose of. It contains about 90 per cent. of water, much of which must be drained or dried out of it before it can be handled. It is hard to find places to put it where it will not cause a nuisance. Usually it must be dug into the ground. It has so slight a manurial value that it is seldom, in winter hardly ever, that farmers can be found who will accept it as a gift and cart it away.

A good example of this process is to be found in Winchester, near the Upper Mystic Lake, where the Boston Water Board has been using it in treating the drainage from the tanneries which comes in the sewer emptying into the Lower Lake. This sewer caused a great nuisance. In the hope of abating it the Water Board pumps the sewage, amounting to about 400,000 gallons a day, passes it through settling tanks and thence through ditches about 1,000 feet long, across which are about a dozen coarse filters made of brushwood. Although much sludge is intercepted in the tanks and in the ditches, the effluent which flows into the lake does not look very different from the sewage when first pumped from the sewer. A considerable nuisance still continues in the lake and river below, although perhaps it may be less than it would be were no process of clarification carried on. The intercepted sludge is pumped into pits dug in the gravel and allowed to dry out. Some of it is then carted away, some of it dug into the ground and some has been burned, which is possible, owing to the bark contained in it. The yearly cost of these operations is about $6,000, and but little good result is obtained.

Such methods sometimes may prove useful as temporary expedients to mitigate nuisances, but they cannot be recommended as of general application.

SECT. 96. *Clarification by the use of precipitants.* — Although it is impracticable to extract the solid particles by simple subsidence or by the use of artificial filters, clarification can be accomplished by adding a precipitant to the sewage before it enters the settling tanks. This mode of treatment has been adopted by about fifty cities and towns in England. A great variety of precipitants have been used; the two most generally employed, and the least expensive, are lime and sulphate of alumina. The former of these is much the cheaper, and as the results obtained with it seem to be about as satisfactory as those where more expensive chemicals are used, it is generally employed for the purpose, either alone or in combination with a small quantity of other chemicals. To clarify ordinary town sewage, about one ton of lime is necessary for each million gallons of sewage. Ordinary quicklime, such as is used for building, is employed. A rich, fat lime is to be preferred. The lime is first slaked by adding to it an equal weight of water. It is then ground as fine as possible in a small pug-mill, a little water being added during this process. The paste is then mixed with more water, producing a cream of lime like ordinary whitewash. This is added to the sewage in a well in which are revolving paddles called agitators, by which the lime and sewage are thoroughly incorporated. Thence the sewage flows to settling tanks. Within a few minutes after the addition of the lime, a flocculent precipitate is seen to form throughout the body of the sewage and to sink rapidly to the bottom of the tank. If the tank after being filled is left at rest for half an hour, the precipitate will have all settled to the bottom, and the supernatant liquid can be drawn off entirely clear, with the exception of a little scum which may be floating on the surface. To carry out this process requires the use of a number of tanks, so that while some are filling, others may be at rest and still others emptying. One or more attendants are needed to divert the sewage from one tank to another and to open and close as required the valves connecting with them. To avoid the necessity of such supervision, a modification of the process is more commonly used. By this, the sewage, after the precipitant has been added to it, flows continuously through a series of tanks. These tanks are built so large that the sewage is several hours in passing through them, and its motion is so slow as to interfere but slightly with the subsidence of the precipitate, so that little if any of it flows off with the effluent. The tanks are so arranged that any one of them can be isolated for the removal of the sludge contained by it. In round numbers, about one ton of semi-fluid black mud will be precipitated from each 50,000 gallons of sewage of the average character found in American towns. This sludge contains about 90 per cent. of water and is somewhat difficult to dispose of. In some cases it is pumped on to porous land, where the water drains or evaporates out of it until it is hard enough to handle, when it is either dug into the ground or carted away. In other cases it is passed through presses of peculiar construction which reduce it to about one-fifth of its former bulk and leave it in the form of cakes containing about 50 per cent. of moisture and of the consistency of damp clay. The product in either case is almost valueless, and it is rarely that farmers are willing to carry it away.

As will be readily perceived from the foregoing brief description, sewage precipitation requires a somewhat expensive plant and force of workmen to carry it on properly. Often it is necessary to elevate the sewage by pumping. There must be buildings to contain the engines, boilers, grinding mills, agitators, presses, pumps and other machinery. Two sets of workmen are needed, one for the day and one for the night, and very intelligent supervision is requisite. As a rough approximation, the yearly cost of this process in England is about 37 cents per individual of the population whose sewage is treated. Owing to the higher cost of labor and materials in this country, the expense here would probably be double that in England. The daily wages of an ordinary laborer at the English sewage works rarely exceeds, if it reaches, 3*s.* per day, or about half what would be paid here. On this basis of computation, the expense to a city of 50,000 inhabitants treating its sewage by this method would be about $37,000 yearly.

Sewage is not purified by any process of precipitation. It is, indeed, only partly deodorized, and is of course not fit to go into any stream used as a source of water supply. As much more thorough purification, at less expense, can be obtained by filtration through land, a precipitating process could be recommended only where the effluent could be discharged into water not used as a source of water supply, and where it is impracticable to obtain suitable areas of land for its purification.

SECT. 97. *Purification by land.* — By applying sewage to land it can be purified both from its suspended impurities and from those in solution; and in the present state of sanitary science this is the only practicable way in which the latter purification can be effected. By this method the particles in suspension are removed by filtration and the soluble impurities are oxidized by being brought into contact with the air contained in the earth. As stated in section 95, it is impracticable to filter sewage thoroughly through artificial filters, because, if any such filter is fine enough to arrest the fine particles, these very soon clog its surface. An area of land when used for this purpose constitutes a very fine filter and retains the solid particles upon its surface. The reason the land filter is not clogged is because it is so large. In the case of the artificial filter, a ton of mud may accumulate upon 50 square feet of surface, whereas with the land

Plate II.

Sewage disposal at State Prison, Concord, Mass., 1884.

filter the same amount will be distributed over (say) 100,000 square feet.

After depositing its sediment, the sewage water slowly soaks into the ground. One-quarter part or more of the bulk of any porous earth consists of voids containing air. A part of the sewage water is evaporated from the soil, and the rest, as it sinks, spreads over every particle of earth in a thin film, and is thus brought in contact with the air contained in the ground. If 20,000 gallons of sewage filter evenly through an acre of land, where the ground water stands six feet below the surface, each gallon of sewage will be brought in contact with at least 25 times its bulk of air. The effect of this is to oxidize and change the organic impurities into harmless compounds, so that the effluent water, so far as can be determined by the senses and by chemical tests, is inoffensive and innocuous.

The essential requirement for this method of treatment, therefore, is a large area of porous land, in which the ground water stands at least six feet below the surface, either from natural causes, or on account of artificial drainage. The land must be reasonably flat, in order to avoid great expense in preparing it to receive the sewage; and if it is so low that the sewage will flow to it by gravitation, the expense of pumping will be avoided. A good example of this method of disposal, under favorable conditions, is to be found at the State Prison at Concord. The accompanying view (Plate II.) is from a photograph taken in 1884. The sewage, which, at the time the place was visited and for some months before, averaged 80,000 gallons per day, is collected in a tank within the prison yard. At this point it passes through screens which remove rags and any bulky objects. It is then pumped intermittently during the day into an iron pipe, which passes through the wall and empties into a rough V-shaped wooden trough, about 300 feet long, just outside the wall. From the joints in this trough the sewage drips in streams on to the land. The ground consists of a bank of gravel, with a flat surface, about 15 feet higher than the neighboring river. The whole extent of surface reached by the sewage does not exceed three-quarters of an acre. No nuisance is caused by the operation, and the only effect noticed is that grass on the area irrigated grows much more luxuriantly. The effluent doubtless reaches the river, but as there is no under drainage its course cannot be traced. A somewhat similar and equally satisfactory disposition of sewage is made at the Worcester Lunatic Hospital.

There are about 150 places in England where this method of disposal is employed. Owing to the great value of land in that country, which, when purchased for this purpose, generally costs from $500 to $1,500 per acre, areas used for sewage purification are commonly cultivated, in order to obtain some return partly to offset the cost of treatment. At all the sewage farms which I visited, this cultivation of the land seemed to interfere more or less with its use for purifying the sewage. An amount of water which is not too great for the land to purify effectually, if it were used only for this purpose, seems to be more than any crop will endure. Even Italian rye grass, which seems to stand water better than any other crop, is injured if sewage is applied to it continually, or at all within two weeks before it is cut. As such grass cannot be cured, but must be used as soon as cut, so that a market rarely can be found for any large quantity of it. Grains, which are grown to a considerable extent on nearly all the English farms, would be spoiled if irrigated at all; consequently the area available for sewage purification is lessened by the extent devoted to such crops. Root crops are benefited by a sparing and judicious irrigation, which ceases altogether in wet weather.

No doubt, when sewage is applied to land under cutivation, the part of it assimilated by vegetation is more effectually disposed of than it could be in any other way; but the land must be capable by itself of purifying the sewage in winter, when not aided by vegetation; and assimilation by plants is not, therefore, an essential part of this method of purification.

Sewage farms, as a whole, are rarely if ever profitable. There are times and seasons at which irrigation may be of great benefit to some crops; and if it need be applied to them only at such times, it would be very valuable. As stated in section 12, the market gardeners in Arlington, during certain days in the summer, find it profitable to buy water for irrigating their gardens, at the rate of $1\frac{1}{2}$ cents per 100 gallons. For the same purpose, sewage would be worth as much, or perhaps more. At Reading, England, 25 acres of the sewage farm are rented for £10 per acre, with the understanding that sewage is to be furnished to it only at such times and in such amounts as the farmer desires. The rent for the land without sewage would not be more than £2 or £3 per acre. At the Pullman sewage farm, in this country, about 10 acres of land are prepared to dispose of the sewage, which is applied to the rest of the farm only when it will be of benefit to the crops. This farm has made a profit of over $5,000 a year, not taking into account the expense of pumping, or interest on the cost of the land and its preparation.

What makes sewage farming as a rule unprofitable is, that the sewage must be disposed of at all times, when it does only harm, as well as when it does good. At nearly all of the English farms which I visited, the constant effort seemed to be to avoid applying the sewage to the land under cultivation. Many of them had some small waste tract on which the sewage was poured continuously in too great quantities to allow of purification. At one noted farm, on the day I visited it, the whole of the sewage arriving from the town was being turned into the river without touching the land, the condition of the crops at that time forbidding the application of sewage to them. On the occasions when I have visited Pullman, the sewage has been confined to the small filtration areas, and the purification has not been very thorough, not so much so as it would have been if the sewage had been applied to more land.

Since the cultivation of sewage filtration areas interferes with the primary object, which is the purification of the sewage, and, as a rule, is not profitable, there seems to be no good reason why it should be attempted. If it is proper to dedicate land to use as a park for the pleasure of the public, there is no reason why it may not be dedicated to sewage purification in order to preserve the public health.

The principal objection to cultivating filtration areas is that it interferes with the systematic intermittent application of the sewage to different parts of the land in turn, alternating regularly irrigation with periods of rest for renewed aeration; all of which is necessary for a constant, thorough purification of the sewage. Sewage utilization can be best accomplished when a filtration area is provided sufficient to dispose of the sewage at all times, and so situated with regard to neighboring farms that the sewage can be diverted to them for use at such times as it can be profitably used.

Land on which sewage is purified need not cause any nuisance. Earth is a good deodorizer, and prevents the particles which lodge upon its surface from becoming offensive. It would be too much to say that no smell at all would ever be noticed from such land. On muggy days, when odors from all sources are most noticed, a slight one will prevail over even a well-managed sewage farm. But there is no record of sickness being caused by this. At one sewage farm in England there are seventy children living in cottages entirely surrounded by the irrigated land. They are said to be in excellent health, and certainly looked so. Very little prejudice is now felt in England against the proximity of sewage farms, and such farms are frequently established in the immediate vicinity of thickly settled residential parts of towns. The accompanying plates (Nos. III, IV, V, VI, VII), are from photographs of English sewage farms, taken for the information of your commission in 1885. They show the proximity of the farms to the towns. It was said that in none of these cases did the farms cause any nuisance, and that the neighboring property was not depreciated in value.

Where the amount of sewage is trifling, and it must be disposed of on land so near dwellings that a nuisance is feared, or the sight of it would be objectionable, the sewage can be distributed to the land through a system of pipes laid just below the surface. This method is frequently used for disposing of the drainage on private estates, and an example of it also exists at the Woman's Prison at Sherborn.

Apprehensions are sometimes expressed that the severity of the winters in our State might interfere with land filtration at that season. No trouble has ever been experienced from this cause. Sewage is so warm that it keeps the earth to which it is applied from freezing, or thaws it if already

Plate III.

Luton, England. View at sewage filtration fields, 1885.

Plate IV.

South Norwood Irrigation Farm, Borough of Croydon, England, 1885. The field in foreground was under irrigation when photograph was taken.

Plate V.

Bedford, England View at sewage farm, 1885. Field beyond bushes is used for irrigation.

View at sewage farm, Wimbledon, England, 1885. A precipitation tank is in foreground. The fields beyond are occasionally used for filtration

Plate VII.

View at sewage filtration fields, Mitcham, England, 1885.

frozen. The winters at Pullman are colder than in most parts of Massachusetts, but irrigation has always proceeded there without interruption. I made a visit to that farm in February, 1885. For the five days previous the mercury had not risen to 0 Fahrenheit, and had been as low as —25. On the day of my visit, the mercury standing at —12, I found the sewage going on to the land, and covered by a stratum of ice from one to eight inches thick. I broke the ice, and with a spade dug a hole in the ground below, which was perfectly open. As the weather moderated the sewage rapidly melted the ice above it.

Where nothing but clay or other non-porous land, through which sewage will not filter, can be obtained, a different method of land purification must be adopted. It is found that if sewage flows slowly, in a thin film, over the surface of large areas of land, it is thereby purified. The particles in suspension are left upon the land, and the organic matter in solution is oxidized by being exposed for a long time to the action of the atmosphere. To be pretty thoroughly purified, it is necessary that the sewage should flow thus for a long distance, (say) about 1,500 feet, and comparatively small quantities of sewage must be applied to the irrigation areas. The land must, naturally or by artificial grading, have a gentle slope of 1 in 200 to 500. The best example of this mode of treatment is to be found in Croydon, England. At this place about 3,000,000 gallons of sewage daily are purified upon about 450 acres of land. The sewage is applied to any given tract for three days consecutively, after which that tract receives no sewage for about three weeks.

It would be impossible, in so brief an account, to give details as to laying out and managing sewage filtration areas. For any given case these would have to be designed by an expert, having regard to the local conditions of the place.

SECT. 98. *Treatment with dry earth.* — This cannot be called a method of disposing of sewage, but only of one of the constituents of sewage; namely, human excrement. As this is generally considered the most dangerous element, and cases may occur where, if it could be eliminated, the rest of the sewage could be disposed of satisfactorily, the method is worth referring to here.

If a fecal discharge be surrounded with one and one-half pounds (equal to one and one-half pints) of dry earth, it is at once deodorized and rendered harmless, and will so remain indefinitely. In the course of a few weeks it will disappear, and apparently nothing will remain but the earth, in the same condition as it was before use. An equal amount of dry earth will also soak up and deodorize an ordinary single evacuation of urine, and, so far as subsequent putrefaction or any other ill effect is concerned, will entirely destroy it.

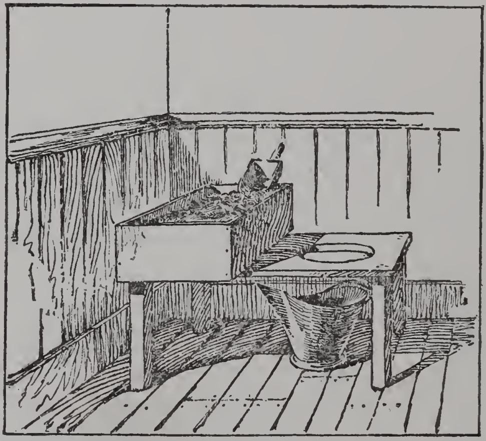


Fig. 2.

The resulting products, which resemble nothing but the earth, are entirely harmless. They can be kept in a sleeping room with perfect safety and without the slightest offence. The earth can even be re-dried and used several times in succession, or it may be applied to land as a manure. Any loamy or clayey earth (but not sand) will do, provided it is thoroughly dried and sifted. Sifted ashes also answer very well, but a double quantity of them must be used.

All the appliances necessary to the possession of a perfect sanitary contrivance for disposing of excrement, are: a seat; a coal hod to receive the earth and excrement; a box of dry earth, and a scoop to distribute it with. More elaborate apparatus can be bought, which distributes the right amount of earth when a handle is pulled, or automatically on arising from the seat. The system is perfectly simple in its operation, and only requires reasonable care on the part of the user. Unfortunately reasonable care cannot be expected from the generality of persons, and while a neglected water-closet is bad enough, a neglected earth closet is still worse. I have used one of these contrivances for months with entire success. At the same time another one used by my employés was an offensive nuisance, because continually neglected. The system has great merit, and there are many cases where it could be adopted with advantage, especially as a substitute for privy vaults.

There are certain minor objections to the system, such as difficulty in procuring and handling the requisite amount of earth; but what prevents it from being of universal application is that it does not at all solve the problem of the proper disposal of sewage. The waste water supply of a town, even without excrement, is still noxious sewage and must be disposed of as such. Indeed, chemical analysis fails to detect any marked difference between the sewage of towns having water closets and of those where such matters are not admitted to the sewers. The town of Bradford, England, has dry ash closets for a large part of the dwellings, but its sewage is as foul and its purification works as elaborate as those in towns where water closets are more commonly used.

SECT. 99. *Separation of sewage from rainfall.* — In most towns, besides the necessity for removing sewage proper, that is, the contaminated water supply, there also exists the need of removing promptly the rainfall, which otherwise may flood streets and yards and cause various kinds of damage. Usually the removal of both sewage and rainfall is accomplished by admitting them both to the same system of sewers and discharging both at the same outlets. Indeed, until near the middle of the present century sewers were chiefly built in order to facilitate the removal of rain water, and it was comparatively recently that people were permitted to turn sewage proper into them. The quantity of rain water falling on any district during a heavy storm may be fifty or more times greater than the sewage furnished by the district in the same time; so that a sewer designed for carrying the rain can take the sewage also without increase in size.

So long as it was considered sufficient to put sewage as well as rain into streams or bodies of water, this double use of the sewers was proper and economical. When, however, it was thought necessary to purify the sewage by treating it in various ways before permitting it to escape, it was found that such operations were rendered very difficult when the sewage, owing to the presence of rain water, varied greatly both in amount and character. It is a comparatively simple matter to design works to purify a regular daily quantity of (say) one million gallons of sewage of nearly uniform quality. It would be almost impossible to design works to handle and purify sewage liable to vary in quantity from one to fifty million gallons, and also to vary greatly in its chemical constituents. For this reason the proposition is generally accepted at present, that wherever sewage must be purified by any mode of treatment, it should be kept separate from the rainfall and conveyed in sewers which are used for no other purpose. In such cases, when it is also necessary to remove the rainfall by means of sewers, a distinct system of such structures, devoted to that purpose only, must be built. Such a double system of sewerage has both advantages and disadvantages. The sewers for sewage only can be very small, and will cost only about two-fifths as much as do those designed for carrying rain, or say from $6,000 to $8,000 per mile. In some places, where the removal of rain is not a pressing necessity, and the cost of a large system of sewers would preclude its construction, small sewers for removing the noxious sewage proper can sometimes be built for a sum within the means of the town. When the system for removing rain must be co-extensive with that for removing the sewage, the cost of the double system will be about two-fifths greater than that of a single one. Usually, however, the rain water system need not be so extensive as the other, and the rain can be discharged at less distant outlets into brooks traversing the town, where it would not do to put sewage. The first portion of a rainfall, which washes yards and streets, becomes very dirty; but the filth contained by it is not considered so dangerous as ordinary sewage, nor, coming as it does only occasionally, is it so liable to cause nuisances. Notwithstanding any disadvantages, the necessity for keeping the sewage by itself, whenever it is to be treated in any way, is so apparent that it may be laid down as a rule that it should be done where practicable.

SECT. 100. *Considerations affecting choice of methods in Massachusetts.* — Almost all the examples of sewage treatment on which the foregoing statements are based, occur in England. The conditions, climatic and other, existing in Massachusetts are somewhat different from those in England. How far this difference of conditions might affect the choice of methods of disposal here, can only be definitely learned by experiment. A few surmises, however, on this point may be useful.

As regards turning crude sewage into water, it may be said that as a rule the streams in Massachusetts are larger than those in England and the populations about them are much less dense; consequently turning crude sewage into streams would generally cause less pollution here than there. On the other hand, England does not suffer from the prolonged summer droughts which we habitually experience; droughts which often reduce fair-sized streams to mere threads, and expose a large portion of their beds to the influence of the sun. On this account a degree of pollution which, in the case of an English stream might not cause offence, in this country might cause at times a dangerous nuisance. No differences of conditions occur to me which would affect discharging into the sea.

As regards clarification by chemicals, I think it may be stated as a fact that when such processes are resorted to in England, it is usually in order to avoid great expense and difficulty which would be entailed in securing land for purification by filtration. Such difficulties would seldom be encountered here. The chief items of the expense of chemical treatment are, interest on cost of plant, and cost of chemicals and labor. Buildings and machinery are much less expensive there than here; so, also, are the chemicals commonly used in treating sewage. At some of the English works, from 10*s*. to 15*s*. per ton is paid for lime, equal to from $2.40 to $3.60; in this country from two to three times as much would be paid. Common labor at the English works averages from 2*s*. 8*d*. to 3*s*. per day, or from 64 to 72 cents; here it would probably be about $1.50. Whether any serious trouble would be caused by the cold of our winters, which exceeds in severity anything ever experieneed in England, can only be told by experiment. Owing to the warmth of the sewage, not much ice could form in the settling basins within the three or four hours occupied by the sewage in passing through them, and it would seem as though there ought not to be much difficulty on this account. As the demand for artificial fertilizers is much less here than in England, the possibility of finding farmers willing to take the sludge would be even more remote in this State. As a whole, the conditions here seem to be less favorable to adopting this method of disposal than in England.

As regards disposal on land, England possesses one advantage, in that a large part of its surface is flat or gently rolling, so that usually it is possible to find level areas near to towns. The surface of Massachusetts is so broken that sometimes not even 10 acres of fairly level land, in one lot, can be found within several miles of the town. This would tend to restrict the number of acres which could be used in any given case, and add to the expense of preparing the land by grading. It would also favor the adoption of methods of filtration, applying large quantities of sewage to small areas, rather than broad irrigation, for which large areas are necessary and very little sewage is applied to each acre. The first cost of adopting this method of disposal consists largely in the purchase of the land. In this we have a great advantage. The English sewage farms usually cost from $500 to $1,500 per acre, whereas here land can generally be procured for one-tenth as much. As a whole, the conditions affecting disposal on land are more favorable in Massachusetts than in England.

There is less inducement here to cultivate the areas on which the sewage is disposed of. To an American travelling through it, England looks like one great farm or garden. The rent of land is so high, and the food producing area so small in proportion to population, that every available square foot seems to be cultivated. Moreover, the winter season, during which all vegetation is dead, lasts only for a month or two, and not half the year as with us. On the other hand, during our long summer droughts, when the ground is parched, irrigation would be more needed by the land, and would prove more valuable than it ever is in England. On the whole, it is probable that there would be less inducement to cultivate land used for purification, and more to arrange the works in such a manner that the sewage could be utilized for short periods in summer when it is needed.

SECT. 101. *Conclusions.* — The proper disposal of sewage is always a difficult and expensive matter.

The least expensive method is to turn crude sewage into water; but this should not be permitted if the water is liable to be used for domestic purposes. In any event, there must be at all times enough water to dilute the sewage twenty-fold or more, and a current which will carry all of the suspended particles to a distance and distribute them widely.

It has not been found practicable thoroughly to clarify sewage by passing it through settling tanks or artificial filters.

Sewage may be clarified by chemical precipitation, but will not by such means be rendered fit to go into water used for domestic purposes, or into any water course where it will not be always greatly diluted. Such treatment could be recommended only where land purification was impracticable.

The only practicable method yet discovered of purifying sewage is by its intermittent application to large areas of land. The purification will be more effectually and more easily accomplished when the land is devoted solely to this purpose.

Excrement may be satisfactorily disposed of by the application of dry earth to it. This treatment may often prove useful, but is not of general application, and affects but slightly the question of sewage disposal.

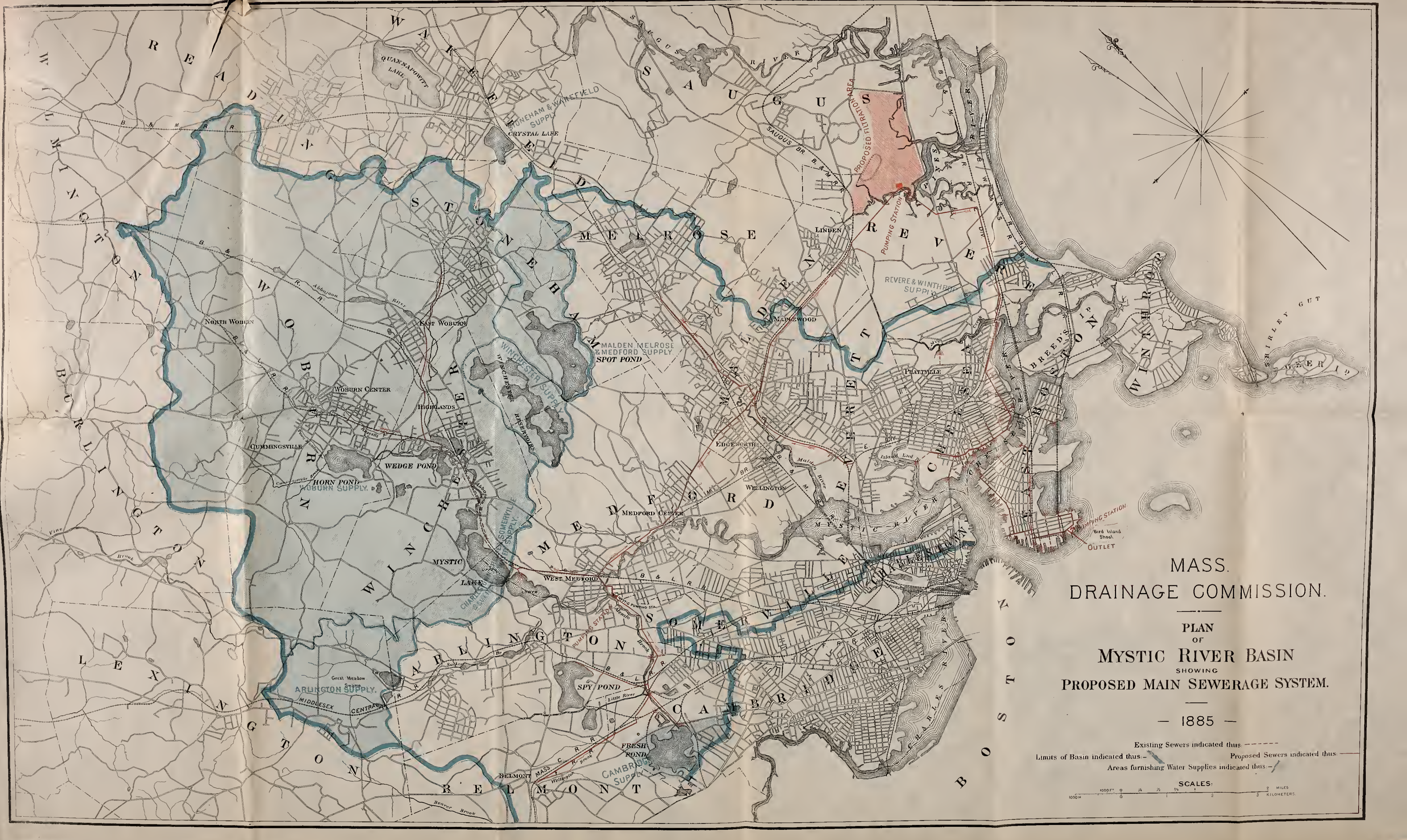
Where sewage is to be treated in any way, it is better to keep it separate from the rainfall in a distinct system of sewers.

PART III.—SYSTEMS OF SEWAGE DISPOSAL RECOMMENDED.

The Mystic Valley System.

Section 102. *General considerations.*—The investigations of the needs of the towns in the Mystic River basin in respect to sewerage as recorded in Part I, § 4–20 inclusive, show that in Stoneham, Woburn, Winchester, Medford, Cambridge, Somerville, Charlestown, Malden, Everett and East Boston, there is a present need of, and willingness to adopt, any practicable system or systems of sewerage, to remedy evils and nuisances caused by present methods of disposing of filth. Belmont, Arlington, Melrose and Revere do not yet realize any urgent necessity for building sewers, but will do so in the near future, should their population continue to increase in its present ratio. The method of disposal at Chelsea is not satisfactory, and will become less so in the future; so that a change in that city would be desirable, but hardly would be favored at present on account of expense.

Sect. 103. *Advantage of a united system for the Mystic Valley.*—In the consideration of the physical conditions affecting these towns, in Part I, it was shown that it would be difficult, if not impossible, to find places near to centres of population where sewage could be discharged with any reasonable assurance that it would not cause a nuisance The great length of sewer which would be required to reach any practicable distant point for discharge, would preclude the adoption of such a method of disposal for each town by itself. As the discharging capacity of a sewer increases very rapidly with its size, whereas the corresponding increase in cost is comparatively slight, it


MASS.
DRAINAGE COMMISSION.
PLAN
OF
MYSTIC RIVER BASIN
SHOWING
PROPOSED MAIN SEWERAGE SYSTEM.
— 1885 —
Existing Sewers indicated thus
Limits of Basin indicated thus
Proposed Sewers indicated thus
Areas furnishing Water Supplies indicated thus
SCALES
MILES
KILOMETERS
WILMINGTON
READING
WAKEFIELD
SAUGUS
SAUGUS RIVER
QUANNAPOWITT LAKE
STONEHAM & WAKEFIELD SUPPLY
CRYSTAL LAKE
PROPOSED FILTRATION AREA
PUMPING STATION
STONEHAM
MELROSE
LINDEN
REVERE
REVERE & WINTHROP SUPPLY
WINTHROP
SHIRLEY GUT
DEER ID
BREED'S ID
WOBURN
NORTH WOBURN
EAST WOBURN
WOBURN CENTER
HIGHLANDS
CUMMINGSVILLE
HORN POND
WOBURN SUPPLY
WEDGE POND
WINCHESTER
WINCHESTER SUPPLY
WINCHESTER RESERVOIRS
MALDEN MELROSE & MEDFORD SUPPLY
SPOT POND
MALDEN
MAPLEWOOD
EVERETT
PRATTVILLE
CHELSEA
EAST BOSTON
EDGEWORTH
WELLINGTON
MEDFORD
MEDFORD CENTER
MYSTIC RIVER
MYSTIC LAKE
SOMERVILLE SUPPLY
WEST MEDFORD
CHARLESTOWN
PUMPING STATION
Bird Island Shoal
OUTLET
BURLINGTON
LEXINGTON
ARLINGTON
ARLINGTON SUPPLY
Great Meadow
MIDDLESEX CENTRAL
SPY POND
Little River
SOMERVILLE
CAMBRIDGE
FRESH POND
CAMBRIDGE SUPPLY
BELMONT
BOSTON
CHARLES RIVER
Beaver Brook

evidently would be much cheaper for the towns to combine and build a single conduit to convey the sewage from all of them to a proper place of disposal. Such a sewer or system of sewers, if built at present, should be designed to take at once the sewage from the towns having present need of sewerage, and should be adapted to receiving later, branches from such places as may desire to connect with it hereafter. The sewers and other works should be proportioned not only with reference to present population, but also with reference to any prospective increase within a reasonable period of time, say for instance fifty years. The limit to be observed in this respect is a matter of judgment. It would be false economy to build works which might prove insufficient and need to be replaced in the near future; on the other hand, it would be extravagant to build sewers vastly larger than required for present needs to serve populations which, if they should exist in the remote future, would be better able to bear the expense of new and enlarged systems.

SECT. 104. *Disposition of the sewage.* — The first question to be considered in designing such a system is, to what place the sewage shall be carried, and what disposition shall be made of it. It must be put somewhere where it can do no harm. As has been shown in Part II, there are but three practicable methods of disposing of it:

First, it may be turned in a crude state into water;

Second, it may be clarified by precipitating processes before going into water;

Third, it may be purified on large areas of land.

SECT. 105. *Practicability of turning the crude sewage into water.* — The consideration of this method of disposal (§ 94) showed that where practicable it generally would prove to be the cheapest one, but that it only would be effectual where the sewage could be discharged into a large body of water and into a current which would be sure always to carry all the suspended particles to a distance and distribute them widely. That such conditions do not exist within the river itself or its tributaries, is shown by the fact that they are already polluted in part by the slight amount of sewage which they receive. Should the population within the

Mystic Valley increase to 300,000 or 400,000, the daily quantity of sewage will amount to 25,000,000 gallons or more. It is evident, therefore, that a body of water sufficient to dilute the sewage, can be reached only by carrying the outfall into the sea. It is necessary therefore to search for an outlet in the vicinity of Boston Harbor near the mouth of Mystic River.

The accompanying cut (Fig. 3) is intended to show the principal ebb currents existing in the harbor between Hull

Fig. 3.

and Nahant. It will be seen that there are only two such which could be reached by a sewer following the Mystic Valley. One of these passes through Shirley Gut, between the mainland and Deer Island. The other, starting from the confluence of Charles and Mystic Rivers, follows the main ship channel and passing to the southward of Deer Island enters Broad Sound. The former of these currents has been suggested as a practicable place for the discharge of sewage, by the State Commission appointed in 1875, and again by that appointed in 1881. Examinations of the physical characteristics of this current have been made during the past year. It was ascertained that although the velocity of flow is very great immediately within the Gut, yet a short distance outside that point, as the current widens, its motion becomes very slight. Moreover, what slight current exists tends to skirt the shores of the mainland for about a mile, and then turning is lost in slack water to the northeast of Deer Island. Should any considerable quantity of sewage be discharged at Shirley Gut, even if such discharge were restricted to the first few hours of ebb tide, there is great probability that the particles in suspension would be deposited upon the Winthrop shore and back of Deer Island in sufficient quantities to cause a serious nuisance.

The other current, which traverses the main ship channel, could be conveniently reached only from East Boston or from the end of Deer Island. The former point is too near densely populated districts to make it a suitable place at which to discharge great quantities of sewage. A small amount of sewage, as for instance that from East Boston alone, probably would be sufficiently diluted and distributed to insure its not causing trouble; but if 25,000,000 gallons were put there, it would be a source of offence to the shipping in the harbor, and a portion of it doubtless would find its way out of the current on to the flats about East Boston and South Boston. Moreover, a storage reservoir at East Boston would be very objectionable, and it would be impossible to discharge the sewage continuously, since during flood tide it would be carried up into the Charles and Mystic Rivers. The only practicable point of discharge into this current, therefore, is at the end of Deer Island. The current is about 1,800 feet distant from the island, and an outlet sewer of this length would have to be built from the land. It could be located on a bar which extends out to the edge of the current. It would be necessary to discharge the sewage only during ebb tide, since the flood current spreads out laterally, and would be apt to cause deposits of sludge upon the flats within the harbor. A storage reservoir upon Deer Island therefore would be necessary. The ebb current loses much of its force after passing the island, and spreads out considerably. It is possible that some deposits might occur in the slack water northeast of the island, but it is not probable that serious nuisances would result. The chief objection to this scheme is its great cost. Since the sewage stored in the reservoir on the island during the whole of flood tide and the latter part of ebb tide, would have to be emptied in about an hour during the early part of ebb tide, the conduit through which it must flow from the reservoir to the outlet necessarily would be a very large one, say not less than 12 feet in diameter. This structure would be exposed to the full force of an easterly gale, and to prevent its destruction a pier one third of a mile long, protected on its sea side by a massive wall of cut stone masonry, would be needed. Such a pier hardly could be built for less than $500,000. The reservoir and its appurtenances at the end of the island might cost $300,000 more. The United States government has for some time had under consideration the construction of fortifications at the end of Deer Island, to form the principal defence of Boston harbor. It is possible that the location of a sewage reservoir in the immediate vicinity of such works would be objected to. In case of war, such a reservoir and outlet would be exposed to destruction. The chance of any such contingency is perhaps slight, but it is a slight chance of a somewhat serious danger.

In any system built for the Mystic Valley, the sewers before reaching the sea coast would fall to depths considerably below low tide level; and in order that the sewage might be stored in a reservoir, and turned into the sea shortly after the time of high tide, it would have to be elevated considerably by pumping. If the pump wells were located near the sea coast, the sewers before reaching them would be about 20 feet below low water, and on account of the depth of excavation and the difficulty of controlling the amount of water which would be found in trenches of such depth, the work would be very expensive. To avoid such expense, the previous commissions, in devising systems of sewerage for the Mystic Valley, recommended that the pumping station should be located at the westerly extremity of Breed's Island, and from that place to Point Shirley the sewer should be so elevated that the sewage could flow by gravitation to the reservoir, which itself should be high enough to be emptied at the time of high water. Such an arrangement would be cheaper, provided the sewer beyond the pumping station could be built on firm ground. In this case, however, the location for part of the distance would be across marshes where the surface mud is from 10 to 20 or more feet deep, affording no foundation for the support of a masonry structure. A foundation on piles would be possible, but the tops of the piles would have to be cut off little

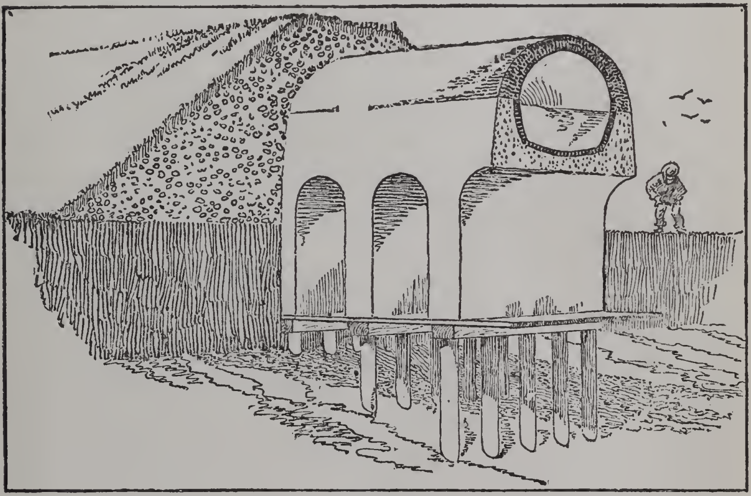


Fig. 4.

above mean tide level, to prevent decay. The intervening space between the tops of the piles and the bottom of the sewer might be filled with arches of masonry. To protect the sewer from frost, an earth embankment around and above it would be needed. Some such method of construction would be necessary as is shown in the accompanying cut (Fig. 4.) It will be seen that, built under such conditions, the sewer would be very expensive, and would cost at least $100 per foot.

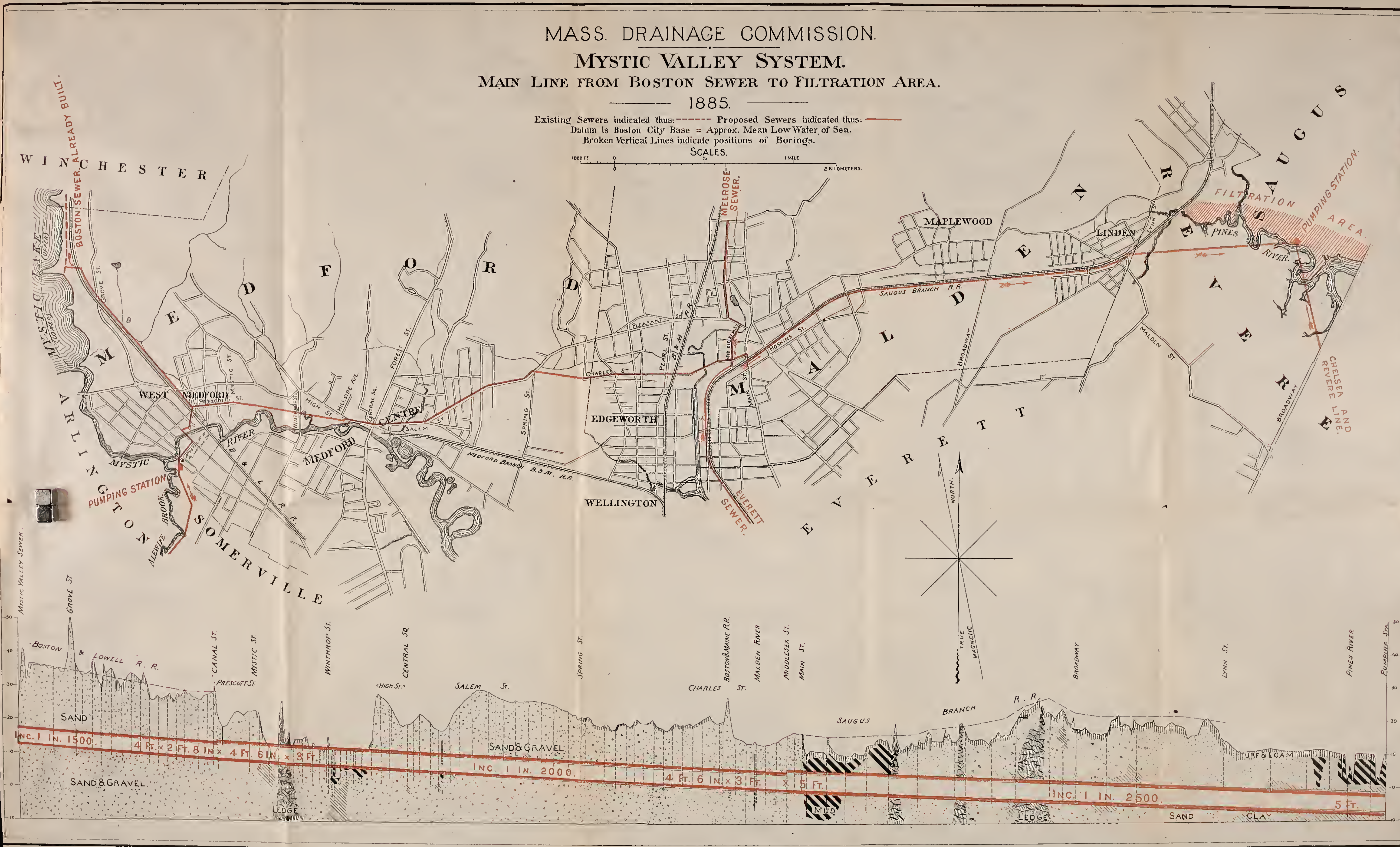
Probably a cheaper method of construction would be to have the sewer beyond the pumping station consist of one or more lines of cast iron pipe, through which the sewage could be forced under pressure. As the distance is about five miles, the friction when pumping at the maximum rate would be great, and it would be necessary either to have very large pipes or very powerful engines with large consumption of fuel, which would add to the yearly cost of maintenance.

In conclusion, it may be said of this scheme that it is practicable, and that by it the sewage could be disposed of, although there is a possibility that some slight nuisances might be caused by deposits in the neighborhood of Deer Island; that it would be a very expensive system to build; and that approximate estimates show that it would cost at least twice as much as the scheme hereafter recommended.

SECT. 106. *Practicability of adopting methods of clarification.* — If all of the solid particles were eliminated from the sewage, the clarified effluent doubtless could be turned into the sea without causing any nuisance, or even could be discharged into the lower part of the river itself where the amount of water contained in it is large. By this method of disposal the building of a large storage reservoir, a pier extending into the sea, and four or five miles in length of large outfall sewer would be avoided. On the other hand, it would entail the expense of providing buildings, machinery, tanks and other plant necessary for carrying on a precipitating process, and also a yearly outlay for labor and chemicals needed. There would be produced every day from 100 to 400 tons (depending on population) of semi-fluid sludge, which would be valueless, and would be somewhat difficult to get rid of without causing a nuisance. Two hundred and fifty thousand dollars probably would cover the first cost of the plant. As explained in § 96, the probable yearly expense of treatment would amount to about 75 cents per head of population in the districts furnishing the sewage. As the present population in the Mystic Valley is 100,000 or more, the yearly expenditure on this account probably would amount to at least $75,000. Should the population increase to 400,000, the yearly expense would be about $300,000, which at present rates for municipal loans represents the interest on $8,000,000 to $10,000,000. Looking to the future, this method of disposal probably would be the most costly of any, and on that account it cannot be recommended.

SECT. 107. *Practicability of purification on land.* — This is the only remaining method of treatment, and the only one by which purification can be effected. To adopt it in this case, it would be necessary to use an area of land which eventually might amount to nearly 1,000 acres. The land must be porous, and must be underdrained so as to contain air to a depth of about six feet. It should be flat or gently sloping, should not be expensive to buy, should be somewhat remote from thickly populated districts, should be easily accessible from the lower part of the Mystic Valley, and its surface should not be so high as to entail great expense in pumping the sewage upon it. There is one, and but one, tract of land which fulfils these several conditions. It is the tract of meadow land lying to the westward of the Lynn turnpike in Saugus and Revere, in the vicinity of Pines River. The total area of this tract is more than 1,000 acres. Its surface is very flat, averaging about one foot above ordinary high tide level, or about eleven feet above low tide, the higher land being principally in Saugus. Some 25 borings made, and more than 100 holes dug with the spade, during the past year, over a portion of this tract including about 500 acres, show that the soil consists of moderately coarse sand, sometimes reaching the surface and sometimes overlaid by a layer of peat from a few inches to three feet in thickness. Ground water ordinarily stands about 4 feet below the surface, and can be lowered by drainage. The land is assessed at from $40 to $100 per acre, and there are very few houses within half a mile of it. With any probable increase of population and amount of sewage hereafter, a sufficient area could be obtained to effect purification by means of intermittent filtration. At the time of high water of spring tides, this land is overflowed by the sea. Low dikes, or tide gates at the turnpike, would be necessary to prevent this. The effluent would discharge a little below the level of mid tide; and while the sea was above this elevation it would be necessary to store the sewage in large tank sewers, or to raise it a few feet by pumping. The effluent would reach the sea through Pines River, and would be sufficiently pure to cause no nuisance to the summer hotel situated near the mouth of that estuary. To buy say 500 acres of this land, which would be sufficient for at least 25 years, should not cost over $50,000. To underdrain and otherwise prepare a portion of the tract for present needs, would cost about $125,000 more. As purification at this point is believed to be at once the cheapest and most effectual method of disposal in the case under consideration, it is recommended that it be adopted for the sewage of the Mystic Valley district.

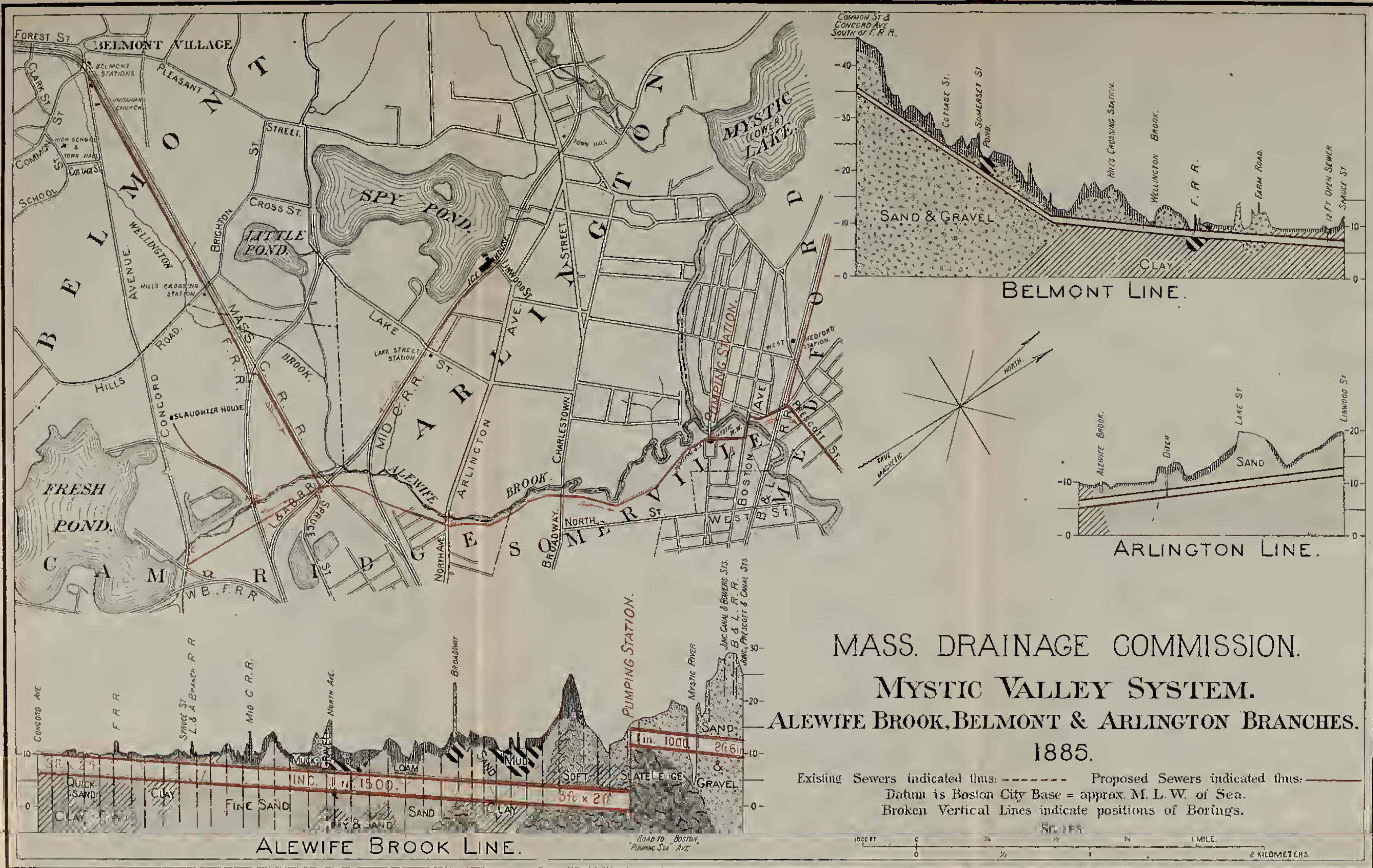
SECT. 108. *General design.* — In designing the sewerage system herein described for the Mystic Valley, no attempt has been made to indicate the arrangement of the local sewers to be built by each town for its own needs. To have done this in every case would have required an expenditure of much more time and money than was available for the purpose. Nor do I understand that this was expected from your commission. Such problems are comparatively simple, and their solution properly belongs to the local authorities. The difficulty experienced at each town has not been to devise a sewerage system for the town, but to find a proper place to put the sewage after it has been collected. It should be clearly understood that the system designed for your commission proposes only to do away with this one difficulty *by furnishing suitable inlets accessible to the thickly settled portion of each town into which the sewage collected by the local systems may empty, and from which the combined sewage from all of them shall be conveyed to a practicable place of disposal.* In doing this the topography of each town has been examined sufficiently to ascertain the point or points to which the sewage naturally would be brought, and which therefore must be reached by the intercepting sewers of the general system. In calculating the sizes of the intercepting sewers it has been assumed that each town not already provided with sewers will build a separate system, devoted solely to the removal of sewage proper, *i. e.*, the contaminated water supply. As nothing larger than pipe sewers will be needed for such systems, they can be built very cheaply, and the average cost of them should not much exceed $5,000 per mile. In the case of those cities which already have sewers


MASS. DRAINAGE COMMISSION.
MYSTIC VALLEY SYSTEM.
MAIN LINE FROM BOSTON SEWER TO FILTRATION AREA.
1885.
Existing Sewers indicated thus: Proposed Sewers indicated thus:
Datum is Boston City Base = Approx. Mean Low Water of Sea.
Broken Vertical Lines indicate positions of Borings.
SCALES.
1000 FT
0
1 MILE.
2 KILOMETERS.
WINCHESTER
MEDFORD
MALDEN
EVERETT
REVERE
SAUGUS
ARLINGTON
SOMERVILLE
MYSTIC LAKE (UPPER)
MYSTIC LAKE (LOWER)
BOSTON SEWER. ALREADY BUILT.
MELROSE SEWER.
EVERETT SEWER.
FILTRATION AREA
PUMPING STATION.
PUMPING STATION
CHELSEA AND REVERE LINE.
MAPLEWOOD
LINDEN
PINES RIVER.
WEST MEDFORD
MEDFORD
CENTRE
EDGEWORTH
WELLINGTON
MYSTIC RIVER
ALEWIFE BROOK
GROVE ST.
MYSTIC ST.
PRESCOTT ST.
WINTHROP ST.
HIGH ST.
HILLSIDE AVE.
CENTRAL SQ.
FOREST ST.
SALEM ST.
SPRING ST.
CHARLES ST.
PLEASANT ST.
PEARL ST.
B. & M. R.R.
MIDDLESEX ST.
MAIN ST.
HOSKINS ST.
BROADWAY
MALDEN ST.
LYNN ST.
SAUGUS BRANCH R.R.
MEDFORD BRANCH B. & M. R.R.
B. & L. R.R.
NORTH.
MYSTIC VALLEY SEWER.
GROVE ST.
BOSTON & LOWELL R. R.
CANAL ST.
MYSTIC ST.
PRESCOTT ST.
WINTHROP ST.
HIGH ST.
CENTRAL SQ.
SALEM ST.
SPRING ST.
CHARLES ST.
BOSTON & MAINE R.R.
MALDEN RIVER
MIDDLESEX ST.
MAIN ST.
TRUE MAGNETIC
SAUGUS BRANCH R. R.
BROADWAY
LYNN ST.
PINES RIVER
PUMPING STA.
SAND
SAND & GRAVEL
SAND & GRAVEL.
INC. 1 IN. 1500.
4 FT. × 2 FT. 8 IN. × 4 FT. 6 IN. × 3 FT.
INC. 1 IN. 2000.
4 FT. 6 IN. × 3 FT. × 5 FT.
INC. 1 IN. 2500.
5 FT.
LEDGE
MUD
TURF & LOAM
SAND
CLAY
50
40
30
20
10
0
10

admitting rain, the intercepting sewers are designed only large enough to take the present and prospective sewage proper, it being intended that any surplus due to rain water shall overflow through tide-gates at the present out lets. The necessity for this where the sewage is to be pumped and disposed of on land, has been explained sufficiently in § 99. Indeed, the building of sewers of sufficient capacity for carrying off the rain from so large a district would be entirely impracticable on account of the expense. The general design of the proposed intercepting system is shown on Plate VIII. The exact location of the sewers and the general details of construction are given in the following sections.

SECT. 109. *Main Sewer.* — The main sewer of the proposed Mystic Valley system begins at the upper end of the brick sewer already built by the Boston Water Board. About $108,000 were spent in building this sewer, and that amount will be saved by incorporating it into the new system. The discharge of filth from Woburn and Winchester at the present sewer outlet causes a great nuisance to Medford, and in any event would not be permitted to continue much longer. As stated in sections 8 and 9, the tanneries above have turned much solid refuse into the sewer, which has tended to clog it, and only has been prevented from doing so by continual flushing, scraping and hand removal. Such matter would cause even more trouble in the proposed extension of the old sewer, because the inclination there will be much less. In order that any sewer which it is practicable to build for the Mystic Valley shall work at all, it will be necessary to prohibit the putting into it of any solid substances which will not be carried along by a velocity of 2 feet per second. Such substances never should be put into sewers, but should be retained and disposed of where they are produced.

This upper end of the sewer is in Winchester just east of the Woburn Branch Railroad, near the head of Wedge Pond. Here sewage from Stoneham and Woburn will be brought by branches described in the succeeding section. The sewer already built, which is to constitute the upper portion of the main sewer, extends southerly along the Lowell Railroad for a distance of over two miles, to a point within the limits of Medford. It is a well-built brick structure, 26 by 28 inches in dimensions, with an inclination of 1 in 500, and a discharging capacity of over 7,000,000 gallons per day, or more than sufficient for the future requirements of the regions tributary to it. Three hundred and twenty feet above its present outlet into Lower Mystic Lake this sewer will be cut off, and extended southerly along the railroad by building a new sewer 4 ft. by 2 ft. 8 in. in dimensions, with an inclination of 1 in 1,500. The new sewer is located partly in the railroad location and partly in private land just east of it, to Prescott Street in West Medford, at which point the Alewife Brook Branch is taken in. The elevation of the bottom of the invert here is about 9 feet above mean low water in Boston harbor. After receiving sewage from the Alewife Brook sewer, the main sewer is increased in size to 3 ft. by 4 ft. 6 in., egg shaped, with the larger end of the egg below, and its inclination is flattened to 1 in 2,000. The location follows Prescott Street to its end, and thence passes through marsh land by a nearly straight line to High Street a little east of Hillside Avenue, and continues in High Street to Central Square. At this point the grade of the invert is about 5½ feet above low water. Branches to bring sewage from that portion of Medford north of the river can cross the river at Winthrop Street and a little south of Forest Street. Leaving Central Square, the sewer follows Salem Street to near its junction with Spring Street, and thence crosses private land to the end of Charles Street in Malden. A branch to bring to the main sewer sewage from the villages of Wellington and Edgeworth, parts of which are situated in the towns of Medford and Malden, must be built by joint action of these towns. A good location for this sewer can be found westward from the Boston & Maine Railroad, and parallel to it, and the best point for connecting with the main sewer probably will be at the intersection of Charles and Pearl Streets in Malden. The sewer continues in Charles Street to Middlesex Street, by which time its invert is at about the elevation of low water. At this point two branches, one from Melrose on the north and the other from Everett on the south, are


MASS. DRAINAGE COMMISSION.
MYSTIC VALLEY SYSTEM.
ALEWIFE BROOK, BELMONT & ARLINGTON BRANCHES.
1885.
Existing Sewers indicated thus: - - - - - - Proposed Sewers indicated thus: ———
Datum is Boston City Base = approx. M. L. W. of Sea.
Broken Vertical Lines indicate positions of Borings.
BELMONT LINE.
ARLINGTON LINE.
ALEWIFE BROOK LINE.
BELMONT VILLAGE
BELMONT
ARLINGTON
CAMBRIDGE
SOMERVILLE
MEDFORD
SPY POND.
LITTLE POND.
FRESH POND.
MYSTIC (LOWER) LAKE.
PUMPING STATION.
SAND & GRAVEL
CLAY
SAND
FINE SAND
QUICK SAND
NORTH
TRUE MAGNETIC
1 MILE.
2 KILOMETERS.

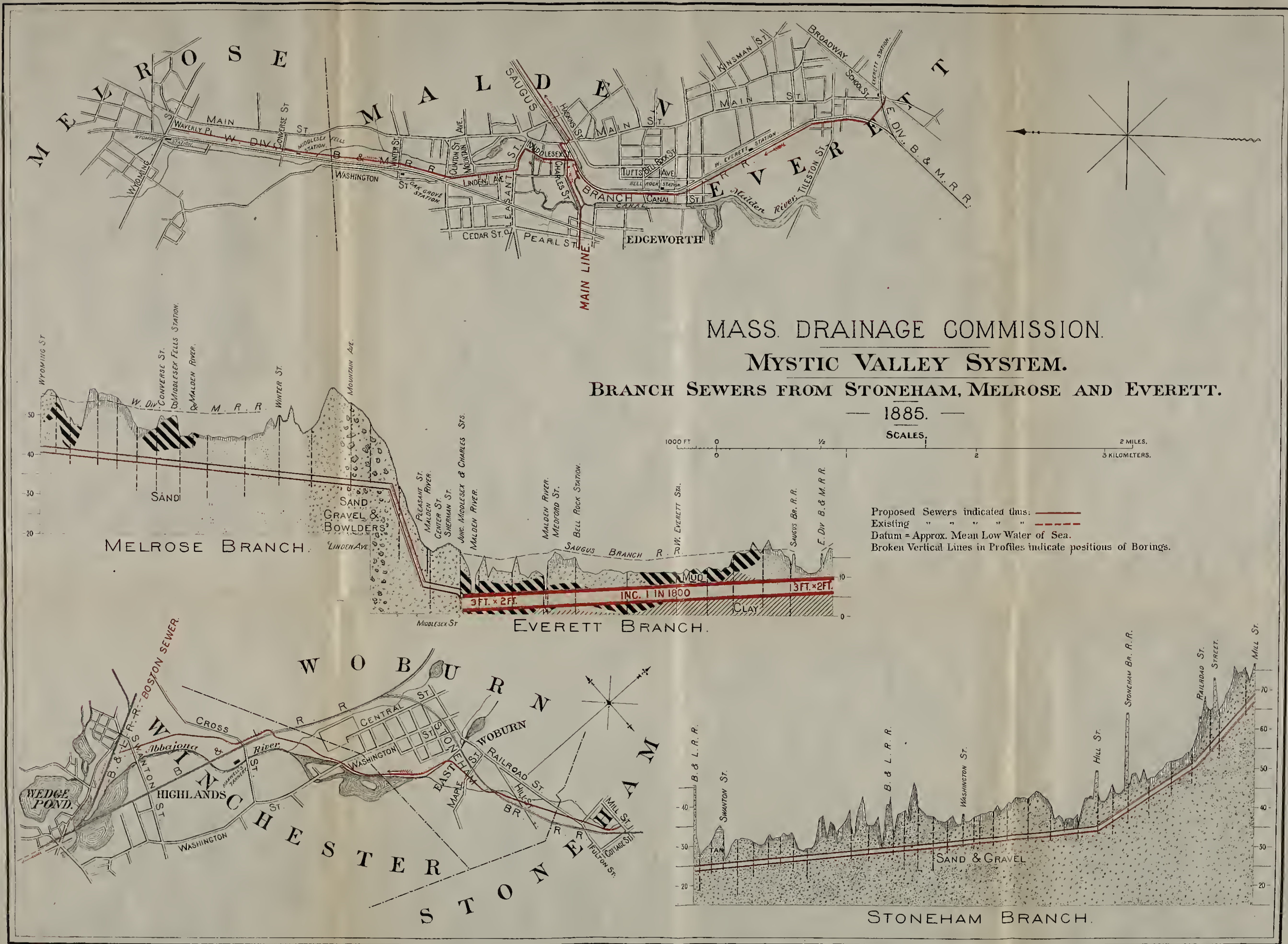
taken in. The main sewer is increased in size to 5 feet circular, with an inclination of 1 in 2,500. Leaving Middlesex Street, the sewer passes through Charles and Main Streets to the Saugus Branch Railroad, the southerly side of which it follows through Maplewood and Linden to the Revere line. Thence it extends about a mile across meadow land to a proposed pumping station in the edge of Saugus, just north of Pines River. The bottom of the sewer at the pumping station is about 7 feet below low water. The pumping station at the end of the sewer will be situated not far from the centre of the total area of about 1,000 acres which eventually may be needed for purification purposes. It is proposed at first to acquire 500 acres in Saugus northerly from the pumping station and to prepare about 200 of them for immediate use. Three pumps with their appurtenances are to be at first provided, each pump capable of elevating 5,000,000 gallons per day to an average height of 25 feet. The sewage is to be distributed by means of hydrants connected with force mains laid below the surface. The land is to be divided into a number of distinct areas, separated by low dikes, and the sewage will be applied intermittently to each area in turn, allowing sufficient time after any application for renewed aeration of the soil. These areas are to be underdrained at a depth of about 6 feet, by drains 50 feet apart. The drains will discharge into an effluent sewer passing through the pumping station and emptying through tide gates into Pines River. For a few hours at high tide, the effluent can be discharged by pumping it about 8 feet high. This can be accomplished by a small centrifugal pump with little expenditure of power.

SECT. 110. *Woburn and Stoneham branches.* — The branch which connects the greater part of the main village of Woburn with the main sewer, already has been built by the Boston Water Board, and consists of a 15-inch pipe with a least inclination of 1 in 350. This will discharge more than 2,000,000 gallons per day. To bring sewage from the west side of the main village and from Cummingsville, other branches will be needed, which, as they seem more properly to be town sewers, are not included in the scheme. Locations for such sewers were surveyed by Mr. Doane in 1874. Lines with good inclinations and light cuts were found, and profiles of them are on record. As explained in the preceding section, it will be necessary that the tanneries now using the sewer already built and those connecting with any future extensions shall intercept solid refuse in their drainage before permitting it to enter the sewers.

The branch to Stoneham, which also serves parts of Winchester and Woburn, starts from the upper end of the main brick sewer, and is built chiefly through private lands on the westerly side of Abajona River. It is a 15-inch pipe, with a least inclination of 1 in 1,000, which is on its lower portion. In Winchester it will take the sewage from Winchester Highlands and from Maxwell's tannery, and in Woburn that from East Woburn. Leaving East Woburn, the sewer follows the line of a brook to Fulton Street in Stoneham, and thence runs north of the railroad to Mill Street. To this point the sewage naturally would gravitate by any system of town sewers.

SECT. 111. *Alewife Brook branch.* — This branch, designed to take the present and prospective sewage from parts of Cambridge and Somerville and the whole of Belmont and Arlington, is oval, 2 feet by 3 feet in dimensions, throughout its whole extent. It starts at Concord Avenue in Cambridge, and follows the easterly side of Alewife Brook to the pumping station of the Mystic Water Works in Somerville, a distance of about 11,000 feet. At its upper end, the invert of the sewer is 7 feet above low water, and descends by an inclination of 1 in 1,500 to 1 foot below low water at the pumping station. At this point a pump well and pair of centrifugal pumps will be provided, and the sewage will be raised about 13 feet, or high enough to flow by gravitation to its connection with the main sewer at Prescott Street in Medford. Steam and attendance for the pumps can be obtained by arrangement with the officials of the water works pumping station.

Branches to bring to the Alewife Brook sewer, the sewage from Belmont and Arlington, can be best built on locations which are indicated on Plate X. The former of these starts near Belmont village, and following the northerly side of


MASS. DRAINAGE COMMISSION.
MYSTIC VALLEY SYSTEM.
BRANCH SEWERS FROM STONEHAM, MELROSE AND EVERETT.
— 1885. —
SCALES.
1000 FT 0 ½ 2 MILES.
0 1 2 3 KILOMETERS.
Proposed Sewers indicated thus:
Existing " " " " "
Datum = Approx. Mean Low Water of Sea.
Broken Vertical Lines in Profiles indicate positions of Borings.
MELROSE
MALDEN
EVERETT
MAIN LINE.
EDGEWORTH
W. DIV. B & M. R. R.
E. DIV. B. & M. R. R.
Malden River
MELROSE BRANCH.
EVERETT BRANCH.
SAND
SAND GRAVEL & BOWLDERS
MUD
CLAY
INC. 1 IN 1800
3 FT. × 2 FT.
3 FT. × 2 FT.
WOBURN
WINCHESTER
STONEHAM
WEDGE POND.
HIGHLANDS
BOSTON SEWER.
Abbajona River
STONEHAM BRANCH.
SAND & GRAVEL

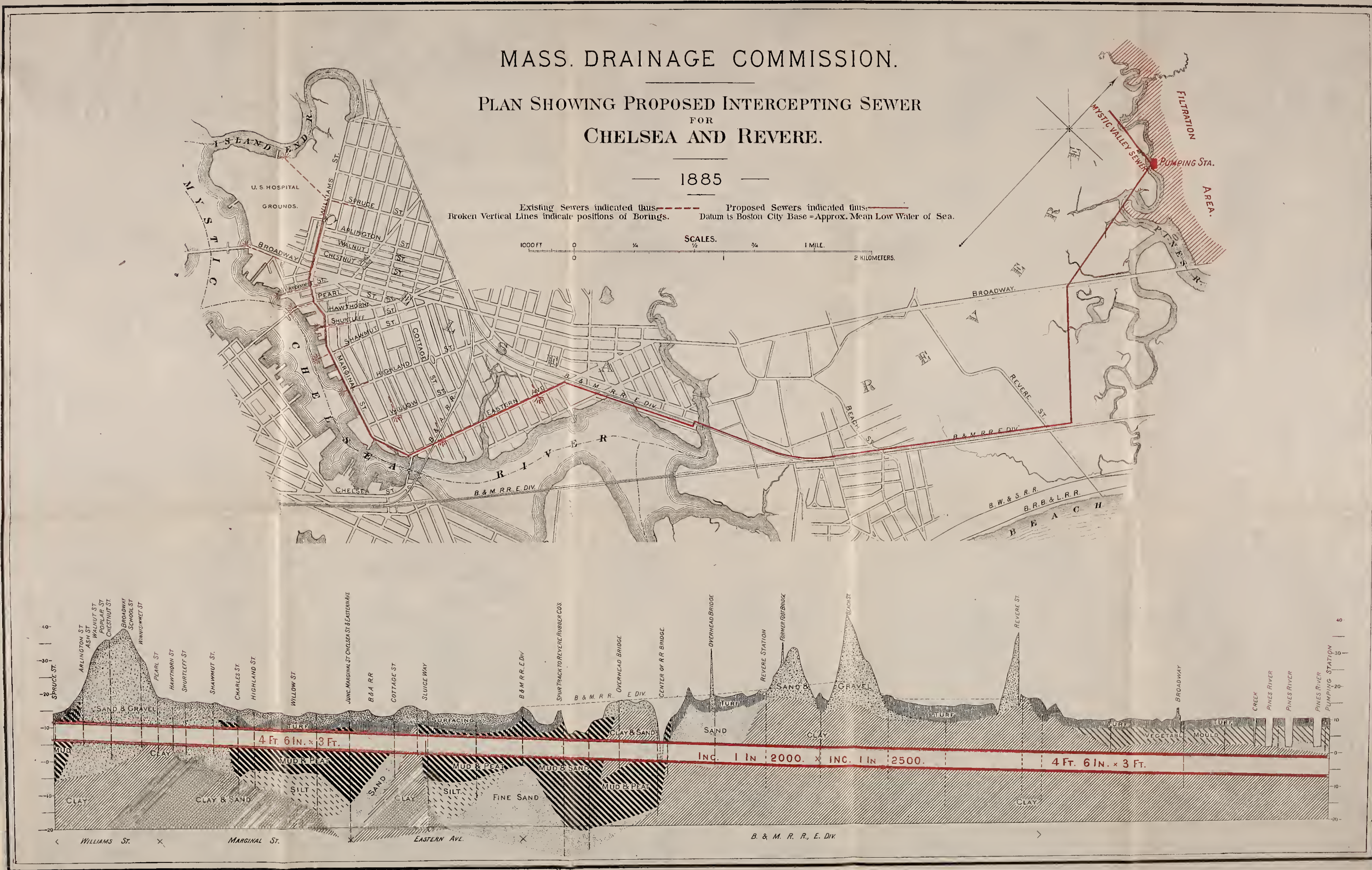
the Massachusetts Central Railroad, joins the Alewife Brook sewer near the foot of Spruce Street. It is about 9,000 feet long, and for its upper 4,000 feet consists of a 12-inch pipe. This portion has an inclination of about 1 in 150. For the lower 5,000 feet the sewer is 15 inches in diameter and has inclinations of 1 in 1,000 and 1 in 1,500. The Arlington branch begins at Linwood Street near the ice house. This is a low point on the border of Spy Pond, and is conveniently accessible from the greater part of the town. The sewer, which is a 15-inch pipe with an inclination of 1 in 800, follows the east side of the Middlesex Central Railroad location.

SECT. 112. *Melrose and Everett branches.* — The Melrose branch of the Mystic Valley system is intended to start at the junction of Waverly Place and Wyoming Avenue. This is the point towards which the sewage of the town would naturally gravitate. The sewer is to be a 15-inch pipe with an inclination of 1 in 1,000. Its capacity when flowing full is $1\frac{1}{3}$ million gallons per day, which is an ample provision for the present amount of sewage and any probable increase in the future. The sewer follows Waverly Place and a proposed extension of it to Linden Avenue in Malden. It continues in Linden Avenue to Pleasant Street. A few hundred feet before reaching Pleasant Street, the ground drops off rapidly, and the sewer falls correspondingly at the rate of 1 in 30 for a distance of about 800 feet, to a point in Middlesex Avenue, just north of the river. The sewer passes under the river and continues in Middlesex Avenue, with an inclination of 1 in 500, to a connection with the main sewer at Charles Street. This branch enters the main sewer about 3 feet above its bottom.

The Everett branch starts at the junction of Broadway and Main Street. This is the best focus at which sewers from different parts of the town can concentrate. The elevation of the invert here will be $6\frac{1}{2}$ feet above low water. This is as low as it is practicable to place the sewer and still reach the main sewer with sufficient inclination. There should be no difficulty in bringing house sewage to this sewer, even from the low lying territory bordering Mystic River, although perhaps the house drains for such sewage cannot be laid below the cellar floors, as they should not be in any case. The sewer is to be an oval brick structure, 2 feet by 3 feet in dimensions, with an inclination of 1 in 1,800. It follows the westerly side of Saugus Branch Railroad to a junction with the main sewer at the corner of Middlesex and Charles Streets. At the immediate connection the invert of the branch is 1.25 feet above that of the main sewer.

SECT. 113. *Chelsea and Revere branch.* — As stated in previous sections, a better method of disposing of sewage eventually will be needed at Chelsea, although possibly it may not be considered wise to provide for one at present. At Revere the problem of sewerage is not now a pressing one, but will become so hereafter. A branch intercepting sewer to connect with the Mystic Valley system therefore has been designed, and can be constructed whenever the need for it is apparent. The upper end of this sewer is at the corner of Williams and Spruce Streets in Chelsea, where the sewer at present causing the most nuisance will be taken in. The elevation of the invert is 6½ feet above low water. This is just low enough to receive sewage from the territory tributary to it, and could not be lower and still reach the filtration field with sufficient inclination. As it is, nearly 2,000 feet of the common sewer in Spruce Street will have to be rebuilt at a somewhat higher elevation. The new intercepting sewer is designed to be egg shaped, 4 feet 6 inches high by 3 feet wide throughout its whole extent. This is somewhat larger than is needed for the upper portion, but the increase in cost over that of a smaller sewer will not be great, and the proposed sewer is as small a one as can be very conveniently entered. The Chelsea sewers intercepted by it take rain water from the streets, which is liable to bring road-detritus, sand and rubbish of different kinds with it. As the inclination of the intercepting sewer is but one in 2,000, deposits may occur in it which may require hand removal by men entering the sewer.

From its upper end in Spruce Street, the sewer runs through Williams Street to Marginal Street. For a distance of 1,500 feet in the neighborhood of Broadway, the surface of the ground is high, so that deep and expensive excavation will be necessary. The greatest depth, which is at Broad-


MASS. DRAINAGE COMMISSION.
PLAN SHOWING PROPOSED INTERCEPTING SEWER
FOR
CHELSEA AND REVERE.
1885
Existing Sewers indicated thus
Proposed Sewers indicated thus
Broken Vertical Lines indicate positions of Borings.
Datum is Boston City Base = Approx. Mean Low Water of Sea.
SCALES.
1000 FT
1 MILE.
2 KILOMETERS.
MYSTIC VALLEY SEWER
PUMPING STA.
FILTRATION AREA.
PINES R.
ISLAND END R.
U. S. HOSPITAL GROUNDS.
MYSTIC
CHELSEA
REVERE
CHELSEA RIVER
BROADWAY
B. & M. R.R. E. DIV.
B. W. & S. R.R.
B. R. B. & L. R.R.
BEACH
REVERE ST.
BEACH ST.
WILLIAMS ST.
MARGINAL ST.
EASTERN AVE.
SAND & GRAVEL
CLAY
MUD & PEAT
CLAY & SAND
SILT
FINE SAND
MUD & SAND
TURF
SAND
VEGETABLE MOULD
4 FT. 6 IN. × 3 FT.
INC. 1 IN 2000.
INC. 1 IN 2500.
WILLIAMS ST.
MARGINAL ST.
EASTERN AVE.
B. & M. R. R., E. DIV.

way, will be about 34 feet. The sewer follows Marginal Street to Eastern Avenue, and the latter avenue to the Eastern Division of the Boston & Maine Railroad. It is then located just south of the railroad and parallel to it, to Mill Creek, which it crosses by means of an iron pipe supported on piles. Continuing along the railroad it reaches Beach Street in Revere, from which point its inclination is flattened to 1 in 2,500. Still following the railroad, it reaches a point just beyond Revere Street, where it turns to the left, and crosses marsh land to the pumping station at the filtration area. At the pumping station the invert of the sewer is seven feet below low water, which is about the same elevation as that of the main sewer coming from the Mystic Valley.

SECT. 114. *Estimates of cost.* — In making the following estimates of cost of the different portions of the Mystic Valley sewer system, it has been assumed that the work would be done either by responsible contractors or by day's labor under competent superintendents who were untrammelled in the selection of their subordinates. For work connected with politics no trustworthy estimates could be made. The prices given are believed to be ample to cover all expenses incidental to building the system in complete working order. Present market rates of wages and prices of materials have been used, and should these increase greatly during the progress of the work, a corresponding increase in the estimate must be made. No value has been given to the Mystic Valley sewer already built. Should anything be paid to Boston for it, that amount must be added to the estimate.

SECTION 114. *Estimates, — Mystic Valley Sewer.*

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	Summary of Cost.	REMARKS.
Main Sewer, from present sewer to Prescott St.,	4 ft. × 2 ft. 8 in.	15	5,950	$8 00	$47,600	. . .	Gravel.
In Prescott St. to High St.,	4 ft. 6 in. × 3 ft.	7	4,800	7 90	37,920	. . .	Wet gravel, a little rock.
In High, Salem and Charles Sts., to Middlesex Ave.,	4 ft. 6 in. × 3 ft.	17	12,200	11 55	140,910	. . .	Sand and gravel.
From Middlesex Ave. to Revere line, along railroad,	5 ft.	18	13,500	15 00	202,500	. . .	Wet sand and gravel, 8,000 yds. rock, 600 [piles.
From Revere line to pumping station,	5 ft.	17	4,500	12 40	55,800	. . .	Sand and clay.
Land damages for main sewer,	. . .	. . .	. . .	. . .	21,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	50,573	$556,303	
Pumping station and machinery,	. . .	. . .	. . .	. . .	$150,000		
500 acres of land,	. . .	. . .	. . .	. . .	50,000	. . .	Assessed at $40 to $100 per acre.
Preparing about 200 acres,	. . .	. . .	. . .	. . .	125,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	32,500	357,500	
Stoneham Branch,	15 in.	7	14,200	2 00	$28,400	. . .	Gravel.
Land damages,	. . .	. . .	. . .	. . .	5,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	3,340	36,740	

Alewife Brook Branch, to pumping station,	3 ft. × 2 ft.	12	11,229	4 00	$44,916		Clay, sand and gravel, 300 yds. rock.
Beyond pumping station,	2 ft. 6 in.	6	2,130	3 15	6,709		Iron pipe across river.
Pumping station,					10,000		
Land damages,					4,000		
Engineering and contingencies, 10 per cent.,					6,562	72,187	
Belmont Branch,	12 in.	8	3,700	1 80	$6,660		Sand — will need sheeting.
	15 in.	5	5,500	1 30	7,150		Clay.
Land and other damages,					1,000		
Engineering and contingencies, 10 per cent.,					1,481	16,291	
Arlington Branch,	15 in.	10	8,100	2 40	$19,440		Sand — will need sheeting.
Land and other damages,					1,000		
Engineering and contingencies, 10 per cent.,					2,044	22,484	
Everett Branch,	3 ft. × 2 ft.	8	9,363	$3 15	$29,493		Clay.
Land damages,					1,000		
Engineering and contingencies, 10 per cent.,					3,049	33,542	
Melrose Branch, including land,	15 in.	11	10,600	2 00	$21,200		Sand and gravel.
Engineering and contingencies, 10 per cent.,					2,120	23,320	
Carried forward,						$1,118,367	

Estimates, — Mystic Valley Sewer — Continued.

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	Summary of Cost.	REMARKS.
Brought forward,	. . .	. . .	. . .	. . .	. . .	$1,118,367	
Chelsea and Revere Branch, Spruce to Park Street,	4 ft. 6 in. × 3 ft.	22	2,300	10 40	$23,920	. . .	Hard gravel, 34 ft. cut at Broadway.
From Park Street to Eastern Railroad,	4 ft. 6 in. × 3 ft.	12	8,100	12 35	100,035	. . .	3,000 piles.
Along railroad,	4 ft. 6 in. × 3 ft.	18	11,600	13 40	155,440	. . .	2,500 piles, iron pipe across Mill Creek.
Across marsh to pumping station,	4 ft. 6 in. × 3 ft.	16	6,450	9 40	60,630	. . .	Clay.
Tide gates and connections,	. . .	. . .	. . .	. . .	20,000	. . .	1,800 ft., Spruce Street sewer to be re-built.
Land damages,	. . .	. . .	. . .	. . .	5,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	36,502	401,527	
Total,	. . .	. . .	. . .	. . .	. . .	$1,519,894	

SECT. 115. *Apportionment of cost of Mystic Valley system.* — To make an equitable apportionment, among the towns benefited, of the cost of building and maintaining the Mystic Valley sewerage system, is very difficult. It would seem as if the proper basis for such an apportionment should be that upon which people pay for most other things; that is, value received. But the relative proportion of value received by each town is a matter difficult to determine; for it is evident that all of the following considerations enter into the problem: —

1. The number of persons benefited; that is, the population of each town.

2. The amount of sewage contributed by each town, and disposed of by the works. This often is not in proportion to the population.

3. The area of land which the system benefits by affording sewerage facilities, making the land more valuable for dwellings and manufactories.

4. The valuation of property benefited, which is the common basis of apportionment in the case of other taxes.

5. The estimated cost of that portion of the system used in disposing of the sewage in any case. This would vary with each town. The sewage of Stoneham, for instance, will flow through nearly ten miles of sewer; that of Malden through only three miles, or less.

6. The extent to which the proposed sewers serve each town, by reason of their location within the town boundaries, in facilitating and cheapening the building of the tributary town systems. Stoneham, for instance, is only reached at one point, to which all of her sewage must be brought; in Malden, on the other hand, the main sewer itself takes the place of a common sewer, three miles long, intersecting the town in such a way as to be conveniently and cheaply reached from all parts of it.

All of these considerations might be introduced as factors in calculating the relative amounts to be paid, giving to each factor a certain numerical weight. Some of the factors, however, are indeterminate at present, and could only be guessed at, which makes their use unsatisfactory. I have tried to frame just principles of apportionment by different combinations of the factors most easily ascertained, such as population, area, valuation and length of sewer used. The processes were somewhat complex, and the results did not commend themselves to my own judgment, and would, I am sure, be unsatisfactory to some of the towns. I am of opinion that the simplest, most practicable, and, on the whole, fairest principle of apportionment in this case, would be that based on population. The following table shows the amounts which would have to be paid by the different towns on the foregoing basis of apportionment. The total cost of construction is assumed to be $1,520,000, and the yearly charge for maintenance and renewals, $20,000. The first named sum does not include anything in payment for the Mystic Water Works sewer already built. The sewer cost about $108,000; but it is assumed that Boston will contribute this in consideration of being relieved from any further care of it. Should Chelsea and Revere not be required to join the scheme at present, the sum saved by not building the branch sewer to reach those places will just about balance the amounts apportioned to them. After the works are fairly in operation, a juster basis of apportionment of charges for maintenance will be found in the proportion of the total amount of sewage contributed by each town, which then can be determined with approximate accuracy.

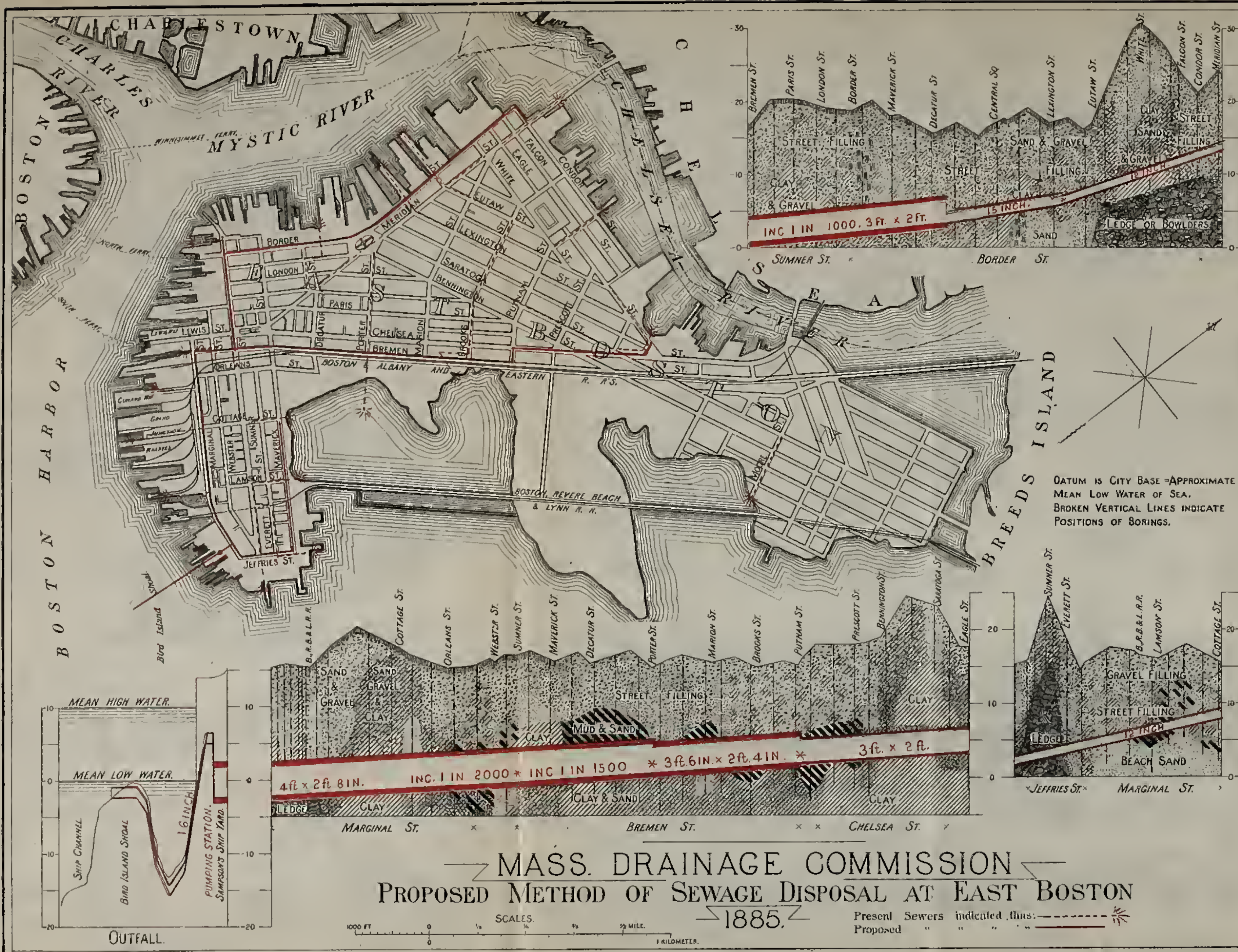
Apportionment of Cost for Mystic Valley System.

NAME OF TOWN.	Population, 1885.	Proportion of Cost of Construction.	Interest on Cost of Construction @ 3 per cent.	Yearly Charge for Maintenance.
Stoneham, ...	5,652	$84,165	$2,524 95	$1,107 43
Woburn, ...	11,750	174,971	5,249 13	2,302 25
Winchester, ...	4,390	65,372	1,961 16	860 16
Medford, ...	9,041	134,631	4,038 93	1,771 46
Belmont, ...	1,639	24,407	732 21	321 14
Arlington, ...	4,673	69,587	2,087 61	915 61
Cambridge, ...	7,000	104,238	3,127 14	1,371 55
Somerville, ...	700	10,423	312 69	137 16
Melrose, ...	6,101	90,851	2,725 53	1,195 41
Malden, ...	16,407	244,319	7,329 57	3,214 72
Everett, ...	5,375	80,040	2,401 20	1,053 16
Chelsea, ...	25,709	382,837	11,485 11	5,037 33
Revere, ...	3,637	54,159	1,624 77	712 62
Totals, ...	102,074	$1,520,000	$45,600 00	$20,000 00

SECT. 116. *East Boston.—Proposed Intercepting Sewer.* —East Boston, being an island surrounded by tide water, hardly can be said to be in any river valley, but it is more nearly related to the Mystic River basin than to any other. Although it would be possible to collect the sewage of East Boston and pump it across Chelsea Creek into the Chelsea branch of the Mystic Valley sewerage system, it will be easier and less expensive to build a distinct system of intercepting sewers for this district with an outlet into the current in Boston Harbor shown in Fig. 3, p. 138. The average daily amount of sewage furnished by East Boston at present is about 1,500,000 gallons. As most of the land already is occupied, it is not likely that this will increase in the future to more than 2,500,000 gallons. The discharge of such an amount of sewage into so good a current will be much preferable to the present method of disposal, and probably never will cause a serious nuisance. A scheme for intercepting the sewage and discharging it into the harbor has been roughly designed, and, if thought desirable, could be carried out by Boston.

The details of this scheme, showing the locations of intercepting sewers, with their sizes and inclinations, are shown on Plate XIII. As will be seen, there are three principal intercepting sewers to bring the sewage from the present outlets to a pumping station at the southeasterly extremity of the island, near Sampson's ship yard. At this point the bottom of the pump well is about 4 feet below low water, and it will be necessary to raise the sewage by pumping from 10 to 20 feet, depending on the stage of tide. It would be possible to build a storage reservoir with a capacity of about 1,500,000 gallons, so that the sewage only need be discharged during the early part of ebb tide. This would be more expensive, both on account of the cost of the reservoir and because a much larger pipe for an outlet would be necessary. Moreover, storing the sewage so near a populous district would be more likely to cause a nuisance than would the continuous discharge of a comparatively small amount of sewage at all stages of the tide.

The sewage is to be discharged through a cast iron force main 16 inches in diameter, laid in a trench dredged in the bottom of the harbor. If found necessary, the pipe can be further protected by piles driven on either side of it, cut off at the surface of the bottom. The immediate outlet will be on the southerly side of Bird Island flats, at the edge of the current.


MASS. DRAINAGE COMMISSION
PROPOSED METHOD OF SEWAGE DISPOSAL AT EAST BOSTON
1885.
CHARLESTOWN
CHARLES RIVER
BOSTON
MYSTIC RIVER
CHELSEA
CHELSEA RIVER
BOSTON HARBOR
BREEDS ISLAND
EAST BOSTON
Bird Island
Shoal
BOSTON & ALBANY AND EASTERN R. R'S.
BOSTON, REVERE BEACH & LYNN R. R.
DATUM IS CITY BASE = APPROXIMATE MEAN LOW WATER OF SEA.
BROKEN VERTICAL LINES INDICATE POSITIONS OF BORINGS.
SUMNER ST. BORDER ST.
INC. 1 IN 1000. 3 ft. × 2 ft.
15 INCH.
12 INCH.
STREET FILLING
CLAY & GRAVEL
SAND & GRAVEL
SAND
LEDGE OR BOWLDERS
MARGINAL ST. BREMEN ST. CHELSEA ST.
4 ft. × 2 ft. 8 IN.
INC. 1 IN 2000 * INC. 1 IN 1500 * 3 ft. 6 IN. × 2 ft. 4 IN. * 3 ft. × 2 ft.
MUD & SAND
CLAY & SAND
CLAY
LEDGE
JEFFRIES ST. MARGINAL ST.
GRAVEL FILLING
BEACH SAND
MEAN HIGH WATER.
MEAN LOW WATER.
SHIP CHANNEL
BIRD ISLAND SHOAL
16 INCH.
PUMPING STATION. SAMPSON'S SHIP YARD.
OUTFALL.
SCALES.
1 KILOMETER.
Present Sewers indicated thus:
Proposed " " "
Photo. Litho. Forbes Co. Boston.

SECTION 117. *Estimate for East Boston Intercepting Sewer.*

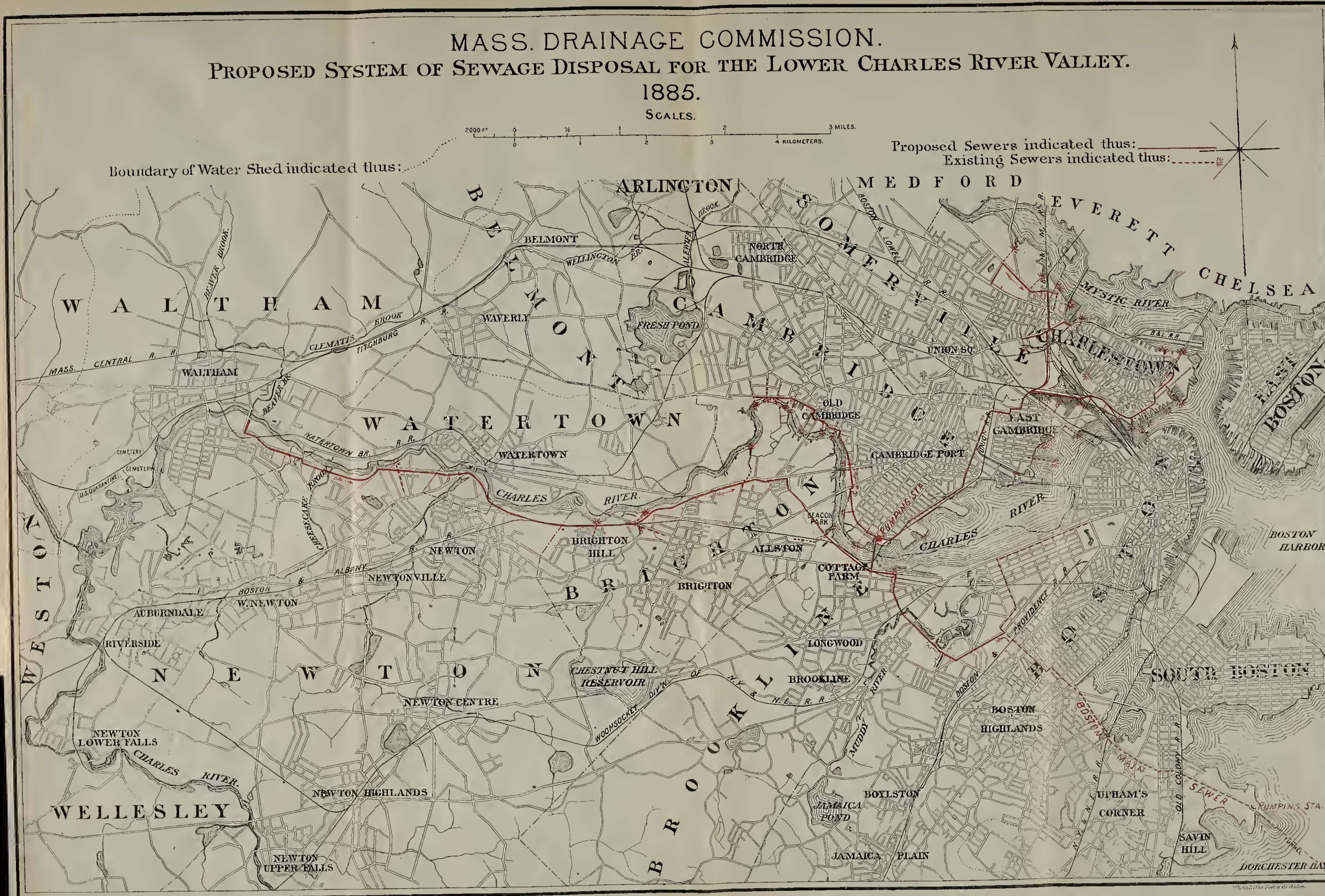
SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	REMARKS.
Meridian to Eutaw Street,	12 in.	16	1,750	$2 15	$3,762 00	Hard clay.
Eutaw to Lexington Street,	12 in.	12	550	1 90	1,045 00	Partly filled land.
Lexington to Decatur Street,	15 in.	$14\frac{1}{2}$	1,400	2 70	3,780 00	Partly filled land.
Decatur to New Street,	3 ft. × 2 ft.	18	1,300	5 15	6,695 00	Hard clay; 4 in. wall.
New to Maverick Street,	3 ft. × 2 ft.	20	1,400	5 85	8,190 00	Hard clay; 4-in. wall.
Cottage Street to Sampson's Yard,	12 in.	14	2,800	3 30	9,240 00	Part clay, part filling, some rock.
Eagle to Putnam Street,	3 ft. × 2 ft.	$18\frac{1}{2}$	2,250	5 15	11,587 00	Hard clay; 4-in. wall.
Putnam to Porter Street,	3 ft. 6 in. × 2 ft. 4 in.	$15\frac{1}{2}$	2,000	9 35	18,700 00	Filling and marsh. Wet.
Porter Street to Sampson's Yard,	4 ft. × 2 ft. 8 in.	19	5,200	12 40	64,480 00	Filled land, a little rock. Wet.
Tide gates and connections,	. . .	. . .	. . .	. . .	10,000 00	
Pumping station,	. . .	. . .	. . .	. . .	50,000 00	
Force main,	16 in. pipe	. . .	2,500	8 00	20,000 00	
Land damages,	. . .	. . .	. . .	. . .	10,000 00	
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	21,748 00	
					$239,227 00	

The Lower Charles System.

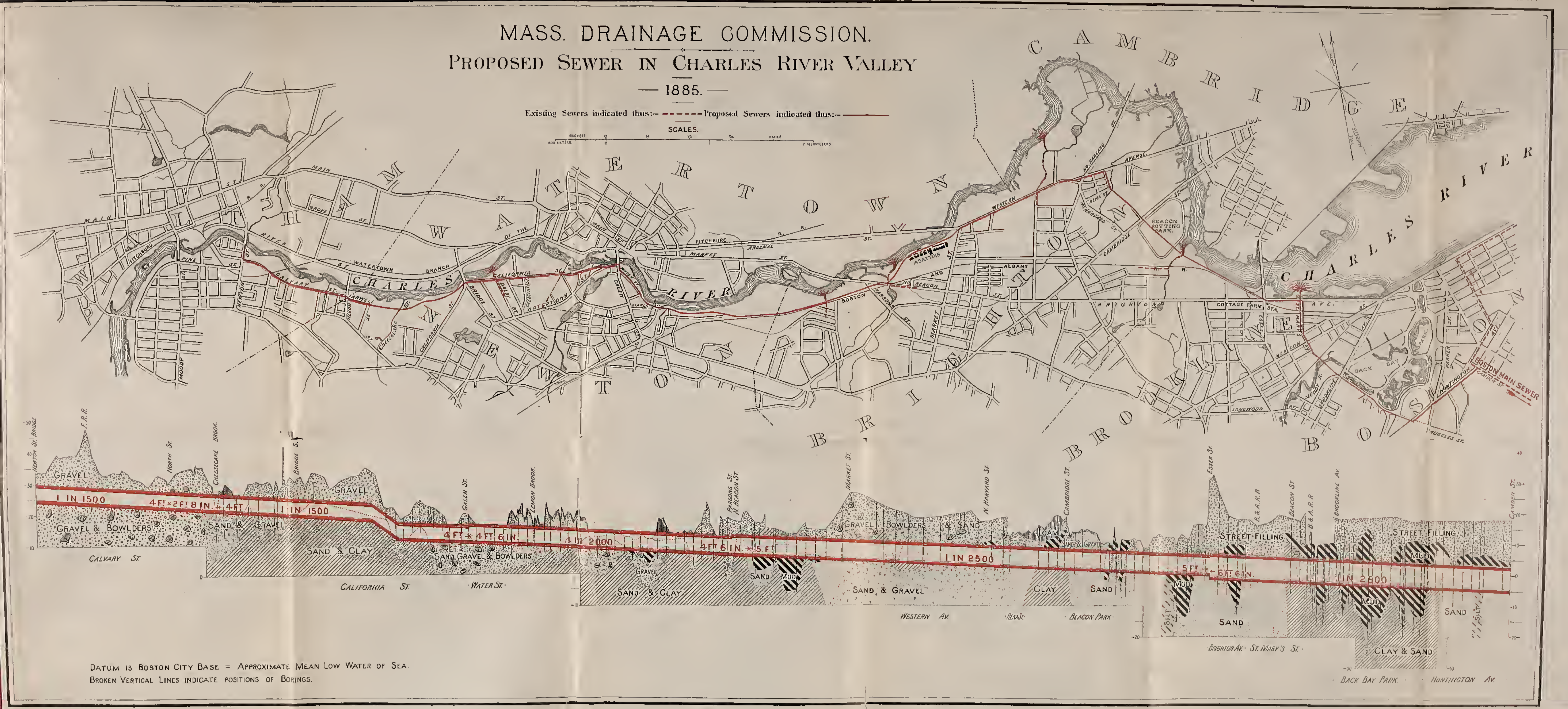
Sect. 118. *Natural division of Charles River basin in respect to need of sewerage.* — In Part I are given the investigations made in regard to the need of sewerage of the cities and towns in the Charles River valley. From these it appeared that in the thickly settled districts in the neighborhood of Boston, comprising Waltham, Newton, Watertown, Brighton, Brookline, Cambridge, Somerville and Charlestown, there either now existed an urgent need for sewerage or for a more satisfactory disposal of sewage. Above Waltham, with the possible exception of Dedham, which naturally drains through Mother Brook into the Neponset Valley, there is not at present any pressing need of sewerage except at Milford, near the head waters of the river. The district comprising the cities and towns first mentioned may therefore be considered by itself.

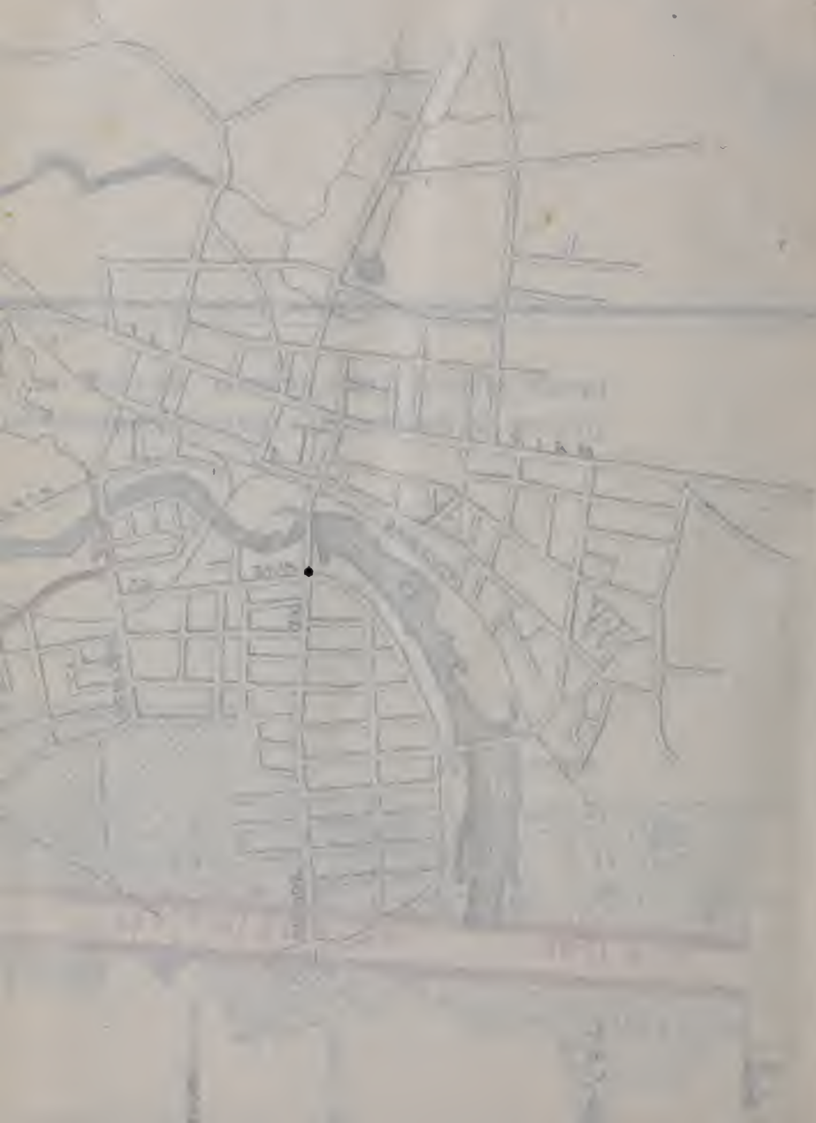
Sect. 119. *Disposition of the sewage.* — As the Charles River already is polluted considerably, it follows that no additional discharge of sewage into it would be permissible; indeed, to do away with the nuisances already existing, it is necessary that the sewage now entering the river should be diverted to some other outlet. It might be possible, from a sanitary point of view, to permit the sewage to enter the river after it had been thoroughly clarified; but as any process of clarification would entail a present annual expense of about $100,000, and several times that amount in the future, such a method of disposition would not be advisable if it could be avoided. There are no areas of land suitable for sewage purification in the Charles River valley below Waltham. It is possible that tracts might be found above that point, but it would be very expensive to carry the sewage to them. Moreover, the effluent would return to the river above the points where Waltham and Watertown take their water supplies; and if, through bad management, the purification should be incomplete, serious results might follow. In this case, therefore, discharging crude sewage into the sea seems most feasible. It evidently would be much cheaper for the towns to combine in building a single sewer to reach some satisfactory outlet, than to build independent sewers for themselves. The only tidal currents which are able to dispose of large quantities of sewage, and at the same time are reasonably accessible, are that traversing the main ship channel and passing Deer Island, and that going through the western way of Boston Harbor between Moon Island and Long Island. The difficulties in the way of reaching the former current have been referred to in § 105. In the present case the expense would be increased on account of the greater length of sewer which it would be necessary to build in order to reach the outlet. Into the latter current, near Moon Island, the sewage of Boston is discharged by its new main drainage system. The main and outfall sewers which extend from the city proper to the channel at Moon Island are much larger than is necessary for Boston alone, and have sufficient capacity to take, in addition, all of the present and prospective sewage from the Charles River district under consideration. The upper section of the Boston main sewer, which is the smallest part of it, and ends in Camden Street at Huntington Avenue, is 7½ feet in diameter. When flowing only half full, it is able to discharge 2,000,000 gallons per hour, and its ordinary flow at present is not more than one-tenth of that quantity. The pumps already provided at the pumping station, when all in operation, have a combined capacity of about 120,000,000 gallons per day, although the average daily amount pumped, including rain water, during the past year, did not reach 30,000,000 gallons. The pumping station is designed so that it can be increased to double its present capacity, as is also the storage reservoir at Moon Island. The whole main drainage works of Boston were designed with special reference to taking sewage from the towns bordering the Charles River as far as Waltham. Practically, therefore, this tidal current in Boston Harbor, in so far as its accessibility for purposes of sewerage is concerned, already has been transferred to Huntington Avenue in Boston, within a mile of the Charles River at Brookline. This furnishes the best, and indeed the only practicable outlet for the sewage of the Charles River valley.

SECT. 120. *Main sewer.* — Although the Boston main drainage works are of sufficient capacity to take the sewage from this district, they are entirely inadequate to deal with the rain water falling on it. If this outlet is adopted, it will be necessary therefore that the sewer system tributary to it should not receive any rain water. It has been assumed in calculating the sizes of the intercepting sewers that this will be the case. The general scheme, as designed, is shown on Plate XIV, and the exact location of the sewers and the character of the ground to be excavated are shown on Plates XV and XVI. As designed, the sewer starts at Newton Street in Waltham, on the south side of Charles River. A branch is to be built crossing the river to its north side, to a basin into which the local sewers on the north side of the river can empty. This point, being at the junction of Beaver Brook and the river, is the lowest in the city, and towards it the sewage naturally would gravitate. The grade of the sewer is established at about the level of extreme low water in the river. The sewer is oval, 4 ft. high by 2 ft. 8 in. wide, and when flowing half full will have a capacity for discharging about 6,000,000 gallons per day. This is larger than is absolutely necessary, but the cost due to the increased size will not be great, and a smaller sewer could not be entered conveniently for examination or repairs. Moreover, the size will allow of possible future extensions. The inclination of the sewer is to be 1 foot in 1,500. If a steeper inclination were adopted the sewer grade would soon fall below the elevation of ground water, which on the location near the river is very abundant, and thus greatly increase the cost of excavation. The sewer will have a constant flow, and experience with the Boston intercepting sewers shows that the velocity will be about 2 feet per second, and that deposits are not likely to occur. If found necessary, the sewer can be thoroughly flushed at intervals with water taken from the river at Waltham above the dam, or with sewage from the high land on the south side of the river, which sewage can be collected in a tank and discharged automatically at intervals into the head of the sewer. From Newton Street the sewer location is in Calvary Street to North Street. At one point the depth of excavation will be about 23 feet, but the average cut will not be over 12 feet, and it will be cheaper to build the sewer in the street than to incur damages for a


MASS. DRAINAGE COMMISSION.
PROPOSED SYSTEM OF SEWAGE DISPOSAL FOR THE LOWER CHARLES RIVER VALLEY.
1885.
SCALES.
3 MILES.
4 KILOMETERS.
Proposed Sewers indicated thus:
Existing Sewers indicated thus:
Boundary of Water Shed indicated thus:
ARLINGTON
MEDFORD
EVERETT
CHELSEA
EAST BOSTON
SOMERVILLE
CAMBRIDGE
BELMONT
WALTHAM
WATERTOWN
NEWTON
BRIGHTON
BROOKLINE
BOSTON
WESTON
WELLESLEY
NORTH CAMBRIDGE
MYSTIC RIVER
CHARLESTOWN
UNION SQ.
OLD CAMBRIDGE
EAST CAMBRIDGE
CAMBRIDGE PORT
FRESH POND
WAVERLY
CHARLES RIVER
PUMPING STA.
BEACON PARK
ALLSTON
COTTAGE FARM
BRIGHTON HILL
NEWTONVILLE
W. NEWTON
AUBURNDALE
RIVERSIDE
LONGWOOD
CHESTNUT HILL RESERVOIR
NEWTON CENTRE
NEWTON LOWER FALLS
NEWTON HIGHLANDS
NEWTON UPPER FALLS
BOSTON HARBOR
SOUTH BOSTON
BOSTON HIGHLANDS
BOSTON MAIN SEWER
UPHAM'S CORNER
SAVIN HILL
DORCHESTER BAY
JAMAICA POND
JAMAICA PLAIN
BOYLSTON
MUDDY RIVER
MASS. CENTRAL R.R.
FITCHBURG R.R.
CLEMATIS BROOK
BEAVER BROOK
WATERTOWN BR. R.R.
CHEESECAKE BROOK
WELLINGTON BR.
ALEWIFE BROOK
BOSTON & LOWELL R.R.
BOSTON & ALBANY
WOOSWOCKET DIV'N OF N.Y. & N.E. R.R.
BOSTON & PROVIDENCE R.R.
OLD COLONY R.R.
U.S. QUARANTINE
CEMETERY

location through private lands. The trench will be entirely in coarse gravel, and the lowest part of it probably will be wet. From North Street for a distance of about 700 feet, the sewer location is in that part of Farwell Street parallel to the river, whence it passes on to private land, and follows the river for a distance of about 3,500 feet to Bridge Street. At North Street the sewer enters Newton. As it is possible that a considerable portion of the sewage of Newton may be brought to the interceptor along the valley of Cheesecake Brook, the sewer at that point is increased in size to 4 feet circular, with a capacity, running half full, of over 10,000,000 gallons per day. At both North and Bridge streets, the sewer is near the river and at about the elevation of the surface of the water, so that at these points sewage from the north side of the river can be brought across to the interceptor. At Bridge Street the sewer enters California Street, which it follows to Galen Street in Watertown. The excavation will be in water-bearing gravel, and to avoid the expense of excessive pumping the inclination of 1 in 1,500 is maintained as far as possible, and the elevation of the sewer kept at about the same height as that of the surface of the river. From Crescent Street eastward, the grade of California Street falls rapidly, and in order that the sewer may be below the surface without too much re-grading, the sewer itself is lowered 6 feet in a distance of about 800 feet, and thence continues with an inclination of 1 in 2,000. From this point to the dam in Watertown, the sewer will be expensive to build, on account of the great amount of water which will be met with in excavating. At Galen Street a branch is to be built across the river, to take from the north part of Watertown the sewage which will naturally gravitate to this point, owing to the topography of the town. Opposite Watertown village the grade of the intercepting sewer is at about the elevation of high tide in the river. Although this is a little higher than would be desirable, it is not too high to take the Watertown sewage, and is as low as it is practicable to build a sewer which shall connect with the Boston intercepting system and have sufficient inclination to prevent the formation of deposits. After receiving the sewage of Watertown at Galen Street, the sewer is increased in size to 4 feet 6 inches in diameter. This sewer running half full has a capacity of about 14,000,000 gallons per day. After crossing Galen Street, the sewer is located in Water Street for a distance of about 1,200 feet, to Parker's starch factory. At this point, digging a trench would tend to drain the springs or wells which supply water for the factory. As this water is very pure, and its use is thought to be necessary for obtaining a high grade starch, the temporary deprivation of it might cause pecuniary damage to the factory. A possible way of avoiding this would be to swing the sewer out into the edge of the river channel, and protect it carefully with a paved embankment. After leaving Water Street, the sewer follows the river bank through private lands to the Brighton line. Thence it runs parallel to and just outside of the Boston & Albany Railroad embankment to Beacon Street. The sewer near the railroad will be underlaid by a few feet of marsh mud. Here it will be necessary to excavate to hard ground, and to replace the mud with gravel filling or concrete up to the sewer bottom. The top of the sewer will project above the surface of the marsh, and it will be necessary to build a low embankment over it. The gravel to make this can be brought by the railroad before the sewer is built, and can be used to make a roadway which will furnish an approach to the work for the men and teams employed in building it. At North Beacon Street a portion of the sewage from Brighton may be intercepted, and the sewer at that point is increased in size to 5 feet diameter, and in capacity, when flowing half full, to 16,000,000 gallons per day. Its inclination from this point on is 1 in 2,500. Leaving North Beacon Street, the sewer passes through private ways, along the margin of the river and between it and the buildings of the Brighton abattoir, to Market Street. Near the abattoir it will be necessary to raise the surface of the roadway somewhat, in order to cover and protect the sewer, the grade of which at that point is about 6½ feet above low water. For about 600 feet in this locality, in order to secure a firm foundation for the sewer, it will be necessary to drive piles through the mud, which is found to extend about 10 feet below the sewer grade. From Market Street the

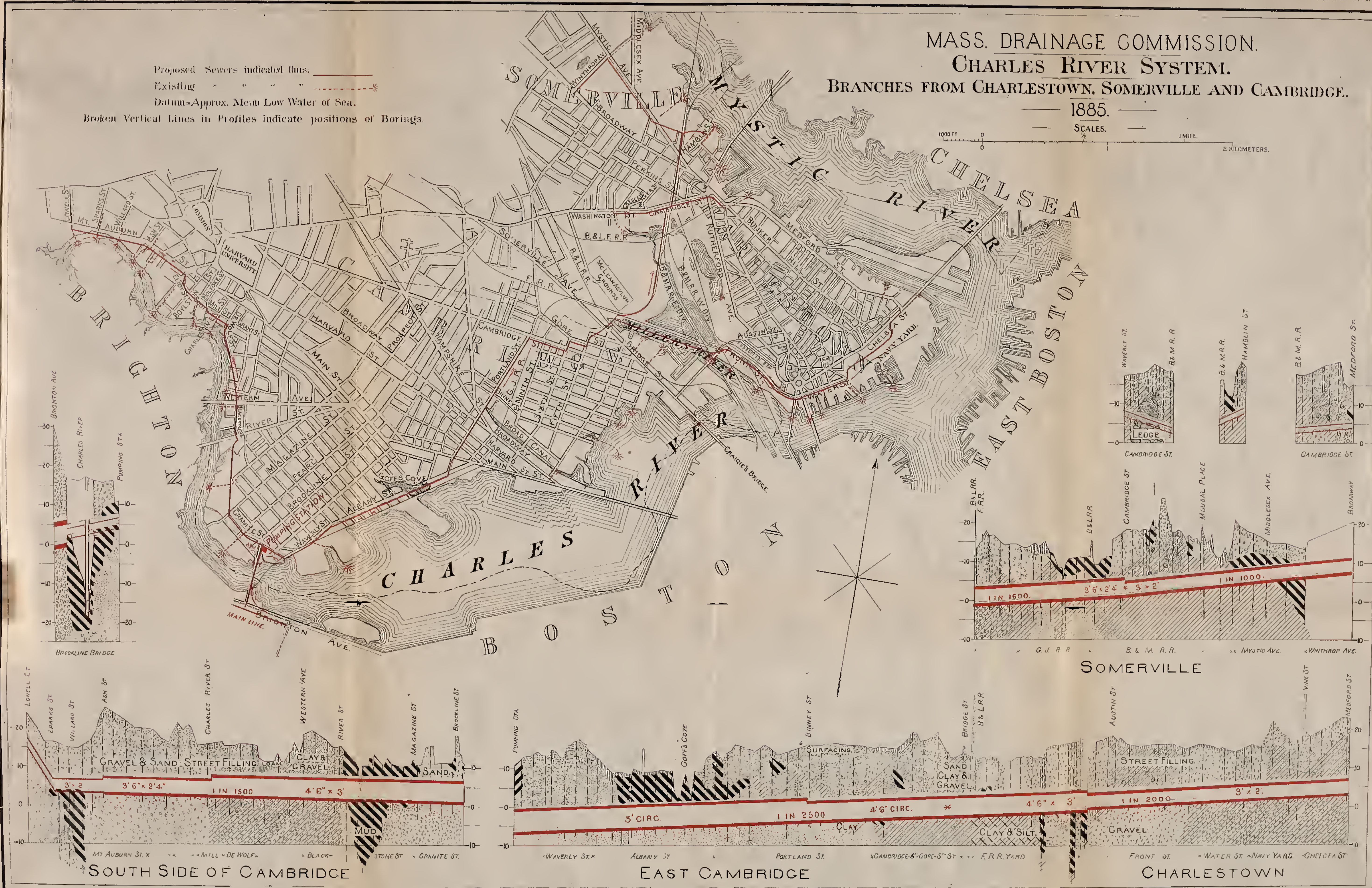

MASS. DRAINAGE COMMISSION.
PROPOSED SEWER IN CHARLES RIVER VALLEY
— 1885. —
Existing Sewers indicated thus:- - - - - - Proposed Sewers indicated thus:———
SCALES.
WALTHAM
WATERTOWN
CAMBRIDGE
NEWTON
BRIGHTON
BROOKLINE
BOSTON
CHARLES RIVER
BOSTON MAIN SEWER
BEACON TROTTING PARK
ABATTOIR
BACK BAY PARK
GRAVEL
1 IN 1500
4 FT × 2 FT 8 IN. × 4 FT
GRAVEL & BOWLDERS
SAND & GRAVEL
SAND & CLAY
4 FT × 4 FT 6 IN.
1 IN 2000
SAND GRAVEL & BOWLDERS
4 FT 6 IN. × 5 FT
SAND
MUD
GRAVEL BOWLDERS & SAND
SAND & GRAVEL
1 IN 2500
LOAM
CLAY
STREET FILLING
5 FT × 6 FT 6 IN.
SILT
CLAY & SAND
CALVARY ST.
CALIFORNIA ST.
WATER ST.
WESTERN AV.
BLACON PARK
BRIGHTON AV. · ST. MARY'S ST.
BACK BAY PARK · HUNTINGTON AV.
DATUM IS BOSTON CITY BASE = APPROXIMATE MEAN LOW WATER OF SEA.
BROKEN VERTICAL LINES INDICATE POSITIONS OF BORINGS.



sewer is built in Western Avenue to a point about 600 feet beyond its junction with North Harvard Street. Thence it passes, partly through private land, to Cambridge Street opposite Beacon Park, and across the Park to the marsh just outside of the Boston & Albany Railroad. From Market Street to this point, much water probably will be encountered. Following the margin of the river outside the Boston & Albany Railroad, the sewer, which will again require piling below it, reaches Essex Street near Cottage Farm station. By this time the grade of the sewer has fallen to about the level of mean low water. At this point the sewage from Cambridge, Somerville and Charlestown is taken in, and the sewer is increased to 6 ft. 6 in. in diameter, with a capacity, when flowing half full, of 33,000,000 gallons per day. The larger sewer is lowered 1 foot, owing to the greater depth of sewage which it will contain, so that the contents of the sewer above shall not be dammed back and the inclination of the surface of the sewage lessened. From Essex Street the sewer location follows Brighton Avenue to St. Mary Street, and it is possible that some piling will be needed. At St. Mary Street the intercepting sewer passes under the main Brookline sewer and receives the sewage from it. A connection between these two sewers is to be so constructed that the latter will afford an outlet through which the contents of the intercepting sewer can overflow, should an accident to the Boston main drainage works at any time render them incapable of disposing of the sewage. At this point the intercepting sewer turns and follows the easterly side of St. Mary Street. The Brookline sewer already is built in the centre of this street, which is but 40 feet wide. While it might be possible to build the new sewer within the street lines without endangering the sewer already built, the process would be slightly hazardous and would require the removal of a row of fine shade trees of 30 years' growth. It is proposed, therefore, to widen the street by the addition of 12 feet on its east side. There is a proposed extension of St. Mary Street across Muddy River to Brookline Avenue, and in this the sewer is located. At Brookline Avenue the sewer enters the Back Bay Park, and is to be built in a driveway on its southerly margin.

Here deep beds of mud will be encountered and a pile foundation will be necessary. Leaving the park by a proposed extension of Ruggles Street, the sewer reaches Huntington Avenue, which it follows to a junction with the Boston main sewer at Camden Street. At the junction the invert of the sewer is about 5 feet below the elevation of low water of the sea.

SECT. 121. *Charlestown and Cambridge Branches.* — The branch intercepting sewer designed to convey sewage from Charlestown, Somerville and Cambridge to the main sewer in Brighton Avenue at Cottage Farm station, begins in Medford Street at the northeasterly corner of Charlestown. The grade of the invert of the sewer will be about 4.2 feet above low water. At this point most of the sewage from the northerly side of Charlestown will be taken in. The intercepting sewer will be oval, 3 feet high by 2 feet wide. Its inclination will be 1 in 2,000, and its discharging capacity when flowing half full 2,500,000 gallons per day. Arrangements can be made for flushing this sewer by admitting tide water at its upper end. Leaving Medford Street, the sewer follows Chelsea Street to near Vine Street, where it enters the Navy Yard grounds. It is stated by government officials that no objection will be made to building the sewer through the Navy Yard. Leaving that place, the sewer passes through Water Street and Front Street to a junction with the Rutherford Avenue sewer, 400 feet west of Austin Street. At this point the sewage from the southwesterly side of Charlestown is taken in, and the intercepting sewer will be increased in size to 4 ft. 6 in. by 3 ft., and its grade will be lowered 6 inches. Thence, with an inclination of 1 in 2,500, the sewer is built along the Fitchburg Railroad on a line which has been suggested by the railroad officials as that which will best suit the arrangement of their tracks. From near the McLean Asylum grounds, there will be built along the line of the Grand Junction Railroad a sewer, branches from which will intercept and bring to the main sewer the sewage from the districts in the neighborhood of Charlestown Neck. The main sewer continues along the railroad to Bridge Street in Cambridge, at which point the large sewer used jointly by Somerville and East Cambridge will


MASS. DRAINAGE COMMISSION.
CHARLES RIVER SYSTEM.
BRANCHES FROM CHARLESTOWN, SOMERVILLE AND CAMBRIDGE.
1885.
SCALES.
Proposed Sewers indicated thus:
Existing " " " "
Datum=Approx. Mean Low Water of Sea.
Broken Vertical Lines in Profiles indicate positions of Borings.
SOMERVILLE
MYSTIC RIVER
CHELSEA
EAST BOSTON
BRIGHTON
CAMBRIDGE
CHARLES RIVER
BOSTON
MILLERS RIVER
HARVARD UNIVERSITY
SOUTH SIDE OF CAMBRIDGE
EAST CAMBRIDGE
CHARLESTOWN
SOMERVILLE
GRAVEL & SAND
STREET FILLING
CLAY & GRAVEL
SAND
MUD
SURFACING
CLAY
CLAY & SILT
GRAVEL
LEDGE
1 IN 1500
1 IN 2500
1 IN 2000
1 IN 1000
5' CIRC.
4' 6" CIRC.

be intercepted. Sewage from East Cambridge will be brought to the interceptor either by laying a separate pipe in Bridge Street or by building a new bottom with reversed inclination in the Bridge Street sewer, which, where it passes through East Cambridge, is very flat. If necessary, a storm overflow outlet for this sewer can be constructed emptying into Miller's River. At Bridge Street the intercepting sewer is increased in size to 4 ft. 6 in. circular. Leaving Bridge Street the sewer follows Fifth, Gore, Sixth and Cambridge streets to Portland Street. It is necessary to locate it so far inland, in order to avoid crossing a navigable channel to the north of East Cambridge, and a ship canal to the south of it. In Portland Street the large sewer which discharges at Binney Street will be intercepted, and the size of the sewer is again increased to 5 feet in diameter. Continuing in Portland Street, and a proposed extension of it south of Main Street to the marsh near Goff's Cove, the sewer enters a projected street called Albany Street, which runs nearly parallel to and north of the Grand Junction Railroad to Waverly Street. Following Waverly Street to its end, the sewer turns to the right into a proposed street between Henry Street and the marsh, and reaches Brookline Street. At this point the invert is about 5.75 feet below low water, and it is proposed to build a pumping station at which the sewage can be raised about 10 feet, so that it will flow through a siphon across Charles River to the main intercepting sewer.

To intercept the sewage which now enters Charles River on the southwesterly side of Cambridge above Brookline Street and bring it to the pumping station, a branch sewer is to be built along the northerly margin of the river. The upper end of this sewer is in Mt. Auburn Street at Lowell Street. At this point the intercepting sewer consists of a 12-inch pipe, and is built in Mt. Auburn Street from Lowell Street to Sparks Street, with an inclination of 1 in 56. After taking in the Sparks Street sewer, the size of the intercepting sewer is increased to 2 ft. by 3 ft., and its inclination flattened to 1 in 1,500. The sewer continues in Mt. Auburn Street to Eliot Square. At Ash Street it is increased in size to 2 ft. 4 in. by 3 ft. 6 in. From the square the sewer follows Eliot, South, Mill and DeWolf Streets, and thence is built across marsh land to Blackstone Street and Western Avenue. At Charles River Street a further increase in size to 3 ft. by 4 ft. 6 in. takes place. From Blackstone Street at River Street, the sewer crosses private marsh land near the river to Magazine Street at Granite Street, which it follows to the pumping station at Brookline Street.

As the Cambridge, Somerville and Charlestown sewers all receive storm water, for which it is not proposed to provide accommodation in the intercepting sewers, it will be necessary to retain for the discharge of such waters all of the old outlets, and to protect them with efficient tide gates. It is proposed at first to provide at the pumping station two pumps, each of them of sufficient capacity to elevate 12,000,000 gallons of sewage per day, which is more than twice as much as the present water supply of the districts from which the sewage will come. As the lift is so low, centrifugal pumps will be most suitable for the work, and comparatively small and inexpensive ones will answer. It is proposed to pump through a force main 30 inches in diameter, which will cross under the channel by means of a siphon. On the Boston side of the river, the force main will discharge into a 5-foot sewer connecting with the main sewer.

Section 122. — *Estimate of Cost.*

Main Sewer.

SECTION.	Size of Sewer.	Average Cut. Feet.	Length. Feet.	Approximate Cost per foot.	Total Cost.	Summary of Cost.	Remarks.
Newton Street, Waltham, to Cheesecake Brook,	4 ft. × 2 ft. 8 in.	11.4	5,700	$9 75	$55,575	. . .	Wet gravel and bowlders. [grading.
Cheesecake Brook to Galen Street,	4 ft. circular	9.8	7,900	10 60	83,740	. . .	Wet gravel and bowlders, 7,500 yds. re-
Galen Street to Parsons Street,	4 ft. 6 in.	7.7	8,450	13 50	114,075	. . .	20,000 yds. filling and embankment, 500
Parsons Street to Essex Street,	5 ft.	14.0	15,350	15 00	230,250	. . .	Wet gravel and mud, 1,500 piles. [piles.
Essex Street to St. Mary's Street,	6 ft. 6 in.	19.0	1,230	22 40	27,552	. . .	Wet gravel and mud, 400 piles.
Brighton Avenue to Camden Street,	6 ft. 0 in.	18.6	8,670	24 00	208,080	. . .	5,000 ft. sand and gravel, rest mud.
Land and other damages,	. . .	. . .	. . .	. . .	60,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	77,927	$857,199	
Carried forward,	. . .	. . .	. . .	. . .	. . .	$857,199	

Estimate of Cost — Continued.

East Cambridge and Charlestown Branch.

SECTION.	Size of Sewer.	Average Cut. Feet.	Length. Feet.	Approximate Cost per foot.	Total Cost.	Summary of Cost.	REMARKS.
Brought forward,	. . .	. . .	. . .	. . .	. . .	$857,199	
Medford Street to Rutherford Avenue sewer,	3 ft. × 2 ft.	16.0	6,860	$5 50	$37,730	. . .	Hard ground, crowded paved streets.
Rutherford Avenue sewer to Bridge Street,	4 ft. 6 in. × 3 ft.	16.5	3,330	13 50	44,955	. . .	Among R. R. tracks, 700 ft. pile foundation.
Bridge Street to Binney Street,	4 ft. 6 in.	19.5	4,095	12 65	51,802	. . .	Gravel and clay.
Binney Street to Pumping Station,	5 ft.	18.0	7,565	15 90	120,283	. . .	Sand and gravel, 1,500 ft. mud.
Land and other damages,	. . .	. . .	. . .	. . .	20,000		
Tide gates and sewer connections,	. . .	. . .	. . .	. . .	20,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	29,477	324,247	

East Somerville Branch.

SECTION.	Size of Sewer.	Average Cut. Feet.	Length. Feet.	Approximate Cost per foot.	Total Cost.	Summary of Cost.	REMARKS.
Winthrop Street to Cambridge St,	3 ft. × 2 ft.	14 0	5,960	$5 90	$35,164	. . .	Clay and gravel, some mud and rock.
Cambridge Street to Fitchburg Railroad,	3 ft. 6 in. × 2 ft. 4 in.	14.0	3,950	5 60	22,120	. . .	Clay and gravel.
Branch pipe sewers,	12 in.	12.0	3,450	4 00	13,800	. . .	Clay, gravel and rock.
Land and other damages,	. . .	. . .	. . .	. . .	5,000		
Tide gates and sewer connections,	. . .	. . .	. . .	. . .	5,000		
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	8,108	89,192	

South Side of Cambridge Branch.

Lowell Street to Sparks Street,	12 in.	19.5	680	$3 00	$2,040		Sand and gravel.
Sparks Street to Ash Street,	3 ft. × 2 ft.	14.0	1,382	6 00	8,292		100 ft. of pile foundation.
Ash Street to Charles River Street,	3 ft. 6 in. × 2 ft. 4 in.	19.0	2,805	7 90	22,159		Sand and gravel.
Charles River Street to pumping station,	4 ft. 6 in. × 3 ft.	14.6	6,483	12 00	77,796		Clay, gravel and mud, 1,000 ft. pile [foundation.
Land and other damages,					12,000		
Tide gates and sewer connections,					5,000		
Engineering and contingencies, 10 per cent.,					12,729	140,016	

Pumping Station in Cambridge.

Land,					$15,000		
Buildings and machinery,					100,000		
Force main, including siphon,	30 in.		1,400		15,000		
Sewer beyond force main,	5 ft.	25	350	$18 00	6,300		
Engineering and contingencies,					13,630	149,930	
Total for Charles River System,						$1,560,584	

SECT. 123. *Apportionment of cost of Charles River system.* — In the case of the Charles River system, for apportioning the cost of construction and charge for maintenance, the same principles are applied as in the case of the Mystic Valley system (Sect. 115), so far as they are applicable. The total cost of construction, which is assumed to be $1,561,000, is divided among the cities and towns in proportion to their populations, and the same is true of the $12,000 necessary for maintenance. For the sake of simplicity, the Brighton and Charlestown districts of Boston are treated as if they were independent municipalities. There remains to determine the amounts to be paid to Boston for the use of its main and outfall sewers, pumping station and reservoir, and for the maintenance of these works and the cost of pumping. The value of the portion of the Boston system which will be used to dispose of the sewage received from the Charles River system, is estimated at $3,000,000. The money to build this was borrowed at 4 per cent.; but as rates for good municipal loans are now lower, it is assumed that at present 3 per cent. would be a fair charge for interest. This makes an annual charge of $90,000. The annual cost of maintenance, including pumping after the Charles River system is added, is estimated at $50,000. This added to the $90,000 makes $140,000. This should be paid by Boston and the cities and towns of the Charles River system in proportion to the amount of sewage contributed by each. The average daily amount of sewage at present contributed by Boston is about 27,000,000 gallons. As new sewers are continually building, it may be assumed that by the time the Charles River system is completed, this amount will reach 30,000,000 gallons. The amount which will be contributed by the Charles River system at first, can only be estimated from the amounts of the present water supplies of the towns tributary to it. After the new system is fairly in operation, the average amount contributed by each town can be gauged with comparative accuracy. It is estimated that at first it will be about 8,000,000 gallons. This in additiou to Boston's sewage makes 38,000,000 gallons per day, or 13,870 million gallons per year. Dividing the annual charge, $140,000, by

13,870, gives almost exactly $10 as the cost of disposing of a million gallons. The following table gives the apportionment to each city and town, based, for construction and maintenance upon populations, and for payments to Boston on the estimated number of millions of gallons to be contributed by each town annually.

Apportionment of Cost for Charles River System.

NAME OF TOWN.	Population, 1885.	Proportion of Cost of Construction.	Interest on Cost of Construction @ 3 per cent.	Yearly Charge for Maintenance.	Million Gallons per annum.	Annual Charge for Outfall and Pumping, $10 per million gals.
Waltham, . . .	14,609	$126,377	$3,791 31	$971 51	146	$1,460 00
Newton, . . .	19,759	170,928	5,127 84	1,314 02	183	1,830 00
Watertown, . .	6,238	53,963	1,618 89	414 83	73	730 00
Brighton, . . .	8,523	73,729	2,211 87	566 79	110	1,100 00
Charlestown, . .	37,673	325,896	9,776 88	2,505 28	730	7,300 00
Somerville, . . .	*29,292	253,394	7,601 82	1,947 93	620	6,200 00
Cambridge, . .	*52,660	455,543	13,666 29	3,501 92	912	9,120 00
Brookline, . . .	9,195	79,543	2,386 29	611 47	146	1,460 00
Part of Boston Proper,	*2,500	21,627	648 81	166 25	45	450 00
Totals, . . .	180,449	$1,561,000	$46,830 00	$12,000 00	2,965	$29,650 00

* Population contributing to Charles River system.

The Upper Charles Basin.

SECT. 124. *General considerations.* — In the Charles River basin, above Waltham and Newton, if we except Dedham, which, in reference to sewerage, it is better to consider in connection with the Neponset basin, there are only three towns which have public water supplies, and in which the need of sewerage is either felt at present or is likely to be felt in the near future. These towns are Milford, Franklin and Wellesley.

Milford already has a few sewers, by which the sewage is disposed of in an unsatisfactory manner, so that nuisances exist, and there seems to be a desire on the part of the citizens of that town to find some remedy for the present state of affairs. Franklin already has built one short section of sewer, the discharge from which causes no nuisance to the town, but is not wholly satisfactory, because the sewage in a crude state reaches Charles River, from which water for drinking is taken by six towns below. Moreover, the free use of water, which always follows the introduction of a public supply under pressure, is sure sooner or later to cause sewage disposal in cesspools to be ineffective and unsatisfactory, and to lead to the desire for sewerage. Wellesley has just introduced a public water supply, and therefore does not yet feel the need of sewerage. As the population generally is scattered, it probably will be several years before the need of sewerage becomes urgent. On the other hand, there being much wealth in the town, it is probable that the convenience of a sewerage system may lead to its adoption earlier than absolute necessity would require.

The probability of the introduction of water supplies and the need of sewerage in the other towns of the upper basin, is too remote to warrant your Commission in investigating and suggesting the methods of disposal which they should adopt, when, if ever, the need of sewerage arises. Local nuisances, indeed, exist in some of these towns, but the remedy for them will consist, not in building sewerage systems, but in adopting some special treatment applicable to each case. Accordingly, examinations of the sewerage problem have been made only in the three towns above mentioned.

It is assumed that your Commission would not recommend any compulsory legislation requiring these three towns at once to build sewerage systems, and it is considered improbable that any of them would, of its own accord, adopt any such system at present. Whenever either of them desires to do so, it doubtless will engage some competent engineer to study the topography of the town and all the conditions affecting sewerage then and there existing, and to devise a system which will be most suitable, having regard to all the circumstances of the case. In the examinations made by myself at these towns, and the recommendations herewith submitted, the purpose kept in view has been merely to indicate the general principles in accordance with which the sewage should be disposed of. Heretofore, in Massachusetts, it generally has been considered sufficient in devising sewerage systems to discharge the crude sewage into some water course. I assume that for the future it will be considered necessary to purify sewage somewhat before discharging it into any but very large bodies of water not used as sources of water supply. In designing the plans herewith submitted, the topography of the several towns has been cursorily examined, in order to find some practicable line for an outfall sewer, which should reach land suitable for sewage purification. It is not claimed that the only, or even the best, places for such treatment have been ascertained, but the plans submitted show the principles which underlie such work, and may be useful as suggestions, even if entirely modified by the engineers finally employed by the towns.

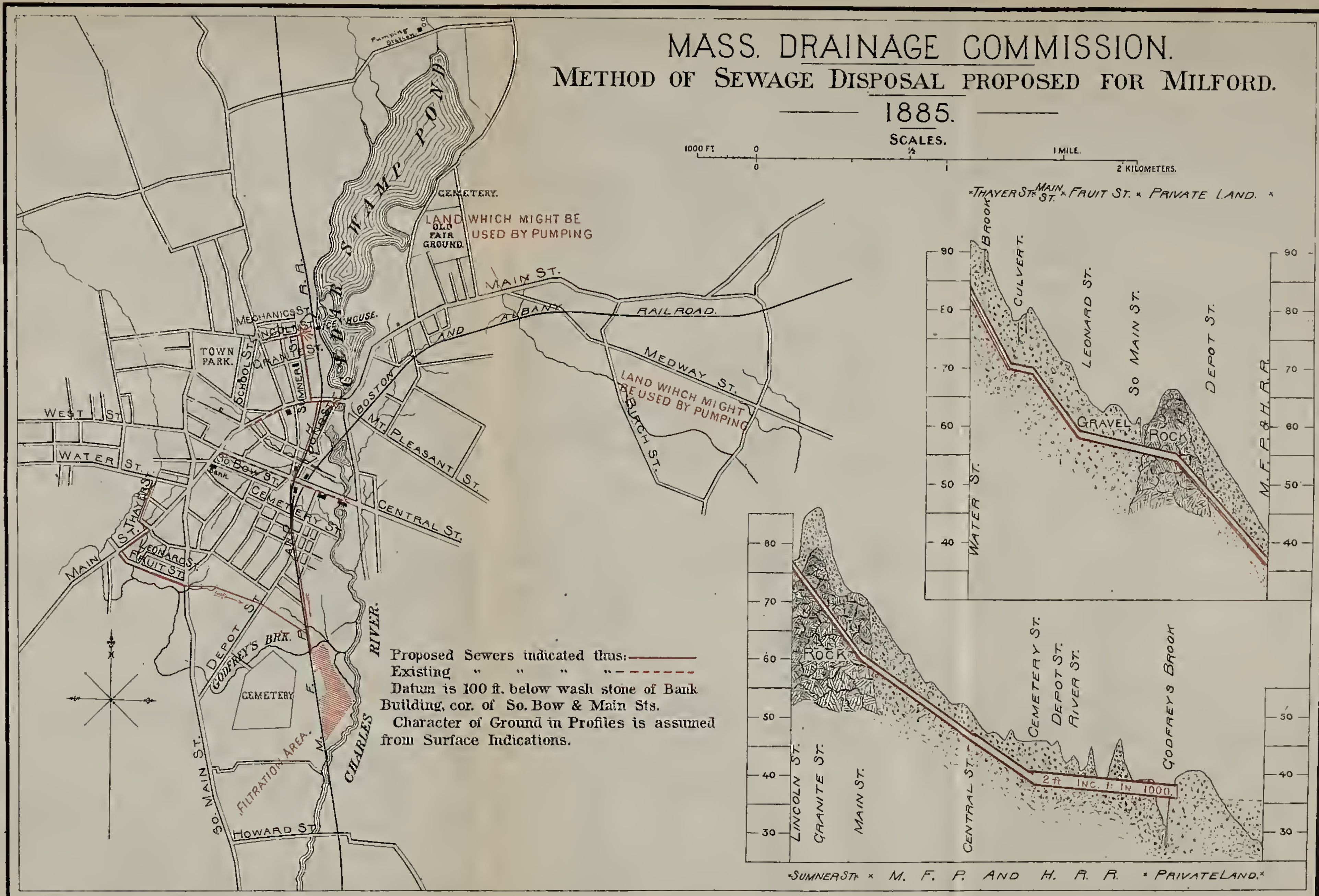
SECT. 125. *Proposed system of sewage disposal for Milford.* — In order to remedy the evils already existing at Milford, it will be necessary to abandon the present sewer outlet at Main Street, which causes a nuisance, and build an intercepting sewer to convey the sewage to some point where it can be disposed of without doing any harm. This intercepting sewer should be so located as conveniently to be reached by small pipe sewers, running down from all parts of the town. Where can the sewage be disposed of so that it will do no harm?

It would cause no further nuisance to Milford if it were simply turned in a crude state into Charles River, say half a mile below the settled portion of the town. If it were thus disposed of, however, it would in time foul the river water, and would be apt to cause trouble at South Milford, Bellingham and Medway. This might lead to complaints, or even to lawsuits and injunctions. Moreover, the water of Charles River is finally used for drinking, and in view of the little that is definitely known concerning the distance to which sewage, and the disease germs which are sometimes contained in it, must flow before becoming innocuous, it does not seem right that the river should be thus contaminated.

Surveys were made to ascertain whether it would be practicable to build an outlet sewer which should cross the divide bounding the Charles River basin and discharge into Mill River, a tributary of the Blackstone, which river is not used as a source of domestic water supply. It is by no means certain that crude sewage could be discharged continuously into Mill River without causing trouble. The length of sewer beyond Milford necessary to reach this outlet would be about three miles. The divide at one place is unusually low, but still in its neighborhood, for a distance of 3,000 feet, the depth of excavation required would average 25 feet. This project was considered impracticable, chiefly on account of its great cost.

I assume, therefore, that the sewage must finally reach Charles River, and must be purified before entering that stream. As explained in Part II, the only way in which purification can be accomplished is by intermittent filtration through five or six feet of porous soil. To find a suitable place of disposal we therefore must look for areas of porous land, whose surfaces are at least six feet above neighboring watercourses. Unfortunately, the surface of a small part of the town, near the depots and between them and the river, is not itself more than five feet above high water in the river. As the sewers hereafter built to serve this portion of the town must be several feet below the surface of the ground, it is evident that the sewage from them could not flow by gravitation upon any land high enough to be used for purification. If, then, the sewage from the whole of the town is to be collected at one point and conveyed to a single place of purification, it will be necessary to force it to that place by pumping. If the sewage is pumped, there are several areas of land which might be procured for disposing of it by filtration.

One of these is the Charles River Riding Park, or Old Fair Grounds, owned by William Knowlton of Upton. This tract contains about 20 acres, assessed at $100 per acre. The ground would require some grading to level it properly. The soil consists of sand and gravel, and is sufficiently porous. The average elevation of the surface of this land is about 40 feet higher than the elevation of the point to which the sewage from the whole town could flow by gravitation. Consequently the sewage would have to be lifted to this height by the pumps, and the length of iron force main required to reach this tract would be about one and a quarter miles. There are two objections to selecting this land. There are a good many houses within a few hun-


MASS. DRAINAGE COMMISSION.
METHOD OF SEWAGE DISPOSAL PROPOSED FOR MILFORD.
1885.
SCALES.
1000 FT 0 ½ 1 MILE.
0 1 2 KILOMETERS.
Proposed Sewers indicated thus:
Existing " " " "
Datum is 100 ft. below wash stone of Bank Building, cor. of So. Bow & Main Sts.
Character of Ground in Profiles is assumed from Surface Indications.
SWAMP POND
CEMETERY.
LAND WHICH MIGHT BE USED BY PUMPING
OLD FAIR GROUND.
MAIN ST.
BOSTON AND ALBANY RAILROAD.
MEDWAY ST.
LAND WHICH MIGHT BE USED BY PUMPING
BIRCH ST.
MT. PLEASANT ST.
CENTRAL ST.
MECHANICS ST.
LINCOLN ST.
ICE HOUSE.
TOWN PARK.
SCHOOL ST.
GRANITE ST.
SUMNER ST.
WEST ST.
WATER ST.
So. Bow ST.
Bank
CEMETERY ST.
THAYER ST.
MAIN
LEONARD ST.
FRUIT ST.
DEPOT ST.
GODFREY'S BRK.
CEMETERY
RIVER.
CHARLES
FILTRATION AREA.
SO. MAIN ST.
HOWARD ST.
THAYER ST. MAIN ST. FRUIT ST. PRIVATE LAND.
BROOK
CULVERT.
LEONARD ST.
SO MAIN ST.
DEPOT ST.
WATER ST.
GRAVEL
ROCK
M. F. P. & H. R. R.
ROCK
LINCOLN ST.
GRANITE ST.
MAIN ST.
CENTRAL ST.
CEMETERY ST.
DEPOT ST.
RIVER ST.
GODFREY'S BROOK
2 ft INC. 1 IN 1000.
SUMNER ST. M. F. P. AND H. R. R. PRIVATE LAND.

dred feet of it, and perhaps fifty within a third of a mile. If the filtration were properly managed, I think that no damage would be caused to the neighboring residents; but doubtless danger would be apprehended by them, and occasionally, on muggy evenings, they might notice a slight smell. Again, the purified effluent from this land naturally would go into Cedar Swamp Pond, where the supply of ice for the village is procured. If the farm were badly managed and purification at times should be incomplete, some danger might arise from this source.

Another available tract of land consists of portions of the farms of Norcross, Spaulding and Cook, lying south of the Medway road, about three-quarters of a mile east of the riding park. From thirty to forty acres could be procured here, which are assessed at an average of $45 per acre. The land is fairly porous, with occasional bowlders and ledge, and would not require much grading to fit it for its purpose. There are no settlements near the land, and the effluent would go into small brooks which join Charles River in Medway. To reach this land would require a lift of 35 feet, and a force main about two miles long.

Another tract considered was the farm owned by Wm. S. Wilkinson, about a mile south of the village, near the South Milford road. The farm contains 24 acres, assessed at $50 per acre. Probably 15 acres could be utilized for filtration. The land seems to be porous, and is remote from dwellings. The effluent would go by a brook into Charles River at a point a mile or two below the village. If the force main to this land were carried through private grounds, the lift required would be about 16 feet, and the distance would be about a mile.

An objection which applies equally to the use of any of these tracts, is the very considerable expense entailed in pumping the sewage to them. A pumping station, with pumps and other necessary machinery, hardly could be built for less than $20,000. It would be necessary that the machinery should be in duplicate, in order that there might be no intermission in the pumping while making repairs. The yearly cost of pumping, including wages, fuel and repairs, would not be less than $3,000, and might exceed that sum. At the present rates for municipal loans, this represents the interest on from $75,000 to $100,000. This expense would be avoided if pumping could be dispensed with.

Sewage from nine-tenths of the town could be collected by gravitation at an elevation of from six to ten feet above the level of the water in the river, and could be disposed of on land at that elevation if any suitable areas existed. I was unable, however, to find any such within accessible distance. The meadow lands near the river are too low to be under-drained five feet deep, as would be necessary for efficient filtration, and from the meadow the land rises rapidly to heights which could be only reached by pumping. An area of sufficient extent and at a suitable elevation, however, could be prepared by grading at an expense which would not exceed $10,000. It is true that sewage from the low district, near the depot, could not by gravitation reach any land thus prepared; but that district contains few inhabitants, and should sewers ever be needed there the daily amount of sewage would be very small. If need be, it could be conducted to a tank located near one of the factories using steam, and an arrangement made by which it should be pumped every day about 10 feet high into the sewer leading to the filtration area. All things considered this plan seems to be, not the best but the most expedient to be adopted by Milford, because it is by far the least expensive.

The tract of land which seems to be most suitable for conversion into a filtration area, on account of its accessibility, remoteness from habitations, character of soil and the facility with which it can be graded, is that comprising portions of the Whitney, Nugent and Wilkinson estates, bounded by the M., F., P. and H. Railroad, Charles River and Godfrey's Brook. This land lies east of Vernon Grove Cemetery, and is about three-quarters of a mile south of the village. It is assessed at from $40 to $70 per acre. Fifteen acres would be amply sufficient for many years, and could be prepared by grading from the higher parts of the land down to the lower, moving in all about 40,000 yards of earth. The earth to be moved is sand and gravel, with occasional bowlders, and the cost of grading should be less than 25 cents per yard. The position of this tract of land, and the routes of the principal intercepting sewers to convey the sewage of the town to it, are shown upon the accompanying plan. (Plate XVII.) These sewers can be conveniently reached by branch pipe sewers (costing from $5,000 to $8,000 per mile), from all parts of the town, except the low district before referred to, between the river and the railroad. As will be seen, one sewer starts on Sumner Street near the present outlet of the Lincoln Street sewer, and crossing Main Street near the present outlet of the Main Street sewer, follows the line of the M., F., P. and H. Railroad, to the filtration area. Another sewer, starting at Water Street, follows Thayer, Main and Fruit streets, and finally joins the sewer first mentioned. As explained in section 99, it will be necessary to exclude all rain water from the sewage which is to be purified. The connections with the sewers already built should be so modified as to keep rain water from entering them, or, if thought preferable, the old sewers should be used solely for the purpose of removing rain water, and should be duplicated by small pipe sewers, to which the house sewage now entering them should be diverted. In the latter case the present sewer outlets could be retained, as the discharge of rain water only at these points would not be objectionable. On the succeeding page is given an approximate estimate of the cost of building the system as proposed, and as shown by the plan.

SECT. 126. *Approximate Estimate of Cost, Milford.*

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	REMARKS.
Main interceptor, Summer St., from Mechanics St. to Main St.,	10-inch,	12	1,500	$1 00	$1,500	Chiefly sand and gravel.
Along railroad, Main St. to Central St.,	12 "	10	2,000	1 25	2,500	Chiefly sand and gravel.
Central St. to Cemetery St.,	15 "	8	1,000	1 50	1,500	Chiefly sand and gravel.
Cemetery St. to field,	24 "	8	2,500	2 50	6,250	
West side interceptor, Main St. to Fruit St.,	12 "	9	1,600	1 25	2,000	
Fruit St. to main sewer,	15 "	10	3,600	1 80	6,480	600 feet of rock cut.
Land and other damages,					500	
Cost of filtration area,					1,200	
Grading and preparation,					13,000	
Engineering and contingencies, 15 per cent.,					5,239	
Total,					$40,169	

SECT. 127. *Proposed system of sewage disposal for Franklin.* — It would be entirely impracticable to convey the sewage of Franklin for disposal outside the Charles River watershed. As it must, therefore, finally go into water afterwards used for drinking, it should be purified as thoroughly as possible before being discharged. Such purification can be best effected by filtration through aerated soil. The topography of Franklin will render somewhat difficult the bringing of the sewage to one point. The main village, which is the only portion of the town likely to need sewerage, is situated on a divide separating the watersheds of two principal tributaries of Charles River; namely, Mine Brook and Mill River. The only practicable focus to which the sewage from nearly the whole of the village could be brought, is about the corner of Union and Cottage streets. The sewage from the town sewer in Main and Depot streets, and that from the drain from Dean Academy, all of which now goes in the opposite direction to Mill River, can be brought to this focus by a sewer following along the location of the New York and New England Railroad. Sewage from that portion of the village on the other side of the divide can be collected and brought to the same point by a sewer starting at the Catholic church and following Union Street. That from the district southeast of the railroad would reach the focus through Cottage Street. Having collected the sewage, the next problem presented is to find a tract of land on which it can be purified by filtration. The amount of sewage to be provided for would be about the same as that of the water supply. At present this is only about 30,000 gallons per day, but within a few years it probably will increase to 100,000 or 200,000 gallons. From five to ten acres of good porous land would be ample to dispose of this amount by intermittent filtration. To avoid pumping, the land must be so low that the sewage can flow to it by gravitation, and to save expense it should be not far from the corner of Cottage and Union streets. To avoid any possible chance of contamination of the town water supply, the land should not be near the pumping well in the valley of Mine Brook. These considerations somewhat limit the choice of locations. Under the circumstances, the land which seems most available is that known as the Beet Sugar Company's grounds, southwest of the village and north of the railroad. The soil is gravelly, but its surface is so broken that considerable grading will be necessary to fit it for the purpose. By moving about 30,000 cubic yards of earth, at an expense not exceeding $7,500, level filter-beds, which can be under-drained six feet deep, can be prepared over an area ten acres in extent. The scheme as proposed is indicated upon the accompanying plan. More extended examinations and studies by an engineer devoting his whole attention to the subject, very possibly might suggest modifications and improvements in this plan. In the following section is given an approximate estimate of the cost of building the sewerage works indicated on the plan.

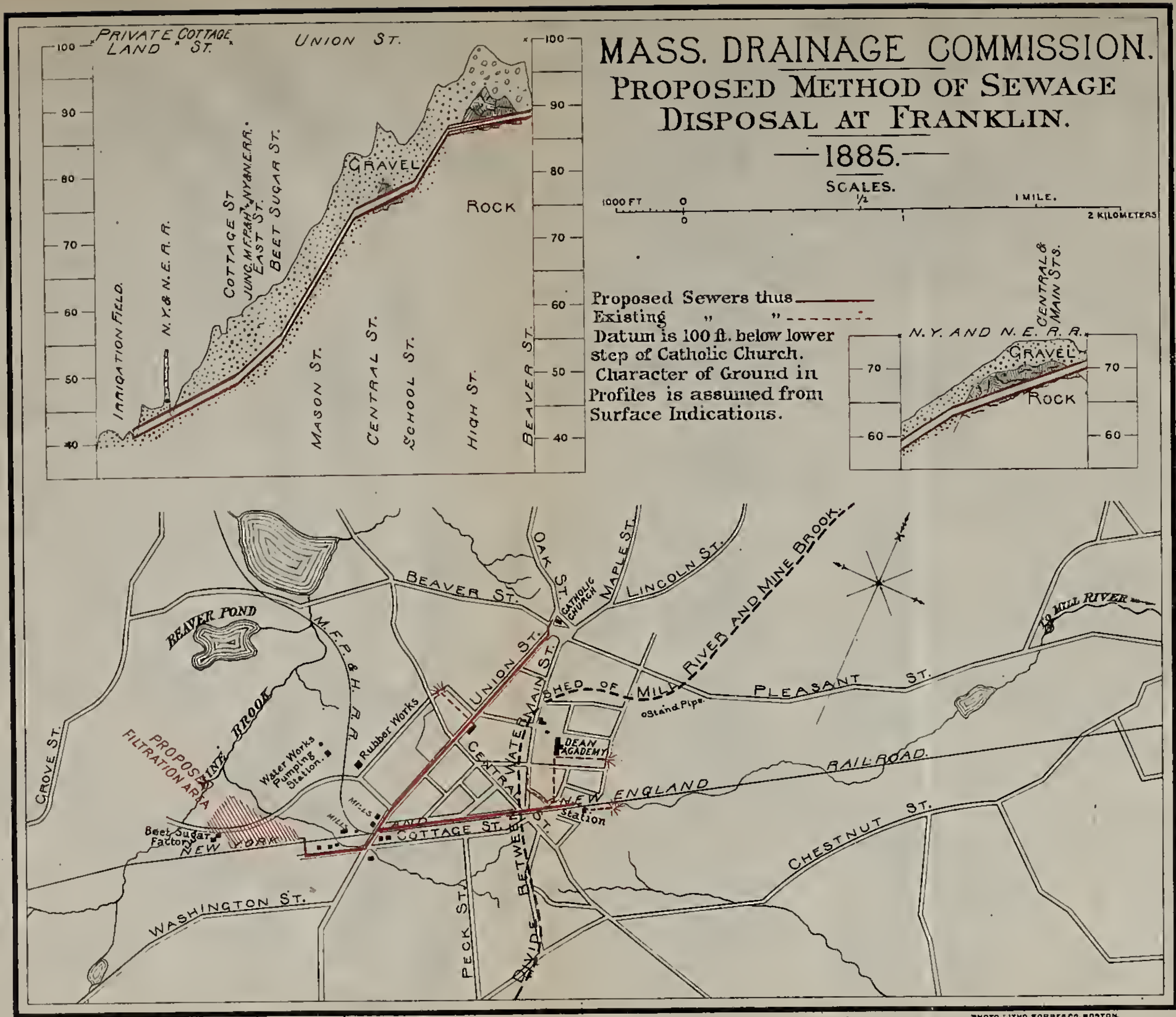


PHOTO LITHO. FORBES CO. BOSTON.

SECT. 128. *Approximate Estimate of Cost, Franklin.*

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	REMARKS.
Main sewer in Union St., Beaver St. to School St.,	10-inch,	9	1,900	$1 00	$1,900	Chiefly sand and gravel.
School St. to East St.,	12 "	9	2,200	1 25	2,750	Chiefly sand and gravel.
East St. to Cottage St.,	15 "	9	400	1 50	600	Chiefly sand and gravel.
Sewer along railroad, from town sewer to Union St.,	12 "	6	3,000	1 25	3,750	
Cottage St. to filtration area,	15 "	9	1,600	1 50	2,400	
Land and other damages,					500	
Cost of land,					750	(Say) 10 acres at first.
Preparation of land,					9,500	
Engineering and contingencies, 15 per cent.,					3,306	
Total,					$25,456	

Sect. 129. *Proposed system of sewage disposal at Wellesley.* — As before stated, it is improbable that sewerage will be needed at Wellesley for many years. The only reason for making examinations and suggestions in regard to the sewerage problem at this place is that, as every town which has adopted a public water supply is tending steadily, if slowly, towards a final need of sewerage, the rule was laid down at the outset to make such examinations at every place in which a water supply had been introduced.

This town drains naturally in two opposite directions, southwest and northeast, into two different portions of Charles River. The divide separating these two watersheds is nearest to the lower portion of Charles River on the northeastern side of the town. Omitting the village at Newton Lower Falls, nearly the whole of the more thickly settled portions of the town is within the watershed of a brook, the main branch of which nearly bisects the town and runs in a southwesterly direction, parallel to and east of Washington Street, until it joins the Charles River opposite Dover. Any main sewer built to receive branches from different parts of the town of necessity must follow the low land near to this brook. From the upper end of such a sewer, at the corner of Walnut and Washington streets, to its lower end, near Charles River, would be nearly three miles. Different portions of the sewer would have different rates of inclination, the least of which would be a little less than one in 500. With this slope a 15-inch pipe will deliver 1,500,000 gallons daily, and probably would be as large a sewer as it would be expedient to build. The sewage having been thus collected at a point near the junction of the brook with the river, the next question is, what to do with it. It could not be turned in a crude state into the river, because that would endanger water supplies below, and would violate the Public Statutes. It, therefore, must be first purified by filtering it through porous land. This land should be selected, if possible, not far from the lower end of the sewer, in the vicinity of or west from Dover Street. Much expense would be avoided if the sewage could flow by gravitation to the land on which it was purified. I have failed, however, to find any suitable areas, at the same time low

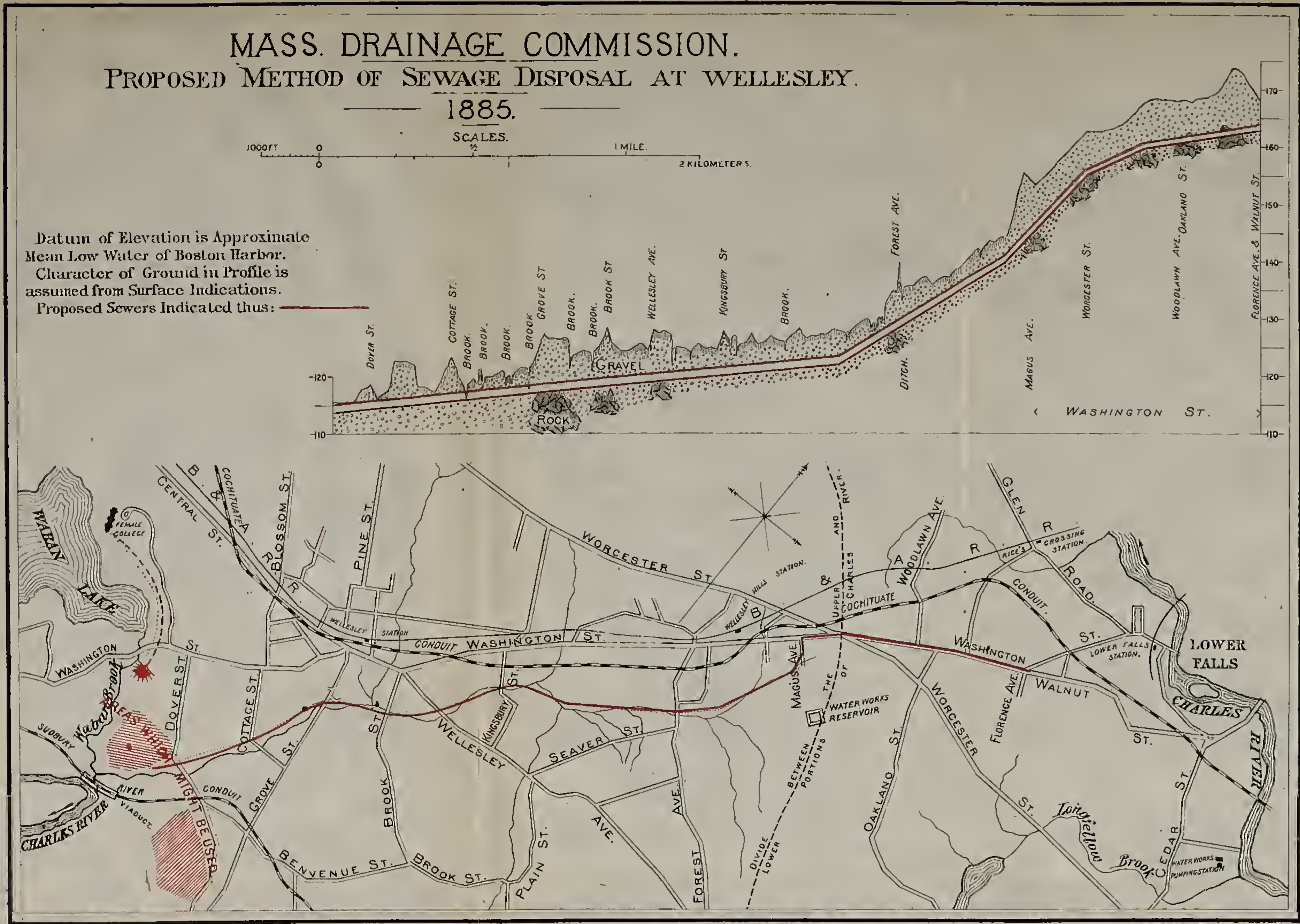


PHOTO LITHO FORBES CO. BOSTON.

enough to be reached by gravitation and high enough above the river to be underdrained six feet deep, which would be necessary for effective purification. It is probable, therefore, that pumping will have to be resorted to. If this is done, there are several tracts near the end of the sewer which could be used for filtration. It would require a more careful examination than I have been able to give, to decide which of these tracts it would be best to select; and the question of choice may be much affected by new conditions arising before a selection becomes necessary. It is not possible from the present data to make an accurate estimate of the probable cost of collecting and disposing of the Wellesley sewage by the method indicated on the accompanying plan. The following is a rough approximation: —

14,000 feet pipe sewer at $1.10,	$15,400
Land and special damages,	2,000
Pumping station and plant,	20,000
Force main,	5,000
Filtration area (say),	2,000
Preparation of land,	5,000
Engineering and contingencies, 10 per cent.,	4,940
Total,	$54,340

The Sudbury and Cochituate Basins.

Sect. 130. *General considerations.*—From the investigations made in these districts, whence the water supply of Boston is taken, and also those of Natick, Framingham, Westborough, Cochituate village and Sherborn Prison, it appears that a need for sewerage now exists at Natick, South Framingham, Marlborough and Westborough, and that the lack of it at these places endangers the purity of Boston's water supply. That the supplies of Natick and Framingham also are subject to pollution. That the drainage from the Women's Prison at Sherborn may be a source of danger. That in the greater part of Framingham and in Wayland, Ashland, Southborough and Hopkinton no present need of sewerage is felt, nor is the danger of pollution of the water supplies very apparent. The towns which need sewerage are somewhat widely separated, so that it would be too expensive for them to combine in building a single system of sewerage. They are too remote from the sea to be able to discharge their sewage into it, and even if it were practicable to find outlets into water courses which are not tributary to the Boston supply, it would not be advisable to turn crude sewage into such water courses, on account of the danger of causing nuisances in the future to towns situated below the outlets. Clarified sewage could be discharged into streams outside the basin without danger of causing a nuisance, but the process of clarification would be very expensive. Purification on land is the cheapest practicable method of disposal which such towns can adopt. Where it is possible to select areas of land for purification, so situated that the effluent can be diverted outside the basin, it will be expedient to do so, because then the discharge of sewage which is not completely purified will not be in violation of the Public Health Act, and will not subject the towns to vexatious suits and injunctions.

It may be useful here barely to mention a scheme which is not worthy of serious consideration, but has been often referred to in newspaper articles. It has been said that the State should build a trunk sewer, to be used by the towns between Worcester and the sea, connecting with the Boston Main Drainage works. It might be possible to find a location for such a sewer, but it evidently would be very difficult, since the line would cross the high divides separating the Blackstone, Sudbury and Charles River watersheds. Tunnelling far below the surface would be necessary at such places, and as the course of the sewer must meander in following the most favorable lines, its length would not be less than 50 miles. It would cost fully as much as did the conduit which brings water from Sudbury River to Boston. The engineer's estimate of this was $200,000 per mile, but the cost was somewhat less. Supposing that the sewer could be built for $150,000 per mile, this would amount in the aggregate to $7,500,000. Where the sewer passed through or near to intermediate towns, it might receive small branch sewers which could be built at moderate expense from such places. But to bring the sewage from a town only five miles distant from the trunk sewer, would cost about $100,000, or more than commonly would be needed for separate disposal near the town. This scheme, if it could be carried out, would accomplish what can be done otherwise for one-eighth as much money, and it may be said of it that it only is not impossible in the sense that nothing is impossible with enough time and money.

SECT. 131. *Proposed sewerage system for Natick, South Framingham, Sherborn Prison and Ashland.* — Natick and South Framingham are so situated with respect to each other, that it will be cheaper for them to unite in constructing a joint system for the disposal of their sewage than it would be if each built works separately. Such a system also can be conveniently reached by a sewer from Sherborn Prison, and also by one from Ashland when the need of it is felt. As stated in the previous section, the only method of disposal which is practically available, is to purify the sewage by applying it to land so situated that the effluent will not flow into water within 20 miles above where such water may be taken for a public water supply. This precludes the use of land within the Charles River basin, or any within the watershed furnishing water to Boston. Plate XX shows the position of this watershed in the neighborhood of Natick and Framingham. It will be seen that the dividing ridge is nearest to these towns at a point nearly opposite to and west from the middle of a line joining them. At this point also the ridge is lower than at most others, so that water from one valley can be diverted to the other with less lift than at any other place. The land beyond the ridge is reasonably flat and porous, and therefore suitable for the purification of sewage. An examination of all the land near to the watershed and outside of it, showed that the tract selected and indicated on the plan was the most accessible, and all things considered the most suitable, to use for purifying the sewage of Natick and South Framingham. A scheme therefore has been designed by which the sewage from those places is to be brought to a common pumping station, and thence forced to the land referred to, to be purified by filtration, the effluent escaping into Sudbury River below where its waters are taken by Boston. The following is a description of the proposed works. The described sewers are merely intended to furnish outlets for the town systems, which, it is assumed, will be built by the towns themselves.

In Natick the upper end of the sewer is in Washington Avenue opposite the end of Cochituate Street, just north of Pegan Brook. This is the lowest part of the town, and can be reached from any part of the main village, and from the village of Felchville if necessary. The sewer is to be of brick, 2 feet in diameter, with an inclination of 1 in 1,500, and will have a discharging capacity of over 3,000,000 gallons per day. The sewer follows the northerly side of Pegan Brook to the junction of Bacon's Brook, where it turns to the left and crosses the Boston & Albany Railroad to West Central Street, and continues in this street to Mill Street. For a distance of about 2,000 feet, where the street crosses Lake Cochituate, its surface is so low that the sewer will be about 2 feet above the street. At this place it is proposed to construct the sewer of iron water pipes, supported on trestles placed on the northerly side of the street, and boxed in as a protection against frost. The pumping station is located at Mill Street just north of the railroad, about 8,500 feet from the point of beginning.

The sewer from Framingham is intended to start in Waverly Street at Concord Street. It is to be a 2 feet by 3 feet egg-shaped brick structure with an inclination of 1 in 1,000 throughout its entire length. It is located in the lowest part of the village, so that it can be conveniently reached from the surrounding territory. It is to be built eastward in Waverly Street to Beaver Dam Brook, the easterly side of which it follows to the railroad and across it. Thence it is located in private land just north of the railroad to the pumping station at Mill Street.

At the pumping station are to be provided two pumps, with boilers and other appurtenances, each pump capable of raising 1,000,000 gallons of sewage in twelve hours to a total height of 35 feet. As the sewers will have a storage capacity of about 500,000 gallons, which equals the present daily supply of sewage from the two towns, it will not be necessary to run the pumps during the night, and the services of a night attendant can be dispensed with. The force main

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PLAN SHOWING PROPOSED SYSTEM OF SEWAGE DISPOSAL FOR NATICK, SOUTH FRAMINGHAM, ASHLAND AND SHERBORN PRISON.

— 1885 —

from the pumping station to the filtration area is to be a light 16-inch iron pipe, laid partly in Mill Street and partly across private land to the field north of Hartford Street. It is proposed to purchase about 50 acres at this place, and to lay out a part of it for present use. The land is valued at about $100 per acre. About twenty borings made in different parts of the field show that the character of the ground is gravelly, and well fitted effectually to purify the sewage at all times. The effluent will flow through a brook into Sudbury River at Saxonville.

South of Hartford Street is a large tract of land partly devoted to market-gardening. This land is crossed by the force main. It is well adapted for receiving sewage, but as it is within the Cochituate watershed, it was not thought wise to use it as a filtration area. During the summer months, however, when the land is under cultivation, sewage can be drawn from the force main and applied to the crops in such quantities as to be wholly taken up by them, and probably to their great benefit. Should such use of the sewage prove to be very advantageous, it is possible that the farmers might be able to pay for it as much as those in Arlington do for pure water, as mentioned in section 12.

As heretofore stated, owing to the inadequacy of the filtration area at Sherborn Prison, the effluent from it, amounting to 30,000 gallons per day, has been found to be imperfectly purified. As the cheapest remedy for the pollution of Lake Cochituate from this source, it is proposed to build a drain to bring the prison sewage to the before described sewer in South Framingham. This drain, which will consist of an 8-inch pipe, will start at the present 6-inch outlets, near the prison, and with an inclination of 1 in 100 will follow the old railroad location to Irving Street. Following Irving Street with an inclination of 1 in 1,500, the drain passes above the Sudbury River conduit, at which point an iron pipe with lead joints will be substituted. Turning into South Street, the sewer reaches the Framingham sewer at Waverly Street. The total distance from the prison to Waverly Street is about 4,500 feet, but about 1,500 feet of the lower portion of the sewer in South and Irving streets will serve a portion of the village as a common sewer.

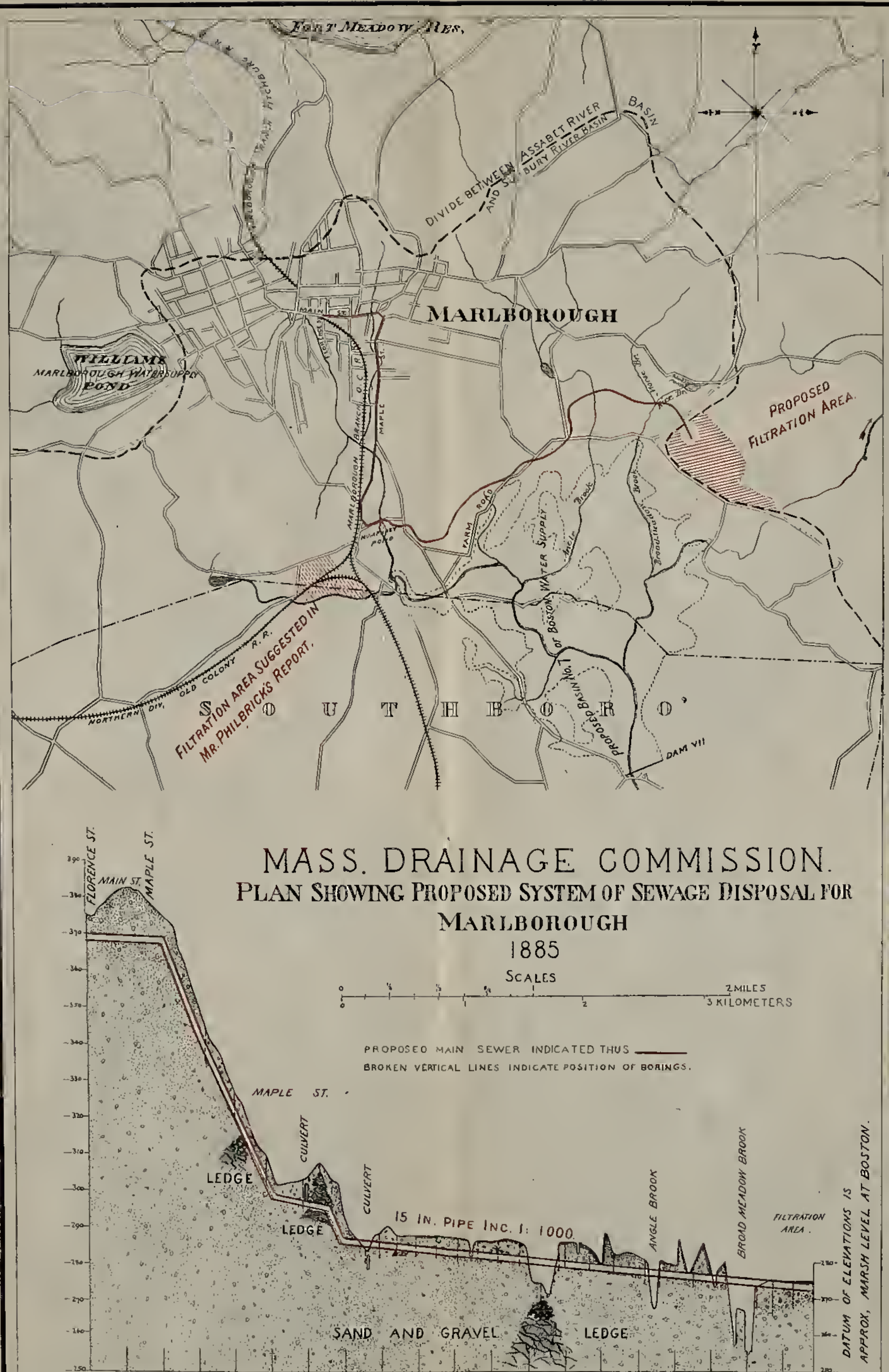
Whenever it shall be thought necessary to provide a sewerage system for Ashland, such system can find an outlet by the building of a main sewer to connect with the Framingham sewer. The distance will be about 12,000 feet, and surveys show that a practicable line for a sewer with fair inclination exists. In building a town sewer from the main sewer up Waverly Street in the direction of Ashland, this contingency should be borne in mind, and the sewer should be large enough to receive eventually the Ashland sewage. Probably a 15-inch pipe would be ample for the purpose.

SECT. 132. *Estimate of cost.* — The following is believed to be a liberal estimate of the cost of all the works needed to dispose of the sewage from South Framingham, Natick and Sherborn Prison. It is based on present prices for labor and materials. It is assumed that the town systems to connect with these sewers will be designed and built by the towns themselves. Such systems, as they cannot receive rain, will consist mainly of small pipes, and the cost of them should not much, if at all, exceed $6,000 per mile. It will be necessary either to disconnect the street catch basins from the Framingham sewers already built, or to duplicate such sewers by pipes with which the house drains may be connected, leaving the old sewers to discharge surface water into Beaver Dam Brook, as heretofore. The yearly cost of maintaining the pumping station and the filtration area should not much exceed $3,000.

Estimate, — Natick, South Framingham and Sherborn Prison.

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	REMARKS.
Natick to pumping station at Mill Street,	2 ft.	6	8,500	$3 30	$28,050	Sand and gravel, 2,000 feet iron pipe.
Land damage, 2,500 running feet,	. . .	. .	. . .	. . .	1,000	
South Framingham to pumping station,	2 ft. × 3 ft.	9	10,300	3 95	40,685	Sand and gravel.
Land damages, 4,000 running feet,	. . .	. .	. . .	. . .	2,000	
Pumping station and pumps,	. . .	. .	. . .	. . .	20,000	
Force main in Mill Street and private land,	16-in. water pipe.	4	4,500	2 50	11,250	
Irrigation field, say,	. . .	. .	. . .	. . .	10,000	
Preparing part of field,	. . .	. .	. . .	. . .	6,000	
Sherborn Prison, from screen tank to main sewer, corner Waverly and South streets,	8 in.	5	4,500	80	3,600	Sand and gravel.
Engineering and contingencies, 10 per cent.,	. . .	. .	. . .	. . .	12,258	
					$134,843	

Sect. 133. *Proposed system for Marlborough.* — The sewerage system now under consideration for Marlborough seems to be unobjectionable except as regards the place at which it is proposed to purify the sewage. The main sewer extending through Main and Maple streets will best provide for present emergencies, and can be reached from most of the town as it becomes necessary to extend branch sewers. Part of the town south of Main Street, too low to drain into that sewer, eventually will need other sewers along the brook lines to join the main in Maple Street below Howe Street. From all of the land under consideration for purifying the sewage, the effluent would, within four miles, flow into Basin No. 3 of Boston's water supply. To avoid the danger to this water supply from possible occasional imperfect purification, and the consequent danger to Marlborough of suits and injunctions on that account, it is desirable to obtain, if possible, an area for purification so situated that the effluent will not be discharged within 20 miles of a public water supply. If this be done, even if the process of purification proves to be incomplete, the Public Health Act will not thereby be violated. Examinations have shown that the most accessible tract of land suitable for sewage filtration, and outside the basin furnishing Boston's water supply, is that situated about two miles east of the centre of the village, between the Farm Road and the road to Framingham. About 40 acres of gently sloping land are available here. The land can be reached by gravitation, is porous, and the effluent will be discharged into a stream running through Hagar's Pond and Larnum Brook to Sudbury River in Wayland, below the intake of Boston's water supply. The distance from the town to this field, by a practicable sewer line, is about 11,000 feet more than that to the field recommended by Mr. Philbrick in his proposed sewerage scheme. The main outlet sewer recommended in that scheme was a 15-inch pipe. For laying a 15-inch pipe for an additional 11,000 feet, $2 per foot would be an ample price. An additional expenditure of $22,000, therefore, would dispose of the sewage without danger of polluting Boston's water supply, and would relieve the town from all liability to contentions on that account. The area of land available is some-



MASS. DRAINAGE COMMISSION.

PLAN SHOWING PROPOSED SYSTEM OF SEWAGE DISPOSAL FOR MARLBOROUGH

1885

SCALES

0 ¼ ½ ¾ 1 2 MILES

0 1 2 3 KILOMETERS

PROPOSED MAIN SEWER INDICATED THUS

BROKEN VERTICAL LINES INDICATE POSITION OF BORINGS.

what larger, and its value per acre is only about half as much. It therefore is recommended that the sewage of Marlborough be disposed of by intermittent filtration at this place.

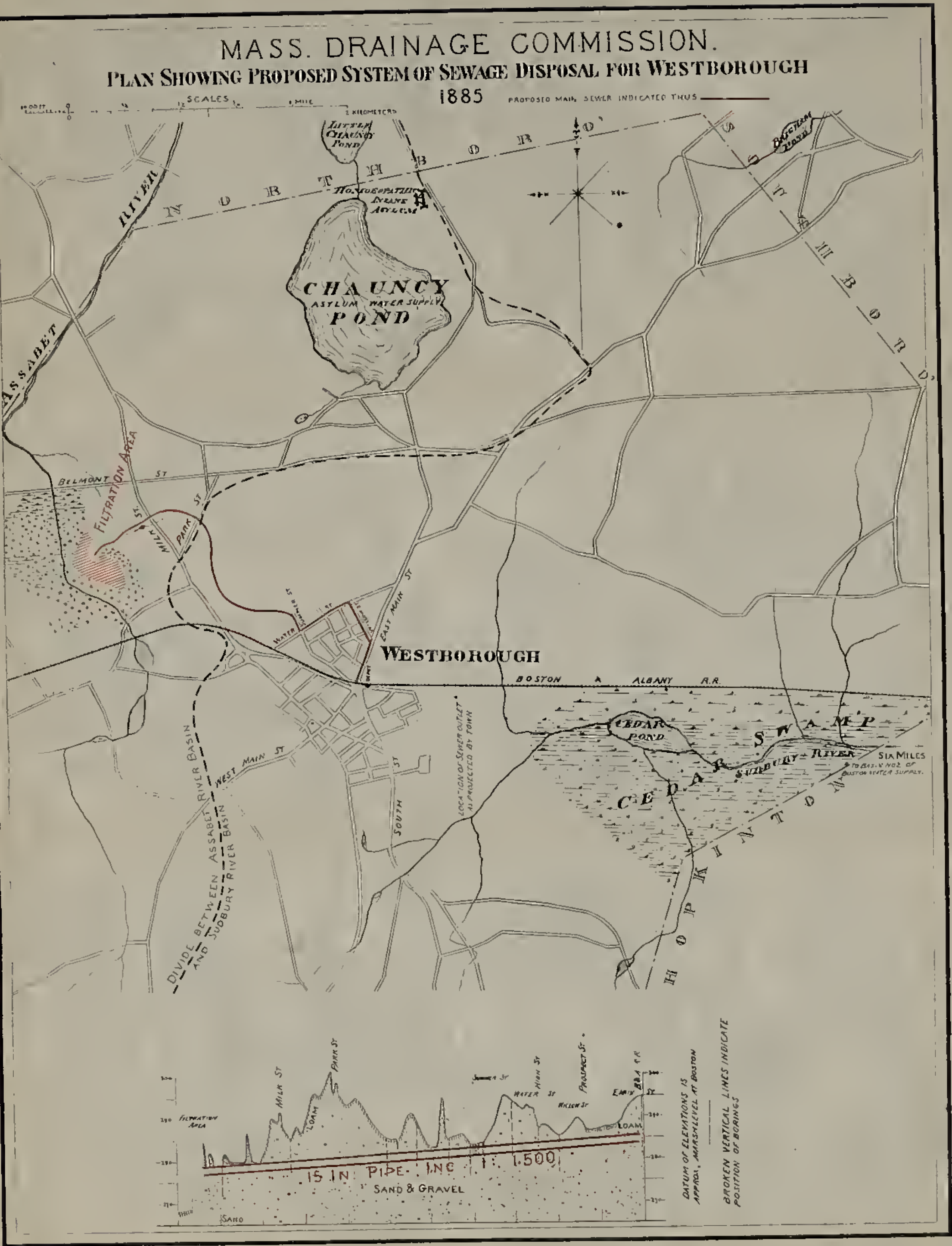
On Plate XXI is given a plan and profile of the main sewer of the proposed scheme. The upper end of the sewer is on Main Street at the corner of Florence Street. The sewer is a 15-inch pipe, with its bottom at this point about 7 feet below the surface, and laid at an inclination of 1 in 1,000. The sewer follows Main Street to Maple Street, and that street to a street turning to the east just north of Humphrey's Pond. So far, the location is identical with that recommended by Mr. Philbrick and adopted by the town authorities. Leaving Maple Street, the new line, as indicated on the plan, is located chiefly in private land on either side of the Farm Road. A somewhat circuitous route has been adopted for the purpose of preserving a uniform inclination of 1 in 1,000 without deep cutting, and also, in order that the sewer shall not rise above the surface of the ground more than is unavoidable. As it is, the sewer will be above the ground at three places. The first of these is between the estates of George Bigelow and E. L Fay, where for a distance of about 1,000 feet, in order to avoid rock excavation, an iron pipe supported on trestles about 5 feet high, along the side of the road, will be substituted for the ordinary earthenware sewer. If the pipe is protected by a wooden box, no trouble on account of freezing need be anticipated. Similar methods of construction will be necessary where the sewer crosses Angle Brook and Broad Meadow Brook. The sewer enters the irrigation field at a knoll, and the immediate outlet is well above the surface of the land. The area which it is proposed to acquire at first, comprises 40 acres assessed at about $40 per acre, and is divided among three estates. The most valuable of these, containing 14 acres on which are a house and barn, is assessed at $2,000 and is in the market for $3,000. A house probably would be needed so that those managing the filtration areas might live on the premises. Seventeen borings and two test pits have been made in different parts of the field. As a rule, the soil consists of 3 feet of sandy loam, below which is 2 feet of somewhat fine white sand, then a few inches of very fine silt, and finally a bed of coarse gravel. It is probable that comparatively little underdrainage will be necessary, but it will be advisable to lay one main pipe drain along the edge of the field where it borders the road, to the ditch leading towards Hagar's Pond. For a short distance this ditch should be cleaned out and deepened, and the culvert under the road should be stopped off.

SECT. 134. *Estimate of Cost, Marlborough.*

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	REMARKS.
Main and Maple streets to Cork Street,	15 in.	11	2,200	$2 00	$4,400	Coarse gravel and bowlders.
Maple Street below Cork Street,	15 in.	7	4,800	1 50	7,200	Coarse gravel and bowlders.
Proposed extension east of Maple Street to field,	15 in.	5	13,000	2 00	26,000	
Land damages, say					2,000	
40 acres of land and buildings,					7,000	
Preparation of land,					10,000	
Engineering and contingencies, 10 per cent.,					5,660	
					$62,260	

SECT. 135. *Proposed system for Westborough.* — Without going into the question of Westborough's legal right to turn unpurified sewage into streams furnishing Boston's water supply, it is assumed that such method of disposal would be too objectionable to be adopted. Even admitting that the sewage might be so purified as not to endanger the purity of the water supply, the conditions and precautions necessary to insure this would be so difficult of attainment, that it would be much more satisfactory to dispose of the sewage outside of the watershed. This can be done at comparatively little increased cost. The following scheme has been designed, and is recommended for adoption. It is roughly indicated on Plate XXII.

As will be seen, the sewer starts near the centre of the town, where Main Street crosses the railroad. This point will be a convenient focus at which the town sewers can concentrate. The sewerage plan heretofore designed for the town can be altered so as to bring the sewage to this point, simply by reversing the inclination of the South Street sewer. At its upper end the proposed main sewer is 11 feet below the surface. This is low enough to be reached from all parts of the town, except marsh land, which is not liable to be much built upon, and is two feet lower than the head of the main sewer of the scheme previously contemplated. The sewer itself is a 15-inch pipe, and has an inclination throughout its whole extent of 1 in 1,500, and a discharging capacity of about 1,000,000 gallons per day. The sewer is laid in East Main, Willow, Water and Summer streets. Just beyond the culvert on the latter street, the sewer passes into private land and follows the line shown on the plan, crossing the divide at Park Street about half way between Milk and Belmont streets. At this point the excavation will be about 21 feet deep, but will not be very expensive, because not much water will be met with. The sewer continues westwardly to and across Milk Street to a gravelly knoll, which is nearly surrounded by the meadow land bordering Assabet River. The knoll is about 15 acres in extent; its highest point, near its centre, is about 17 feet above the general level of the meadow. From this high point the land slopes somewhat unevenly in all directions


MASS. DRAINAGE COMMISSION.
PLAN SHOWING PROPOSED SYSTEM OF SEWAGE DISPOSAL FOR WESTBOROUGH
1885
SCALES
PROPOSED MAIN SEWER INDICATED THUS
NORTHBOROUGH
SOUTHBOROUGH
HOPKINTON
ASSABET RIVER
LITTLE CHAUNCY POND
HOMOEOPATHIC INSANE ASYLUM
CHAUNCY POND
ASYLUM WATER SUPPLY
FILTRATION AREA
BELMONT ST
MILK ST
PARK ST
EAST MAIN ST
WESTBOROUGH
BOSTON & ALBANY R.R.
WEST MAIN ST
SOUTH ST
DIVIDE BETWEEN ASSABET RIVER BASIN AND SUDBURY RIVER BASIN
LOCATION OF SEWER OUTLET AS PROJECTED BY TOWN
CEDAR POND
CEDAR SWAMP
SUDBURY RIVER
SIX MILES
15 IN. PIPE. INC. 1 : 1.500
SAND & GRAVEL
LOAM
SAND
DATUM OF ELEVATIONS IS APPROX. MARSH LEVEL AT BOSTON
BROKEN VERTICAL LINES INDICATE POSITION OF BORINGS

until it falls to the level of the meadow. By excavating 33,000 cubic yards of gravel from the higher levels and moving them to the lower ones, a level area can be graded, 10 acres in extent, with its surface about 6 feet above the elevation reached by spring freshets. Such grading should not cost more than 25 cents per cubic yard. It is intended to have the sewer outlet at about the centre of the graded area and about 6 inches above its surface. The land is to be divided into four distinct beds, upon which the sewage can be turned in rotation. A small amount of underdrainage will be necessary. The effluent would finally reach Assabet River, either through ditches or by flowing over meadow land.

SECT. 136. *Estimate of Cost, Westborough.*

SECTION.	Size of Sewer.	Average Cut. ft.	Length. ft.	Approximate Cost per foot.	Total Cost.	REMARKS.
In East Main, Willow, Water and Summer streets,	15 in.	8	3,700	$1 80	$6,660	Sand, gravel and bowlders.
Through private lands to filtration area,	15 in.	10	6,640	2 25	14,940	Sand and gravel.
Land damages,	. . .	. .	. . .	. . .	3,000	
Purchase of filtration area, say	. . .	. .	. . .	. . .	1,500	
Grading and preparing land,	. . .	. .	. . .	. . .	15,000	
Engineering and contingencies, 10 per cent.,	. . .	. .	. . .	. . .	4,110	
					$45,210	

SECT. 137. *Proposed system for Hopkinton.* — The public water supply of Hopkinton is very small in amount, at present not exceeding 20,000 gallons per day; nor is there any probability of this amount increasing greatly in the near future. There seems, therefore, to be some reason in the opinion expressed by one of the selectmen, that the subject of sewerage for the town need not be seriously considered for more than ten years to come. On the other hand, in a part of the main village the buildings are close together, which is apt to make disposal in cesspools objectionable. It is more objectionable when the introduction of a public supply leads to a free use of water; and it may be stated as a general rule that such introduction is followed, sooner or later, by a desire for sewerage. Moreover, a few drains already connect with the water courses, and the discharge from these and from any which may be built hereafter must go into Boston's water supply. In view of these conditions it seemed proper to examine cursorily the problem of sewage disposal at this place, to see what methods might be adopted if sewers should be built in the future.

Sewage from different parts of the village would naturally gravitate to the junction of Main and Cedar streets. From this point an outlet sewer could be carried either down Cedar Street, or perhaps better, could be built near the brook to the west of Cedar Street. The inclination is so rapid that probably a small pipe not over ten inches in diameter would prove amply sufficient. As the sewage eventually would reach Boston's water supply, it will be necessary to purify it very thoroughly before permitting it to escape. At the bottom of the hill to the west of Cedar Street is a large tract of land which could be utilized for this purpose. The price would not much exceed $50 per acre, and it probably would prove most satisfactory and economical to acquire 25 acres or more, and dispose of the sewage by broad irrigation. Very little sewage then need be applied to each acre, so that the land could be cultivated and the sewage would prove of benefit to the crops. At this town the conditions are unusually favorable to utilizing the sewage and obtaining some return from its manurial constituents. The lower part of the main sewer might be made of iron, in which case the sewage could be under pressure and could be very conveniently distributed over the land by means of hydrants. The effluent would go into Indian Brook and thence into Sudbury River, and after flowing about six miles finally would reach Basin No. 2 of Boston's water supply. The amount of sewage will be so small in proportion to the area of land available for its purification, that should the process be carefully conducted, I think no danger need be apprehended on this account. At any rate, such precautions against pollution are all that reasonably could be required from Hopkinton. It is possible that Boston might prefer that the sewage should be carried for purification to a point beyond the divide separating the Sudbury from the Blackstone basin, and might be willing to pay the increased cost of such removal. If such an arrangement could be made between the city and the town, it would be possible to build an extension of the outfall, which would follow along the side of the hill, as shown approximately by a broken red line on the accompanying plan. The sewer would cross a low point in the divide, just east of the Claflin estate and northwest of the road to Upton. Just beyond the divide is land which might be utilized, from which the effluent would flow into North Pond reservoir, and so into Blackstone River. The additional length of sewer required to reach this point would be about two miles, and the extra cost should not much exceed $12,000. The land is not quite so suitable for purifying sewage as the tract first mentioned, but this is compensated by the fact that the effluent would go into water that is not used subsequently for domestic purposes.

SECT. 138. *Estimate of cost.* — In view of the remoteness of the contingency that the town will soon adopt a sewerage system, I have not thought it necessary to make a detailed estimate of the cost of one. Should an irrigation field near Indian Brook be selected, the cost of procuring and preparing a sufficient area of land, and of conducting the sewage to it from Main Street, should not be more than $10,000.

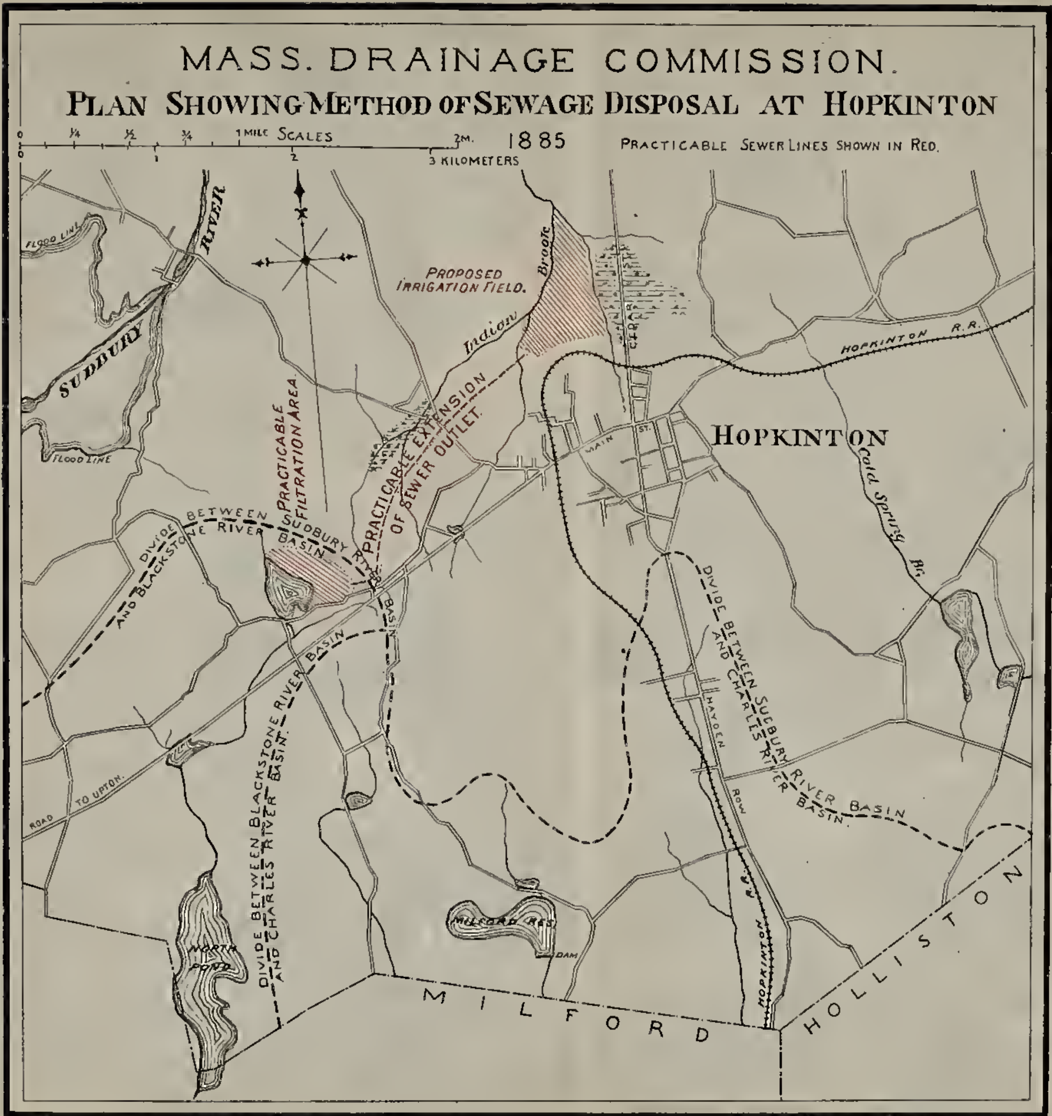


PHOTO LITHO. FORBES CO. BOSTON.

The Lower Neponset Basin.

Sect. 139. *Natural division of the Neponset Basin.* — In considering its need of, and facilities for, sewerage, this basin, like that of the Charles River, naturally divides itself into two distinct parts. The first of these, which may be called the lower or urban district, extends from the mouth of the river up to and including Hyde Park and Dedham. The second, which may be designated the upper or rural district, includes the rest of the basin from Norwood and Canton on either side of the river to its head waters. These two districts are separated geographically by the Fowl Meadows, — a broad area of marsh land extending about six miles along either side of the river between Hyde Park and Canton. The urban district, though much the smaller, contains more than half the inhabitants of the whole basin, and is rapidly increasing in population. The population of the rural district has increased but little during the last ten years. The urban district is all near enough to the sea to make it practicable to discharge its sewage into tide water, should this method of disposal prove most feasible. The towns in the rural district are so remote from the sea that their sewage must be disposed of on land.

Sect. 140. *Sewerage of the lower basin.* — The sewage of Dorchester is largely turned into the sea near the mouth of Neponset River. This has caused so serious a nuisance that the city is now building a branch over a mile long, of its main drainage system to intercept some of the sewers now discharging near Harrison Square and divert their sewage to the pumping station. This branch sewer is five feet in diameter, and is designed with the idea of ultimately extending it along the margin of Dorchester bordering the Neponset River, to reach Neponset, Milton Lower Mills and Mattapan. The amount of sewage discharged into the river at these places at present is not great enough to create serious nuisances, or to warrant the expenditure of the $100,000 which would be required to build the five miles of sewer necessary to reach the upper part of Dorchester. There is no question but that, as the population of this district increases, and sewers are built for it, such an intercepting sewer will become necessary and will be built; but it may not be for ten years or more. About two miles above Dorchester is Hyde Park, which has a present urgent need for sewerage. Two miles above Hyde Park is Dedham, also needing sewerage. These towns could not afford by themselves to build so long a sewer along the Neponset River to join the Boston system. Such a sewer, however, would form the best outlet for their sewage, and no doubt they would be willing to join with Boston in building it whenever it is needed for the Dorchester district. The pumping station, outfall sewers and reservoir of the Boston Main Drainage Works have ample capacity to take the sewage from this lower Neponset district. There can be no doubt that in the future the branch sewer, of which Boston has already begun to build the first mile and a half, will extend along the river as far as Dedham, and furnish an outlet for the whole district. At present, however, there is need for the upper third of this sewer, and not for the lower two-thirds. The problem, therefore, is to build the upper third of the Neponset valley sewer, so designed as to location and elevation as finally to be extended and connect with the Boston system, and until that extension is built temporarily to dispose of the sewage without causing a nuisance. The sewage which for several years would be contributed by Dedham and Hyde Park probably would not exceed in the aggregate 500,000 gallons per day. It would not do to discharge this in a crude state into the Neponset at Hyde Park, because it would be sure to create nuisances for the residents and manufacturers below. If the sewage were first clarified chemically, it could be put into the river without danger; but the process of clarification would cost perhaps $50,000 for the plant and a yearly expenditure of $15,000 more. There is no land near the lower limits of Hyde Park suitable for filtration, and the cheapest way of disposing of the sewage temporarily will be to pump it through a pipe two and a half miles long into one of the Boston sewers in Washington Street in West Roxbury.

Sect. 141. *Proposed system for Dedham and Hyde Park.* — No attempt has been made to ascertain how the common sewers in the village of Dedham will be arranged.

It is evident from the topography of the town that under any arrangement the sewage finally must be collected at the low point where Wigwam Brook crosses High Street under the railroad. Accordingly, leaving the town system to be designed hereafter as occasion requires, I assume this point as the focus at which the sewage will be collected, and from it start the intercepting sewer to carry the sewage away for disposal. Beginning at High Street under the railroad bridge, the sewer follows that street to a roadway next east of Harvard Street, into which it turns, and from which it enters private land and runs eastwardly, parallel to and about three hundred feet north from High Street. Different portions of this sewer will have different rates of inclination, the least of which will equal 1 in 500. As a 15-inch pipe with that inclination will discharge nearly 2,000,000 gallons per day, such a pipe will be as large as need be used. Following near the southerly line of Brookdale Cemetery, the sewer reaches Maverick Street at the upper mill of the Merchants' Woollen Company. At this point a branch sewer probably will be eventually taken in. Following the south side of Mother Brook, by a line which must be selected with great care, and will be expensive in any event on account of the rock, the sewer reaches Bussey Street, where another branch will be intercepted. Thence, still following the brook across Mill Lane and by the stone mill, the sewer reaches the flat land near the junction of River and Milton streets. At or before reaching this point, all of the sewage from East Dedham and Oakdale could be intercepted. If it were desired to keep the Dedham sewerage system separate from that of the rest of the lower Neponset valley, the sewer proper might end here, and the sewage could be disposed of by purifying it by filtration upon land near by. There is a tract of land admirably adapted to this purpose, one corner of which is within five hundred feet of the junction of River and Milton streets. The tract lies east of Oakdale and between the Dedham Branch and New York and New England railroads. From twenty to forty acres would be available. It is fairly level, and consists of a bed of coarse gravel, naturally underdrained more than twenty feet deep. Any amount of sewage which would ever be furnished by Dedham could be poured upon this land, and would at once disappear and cause no further trouble. What eventually would become of it probably never would be known, but the purification would be so complete that no danger from it need be apprehended. The only objection to this scheme is, that it probably would be more expensive than one adopted in conjunction with Hyde Park. Only about a mile in length of sewer to reach the Hyde Park system would be saved, and the portion saved eventually would have to be built, as forming part of the future Neponset River system connecting with the Boston outlet. A pumping station also would be required, from which the sewage would be elevated about twenty feet by a force main to reach the land. The first cost of this would be not less than $20,000, and the running expenses might be $3,000 per year, or the interest on $75,000 more.

Continuing on its course to Hyde Park, the sewer enters River Street, which it follows to the bridge, and crossing Mother Brook, continues in the same street to the cotton factory. It is assumed that somewhere about this point sewage from the Readville district may be taken in. Accordingly the sewer is increased in size to a circular brick structure two feet in diameter. The minimum grade of this will be not less than 1 in 1,000, at which inclination such a sewer will discharge more than 4,000,000 gallons per day. Continuing in River and Business streets to Barry Street, the sewer crosses the railroad and Central Park Avenue, and passes through the grounds of Bleakie's woollen mill to Walnut Street. From Walnut Street the line follows just west of the New York and New England Railroad, and finally reaches the corner of Pierce and Arlington streets. Hereafter it will extend through Dorchester on locations which cannot greatly differ from those indicated on the accompanying plan. (Plate XXIV.) It will be seen that from Dedham to the lower limits of Hyde Park the sewer has been located in the lowest land, bordering Mother Brook and Neponset River. It therefore can be reached from all parts of the adjacent territory. Further and more minute investigations may suggest modifications and improvements in this location. At Arlington Street it is proposed to build

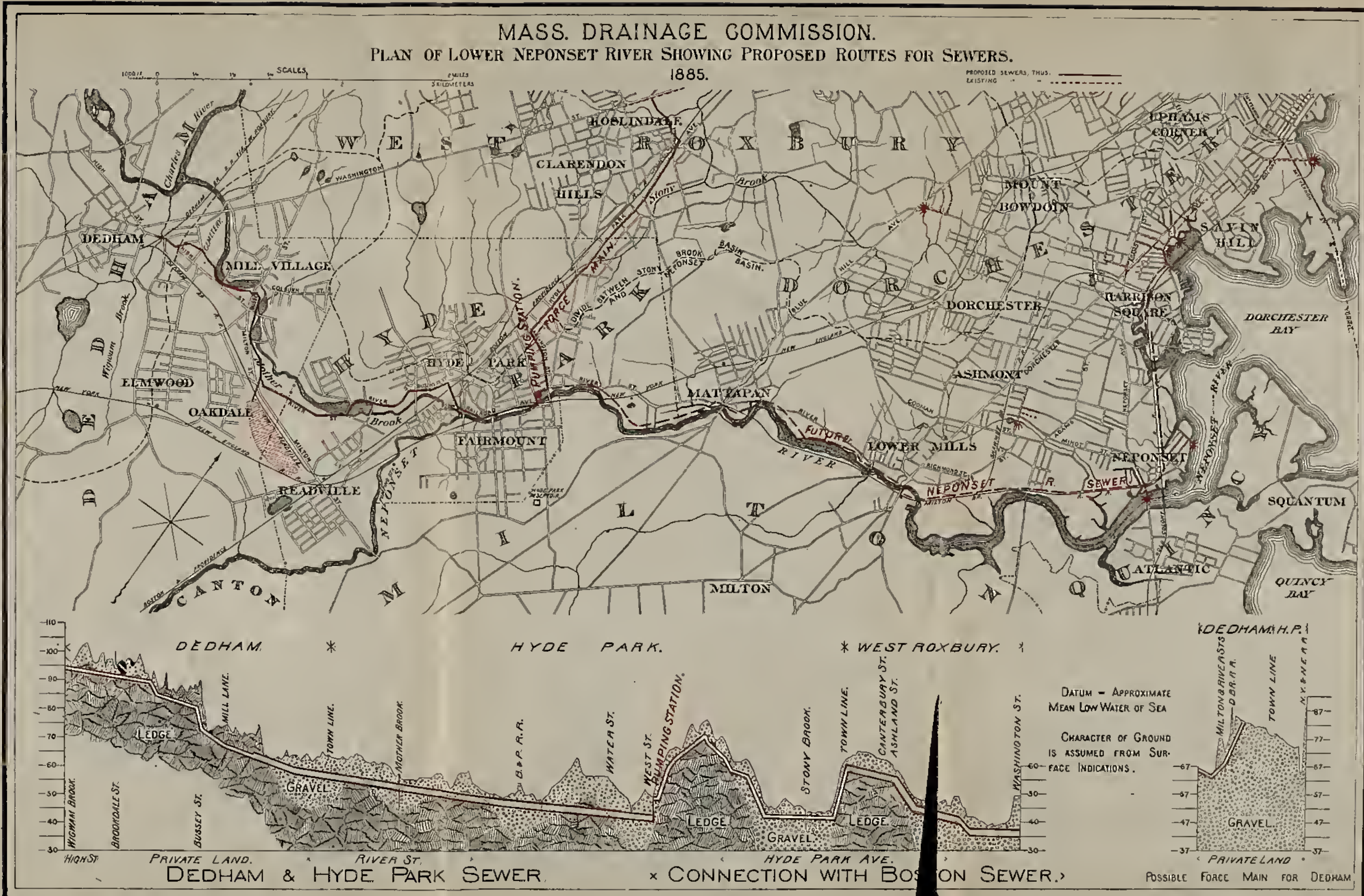


PHOTO LITHO. FORBES CO. BOSTON.

a pumping station, from which the sewage will be pumped through a 16-inch iron force main, $2\frac{2}{3}$ miles long, into a Boston sewer in Washington Street, at Roslindale. Several routes have been examined for the force main. Further examinations will be useful before a final route is decided upon. That which at present seems preferable follows Arlington Street and Hyde Park Avenue to the Mount Hope railroad station, and thence passes through Florence Street and private lands to the Boston sewer in Washington Street. On this line are two summits; the first met with being the higher by ten feet. The lift required will be about thirty feet. From the further summit, which is about at the line between Hyde Park and West Roxbury, the sewage can flow by gravity for the last 6,000 feet. For this distance, therefore, it can be used as a common sewer, and can receive branch sewers from the neighboring territory. In the following section is given an approximate estimate for the sewage disposal scheme for Dedham and Hyde Park as described, and as shown on the plan.

SECT. 142. *Estimate of Cost, Dedham and Hyde Park.*

SECTION.	Size of Sewer.	Average Cut, Feet.	Length, Feet.	Approximate cost per foot.	Total Cost.	REMARKS.
Railroad bridge, Dedham, to town line, Hyde Park,	15-inch,	5	9,200	$2 50	$23,000	Much ledge; difficult line.
Dedham line to cotton mill,	15 "	7	3,700	1 50	5,550	Gravel; iron across brook.
Cotton mill to pumping station,	24 "	9	8,000	3 50	28,000	A little ledge.
Pumping station,	. . .	. . .	. . .	. . .	25,000	
Iron force main,	16 "	. . .	8,000	2 75	22,000	
Brick sewer beyond force main,	24 "	6	6,100	2 50	15,050	
Land and special damages,	. . .	. . .	. . .	. . .	5,000	
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	12,360	
Total,	. . .	. . .	. . .	. . .	$135,960	

The Upper Neponset Basin.

Sect. 143. *General considerations.* — In considering the needs in respect to sewage disposal of the towns of the upper Neponset basin, the same general principles were followed as in the case of the upper Charles River basin (Sect. 124). In accordance with these, the problem was examined only at those towns in which works to furnish a public water supply were already in operation or were about to be put in operation. It was assumed that only at such places would the need of sewerage soon be felt. The water works at Sharon have been in operation since last summer; those at Norwood are just completed and will be running by the time this report is issued; at Stoughton a company has been organized and a source of partial supply secured, and there is an expectation of soon completing the works. One exception to the rule above stated was made in favor of Canton. This town has not yet voted to adopt a water supply, but only failed of such action by a few votes. It is considered probable that a public supply soon will be introduced, and owing to local conditions the building of a sewerage system must immediately follow it. Indeed, at this town a need of a sewerage system exists independent of that entailed by the adoption of a water supply. Accordingly examinations have been made and schemes for the disposal of sewage devised for the four towns above mentioned. In the other towns of the upper basin, the need of sewerage was considered too remote to require recommendations as to disposal at present.

Sect. 144. *Proposed system for Sharon.* — The only part of Sharon in which there is any likelihood of a need of sewerage being experienced in the near future, is that portion of the main village in the vicinity of Main and Lake streets within a short distance of their junction. All of this region either naturally drains or can be made to drain to the southward towards Massapoag Brook and Lake. To the north of the schoolhouse, on Main Street, the town slopes in the opposite direction to the northward, towards Beaver Hole Meadow Brook. The population in this part is so scattered, that there is no probability of there being any need of sewerage there.

An obvious line for a sewer which can be reached from all the thickly-settled parts of the village, starts in Main Street at the schoolhouse, following that street to the square opposite the Unitarian Church. Thence it follows Lake Street to Tolman Street, and the last named street for about 200 feet to a small brook, tributary to the mill pond of the Knife Works. Turning to the south and following the low land bordering the brook, it finally reaches a tract of land owned by H. S. Sheppard, situated north of Ames Street and east of Lake Street. On this land the sewage can be purified by filtration, after which it would reach the mill pond through the brook. It would not do to turn it into the brook without thus purifying it; since, as the pond is within 20 miles of the Hyde Park filter-basin, such a course would be in violation of the public statutes. The tract of land referred to is quite level and porous, and is assessed for $60 per acre. As it probably will be some years before the daily amount of sewage will much exceed 100,000 gallons, an area of from five to ten acres ought to be amply sufficient. With reasonbly good management, I think that no nuisance need result from the nearness of the proposed filtration area to the village. Should any be apprehended, other suitable tracts further away doubtless could be obtained. The land cultivated as market gardens at Sharon Heights, about a mile from the centre of the village, is admirably suited for the purification of sewage, of which any amount could be disposed of without any need of underdrainage, and with considerable benefit at times to the crops. Such land, however, hardly could be reached without pumping, which would greatly add to the cost of the system.

In the following section is given an approximate estimate of the cost of such a scheme as has been described, and is indicated on the plan. (Plate XXV.)

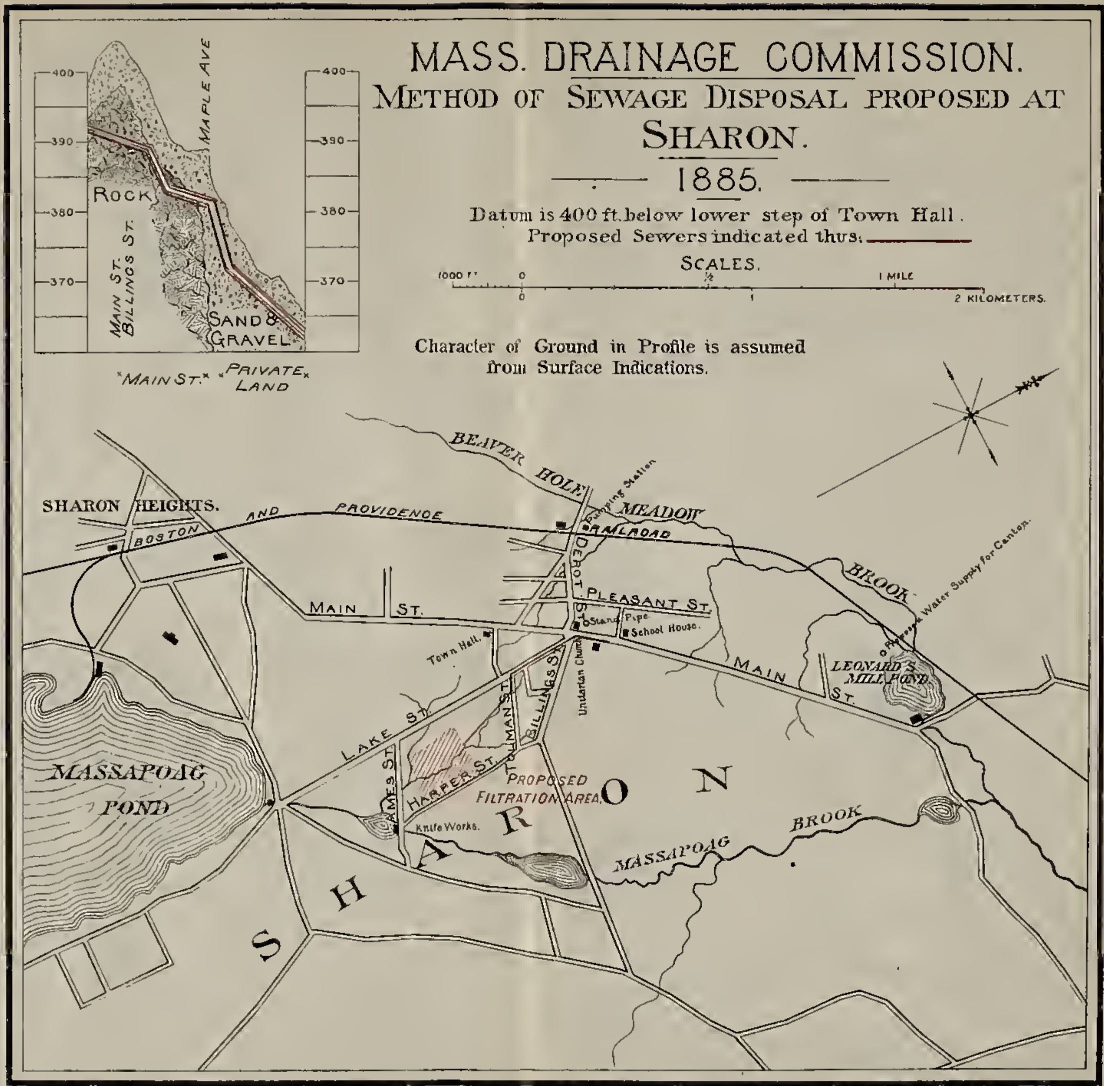
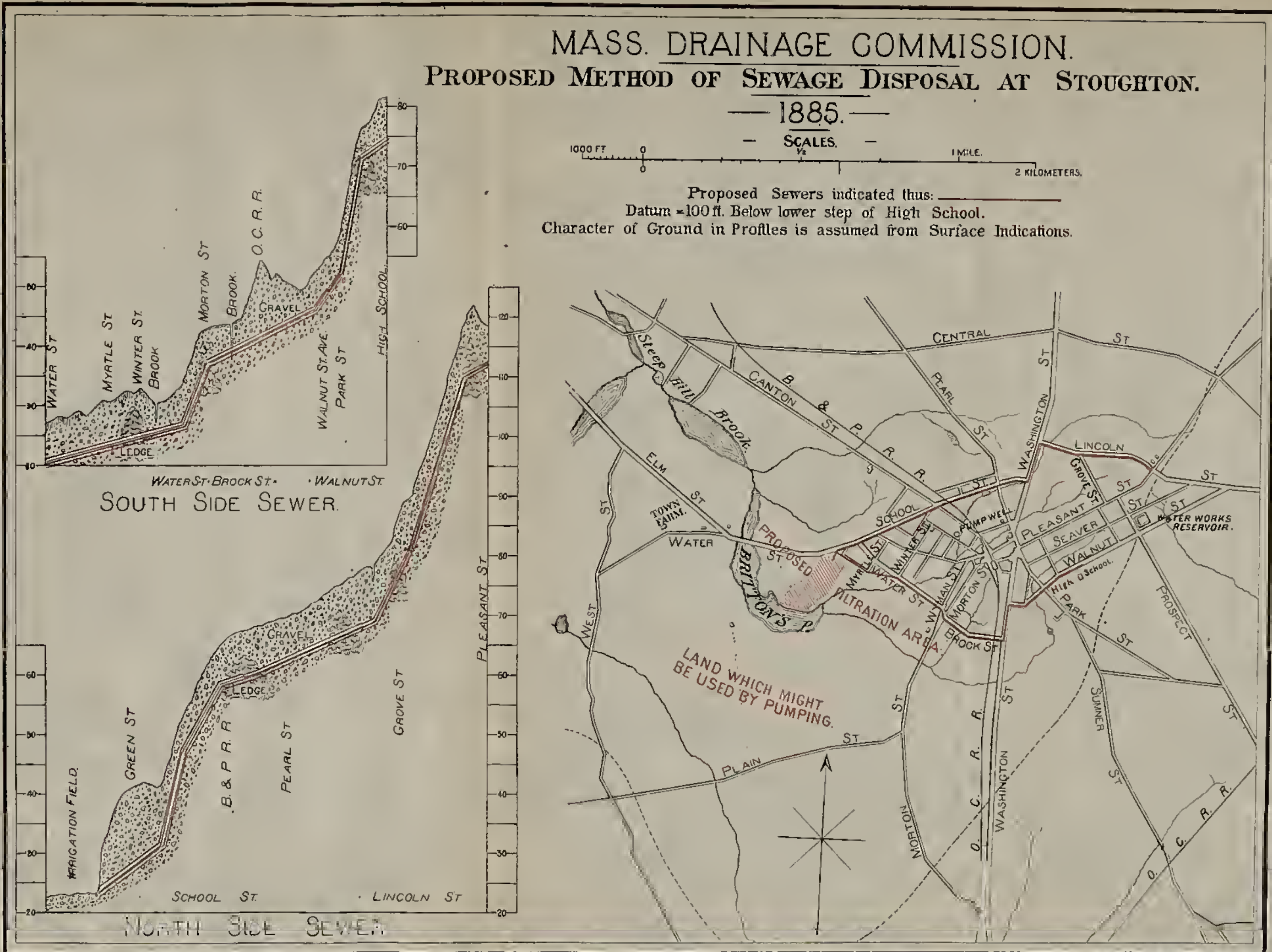


PHOTO LITHO FORBES CO BOSTON.

SECT. 145. *Estimate of Cost, Sharon.*

SECTION.	Size of Sewer.	Average Cut, Feet.	Length, Feet.	Approximate cost per foot.	Total Cost.	REMARKS.
Main St., schoolhouse to Lake St.,	8 inch,	12	800	$1 00	$800	
Lake and Tolman Sts.,	12 "	8	1,000	1 00	1,000	
Along brook to field,	12 "	4	1,200	75	900	
Land and special damages,					500	
Purchase of filtration area,					1,500	
Preparation of filtration area,					2,500	
Engineering and contingencies, 20 per cent.,					1,440	
Total,					$8,640	

SECT. 146. *Proposed system for Stoughton.* — The whole of the main village of Stoughton, which is the only part of the town where there is any likelihood of there being any need of sewerage, naturally drains westward towards Britton's Pond and Steep Hill Brook. Accordingly the sewage must flow in that direction. An obvious point at which it could all be made to concentrate is at the corner of School and Water streets, near the western extremity of the village. To convey the sewage to this point two intercepting sewers will be necessary, one on each side of the village. That on the north side might start at the corner of Lincoln and Pleasant streets. It would follow Lincoln, Washington and School streets to a junction with the south side sewer at Water Street. The latter sewer might start in Walnut Street, at the High School, and be laid in Walnut, Washington, Brook and Water streets to School Street. Into these two sewers branches from all parts of the village would drain. Having thus collected the sewage, the next problem is, what to do with it? It would violate the public statutes to turn it in a crude state into Steep Hill Brook, since the distance above a point where a public water supply is taken from the Neponset is less than twenty miles. Accordingly it would be necessary first to purify the sewage upon land. To avoid the very considerable expense which would be incurred for elevating the sewage by pumping, the land selected should be such that the sewage could flow upon its surface by gravitation. The only easily accessible land which is lower than the sewage will be when collected, lies between the main village and Britton's Pond, and forms part of the farm of Patrick Burns. This land is somewhat near to the settled portions of the village, but with reasonable care, no danger on that account need be apprehended, and no nuisance should result from its use. The area available is somewhat limited; probably not more than six acres could be conveniently prepared and used. This would prove ample for the present, and probably for many years to come. If in the future the population and amount of sewage should increase so greatly that the tract referred to should prove to be too small and too near to then existing residences, the sewage could be conveyed



MASS. DRAINAGE COMMISSION.
PROPOSED METHOD OF SEWAGE DISPOSAL AT STOUGHTON.
1885.
SCALES.
1000 FT 0 ½ 1 MILE.
0 2 KILOMETERS.
Proposed Sewers indicated thus:
Datum = 100 ft. Below lower step of High School.
Character of Ground in Profiles is assumed from Surface Indications.
SOUTH SIDE SEWER.
WATER ST
MYRTLE ST
WINTER ST.
BROOK
MORTON ST
BROOK
O. C. R. R.
GRAVEL
WALNUT ST. AVE.
PARK ST
HIGH SCHOOL
LEDGE
WATER ST. BROCK ST. WALNUT ST.
NORTH SIDE SEWER.
IRRIGATION FIELD.
GREEN ST
B. & P. R. R.
PEARL ST
GROVE ST
PLEASANT ST
GRAVEL
LEDGE
SCHOOL ST
LINCOLN ST
CENTRAL ST
Steep Hill Brook
CANTON ST
B. & P. R. R.
PEARL ST
WASHINGTON ST
LINCOLN
GROVE ST
PLEASANT ST
SEAVER ST
WALNUT ST
WATER WORKS RESERVOIR.
PUMP WELL
SCHOOL ST
ELM ST
TOWN FARM.
WATER ST
PROPOSED FILTRATION AREA.
BRITTON'S P.
MYRTLE ST
WINTER ST
WATER ST
MORTON ST
BROCK ST
High School
PARK ST
PROSPECT ST
WEST ST
LAND WHICH MIGHT BE USED BY PUMPING.
PLAIN ST
MORTON ST
O. C. R. R.
WASHINGTON ST
SUMNER ST
O. C. R. R.

by pumping to other more remote areas where much more land could be obtained, somewhat better adapted for the purpose. Such areas, which are very suitable, exist on the farm of James Hearn, south of Water Street and west of the pond, and also in the vicinity of the Poor Farm. From an engineering point of view solely, it would be better to pump the sewage and purify it on one of these tracts at first; but adopting such a method of disposal would double the cost of the scheme. The following section gives an approximate estimate of the cost of the system recommended and shown on Plate XXVI. It will be noticed that a large part of the estimate is for building sewers which properly belong to the ordinary town system.

SECT. 147. *Estimate of Cost, Stoughton.*

SECTION.	Size of Sewer.	Average Cut, Feet.	Length, Feet.	Approximate cost per foot.	Total Cost.	REMARKS.
North side sewer, Pleasant to Washington St.,	8-inch,	8	2,100	$0 80	$1,680	Chiefly sand and gravel.
Washington St. to railroad,	10 "	9	2,000	1 00	2,000	
Railroad to Water St.,	12 "	8	2,200	1 10	2,420	
South side sewer, High School to Walnut Ave.,	8 "	7	1,000	75	750	
Walnut Ave. to Wyman St.,	10 "	8	2,000	1 00	2,000	
Wyman to School St.,	12 "	9	2,000	1 25	2,500	Perhaps a little rock.
Land and special damages,	. . .	. . .	. . .	. . .	1,000	
Filtration area and preparation,	. . .	. . .	. . .	. . .	4,000	
Engineering and contingencies, 10 per cent.,	. . .	. . .	. . .	. . .	2,542	
Total,	. . .	. . .	. . .	. . .	$18,802	

SECT. 148. *Proposed system for Norwood.* — It is expected that the Norwood water works will be put in operation about the end of 1885. For the first few years the daily supply probably will not exceed 100,000 gallons. The ultimate capacity of the works is said to be 300,000 gallons. Population being nowhere dense, it will be some years before the need of sewerage becomes a pressing one. The fact that already there are a few local nuisances, however, may hasten the building of sewers. The sewage must finally go into the Neponset, and as it would be illegal to discharge crude sewage there, purification will be necessary. A tract of land suitable for this purpose, which is accessible by gravitation from all parts of the main village, may be selected from the farms of A. W. and E. Fuller and Patrick Mahoney, lying between Dean and Pleasant streets, south of the village brook. The position of this land is shown on the accompanying plan (Plate XXVII), and also approximately the lines by which the main sewers might reach it. As will be seen, the main interceptor from the north part of the town starts at the low point in Cemetery Street, near Smith's tannery. For about three-quarters of a mile the location is near that of the present wooden drain described in section 66.

Near the crossing of Pleasant Street the main sewer receives a branch from the south part of the village. Sewage will reach the field by gravitation, but to cross some lower marsh land just before arriving at the field a cast-iron siphon may be necessary. A more extended and thorough examination of the problem at this town might suggest many alterations or modifications of this scheme. Sufficient surveys have been made to prove that the scheme, as shown on the plan, is, if not the best, at least a practicable one, and the rough estimate of cost given in the next section shows that it would not be unreasonably expensive.

SECT. 149. *Estimate of Cost, Norwood.*

SECTION.	Size of Sewer.	Average Cut, Feet.	Length, Feet.	Approximate cost per foot.	Total Cost.	REMARKS.
Main interceptor, Cemetery to Pleasant St.,	12 inch,	5	4,200	$1 25	$5,250	Hard gravel and bowlders.
Pleasant St. to field,	15 "	5	1,300	2 00	2,600	500 feet siphon.
Branch, Washington to Pleasant St.,	12 "	6	2,000	1 25	2,500	
Land and other damages,					1,200	
Cost of land,					1,500	
Preparation of land,					4,000	
Engineering and contingencies, 15 per cent.,					2,557	
Total,					$19,607	

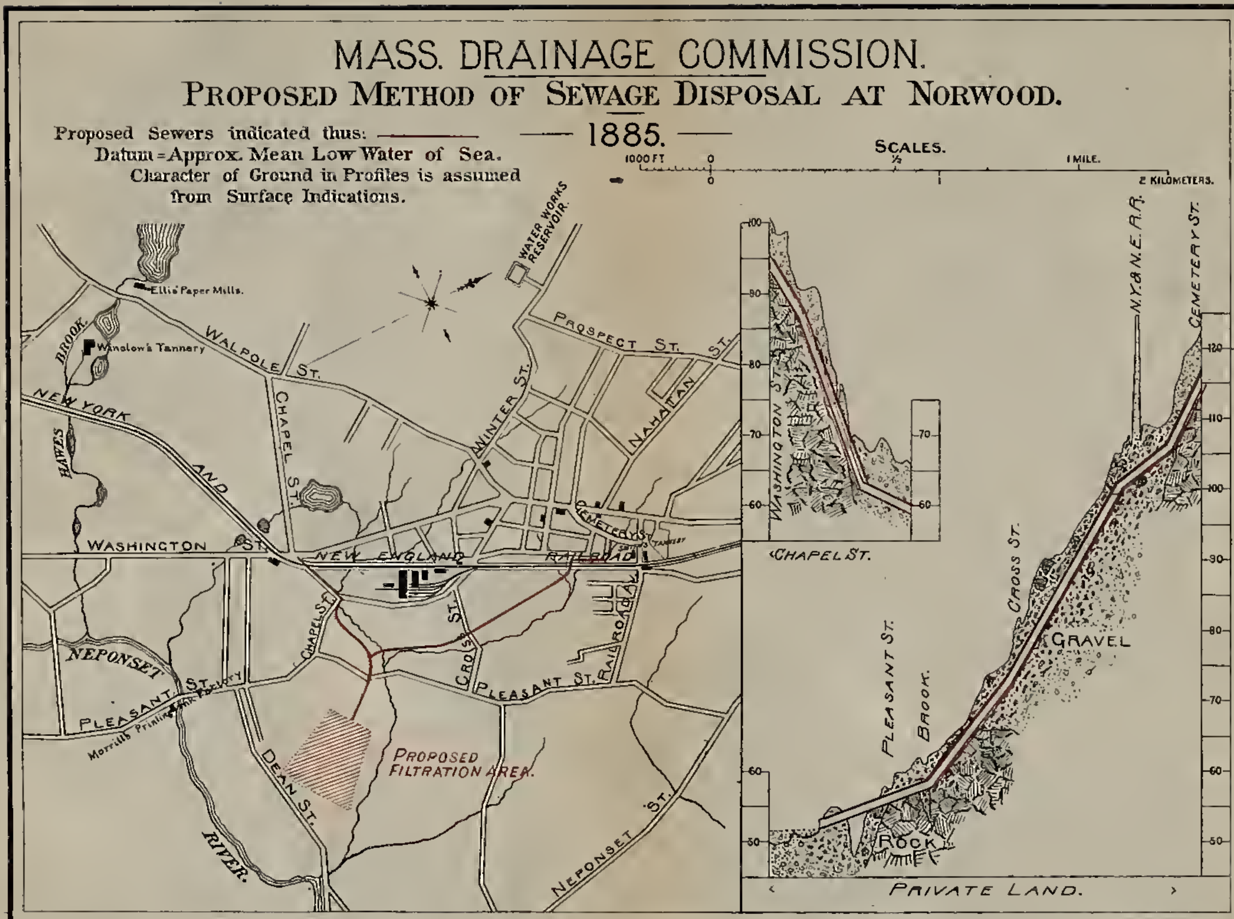
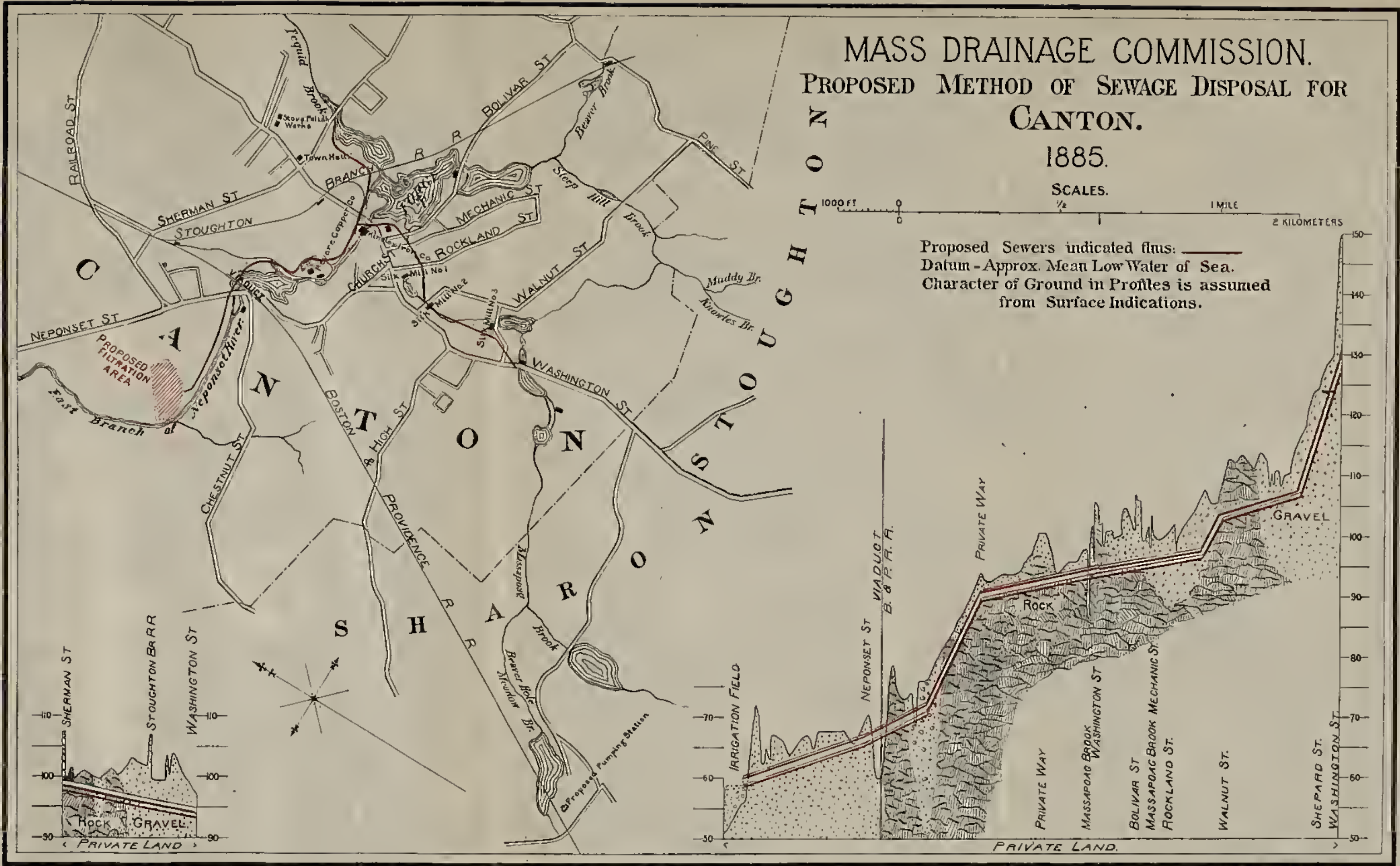
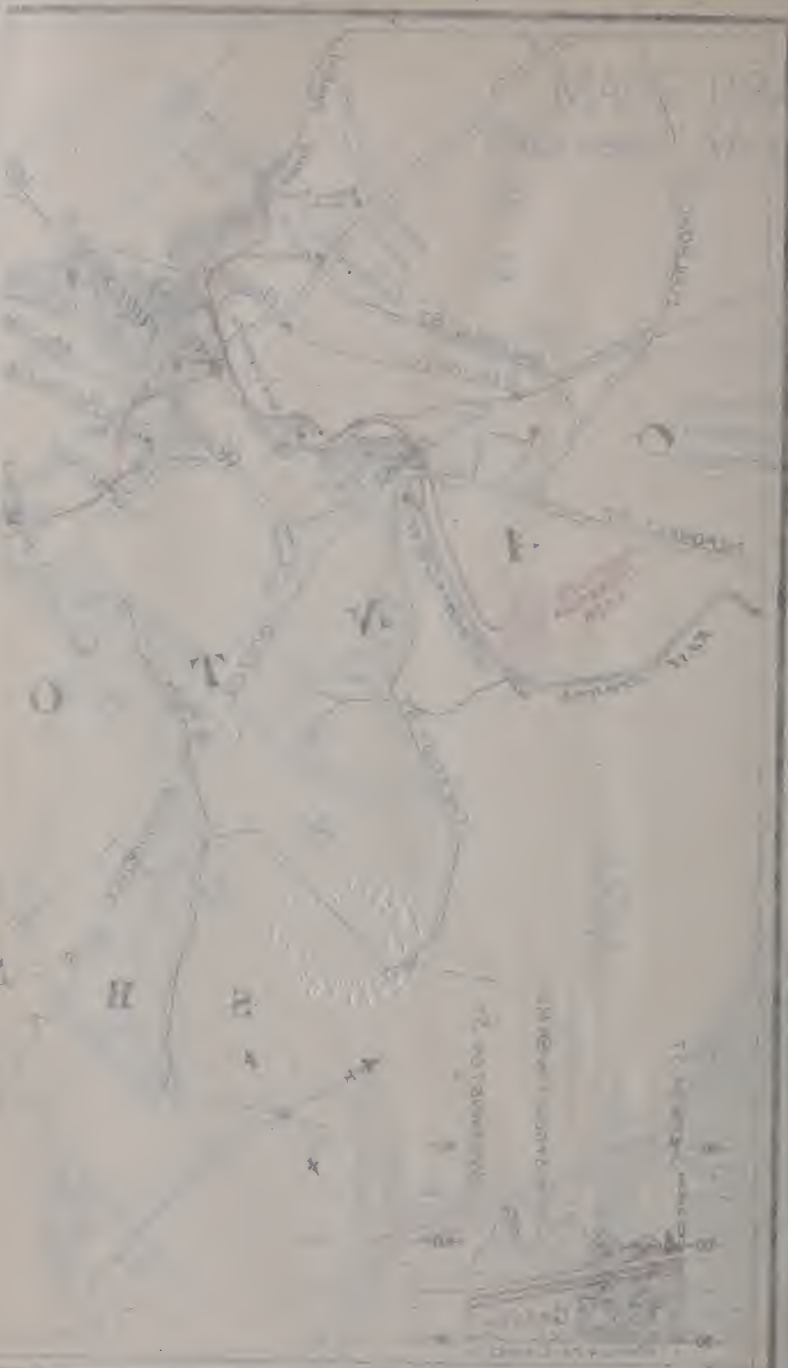


PHOTO LITHO. FORBES CO. BOSTON.

SECT. 150. *Proposed system for Canton.* — The low point in the village of Canton at which the sewers in the main streets of the village naturally would concentrate, is where the east branch of the Neponset is crossed by Washington Street. For the part of the town south of this stream, it is probable that a sewer in Washington Street would be the first to be desired. In order that a sewer in that street should receive sewage from the mills and dwellings near Massapoag Brook, and from the part of the town east of that brook, it would be necessary to place it very low. In view of the liability of encountering ledge rock near the surface, which would make deep excavations expensive, it seems from a cursory examination as if it would be preferable, because cheaper, to build a main sewer following the low land near the brook up to the southerly crossing of Washington Street. Such a sewer would receive the foul drainage from the silk and other factories on the brook, and would intercept branch sewers in Bolivar, Mechanics, Rockland and Walnut streets, on the east side of the brook, and also in Washington and High, and parts of Church and Neponset streets, west of the brook. Sewage from most of that part of the village north of the east branch could reach the focus before referred to by means of a sewer running down Washington Street. That from the region near Pequid Brook would have to be brought down by a sewer along the north side of that brook.

Having decided how the sewage must be collected, it remains to be considered, to what point it shall be taken for disposal. It cannot be taken outside of the Neponset watershed. Since it must enter the Neponset less than 20 miles above a point whence a public water supply is taken from that stream, a compliance with the public statutes requires that it shall be purified before reaching the river. The most accessible land suitable for this purpose which can be reached without pumping, appears to be a tract comprising portions of the farms of Daniel Fuller and S. M. White, on the north side of the east branch about half a mile below the viaduct. To reach this land the sewer could follow either bank of the river, and surveys for it have been made on both sides. There was not time enough to make very thorough examinations, but the route on the north side seems somewhat preferable. By this route the sewer passes through the grounds of the Kinsley Iron and Machine Company, and through vacant lands of the Revere Copper Company, on a line shown approximately on the accompanying plan. (Plate XXVIII.) This section of the sewer could receive branches from those parts of the town on either side of it whose sewage could not be taken into the upper portion of the system. Reaching the viaduct, the sewer passes under the northerly arch of that structure. After crossing Neponset Street the sewer line goes through private land until it reaches the filtration area, which is on the northwesterly slope of a ridge composed of coarse sand and gravel with a few bowlders. Considerable grading will be necessary to prepare the land for its purpose. As Canton has not yet constructed water works, and as sewers evidently will not be built until after that event, it is impossible at present to decide how much sewage must be provided for and how large a filtration area must be constructed. In order to make an approximate estimate, I assume that filter beds aggregating ten acres will be sufficient at first. Those at Pullman, Ill., of this size are considered sufficient for disposing of the 800,000 gallons of sewage discharged daily by that town. In section 151 is given an estimate of the probable cost of building the main and outfall sewers and preparing the filtration area, as shown on the accompanying plan. This estimate is merely approximate, being based on the somewhat meagre information which could be obtained in the brief time available for investigations at this town.


MASS DRAINAGE COMMISSION.
PROPOSED METHOD OF SEWAGE DISPOSAL FOR
CANTON.
1885.
SCALES.
Proposed Sewers indicated thus:
Datum - Approx. Mean Low Water of Sea.
Character of Ground in Profiles is assumed from Surface Indications.
CANTON
STOUGHTON
SHARON
PROPOSED FILTRATION AREA
Neponset River
East Branch
Proposed Pumping Station
PRIVATE LAND
Rock
GRAVEL
PHOTO LITHO. FORBES CO. BOSTON



SECT. 151. *Estimate of Cost, Canton.*

SECTION.	Size of Sewer.	Average Cut, Feet.	Length, Feet.	Approximate cost per foot.	Total Cost.	REMARKS.
Main interceptor, Washington St., to Mill No. 3,	8-inch,	6	700	$1 00	$700	A little rock.
Mill No. 3 to Walnut St.,	10 "	6	1,200	2 25	2,700	Rocky and wet.
Walnut St. to Iron Works,	12 "	4	2,100	2 25	4,725	Rocky and wet.
Iron Works to viaduct,	15 "	6	3,500	2 75	9,625	Rocky; 100 feet iron pipe.
Viaduct to field,	15 "	4	2,300	1 50	3,450	Gravel.
Land and other damages,					1,500	
Cost of land,					1,200	
Grading and preparation of land,					10,000	
Engineering and contingencies, 20 per cent.,					6,780	
Total,					$40,680	

The Blackstone Basin.

Sect. 152. *Recommendations.*—The description given in Part I, of the conditions existing in the Blackstone River valley, shows that there is only one serious case of pollution which calls for an immediate remedy. This is the nuisance caused to the towns below, by the discharge of the sewage of Worcester through Mill Brook into the river. As stated in Part I, the magnitude of this evil is sufficiently proven and generally recognized. Under instructions from the Legislature, a scheme by which the evil could be remedied was devised by a committee of experts selected by the State Board of Health. The committee included an engineer noted for his knowledge and skill in sewerage matters, and two other gentlemen also skilled in sanitary science.

Briefly stated, the scheme devised by the committee consisted of sewers on either side of Mill Brook, by which the sewage now entering the brook should be intercepted, and conveyed to a tract of land near the river below the city, for purification by filtration. Most of the sewage was to flow by gravitation, and a portion which was too low to do so, was to be pumped. A detailed account of this scheme, with plans and estimates, was printed and is on record. So far as I am aware, no doubt is entertained as to the practicability of the plan. As a solution of the problem at Worcester already has been devised by competent authority, I do not see that your Commission need take any further action in the matter, except in so far as is necessary to satisfy yourselves that the plan is both practicable and well considered. Instructed by your Commission that this was all you desired, I have simply made sufficient investigations to verify the statements in the committee's report concerning the essential features of the scheme. An examination of the territory below Worcester, shows that the tract of land selected as a filtration area is the most accessible one suitable for the purpose. A large number of borings and four test pits, proved that the soil is porous, and well adapted to filtration. Lines of levels between the city and the filtration area show that good routes for a sewer with sufficient gradients can be selected. From a knowledge of the heights of the city sewers where they will be intercepted, it is evident that such interception is practicable in such a way that most of the sewage can flow to the field by gravity, should that arrangement be considered most economical. A verification of the estimates prepared by the committee, shows that if they err at all it is upon the side of safety. Some slight modifications as to details might be suggested, in the methods of interception and routes of the sewers. Worcester, however, has a very competent city engineer, fully acquainted with the science and practice of sewerage. From his intimate knowledge of the city and its system of sewerage, he would be better able than any temporary committee to work out satisfactory details for a system of interception upon the general plan recommended. If your Commission is satisfied that some action is necessary, and that the scheme of purification designed by the former committee is feasible, it seems to me that you can with propriety and safety recommend that Worcester be required to purify its sewage in some way, leaving the choice of methods and its details to be determined by the city itself.

PART IV. — GENERAL INFORMATION AND SUGGESTIONS.

Section 153. *Different aspects of the problem of the prevention of pollution.* — In Part I. of this report it appears that the problem of preventing the pollution of streams by filth presents itself under several different aspects, as follows: —

1. The prevention of the pollution of drinking water by sewage proper and by human excrement.

2. The prevention of the pollution of drinking water by refuse from manufacturing processes.

3. The prevention of the pollution of water not used for drinking, by sewage or refuse from manufactories to an extent which causes offensive emanations, unfits the water for use in manufacturing or makes it very unsightly.

4. The prevention of existing pollution.

5. The prevention of additional or prospective pollution.

One or all of these features may be present in any single actual case under consideration.

Sect. 154. *The pollution of drinking water by sewage.* — It is not necessary that drinking water should be absolutely pure. Indeed, pure water seldom is found outside of a chemist's laboratory. Water is pure when it is condensed in clouds, but it absorbs a little foreign matter from the air before reaching the earth, and more from the earth while flowing over or through it. A private supply of rain water, caught from the roof of a house, is tolerably clean. It evidently would not be so if people lived on the roof. To supply enough water for a large city may require an area (corresponding to the roof) of about 100 square miles. If this area were unpopulated, the water flowing from it would be clean. In proportion as the area is populated the liability to pollution increases.

Drinking water as commonly used contains a variety of organic and inorganic matters in solution, and a variable number of organic germs, spores and animalculæ. These do not necessarily render the water unwholesome. It is probable that a large proportion of the inhabitants of Massachusetts and of the whole country habitually drink water which has been more or less contaminated by human excrement. When such contamination is very slight, and sometimes even when it is great, most persons experience no evil result from it. It *may*, however, be very dangerous. Under what conditions and to what degree water may be thus contaminated without there being a risk in drinking it, cannot be definitely stated. Unless the contamination is considerable, the risk for most persons evidently is slight, but it is a slight risk of no less a penalty than disease and death. Even if such pollution were not dangerous, the idea of it is repulsive. The only safe rules to follow in regard to this matter are to permit no such pollutions of drinking water which can be prevented, and to avoid if possible the use of water which is liable to such pollution.

It would not be possible entirely to prevent pollution of the water courses in this State. Some of them, as the Connecticut and Merrimac, run through other States before reaching this one, and therefore are beyond the control of our laws. It would be possible to prohibit Lowell from polluting with crude sewage the water of the Merrimac, afterwards used by Lawrence, but it would not be possible to prohibit Nashua and Manchester, in New Hampshire, from doing so. In the cases of smaller streams, wholly within the State, in one instance it might be impossible to keep the water pure enough for drinking; in another, it might be possible, but impracticable on account of the expense and difficulty; in another, it might be practicable but not expedient, and in another it might be both practicable and necessary. It seems as if it would be a good thing to have some State authority competent to decide as to any watershed, whether it were practicable and expedient to keep its waters sufficiently pure for drinking, and if not, to prohibit the taking of town supplies from it. Even if some of the minor watersheds of the State, most available for the purpose, were dedicated to furnishing domestic water supplies, it would be very difficult, if not impossible, to ensure their being kept entirely free from pollution ; that is, if people were allowed to live on them. Foul refuse must be put somewhere. Where there are no sewers, it invariably is put into the ground in vaults or cesspools. The earth, below a few feet from the surface, constitutes a vast wet sponge. Water is abstracted from this sponge at wells, and also flows from it into the streams. Water is added to the sponge at every vault and cesspool, and also by the rain which soaks through the earth. It commonly is supposed that foul matters are purified by being brought in contact with the earth. They are so, where the earth is dry and full of air ; but when the earth is soaked with water, it is probable that purification is accomplished only through dilution.

The best way to accomplish purification, therefore, is to collect the foul matters by means of sewers, and to apply them systematically over the surface of large areas of land, through which they may filter and thus come in contact with the air contained in the interstices of the soil. Even when this is done, it cannot be certain that all danger will be eliminated and the water made absolutely pure. Therefore, where it is possible to carry on this process outside the watershed, so that the effluent will go into a stream not used as a source of water supply, such disposition of it is preferable. In the case of towns situated in the centre of a large watershed, as for instance that of Charles River, it would be impracticable to convey the sewage to any point beyond the divide. Where such a watershed furnishes water supplies, it may be necessary to purify sewage within it as carefully as possible, and allow the effluent to enter the river.

SECT. 155. *Prevention of pollution of drinking water by manufacturing waste.* — The refuse from most of the manufacturing processes does not cause as dangerous pollution as domestic sewage, because not so liable to contain the *contagium* of specific diseases. The refuse from different kinds of manufactories varies greatly in respect to dangerous and polluting qualities, and also in respect to the facility with which it can be purified. In treating wool, stale urine is sometimes used; in tanning leather, large quantities of hen manure are occasionally employed. The refuse due to wool scouring is very large in amount and difficult to treat. The dirt washed from foul foreign rags in paper-making commonly would be viewed with suspicion. Most vegetable dyes, acids and alkalies, are not especially dangerous if sufficiently diluted. As it is impossible to say how much danger may arise from any such pollution, the only safe rule to follow is to require that all such drainage going into drinking water shall be purified as thoroughly as possible. It would be better if manufactories furnishing foul refuse, presumably dangerous or difficult to treat, were excluded from watersheds from which drinking water is taken, except when their drainage could be carried outside of it for disposal.

The purification of foul drainage on such watersheds should be limited to filtration through aerated earth, because that is the only process at present known by which real purification can be accomplished. As explained in Part II., chemical precipitation simply clarifies water without purifying it. It should be required that the privies for operatives at mills should not discharge into streams, but that such filth should be treated by dry methods of removal. This frequently is done at present, and its being made compulsory would entail no serious hardships.

The satisfactory disposal of manufacturing refuse at some mills is well nigh impossible, on account of the great quantity of water with which the refuse is mixed. It is not uncommon to find mills using 500,000 to 1,000,000 gallons of water per day. But a small portion of this water is seriously contaminated in the using, but commonly the small amount of polluted water is mixed with the larger quantity of almost clean water, and the whole discharged through a single drain. Even if a sewer were accessible, it would not do to turn this water into it. Such a course would rob the stream of a large proportion of its contents, to the detriment of the users below. It also would make it exceedingly difficult and expensive to build town sewerage systems, since it would be necessary to design the system as a whole and in all its parts with reference to receiving such exceptional and enormous quantities of sewage. Probably there can be little mitigation of the nuisances caused by manufacturing refuse until the manufacturers themselves learn to use less water and to separate their drainage, so that comparatively clean waters shall go back into the stream and foul drainage shall be turned into sewers, or otherwise disposed of.

Where it is necessary to purify foul liquids by filtration, but no land suitable for this purpose is accessible, sometimes it will be possible, although quite expensive, to construct filtering grounds artificially. A gravel bed an acre in extent and six feet deep might filter sufficiently 100,000 gallons per day of some kinds of manufacturing waste. Such a bed would contain nearly 10,000 cubic yards of gravel, and at 50 cents per yard would cost about $5,000.

SECT. 156. *The pollution of streams not used as sources of water supply.* — In the case of streams whose water is not used for drinking, the degree of purity which is necessary is only such as will ensure that no nuisance either to health or the senses shall be caused, and that the water shall remain sufficiently pure for manufacturing and other necessary purposes. If towns are permitted to have public water supplies, they also must have sewerage systems, and the sewage eventually must find its way into the streams. The manufacturing industries of Massachusetts are so essential to its prosperity that nothing must be done which will seriously interfere with their operations. Great quantities of water are necessary for most manufactures and much foul drainage results from them. This also must reach the streams. As it would be very difficult and expensive, if not impossible, to purify such sewage and foul drainage sufficiently to make it fit for drinking, it is evident that a large proportion of the streams in the State cannot be kept pure enough for that purpose. If, however, manufactures are to thrive and nuisances are to be avoided, the water in the streams must be kept reasonably clean. It will not be so if crude sewage from towns and crude refuse from manufactories are turned into the streams. Already nuisances exist on the Mystic, Charles, Neponset and Blackstone Rivers, and on the last three, manufacturers complain that the water is too dirty to use for some of their processes. Suits on this account have been brought, and more are threatened. This evil is increasing, and it is evident that, in the interest of public health and the prosperity of manufacturers, the pollution of streams should be done away with, or at least lessened.

How this has been and can be done, in the case of town sewage, has been explained in Part II. The processes there described, or some modifications of them, doubtless could be used for purifying manufacturing refuse. In some of the sewage purification works in England, the great bulk of the sewage successfully treated is refuse from manufactories. Unfortunately there are not many instances in which manufacturers have been compelled to purify their own foul drainage, so that not much can be learned from the experience of others. A few somewhat unsatisfactory cases, however, can be cited.

The Wanskuck Mills, Providence, R. I., are among the largest of those in the United States making woollen and worsted goods. Until 1881, the dirty water resulting from the different operations, amounting to about 400,000 gallons per day, flowed directly into West River. The yearly amount of refuse contained in this water included about 64,000 pounds of dyestuffs, 100,000 pounds of alkali, 4,000 pounds of acid, 53,000 pounds of fuller's earth, and 400,000 pounds of grease. A dyeing and bleaching company below brought a suit against the Wanskuck Company on account of the serious injury to its operations by the pollution of West River. After protracted litigation, the Supreme Court granted a permanent injunction forbidding such pollution. In compliance with this injunction, attempts have been made to purify the waste water before permitting it to enter the river. At first, filtration through land was tried. The foul liquid was pumped on to a tract of gravelly land near the mills, about forty feet above the river. An acre and a half was prepared by making furrows four feet apart on the surface. The liquid was made to flow during the morning through the furrows on one half of the land, and during the afternoon through those on the other half. For about three weeks this process was successful, as the water filtered through the land and came out clean. After this time the surface of the furrows became clogged, the water would not soak away fast enough, and the process was abandoned. It is stated, however, that a few days later the water had disappeared, and the film of sediment which had choked the ground dried, cracked and curled up, showing clean sand underneath it. It is probable that after this interval, if the water had been applied again, it would have filtered away as before, and the process might have been continued intermittently by allowing occasional periods during which the film of sediment could dry and crack. When a considerable amount of sediment had accumulated, and had been allowed to dry, it easily could have been broken up with tools and thrown upon the ridges between the furrows. As the liquid filtered for three weeks before the surface of the ground became clogged, whereas it took less than a week for the film of sediment to dry and crack, continuous purification could have been effected by the use of double the quantity of land, divided into two plots, used alternately. Two gentlemen, one of them the superintendent, who observed the experiment, are now of the opinion that this method would have proved sufficient. At the time that the first experiment was thought to be a failure, purification by precipitation was adopted, and has been continued since. A set of six connected basins was excavated on the land previously used for filtration. Two of these basins, about 30 feet by 60 feet each, were connected with four others about 75 feet by 220 feet each, all being 5 or 6 feet deep. About a barrel of lime to 100,000 gallons is added to the waste water at the mill before pumping. This addition is made rudely, the lime not being previously ground, or even slaked. The water flows through one of the smaller basins, in which most of the deposition takes place. Leaving the small basin it flows through the four larger ones successively, where further deposition takes place. To the eye, the effluent from the last basin looks about as dirty as the water which leaves the pumps. A decided smell from the basins is noticed in muggy weather, and as a whole the result is not satisfactory. As such processes have proved effective elsewhere, the failure must be due to defects in the practical management of the process. For a while after it was attempted, sulphate of alumina was used as a precipitant. The cost of this chemical, which amounted to about $7 per day for each 100,000 gallons, or $6,000 per year for the whole amount treated, was considered so great as to preclude its use. The sludge which is cleaned from the basins is found to be commercially valueless. It is said to have proved beneficial when applied to grass in the neighborhood, but in practice it is found that although it is given away, nobody comes for it a second time. It is thought that of the whole liquid waste, 50,000 gallons would comprise all of the water used in washing wool and the greater part of the polluting refuse.

A method of wool scouring is practised in the Lorraine Mills, Saylesville, R. I., by which the grease is preserved, and most of the other dirt is eliminated from the wash water before permitting it to escape. The wool is washed in a machine having three bowls, a longitudinal section of which is roughly indicated by the accompanying cut (Fig. 5). Six

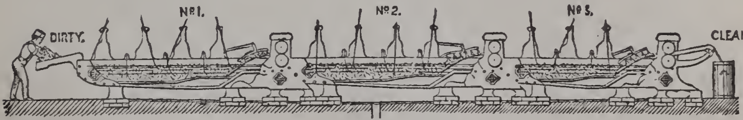


Fig. 5.

hundred pounds of wool are washed at a time, and pass successively from bowl 1 to bowls 2 and 3. When a new charge of dirty wool is put into bowl 1, the water previously used in bowl 2 is transferred to bowl 1, that from 3 is put into 2, and clean water is used only in bowl 3. Thus bowl 1, in which the wool is first washed, always contains water which has been used twice before, and bowl 2 that which has been used once. The amount of clean water added in bowl 3 at each washing is about 400 gallons. To this about 27 pounds of soap are added, and a small quantity of free lye. Six hundred pounds of wool therefore are washed with about 400 gallons of water, which is very much less than is commonly used for the purpose, and probably is as little as will accomplish the work. The resulting product is about 300 pounds of clean wool. The water from bowl 1 is drawn off into a "cooler," which is a pit about 30 feet across on top, dug in the ground. In this the water cools, and a small part of it evaporates or leaches into the ground. Most of it flows into a tank in the "save-all" house, from which it is pumped into three smaller tanks for treatment. These latter are about 7 feet square by 5 feet deep. In them the alkaline liquid receives a small quantity of sulphuric acid. This causes the greasy particles to separate from the water, and rise as foam. The water below is then drawn off, and escapes into the river. It is clear, and about the color of amber. It has an odor like that of wool, and is somewhat acid. The greasy scum is drawn off upon 4 artificial filters of gravel, having a superficial area of about 200 square feet each, and 2 feet depth of filtering material. The scum solidifies somewhat upon the filters, and is shovelled into bags, which are put between sheet-iron plates, in a press contained in a tight box which can be filled with steam. The grease flows from the press as oil, and what remains in the bags is reduced to "soot cake." The oil is somewhat further refined, and then barrelled for the market. When cool, it has the consistency of lard or common soap-grease, and is of a reddish color, with an odor of wool. It is used either for stuffing leather, or as a lubricant, or in the manufacture of soap, etc. The "soot cake," which is principally dirt, contains as it comes from the press about 50 per cent. of moisture. It has been analyzed by two chemists, one of whom reports it valueless, and the other as having some manurial value. From 18,000 pounds of wool there are obtained a ton of grease, and 1,200 pounds of "soot cake." The cost of the plant for extracting these, not including buildings, was $2,500. The process has only recently been put in operation, but is thought to be remunerative.

Two mills in Millbury, Mass., each scouring about 1,000 pounds per day of wool in the grease, retain the first scour, which is supposed to contain about five-sixths of the dirt, thus lessening in that proportion the pollution which they otherwise would cause to the river. The first scour is retained in vats, which are cleaned periodically, and their contents used as a fertilizer. In these two cases the process is thought to be a paying one.

Next to the pollution caused by wool washing, the refuse from tanneries seems to cause the most trouble. There are very few cases in which attempts have been made to purify this refuse. The drainage from a tannery can be clarified chemically by the use of salts of iron, sometimes in conjunction with lime, as precipitants. At one place which I visited in England, a little sulphate of iron was first added to the drainage, uniting with the tan in forming tannate of iron, which was afterwards precipitated by the addition of lime water from the lime vats. The liquid, which was nearly colorless, was then filtered through gravel. Where the water contains a great deal of tan bark, it probably would be necessary to intercept this in some way before purifying the water by intermittent filtration, because otherwise the bark would clog the surface of the ground. At Maxwell's tannery, in Winchester, a mechanical filter (Fig. 6), to strain

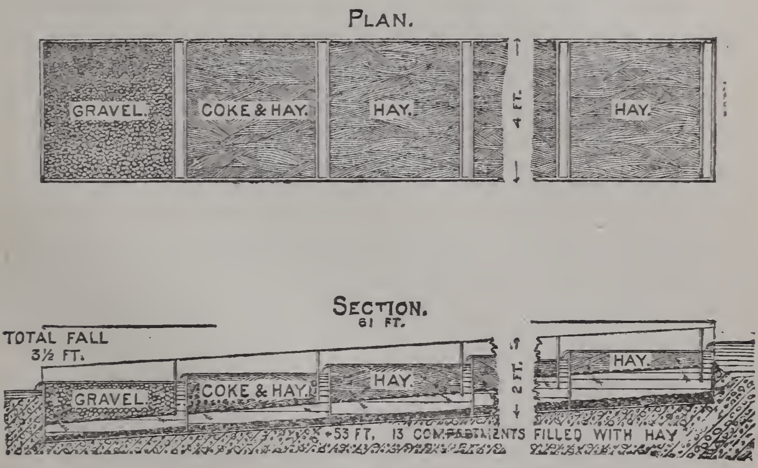


Fig. 6.

out the bark and coarse lime, has lately been put on trial. This consists of a wooden box, about 4 feet wide, 2 feet deep and 60 feet long. This is divided into compartments which are filled with hay, through which the water filters. The effluent generally is clear, but of a deep mahogany color. The experiment has been tried for too short a time to warrant an opinion as to its merits. At the purification works of the Mystic Water Works in Winchester, experiments in precipitation with iron and lime are about to be tried.

Some experiments made by myself on a very small scale at the same point, show that it is possible thus to obtain very thorough clarification. Whether the expense of carrying on such experiments upon a large scale would be so great as to preclude the attempt to do so, is yet to be ascertained.

The pollution caused by spent dye liquors from dye works, while it does not often cause unhealthful nuisances, is apt to discolor a stream for a long distance, and make it unsightly. Filtration through land probably would be an effectual remedy in most such cases. Often the evil could be much palliated, if only the thicker portion of the spent dyes in the bottoms of the vats were retained and treated. In several cases, indigo used in dyeing is recovered at a profit.

The pollution from paper mills is principally caused by the dirt washed from rags and old paper stock. Of domestic rags, as received by the manufacturer, 25 or 30 per cent. in weight is said to be dirt. It seems as though the pollution could be much lessened if comparatively little water were used in the first washing; and this, which would eliminate most of the dirt, were kept separate, and treated by filtration or otherwise.

Through the courtesy and interest of Messrs. C. F. Crehore & Son, I was enabled to have examinations made of the various wastes produced at their mill at Newton Lower Falls, which is one of the many paper mills situated on the Charles and Neponset rivers. At this mill domestic rags and tarred hemp junk are made into card and press papers for mills. In the process, the stock is first cut and dusted, which removes part of the waste in a dry state. This refuse easily can be kept from the stream. The stock then is boiled with lime, to saponify the dirt and bleach out the color. The waste water from this process is called "bleach liquor." The next process is that of washing, which is done in the "paper engines," where the stock is passed under a heavy roller with steel blades, acting against a bed plate also set with steel blades, the whole so arranged as not to cut the stock, but merely to separate the fibres. A constant stream of water passes through the engine for an hour or more. At first the effluent "wash water" looks very dirty as it leaves the washing engine. Towards the end of the operation it appears to flow away clean. "Sand boxes" in the bottoms of the washing engines receive the heavier particles, such as sand, dirt, buttons etc., removed from the stock. The washed stock, reduced to pulp, is drawn out in a thin continuous sheet, from which the water is removed by pressure and heat.

Mr. Crehore kindly collected eight samples of refuse from these several operations. These comprised solid refuse from the "sand boxes," and samples of "bleach liquors" and "wash waters" obtained from treating rags and junk respectively. These samples were submitted for analysis to Prof. Nichols of the Massachusetts Institute of Technology, and his report upon them is given below.

Mr. Eliot C. Clarke.

Dear Sir: — You have submitted to me for examination samples of waste material from Crehore's Paper Mill. In reply to your general questions I would say that, in my opinion, the solid waste from the "sand boxes," the liquor from the "boilers" and the first portions of the "wash water" ought not to be discharged into a stream whose dry weather flow is only nine million gallons and which is used as a source of water supply. I do not know of any use to which the refuse can be put or any treatment to which it can be subjected by which pecuniary profit can be derived from it. It becomes, therefore, a problem of disposing of the material in the least expensive manner without discharging it directly into the river, — a problem not altogether easy to solve.

The details of the examination of the various samples and such recommendations as I am able to make are as follows:

1. *Material from sand boxes.*

The dirt from the "rags" sand box, after draining off the liquid, weighed 252 grams while wet, and 98 grams when dry. In bulk, it was mainly fibre; by weight, the larger part was sand, buttons, metallic hooks, pins, paper fasteners, wire, etc. Expressed in per cents. we have, —

Water,	61 per cent.
Buttons and other heavy dirt,	24 "
Fibre and light dirt,	15 "
	100

Calculating on the dry material we have, —

Buttons and heavy dirt, ...	61 per cent.
Fibre and light dirt, ...	39 "
	100

The "fibre and light dirt" burned readily, leaving about half its weight of ash, or more exactly we have, —

Volatile and combustible matter, . .	47.72 per cent.
Ash, ...	52.28 "
	100.00

The "fibre and light dirt" contained matter soluble in ether, ...	1.29 per cent.
Matter soluble in ether after treatment with hydrochloric acid, ...	5.80 "
Phosphoric acid, ...	0.37 "
Nitrogen, ...	0.59 "
Potash not determined.	

In my opinion there is not grease enough to pay to extract or fertilizing matter enough to give a commercial value to the material as manure. There is, however, no reason why it should be discharged into the stream. If removed from the sand boxes and dried, either by waste heat, if any is available, or by exposure to the air, it can then be burned under the boilers. This is, in my opinion, the best disposition to make of it. It would, no doubt, be better to arrange for the settling of the heavier portion, containing bits of metal, etc., and dry and burn only the lighter portion. The heavier portion could be simply mixed with the ashes of the establishment without harm and be disposed of with them.

2. *Material from the "Rope" sand boxes.*

The sample received weighed wet 67 grams, dry 13 grams. When dry it burned readily, leaving less than half its weight of ash. We have, then, —

Water, ...	81 per cent.
Dry fibre and dirt, ...	19 "
	100

The dry fibre, etc., consisted of —

Volatile and combustible matter, . .	63.6 per cent.
Ash, ...	36.4 "
	100.0

Ether extracted 18 67 per cent. of a tarry matter which burned with a smoky flame. The fibre contained —

Phosphoric acid, ...	0.42 per cent.
Nitrogen, ...	0.10 "

The best disposition that can be made of this material is the same as that suggested in the previous case.

3. *B'each liquor from the rag boilers.*

This was a frothy, dark-colored, turbid, strongly alkaline liquid containing a large proportional amount of organic matter. The results of a partial examination appear in the table.* If this liquid had to be disposed of by itself, the best method would probably be to evaporate it under the grate-bars or in some other way by waste heat if possible. It would give about 9 or 10 per cent. of its weight of a thick syrup, which could then be burned, and by its burning return part of the heat required to evaporate it. As, however, the first portions of the wash water are unfit to discharge into the stream, it would probably be better to mix all the liquors together for treatment.

4. *Bleach liquor from Rope.*

This resembles the previous sample in general respects and might be treated similarly.

5, 6, 7, 8. *Wash water from Rags and from Rope.*

Samples 5 (rags) and 6 (rope) were taken 10 minutes after washing began, and samples 7 (rags) and 8 (rope), after 2 hours. The latter, although turbid and uninviting to the eye, might be discharged into the stream after a simple process of filtering through sand or sand and gravel. The first portions of the wash water are, however, too foul to be thus discharged. I have made a number of experiments with various chemical precipitants; with the stronger liquors very little satisfaction was obtained. With the weaker liquors, or with a mixture of the strong and weak together, better results were obtained, but the method would be expensive and the effluent ought not to go into a stream used for water supply. In my opinion, the best way of disposing of these liquors is by " intermittent downward filtration," through a sufficient amount of land. Judging from the published experience in other places this would be quite practicable, but I do not feel wholly sure of the success with the bleach liquor from the ropes,

* Page 236.

as the organic matter therein contained is not as readily oxidized as is that from the rags. Experience might show that a larger area of land was necessary if this liquid were mixed with the rest than is usually required, but I think it would be better to evaporate this liquid as indicated above. The amount of heat required would not be great. I do not possess accurate information as to the amounts of the various liquids of which samples were sent to me; but I assumed, on the strength of rough estimates which you gave me, that the daily discharge is approximately made up of —

700 gallons of bleach liquor, ...	(Rags.)
700 " " " "	(Rope.)
50,000 " " wash water, ...	5
50,000 " " " "	6
150,000 " " " "	7
150,000 " " " "	8

After the samples had been in my laboratory for more than two weeks, and had, consequently, undergone some chemical change, I made a mixture in this proportion and had it analyzed with the results which follow, and which represent, approximately,* the character of the present discharge: —

Total solids in solution, ...	120.000 parts in 100,000
Organic and volatile matter, ...	80.000 " " "
Inorganic matter, ...	40.000 " " "
Solids in suspension, ...	74.000 " " "
Organic and volatile, ...	30.000 " " "
Inorganic, ...	44.000 " " "
Alkalinity as lime, ...	25.400 " " "
Ammonia, ...	0.833 " " "
Albuminoid ammonia, ...	3.050 " " "
Total organic nitrogen, ...	5.353 " " "

In the absence of more definite knowledge of the composition which the united waste liquids would have, and in the absence of knowledge as to the land which may be available, it is impossible to estimate accurately the amount of land required for treating the liquid. Of land favorable for the purpose perhaps some 3 or 4 acres would be required. The liquid is rather alkaline to be used for irrigation, but if exposed to the air would lose some of

* *Analytical Note.* — These results of analyses vary somewhat from those calculated from Table I, mainly because the liquors had undergone some change since the first determinations were made, but partly because, in liquids of this character (*i. e.*, containing caustic lime), some of the determinations, such as that of the total solids, do not have a high degree of accuracy.

its alkalinity, or if there were acid refuse from some other establishment which could be mixed with it, it would be an advantage. To neutralize 400,000 gallons of a mixture such as described above would require 1,500 lbs. of oil of vitriol. A portion of the organic matter would then settle out as sludge (which could be filtered off, dried and burned), but the lime would go into the effluent as sulphate of lime, which would be of disadvantage to the stream as a source of water supply.

If a sewer were built — of which I have heard mention — the refuse could be sent into it and be mixed with the sewage without harm and all be treated together, but unless the water found its way as a purified effluent into the river again, this would be robbing it of too large a proportion of water. I cannot help believing that the washing of the rags could be conducted so as to use much less water, and if the sewer is to discharge its contents into the sea, some effort should be made to lessen the amount of water used and to separate the foulest liquids from those which are not so foul. According to your estimates about 320,000 gallons of water are used for bleaching and washing one ton of stock. It is stated that the amount of water used in Great Britain in boiling and washing Esparto grass varies from 4,000 to 15,000 gallons per ton of grass. For rags more water is required, and, I presume, for oakum, but certainly not 300,000 gallons.

All of which is respectfully submitted.

WM. RIPLEY NICHOLS.

MASS. INSTITUTE OF TECHNOLOGY, Nov. 13, 1885.

TABLE I. — *Examination of various Samples of Refuse from Crehore's Paper Mill.*

[Results expressed in Parts in 100,000.]

	UNFILTERED.		AFTER FILTERING THROUGH PAPER.		Alkalinity expressed as *lime.*	Organic Nitrogen.
	Total Solids.	Volatile.	Total Solids.	Volatile.		
RAGS.						
Drainings from dirt, ...	–	–	–	–	73.2	–
Bleach liquor, ...	7326.	5032.	7222.	–	749.6	360.
Wash water after ten minutes, . .	537.5	–	393.	–	120.9	–
Wash water after two hours, . . .	18.5	11.5	11.	4.5	0.5	–
ROPE.						
Drainings from dirt, ...	–	–	–	–	13.	–
Bleach liquor, ...	8193.	–	8120.	5144.	178.	51.
Wash water after ten minutes, . .	492.5	–	369.	–	57.	–
Wash water after two hours, . . .	38.	28.	18.	9.	0.8	–

TABLE II. — *Examination of various Samples of Refuse from Crehore's Paper Mill.*

[Results expressed in Pounds to 1,000 Gallons.]

	UNFILTERED.		AFTER FILTERING THROUGH PAPER.		Alkalinity expressed as *lime.*	Organic Nitrogen.
	Total Solids.	Volatile.	Total Solids.	Volatile.		
RAGS.						
Drainings from dirt, ...	–	–	–	–	6.1	–
Bleach liquor, ...	611.2	419.8	602.3	–	62.5	30.0
Wash water after ten minutes, . .	44.8	–	32.8	–	10.1	–
Wash water after two hours, . .	0.05	0.96	0.92	0.47	0.04	–
ROPE.						
Drainings from dirt, ...	–	–	–	–	1.1	–
Bleach liquor, ...	683.5	–	677.3	429.0	14.8	4.3
Wash water after ten minutes, . .	41.1	–	30.8	–	4.8	–
Wash water after two hours, . .	3.2	2.3	1.5	0.75	0.7	–

Manufacturers as a class are very intelligent, and there is no limit to the ingenuity they have displayed in devising processes and machinery for accomplishing desired ends. This ingenuity hitherto has not been directed towards purifying their refuse, because such purification has not been considered necessary. The mechanical problems involved are not so difficult but that they probably can be solved, if only intelligent efforts and experiments are made in that direction. In pursuance of the constant policy of the Commonwealth in fostering manufactures, it is possible that in some cases it might be proper and expedient for the State itself to conduct experiments in purification, which would be for the benefit of the whole community, but which might be too expensive for any individual to undertake. It also might be advantageous to experiment somewhat on the best methods of utilizing sewage, night soil and other refuse products as fertilizers. Such experiments could be conducted at some of the agricultural colleges.

SECT. 157. *Present and prospective pollution.* — It is much easier to design a proper system of sewerage than to remedy the defects of one already constructed. Indeed, thoroughly to do the latter is well-nigh impossible. Unfortunately, the sewers in many towns of the State have been built piecemeal and without any system. First, a single drain is built, chiefly to remove surplus rain water. It discharges little or no sewage, and the position of the outlet is thought to be unimportant. House drains are afterwards connected with it, so that it assumes the functions of a sewer. Then another branch sewer connecting with it is built, and from time to time more are added. So a network of pipes grows up, without system, and without adaptation of one pipe to the others. The sewers work badly, and the amount of sewage discharged at the outlet begins to make a nuisance. Then, perhaps, but not before, some expert in sewerage is called in consultation. It is, however, too late, — the mischief has been done, — and he rarely can suggest any but palliative measures, unless the town is willing to abandon all of the work already done, and begin again *de novo*. Many nuisances and much expense would be avoided if it were required in the future that no towns should be allowed to build sewers, except such as formed parts of a well digested scheme for the whole town; which scheme provided for the proper disposal of the present and prospective amounts of sewage, and had first been submitted to, and approved by, some expert appointed by the State.

The same principle applies to manufactories. Nearly all of those already existing were located and built without any reference to treatment or purification of their waste products, and many of them are so situated and arranged that it will be difficult to find room and other facilities for carrying on processes of purification. In such cases, the most that can be done is to use the most available means in any given case. In the case of manufactories built hereafter, it will be much easier to do away with the liability to pollution, because the need of this can be considered in selecting the location and arranging the works. A scouring mill, tannery, or dye works, for instance, which produces much refuse difficult to cleanse thoroughly, would not select as a site for its operations a point where its effluent must necessarily go into water used for drinking, but would, instead, build upon some stream which never would be used for that purpose. It would not be located in the centre of a town, where its operations might cause a nuisance, but instead would seek some place where an ample area of porous land could be obtained for filtration, and would so arrange its tanks and vats that foul liquids would flow by gravity to suitable places for purification.

This condition of things could be brought about in either of two ways: —

1. A law could be passed, requiring that at all manufactories established in the future, the foul drainage should be effectually purified. This would place upon the manufacturers the responsibility of so locating and arranging their works as to do this to their best advantage. The objection to this is, that any general law would affect equally all kinds of manufactures and all parts of the State. To be useful, it must require the degree of purification which is necessary in the most important cases, — a degree much higher than ordinarily would be required.

2 The other way would be to have some central authority, which should consider each case on its own merits, bearing in mind the importance of the industry, the degree of purification which it is necessary to obtain, and the means practically available for that purpose. By this method, any new manufactory would be required to submit a statement, showing the site to be occupied, the facilities afforded for purification, and the means to be adopted to that end. The objection to this plan is, that it would place too much authority in the hands of one person or board. This objection might be somewhat obviated if the board were not empowered to *prohibit* the establishment of a manufactory which could not show that it would sufficiently purify its waste products; such manufactory, however, if established without the permission of the board, being subject to stricter supervision and penalties if causing pollution. Some good results even might be attained by a board having only advisory powers. It is possible that none of these methods will be considered practicable, but they are submitted for consideration.

SECT. 158. *Useful Statistics.* — The following table gives populations, areas and valuations at all of the cities and towns in the different districts under consideration by your commission. The facts shown by the table have some bearing upon the problems before you, and may facilitate their solution: —

Useful Statistics.

CITY OR TOWN.	POPULATION.				Taxable Area. Acres.	VALUATIONS, 1885.		
	1870.	1875.	1880.	1885.		Personal.	Real.	Total.
Arlington,	3,261	3,906	4,100	4,673	2,867	$946,575	$3,790,803	$4,737,378
Ashland,	2,186	2,211	2,394	2,633	7,465	243,958	1,117,595	1,361,553
Auburn,	1,178	1,233	1,317	1,268	9,455	108,819	378,976	487,795
Bellingham,	1,282	1,247	1,223	1,198	10,989	110,355	464,480	574,835
Belmont,	1,513	1,937	1,615	1,639	2,735	658,157	2,174,855	2,833,012
Blackstone,	5,421	4,640	4,907	5,435	9,643	662,590	1,653,755	2,316,345
Boston (whole city),	250,526	341,919	362,839	390,406	19,100	189,605,672	495,973,400	685,579,072
Brighton,	4,967	6,200	6,693	8,523	2,002	1,279,800	8,097,700	9,377,500
Brookline,	6,650	6,675	8,057	9,195	3,830	12,967,400	16,988,300	29,955,700
Cambridge,	39,634	47,838	52,669	59,660	3,300	12,758,255	42,588,300	55,346,555
Canton,	3,879	4,192	4,516	4,380	11,488	1,194,915	2,161,540	3,356,455
Charlestown,	28,323	33,556	33,731	37,673	377	5,518,000	22,754,700	28,272,700
Chelsea,	18,547	20,737	21,782	25,709	961	2,287,980	16,166,714	18,454,694
Dedham,	7,342	5,756	6,233	6,641	12,203	1,429,836	3,802,715	5,232,551
Dorchester,	12,261	15,788	17,890	21,500	3,882	4,655,600	19,439,200	24,094,800
Douglas,	2,182	2,202	2,241	2,205	21,089	211,570	810,830	1,022,400
Dover,	645	650	653	664	8,986	329,924	412,667	742,591
East Boston,	23,816	27,420	28,381	31,419	875	1,710,500	16,253,300	17,963,800

Everett,	2,220	3,651	4,159	5,375	1,828	432,750	4,700,850	5,133,600
Framingham,	4,968	5,167	6,235	8,275	14,507	1,505,780	4,474,420	5,980,200
Franklin,	2,512	2,983	4,051	3,983	15,564	453,615	1,514,055	1,967,670
Foxborough,	3,057	3,168	2,950	2,814	12,032	366,990	1,115,202	1,482,192
Grafton,	4,594	4,442	4,030	4,498	13,549	738,798	1,504,002	2,242,800
Holden,	2,062	2,180	2,499	2,470	21,538	221,412	791,905	1,013,317
Holliston,	3,073	3,399	3,098	2,926	11,206	463,557	1,205,418	1,668,975
Hopkinton,	4,419	4,503	4,601	3,922	16,705	568,718	1,631,265	2,199,983
Hyde Park,	4,136	6,316	7,088	8,400	2,406	624,935	4,577,150	5,202,085
Leicester,	2,768	2,770	2,779	2,923	14,834	626,700	1,097,493	1,724,193
Lexington,	2,277	2,505	2,460	2,718	10,050	632,211	2,248,249	2,880,460
Lincoln,	791	834	907	901	8,913	467,079	602,890	1,069,969
Malden,	7,367	10,843	12,017	16,407	2,650	1,997,933	10,655,050	12,652,983
Marlborough,	8,474	8,424	10,127	10,941	12,845	864,800	3,306,295	4,171,095
Medfield,	1,142	1,163	1,371	1,594	8,098	308,245	802,613	1,110,858
Medford,	5,717	6,267	7,573	9,041	4,420	1,935,786	6,185,425	8,121,211
Medway,	3,721	4,242	3,956	2,777	6,336	312,160	946,320	1,258,480
Melrose,	3,414	3,990	4,560	6,101	2,700	395,415	4,374,250	4,769,665
Mendon,	1,175	1,176	1,094	945	10,822	92,904	467,708	560,612
Milford,	9,890	9,818	9,310	9,343	11,686	1,309,153	3,892,376	5,201,529
Millbury,	4,397	4,529	4,741	4,555	9,151	600,325	1,515,386	2,115,711
Millis,	–	–	–	683	6,493	54,254	357,215	411,469

Useful Statistics — Concluded.

CITY OR TOWN.	Population.				Taxable Area, Acres.	Valuations, 1885.		
	1870.	1875.	1880.	1885.		Personal.	Real.	Total.
Milton,	2,683	2,738	3,206	3,555	8,033	$8,166,100	$4,219,050	$12,385,150
Natick,	6,404	7,419	8,479	8,460	8,430	990,150	3,942,750	4,932,900
Needham,	3,607	4,548	5,252	2,586	7,491	200,480	1,728,341	1,928,821
Newton,	12,825	16,105	16,995	19,759	9,939	7,865,000	21,134,820	28,999,820
Norfolk,	1,081	920	930	825	9,099	63,150	340,938	404,088
Northbridge,	3,774	4,030	4,053	3,785	9,487	860,845	1,196,260	2,057,105
Norwood,	–	1,749	2,345	2,921	6,216	447,014	1,618,928	2,065,942
Paxton,	646	600	592	561	8,574	36,965	244,133	281,098
Quincy,	7,442	9,155	10,570	12,144	8,836	1,884,490	6,604,975	8,489,465
Randolph,	–	4,064	4,027	3,807	5,907	532,750	1,465,450	1,998,200
Reading,	2,664	3,186	3,181	3,539	5,735	200,633	2,163,309	2,363,942
Revere,	1,197	1,603	2,263	3,637	3,380	226,550	3,201,000	3,427,550
Sharon,	1,508	1,330	1,492	1,328	14,027	283,812	817,701	1,101,513
Sherborn,	1,062	999	1,401	1,391	9,956	114,085	707,385	821,470
Shrewsbury,	1,610	1,524	1,500	1,450	12,730	227,895	763,835	991,730
Somerville,	14,685	21,868	24,933	29,992	1,935	1,814,500	23,063,900	24,878,400
Southborough,	2,135	1,986	2,142	2,100	9,464	272,334	1,101,309	1,373,643
Stoneham,	4,513	4,984	4,890	5,652	3,560	399,675	2,710,335	3,110,010

Stoughton, ...	4,914	4,842	4,875	5,183	11,448	433,890	1,839,260	2,273,150
Sutton, ...	2,699	3,051	3,105	3,101	20,160	360,605	912,056	1,272,661
Upton, ...	1,989	2,125	2,023	2,265	12,990	197,826	669,233	867,059
Uxbridge, ...	3,058	3,029	3,111	2,948	17,760	627,121	1,314,580	1,941,701
Walpole, ...	2,137	2,290	2,494	2,443	12,425	303,826	1,267,561	1,571,387
Waltham, ...	9,065	9,967	11,712	14,609	7,660	2,404,432	8,474,800	10,879,232
Watertown, ...	4,326	5,099	5,426	6,238	2,047	1,352,040	5,130,310	6,482,350
Wayland, ...	1,240	1,766	1,962	1,946	9,275	244,125	994,355	1,238,480
Wellesley, ...	-	-	-	3,013	5,765	2,031,337	2,521,504	4,552,841
Westborough, ...	3,601	5,141	5,214	4,880	12,203	499,579	2,068,163	2,567,742
Weston, ...	1,261	1,282	1,448	1,427	19,496	821,766	1,075,300	1,897,066
West Roxbury, ...	8,686	11,783	14,032	17,424	5,742	7,969,500	14,993,500	22,963,000
Winchester, ...	2,645	3,099	3,802	4,390	3,465	1,081,355	3,069,722	4,151,077
Woburn, ...	8,530	9,568	10,931	11,750	7,683	1,908,434	5,947,463	7,855,897
Worcester, ...	41,105	49,317	58,291	68,383	20,835	13,506,841	39,207,550	52,714,391
Wrentham, ...	2,292	2,395	2,481	2,710	19,144	227,148	1,105,325	1,332,473

Date Due