THE SOLUTION OF A MUNICIPAL DRAINAGE PROBLEM

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The Solution of a Municipal Drainage Problem

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PREFACE

The purpose of this thesis is to develop a practical and economical remedy for a costly drainage problem now existing in the city of Manchester, New Hampshire. The author was employed by the engineering department of that city for a period of seven years and fully realizes the necessity for an effective solution to this problem. For a number of years the annual cost of street repairs necessitated by washouts coincident with heavy rain storms has been an unwarranted burden on the taxpaying public and a serious drain on the limited budget of the city highway department. In addition, considerable and recurrent damage to property of the Boston & Maine Railroad has disrupted traffic and brought repeated threats of lawsuit from that corporation. Motor traffic along Canal Street, a north-south artery, is hazardous during and immediately after a heavy rain storm. For these reasons a prompt solution of the problem is indicated.

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Chapter I

INTRODUCTION

It will be well to describe in detail the problem we are faced with. Manchester is an industrial city situated on both east and west banks of the Merrimac River where the land slopes quite steeply. All natural drainage is toward the river. Three or four times during each summer excessively heavy showers occur wherein the rainfall rate may be higher than three inches per hour. The duration of these showers is usually about fifteen to twenty minutes, and a total precipitation of more than one inch may be recorded. The run-off coefficient is high due to the developed nature of streets and buildings and may average about 85 to 90% in the area concerned in this problem. Both sewage and storm run-off are carried in a combined system that was designed many years ago to care for normal flow plus anticipated storm excess. But development and extension of the city has increased the run-off considerably so that the drains are now greatly overtaxed during heavy rains.

In the area from West Pennacook Street southerly to Langdon Street and from the river easterly to Elm Street other factors are present which tend to increase the property damage during storms. A 42" x 63" brick culvert following the course of an old brook originating in the northeast section of the city carries a large part of the drainage from that area to the river. From Elm Street to a point about 300 feet east of Canal Street it runs parallel to and about fifty feet north of West Pennacook Street and then empties into an old, crooked 24" x 36" brick sewer running down West Pennacook Street. A number of laterals are connected to it so that its drainage area is approximately 480 acres. Recent expansion of the city has been in this section, and so storm run-off is greatly increased. Consequently during and immediately after a storm this culvert carries a tremendous volume of water under high head. Naturally this large volume of water cannot be cared for in the drastically reduced size West Pennacook Street sewer,and so the force of the water causes it to rise in the manhole, lift off the manhole cover, and overflow to rush down West Pennacook Street with a scouring velocity directly responsible for much damage.

The large volume of water brought down by this culvert serves to aggravate conditions in the already congested Canal Street sewer which is a 24" x 36" brick structure. Because of the fact that between Canal Street and the river there is a strip of privately owned property about 200 yards wide, no overflows to the river exist north of Bridge Street. This means that water entering the Canal Street sewer at Pennacook Street must be carried more than a mile before it reaches the Bridge Street outfall to be emptied into the river. Within this strip of private property there are: the double track main line of the Boston & Maine Railroad which carries an average of four trains per hour; two thirty feet wide canals formerly used to carry wash water for textile mills but inactive now; and a double row of mill buildings. All these present a barrier to the construction of other outfall sewers.

Even though drains could be redesigned for greater capacity the condition would be only partially alleviated. Storm run-off from the immediate area during showers of the cloud burst variety rushes down Pennacook, Brook, and Langdon streets in such volume that it runs far out from the curb beyond the reach of the usual type of catch basin inlet. In fact, at times a solid sheet of water extending from curb to curb runs down these streets. Even that portion of the flow adjacent to the curb does not find its way into the drains, because its high velocity causes it to jump over the conventional inlets and continue down the gutters.

It is time now for a statement of the specific damage arising from the conditions mentioned above. Marked similarity has been noted of the damage resulting from each intensive rain storm. Curb stone and pavement washouts occur on West Pennacook, Brook, and Langdon streets from Canal Street easterly about 150 feet. Curbing and pavement is washed out on the west side of Canal Street opposite Pennacook Street and to about 100 feet southerly therefrom; and opposite Brook and Langdon streets. The roadbed of the Boston & Maine Railroad at a point opposite West Pennacook Street usually incurs wash-outs averaging 25 feet long and four to six feet deep under both tracks. As this is the main line of this railroad from Boston through northern New England to Montreal, the damage causes expensive delay to a large volume of traffic. Gravel and stone from these washouts opposite Pennacook Street are deposited in the east canal necessitating an expensive cleaning operation. The canal walls of stone block construction are partially destroyed in each storm. The 24" x 36" brick sewer in Canal Street breaks under the great overload; and undermining of the pavement results, creating a hazard to motor vehicle traffic. Danger to motor traffic is further increased, because manhole covers are lifted off by the pressure within the manholes and because rubble from the washouts is deposited all over the streets.

Any attempts at a solution to this problem must be based on both efficiency and economy, for the annual appropriation to the highway department for new construction in the city at large is limited. The following pages offer a plan that can be put into effect at a nominal cost to the taxpayers. It is proposed to construct two overflows from the Canal Street sewer to the east canal. Two are required, because there is insufficient clearance beneath the railroad tracks for one pipe large enough to carry the expected flow and because the general topography of the area dictates such construction for economie's sake. The Public Service Company of New Hampshire, present owner of the canal property, has agreed to allow storm water only to be discharged into their canal provided it is done at a velocity not exceeding twelve feet per second. These overflows are designed to serve purely as such and will function only when an excess of storm water fills the Canal Street sewer. Normal sewage flow will continue to be carried down Canal Street. Open gratings will be substituted for all manhole covers to minimize the chances of their being lifted off when the system is overloaded. Catch basin inlets are redesigned to catch a maximum amount of surface drainage under all conditions. The most notable features of the new design being the use of cover gratings having a larger percentage of open area and the installation of the inlets from curb to curb.

Chapter II

DESIGN OF INLETS

Chapter II: Design of Inlets

The standard type of catch basin inlet in use at the present time in the city of Manchester consists of a sand well of brick with a cast iron trap at the outlet pipe and a cast iron cover grate set into a cast frame. The amount of water entering the basin is of course determined by the size and location of this grate. The grating used is a U shaped casting measuring 18" x 24" with slotted openings one inch wide separated by one inch metal bars. Effective open area in this type of grating is approximately 40% of the total. Catch basins are installed so that the flat side of the U is adjacent and parallel to the curbing. This means that only water flowing less than two feet from the curb will pass over the grating and have any chance of entering the drain. A grating of this type is prone to clog up with leaves and other gutter debris. Because of the small open area, water flowing at high velocity as during storms, tends to run over the grating without falling through, even when the openings are free of debris. Hence, before any attempt is made to enlarge the sewers and provide overflows, consideration must first be given to the problem of trapping surface runoff into the underground drainage system.

First necessity is to discard the inefficient gratings now being used and replace them with a style having a maximum open area without sacrifice of vehicle carrying capacity.

It would be possible to design and have fabricated in the city shops, a grating satisfying these requirements or to contract for its manufacture with nearby steel works or foundries. However, since there are now two firms manufacturing a type of open grid bridge decking adaptable to our needs, it will prove more economical to purchase such at production prices and design the catch basins to enable use of this material for gratings. Both forms of grid have approximately the same percentage of open area per square foot. One type made by the United States Steel Company has less structural strength though than the other made by the Irving Subway Grating Company and must be supported on shorter spans. Now since any form of support placed beneath tends to make the supported area ineffective for the passage of water,the better choice is the type that will carry required loads over the longest unsupported spans. Therefore, the type sold under the tradename of Irving Decking will be used in this design. This steel mesh consists of alternate straight or carrying bars and reticuline or crimped bars on edge and fastened together at points of contact with all top edges of bars flush. It is 80% open, which is an increase of 40% over the heavy iron castings now being used. Two other desirable features are found in this grating. It weighs only 15 1/4 pounds per square foot and therefore the gratings for the large size catch basins needed in this instance can be made in one piece and yet easily handled. Also since the top edges of the bars present very little surface for the retention of snow and dirt, the units are practically self cleaning. Standard sizes carried in stock by the manufacturer are units measuring 60 3/16" in length and 23 3/4", 41 1/2", or 59" in width,and so catch basin design is adapted to accomodate these units ar multiples thereof.

Reference is now made to the appended print of proposed standard catch basin grates for three methods of installation, which will serve to meet all conditions of this particular problem. It is believed also that these designs can be used as a standard for future construction in other sections of the city where similar drainage problems are encountered.

The first method of installation is intended for use where a moderate volume of storm water is to be expected and where the crown of the roadway is sufficient to insure that maximum volume of flow is in the gutter and that the outer edge of flow is never more than five feet from the curb. Catch basins of this type will be used near the top of the grade on Pennacook, Brook, and Langdon streets in order to lead water into the drains before it acquires any large volume or high velocity. A 23 3/4" x 60 3/16" grating is utilized and placed so that the larger dimension is perpendicular to the curb. The sand well may be made either of concrete or double course brick with inside dimensions of 18 3/4" x 57 3/4". Depth should be at least six feet in order to provide sufficient space for sand collection so that too frequent cleaning out will not be necessary.

The outlet pipe must be at least 3 1/2 feet below the surface to minimize the danger of freezing in cold weather. The masonry walls are built up to within three inches of the pavement surface which is just sufficient space to set the grating flush with the top of the pavement. A prefabricated frame to hold the grating in place is made by welding pieces of angle iron together as shown in the appended prints. 2" x 3" x 3/8" angles are used on the shorter sides and 3" x 3" x 3/8" angles are used on the longer sides. The frames are anchored to the masonry by means of clips made from 2" x 2" angles and welded onto the underside of the frames. Consultation of the table of safe loads published by the manufacturer of this grating, a copy of which is appended, shows that no intermediate supports are necessary to carry the heaviest vehicle loads across the span of this catch basin.

For use farther down these steeply sloping streets, where storm water attains a greater velocity though still continuing to run not more than five feet from the curb, a modification of the preceding design is to be used utilizing a grating 41 1/2" x 60 3/16". It is placed with the longer side perpendicular to the curb. The inside dimensions of the sand well are made 36 1/2" x 57 3/4". The construction may be either concrete or two course brick as before. Same depth and location of the outlet pipe are used as in the single span catch basin, and a welded frame is made of angles in the same manner except that the width is increased to accomodate the 41 1/2" wide grate. Since this type of grating will not carry vehicle traffic over such a wide span, an intermediate support must be provided. Assuming that the maximum wheel load including impact that the grating will be subjected to is 10,000#, a 5" H beam weighing 13.5#/foot will offer ample support. To facilitate cleaning of the catch basin, it is advisable to have this H beam installed in such a manner that it will be easily removable and yet firmly fixed when in place. The appended prints show in detail a method for accomplishing this by welding a 6" piece of 3" x 4" x 3/8" angle onto the inside of a 6" channel to serve as a seat for the beam. This channel must extend six inches into the masonry of either side wall to obtain sufficient bearing area to avoid crushing of the brickwork. Stops are to be welded onto this beam seat to hold the beam in place, the top flange of the beam coped out so that it can be lifted over the stops for removal. The advantage of this second design over the first is that its extra width will tend to trap a greater percentage of water flowing at the high velocities attained on the steep grades of these streets. Water flowing at high speed and large volume has a tendency to ride over a grating for a distance of about two feet before it drops through. So it is anticipated that during severe storms two feet of width on the uphill side will serve mainly to disrupt the continuity of flow, and most of the water will fall through the grating in the remaining width.

Another factor tending to cause water to override a catch basin of any type is that a heavy flow forms a blanket over the grating so that air can not escape from the basin. Pressure thus built up resists the entrance of water. Such effect can be neutralized by installing a vent made of three inch pipe from the sand well up through the curbing.

Either the single or double span inlets just described are adaptable to a progressive method for the installation of additional sections to increase the water trapping area in the event that this should prove necessary at any future time. One must realize that conditions precedent to storm drainage change from time to time, and a structure quite adequate at the present time may need enlargement in later years. Higher development of any section of a municipality is accompanied by increased paved areas and additional building coverage, factors which raise the runoff coefficient and increase the amount of water to be cared for during a given time interval. In the appended print on standard catch basin designs is described the manner of adding additional sections to an original installation. Because when the volume of water flowing down the gutter of a paved street is increased it tends to creep up across the crown of the roadway and flow in a wider stream with the outer edge of flow farther from the curbing, it may bypass an outlet extending only five feet from the curbing. Therefore, the logical place to install extra sections is from the outer edge of the original catch basin outward toward and perpendicular to the centerline of the roadway. Sections to be added are made up in the same manner as the original. Use the same size grating and fabricate a frame of the same type. Where the added frame abuts the original they should be tack welded together for rigidity. A catch basin grating must be a rigid, integral part of the whole structure to prevent movement under vehicular traffic which would cause spalling of the pavement adjoining. Such pavement damage is a source of annoyance to traffic and a constant maintenance expense. A sand well in the additional sections is unnecessary and will be omitted. Instead a channel with a width equal to the inside width of the grating frame and a depth of 18 to 24 inches should be constructed of concrete or brick masonry. The bottom of this channel should have a slope toward the sand well of the original catch basin, so that water will drain easily and sediment will not remain in the channel. Steel mesh reinforcement should be used in the bottoms of these added units and their sides well anchored to the bottoms because, due to their shallow depth, they are subject to damage from frost action.

The third standard design proposed is for a catch basin extending from curb to curb at right angles to the centerline of the roadway and built as a single unit. In action it is similar to the construction of five of the single units described above placed end to end across the roadway, but it has the advantage of economy and strength arising from unit construction. A structure of this type is necessary at the foot of the long steep grades of Pennacook, Brook, and Langdon streets where a tremendous volume of water has attained a high speed, overflowed the gutters and is running the full width of the roadway from curb to curb. Two sand wells similar to that used in the previous designs are constructed of brick or masonry on either side of the road with long dimension perpendicular to the curbing. They are made six feet deep with inside dimensions of 36 1/2" x 57 3/4", and the walls are built up to within three inches of finish pavement grade. A channel of concrete or brick is built across the roadway to connect these sand wells. Its inside width should be 36 1/2" and the depth 18" at the centerline of the roadway and sloping both ways from the center to 24" where it joins the sand wells. This is a slope of six inches in ten feet and is sufficient to insure the channel being washed clean at all times. Outlet pipes are located on the sides of the sand wells 3 1/2 feet below paving grade. A frame to fit the grating is made by welding 3" x 3" x 3/8" angles together as shown. Since the span is too great for the grating to carry traffic load unsupported, steel I beam supports are needed. The highway department at present has in stock many hundred feet of A.S.C.E. 50# railroad rails removed from the city streets when busses were substituted for street cars. So in the interest of economy, the design is such that these rails can be used as supports. 4'-8" lengths of rail are embedded in the masonry walls so that their base side is upward and seven inches below the pavement grade. Rails are parallel to the centerline of the roadway and spaced 32 3/4" apart. A single rail rests on these supports and runs lengthwise down the center of the catch basin and in turn provides intermediate support for the grating and frame. The outside edges of the frame are anchored in place by means of 6" x 3 1/2" x 3/8" x 3" angles, one leg of which is welded to the frame and the other leg welded to the supporting rails, as shown on plan. The 41 1/2" wide grating will be used. For convenience of cleaning and also to facilitate fitting to the crown of the roadway, the grating will be made in four sections. Usual 41 1/2" x 60 3/16" size is to be used over both sand wells, and then the center section is to be broken at the midpoint. This center section, not being of standard length, must be spliced which is simply done using tools that are loaned by the manufacturer for this purpose.

Although a modification of this design using only a single span grating 23 3/4" wide would be of no value in the area dealt with in this problem, it is conceivable that it would be suitable for other locations. Hence, it is well to note here that such installation could be made by following the same general plan as above except that the supporting rails could be omitted as unnecessary and the width of the substructure altered to fit the narrower grating.

As mentioned at the beginning of this chapter, it is believed that the aforementioned standard designs will be sufficient to meet any and all conditions even during the severest storms. They provide an efficient and economical means of preventing the unrestrained rush of large volumes of water down the streets, thus eliminating the chief cause of washouts.

Chapter III

THE DRAINAGE SYSTEM

Chapter III: The Drainage System

In the previous chapter methods for the collection of surface runoff under all conditions were discussed. That subject, of course, was of prime importance, for without means of arresting the uncontrolled rush of flood waters, the design of the underground drainage system was immaterial. However, now that catchbasins have been designed capable of collecting the storm water, the drainage system must be revised and added to where necessary to carry it to points of discharge. In order to make any intelligent computation of pipe sizes and grades required, an accurate knowledge of the amount of water to be cared for is of prime importance. A basic factor in such determinations is to have complete rainfall data collected over a period of years. From such data curves can be plotted and extended to give reliable predictions of rainfall expectancy in future years. A few years ago the firm of Fay, Spofford, and Thorndike, Boston, Massachusetts, consulting engineers was engaged by the city of Manchester to make investigation of and report on the sewage system of the city. In their report was included a rainfall curve with intensity in inches per hour plotted against duration in minutes and based on an eleven year frequency. This curve is reproduced in the appendix of this thesis and is used as a basis for design. Since this problem deals with damages caused by short duration, severe rainstorms, a figure of two inches per hour is selected from the curve and results using this figure are checked against computations made using a value of one inch per hour at 100% runoff. The greater value is taken for design. The reason for using the check of one inch per hour at 100% runoff is that this figure is representative of a typical winter storm when ground is frozen solid.

Before beginning any construction, it is well to note certain limitations that must be imposed. Because of the tremendous volume of water to be cared for during a storm, it is necessary that the system be secure at all times against the possibility of a sudden shower. Reliable weather reports may be obtained from the army air base on the outskirts of the city and should be consulted before any existing sewer line is opened. In the event of a bad weather forecast, work should be suspended. Any new or supplementary lines should be completed before being connected to a higher part of the system.

The greatest single cause of damage is due to the 42" x 63" Christian Brook culvert emptying into the smaller 24" x 36" West Pennacook Street sewer. Therefore, first consideration is given to a relief of this condition. The Christian Brook culvert is capable of discharging 255 cubic feet of water per second, and so provision must be made to take care of this amount. This can be done by laying a larger pipe down West Pennacook Street to the Canal Street drain and then providing an overflow that will function only during periods of overload to discharge excess storm water into the East canal. Because the exact location of the old West Pennacook sewer is unknown and it is unwise to disturb it until the new pipe is laid, the new pipe shall be located north of the street line as shown on the plan. There is no additional cost for right of way in so doing, because the property on that side of the street is already owned by the city. Computations show that a 48" concrete pipe laid on a 3% grade will be adequate to carry the amount of water involved. In construction a new manhole should be built just west of the existing one at the terminus of the Christian Brook culvert, and the very last operation should be the connection of these two manholes and the sealing of the connection of the West Pennacook sewer.

Considerable thought was given to the design of a manhole at the intersection of the new pipe with the Canal Street sewer. It is at this point that the operation of the overflow to the canal must be regulated. The Canal Street sewer north of West Pennacook Street is of 24" x 36" brick construction, and computations show that it will carry a maximum flow of 39 cubic feet per second to contribute to our problem. Since this is a combined sewerage system, the manhole must be so constructed that in normal periods the sewage flow will continue to run down Canal Street and not be allowed to pass through the overflow into the canal for obvious reasons. It is true that no practical design to filter out all sewage at flood times is possible. However, during a storm when the sewers are running full enough to create a discharge through the overflow, sewage will be so well diluted in the enormous volume of storm water that no nuisance will be created. Regulation of the flow of water through the manhole is to be controlled by the location of the outlet pipes. A sketch of the proposed manhole is included in the appendix. It may be either concrete or brick masonry construction, should be steel reinforced to resist pressure, and will be pentagonal in shape. The 48" pipe coming down West Pennacook Street will enter with an invert elevation of 85.50 feet,and the invert elevation of the 54" overflow will be 84.70 feet. Because this latter elevation is well above the top of the 27" pipe leading down Canal Street, sufficient water must be flowing to fill this pipe and back up in the manhole before any will run out the overflow. A reinforced concrete slab top should cover this manhole.

The 24" x 36" sewer in West Pennacook Street will no longer carry a continuous flow of water since its upper end is to be sealed. However, its removal doesn't merit the cost involved. Therefore, because it will collect some subsurface drainage water that would possibly cause undermining of the pavement if uncared for, its lower end must be connected into the drainage system. For this purpose a temporary manhole must be constructed at the intersection of this sewer with the new 48" drain.

Construction of the overflow into the canal presents more problems for consideration. It is estimated that it will be required to carry during maximum flood stage not only the 255 cubic feet per second discharged by the Christian Brook culvert but also an additional 95 cubic feet per second from surface drainage on West Pennacook and Canal streets. Hence, it should be designed for a maximum capacity of 350 cubic feet per second. As stated in chapter I, the owners of the canal property are willing to allow discharge into their canal only if the velocity does not exceed twelve feet per second. So it is impossible to run the overflow directly from Canal and West Pennacook streets to the canal, because the minimum grade attainable at that point is 10.3% and would cause excess velocity. The pipe would have to be kept down to give clearance under the railroad tracks, and so any structure built to kill the velocity would have to be below the canal level and expensive to construct. The city has no equipment to build cofferdams, and the canal water level can be lowered only one foot, because one mill using it for water power has no other source of power whatsoever. Consequently, it will prove more economical to dissipate the excess velocity by running the overflow southerly parallel to Canal Street for a sufficient distance to keep the grade under 0.70%. In order not to interfere with the sewer, gas pipeline, and two water mains already beneath the roadway, this overflow pipe would best be installed beneath the west sidewalk. To clarify this location the reader's attention is again directed to the layout plan appended. A 54" concrete pipe laid on a 7.50% slope will be sufficient to carry the flow from the regulating man hole at Canal and Pennacook streets diagonally across the street to the west sidewalk.

Here another manhole should be built and needs some description, as it is also of special construction. A sketch will be found in the appendix to illustrate its construction. To best accomodate the various connections it is pentagonal in shape, made of steel reinforced masonry, and has a reinforced concrete slab top. The 54" pipe enters with an invert elevation of 82.00 feet. A 42" leader is installed to the north to provide for possible extension in that direction at a later date. A 24" drain from the two large curb to curb catch basins planned for this intersection enters through a trap to be built as an integral part of the manhole. Discharge will be through a 72" concrete pipe leading off to the south with an invert elevation of 80.47 feet.

72" concrete pipe laid at a grade of 0.70% will be sufficient to carry the maximum flow of 350 cubic feet per second. 400 feet of pipe will be necessary to go far enough south so that the grade can be kept at 0.70% and the resulting velocity under twelve feet per second. To attain this distance, the pipe is laid parallel to Canal Street for 346 feet and then run westerly 54 feet to the canal. In order to keep the grade as flat as required and still fit the natural ground slope on the stretch parallel to Canal Street,four step-downs are required. A drop of 0.75 feet is made in the first, 2.75 feet in the second, and 1.5 feet in the remaining two. Locations of these steps are shown on the plan. They are made by splitting a pipe lengthwise and laying one half to the invert grade of the lower part of the step. The remaining half is raised to correspond to the top of the adjacent pipe of the upper part of the step. The spaces between the two halves and at the ends is sealed with brick masonry. For the three steps 1.5 feet and less high, only one length of pipe (four feet) need be split; but for the 2.75 foot step it will be necessary to split two lengths of pipes. Sketches illustrating these steps are included in the appendix. No special design is necessary for the manhole required at the angle point other than that a rounded invert curved to a two foot radius should be provided to guide theflow more smoothly around the 100 degree bend in the pipe. A two foot stepdown should be made at the entrance to this manhole. Where the 72" pipe discharges into the canal the granite block canal wall, which rises six feet above water level, is broken through and then rebuilt around the pipe. Elevation of the invert of the overflow is 0.26 feet below water level of the canal.

The next item of importance is to relay a portion of the old 24" x 36" brick sewer running southerly from West Pennacook Street down the east side of Canal Street. Due to the construction of the jump manhole regulating the operation of the overflow, this sewer will be running full and under pressure whenever there is sufficient flow to utilize the overflow. The maximum head attained will be about four feet. As the sewer is many years old and has been broken and patched frequently in the past, it can not withstand such pressure. By relaying just a short portion of it with concrete pipe having well made joints this relaid portion can be made to act as a metering pipe to control the amount of water flowing and thus relieve pressure on the rest of the sewer. By so doing the remainder of the old sewer can be made to serve many more years. Relaying should be done from the manhole at Canal and West Pennacook streets to the first manhole south of there. This is a distance of 209 feet. 27" concrete pipe should be used and laid to an 0.60% grade.

The construction described on the preceding pages should eliminate all causes of the problem in the area of Canal and West Pennacook streets. Now we must turn our attention to a remedy for conditions existing on West Brook and Langdon streets. The problem here is much simpler than that at West Pennacook Street, because there is only surface drainage to contend with and the construction will be all new and unhampered by the need to tie in with existing drains. Also since the street grade of Canal Street is nearly level in this area and only ten feet above the water level of the canal, there will be no difficulty in keeping the discharge velocity less than the stipulated 12 feet per second. It is proposed to place a curb to curb catch basin of the type described in chapter II on West Brook Street just east of the easterly street line of Canal Street. Existing catch basins of the old type will be left in place and connected to the new installation, in the belief that they may catch some additional water. An identical installation is to be made on Langdon Street just east of Canal Street. The estimated quantity of surface water to be caught on each street is 25 cubic feet per second. This is a total of only 50 cubic feet per second; however, the drainage system will be designed to carry slightly over twice that amount to allow for anticipated future extension. There are indications that in the near future lines will have to be run east to intercept surface water east of Elm Street, because the large Elm Street drain is becoming overburdened due to development in its drainage area. Extension southerly on Canal Street for one more block quite possibly may be needed shortly.

The reader's attention is again directed to the layout plan appended. The main discharge pipe to the canal will run at right angles to Canal Street from a point approximately midway between the intersections of West Brook and Langdon streets with Canal Street. 48" concrete pipe should be used and laid to a 0.60% grade with the invert elevation at the outlet 0.26 feet below the water level of the canal. This outlet should be built into the granite block wall of the canal in the same manner as the West Pennacook Street overflow. Capacity of this 48" pipe will be 114 cubic feet per second, and its discharge velocity when flowing full will be 9.2 feet per second which is well under the maximum allowable value.

Laterals are to be run north and south from this main pipe beneath the west side of the Canal Street roadway. The lateral running northerly to West Brook Street should be 30" concrete laid to a grade of 1.30%. It will have a maximum capacity of 44 cubic feet per second. The lateral running southerly to Langdon Street should be 36" concrete laid to a 0.40% grade. It will have a capacity of 40 cubic feet per second. A conventional type manhole is to be built at the junction of the main and laterals and at the terminus of each lateral. 15" Akron drains from the catch basins are to be connected to these terminal manholes. Open gratings instead of the usual solid type are to be used for all manhole covers.

All computations for required pipe sizes, capacities, grades, and velocities necessary to the preceding designs were made with the aid of flow diagrams based on Manning's Formula found in Steel's text on "Water Supply and Sewerage". Results were checked by reference to blueprinted flow diagrams prepared by Professor Theroux of the Civil Engineering Department at Michigan State College.

Chapter IV

SUMMARY

Chapter IV: Summary

In an attempt to make recommendations for improvements in the existing drainage system, an effort has been made to get at the source of the troubles and starting from there to develop a solution by progressively eliminating each individual cause. The several suggestions made constitute what are believed to be practical, efficient, and economical remedies for the various conditions which contribute to this problem. Construction of a 48" concrete drain from the terminus of the Christian Brook culvert down West Pennacook Street to Canal Street will remove the bottleneck at this point. This new drain will be adequate to carry the full discharge of Christian Brook and prevent future overflow of large volumes of storm water into West Pennacook Street thus removing a prime cause of damage. Proposed designs for catch basins have a grating offering maximum open area for the free passage of water. Their size and shape is such that they can efficiently handle abnormal quantities of storm runoff flowing down steep grades. Three standard designs insure types to fit varying conditions of location. Installation of these designs at the points shown on the plan will collect surface water into the drains before it has opportunity to attain a damaging velocity. Construction of a 72" concrete overflow drain from the intersection of West Pennacook and Canal streets to the canal will provide for rapid discharge of excess water during storms. Thus congestion in the Canal Street sewer; and the damage, both to the sewer and the efficiency of the drainage system as a whole, resulting from such congestion is prevented. Relaying a portion of the Canal Street sewer from West Pennacook Street southerly to act as a metering pipe and construction of the special design jump manhole described are two features necessary to control the operation of the overflow. Sewage will not be discharged into the canal, since the overflow will function only during flood periods. A 48" concrete overflow from Canal Street into the canal at a point between West Brook and Langdon streets will care for all surface runoff in that area so that no additional burden will be placed on the Canal Street sewer at this point. Throughout the proposed design, sufficient capacity in excess of that required has been left to provide for future extension of the system so that a new problem will not develop as the city grows. It is evident that partial use of these recommendations is not feasible, since they are interrelated in such a way that to put some into effect means using all of them. The writer firmly believes that by so doing future damage to highways and adjacent property as a result of heavy rain storms can be completely eliminated.

APPENDIX

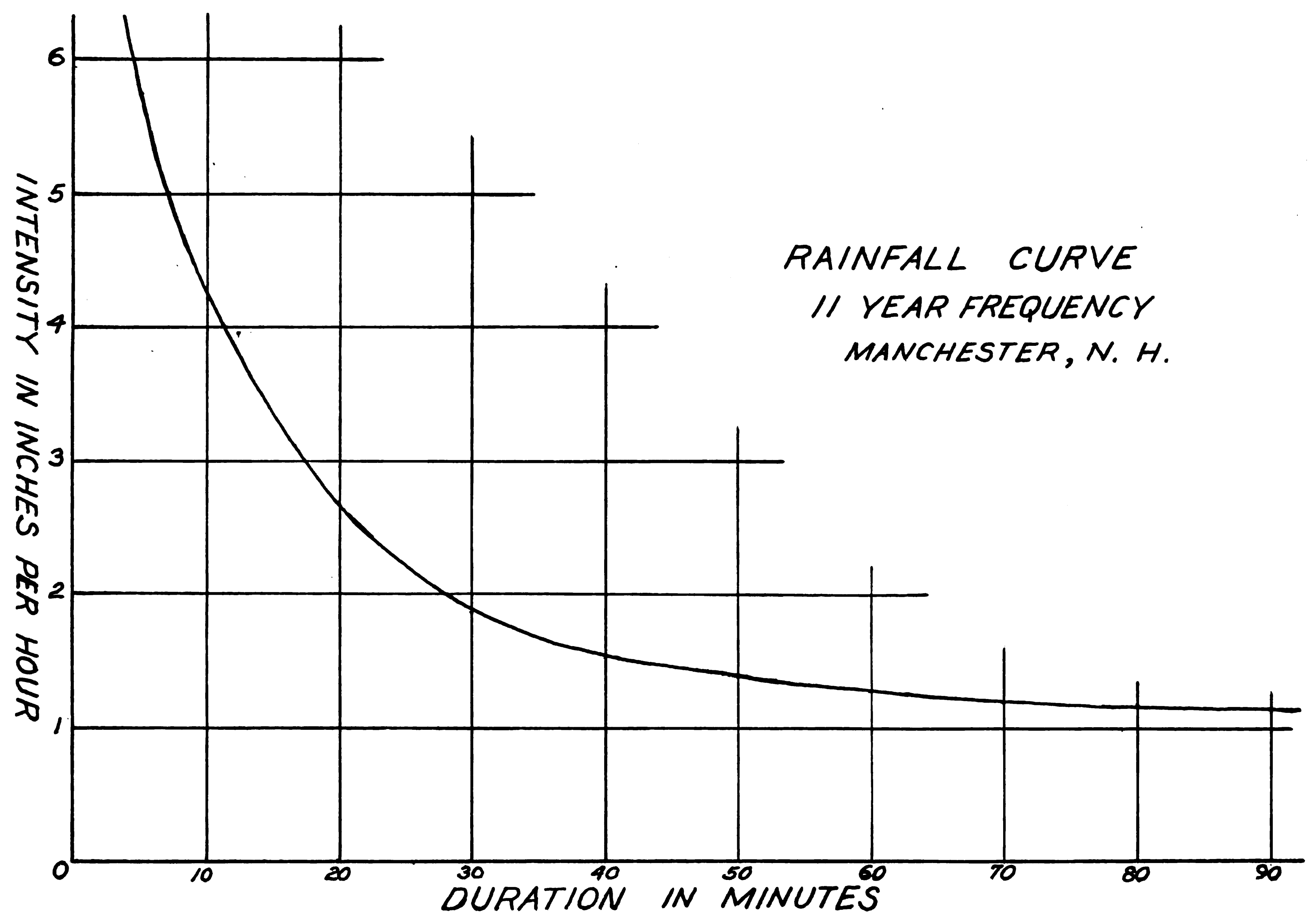

RAINFALL CURVE
11 YEAR FREQUENCY
MANCHESTER, N. H.
INTENSITY IN INCHES PER HOUR
DURATION IN MINUTES
0
1
2
3
4
5
6
10
20
30
40
50
60
70
80
90

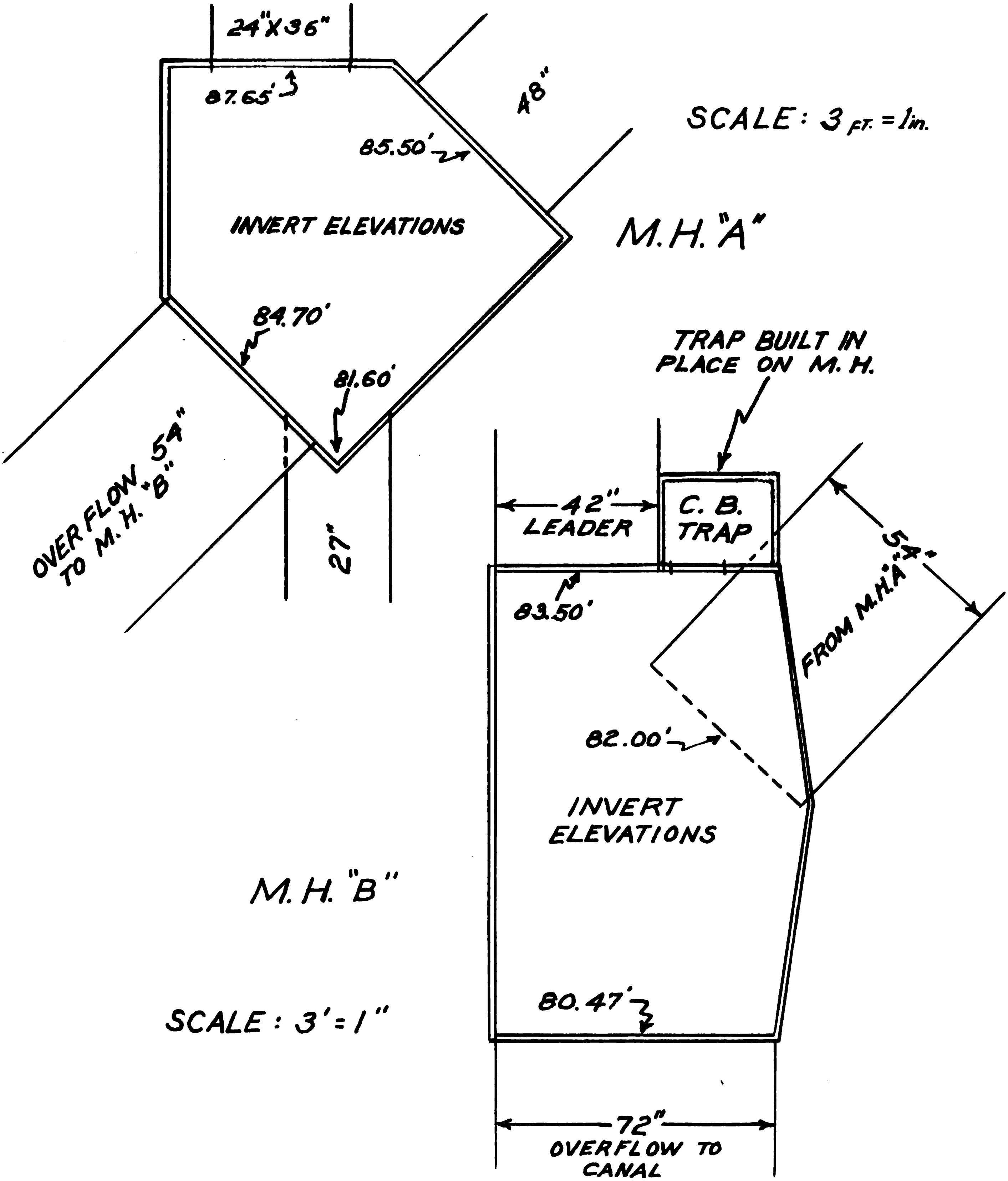
TABLE OF REQUIRED SUPPORT FOR VARYING LOADS AND SPANS

DESIGN CONDITIONS

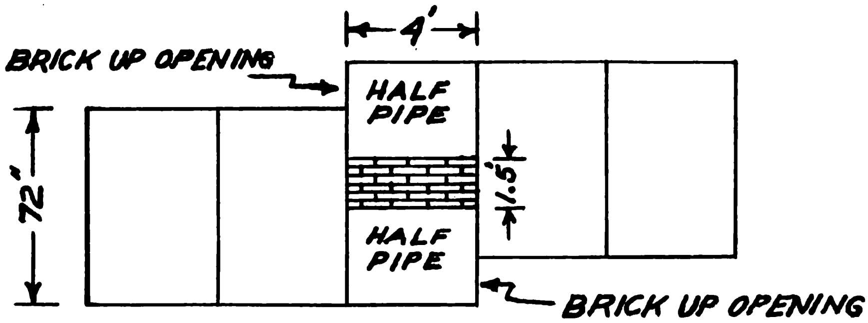
1. ALLOWABLE STRESS 180 #/□"
2. IMPACT 30 %
3. CONTINUITY COEFFICIENT 80%
4. WHEEL LOAD 50%

SUPPORT I BEAMS		LOADING H-20 SPAN		LOADING H-15 SPAN	
DEPTH	WEIGHT	FROM	TO	FROM	TO
3"	5.7#			2'-0"	2'-1½"
3	6.5	2'-0"	2'-3"	2'-1½"	2'-6½"
3	7.5	2'-3"	2'-5¾"	2'-6½"	2'-8"
4	7.7			2'-8"	3'-1¾"
4	8.5	2'-5¾"	3'-1¾"	3'-1¾"	3'-11"
4	9.5	3'-1¾"	3'-4½"	3'-11"	3'-11⅝"
5	10.0	3'-4½"	3'-7⅛"	3'-11⅝"	5'-4¾"
5	12.25	3'-7⅛"	4'-10¾"	5'-4¾"	5'-11⅜"
6	12.5	4'-10¾"	6'-3"	5'-11⅜"	7'-9¼"
6	14.75	6'-3"	6'-7¾"	7'-9¼"	8'-3½"

SCHEMATIC LAYOUT FOR TWO SPECIAL MANHOLES

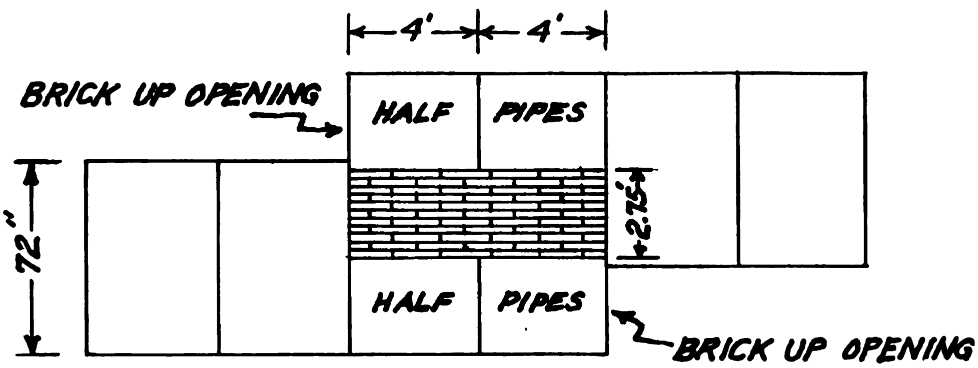


METHOD OF CONSTRUCTING STEPDOWNS IN 72" OVERFLOW

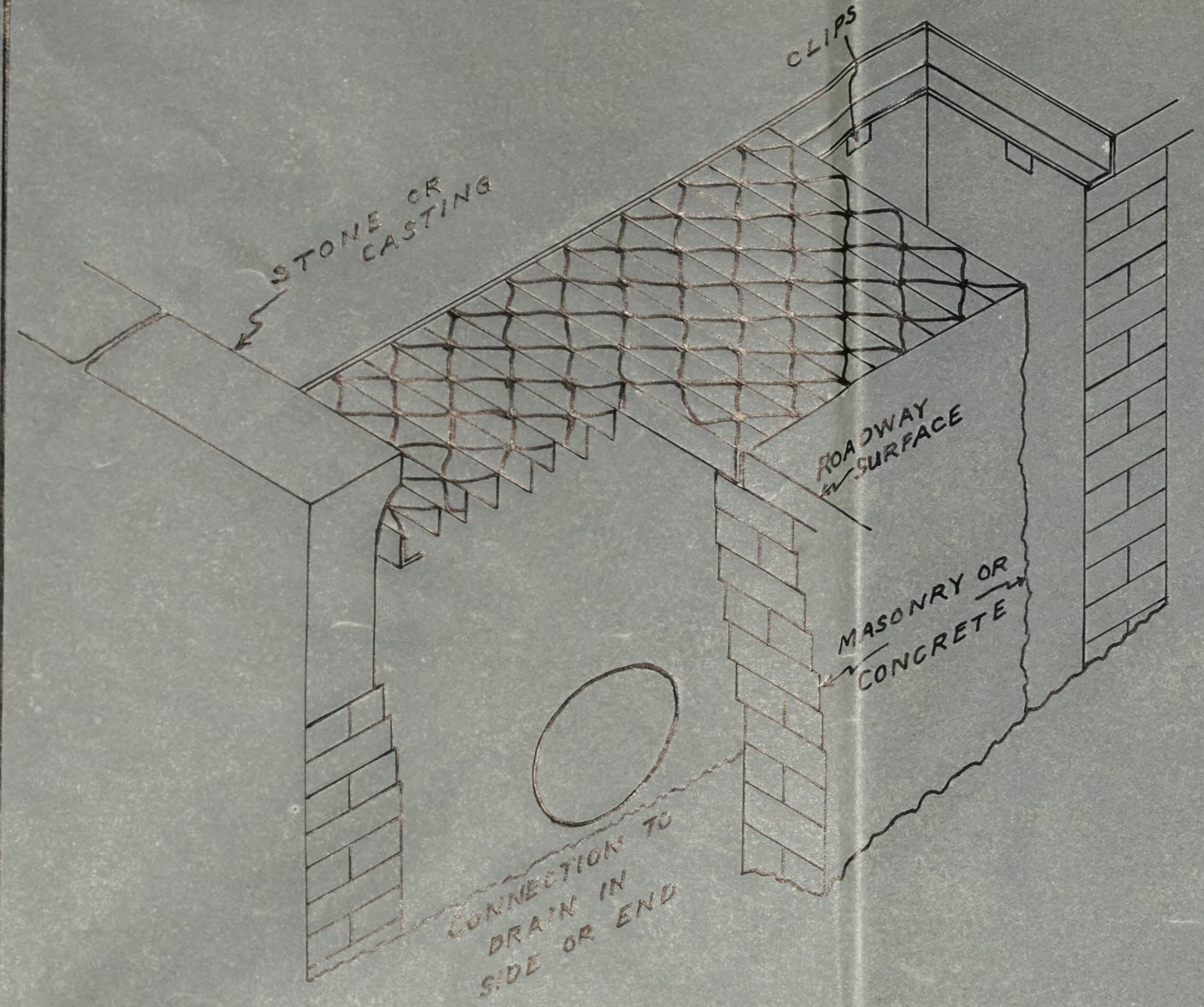


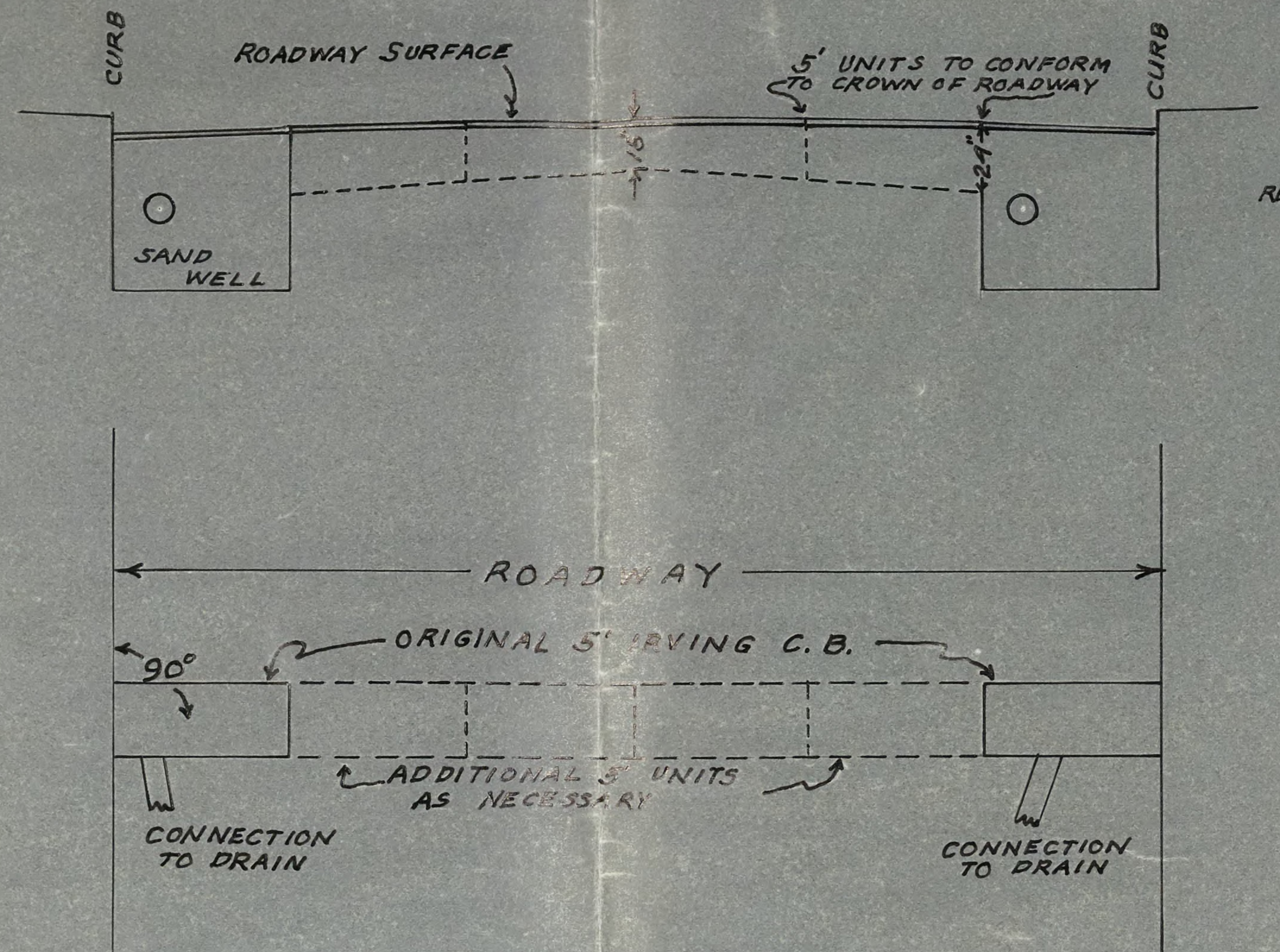
FOR STEPS LESS THAN 1.5' SPLIT ONE PIPE

FOR 2.75' STEP SPLIT TWO PIPES

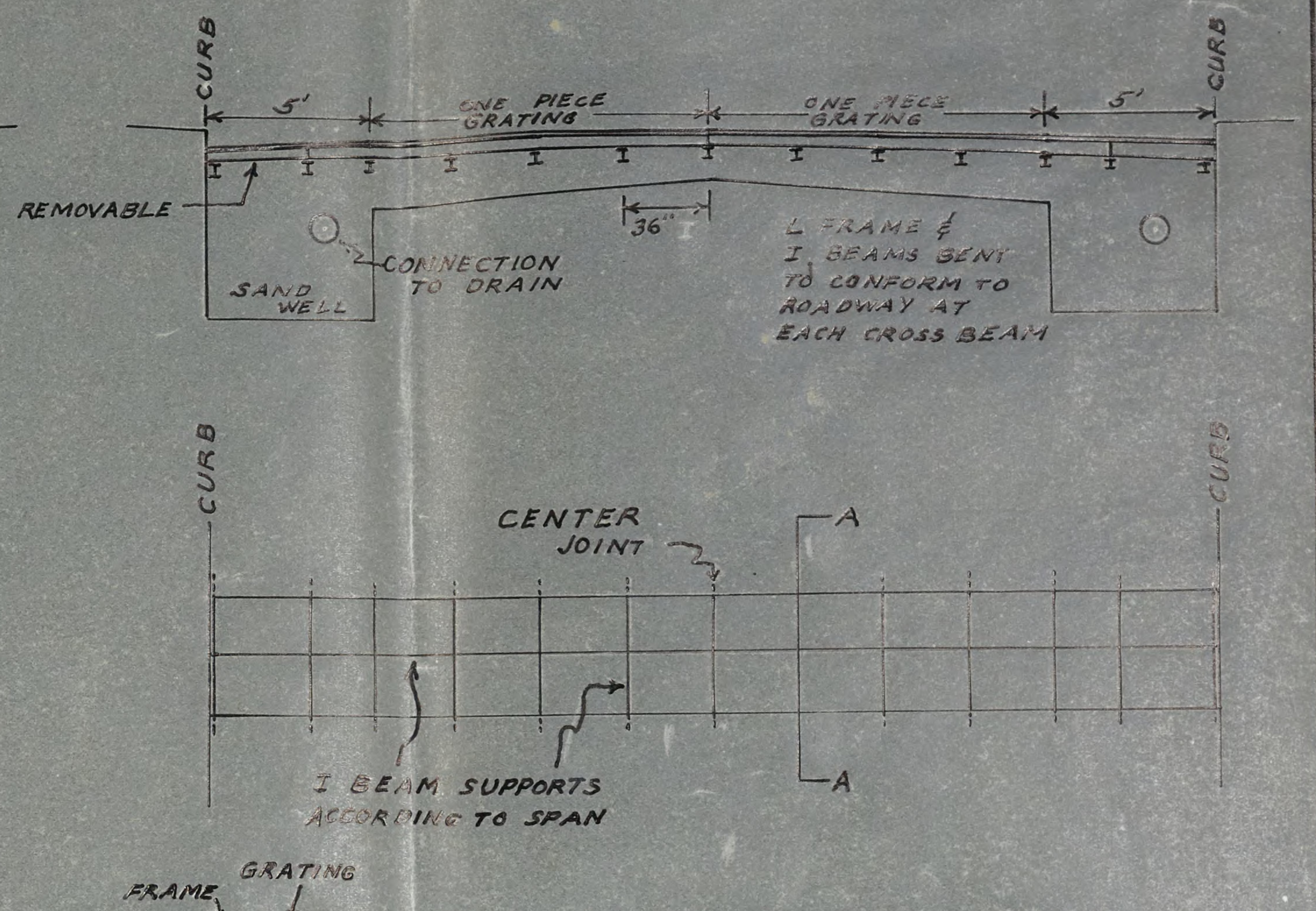


[redacted]





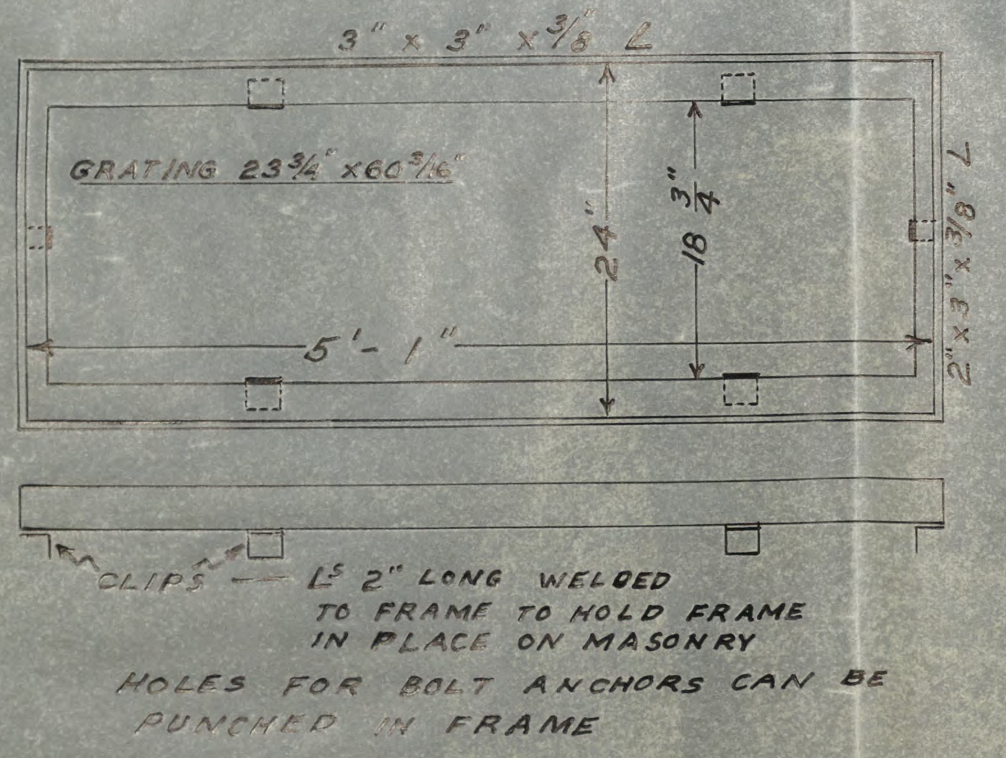
PROGRESSIVE METHOD OF INSTALLING 5' SECTIONS (ANY SPAN)



CURB TO CURB CATCH BASIN

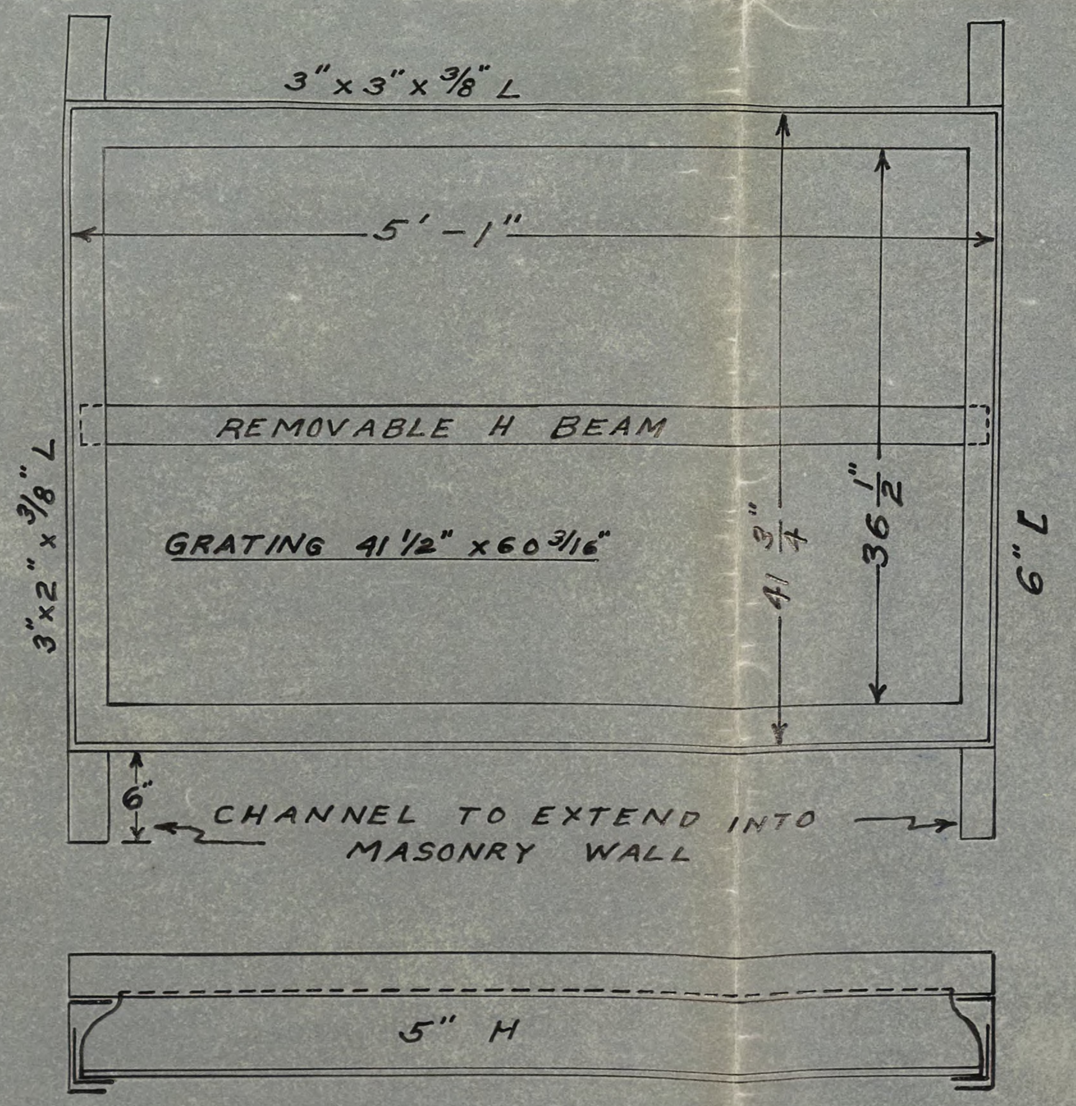
UNIT CONSTRUCTION

DOUBLE SPAN SHOWN



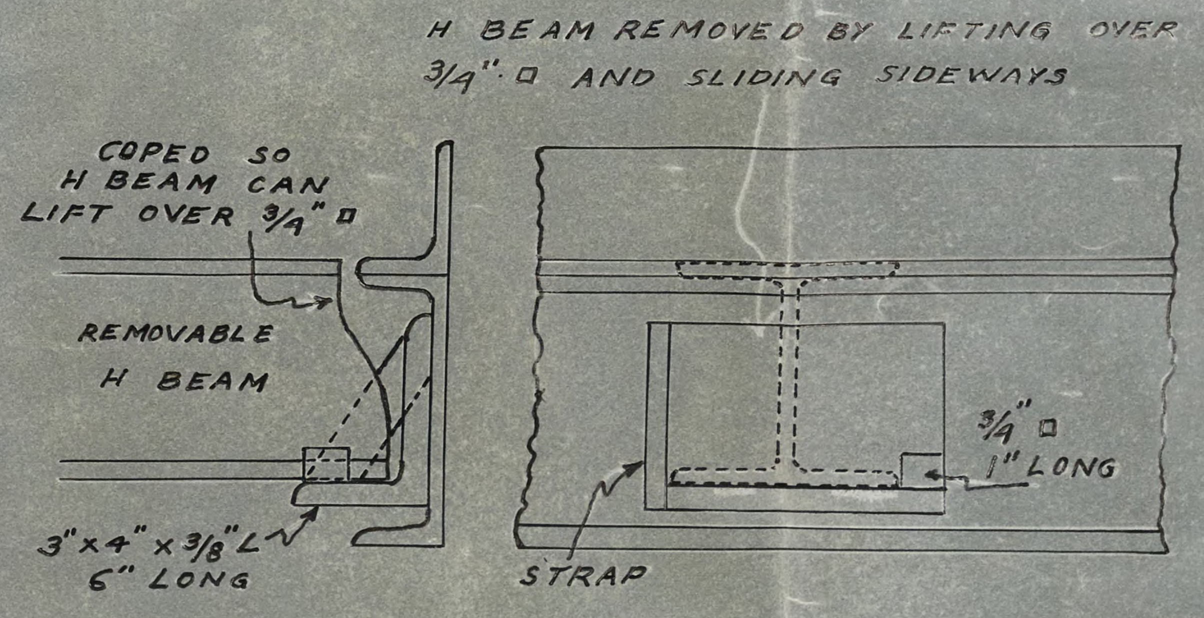
WELDED FRAME

SINGLE SPAN



WELDED FRAME

DOUBLE SPAN

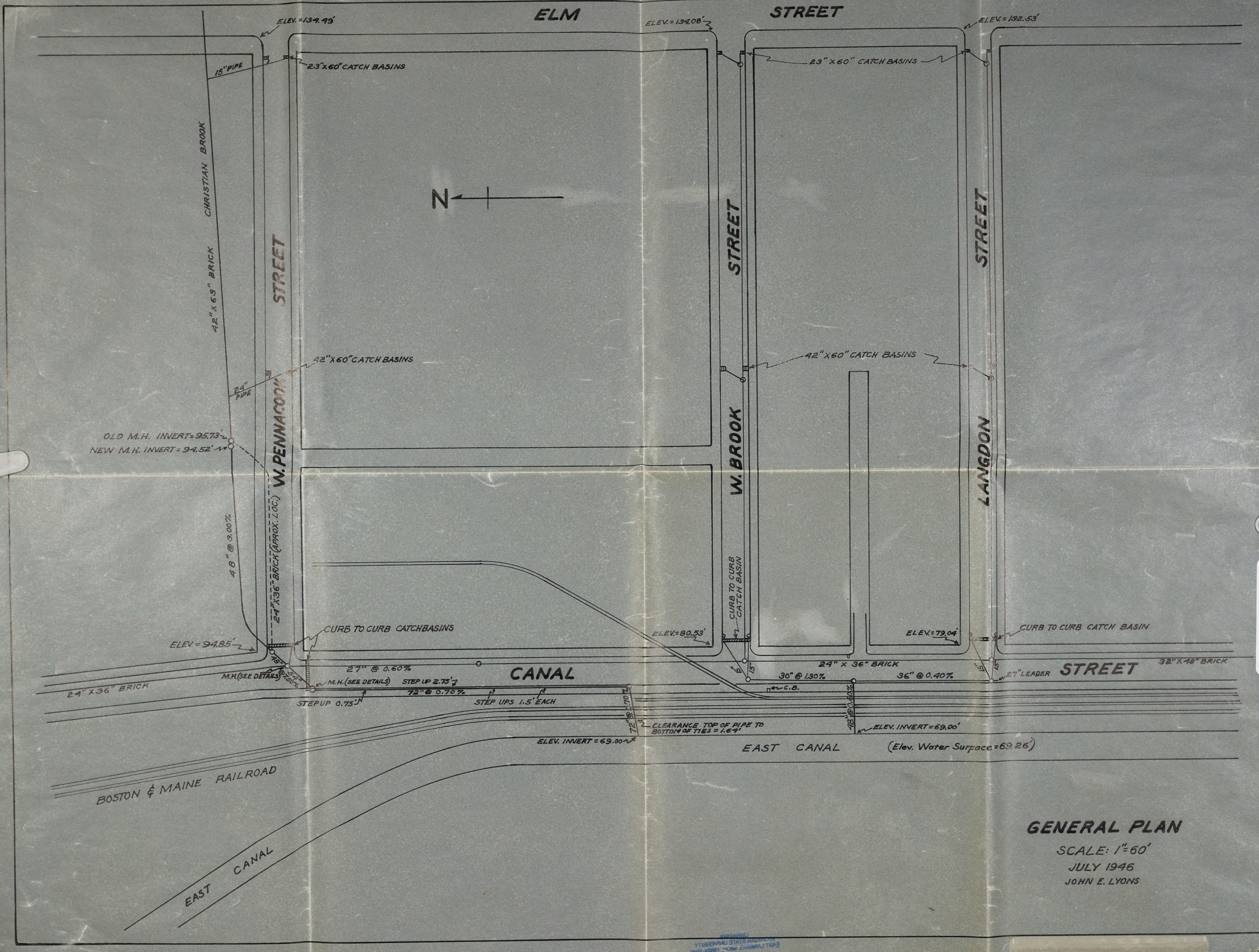


DETAIL OF REMOVABLE BEAM SEAT

INLET DESIGNS

JULY 1946

JOHN E. LYONS


ELM
STREET
ELEV.=134.49'
ELEV.=134.08'
ELEV.=132.53'
15" PIPE
23"X60" CATCH BASINS
23" X 60" CATCH BASINS
N
CHRISTIAN BROOK
42"X 63" BRICK
W. PENNACOOK STREET
W. BROOK STREET
LANGDON STREET
42"X60" CATCH BASINS
42"X60" CATCH BASINS
24" PIPE
OLD M.H. INVERT=95.73'
NEW M.H. INVERT=94.52'
48" @ 3.00%
24"X36" BRICK (APROX. LOC.)
CURB TO CURB CATCH BASIN
CURB TO CURB CATCHBASINS
CURB TO CURB CATCH BASIN
ELEV.=94.85'
ELEV.=80.53'
ELEV.=79.04'
M.H. (SEE DETAILS)
M.H. (SEE DETAILS)
27" @ 0.60%
CANAL STREET
24" X 36" BRICK
30" @ 1.30%
36" @ 0.40%
32"X48" BRICK
27" LEADER
24"X36" BRICK
STEP UP 2.75'
72" @ 0.70%
STEP UP 0.75'
STEP UPS 1.5' EACH
C.B.
CLEARANCE TOP OF PIPE TO BOTTOM OF TIES = 1.64'
ELEV. INVERT=69.00'
ELEV. INVERT=69.00'
EAST CANAL
(Elev. Water Surface=69.26')
BOSTON & MAINE RAILROAD
EAST CANAL
GENERAL PLAN
SCALE: 1"=60'
JULY 1946
JOHN E. LYONS

Pocket has: 2 Plans