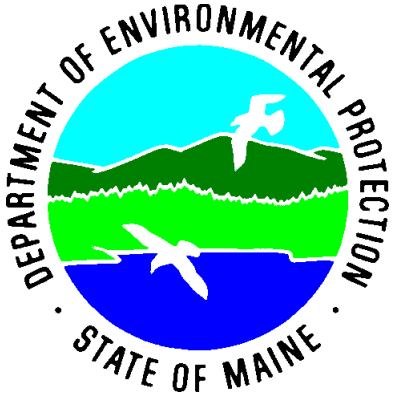


WASTEWATER
RIVER CROSSING SURVEY REPORT
FOR THE STATE OF MAINE

SEPTEMBER 1999

Prepared by the Division of Engineering And
Technical Assistance
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Wastewater River Crossing Survey Report
For the State of Maine

EXECUTIVE SUMMARY

Based on a questionnaire, the State of Maine has ninety-four (94) municipalities and sewer districts that have underwater river crossings that convey wastewater. There are a total of 137 underwater river crossing in the State, with 36% of the crossings being inverted siphons and 64% of the crossings being force mains.

The total length of underwater river crossings is almost 35,000 feet, with individual crossings varying from 1 foot to 3,000 feet in length. Sizes of the crossings range from as small as 2 inches in diameter to as large as 30 inches in diameter. The majority of the crossings, seventy-four percent (74%) are from 4 inches to 12 inches in diameter.

Common pipe materials used today for underwater river crossings are ductile iron (DI) 53%, high density polyethylene (HDPE) 3%, and polyvinyl chloride (PVC) 9%. These materials, coupled with the older standard material of cast iron (CI) 15%, account for 90% of the crossings.

Over one-half of the underwater river crossings have been in operation for over twenty (20) years, with the oldest one having been installed in 1958.

Only one (1) underwater river crossing was reported to have been pressure tested for leaks after it had been in use for two (2) years or more. There appears to be no regular or even periodic testing of underwater river crossing within the State. We believe that there should be periodic pressure testing of major underwater river crossings. For the purpose of this report a major underwater river crossing is defined as any pressurized wastewater conveyance pipe that is four (4) inches in diameter or larger and flows beneath a waterbody of the State.

As these crossings age they become more suceptable to a structural failure and subsequently pose a potential risk to the environment. We suggest that as a condition of license renewal, the Department should require all major underwater river crossings be pressure tested for leaks at least once during each five-year license period. Such a testing requirement would apply to ninety-four percent (94%) of the underwater river crossings reported. A list of the river crossings that would be required to be tested is contained in the Appendix.

INTRODUCTION

As a result of the break in the Winslow to Waterville underwater force main and the subsequent leakage of untreated wastewater into the Kennebec River, the Department decided to survey the pressurized river crossings within the State. In November of 1998 a survey to inventory the wastewater conveyance river crossings within the State was sent to 171 municipalities and districts that have municipal sewers or a wastewater treatment facility. The results of that survey are represented here in this report. A sample of the survey and the results are contained in the Appendix.

The survey concentrated on any pressurized wastewater conveyance system that crossed above or beneath a body of water. A body of water was considered to be, but not limited to, a river, stream, or brook. For the purpose of clarity, all crossings will be referred to as river crossings. The river crossings fall into three (3) general categories: above water force mains, underwater force mains, and inverted siphons. The above water and underwater force mains are pressurized pipes that convey wastewater from a pumping station to a higher elevation where it can follow by gravity. An inverted siphon is a U-shaped section of pipe that uses gravity to force wastewater under the river to the other side where it can continue to flow by gravity. Under normal conditions the inverted siphon flows full and is under pressure.

Non-pressurized gravity sewers were not reported in the survey because it was felt that any leaks of a gravity sewer passing beneath a river, etc. would cause infiltration into the system and therefore not cause pollution of the water body. Any leaks in a gravity sewer passing over a river would have a good chance of being visibly detected. In addition, the sheer number of gravity crossings in the State would have made completion of the survey very cumbersome.

Of main concern are the crossings that are under pressure and pass beneath water bodies. If a leak is present in this type of crossing it could go undetected for some time and leak untreated wastewater into the waters of the State. Although under pressure, the above water force mains do not pose as great an environmental risk because leaks can be visually detected more easily. The above water force mains cross rivers in one of two ways, either in the embankment fill above culverts for short crossings, or by being suspended under bridges for longer crossings. Data was collected on the above water force mains for future reference, however, the main impetus of this report will be on underwater crossings.

RIVER CROSSING SURVEY RESULTS

Of the 171 surveys sent out and received, 77 reported having no pressurized crossings. The remaining 94 respondents reported 197 pressurized crossings. Of these 137 (70%) were underwater crossings. Table 1 contains a further breakdown of the survey results and the type of river crossings.

RIVER CROSSING SURVEY RESULTS
- TYPES OF CROSSINGS -

TYPE OF CROSSING	NUMBER
Above water force main	60
Inverted Siphon	50
Underwater force main	87
Crossings	197

Table 1

The three types of river crossings and their percentage of the total are graphically presented in Figure 1. Underwater force mains constitute 45% of all river crossings.

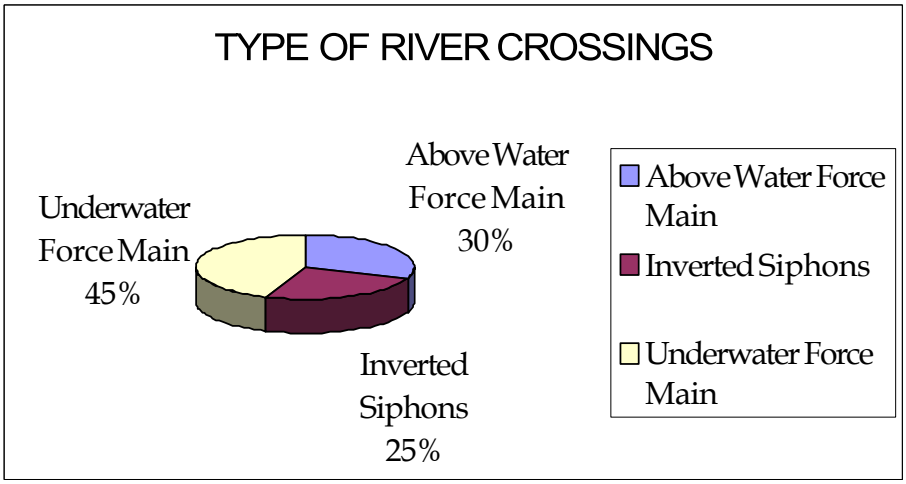


Figure 1

UNDERWATER RIVER CROSSINGS

As was noted in the Introduction, the main focus of this report will be on underwater river crossings. Crossings of these types fall into one of two categories, either inverted siphons or underwater force mains. Of the 137 underwater river crossings reported, 50 (36%) are inverted siphons and 87 (64%) are underwater force mains. Table 2 presents an inventory of the underwater river crossings in the state. A complete listing of inverted siphon and underwater force main crossings can be found in the Appendix.

INVENTORY OF THE STATE'S WASTEWATER CONVEYANCE INVERTED SIPHONS AND UNDERWATER FORCE MAINS

PIPE MATERIAL	NUMBER OF CROSSINGS	PERCENT OF CROSSINGS	PERCENT OF TOTAL LENGTH	YEAR INSTALLED	LENGTH IN FEET	DIAMETER IN INCHES	COMMENTS
Asbestos-cement (AC)	3	2	1	1962-70	6-281	8–12	
Cast Iron (CI)	21	15	6	1958–77	1–876	4–24	48% < 5 ft.
Ductile Iron (DI)	73	54	49	1966–98	2–2,300	4–30	9% > 500 ft.
Fiberglass Reinforced Pipe (FRP)	3	2	2	1978–81	2–626	4–30	
High Density Polyethylene (HDPE)	18	13	38	1975–97	4–3,000	2–24	50% > 500 ft.
Polyvinyl Chloride (PVC)	12	9	1	1972–91	3–199	2–12	
Reinforced Concrete Pipe (RCP)	2	1	2	1971–75	180–425	21–30	
Unknown	5	4	1	1962–90	30-370	6–10	
Total	137						

Table 2

Material

Table 2 lists seven common pipe materials for inverted siphons and force mains. The length of a crossing, potential physical hazards, design pressures, and

materials available at the time of installation all play a part in the material chosen for the crossing. Pipe connections not only vary from material to material, but sometimes within the material category itself. For example, cast iron (CI) pipe can have a push together bell and spigot connection or a ball and socket connection that provides a stronger connection and allows a greater amount of deflection between the pipe pieces. Ductile iron (DI) pipe can have a bell and spigot connection or a mechanical joint connection in which the pipe pieces are bolted together. Polyvinyl Chloride (PVC) pipe is made up of a variety of compounds from different manufactures but is generally of the bell and spigot type. High Density Polyethylene (HDPE) is butt fused together into one continuous pipe. This survey did not attempt to further classify the pipe materials by their connections. A table of the inverted siphon and underwater force main pipe materials can be found in the Appendix.

These four resilient materials mentioned above (CI, DI, HDPE, and PVC) make up 90% of the underwater river crossings, see Table 2. The most common and strongest material, ductile iron, accounts for 54% of the underwater river crossings. Four percent (4%) of the river crossing pipe materials were reported as unknown. Asbestos-cement (AC), fiberglass reinforced pipe (FRP), and reinforced concrete pipe (RCP) make up the remaining 6% (8 in number) of the river crossings. Use of these materials has given way to the more modern materials mentioned in the previous paragraph. Figure 2 contains a breakdown of the underwater river crossings by material and their percentage of crossings.

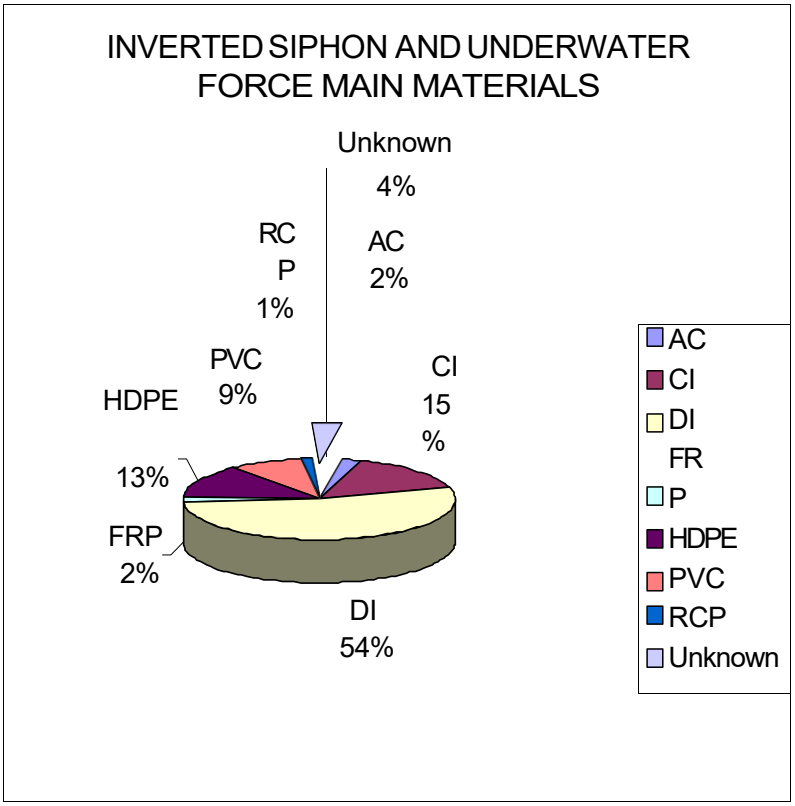


Figure 2

Length

The total linear footage of underwater river crossings reported is 34,945 feet. Ductile iron pipe is the most commonly used material with an estimated 16,996 feet installed, 49% of the total length, see Table 2. The estimated length of HDPE in underwater river crossings is 13,134 feet, 38% of the total. Although the use of cast iron pipe has given way to ductile iron, it is well suited for most river crossings. Cast iron pipe accounts for six percent (6%), 2,135 feet, of the total. These three materials (DI, HDPE, and CI) account for 93% of the linear footage of underwater river crossings installed in the State.

Lengths of the reported river crossings range from as short as one (1) foot to as long as 3,000 feet. The length of the crossing and the method of installation often influence the pipe material chosen for a river crossing. Mechanically jointed ductile iron and continuous sections of HDPE are today's favorites for long underwater crossings. When long crossings are needed, these pipes can be joined together on shore and pulled into the river or joined together on a barge and lowered into the river. Note in Table 2 that HDPE river crossings range in length from 4 feet to 3,000 feet and that 50% of the crossings are greater than 500 feet in length. By comparison, ductile iron crossing lengths range from 2 feet to 2,300 feet, yet only 9% of the crossings are greater than 500 feet in length. This is not because ductile iron is an inferior product, but is probably attributed to the additional cost of mechanically jointed ductile iron pipe. Use of ductile iron pipe is often limited to installations in severe physical environments where it is cost effective.

Diameter

The size of the pipes reported in the river crossing survey varied from 2 inches to 30 inches in diameter. While ninety-three percent (93%) of the crossings are 4 inches in diameter or larger, the majority of the crossings seventy-four percent (74%) are between 4 inches and 12 inches in diameter. Table 3 contains a breakdown of the different pipe sizes and their number.

UNDERWATER RIVER CROSSINGS - PIPE DIAMETERS -			
Pipe Diameter In Inches	Number	Pipe Diameter In Inches	Number
Unknown	3	14	5
2	5	16	3
3	1	18	2
4	25	20	4
6	21	21	1
8	25	24	7
10	11	30	5
12	19		
		Total	137

Table 3

Age

From Table 2, one can see that the oldest underwater river crossing was installed in 1958 and the most recent one in 1998. In arranging the crossings by pipe material you can also see the general trend away from asbestos-cement, cast iron, fiberglass reinforced pipe, and reinforced concrete pipe toward the newer materials of ductile iron, high density polyethylene, and polyvinyl chloride.

Figure 3 shows the underwater river crossings grouped by age, along with their appropriate percentage of the total number of underwater crossings. From Figure 3 it can be determined that 48% of all of the underwater crossings in the State were installed 20 to 30 years ago. The number of inverted siphons and underwater force mains listed by their year installed can be found in the Appendix.

Table 4 shows the percentage of underwater river crossings over a certain age. For example, 82% of the river crossings are over 10 years old. It is interesting to note that over one half, 51%, of the river crossings have been in operation for over twenty (20) years.

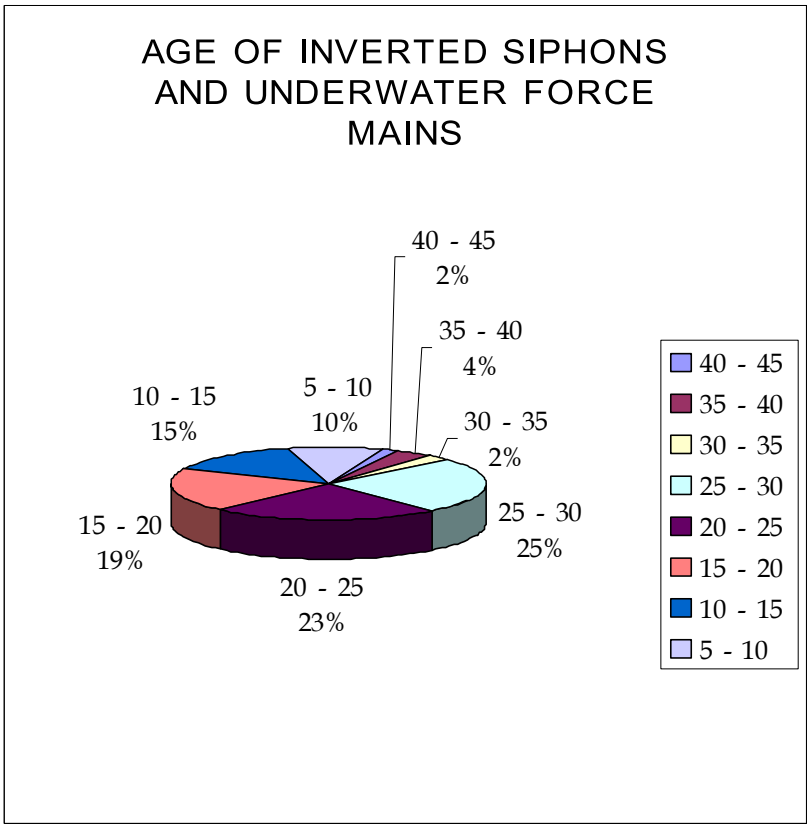


Figure 3

PERCENTAGE OF INVERTED SIPHONS AND UNDERWATER RIVER CROSSINGS OVER A CERTAIN AGE	
AGE (YEARS)	PERCENT OF CROSSINGS
5	91
10	82
15	69
20	51
25	30
30	7
35	5
40	1

Table 4

Testing

Standard engineering practice today is to pressure test any new river crossing before it is placed in service. Four (4) respondents to the survey reported that twelve (12) of the 137 underwater river crossings had been tested at some point after the crossing had been in service for two or more years. Eleven (11) of these were inverted siphons and one (1) was an underwater force main. The crossings ranged in age from 19 to 34 years. A listing of the siphon and underwater force main crossings tested after two years of use can be found in the Appendix.

Each respondent was also asked how the crossings were tested. For the inverted siphons, eight (8) were inspected visually, two (2) were pressure flushed, and only one (1) received a low pressure test. By design, an inverted siphon is a low spot in the pipe. A low spot in a pipe has the tendency to collect solids, which ultimately reduces the carrying capacity of the system and therefore requires periodic cleaning. Cleaning is accomplished by pressure flushing the siphon. It is interesting to note that the inverted siphon that was tested (low pressure test) six (6) years after its installation has not been tested within the last twenty-two
(22) years of use. At this point is is unclear why the siphon was tested after only six years of use.

Only one (1) underwater force main was reported to have been tested and that was actually a visual inspection. Force mains are under constant pressure when the pumps are running and wastewater is being conveyed. Any catastrophic break in the force main would decrease the pressure within the line and should be noticed by the operator of the treatment facility upon checking the pumping station. Less severe or minor leaks in the force main might result in only a minor decrease in pressure and could go unnoticed for some time.

Based on the survey results, only one (1) of the 137 underwater river crossings underwent a true test of the structural integrity of the pipe, using pressure, while the other eleven (11) crossings were visually inspected or cleaned.

Accepting the survey results leads us to the conclusion that zero percent (0%) of underwater river crossings are ever tested. In effect, there is no regular or even periodic structural testing of underwater river crossings within the State.

SUMMARY AND CONCLUSIONS

One hundred seventy-one (171) river crossing surveys were sent out to municipalities and districts within the State that have a municipal sewer system or a wastewater treatment facility. Of that group, seventy-seven (77) responded that they did not have any pressurized wastewater river crossings. The other 94 respondents reported having 197 river crossings of which 137 were underwater crossings. Thirty-six percent (36%) of the underwater crossings are inverted siphons and 64% are force mains. Underwater river crossings present a higher potential risk to the environment than above water crossings do because any leaks in the underwater crossings are harder to visually detect and could go unnoticed for some time.

The materials used for underwater river crossings have changed over time as technology has improved. Common materials installed today are ductile iron (DI) 53%, high density polyethylene (HDPE) 13%, and polyvinyl chloride (PVC) 9%. These materials account for 75% of the underwater river crossings. Older materials that are not presently being installed for crossings are cast iron (15%), asbestos-cement (2%), fiberglass reinforced pipe (2%), and reinforced concrete pipe (1%). The pipe material chosen for a crossing should be carefully selected based on design pressures, length of crossing, potential physical hazards, installation procedures, and environmental considerations.

The total linear footage of underwater river crossings reported was 34,945 feet. The three most common materials: ductile iron (49%), HDPE (38%), and cast iron (6%), account for 93% of the total linear footage installed. Although the use of cast iron pipe has given way to ductile iron and HDPE, it is very well suited for most river crossings. HDPE appears to be the choice for long crossings, with 50% of the HDPE crossings exceeding 500 feet in length. Mechanically-jointed ductile iron pipe appears to be the material of choice for crossings in the most severe physical environments.

The diameters of underwater river crossings range from 2 inches to 30 inches. Seventy-four percent (74%) of the crossings are 4 to 12 inches in diameter.

The oldest underwater river crossing that is still in use in the State was installed about forty (40) years ago in 1958. Over one half, 51%, of the underwater river crossings have been in operation for over twenty (20) years. As these crossings continue to age, the likelihood of a structural failure increases.

None of the respondents reported testing any of the underwater force mains. This is probably because these are pumped conveyance systems and any major break in the line would be noticed as a resulting drop in a pressure reading at the pump station. However, minor leaks could go undetected for some time because the small drop in

pressure might go unnoticed. Some of the respondents reported cleaning or visually inspecting the inverted siphons and one of the inverted siphons was pressure tested for leaks. Overall there appears to be no regular or even periodic testing of underwater river crossings within the State.

RECOMMENDATIONS

The size of underwater river crossings varies in diameter and length. All crossing are unique since the water bodies that they cross vary in size and hydraulic characteristics. A small force main that crosses under a small stream does not face the same physical hazards or pose as great an environmental risk as a larger crossing on a large river does. Therefore, there can be no one design standard that is appropriate for all crossings. Each crossing should be designed to be water tight and free from changes in alignment and grade. Pipes should have mechanically restrained joints and the joints should be restrained in order to prevent movement from stream/river forces. The pipe should be adequately buried and covered with rip rap to protect it from the forces of the river.

Presently there does not appear to be any routine or periodic pressure testing of underwater river crossings within the State. More than one half of the crossings in the State are over twenty (20) years old. Even though the design life of the crossings might be significantly longer than this, the risk of physical failure continues to increase as they age.

As a condition of license renewal, the Department should require that all major underwater river crossings be tested at least once during each five-year license period. For the purpose of this report a major underwater river crossing is defined as any pressurized wastewater conveyance pipe that is four (4) inches in diameter or larger and flows beneath a waterbody of the State. Crossings of this size pose the most environmental risk because of the volume of wastewater that they can convey. The length of the crossing isn't as important, because a discharge from a broken crossing into a small stream or river can have a more severe environmental impact than it might on a larger river.

Owners of a minor crossing should assess the crossing based on its age, material, the water body crossed, etc. and a testing procedure should be established to minimize the risk to the environment. A routine pressure test would not guarantee against a future catastrophic failure, but it would reveal any exiting chronic leaks in the crossing.

The testing procedure for individual crossings will vary, but should conform to the standard testing procedures of the American Water Works Association. Pipes with working pressures under 10 psi can be tested with an air test. Pipes with working

pressures over 10 psi should undergo a hydrostatic (water) test to 150% of their working pressure. Allowable losses should be minimal at most and will vary depending upon the type of pipe and the number of joints, if any.

Typical hydrostatic test – Expell all air out of the high point in the line, generally an air-relief manhole is installed for this purpose. Plug or valve off both ends of the line. Connect a test pump to the line. This requires a ¾ inch tape into the line and can be installed if one does not exist. Pressurize the line to 150% of the working pressure and let it stabilize for ½ hour before measuring the water loss over the next 2 hours, at a minimum. A hydrostatic test generally takes about one half a day and costs $250 - $500 using an outside testing service. In-house testing would be less expensive. Most contractors that install pipe have the appropriate testing equipment, as well as most water districts and some of the larger sewer districts/municipalities.

APPENDIX

RIVER CROSSING SURVEY

RIVER CROSSING SURVEY - QUESTIONNAIR RESULTS

SIPHON AND UNDERWATER FORCE MAIN - CROSSINGS

SIPHON AND UNDERWATER FORCE MAIN – PIPE MATERIALS

SIPHON AND UNDERWATER FORCE MAIN – YEAR INSTALLED

SIPHON AND UNDERWATER FORCE MAIN -
CROSSINGS TESTED AFTER TWO YEARS

SIPHON AND UNDERWATER FORCE MAIN - MAJOR CROSSINGS,
CROSSINGS 4 INCHES IN DIAMETER AND LARGER