ASSESSMENT OF GROUNDWATER INFILTRATION & STORMWATER INFLOW IN MILLINOCKET SEWER SYSTEM

TOWN OF MILLINOCKET, MAINE

SEPTEMBER, 2007

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September 12, 2007

Mr. James Charette, Chief Operator
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Dear Jim:

As you requested, we have prepared this evaluation of excess groundwater infiltration and stormwater inflow (I/I) origins in the Town of Millinocket's municipal sewerage system. Over the thirty years that the Town's wastewater treatment plant has been in operation, significant increases in the plant's influent flow have been observed during periods of spring high groundwater, spring snowmelt, and during heavy precipitation events. Because the Millinocket wastewater treatment plant utilizes large lagoons for its biological sewage stabilization process, the impact of these high flows is somewhat mitigated by the pond volume as the flow surge passes through the facility. Still, excess pond volumes represent an environmental concern because they reduce the treatment plant's efficiency and occupy volume in the Town's wastewater infrastructure that then becomes unavailable for treatment. In addition, peak flow surges upstream in the sewer system can contribute to localized flooding and sewer backup problems. During the high flows experienced in the very wet weather year of 2005, the Town had flooding problems in several areas of the sewer system which had to be reported to the Maine Department of Environmental Protection (DEP). Rather than wait for a future regulatory agency requirement to evaluate the extent of its sewer system excess flow problems, the Town decided to take a proactive approach and commissioned this infiltration/inflow study. Olver Associates Inc. was retained to assist the Town with this project.

The Town of Millinocket has never completed a formal infiltration/inflow study of its sewer system even though past efforts have been made to identify sources of excess flow. The Town has conducted television inspections of some sewer system areas and has completed some previous sewer system remediation work. The objective of a formal I/I study is to examine the entire sewer system as a whole by gauging excess flows throughout the system at the same point in time. This allows

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areas of high flow to be identified with initial estimates made of the origin of these flows. An I/I study is intended to isolate problem areas of the sewer system with regard to high flow production. Data from an I/I study generally serves as the basis for future detailed sewer study and sewer capital improvement projects in selected problem areas of the system. An I/I study is intended to provide the Town with a prioritized long-term overview of sewer system areas that may need attention in the future based on their contribution to the overall excess flow problem.

Over the last year, excess flow data has been collected at key nodes of the Millinocket sewer system in order to evaluate the origin of the observed excess flows. Data was collected during spring high conditions in 2006 to assess groundwater infiltration contributors and then during three high intensity storm events in subsequent months to assess the impact of stormwater inflow. This field data was then balanced over the entire sewer system to develop a comparative assessment of which areas appear to be the greater sources of peak excess flows. This letter report summarizes the results of our I/I evaluation, defines the locations of excess infiltration and inflow origins in the Millinocket sewer system, and provides the Town with a prioritized approach by which it can plan for more specific future studies and sewer remediation projects in the leakiest areas of its sewer system.

1. EXISTING WASTEWATER INFRASTRUCTURE

The Town of Millinocket operates a municipal wastewater collection and treatment infrastructure that includes about twenty-seven miles of sewer pipe ranging in size from 6" Ø to 30" Ø. Pipe materials vary from vitrified clay (VC) and asbestos cement (AC) in older areas of the community to polyvinyl chloride (PVC) in newer or rebuilt areas. Some of the large interceptor sewer sections utilize reinforced concrete (RCP) pipe. Sections of the sewer system predated the construction of the downstream wastewater treatment plant in 1979. Sewage flows that were originally discharged untreated from these areas into the Penobscot River and its adjacent tributaries were collected by interceptor sewers for conveyance to the treatment facility. Five wastewater pumping stations at locations along York Street and the Millinocket Stream, Penobscot Avenue near Riverside Drive, Bates Street along Smith Brook, near the High School off State Street and on Central Street are used to lift the wastewater over topographical elevation differences. Several distinct sewer system regions, or subsystems, divide the overall piping network into ten areas based upon topography. These flows all converge in the Town's interceptor sewer system which consists of 24" Ø and 30" Ø RCP pipes along both sides of the Millinocket Stream. The main pump station at York Street conveys these flows to the Town's wastewater treatment plant via a 24" Ø force main. The overall configuration of the Millinocket sewer system is shown on Figure 1.

For the purposes of isolating excess flows for measurement, it is convenient to consider the sewer system in terms of its ten major subsystems. These are depicted in Figure 1 with letter designations from Subsystem A to Subsystem J. Table 1 below lists the general location of each of these ten sewer subsystems:

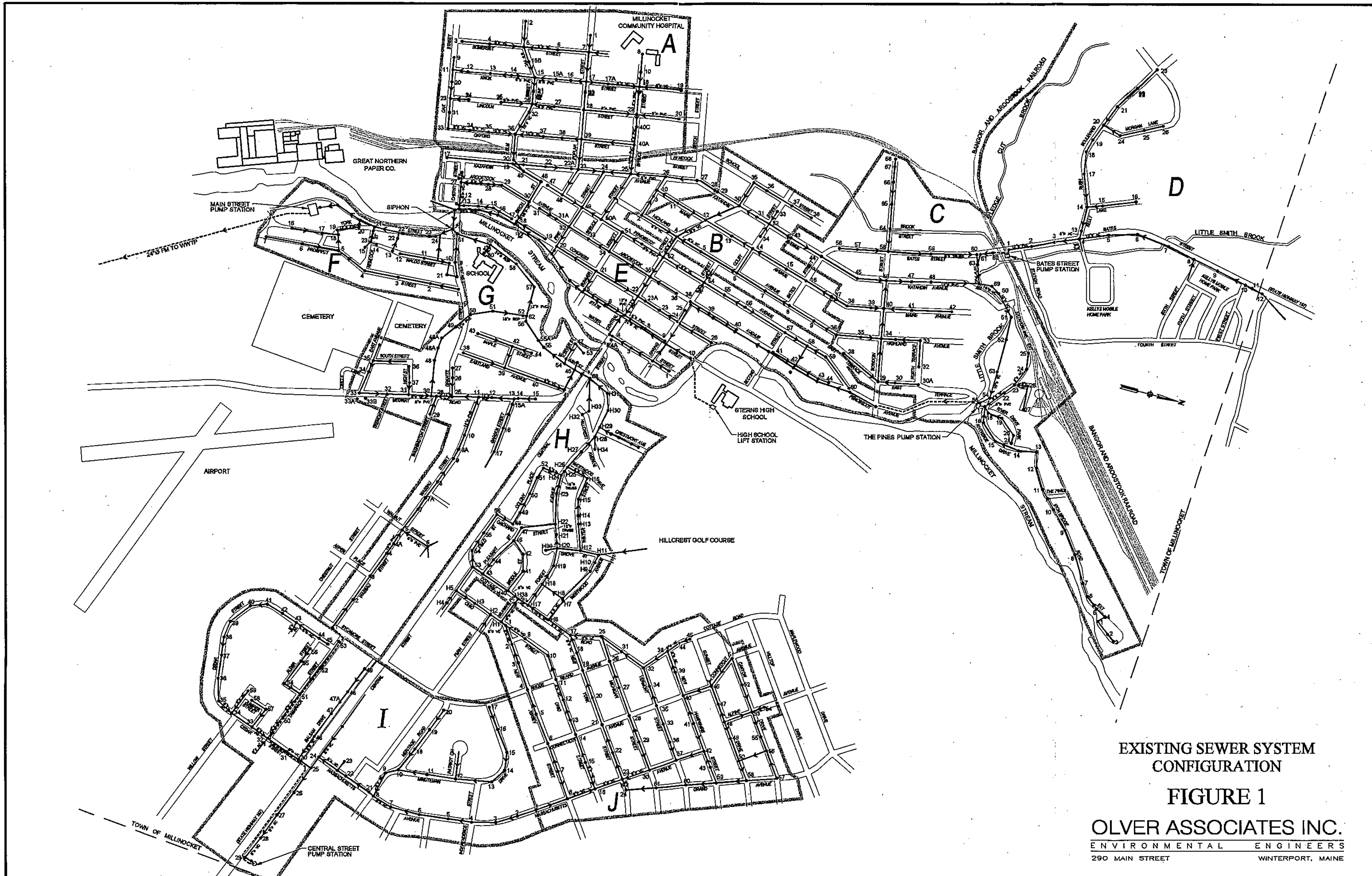
TABLE 1: MILLINOCKET SEWER SUBSYSTEMS

LETTER DESIGNATION	GENERAL AREA SERVED
A	Elm, Poplar and Spruce Street areas
B	Streets feeding into west end of Central Street
C	Between Bates Street and Millinocket Stream and along Riverside Drive and Iron Bridge Road
D	Northern Bates Street area beyond Smith Brook
E	Downtown areas between Penobscot Avenue and Millinocket Stream
F	Southern section of Town between York Street and Prospect Street
G	South of Central Street between Sycamore Street and Millinocket Stream

H	North of Central Street between Cottage Road and Millinocket Stream
I	Streets feeding into east end of Central Street near East Millinocket Town line
J	Streets denoted by "States" between Massachusetts Avenue and Rhode Island Avenue

As shown on Figure 1, the ten sewer subsystems contain over 500 manholes for access along the twenty-seven miles of pipe length. Some of the collector sewer pipe sections and interceptor sewers are located along streams and wet areas. Often, these locations have a greater possibility of excess flow leakage if the manhole and pipe structures are not completely watertight due to their materials of construction, due to deterioration with age, or due to their proximity to flooded areas during peak flow events. Figure 1 also lists approximate pipe sizes and materials based upon a review of old system mapping and on manhole inspections that were conducted during the recent field work for flow measurement. This data suggests that there are significant areas of old clay pipe in the sewer system, some of it of small 6" Ø diameter. Old clay sewer lines are often the sources of excess flow leakage due to their method of construction which typically left open joints between short three-foot long pipe sections. Older sections of clay pipe are also often brittle and easily cracked which provides areas for root intrusion and excess flow entry into the pipe, especially during high groundwater conditions.

For the last thirty years, the Town has operated a biological wastewater treatment plant at the end of its sewer system to biodegrade organic pollutants in the sewage prior to its discharge into the Penobscot River. As shown in Figure 2, the treatment system consists of three partially mixed facultative ponds. Each pond holds about 12 million gallons (MG) of water volume. The ponds each encompass about 4.5 acres with a total depth of about 13 feet and a working water depth of about 10 feet. The top dimensions of each pond are about 610 feet long by 310 feet wide. Because of their sloped sides, the bottom configuration of each pond is about 550



EXISTING SEWER SYSTEM CONFIGURATION

FIGURE 1

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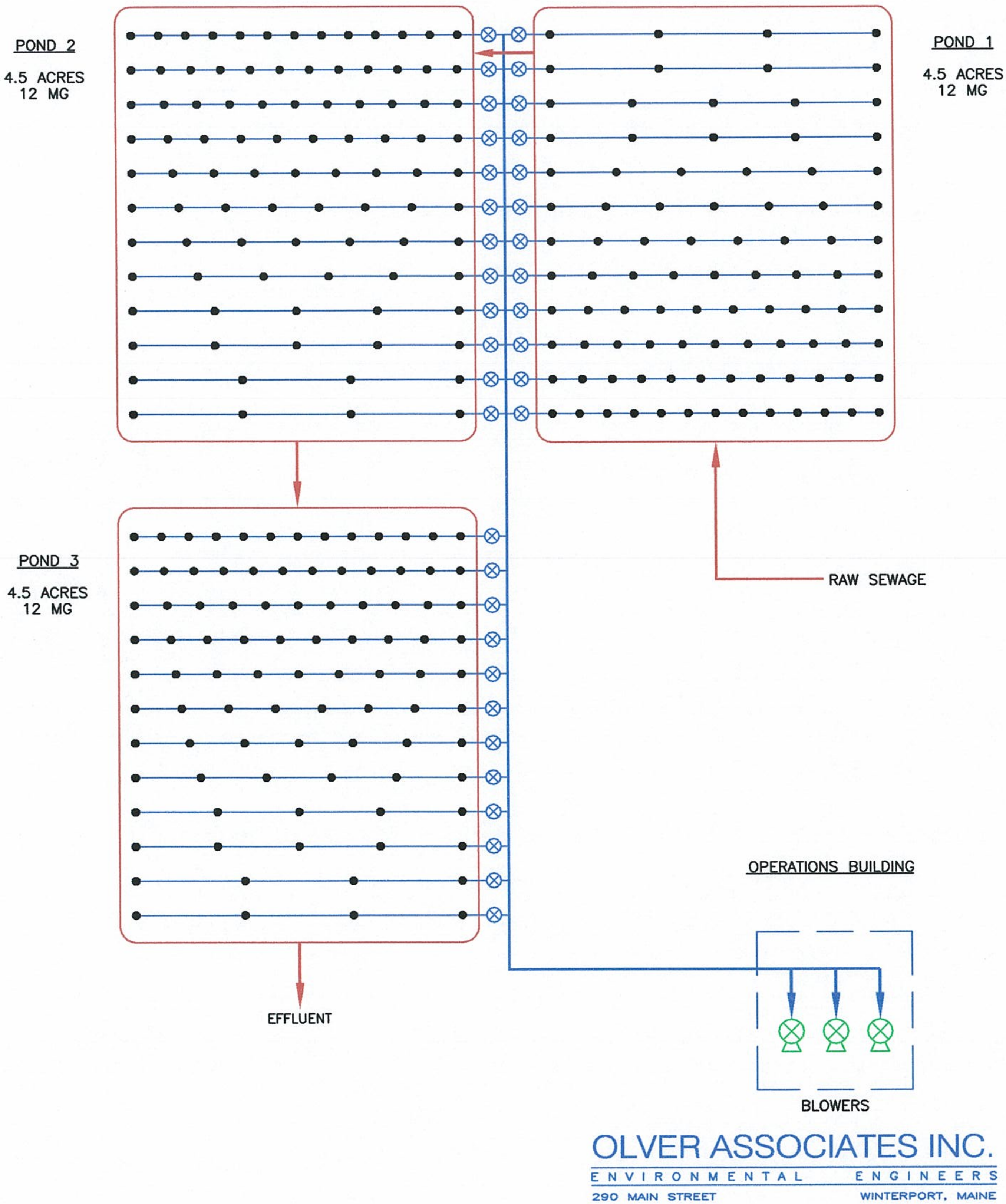
FIGURE 2: EXISTING TREATMENT PLANT PROCESS



feet long by 250 feet wide. Each pond is lined with a PVC liner to keep wastewater in the pond and to keep groundwater out.

The ponds can be operated in series or in parallel, but are normally operated in series. In the wintertime, cold water temperatures cause the microbial reaction rates to slow down. All three ponds must be operated in series in order to provide sufficient detention time for proper treatment to occur. Seasonal summer temperatures allow faster reaction rates for treatment of the wastewater and only two ponds are needed for warm weather treatment to occur. Compressed air is generated at the plant to provide oxygen to microorganisms in the ponds. Three blowers, each capable of providing oxygen laden air, are located in the blower room of the plant's Operations Building. Air is conveyed through an aeration pipeline of varying dimensions out to the three treatment ponds. Twelve lateral air feed lines with buried stem valves are used to divert air flow off a common header line and into each of the three ponds. Within each pond, diffuser tubes discharge air into the pond's water. The frequency of the diffuser distribution is uneven so that more air will be provided at the inlet end of each pond. This is based on the assumption that aeration requirements will be higher in these locations in response to the higher organic levels found near the lagoon's inlets. A schematic diagram of Millinocket's treatment pond system is shown on Figure 2:

The three treatment ponds were designed to process the pollutant loadings listed below in Table 2:

TABLE 2: ORIGINAL TREATMENT PLANT DESIGN LOADINGS

PARAMETER	DESIGN VALUE
Average daily flow (MGD)	2.33
Organic loading (lbs/day)	2200
Solids loading (lbs/day)	2700

In addition to these original loading values, provisions were made on the site to build a fourth lagoon in the future, if necessary, to further increase the plant's design capacity. Of the above pollutant loading parameters, daily wastewater flow and the plant's organic loadings have the most significance in sizing and operating the lagoons. Table 3 lists the current flow and organic loading levels that have occurred at the plant over the past two years:

TABLE 3: EXISTING OBSERVED POLLUTANT LOADING LEVELS

PARAMETER	DESIGN VALUE
WASTEWATER FLOWS (MGD)	
Overall average daily	1.57
Dry weather average daily	1.25
Maximum monthly	3.00
Maximum daily	8.14
ORGANIC LOADING (LBS/DAY)	
Average daily	1350
Maximum monthly	2000
Maximum daily	3400

The data provided in Table 3 suggests that the plant's average daily loading of 1.57 MGD is well within the 2.33 MGD design capacity of the system. If only dry weather days are considered, the average daily flow has averaged only 1.25 MGD, or about half of the plant's design value. Maximum monthly and peak hourly flows observed over the past two years were associated with extreme wet weather periods in the fall of 2005 when fourteen inches of precipitation fell over a two month period. Average daily organic loadings to the plant averaged 1350 lbs/day versus a design loading of 2200 lbs/day. This suggests that typical loadings to the facility are within the expected design range. The maximum daily organic loading on record was 3400 lbs/day which occurred during a heavy rain storm of 1.75 in/day. It is likely that the rain washed organic solids into the plant that had settled in the sewers and elevated the testing results for that day. It appears that the

Millinocket wastewater treatment plant is normally loaded at levels well within its design capacity. Exceptionally high organic loading events are often associated with peak groundwater infiltration and stormwater inflow conditions. This suggests that upstream sewer system excess flows are present that occasionally overload the treatment system.

2. ORIGINS OF INFILTRATION AND INFLOW

Ideally, the Millinocket sewer system would only need to convey sanitary wastewater from the residential, commercial and institutional users that are connected to the Town's sewer mains. This would allow the downstream wastewater treatment plant to process average daily and peak hourly flows that would be roughly proportional to the potable water use of the community. While these typical sanitary flow rates tend to exhibit some normal variation over the course of the day, these fluctuations are relatively easy to predict. Consequently, the operation of the treatment plant could be readily adjusted to process these normal sanitary loadings.

Figure 3 shows the origin of the normal sanitary wastewater flows for which the Millinocket sewer system was intended. Private building sewers that serve each lot bring the flows from each connected user out to the public sewer main in the street. These collector lines become increasingly larger as they near the treatment plant. Manholes are located along the sewer routes for access.

Unfortunately, additional excess flow loadings can occasionally enter the sewer system from both groundwater infiltration and stormwater inflow. These excess flows can create average daily and peak hourly flows that are greater than the base sanitary flows that the system was designed to convey.

Groundwater infiltration is excess clean water that leaks into the sewer system from deteriorated sewer pipes, defective pipe joints, poorly sealed manhole sections, and improperly connected foundation drains. Groundwater manifests itself in the sewer system, and at the treatment plant, as a steady background flow that is relatively consistent on a day-to-day basis, but which may show dramatic seasonal variations. The maximum annual period of groundwater infiltration into the sewer system typically occurs in the spring, shortly after snowmelt at the time

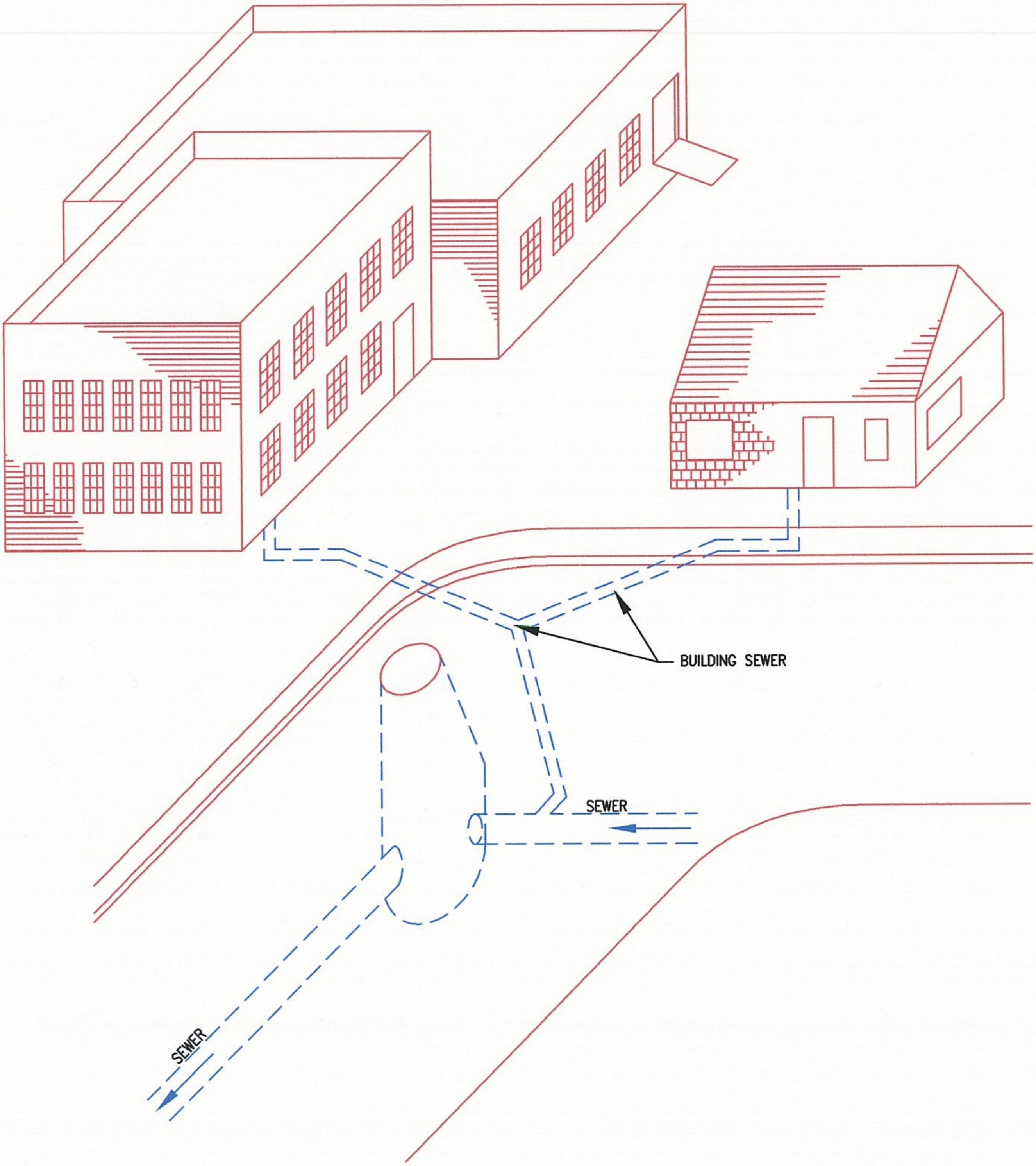


FIGURE 3

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TYPICAL SANITARY FLOW ORIGINS

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when the groundwater table is at its highest elevation and often near the ground surface. Minimum groundwater infiltration periods usually occur in the summer when the groundwater table is at its lowest elevation. The measured magnitudes of both maximum and minimum infiltration are often similar from year to year. Figure 4 shows typical sources of groundwater infiltration into the sewer system.

Stormwater inflow consists of excess clean water that enters the sewer system from roof drains, cellar drains, and surface water runoff. Unlike groundwater infiltration flows that are often easy to predict, inflow volumes can vary significantly as the result of the widely different precipitation events that trigger inflow activity. Numerous factors, such as the magnitude of rainfall per day for a given storm, the peak intensity in inches/hour at which the rain falls, the duration of the storm event, the presence of other factors such as concurrent groundwater saturation conditions, and the presence of either snow cover or frozen soils, can all contribute to extremely variable inflow amounts. This can lead to very high peak flows of clear water into the sewer system during individual precipitation events. The most extreme inflow effect will be observed during long duration, high intensity rain events that occur during the daytime when sanitary sewer system flows are at their highest. If snowmelt is occurring simultaneously, or if peak groundwater conditions are in-place, tremendous peak flows may occur in the sewer system and at the treatment plant. This may result in sewer system flooding, backup, or overflows as well as the inundation of the downstream wastewater treatment plant. Figure 5 shows potential sources of stormwater inflow into the sewer system.

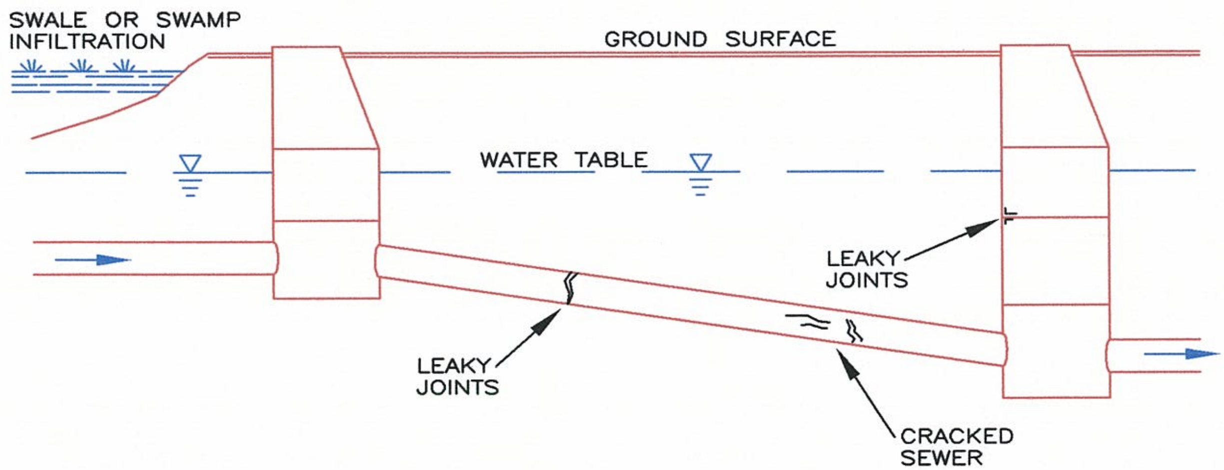

FIGURE 4

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TYPICAL GROUNDWATER INFILTRATION SOURCES

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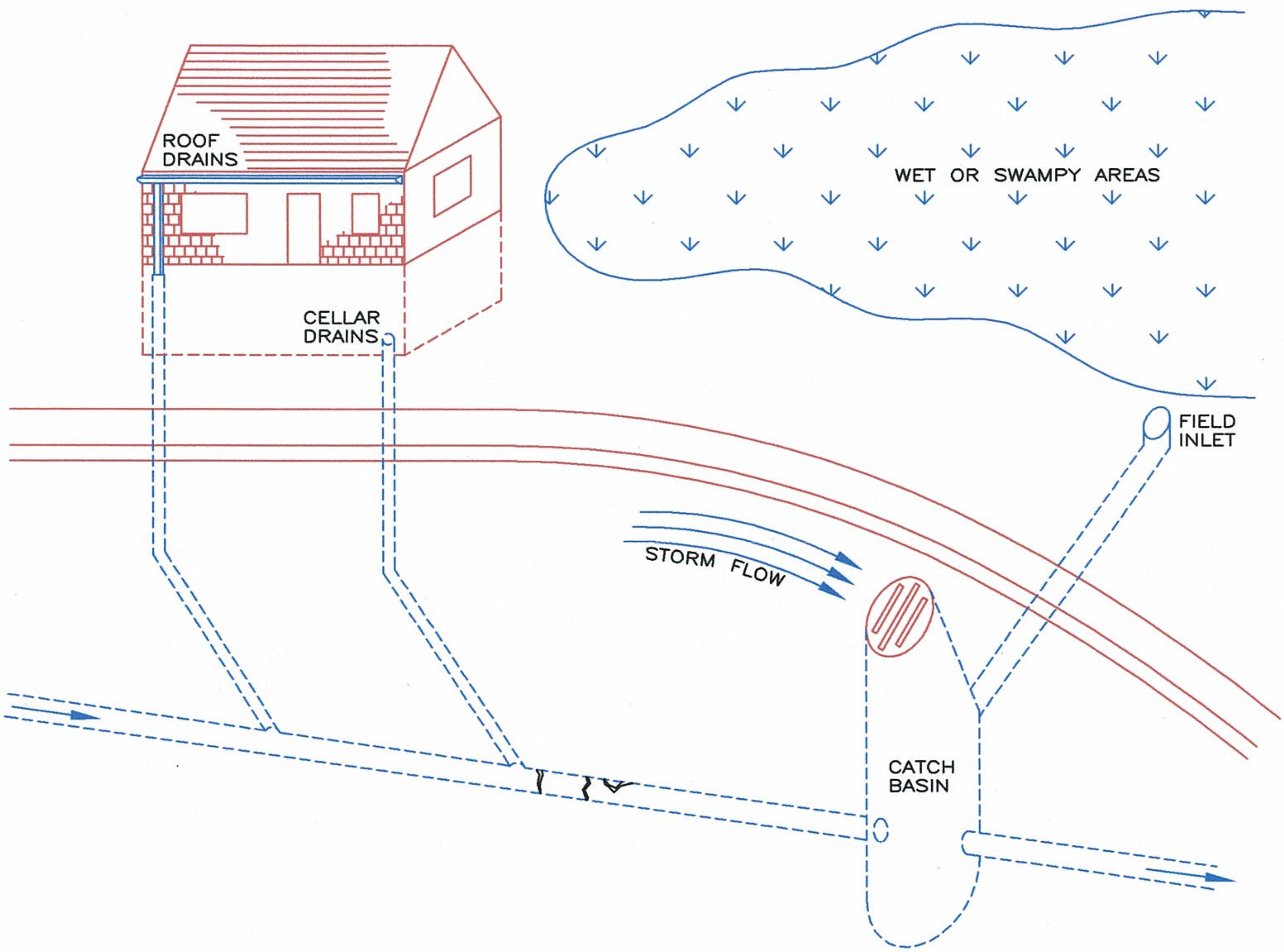

FIGURE 5

TOWN OF MILLINOCKET, MAINE

TYPICAL STORMWATER INFLOW SOURCES

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A review of treatment plant flow records over the last two years provides a general perspective of how peak infiltration and inflow volumes impact the facility. As discussed, the treatment plant receives an average daily flow of 1.25 MGD on dry weather days. During the spring snowmelt season when groundwater levels are at their maximum elevation, it is not uncommon for the plant's flows to reach as much as 2.80 to 3.00 MGD for sustained periods. This additional 1.75 MGD of excess flow can last for several weeks each spring and is generally caused by groundwater infiltration into deteriorated sewers and manholes. Some of the high groundwater levels are caused by the added water table saturation that occurs as the annual snowpack melts.

Treatment plant records also show a general increase in flows during and after rainfall precipitation events. On average, an additional 1.25 MGD of added plant flow occurs for every one inch of rainfall. This represents an average loading condition over a large number of annual storms. Rainfall from individual storms may be either more or less depending on ambient conditions at the time of the storm. More flow will reach the treatment plant if the ground is frozen when it rains or if it has been saturated by prior storms. The peak daily flow of 8.14 MGD that was observed in December, 2005 occurred after fourteen inches of rain fell over a two-month period. This caused an extremely high water table and left little absorptive capacity in the local soils to accept new flows. Alternately, rainfall events that occur in the summer during dry periods of low groundwater levels will not generate as much runoff. Dryer conditions, in addition to the summer vegetative cover, have the ability to allow more water to be absorbed versus reaching the sewer system.

The plant's flow records can be used to develop an estimate of how excess flows impact the wastewater treatment plant. The facility serves about 2,200 connected users including a business district, several schools, and other non-residential users. The equivalent sewered population is estimated to be about 5,500 people. At a typical wastewater production rate of 75 GPCD (gallons per capita per day), the typical sanitary portion of the plant's wastewater flow would be about 400,000 GPD. Normal peak hourly flow factors for small communities are about four times the average daily sanitary flow. This suggests that the peak hourly sanitary flow would be expected to be about 1.60 MGD.

The minimum flows received at the plant on dry weather days in August are typically about 750,000 GPD. If the estimated sanitary flow of 400,000 GPD is subtracted, then minimum groundwater leakage into the system on dry summer days when groundwater levels are depressed would be about 350,000 GPD. In the springtime when groundwater levels are elevated shortly after snowmelt occurs, it is not uncommon for groundwater infiltration levels to add up to 1.75 MGD to the plant's flow.

Rainfall contributions vary with magnitude, intensity, and duration of the storm as well as with the extent of vegetative plant growth and the amount of frozen ground conditions that are present. In general, the observed inflow impact at the plant is about 1.25 MGD per inch of rainfall. (It should be noted that actual peak inflow upstream in the sewer system likely occurs at a much greater rate. The large volume of the treatment ponds and the location of the plant's flow meter after the lagoons will tend to show a lower peak flow than the upstream sewer pipes must carry). At a ten-year frequency rainfall event of about 4.0 inches per day, the plant flow meter would be expected to record a flow of about 5.0 MGD of additional peak hourly inflow.

The above flow components can be summarized to add perspective to how different types of flow sources accumulate at the treatment plant. Table 4 below adds up each flow source for different plant loading conditions:

TABLE 4: TYPICAL TREATMENT PLANT FLOW COMPONENTS (MGD)

FLOW SOURCE	AVERAGE DAILY DRY	MAXIMUM DAILY DRY	PEAK HOURLY DRY	MAXIMUM DAILY WET	PEAK HOURLY WET
Sanitary flow	0.40	0.40	1.60	0.40	1.60
Groundwater infiltration	0.35	1.75	1.75	1.75	1.75
Stormwater inflow	0.00	0.00	0.00	5.00	5.00
TOTALS	0.75	2.15	3.35	7.15	8.35

The above data shows that the treatment plant will seldom have average daily flows less than 0.75 MGD, even in August during dry weather, low groundwater table conditions. As groundwater levels become elevated in the spring, flows at the plant can be expected to increase to between 2.15 and 3.35 MGD on typical days with no significant rainfall occurring. If rainfall occurs during peak sanitary flow periods, high groundwater levels and a ten-year storm event of 4.00 inches/day, flows at the plant could reach 7.15 to 8.35 MGD. Lesser amounts of inflow will be measured during smaller rain events. This data conforms well to the actual flow records measured at the plant over a variety of conditions. It shows that the combination of excess groundwater infiltration and stormwater inflow is relatively large when compared to sanitary flows. For example, if the annual average flow treated at the plant is 1.57 MGD as noted back on Table 3, this is equivalent to about 573 MG/year of total plant flow. If the sanitary flow contribution is 0.40 MGD on average, then about 146 MG/year of actual sewage is being treated. The remaining 427 MG per year, or seventy-five percent of the plant's flow, represents excess groundwater and stormwater that is passing through the plant.

Because peak flows have been observed in the sewer system over many years, the Town has taken some initial steps to identify the origins of these flows. Several areas of the sewer system have been inspected with a television camera over the past decade. These inspections were conducted in areas of the system that were suspected of potentially having excessive flow leakage, structural problems, or root intrusion.

Several areas of the Millinocket sewer system were inspected by television between 1995 and 1996. The reports from that work were reviewed as part of the current I/I study. Previous video records noted several problem areas in the sewer system as follows:

- The sewer line on Elm Street between Oxford Street and Katahdin Avenue passes below a set of railroad tracks. The pipe in this area was found to be 8" Ø VC with sections of cracked, broken and crushed pipe with offset and separated joints. The Elm Street sewer west of the tracks appears to be new 8" Ø PVC, but the old section below the tracks was left in-place and is in very poor condition. It is likely that the old clay sewers on the sidestreets off Elm Street are also in poor condition.

- The sewer on New Jersey Street was found to be a 6" Ø VC pipe in very poor condition. The pipe had many cracked sections with offset joints, protruding building sewer laterals, root intrusion and leaking services. Six-inch diameter clay pipe is too small to meet current sanitary sewer design standards and will be prone to plugging. The inspection report noted that it was difficult to pull the camera through the pipe because of its small size, the amount of debris in the line, and the presence of sewer services protruding into the main pipe. Other streets in this area were named after states and were possibly constructed about the same time. It appears that there are other 6" Ø clay pipes in some of these areas. The six named states streets between New Jersey Street and New Hampshire Street could be a potential area of sewer problems based upon the inspection record of New Jersey Street.

- Bates Street had its sewer inspected from the pump station and north towards the State Park. This line was found to have sags, protruding services, separated joints and leaking service connections. Evidence of past leakage was noted throughout the pipe.

- A series of residential streets off Forest Avenue were reviewed and noted to be mostly 6" Ø clay pipe in poor condition. These streets included Westwood Avenue, Grove Street, Winter Street, Middle Street, Pleasant Street, Orchard Street, and Colony Place. Most of these pipes showed areas of crushed sewers, cracked pipes, offset and separated joints and areas of groundwater infiltration. The small diameter of the pipes does not meet current pipe design standards which made it difficult for the camera to pass through the lines.

- Sewers along the Iron Bridge Road and Riverside Drive were found to be in poor condition. Areas of offset joints, broken and cracked pipes, sags, and leaking manholes were noted. Areas of this pipe appear to often be submerged under peak flow conditions.

- Several sections of the sewer system were inspected and showed that pipes in these areas were in reasonably good condition. These streets included Spruce Street, Prospect Street, York Street, Kelly Lane, Rush Boulevard, Morgan Lane, Medway Road and Wassau Street.

The past television camera work was not intended to represent a complete overview of the Millinocket sewer system. It appears that specific sections of the system were targeted based upon past observations of potential problem areas. A large portion of the camera record shows pipes in poor condition and in need of repair. Millinocket appears to have a relatively old sewer system with significant amounts of clay pipe. This material, which is no longer used but which was prevalent fifty to one hundred years ago, is prone to cracking, leakage, and offset joints. It is likely that many of these areas contribute to Millinocket's excess flow problem. Cracked sewers with open or separated joints are likely sources of groundwater infiltration. Stormwater inflow often enters these same pipes by elevating the groundwater levels after rain events to create a condition called inflow induced infiltration. This suggests that large amounts of rainfall can enter the sewer system through old pipes even if no street catch basins are connected.

Television inspection work is often conducted on sewer systems as part of detailed street-by-street evaluations of known problem areas. This usually follows the completion of a broader first phase review of general sewer system high flow areas. EPA guidelines for the systematic analysis and solution of excess flow problems in sewers have traditionally used a two-step process consisting of an initial Infiltration/Inflow (I/I) Study followed by a Sewer System Evaluation Survey (SSES). Traditional I/I and SSES evaluations usually lead to the development of a Sewer System Master Plan for excess flow abatement. Each of these sewer system evaluation steps can be generally described as follows:

1. An Infiltration/Inflow (I/I) Study is an initial screening evaluation of sewer systems to determine if excess flows are a problem, to quantify the magnitude of the flows, and to screen and isolate areas of the sewer system where excess flows are produced. If an I/I study concludes that there are areas of excess flow in the sewer system, a further, more detailed level of study is usually conducted in these areas as part of an SSES process.

2. A Sewer System Evaluation Survey (SSES) is a second phase study that further evaluates problem areas of the sewer system that were found to be prone to excess flow during an I/I study. The purpose of the SSES phase is to evaluate the problem areas in greater detail, to pinpoint the exact origins of the excess flows, to recommend remediation projects to remove the excess flows, to store them for release in non-peak periods, or to treat them. The final outcome of the SSES process is a schedule of prioritized projects that, when completed, will reduce the excess flow problem.

The current study represents an I/I level investigation that was designed to target the most significant problem areas of the sewer system. Flow gauging was conducted at night during spring high groundwater conditions when only groundwater was flowing in the sewers. Additional flow gauging was conducted at night during several peak rainfall events to measure the impact of precipitation on sewer flows. Measurements were taken at key nodes in the system in order to isolate problems by subsystem and by street area. Flows were estimated by taking depth measurements of the sewer's water surface and applying Manning's equation for pipe flow based on flow depth, pipe size, pipe slope and pipe material. Flows for individual streets were then balanced to obtain a comparative analysis of how different sewers performed with respect to each other. Flow measurements taken during an I/I study are not intended to represent a precise assessment of exact flow volumes in each pipe because of the many variables involved in taking measurements under adverse field conditions. The actual measurement of each line is not as important as the comparative estimate of how different lines perform with respect to each other. The objective of the I/I study approach is to develop a list of the worst sewer pipes in the community based upon their relative rates of excess flow leakage.

As was previously noted, the Town's wastewater treatment plant utilizes three large lagoons with a total volume of 36 million gallons. Each pond also has an area of freeboard above its water surface that can store large amounts of water. Since the plant's effluent flow meter is located after the ponds, peak flows in the sewer system are likely greater than the flows measured at the plant because the ponds' large volume buffers the full impact of the peaks. A review of the plant's inflow records shows that maximum and minimum daily plant flows are typically within a narrow band around the average daily flow. This is due to the storage volume of the ponds.

A better perspective of sewer system peak flows would be obtained from a record of flow taken at the end of the sewer system prior to the volume of the treatment plant lagoons. A flow meter was originally installed at the Main pump station off York Street, but the meter has been inoperable for much of the past few years. It was repaired as part of the present study to provide instantaneous flow measurements during nighttime monitoring events, but the record is not totalized and logged for other days. It should be noted that the sewer system measurements taken as part of this study represent peak "rate" estimates versus peak flow "volumes" of the type recorded at the treatment plant. Because of the time of travel and concentration for the peak flow waves to reach the end of the system and the pump station, it is common for the individual upstream sewer system readings to be higher than downstream flow measurements. As discussed, the actual volume of the upstream flow estimates is not as important as how the flows on each street relate to each other. The purpose of an I/I study is to target sewer system areas that have comparative high flows when compared to all other areas of the system that were observed under similar field conditions.

3. OBSERVED EXCESS GROUNDWATER INFILTRATION AREAS

Groundwater infiltration into the Millinocket sewer system was gauged on March 15, 2006 during the nighttime period between 11:00 A.M. and 5:00 A.M. Temperatures during this period had reached an average high of 40°F in the prior ten days as compared to being below freezing at an average of about 22 °F in the previous ten days before the spring thaw began. During this period, trace amounts of rainfall fell and was absorbed in the snowpack, but precipitated its melting. Rising groundwater infiltration levels were noted at the treatment plant as manifested by minimum plant flows of 0.95 MGD during the previous 22 °F period, followed by an increase to 1.27 MGD prior to the infiltration sampling event. On March 14, the plant experienced an average daily flow of 1.67 MGD with a peak flow of 2.14 MGD. These proved to be the highest flows of the spring period until heavy rainfall events began to fall in subsequent weeks. Therefore, the March 15, 2006 gauging event was considered to be a good representation of spring high groundwater infiltration conditions.

Infiltration for each major sampling node is presented below in Table 5. Data is provided for the major nodes at which high flows were encountered. As in all older sewer systems, evidence of excess flow was evident at some background level in most parts of the system. The streets listed in Table 5 had levels that were higher than the background levels observed in other areas. It should be noted that even new sewer system sections still have some amount of groundwater entry, both from normal gasket leakage and due to the impact of leaking building sewers on private property.

Table 5 presents the raw data that was measured followed by the data expressed in the unitized format of gallons per day per inch-mile of pipe. Since longer sewers of larger diameter have a greater area of sewer surface and joint length over which leakage may occur, the raw leakage rate alone is not always a good indication of a pipe's condition. For example, a raw leakage rate of 100,000 GPD would be more significant in 1,000 LF of 8" Ø pipe than in 5,000 LF of 24" Ø pipe. The use of unitized GPD/inch-mile units allows raw data between two pipes to be compared by accounting for the amount of pipe upstream of the flow measuring point. An inch-mile of pipe is defined as its length in miles multiplied by its diameter in inches. If the raw groundwater infiltration flow in GPD is divided by the amount of upstream pipe in inch-miles, the unitized leakage rate of GPD/inch-mile allows pipe leakage to be compared between various points of the sewer system. For sewer systems of Millinocket's size, EPA guidelines suggest that leakage rates greater than 10,000 GPD/inch-mile are excessive.

TABLE 5: OBSERVED GROUNDWATER INFILTRATION RATES

SEWER SUBSYSTEM	STREET LOCATION	INFILTRATION RATE (GPD)	UNITIZED INFILTRATION (GPD/INCH-MILE)
A	Oxford Street	180,000	85,000
	Knox Street	170,000	80,000
	Somerset Street	50,000	24,000
	Elm Street	90,000	198,000
C	Smith Brook Interceptor	240,000	85,000
	Katahdin Avenue Extension	60,000	65,000
	River Drive Park	10,000	16,000
	Iron Bridge Road	110,000	45,000
D	Bates Street	70,000	19,000
E	Cherry Street	10,000	16,000
	Central Street (West)	30,000	13,000
	State Street	20,000	26,000
G	Wassau Street	130,000	20,000
	Medway Road	90,000	23,000
	Cross-country to interceptor	50,000	14,000
	Millinocket Stream interceptor	180,000	29,000
I	Cedar Street	40,000	26,000
	Minuteman Drive	30,000	8,000
	Central Street (east near PS)	10,000	5,000
J	New Jersey Street	40,000	18,000
	Ohio Street	90,000	38,000
	New York Street	100,000	40,000
	Michigan Street	30,000	16,000
	New Hampshire Street	50,000	38,000
	Cottage Road	70,000	25,000
	TOTAL INFILTRATION	1,950,000	-

As shown in Table 5, many areas of the Millinocket sewer system appear to have groundwater leakage rates higher than the 10,000 GPD/inch-mile defined by EPA as being excessive. On the night of these measurements, the total of all peak infiltration rates observed in the sewer system was 1.95 MGD. This is slightly higher than the downstream flows measured after the lagoons, but these differences are due to the accuracy of the sewer depth measurements under adverse field conditions, the variation in flows that occur due to the time of concentration in the sewer pipes, the large storage volume of the lagoons that mitigate peak flows, and normal variations in the plant's effluent flow meter. As discussed, the raw flow values from sewer system gauging are more significant when streets are compared against each other than for their absolute flow values. Still, there was reasonable correlation found between the magnitude of excess groundwater infiltration observed upstream in the sewer system and the levels of flow measured downstream.

The Table 5 data leads to several observations regarding the major subsystems of the Millinocket sewer system as follows:

- Several streets in Subsystem A in the Elm Street and Spruce Street areas were found to have high groundwater infiltration rates. Oxford Street and Knox Street, which run perpendicular to Elm and Spruce Streets, had high leakage rates in the 80,000 to 85,000 GPD/inch-mile range. These streets both extend from Oak Street to Beech Street and, while there were some slight variations in flows in discrete areas, the overall conditions of each street were similar. It is our understanding that the sewer on Elm Street was replaced in the recent past, but the cross-street areas of Oxford and Knox Street represent old clay lines. The sewer line on Elm Street in the vicinity of Oxford Street and Katahdin Avenue crosses below the railroad tracks and was not replaced in the past Elm Street sewer project. As discussed, a previous television inspection of this line showed it to be in poor condition with many cracks and breaks. The recent flow measurement showed a high rate of leakage in this area at 198,000 GPD/inch-mile.

- No significant groundwater infiltration problems were observed in Subsystem B.

- In Subsystem C, high flows appear to be leaking in along the Smith Brook Interceptor sewer between Bates Street and Katahdin Avenue with leakage rates of 85,000 GPD/inch-mile. In some areas, water could be observed leaking into deteriorated manholes along the stream. High flows were also noted in the "Pines Area" which includes Katahdin Avenue Extension, Riverside Drive, River Drive Park and the Iron Bridge Road. Peak flows in this area were in the 45,000 to 65,000 GPD/inch-mile range. The Town is presently in the process of upgrading the sewer lines in the Pines area due to their poor condition.

- In Subsystem D, flows along the Bates Street sewer were measured at 19,000 GPD/inch-mile in the area beyond the pump station.

- In Subsystem E, elevated levels of infiltration were measured on Cherry Street, West Central Street and State Street, but the unitized rates of 13,000 to 26,000 GPD/inch-mile were lower than in some of the other problem areas noted.

- No significant groundwater infiltration sources were observed in Subsystem F.

- In Subsystem G, the relative rates of leakage on Wassau Street and Medway Road varied from 20,000 to 23,000 GPD/inch-mile with slightly higher levels of 29,000 GPD/inch-mile along the Millinocket Stream interceptor. These values are lower than other problem areas of the overall sewer system, although still high by EPA standards. It should be noted that flow gauging in this area was influenced by the discharge of the Central pump station's force main into the Wassau Street sewer. It appears that surging flows in this line are often the result of the upstream pump station's cycles.

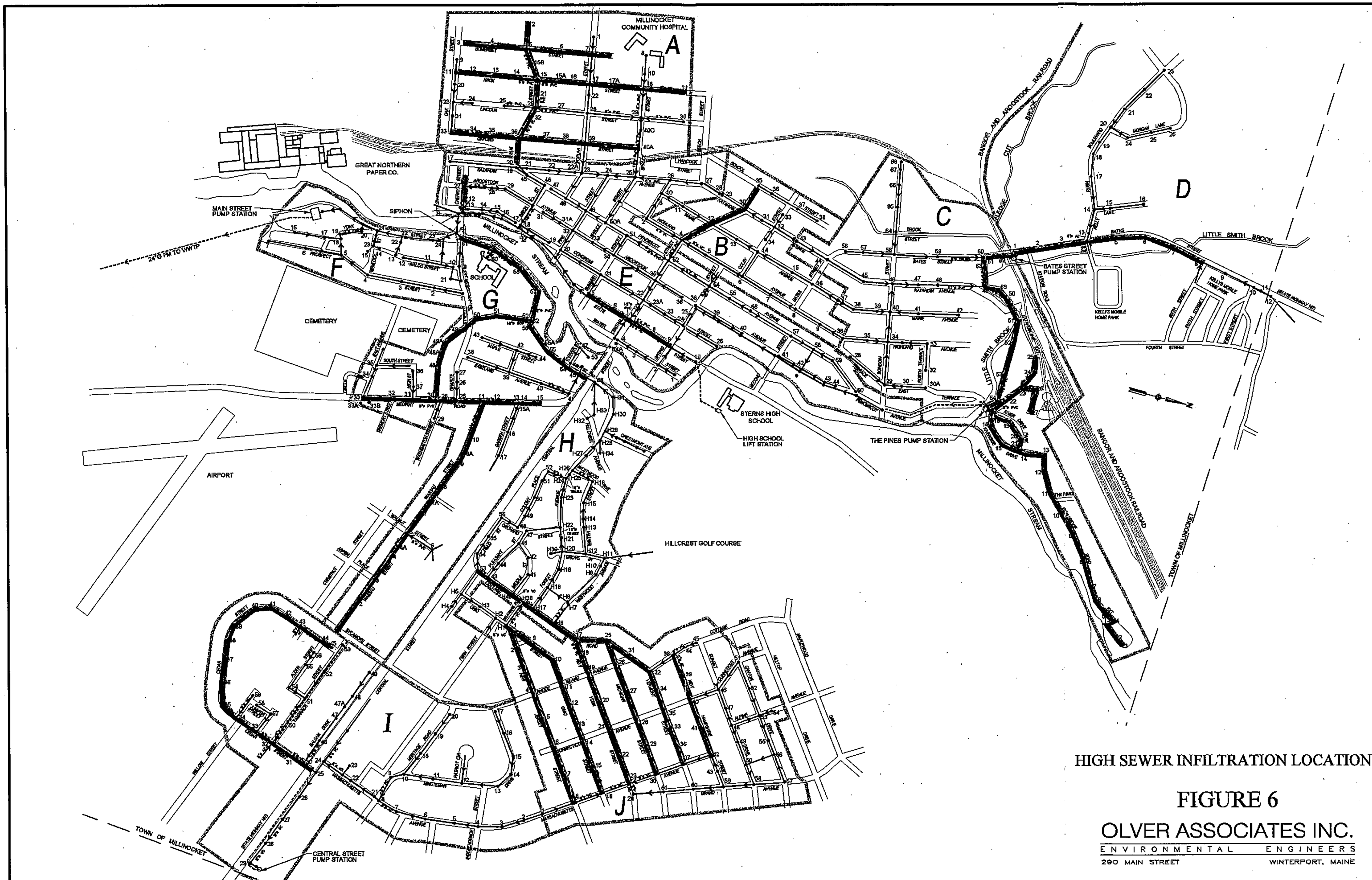
- In Subsystem H, most of the observed flows appeared to be passing through from upstream areas in Subsystem J. It should be noted, however, that previous sewer television work in this area noted significant structural problems in sewers on Westwood Avenue, Winter Street, Pleasant Street, Orchard Street, Middle Street and Colony Place. Many of these sewers were found to be small 6" Ø clay pipes in very poor condition. It is possible that some of the leakage from these streets was masked by the high flow velocity on Forest Avenue created by peak upstream flows from Subsystem J. The fact that these sewers are known to be in poor structural condition may indicate the need to focus on their repair in the near future.

- In Subsystem I, high flows were observed to be present in the Cedar Street areas at 26,000 GPD/inch-mile, but these flows were less than in other parts of the sewer system.
- In Subsystem J, high groundwater leakage rates were observed in many of the named "States" streets. Flows varied from 18,000 GPD/inch-mile on Michigan Street up to 40,000 GPD/inch-mile on New York Street. High flows were evident on all of the adjoining streets including New Jersey Street, Ohio Street, New Hampshire Street and Cottage Road.

Areas of the Millinocket sewer system with the highest observed sources of groundwater infiltration leakage are shown on Figure 6. It should be noted that it is possible that other areas of the sewer system that are not shown could have high infiltration that was not detected during the March 15, 2006 monitoring event. The collection of nighttime flow depth data and the mathematical balancing of the raw data is not an exact science; however, it does yield reasonable conclusions on which areas of the sewer system should be the major focus for groundwater infiltration abatement.

4. OBSERVED EXCESS STORMWATER INFLOW AREAS

Stormwater inflow into the Millinocket sewer system was observed during three storm events that occurred in October, 2006. Nighttime monitoring was conducted during a 1.38 inch/day rain event on October 12, during a 1.75 inch/day rain event on October 20, and during a 2.05 inch/day rain event on October 28. Because the nighttime rainfall became sporadic on October 12, greater weight was given to the analysis of the latter two storms. On October 20, the treatment plant experienced an average daily flow of 2.03 MGD and a peak flow of 3.56 MGD. The flow at the Main pump station was just under 3.00 MGD during the rain monitoring. On



HIGH SEWER INFILTRATION LOCATIONS

FIGURE 6

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October 28, the treatment plant received an average daily flow of 2.41 MGD and a peak flow of 3.75 MGD. The peak flow at the pump station was estimated to be about 3.20 MGD. As discussed, the rate of peak flows upstream in the sewer system were likely higher than these measured flows due to the buffering effect of the lagoons and the time of concentration in the sewer system for the waves of peak flow from various upstream sewers to reach the pump station. Individual depth readings were taken at various upstream sewer system nodes and then balanced to present the data shown in Table 6. Because the amount of stormwater flow is a function of the storm's intensity and duration as well as its magnitude, the flows are presented in unitized terms of gallons per day of peak flow rate per inch of rainfall (GPD/inch). This allows the concentration of each identified high flow area to be compared for various storm events beyond those that were measured. Table 6 presents the comparative flow concentrations for various sewer systems:

TABLE 6: OBSERVED STORMWATER INFLOW RATES

SUBSYSTEM	STREET LOCATION	UNITIZED INFLOW (GPD/INCH)
A	Elm Street	90,000
B	Central Street (West)	50,000
	Highland Avenue	20,000
C	Bates Street	48,000
	Katahdin Avenue	23,000
	Smith Brook Interceptor	100,000
	Katahdin Avenue Extension	32,000
	River Drive Park	6,000
	Riverside Drive/Iron Bridge Road	500,000
D	Bates Street (north of PS)	200,000
E	Penobscot Avenue	45,000
	Central Street	75,000

G	Granite Street School	135,000
H	Colony Place	50,000
	Westwood Avenue	60,000
I	Central Street (east end)	100,000
	Balsam Drive	20,000
	Cedar Street	10,000
	Massachusetts Avenue	15,000
	Minuteman Drive	5,000
J	New Jersey Street	140,000
	Ohio Street	160,000
	New York Street	130,000
	Michigan Street	110,000
	Vermont Street	30,000
	New Hampshire Street	30,000
	TOTAL	2,184,000

As shown in Table 6, many areas of the Millinocket sewer system appear to be influenced by heavy rain events. In the upstream sewer system, peak flow rates of 2.18 MGD/inch were observed. By the time the individual waves of these peak flow rates reach the downstream pump station and treatment plant, their peak intensity is reduced by the time of concentration in the sewer system and by the treatment lagoons' storage volume. As discussed, the comparative inflow volumes between each street are more significant than their absolute value. The data collected during the nighttime monitoring events provides a reasonable comparison of peak inflow contribution rates between various areas of the sewer system.

The Table 6 data leads to several observations regarding inflow in the major subsystems of the Millinocket sewer system as follows:

- In Subsystem A, high inflow rates of 90,000 GPD/inch were observed in Elm Street. A significant part of this flow appears to originate in the lower end of the street below the railroad tracks.

- In Subsystem B, high inflow was observed at the western end of Central Street at 50,000 GPD/inch and on Highland Avenue at 20,000 GPD/inch.

- In Subsystem C, Bates Street was noted to have a peak inflow rate of 48,000 GPD/inch while Katahdin Avenue had a rate of 23,000 GPD/inch. The Smith Brook Interceptor was found to allow 100,000 GPD/inch of inflow to enter the sewer system. The "Pines Area" along Millinocket Stream between Katahdin Avenue Extension, River Park Drive, Riverside Drive, and the Iron Bridge Road had high inflow rates of 32,000 GPD/inch up to 500,000 GPD/inch. The Town is presently in the process of remediating the sewer system in this area.

- Bates Street north of the pump station was found to have an inflow rate of 200,000 GPD/inch in Subsystem D.

- In Subsystem E, Penobscot Avenue had an inflow rate of 45,000 GPD/inch and Central Street in the downtown area had an inflow rate of 75,000 GPD/inch.

- No significant sources of high inflow were observed in Subsystem F.

- High inflow volumes were noted in Subsystem G in the line connecting the Granite Street School to the interceptor sewer. It is possible that roof drains or field drains at the school are connected to the sewer system. Inflow rates of up to 135,000 GPD/inch were measured.

- In Subsystem H, Colony Place was found to have an inflow rate of 50,000 GPD/inch, while Westwood Avenue was observed to have inflow of about 60,000 GPD/inch. Past television inspection work showed these lines to be 6" Ø clay sewers in poor condition.

- The east end of Central Street near the Central Street pump station in Subsystem I had a high inflow rate of 100,000 GPD/inch. Much lower inflow rates were noted on some of the upstream sidestreets including

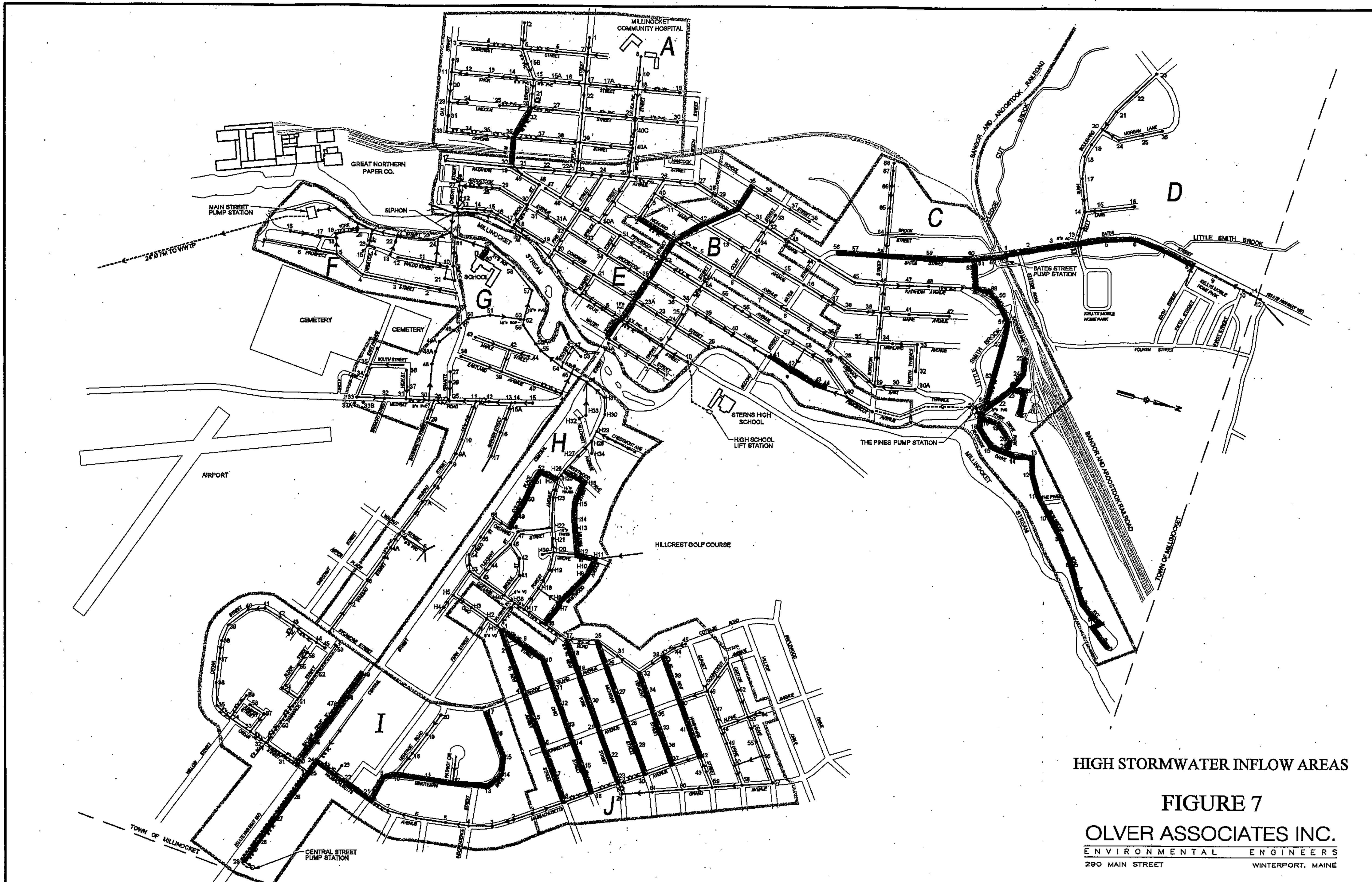
Cedar Street, Balsam Drive, Massachusetts Avenue and Minuteman Drive. These flows ranged from 5,000 to 20,000 GPD/inch.

- In the "States" streets of Subsystem J, high rates of inflow were noted on several streets including New Jersey Street at 140,000 GPD/inch, Ohio Street at 160,000 GPD/inch, New York Street at 130,000 GPD/inch, and Michigan Street at 110,000 GPD/inch. Lesser amounts of inflow were noted on Vermont Street and New Hampshire Street with inflow rates of 30,000 GPD/inch on each street.

Areas of the Millinocket sewer system with the highest observed sources of stormwater inflow are shown on Figure 7. It should be noted that other areas of inflow may exist that were not evident during the nighttime monitoring events. It is not uncommon for high sewer flows and velocities from one area to mask the flows of adjacent nodes as these flows pass by. It is sometimes necessary to first remove the major inflow sources from a sewer system, and then to remeasure the amount left, to clearly observe all sources of inflow. However, the inflow sources presented in Table 6 present a reasonable comparative assessment of the relative origins of excess inflow in the various areas of the Millinocket sewer system. These areas should be the points of focus for any future efforts to abate high inflow sources.

5. POTENTIAL EXCESS FLOW REDUCTION MEASURES

The results of a first phase I/I study are generally to assess the areas of the sewer system where major sources of excessive groundwater infiltration and stormwater inflow are present. Typically, a second phase SSES study follows that further pinpoints the exact sources of the observed high flows and that leads to the design and construction of specific sewer system improvements to correct the identified problems. In this I/I study, many areas of the Millinocket sewer system were found to have high levels of infiltration and inflow. This is not unexpected given the age of the sewer system and the fact that few major sewer remediation or separation projects have been completed over the years. As the system continues to age, the Town will be forced to begin the long-term process of updating its sewerage infrastructure in order to keep it in working condition. Some of these future repair projects may be driven by the need to replace sewer lines that



HIGH STORMWATER INFLOW AREAS

FIGURE 7

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collapse and plug, especially in areas where old clay pipes now exist. In the absence of doing reactive projects to address pipe failures, we recommend that priority be given to those projects that also address the removal of high flows for the sewer system. Because much of the high flow originates in areas of poor pipe condition, most projects that the Town conducts in the sewer system should address both structural and excess flow issues at the same time.

There are many areas of the sewer system where the Town could focus its efforts. The Pines Area project which is now underway is a good starting point and will address sewer issues on Riverside Drive, River Park Drive, Iron Bridge Road and Katahdin Avenue Extension.

In the years ahead, the Town should plan on conducting similar projects in other areas of the sewer system. The availability of financing and the need to keep sewer user fees low will likely drive the discussion on which projects to do and when they should be scheduled. As a guideline to assist the Town in planning for these projects, we suggest the project priorities as shown below in Table 8. While it may be necessary to modify this schedule as other problem areas in the sewer system become evident in future years, this represents a good starting point for planning purposes:

TABLE 8: SUGGESTED SEWER SYSTEM IMPROVEMENT PRIORITIES

PRIORITY	PROJECT AREA	PEAK INFILTRATION (GPD)	PEAK INFLOW (GPD/inch)
1	PINES AREA Katahdin Avenue Extension Riverside Drive River Park Drive Iron Bridge Road	180,000	538,000
2	SMITH BROOK INTERCEPTOR	240,000	100,000
3	GRANITE STREET SCHOOL	-	135,000

4	<u>STATES STREETS AREA</u> New Jersey Street Ohio Street New York Street Michigan Street	220,000	540,000
5	<u>BATES STREET</u>	70,000	200,000
6	<u>ELM STREET AREA</u> Oxford Street Knox Street Elm Street	490,000	90,000
7	<u>CENTRAL STREET (EAST)</u>	10,000	100,000
8	<u>FOREST AVENUE AREA</u> Colony Place Westwood Avenue	-	110,000
	TOTALS	1,210,000	1,813,000

The eight groups of projects defined in Table 8 represent an estimated 1,210,000 GPD of groundwater infiltration and an estimated 1,813,000 GPD/inch stormwater inflow contribution. The removal of these excess flow sources will have a major impact on the capacity of the sewer system and downstream wastewater treatment plant to accommodate future growth. In addition, repairs to the deteriorated sewer systems in these areas will help to stabilize the Millinocket wastewater collection infrastructure and allow it to continue serving the Town in the years ahead.

6. POTENTIAL CAPITAL COSTS OF RECOMMENDED SEWER PROJECTS

It is difficult to predict the costs of doing the proposed sewer remediation work because it is likely that it will take the Town many years to complete these projects. The current Pines Area project has been in the planning stages for the last eight years and represents the first major sewer improvement that the Town has done in over a decade. If the Town were to schedule one of the eight projects every three years, it will take twenty-five years to complete this work. Construction costs over such a long time period are impossible to predict. In the last two years alone, construction costs have risen about thirty percent due to higher energy and material costs. Over the next twenty-five years, the costs of the proposed projects will rise significantly. It is also likely that failures of other older parts of the sewer system, or the need to make improvements at the wastewater treatment plant, will make it necessary to modify the Town's wastewater treatment infrastructure priorities in the years ahead. In order to give the Town an estimate of capital costs in 2007 dollars for initial planning purposes, we have prepared the preliminary cost estimates shown below in Table 9. Detailed cost estimates for each project are attached as Exhibit A. it should be noted than an SSES level study of each sewer area should be conducted as part of the design phase for each project. We recommend that each area of the sewer system be inspected with television cameras to locate connected sewer services and to assess the condition of each line. This will allow the proposed design to consider exact locations of excess flow entry as part of each project. The SSES work may modify the proposed scope of work as presented in this study. For the purposes of preparing this initial planning cost estimate, it is assumed that the old sewer lines in each street will need to be completely replaced. As each SSES level study is completed, it is important that these cost estimates be updated to reflect construction costs at that point in time.

TABLE 9: ESTIMATED IMPLEMENTATION COSTS OF PROPOSED SEWER IMPROVEMENTS

PRIORITY	PROJECT	ESTIMATE
1	"Pines Area"	$ 2,495,000
2	Smith Brook Interceptor	610,000
3	Granite Street School	185,000
4	"States" Street Area	3,100,000
5	Bates Street	560,000
6	Elm Street Area	1,850,000
7	Central Street (East)	600,000
8	Forest Avenue Area	1,450,000
	TOTAL (2007 DOLLARS)	$ 10,850,000

As shown above, the total cost of the identified sewer remediation projects is $10,850,000 in 2007 dollars. Actual costs may vary depending on the scope of work as defined in the subsequent SSES design phases for each project and on the construction costs at the time of the project. After the completion of the Pines Area work, the next proposed project is to upgrade the Smith Brook Interceptor. When future television inspection of this line is done as part of the SSES phase, we recommend that the camera crews also check the condition of the Town's main interceptor lines on both sides of the Millinocket Stream. While these lines did not show high flows in the current study, it was difficult to clearly view these pipes because of all the upstream flow that is passing through. It is always a good idea to periodically inspect main sewer interceptors adjacent to streams given the large amounts of water that can enter from small defects in the pipe. Figure 8 shows the general location of each proposed project area.

7. CLOSURE

The intent of this I/I study is to summarize the high excess flow areas that were found to exist in the Millinocket sewer system. While excess flows are present throughout the system, eight areas were identified which would benefit from future sewer remediation projects to reduce these flows. The first of these projects, the Pines Area, is now underway. As with the Pines project, the Town should consider addressing roadway, stormwater and water main issues at the same time that any sewer work is conducted. This I/I study should assist the Town as a planning tool in the years ahead as it considers potential improvements to its sewerage collection system. As you review this report, please call if you have any questions or if you need additional information. We are available to meet with the Town to review the report in greater detail. As always, we appreciate this opportunity to be of continued professional engineering service to the Town of Millinocket.

Very truly yours,

OLVER ASSOCIATES INC.

William M. Olver P.E., President

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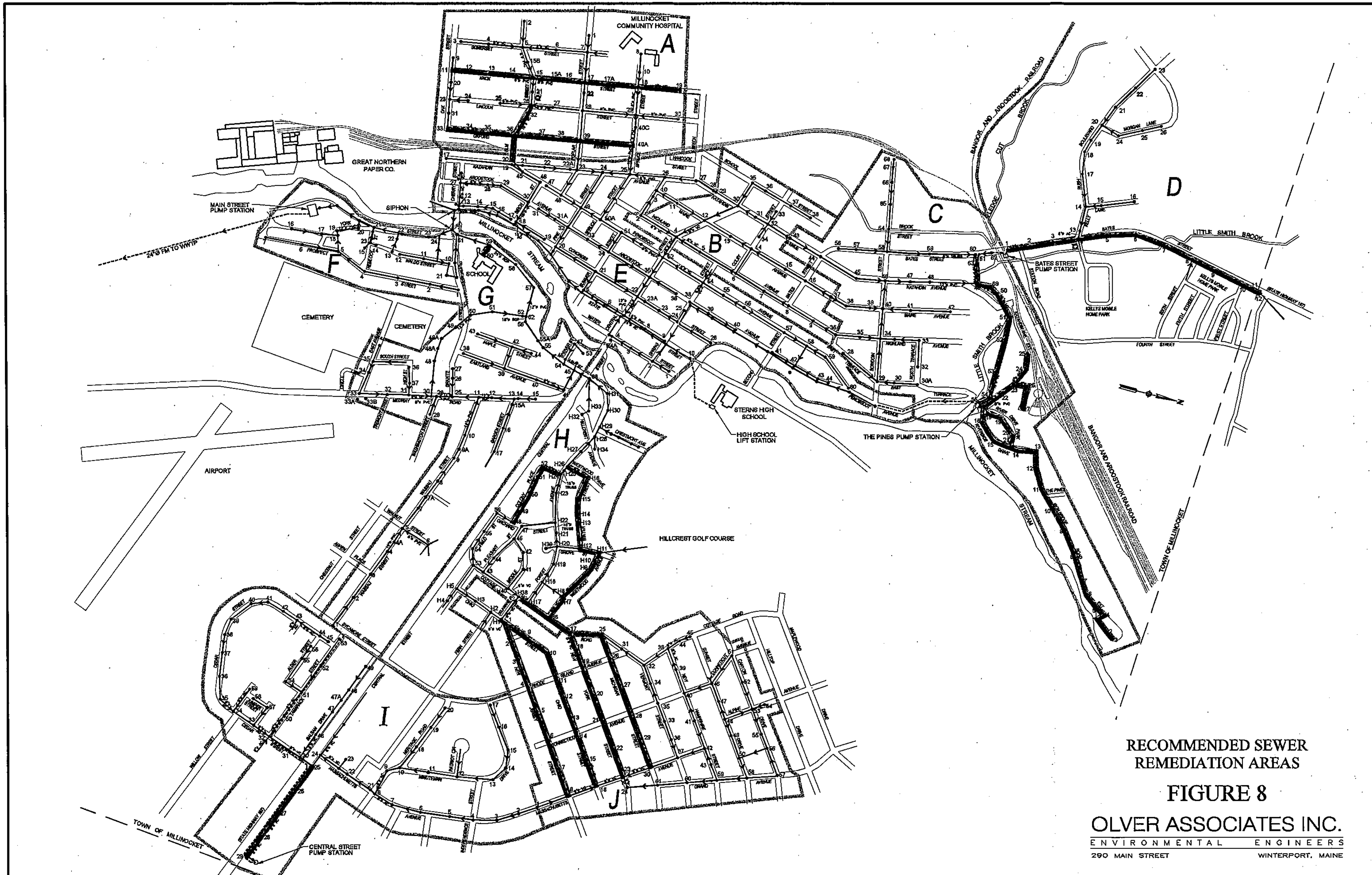

RECOMMENDED SEWER REMEDIATION AREAS

FIGURE 8

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APPENDIX A

ESTIMATED SEWER REMEDIATION COSTS

APPENDIX A.1 PRELIMINARY COST ESTIMATE FOR PINES AREA SEWER REMEDIATION
(KATAHDIN AVENUE EXTENSION, RIVERSIDE DRIVE, RIVER PARK DRIVE, IRON BRIDGE ROAD)

QUANTITY	DESCRIPTION/UNIT PRICE	ESTIMATE
LS	Traffic control @ $20,000/LS	$ 20,000
32 EA	Existing manhole removal @ $400/EA	13,000
4100 LF	8" Ø PVC sewer @ $90/LF	369,000
3200 LF	4" Ø PVC building sewers @ $65/LF	208,000
27 EA	4' Ø Sanitary manholes @ $3,200/EA	86,000
4600 LF	12" – 18" Ø SICPE drain @ $70/LF	308,000
58 EA	4' Ø Catchbasins @ $3,000/EA	174,000
LS	Roadway reconstruction @ $334,000/LS	334,000
2800 Tons	Roadway pavement @ $65/Ton	182,000
3700 SF	2" Trench insulation @ $2.00/SF	7,000
LS	Erosion control @ $13,000/LS	13,000
LS	Owner's testing allowance @ $9,000/LS	9,000
55 EA	Test pits @ $300/EA	17,000
LS	Loam and seed @ $31,000/LS	31,000
LS	General conditions @ $180,000/LS	180,000
	Subtotal	$ 1,951,000
	Ledge probings allowance	5,000
	Design allowance	50,000
	Inspection allowance	50,000
	Ledge removal allowance	50,000
	Sewer connection allowance	207,000
	Contingency allowance	181,000
	Estimate	$ 2,494,000
	(Rounded)	($2,495,000)

APPENDIX A.2 PRELIMINARY COST ESTIMATE FOR SMITH BROOK INTERCEPTOR SEWER REMEDIATION
(BATES STREET TO PENOBSCOT AVENUE)

QUANTITY	DESCRIPTION/UNIT PRICE		ESTIMATE
LS	Traffic control @ $5,000/LS	$	5,000
10 EA	Manhole removal @ $400/EA		4,000
2,000 LF	18" Ø PVC sewer @ $150/LF		300,000
12 EA	4' Ø Manholes @ $3,200/EA		39,000
30 Tons	4" Trench pavement @ $120/Ton		4,000
LS	Erosion control @ $10,000/LS		10,000
LS	Loam and seed @ $40,000/LS		40,000
2,000 SF	Trench insulation @ $2.00/SF		4,000
LS	Owner's testing allowance @ $2,000/LS		2,000
10 EA	Test pits @ $300/EA		3,000
LS	General conditions @ $40,000/LS		40,000
	Subtotal	$	451,000
	Television inspection allowance*		30,000
	Ledge probings allowance		5,000
	Design allowance		32,000
	Inspection allowance		36,000
	Ledge removal allowance		10,000
	Contingency allowance		45,000
	Estimate	$	609,000
	(Rounded)		($610,000)

(*Includes Millinocket Stream interceptors television inspection.)

APPENDIX A.3 PRELIMINARY COST ESTIMATE FOR GRANITE STREET SCHOOL SEWER REMEDIATION

QUANTITY	DESCRIPTION/UNIT PRICE	ESTIMATE	
LS	Traffic control @ $2,000/LS	$	2,000
4 EA	Manhole removal @ $400/EA		2,000
300 LF	8" Ø PVC sewer @ $90/LF		27,000
100 LF	6" Ø PVC building sewers @ $75/LF		8,000
4 EA	4' Ø Manholes @ $3,200/EA		13,000
100 Tons	4" Trench pavement @ $120/Ton		12,000
LS	Erosion control @ $5,000/LS		5,000
LS	Loam and seed @ $7,000/LS		7,000
500 SF	Trench insulation @ $2.00/SF		1,000
LS	Owner's testing allowance @ $1,000/LS		1,000
3 EA	Test pits @ $300/EA		1,000
LS	Roof drain/catch basin removal @ $50,000/LS		50,000
LS	General conditions @ $12,000/LS		12,000
	Subtotal	$	141,000
	Television inspection allowance		3,000
	Ledge probings allowance		1,000
	Design allowance		10,000
	Inspection allowance		12,000
	Ledge removal allowance		2,000
	Contingency allowance		14,000
	Estimate	$	183,000
	(Rounded)		($185,000)

APPENDIX A.4 PRELIMINARY COST ESTIMATE FOR STATES STREETS AREAS SEWER REMEDIATION
(NEW JERSEY STREET, OHIO STREET, NEW YORK STREET, MICHIGAN STREET)

QUANTITY	DESCRIPTION/UNIT PRICE	ESTIMATE
LS	Traffic control @ $40,000/LS	$ 40,000
35 EA	Manhole removal @ $400/EA	14,000
8,500 LF	8" Ø PVC sewer @ $90/LF	765,000
8,500 LF	4" Ø PVC building sewers @ $65/LF	553,000
40 EA	4' Ø Manholes @ $3,200/EA	128,000
3,200 Tons	4" Trench pavement @ $120/Ton	384,000
2,500 Tons	1 ½" Street overlay @ $65/Ton	163,000
LS	Erosion control @ $10,000/LS	10,000
LS	Loam and seed @ $40,000/LS	40,000
6,000 SF	Trench insulation @ $2.00/SF	12,000
LS	Owner's testing allowance @ $10,000/LS	10,000
200 EA	Test pits @ $300/EA	60,000
LS	General conditions @ $215,000/LS	215,000
	Subtotal	$ 2,394,000
	Television inspection allowance	25,000
	Ledge probings allowance	10,000
	Design allowance	170,000
	Inspection allowance	190,000
	Ledge removal allowance	50,000
	Contingency allowance	240,000
	Estimate	$ 3,079,000
	(Rounded)	($3,100,000)

APPENDIX A.5 PRELIMINARY COST ESTIMATE FOR BATES STREET SEWER REMEDIATION

QUANTITY	DESCRIPTION/UNIT PRICE		ESTIMATE
LS	Traffic control @ $15,000/LS	$	15,000
12 EA	Manhole removal @ $400/EA		5,000
3,500 LF	12" Ø PVC sewer @ $130/LF		5,000
1,000 LF	4" Ø PVC building sewers @ $65/LF		65,000
15 EA	4' Ø Manholes @ $3,200/EA		48,000
1,000 Tons	4" Trench pavement @ $120/Ton		120,000
1,300 Tons	1 ½" Street overlay @ $65/Ton		85,000
LS	Erosion control @ $5,000/LS		5,000
LS	Loam and seed @ $15,000/LS		15,000
5,000 SF	Trench insulation @ $2.00/SF		10,000
LS	Owner's testing allowance @ $3,000/LS		3,000
15 EA	Test pits @ $300/EA		5,000
LS	General conditions @ $40,000/LS		40,000
	Subtotal	$	421,000
	Television inspection allowance		10,000
	Ledge probings allowance		4,000
	Design allowance		30,000
	Inspection allowance		35,000
	Ledge removal allowance		20,000
	Contingency allowance		42,000
	Estimate	$	562,000
	(Rounded)		($560,000)

APPENDIX A.6 PRELIMINARY COST ESTIMATE FOR ELM STREET AREA SEWER REMEDIATION
(ELM STREET, OXFORD STREET, KNOX STREET)

QUANTITY	DESCRIPTION/UNIT PRICE	ESTIMATE
LS	Traffic control @ $20,000/LS	$ 20,000
25 EA	Manhole removal @ $400/EA	10,000
4,500 LF	8" Ø PVC sewer @ $90/LF	405,000
800 LF	12" Ø PVC sewer @ $130/LF	104,000
4,500 LF	4" Ø PVC building sewers @ $65/LF	293,000
25 EA	4' Ø Manholes @ $3,200/EA	80,000
1,700 Tons	4" Trench pavement @ $120/Ton	204,000
1,300 Tons	1 ½" Street overlay @ $65/Ton	85,000
LS	Erosion control @ $5,000/LS	5,000
LS	Loam and seed @ $20,000/LS	20,000
5,000 SF	Trench insulation @ $2.00/SF	10,000
LS	Owner's testing allowance @ $5,000/LS	5,000
100 EA	Test pits @ $300/EA	30,000
LS	General conditions @ $130,000/LS	130,000
	Subtotal	$ 1,401,000
	Television inspection allowance	15,000
	Ledge probings allowance	5,000
	Design allowance	100,000
	Inspection allowance	115,000
	Ledge removal allowance	25,000
	Railroad crossing allowance	50,000
	Contingency allowance	140,000
	Estimate	$ 1,851,000
	(Rounded)	($1,850,000)

APPENDIX A.7 PRELIMINARY COST ESTIMATE FOR CENTRAL STREET (EAST) SEWER REMEDIATION

QUANTITY	DESCRIPTION/UNIT PRICE		ESTIMATE
LS	Traffic control @ $25,000/LS	$	25,000
10 EA	Manhole removal @ $400/EA		4,000
1,400 LF	12" Ø PVC sewer @ $130/LF		182,000
1,000 LF	4" Ø PVC building sewers @ $65/LF		65,000
10 EA	4' Ø Manholes @ $3,200/EA		32,000
500 Tons	4" Trench pavement @ $120/Ton		60,000
600 Tons	1 ½" Street overlay @ $65/Ton		39,000
LS	Erosion control @ $2,000/LS		2,000
LS	Loam and seed @ $5,000/LS		5,000
500 SF	Trench insulation @ $2.00/SF		1,000
LS	Owner's testing allowance @ $2,000/LS		2,000
20 EA	Test pits @ $300/EA		6,000
LS	General conditions @ $40,000/LS		40,000
	Subtotal	$	463,000
	Television inspection allowance		5,000
	Ledge probings allowance		4,000
	Design allowance		32,000
	Inspection allowance		37,000
	Ledge removal allowance		10,000
	Contingency allowance		45,000
	Estimate	$	596,000
	(Rounded)		($600,000)

APPENDIX A.8 PRELIMINARY COST ESTIMATE FOR FOREST AVENUE AREA SEWER REMEDIATION
(WESTWOOD AVENUE, COLONY PLACE)

QUANTITY	DESCRIPTION/UNIT PRICE		ESTIMATE
LS	Traffic control @ $20,000/LS	$	20,000
20 EA	Manhole removal @ $400/EA		8,000
4,000 LF	8" Ø PVC sewer @ $90/LF		360,000
4,000 LF	4" Ø PVC building sewers @ $65/LF		260,000
20 EA	4' Ø Manholes @ $3,200/EA		64,000
1,500 Tons	4" Trench pavement @ $120/Ton		180,000
1,000 Tons	1 ½" Street overlay @ $65/Ton		65,000
LS	Erosion control @ $5,000/LS		5,000
LS	Loam and seed @ $20,000/LS		20,000
2,000 SF	Trench insulation @ $2.00/SF		8,000
LS	Owner's testing allowance @ $5,000/LS		5,000
100 EA	Test pits @ $300/EA		30,000
LS	General conditions @ $100,000/LS		100,000
	Subtotal	$	1,125,000
	Television inspection allowance		15,000
	Ledge probings allowance		5,000
	Design allowance		80,000
	Inspection allowance		90,000
	Ledge removal allowance		20,000
	Contingency allowance		115,000
	Estimate	$	1,450,000