OLVER ASSOCIATES INC.

ENVIRONMENTAL ENGINEERS

290 MAIN STREET WINTERPORT, MAINE

MASTER PLAN FOR LONG TERM INFRASTRUCTURE IMPROVEMENTS IN CASTINE VILLAGE

TOWN OF CASTINE, MAINE

SEPTEMBER, 2009

OLVER ASSOCIATES INC.

ENVIRONMENTAL ENGINEERS

September 21, 2009

Mr. Dale Abernethy, Town Manager
Castine Town Office
P.O. Box 204
Castine, Maine 04421

Dear Dale:

Enclosed for your review is a preliminary draft of a proposed Master Plan for long term infrastructure capital improvements in Castine village. The report evaluates the existing condition of the Town's roadway, drainage, sewerage and water distribution infrastructure. Where deficiencies are noted, proposed remediation projects are suggested. A preliminary rationale is included by which the Town can prioritize the scheduling of these repairs in order to phase them in over perhaps the next twenty years. This document is intended as a draft for discussion and to solicit input from the Town. After you have had the opportunity to review the report in detail, we will modify it to reflect your comments, the Selectmen's input, and also citizens' input from the upcoming Public Hearing. As you review the draft report, please call if you have any questions or if you need additional information. We are available to meet with you and the Selectmen at your convenience to discuss our recommendations in greater detail. As always, we appreciate this opportunity to be of continued professional engineering service to the Town of Castine.

STATE OF MAINE
WILLIAM M. OLVER No. 5246
LICENSED
PROFESSIONAL ENGINEER

Very truly yours,

OLVER ASSOCIATES INC.

William M. Olver P.E., President

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EXECUTIVE SUMMARY

The Town of Castine operates a public infrastructure in the village area that includes roadways, storm drains, sanitary sewers and water distribution mains. Many of the village roads are in poor condition with deteriorated pavement and inadequate drainage. Some of the buried water and sewer utility pipes are over 100 years old, structurally deficient, and in poor condition. Groundwater leakage and stormwater inflow occur into old 6"Ø clay sewers in parts of the village. Water lines that are as small as 2"Ø restrict fire flow capacities in other parts of the community.

Over the past few years, the Town has scheduled improvements to its water and sewer systems in response to EPA and DEP mandates related to water treatment and sewer system excess flow regulations. Some streets have been reconstructed at the same time. These repairs have not kept pace with the rate of deterioration of some of the infrastructure. The condition of some of the infrastructure components has deteriorated to the point that improvements will need to be made in the very near future before these systems fail. Going forward, the Town would like to develop a proactive Master Plan which allows it to address and phase in infrastructure improvements on a schedule that provides for their implementation in a cost-effective, timely manner. Olver Associates Inc. was retained by the Town to evaluate the condition of the Town's village infrastructure and to propose a rationale for the implementation of a Master Plan to gradually upgrade these systems.

Each of the four infrastructure components in Castine village were evaluated in detail. A program of soils borings was conducted in July, 2009 to analyze subsurface conditions below each roadway. The Town's Pavement Management Plan was updated in conjunction with S.W. Cole Engineering Inc.. The village's stormwater drainage systems were evaluated using an SCS Hydrocad model for various storm events. The in-place capacity of each storm drain in the village was compared to the capacity needed to meet the current design standard of passing a twenty-five year storm event. Infiltration/inflow studies of the sanitary sewer system were updated to determine areas of the village sewers where excess leakage and poor pipe structural conditions still exist. Previous detailed hydraulic analysis of the water system using the Dirigo Watercad model were reviewed to determine areas of deficient pipe sizes that restrict delivery pressure and fire flow capacity.

Based upon our detailed evaluation as defined in this report, it was noted that:

- One-third of the village's roadways are presently in poor condition with severe pavement deterioration, cracking and rutting. About ten percent of the roads are in very poor condition which implies that their pavement structure and roadbed is at or near complete structural failure. This is, in large part, due to inadequate gravel base below many roads combined with poor drainage systems.

- The lack of adequate drainage throughout the community is a problem in many areas of the village. One-third of the present drainage structures do not have sufficient capacity to convey a twenty-five year design storm. The lack of proper drainage has caused localized flooding in some areas and contributes to premature failure of adjacent roadway pavement surfaces.

- About twenty percent of the sanitary sewers in the village are constructed of 100-year old, 6”Ø clay pipe in poor structural condition. Some of these sewers are in danger of failing and are prone to excessive groundwater infiltration leakage.

- Sixty percent of the Town’s water distribution system utilizes pipes that are smaller in diameter than the current design standard of 8”Ø for fire flow. Fifteen percent of the system still utilizes small pipes that are over 100 years old and only 2”Ø to 4”Ø. This is the primary reason that some areas of the village have inadequate fire flow delivery capacities of only 250 to 550 GPM.

The village infrastructure evolved to its present condition over many decades and, in some areas, over the past century. It will take a significant capital expenditure and time to fully address these deficiencies in order to modernize the Town’s overall infrastructure. The purpose of this Master Plan is to provide the Town with a rationale approach to facilitate the prioritization of these repairs in a manner that allows these deficiencies to be corrected in a cost-effective and timely manner. The proposed rationale defined in this report is as follows:

- A few sections of roadway in Castine have been rated as being in very poor condition. This implies that the pavement and roadway structure has failed or is on the verge of failing. This can lead to safety issues for vehicular and pedestrian traffic. We would suggest that a high priority be placed on addressing those areas defined as being in very poor condition. If buried utilities in these very poor condition roadway areas are also present, the completion of utility projects should be done at the same time for the maximum benefit to the Town.

- The updated Pavement Management Plan suggested that several areas of newer roadway surfaces be protected by either crack sealing or a pavement overlay to extend their useful life. To the extent that no other utility improvement work will be constructed in those areas in the immediate future, we believe that it makes sense for the Town to initiate these proactive and protective measures early on in the planning process to preserve the condition of some of the roadways for as long as possible. In areas where the Pavement Management Plan has recommended crack sealing or an overlay from strictly a pavement perspective, we would recommend delaying those efforts if it appears likely that there will be other utility work needed on those same streets in the foreseeable future. In addition, we would place the extension of the wastewater treatment plant's outfall sewer as an early priority in the capital plan because it is almost certain that this will be mandated by DEP as the result of their new effluent dispersion toxicity regulations.

- We would then suggest focusing efforts on areas of the infrastructure that prioritize immediate roadway improvements concurrent with necessary water system fire flow and capacity issues. Several detailed hydraulic studies of the Castine water system have strongly recommended that a 12"Ø water main be extended from the reservoir to Battle Avenue, down Battle Avenue and then down Main Street. As noted in previous sections of this report, there are numerous other roadway, drainage and sewer system infrastructure needs along those same areas. Because of the water system's importance to the safety of the community, we recommend that a high priority be given to these types of projects which will also lay the foundation for future phased improvements to peripheral areas of the water system.

- Several streets in Castine are in poor condition and also have underlying inadequate water lines as small as 2"Ø below the streets. Some areas also have concurrent sewer system and drainage deficiencies. We suggest that these areas be considered next in establishing project priorities.

- Once the above high priority issues are addressed, the remaining areas of the Town's infrastructure can be considered based on the overall assessment of roadway conditions and utility improvement needs as discussed in this report.

Based upon the above rationale for prioritization, the following eighteen project area priorities and associated implementation costs, as described in detail in this report, are summarized as follows:

PRIORITY	PROJECT/AREA	TOTAL COST ($)	ROAD/ DRAIN COSTS ($)	SEWER COSTS ($)	WATER COSTS ($)
1.	Perkins St. (Battle to Madockawando)	850,000	535,000	99,000	216,000
2.	Wadsworth Cove Rd. (Battle to Beach)	400,000	400,000	-	-
3.	Miscellaneous Overlay/Crack Sealing	245,000	245,000	-	-
4.	Treatment Plant Outfall Extension	300,000	-	300,000	-
5.	Battle Avenue (Madockowando to Main)	760,000	465,000	-	295,000
6.	Main Street (Battle to Water)	1,915,000	1,051,000	435,000	429,000

PRIORITY	PROJECT/AREA	TOTAL COST ($)	ROAD/ DRAIN COSTS ($)	SEWER COSTS ($)	WATER COSTS ($)
7.	Court Street (Tarratine to Main)	1,070,000	646,000	212,000	212,000
8.	Latour Street (Battle to Perkins)	510,000	340,000	-	170,000
9.	Madockawando Road (Battle to Perkins)	495,000	300,000	-	195,000
10.	Water Street (Pleasant to Dyer)	540,000	373,000	-	167,000
11.	Dyer Street (Court to Water)	335,000	188,000	84,000	63,000
12.	State Street (Battle to Court)	355,000	185,000	25,000	145,000
13.	Perkins Street (Madockawando to Main)	1,920,000	1,136,000	227,000	557,000
14.	Stevens Street (Main to Pleasant)	100,000	100,000	-	-
15.	Water/Spring Street (Dyer to Court)	1,210,000	790,000	75,000	345,000
16.	Court Street (Pleasant to Spring)	1,715,000	1,255,000	-	460,000
17.	Pleasant Street (Battle to Water)	770,000	456,000	-	314,000
18.	Tarratine Street (Battle to Perkins)	535,000	425,000	-	110,000
	TOTALS	$14,025,000	$8,890,000	$1,457,000	$3,678,000

In order to address all of the infrastructure remediation needs defined in this report, we estimate that the Town would have to expend $14,025,000 in 2009 current dollars. These projects could be divided between general taxation for roadway and drainage system work, sewer use fees for sewer system work, and water user fees for water system improvements.

The priorities for infrastructure remediation presented in this draft plan are preliminary recommendations to facilitate additional discussion with the Town and to generate citizen input. After these additional discussions and input have been received, the initial Master Plan can be finalized. At that point, a funding strategy to meet the proposed schedule can be defined in more detail. In general, it is recommended that the Town extend this program over a period of perhaps twenty years in order to minimize disruption throughout the community during construction, in order to spread out the costs over a reasonable period, and to phase future projects on a life cycle that will not result in all future pavement useful life expiring at the same time.

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1. OVERVIEW OF CASTINE'S MUNICIPAL INFRASTRUCTURE ISSUES

The Town of Castine, like most Maine communities, is faced with the challenge of allocating its limited available financial resources to a multitude of concurrent infrastructure improvements needs. The Town's infrastructure includes roadways, drainage systems, sanitary sewers, and water distribution mains that provide essential services to the public. Many of these infrastructure components are old and outdated including water lines and sewers that were installed over a century ago. In addition, many of the Town's village roadways were designed without the proper gravel base and drainage systems that are needed to properly support the weight of modern vehicles. The Town faces a large backlog of roadway, drainage, sewer and water system improvement projects to gradually modernize its aged infrastructure.

To assist the Town in its long-term infrastructure improvements planning process, Olver Associates Inc. was retained in 2009 to prepare this Master Plan of capital improvements for Castine's village infrastructure. Each of the four infrastructure components were evaluated in detail and high priority improvement needs were identified. The objective of the study was to allow the Town to make long-term capital improvement decisions based upon a detailed assessment of where annual tax dollars and water and sewer user fees could be best spent to address the highest priority needs first. Over time, the Town hopes to develop an ongoing schedule of infrastructure improvements that will allow it to maintain all components of its infrastructure in optimal condition.

The Town maintains seventeen roadways in the village area that contain a combination of sanitary sewers, water mains, and drainage systems below each road. The "on-neck" area of the village is shown in Figure 1. This area contains about 39,900 linear feet (LF) of paved roadways. About seventy percent of these areas are served by about 27,400 LF of public sanitary sewers. A larger area representing about 32,700 LF, or about eighty percent, also contains public water distribution mains below the road. Some type of drainage is available along most of these roadways, although only 7700 LF, or just under twenty percent, contain closed pipe drainage systems. The remaining areas utilize open roadway ditches and occasional culverts or catchbasins under driveways to route stormwater runoff. Table 1 provides a general breakdown of the different utility lengths along each major village area roadway.

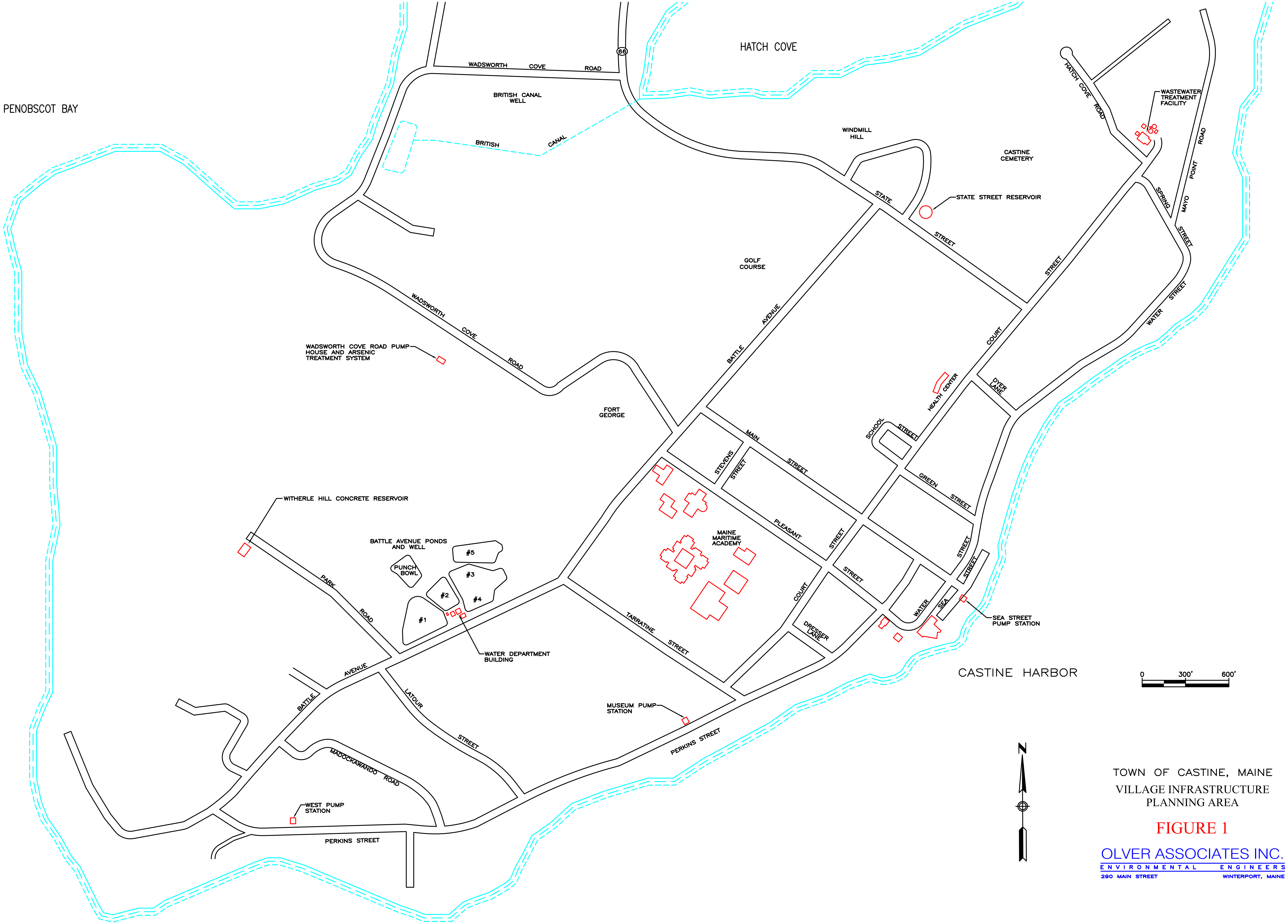

PENOBSCOT BAY
HATCH COVE
CASTINE HARBOR
WADSWORTH COVE ROAD
66
BRITISH CANAL WELL
BRITISH CANAL
WINDMILL HILL
CASTINE CEMETERY
HATCH COVE ROAD
WASTEWATER TREATMENT FACILITY
MAYO POINT ROAD
SPRING STREET
STATE STREET
STATE STREET RESERVOIR
GOLF COURSE
COURT STREET
WATER STREET
BATTLE AVENUE
WADSWORTH COVE ROAD PUMP HOUSE AND ARSENIC TREATMENT SYSTEM
FORT GEORGE
DYER LANE
HEALTH CENTER
SCHOOL STREET
MAIN STREET
STEVENS STREET
GREEN STREET
PLEASANT STREET
MAINE MARITIME ACADEMY
WITHERLE HILL CONCRETE RESERVOIR
BATTLE AVENUE PONDS AND WELL
PUNCH BOWL
#1
#2
#3
#4
#5
PARK ROAD
WATER DEPARTMENT BUILDING
TARRATINE STREET
COURT STREET
DRESSER LANE
SEA STREET
SEA STREET PUMP STATION
LATOUR STREET
MUSEUM PUMP STATION
PERKINS STREET
MADOCKAWANDO ROAD
WEST PUMP STATION
PERKINS STREET
0 300' 600'
N
TOWN OF CASTINE, MAINE
VILLAGE INFRASTRUCTURE PLANNING AREA
FIGURE 1
OLVER ASSOCIATES INC.
ENVIRONMENTAL ENGINEERS
290 MAIN STREET WINTERPORT, MAINE

TABLE 1: APPROXIMATE INVENTORY OF CASTINE VILLAGE INFRASTRUCTURE

LOCATION	ROADWAY (LF)	SANITARY SEWERS (LF)	WATER MAINS (LF)	PIPED DRAINAGE (LF)
Battle Avenue	7000	3400	5000	0
Court Street	4700	4200	4500	1100
Dresser Lane	400	400	400	400
Dyer Lane	400	400	0	200
Green Street	600	600	600	600
Latour Street	1500	1400	1500	0
Madockawando Road	1400	1000	1400	0
Main Street	2100	2000	2100	1600
Perkins Street	5200	5200	5200	200
Pleasant Street	2200	1900	1700	1600
School Street	600	400	600	400
Stevens Street	400	0	0	0
State Street	1200	700	1000	100
Spring Street	600	600	600	0
Tarratine Street	1500	1500	1500	1000
Wadsworth Cove Road	6100	400	2600	0
Water Street	4000	3300	4000	500
TOTALS	39,900	27,400	32,700	7700

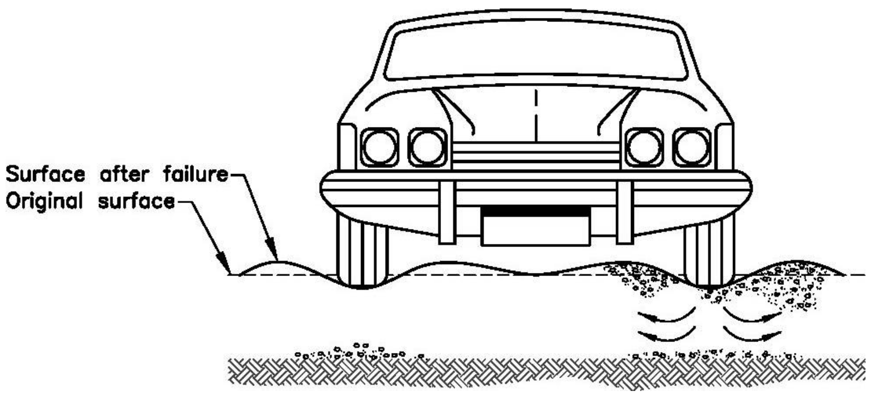
Castine's village roadways contain about 7.6 miles of paved road in varying conditions. Most of the soil subgrade below the village consists of saturated silt and clay soils that do not have the structural capacity to support vehicular wheel loadings. This has led to severe pavement deformation and rutting in many areas of the community as the result of inadequate gravel base below roads and also due to poor roadway drainage. In order to plan for Castine's long-term roadway maintenance and improvements, it is useful to briefly discuss the general considerations that are required for a roadway to maintain its structural stability.

The tires of a vehicle transmit the weight of the car or truck down to the underlying subgrade soils. Depending on the size of the vehicle, wheel loadings can represent tremendous applied stress to the soil as the vehicle passes overhead. Most native, in-place soils do not have sufficient structural capacity to support typical wheel loadings without failure. Signs of soil structural failure under applied loadings include rutting, pumping up of water or clay from under the traveled area, or loss of structural strength and stability. On a paved road, the pavement will also exhibit signs of sags and cracking.

Loadings from vehicular tires create downward forces that tend to push aside, deform, and rut native soils as shown in Figure 2. This is why fields and lawn areas are not able to withstand the heavy loadings of frequent vehicle traffic:

FIGURE 2:

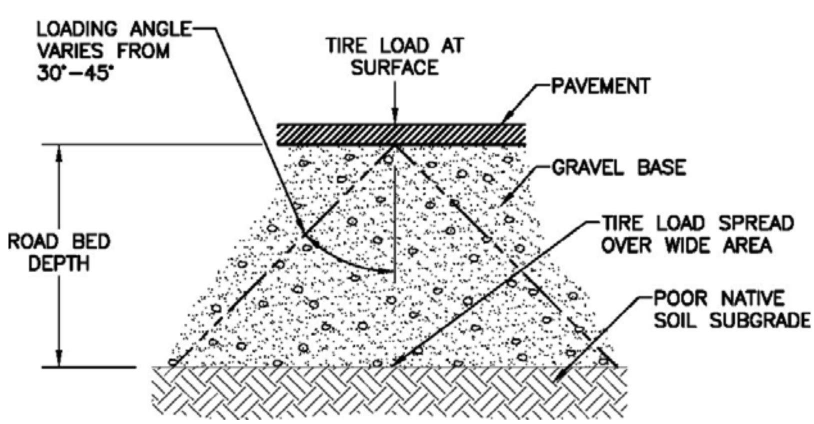
EFFECT OF TIRE LOADS ON NATIVE SOILS



Gravel road bases are placed over native soils to absorb the loading forces from vehicular traffic. Gravel materials, if properly sized, graded and compacted, contain discrete hard rock particles that lock together and form a strong, rigid structure. When loads are applied at the top of the gravel, the compacted gravel particles remain locked together instead of deforming and being pushed aside. The high point load at the bottom of each tire is dissipated as it passes down through the gravel layer. As the gravel gets deeper, the effective force applied by the tire is spread out in a triangular, conical shape. The most critical element of roadbed design from a gravel perspective is to make the gravel layer deep enough so that the wheel loadings from vehicles are fully dissipated before they reach the poor native soils layer below the roadbed. This effect is shown schematically in Figure 3:

FIGURE 3:

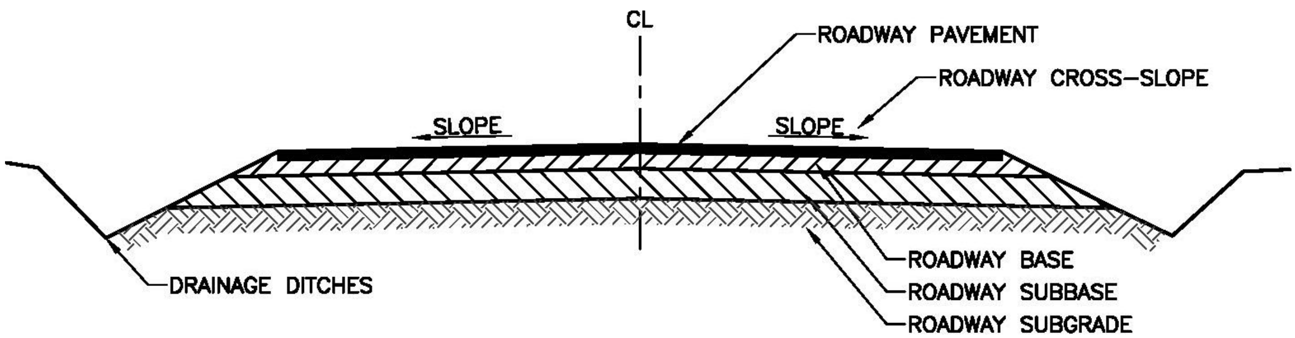
DISSIPATION OF WHEEL LOADINGS THROUGH GRAVEL LAYER



A well designed gravel roadbed has six distinct components that must all be in place, properly specified and properly constructed in order for the roadway to perform satisfactorily. These roadbed components are shown in Figure 4:

FIGURE 4:

TYPICAL ROADBED CROSS-SECTIONAL STRUCTURE



The roadway pavement provides structural stability to the surface of the road and facilitates smooth vehicular traffic flow. It also provides a protective impermeable barrier that sheds surface water to the sides of the roadway and prevents it from saturating the gravel below the road. The ability of the pavement to retain its structure without rutting, cracking, or deformation is depending upon the quality of the gravel below the road and on the adequacy of the drainage adjacent to the roadway.

If the gravel layer is sufficiently deep, the wheel loadings from a vehicle will be highest at the gravel's surface, but will dissipate to negligible amounts by the time they have traveled to the bottom of the roadbed. If the gravel layer is not deep enough, wheel loadings will not be fully dissipated as they pass through the roadbed. This has the effect of applying some of the wheel loading directly to the poor native soils below the road and causes the native soils to move, deform, and pump up fines. Over time, the failure of the native soils below the road will begin to show up at the roadway's surface in the form of rutting, potholes, and native silty clay material being pumped up from below the roadbed.

While the necessary depth of gravel roadbed can be calculated precisely depending on the exact level of expected wheel loadings, there have been general guidelines developed over time that will work satisfactorily in most cases. For the types of roadways in use in Castine, eighteen inches of gravel generally provides an acceptable road base. This is because the wheel loadings from typical vehicles can be effectively reduced to insignificant levels by the time that these forces have traveled through eighteen inches of good gravel.

Good drainage of surface water and groundwater is a critical element of successful roadway performance. Inadequate drainage is a common cause of most roadway and pavement failures. The strength and performance properties of soils and gravel are influenced more by moisture in the soil than by any other factor. The ability of a roadbed to withstand loadings is a function of the moisture content of the gravel. As the moisture content changes, the strength of the roadway also changes. The purpose of good roadway drainage is to control surface water at the top of the road as well as to control the moisture content of the gravel below the road.

Most of the moisture found in a well designed roadbed is attached directly to the surface of the individual gravel particles. Under well drained conditions, this water is minimal and does not hinder the direct content of soils particles with each other. This is critical because gravel gets its strength due to the compaction and interlocking that occurs between individual gravel particles. If a roadbed becomes saturated with excessive water, voids between individual gravel particles become filled with water. This prevents individual particles from adhering together in a tightly locked structure. When traffic drives over the road, some of the applied wheel loading is transmitted directly to the water; however, water has no strength to resist these loads. The result is that the tires will deform the road surface and rut the road. In addition, the saturated gravel performs like it is buoyant and no longer offers the same resistance to loadings as dry gravel. This allows some of the wheel loading to be transmitted down to the poor soils in the subgrade below the gravel base and subbase. This creates the same damaging effect that would occur if the gravel layer were thinner and eventually compromises the integrity of the roadbed.

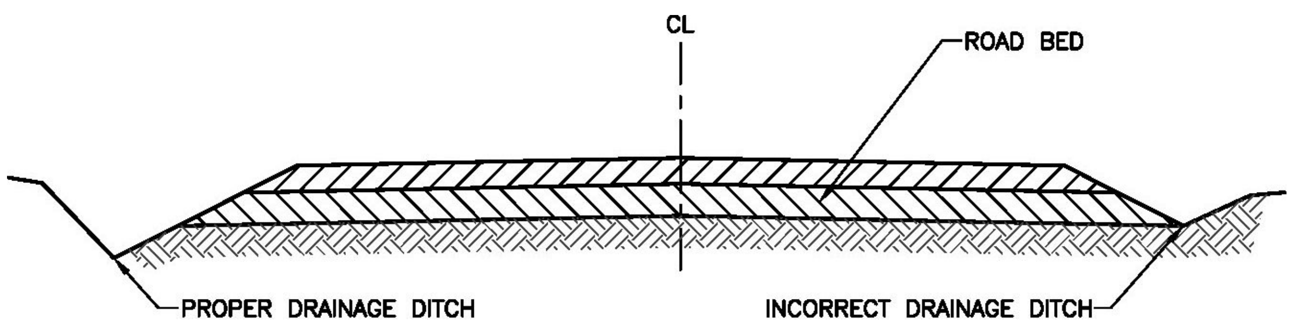
Saturated roadbeds are also much more prone to frost damage than dry soils. Well-drained soils do not have enough water content to form winter ice lenses; however, if water is allowed to saturate the roadbed, large pockets of ice will form from the water. When liquid water is frozen into solid ice, it expands into a greater volume. (This represents the same principle that causes glass bottles and copper pipes to burst if they become frozen.) Frozen conditions caused by water under the road result in the expansion of the roadbed over the winter. As the ice slowly melts in the Spring, it turns back into water and occupies a reduced volume below the roadbed. The result of this freezing and thawing cycle is that empty air voids are created in the road gravel as the ice melts. When a vehicle drives over the surface of the road, its wheel loading pushes down onto the air void and causes it to collapse. The movement of the expanded soil downward into the former ice void results in the creation of a rut or a pothole at the roadway surface. Significant roadway damage can be avoided by preventing water from building up and freezing below the road.

The objective of good roadway drainage design and construction is to keep water from collecting both on the roadway surface and under the roadbed. This is accomplished by providing proper cross-slopes across the road surface, by providing adequately sized culverts to allow water to pass under the road instead of getting absorbed into the road, and by providing underdrain, ditches, or catchbasins to collect surface water and drain the roadbed. The majority of roads in Castine now control water by using culverts and open ditches. Drainage control can also utilize catchbasins, underdrain, and curbing.

In order for a roadside ditch to work properly, the bottom of the ditch and the top surface of the water flowing in the ditch must be lower than the roadway gravel base and subbase. A common error made in ditch design and construction is to utilize shallow ditches that do not allow the roadbed to drain. The proper approach for ditch construction is shown below in Figure 5:

FIGURE 5:

PROPER DITCH CONFIGURATION



The leftside ditch configuration shown in Figure 5 allows water below the road to flow out of the gravel base and subbase and then to discharge into the lower ditch. If the right side ditch is constructed to be shallow such that its bottom is even with the road base, the roadway gravel will remain saturated as long as the ditch is full. During this time, the roadbed will lose much of its strength properties and will behave as a fluidized bed subject to deformation from wheel loadings. If local site considerations prevent deep ditches from being constructed, then closed drainage systems using pipes and catchbasins should be used.

The Town conducted an extensive analysis of roadway conditions in 2006 with S.W. Cole Engineering Inc. Based upon surface observations of each roadway, several sections were identified for future major reconstruction. These areas were found to be in poor condition based upon visual observations, pavement deformation patterns, surface rutting, and cracking conditions in each area. In the planning of reconstruction efforts for roads, the conservative cost estimating approach is to assume that new gravel will be needed below the pavement. It may be possible to reduce the costs of the gravel by reclaiming the existing road base below some areas if the gravel is found to be clean and available at a sufficient depth. Roadway reclamation involves grinding up the existing pavement and roadbed and using the material as future road base instead of installing new gravel. However, if the roadbed is too shallow or full of fine clay or silt materials, reclamation efforts will generally not be satisfactory. As part of this Master Planning process, borings of the soil conditions below target areas of each roadway were made to determine the quality of the gravel road base and to determine if specific roads are viable candidates for reclaiming.

Drainage below most roads in Castine appears to be poor. Only twenty percent of all roads presently have piped drainage systems and many of the eighty percent of the remaining roadways have poorly formed shallow ditches for surface runoff control. The presence of water around and below these roadways has saturated the gravel and reduced its effective life. As part of the proposed infrastructure capital plan, a review of the Town's drainage systems was conducted along each potential project area. This allowed recommendations to be made for future drainage improvements in order to extend the useful life of the road system.

In addition to potential roadway construction projects that the Town may need to implement, ongoing maintenance of all roadways will be essential in the future to extend their useful life. Periodic shoulder maintenance, pavement crack sealing, and occasional pavement overlays are important components of a long-term roadway maintenance plan. In this report, we will define an ongoing program to maintain the Town's roads as they now exist or after they are reconstructed in the future. The study also considers short-term and long-term capital cost needs for adjacent sidewalk and curbing in areas where these features are now present or where they may be added in the future.

Since the construction of the wastewater treatment plant in 1973, the Town of Castine has been addressing peak flow problems within its sanitary sewer system. Many of the upstream sewers to which the treatment plant was connected still utilize 6"Ø clay pipes with open joints. Some of these sewer lines are now well over 100 years old and are prone to excessive groundwater infiltration leakage as well as stormwater inflow after peak rainfall events. These flows historically created peak hydraulic surges at the downstream wastewater treatment plant that occasionally exceeded its original design capacity and resulted in effluent license violations. As part of the Town's long-term infrastructure plan, it is important to consider potential sewer system improvements below the roadways any time that a roadway project is undertaken.

The Town has conducted several studies in the past to identify deficient areas of its sewer system including major evaluations in 1979, 1983, 1994 and 2003. These studies all recommended the replacement or rehabilitation of many old leaking sewer sections. The Town has been actively working since then to slowly upgrade its sewer system. Much progress has been made. Previous projects have greatly reduced the volume of excess peak flows in the system. Last year, the Town also completed an upgrade of its nearly forty-year old wastewater treatment plant which included an expansion of the facility's peak flow capacity. At the present time, the treatment plant has sufficient hydraulic capacity to process typical peak flows that are present in the sewer system. This should protect the Town from future DEP enforcement action and allow all subsequent sewer replacement work to be conducted on a schedule decided by the Town rather than by regulatory enforcement action as has been the case in the past. The general criteria that should be used to define future sewer rehabilitation projects is the age and condition of the pipes below each roadway area in addition to removing any remaining residual leakage that may be present in these lines. Several remaining sewer system areas have been identified for future consideration. These areas all have old 6”Ø clay lines in place or have been identified as still having excessive leakage from groundwater or stormwater sources during the Town’s previous studies.

The Town has also conducted several evaluations of its water distribution system over the past few years. Many areas of the village are still served by old, cast iron water pipes, some of which are very small in diameter and well over 100 years old. This has created areas of poor water pressure throughout the community. Some areas also have inadequate pipe capacity to provide sufficient fire flow water delivery. In general, the minimum water main size that is now considered acceptable for fire flow is an 8”Ø pipe. The Town still has several areas of its water distribution system that are considered deficient by this criteria.

The above discussion suggests that many areas of the village have common infrastructure deficiencies in multiple components. Several areas may have concurrent deficiencies in their roadway, drainage, sanitary sewer, and water supply infrastructure. This is an important consideration when scheduling capital improvement projects in these areas. Roadway work should be delayed on these streets until deficiencies in the buried drainage, water and sewer infrastructure are first addressed.

This capital improvement Master Plan will review all components of the village infrastructure in order to develop a potential list of future projects for consideration by the Town. Each project will be prioritized in order to develop a program of phased improvements that the Town can consider over perhaps the next twenty years.

Once initial capital costs for each project have been prepared in current dollars, they can easily be indexed in the future to maintain updated cost estimates. The Town has expressed a desire to sequence future work such that the cost of any required improvement can be leveled out to a uniform annual debt service for inclusion in the Town’s yearly budgets. In addition, the Town should sequence future project schedules so that each potential project can be designed and bid to general contractors prior to each annual Town Meeting. This will allow voters at the Town Meeting to have specific budgets before them as they consider whether to approve each project.

2. CASTINE'S VILLAGE ROADWAY INFRASTRUCTURE NEEDS

Like most municipalities, the Town of Castine must continually allocate a portion of its financial resources to the maintenance and reconstruction of its roads. Seventeen streets within the village area provide the primary mode of transportation to access the State highways that link Castine to the rest of the world. The Town streets also provide passage to private residences, commercial and industrial properties, as well as to Maine Maritime Academy. Castine is also a destination community for tourists throughout the year and the Town's streets serve as pedestrian routes for both residents and visitors alike.

In general, the public's primary concern for roads is that their surfaces appear smooth and allow for the smooth and comfortable passage of their vehicles. As long as these conditions are met, the public generally has little regard for the state of the road base below the pavement. This perspective results in many communities focusing their limited highway funds on the periodic installation of pavement overlay in order to keep their roadways smooth. Often, these pavement overlays are kept relatively thin in order to spread the limited pavement funds as far as possible. While this approach satisfies the public's immediate demand for smooth roads, it often provides only short-term satisfaction. Unless the roadway structure and drainage systems below the pavement are properly addressed, the life cycle of a pavement overlay project will be limited.

As discussed, an overall roadway system is a combination of several critical factors including:

- Adequate, well compacted pavement depth to support wheel loadings.
- Proper crown and cross slopes of the pavement to shed water off the road surface.
- Adequate well drained granular gravel base and subbase below the pavement to dissipate the wheel loadings such that when they reach the poor soil below the base, their pressure in pounds per square inch will be reduced to minimal levels. (Generally, at least eighteen inches of well graded gravel is required to dissipate normal wheel loadings.)
- Sufficient drainage systems must be in place to remove water from the road base to minimize frost action and to provide the greatest structural strength between interlocked gravel particles.

Ideally, all roads in Castine would have at least three to four inches of well compacted pavement over at least an eighteen inch gravel base and subbase. Ditches, culverts and catchbasins would be available along all roads to carry water away from the road base such that the gravel would never become saturated and no ponding of runoff would occur on the roadway surfaces. These conditions could be achieved if the Town elected to reconstruct all of its roads to meet current design standards. However, such an approach would likely be cost-prohibitive and extremely disruptive to the community. As with other municipalities that own similar old road systems, Castine is forced to make decisions based upon the financial realities associated with maintaining its village infrastructure.

The Town would like to implement a long-term capital plan that will allow the phasing of roadway improvements over time. Once established, such a plan would allow each road to be reconstructed or overlain at about the same time that the previous repairs had reached their expected useful life. This would allow all roadways to always remain in optimal condition throughout the Town. Since this has not been done in the past, the current challenge that faces Castine is to develop the initial rotation of which roads to address first and then to establish an ongoing program for prioritized repairs based on relative need.

In considering how best to proceed, the Town has several approaches that should be considered as follows:

- Some of Castine's roadways likely have insufficient pavement placed over insufficient road base gravel. This allows wheel loadings to reach the underlying poor native clay soils without being fully dissipated. Over time, the underlying soils, which have no resistance to wheel loading, will be rutted, deformed and pumped up to contaminate the overlying gravel. If sufficient drainage is not available, water will also be present below the roadway resulting in accelerated rutting and deformation, excessive frost action and the rapid cracking and deterioration of the upper pavement surface. Roadways that are currently in this condition should be considered as candidates for their eventual full reconstruction. This type of project would require that the old road base material be excavated, that new gravel base and subbase be installed and that new pavement be placed over the gravel. Adequate drainage systems would need to be installed at the same time to prolong the life of the roadway.

- Some of Castine's roadways may not meet current design standards, but may have sufficient good gravel in place to allow some of it to be reclaimed and reused. When roadways are reclaimed, the existing pavement surface and some available depth of good gravel below the pavement are ground up and homogenized. If this material is relatively free from clay and silt particles, it can serve as all or part of the subbase gravel layer below the road. The advantage of this approach is that existing materials will be recycled, the Town does not need to expend its funds on the disposal of old asphalt and gravel materials, and less new gravel materials need to be purchased. The only real disadvantage to this approach is that sometimes communities reclaim roadways as a cost-savings measure without considering that the materials below the road are contaminated and inadequate for reuse. If an existing road contains a mixture of good pavement stratified over prior cold mix layers, or if the underlying gravel is a thin layer of material, or if it is full of clay and silt contamination, the long-term results obtained from road reclamation may not be satisfactory. Castine should consider this approach only on roads that have a reasonable depth of good material in place based upon an analysis of soil test borings. Drainage issues still need to be addressed for any roadway that is reclaimed instead of being fully rebuilt.

- In some cases, existing roads may be in good structural condition with adequate drainage systems available. The Town should prolong the useful life of these roads by enacting ongoing maintenance measures such as periodic crack sealing to prevent water from entering and saturating the road base. As the pavement surface deteriorates over time, roads with inadequate gravel base structure are good candidates for the occasional overlay of the pavement surface, perhaps at a ten to fifteen year cycle. In some areas where adequate roadway gravel and drainage are present, periodic pavement overlays remain an effective use of the Town's annual roadway maintenance funds.

To develop cost estimates for roadway improvement planning, the most conservative approach is to assume that all roads may eventually need to be fully reconstructed. This may result in high cost estimates for projects, but is often done because the extensive soils data completed to make final roadway scope decisions is not normally available at the planning stage. Detailed soils borings to explore the subsurface conditions below the pavement are costly and are typically done at 100 foot intervals during the final design of a project. In order to develop a general understanding of the overall soil conditions below Castine's roads, a limited soils boring program was conducted by S.W. Cole Engineering during the summer of 2009. Borings were conducted at approximately 500 foot intervals throughout the village and were analyzed to determine material composition, material quality, material depth, particle size, and drainage characteristics. On this basis, the general condition of each roadway area was assessed in order to allow recommendations for their future repair and maintenance to be made.

The Town originally retained S.W. Cole Engineering in 2006 to develop a Pavement Management Plan that would provide recommendations for road maintenance in Castine over a three year period. Since the original plan was published, major reconstruction work was needed on Green Street and Dresser Lane. Aside from some minor ditching and patching work that has been completed elsewhere in the Town since then, very little road maintenance has occurred since the original plan was prepared. In 2006, the overall condition of Castine's roads was given an average rating score of 72 which is classified as being in fair condition overall. Applying the same rating system in the 2009 update, the current overall average roadway condition rating has decreased to 66 which implies that many roads have deteriorated over the past three years and are now classified as being in fair to poor condition. Further deterioration will occur if proactive measures are not taken to address the road conditions.

The 2006 road maintenance plan was based primarily on visual observations. The current 2009 plan has had the benefit of preliminary test boring data that was collected throughout the village. Table 2 provides a general summary of the data obtained from those roadway soil borings:

TABLE 2: SUMMARY OF 2009 ROADWAY SOIL BORINGS

STREET/LOCATION	PAVEMENT DEPTH (IN.)	PAVEMENT CONDITION	COLD MIX LAYER (IN.)	BASE DEPTH (IN.)	SUBBASE DEPTH (IN.)	SUBBASE COMMENTS
1. BATTLE AVENUE						
Perkins to Madockawando	3”	Very Good	-	6”	12”	Well graded
Madockawando to Latour	2.5”	Poor	5.5”	6”	9”	Silt/Clay
Latour to Tarratine	2.5”	Poor	5.5”	5”	8”	Silt/Clay
Tarratine to Pleasant	5”	Poor	-	6”	6”	Sand/Silt
Pleasant to Main	4”	Poor	1.5”	4”	12”	Sand/Gravel
2. COURT STREET						
Tarratine to Dresser	2”	Poor	1.5”	2”	11”	Silt/Sand/Gravel
Dresser to Pleasant	2”	Poor	2”	3”	6”	Silt/Sand/Gravel
Pleasant to Green	2”	Fair/Poor	2”	5”	5”	Silt/Sand/Gravel
Green to State	1.25”	Fair	4”	7”	7”	Silt/Sand/Gravel
State to Spring	1.5”	Fair	2.5”	6”	7”	Silt/Sand/Gravel
3. DRESSER LANE						
Court to Perkins	4”	Very Good	-	6”	12”	Well graded
4. DYER LANE						
Court to Water	1.25”	Poor	3”	2”	2”	Silt/Sand/Gravel
5. GREEN STREET						
Court to Water	4”	Very Good	-	6”	12”	Well graded
6. LATOUR STREET						
Battle to Midpoint	1.9”	Poor	-	6”	0”	Reclaimed
Midpoint to Perkins	2.75”	Poor	-	6”	6”	Reclaimed

STREET/LOCATION	PAVEMENT DEPTH (IN.)	PAVEMENT CONDITION	COLD MIX LAYER (IN.)	BASE DEPTH (IN.)	SUBBASE DEPTH (IN.)	SUBBASE COMMENTS
7. MADOCKAWANDO ROAD						
Battle to Midpoint	1.75”	Fair	-	6”	6”	Gravel/Silt/Sand
Midpoint Area	1”	Fair	-	6”	17”	Gravel/Sand/Silt
Midpoint to Perkins	1.5”	Fair/Poor	-	6”	18”	Gravel/Sand
8. MAIN STREET						
Battle to Stevens	3.5”	Very Good	-	6.5”	13”	Reclaimed
Stevens to Court	4”	Good/Very Good	-	6”	11”	Gravel/Silt/Sand
Court to Water	5”	Fair	-	3”	9”	Gravel/Silt/Sand
9. PERKINS STREET						
Battle to Madockawando	2.75”	Very Poor	2.5”	2”	2”	Gravel/Sand/Silt
Madockawando to Latour	2”	Good/Fair	2.5”	6”	12”	Clay/Silt
Latour to Tarratine	3.4”	Good	1”	6”	10”	Gravel/Sand/Silt
Tarratine to Dresser	4.3”	Good	1.75”	3”	7”	Gravel/Sand/Silt
Dresser to Pleasant	4”	Good	1”	5”	5”	Gravel/Sand/Silt
Pleasant to Main	2.25”	Fair	-	6”	6”	Gravel/Sand/Silt
10. PLEASANT STREET						
Battle to Stevens	3”	Good	-	4”	13”	Reclaimed
Stevens to Court	3.5”	Good/Fair	-	6”	10”	Silty gravel
Court to Perkins	2”	Good/Fair	-	9”	19”	Gravel/Silt/Sand
11. SCHOOL STREET						
Court to Court	3”	Very Good	-	6”	12”	Well graded
12. SPRING STREET						
Court to Water	3”	Very Good		-	10”	10” Reclaimed
13. STATE STREET						
Battle to Midpoint	2.4”	Poor	-	8”	6”	Reclaimed
Midpoint to Court	1.9”	Poor	-	8”	7”	Reclaimed
14. STEVENS STREET						
Main to Pleasant	-	Poor	-	-	-	Not probed

STREET/LOCATION	PAVEMENT DEPTH (IN.)	PAVEMENT CONDITION	COLD MIX LAYER (IN.)	BASE DEPTH (IN.)	SUBBASE DEPTH (IN.)	SUBBASE COMMENTS
15. TARRATINE STREET						
Battle to Midpoint	3.4”	Good/Very Good	-	8.5”	10”	Reclaimed
Midpoint to Perkins	3.75”	Very Good	-	8”	3”	Reclaimed
16. WADSWORTH COVE ROAD						
Battle to Pump House	2.5”	Poor	-	3”	4”	Gravel/Sand/Silt
Pump House Along Beach	4”	Very Poor	-	4”	6.5”	Gravel/Sand/Silt
Beach to Route 166	4.5”	Very Good	-	4”	7”	Gravel/Sand/Silt
17. WATER STREET						
Perkins to Main	2.25”	Fair	-	7”	0”	Reclaimed
Main to Dyer	3.5”	Very Good	-	5.5”	6”	Reclaimed
Dyer to Spring	3.25”	Very Good	-	8.5”	5”	Reclaimed

The data presented in Table 2 shows a wide range of existing conditions over the sixteen Castine roadways upon which borings were connected for this study. Due to the short length of Stevens Street, no borings were conducted on that roadway. Several observations can be made as follows:

- Existing pavement conditions varied from Very Poor to Very Good. The better pavement areas were often associated with streets that have had recent reconstruction work or overlays as would be expected.

- Pavement thickness varied from as little as 1” to as much as 5”. In general, current design standards call for at least 4” of pavement for the type of vehicular use expected in Castine village. This would consist of a 2 ½” binder layer covered by a 1 ½” surface layer. Streets with less than 4” of pavement will have shorter pavement lives. The thickness of thinly paved areas can be increased with an overlay provided that the base and subbase gravel below the pavement are adequate.

- Some of the test borings showed that new hot mix pavement has been placed over older layers of cold mix (Macadam) pavement. The cold mix layer is often poorly compacted and prone to disintegration during the reclamation process. This may result in an increased level of silt and fines in the reclaimed mixture which might make it unsuitable for reclaiming. In general, whether the road’s base or subbase is reclaimed or consists of new material, it is preferable to not allow the fines in the material to exceed five percent of the total volume. If excess fines are present, the drainage and strength capacity of the roadway will be diminished and the useful life of the roadway pavement will be shortened.

- New roads for this service class are generally constructed with 18” of gravel consisting of a 6” layer of select aggregate base over a 12” layer of gravel subbase material. It is important that this material be well drained and compacted to provide the longest useful life of the overlying pavement. If a roadway is to be reclaimed, we generally recommend that the total depth of adequate reclaimed material be supplemented by new gravel as needed to create a total thickness of 18”. As discussed, roadways with less than 18” of supporting gravel below the pavement may not fully dissipate the wheel loadings from overhead traffic onto the poor quality clay subgrade below the road. If excessive loads are applied onto the clay surface, they may deform and rut the subgrade causing poor quality materials to be pumped up into the road bed. Over time, this will lead to saturated subbase conditions, frost action, pavement deterioration and rutting of the roadway surface. Given these design standards, the Table 2 data shows that Castine’s roads have a wide mixture of base and subbase depths. Roadway base thicknesses vary from as little as 2” to as much as 9”. Road subbase thicknesses vary from as little as 0” to as much as 19”. In areas with no subbase, it appears that the old road was previously reclaimed and no new material was added. This created a single layer of base/subbase that consisted of reclaimed material. The newer road projects in Castine all have been installed with an 18” road base/subbase while many older areas have less than 4” to 7” of total gravel depth below their pavement.

On the basis of the typical design standards used to evaluate roadways and upon a review of the soils data presented in Table 2, the following observations and comments are made for each of the seventeen roadway areas in the village:

1) <u>BATTLE AVENUE</u> from Perkins Street to Madockawando Road has pavement that is in very good condition. This section of road was fully rebuilt about twelve years ago with 3” of new pavement placed over 18” of gravel base/subbase. Given the age of the pavement, it would be a good candidate for crack sealing to prolong its useful life. The remainder of the pavement from Madockawando Road to Main Street is in poor condition with significant areas of rutting and cracking. The pavement thickness varies from 2.5” to 5” along this area. Some sections have a 1.5” to 5.5” layer of cold mix down below the hot mix pavement. The road base and subbase varies in thickness from 12” to 16”and consists of gravel with high levels of clay and silt particles. Given the thickness of the base, subbase and hot mix between Tarratine Street and Main Street, it might be possible to reclaim this section. However, due to the combination of thin hot mix, thick cold mix, and relatively thin base/subbase gravel with a high clay/silt content, the section of Battle Avenue between

Madockawando Road and Tarratine Street would be a better candidate for long-term reconstruction instead of reclaiming. Additional soils borings should be conducted during the final design stages to quantify soil conditions in greater detail.

2) <u>COURT STREET</u> has pavement rated as poor between Tarratine Street and Pleasant Street, fair to poor in the Green Street area, and then from Green Street to Spring Street, it is rated as being fair. The surface layer of hot mix was thin at only 1.25" to 2" along this entire street versus a recommended thickness of 4". However, there is a cold mix layer below the pavement that varies from 1.5" to 2" near Tarratine Street and up to 2.5" to 4" in the Green to Spring Street areas. The road's base and subbase is generally constructed of gravel with a high silt/sand content with a total thickness of 9" to 13" at the Tarratine Street end and of 13" to 14" at the Spring Street end. The thicker total layers of pavement, hot mix and cold mix at the Spring Street side may explain, in part, why the pavement in that area is in slightly better condition than nearer to Tarratine Street. Drainage may also be better at the Spring Street side as the street approaches the Town's wellfield. Given the poor condition of Court Street between Tarratine Street and Green Street, this area would be a good candidate for an eventual full reconstruction project. Additional useful life of the pavement between Green Street and Spring Street could easily be achieved if this section of roadway were crack sealed and then overlaid in the near future.

3) <u>DRESSER LANE</u> was rebuilt several years ago with 4" of pavement and 18" of base/subbase. Its pavement surface is in very good condition. No work is needed on this street at the present time or in the near future.

4) <u>DYER LANE</u> has pavement in poor condition with significant cracking and allegatoring of the surface. This is likely because the road only has 1.25" of hot mix placed over 3" of old cold mix pavement. The total road base has only 4" of gravel and this material has a high level of silt and sand throughout its structure. Dyer Lane would be a good candidate for a future full reconstruction project.

5) <u>GREEN STREET</u> was rebuilt several years ago with 4" of pavement and 18" of base/subbase. Its paved surface is in very good condition. No work is needed on this street at the present time or in the near future.

6) <u>LATOUR STREET</u> has pavement that is cracked, deformed and in poor condition. The pavement thickness was found to vary from 1.9" to 2.75". It appears that parts of the road were reclaimed prior to the placement of the surface pavement. The total thickness of reclaimed material varied from 6" up near Battle Avenue to about 12" down near Perkins Street. Given the thin layer of pavement and gravel on this street and given the fact that the gravel was reclaimed once in the past, Latour Street is a

good candidate for future full reconstruction in order to provide an adequate gravel base along the entire road.

7) MADOCKAWANDO ROAD has a pavement thickness of 1” to 1.75” along its length. The pavement is currently rated as being in fair condition, but is on the borderline of being poor. It can be expected to deteriorate rapidly over the next few years given its shallow depth. There appears to be relatively thick layers of base/subbase below the road that ranges in thickness from 12” to 24”. This has likely improved the drainage below the road and allowed the pavement to last somewhat longer than that on the adjacent Latour Street. Given the apparent depth of gravel on this street, Madockawando Road may be a good candidate for future reclamation. Additional soils borings should be conducted during the final design stage to verify field conditions in greater detail.

8) MAIN STREET has pavement that is in good to very good condition at the Battle Avenue side and in fair condition approaching Water Street. The hot mix pavement thickness varies from 3.5” to 5”. The road base near Battle Avenue appears to have been reclaimed with 19” of gravel while the total gravel depth is reduced to about 12” near Water Street. The pavement at the upper end of Main Street could have its useful life extended if it was cracked sealed in the near future. The lower end of the street could be a reasonable candidate for crack sealing and then a pavement overlay in the near future.

9) PERKINS STREET between Battle Avenue and Madockawando Road has pavement in very poor condition and represents one of the worst road areas in the village. The surface pavement consists of a 2.75” layer of hot mix that was placed over a 2.5” layer of old cold mix. The total road base in this area is only 4” thick which provides inadequate support for vehicular loadings. This area has also had drainage problems in the past that contribute to the extremely deteriorated roadway surface. The Perkins Street section between Battle Avenue and Madockawando Road should be fully reconstructed in the near future. The pavement along Perkins Street from Madockawando Road to Pleasant Street is in good condition. There is a short section in fair condition between Pleasant Street and Main Street. The hot mix pavement along this route varies from 2” to 4” in thickness. Areas of cold mix are present below the pavement at thicknesses of 1” to 2.5”. Total gravel thickness varies from 10” to 18”. The useful life of this road surface may be extended if the Town conducts crack sealing in the near future. Some short areas of pavement, such as between Tarratine Street and Dresser Lane, would also benefit from a pavement overlay as well.

10) PLEASANT STREET has a pavement thickness of 2” to 3.5” and was rated to be in good to fair condition. The gravel base below the pavement has a thickness that

ranges from 17” to 28” inches. This pavement area is likely in relatively good condition compared to other streets because substantial utility work and roadway upgrades were conducted about fifteen years ago. Compaction of the gravel in some areas may have been less than optimal and cracks have developed in some areas. The useful life of this street could be extended if an overlay of the pavement was completed in the next few years. The work could be divided into two separate projects, if necessary, with half of the street paved each time.

11) SCHOOL STREET was rebuilt about fourteen years ago with 3” of pavement over 18” of gravel base/subbase. Its surface remains in very good condition. It would be a good candidate for a crack seal project in the next few years.

12) SPRING STREET has a 3” pavement surface that was found to be in good condition. There appears to be 20” of reclaimed gravel base and subbase below the road in this area. This section of roadway would be a good candidate for crack sealing in the near future to prolong its useful life.

13) STATE STREET was found to be in poor condition. The present pavement surface varies from 1.9” to 2.4” and was constructed over a reclaimed gravel base that varies from 14” to 15”. Because the pavement is in poor condition, it is possible that the reclaimed material was poorly graded or poorly compacted when it was installed. Due to the potential presence of silt and fines in the road base, it is not recommended to reclaim this material that has previously been reclaimed. This roadway should be scheduled for full reconstruction at some point in the future.

14) STEVENS STREET was found to be in very poor condition with significant potholes and rutting. The surface pavement appears to be heavily deteriorated from standing water. The gravel base below the road is believed to be of poor quality. This road is a good candidate for full reconstruction.

15) TARRATINE STREET was found to have pavement in good to very good condition. The pavement depth varied from 3.4” to 3.75” over a gravel road base that ranged from 11” to 18.5”. The base material appears to have been reclaimed in the past. The entire roadway should be crack sealed in the near future to extend its useful life for as long as possible.

16) WADSWORTH COVE ROAD was found to have pavement that varied from being very poor to very good condition. The road essentially forms three segments extending from Battle Avenue along the beach and then back to Route 166. The first side between Battle Avenue and the Wadsworth Cove Pump House is in poor condition with 2.5” of pavement over 7” of road base. Because of the steep slope and excellent drainage in this area, it may be possible to delay repairs in this section

by overlaying the pavement. The second section of roadway runs from the pump house and along the beach area. Pavement in this area is 4” thick and is in very poor condition. There is about 10.5” of gravel base in this area, but it appears to be of very poor quality. The cracking and rutting of pavement near the beach is one of the worst sections of road in Castine. This road should be completely reconstructed with new gravel. The final leg of the road extends from the beach area back out to Route 166. There is presently 4.5” of pavement over an 11” base/subbase. No immediate repairs are needed on this roadway.

17) WATER STREET was found to be in fair condition between Perkins Street and Main Street and in very good condition between Main Street and Spring Street. The first section of roadway near Perkins Street consists of a 2.25” layer of pavement over 7” of reclaimed gravel. The longer road section between Main Street and Spring Street has a pavement thickness that varies from 3.25” to 3.5” over a road base that varies from 11.5” to 13.5”. The short roadway section between Perkins Street and Main Street appears to have only a binder layer placed over a shallow reclaimed base. It would be a good candidate for pavement overlay to provide a thicker pavement depth. The roadway section between Main Street and Spring Street should be crack sealed at some point in the near future to extend its useful life.

The above discussion presents general recommendations for the repair or maintenance of Castine’s village roads based upon their condition as they existed in July, 2009. Periodic reviews of road conditions and updates to the Town’s Pavement Management Plan will allow recommendations to be modified in future years in response to changing field conditions. The above discussion can be summarized as shown below on Table 3:

TABLE 3: SUMMARY OF INITIAL ROADWAY REMEDIATION RECOMMENDATIONS

PROPOSED ACTION	ROADWAY AREA
1. Complete reconstruction required	Battle Avenue (Madockawando to Tarratine) Court Street (Tarratine to Green) Dyer Lane (Court to Water) Latour Street (Battle to Perkins) Perkins Street (Battle to Madockawando) State Street (Battle to Court) Stevens Street (Pleasant to Main) Wadsworth Cove Road (Pump House along beach)

PROPOSED ACTION	ROADWAY AREA
2. Potential reclaiming recommended	Battle Avenue (Tarratine to Main) Madockawando Road (Battle to Perkins)
3. Overlay recommended	Court Street (Green to Spring) Main Street (Court to Water) Pleasant Street (Battle to Perkins) Perkins Street (Tarratine to Main) Water Street (Perkins to Main)
4. Crack seal	Battle Avenue (Perkins to Madockawando) Main Street (Battle to Court) Perkins Street (Madockawando to Tarratine) Spring Street (Water to Court) School Street (Court to Court) Water Street (Main to Spring)

As the Town reviews the various remediation methods that are recommended for each road system, it should consider that:

- All new pavement could benefit from being crack sealed within three to five years after its initial placement.

- Crack sealing may extend the life of the pavement such that an overlay will not be needed for perhaps eight to twelve years.

- A pavement overlay should extend the life of the roadway perhaps five to ten additional years.

- At that point, roads that were originally reconstructed with new pavement could be reclaimed to begin the above cycle all over again. Roads that had been previously reclaimed should not be reclaimed a second time, but should be reconstructed with new material.

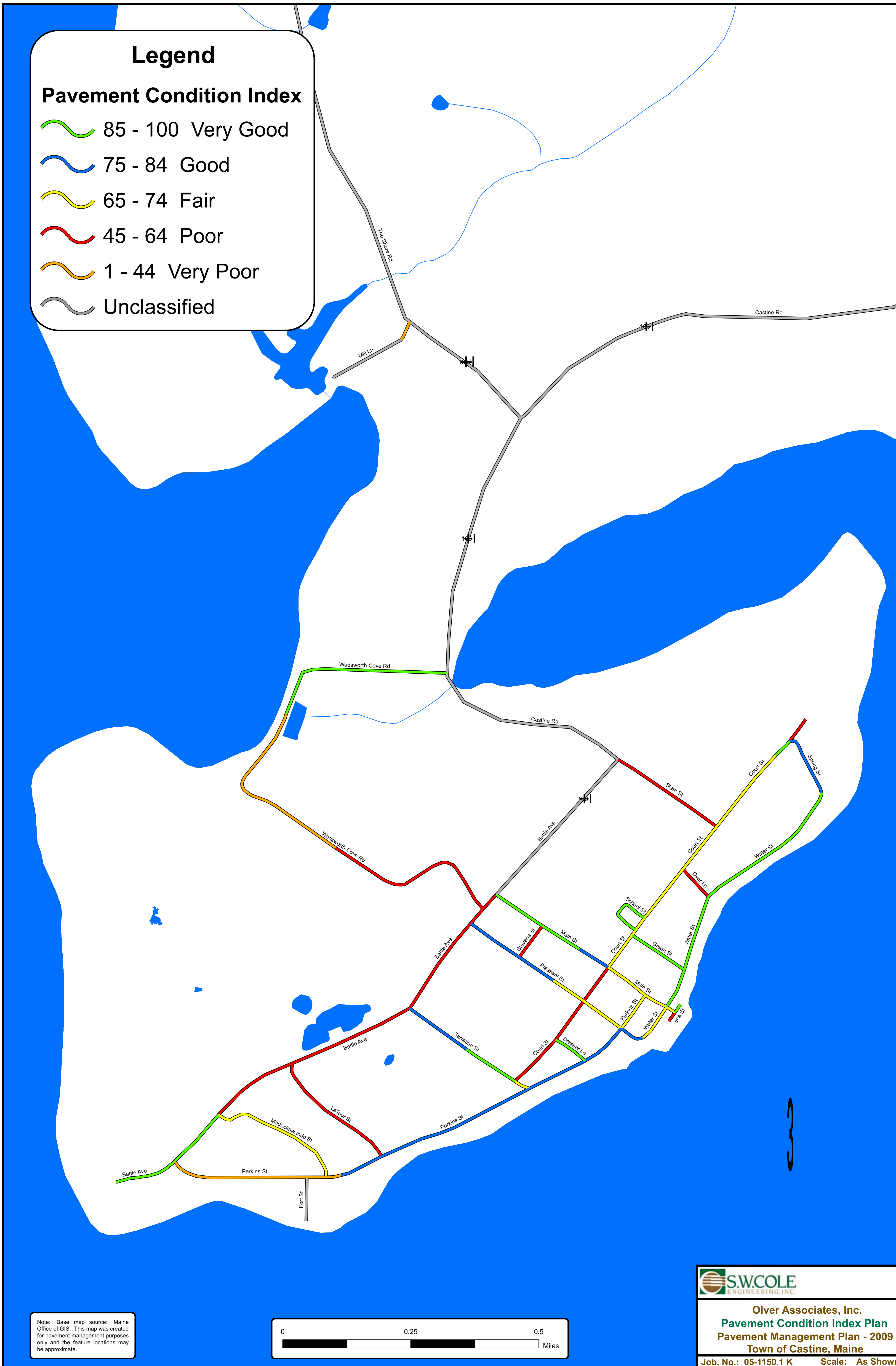
This approach, once implemented, will place all roads in Castine on a fifteen to thirty year life cycle. This will allow the Town to proactively maintain its roads on an ongoing basis while spreading out the cost of the program over many years. In order to establish priorities for road work, it is important to also consider the concurrent infrastructure needs of the Town's drainage, sewerage and water utilities.

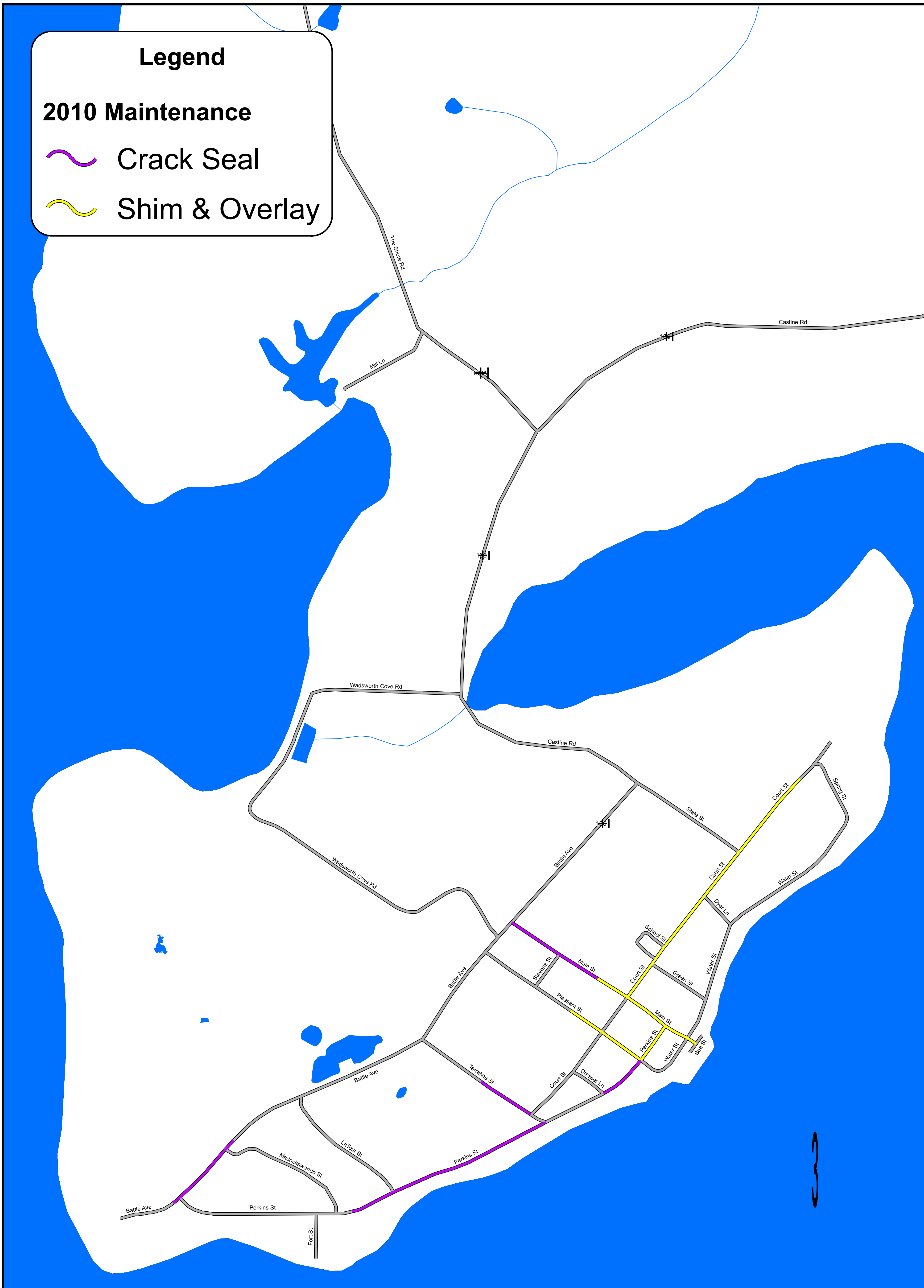
In many communities, poor planning often occurs and results in new road work being constructed and then prematurely excavated to replace or repair older utilities below the road in just a few years. A better approach would be to implement long-term planning that includes completing the upgrade of any deteriorated utilities before roadway reconstruction, reclaiming or repaving. The Town's other utilities are considered in the next sections of this report.

The following sheets from the 2009 S.W. Cole Engineering Pavement Management Plan graphically depict the roadway conditions and recommendations discussed in this section. They include:

- Sheet 1 – Approximate Test Log Locations
- Sheet 2 – Pavement Condition Index
- Sheet 3 – Crack Seal & Overlay Areas (2010)
- Sheet 4 – Crack Seal & Overlay Areas (2011)
- Sheet 5 – Crack Seal & Overlay Areas (2012)
- Sheet 6 – Reclamation & Reconstruction Areas
- Photographs of Road Structural Condition

Legend
Approximate Test Boring Location
The Shore Rd
Mill Ln
166A
166
Castine Rd
Wadsworth Cove Rd
WAD-1
WAD-2
WAD-3
WAD-4
WAD-5
WAD-6
Battle Ave
ST-1
ST-2
ST-3
State St
Court St
CO-1
CO-2
CO-3
CO-4
CO-5
Spring St
SP-1
WA-1
WA-3
WA-4
WA-5
Water St
Dyer Ln
DY-1
School St
Green St
Main St
MA-1
MA-2
MA-3
Stevens St
Pleasant St
PL-1
PL-2
PL-3
Perkins St
PE-1
PE-2
PE-3
PE-4
PE-5
PE-6
PE-7
PE-8
Sea St
Dresser Ln
Tarratine St
TA-1
TA-2
TA-3
BA-1
BA-2
BA-3
BA-4
LaTour St
LA-1
LA-2
LA-3
Madockawando St
MAD-1
MAD-2
MAD-3
Fort St
N
Note: Base map source: Maine Office of GIS. This map was created for pavement management purposes only and the feature locations may be approximate.
0
0.25
0.5
Miles
S.W.COLE ENGINEERING, INC.
Olver Associates, Inc.
Exploration Location Plan
Road Network Assessment
Town of Castine, Maine
Job. No.: 09-0463 K
Scale: As Shown
Date: July 2009
Sheet: 1

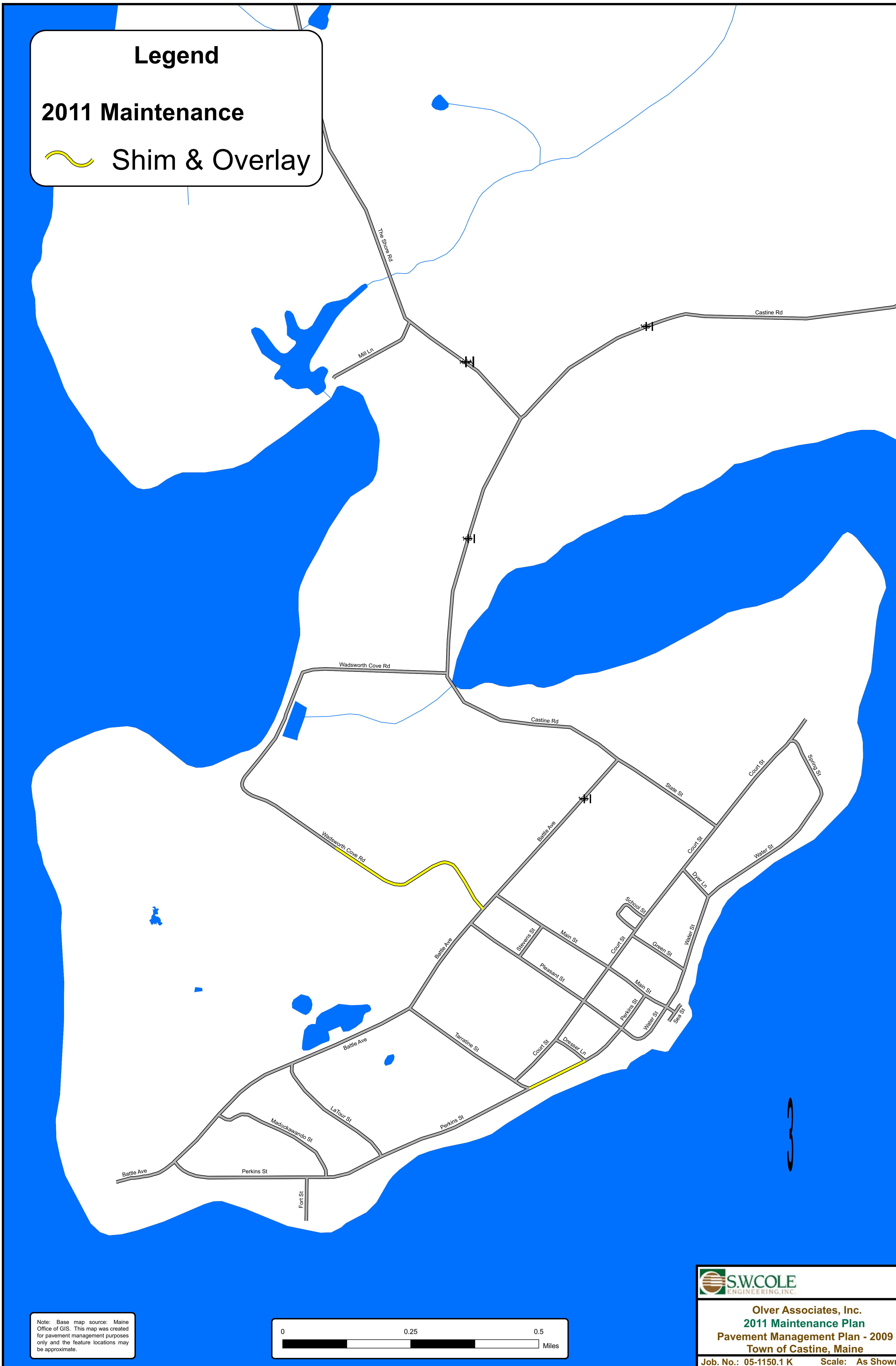

Legend
Pavement Condition Index
85 - 100 Very Good
75 - 84 Good
65 - 74 Fair
45 - 64 Poor
1 - 44 Very Poor
Unclassified
The Shore Rd
Mill Ln
Castine Rd
Wadsworth Cove Rd
Castine Rd
Battle Ave
State St
Court St
Spring St
Water St
Dyer Ln
Court St
School St
Main St
Green St
Water St
Stevens St
Pleasant St
Court St
Main St
Perkins St
Water St
Sea St
Battle Ave
Tarratine St
Court St
Dresser Ln
Battle Ave
LaTour St
Madockawando St
Perkins St
Battle Ave
Perkins St
Fort St
Note: Base map source: Maine Office of GIS. This map was created for pavement management purposes only and the feature locations may be approximate.
0
0.25
0.5
Miles
S.W.COLE ENGINEERING, INC.
Olver Associates, Inc.
Pavement Condition Index Plan
Pavement Management Plan - 2009
Town of Castine, Maine
Job. No.: 05-1150.1 K
Scale: As Shown
Date: July 2009
Sheet: 2



S.W.COLE ENGINEERING, INC.

Olver Associates, Inc.
2010 Maintenance Plan
Pavement Management Plan - 2009
Town of Castine, Maine

Job. No.: 05-1150.1 K **Scale:** As Shown
Date: July 2009 **Sheet:** 3



Legend

2011 Maintenance

Shim & Overlay

Note: Base map source: Maine Office of GIS. This map was created for pavement management purposes only and the feature locations may be approximate.

0 0.25 0.5 Miles

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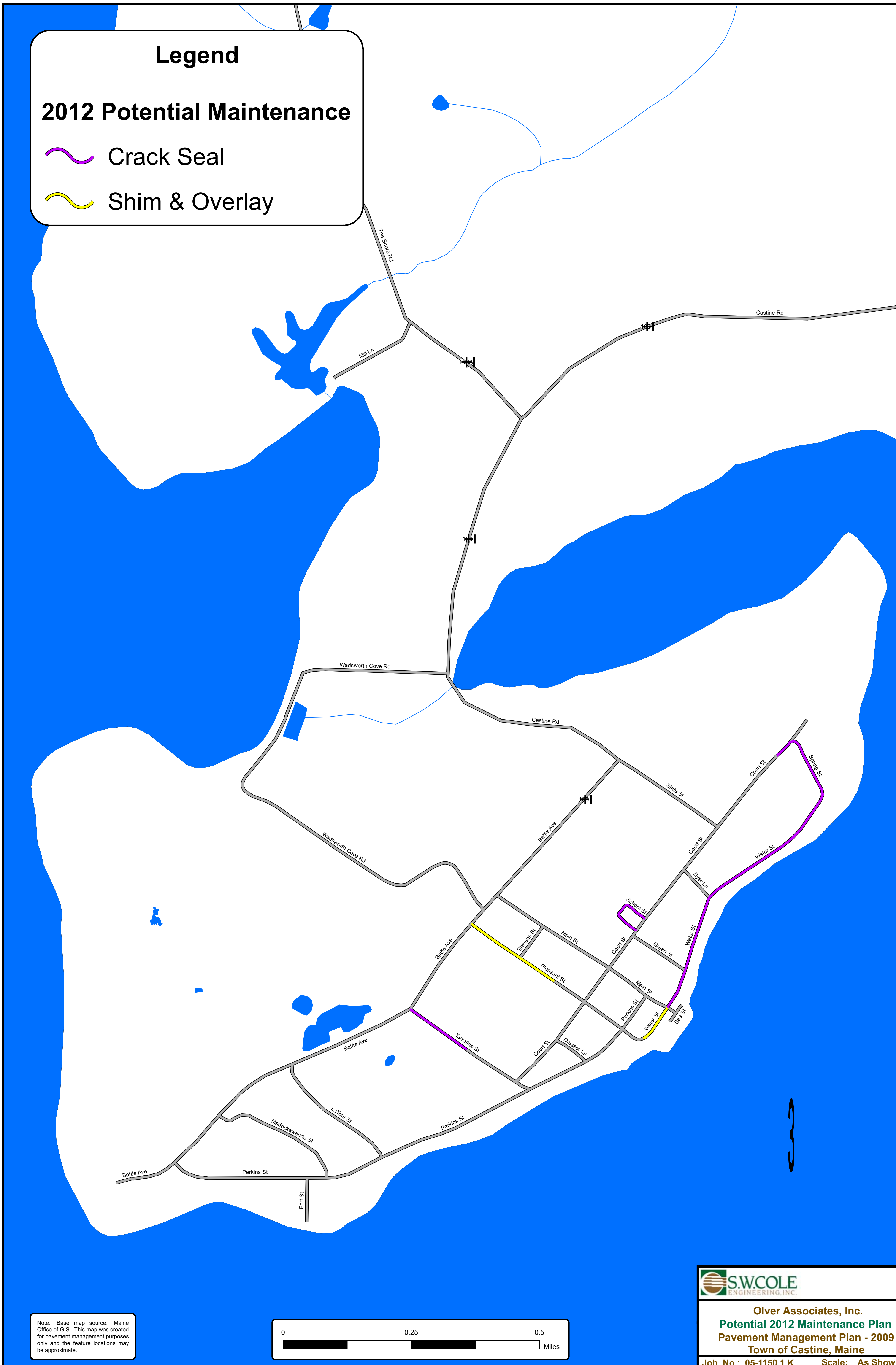
Olver Associates, Inc.
2011 Maintenance Plan
Pavement Management Plan - 2009
Town of Castine, Maine

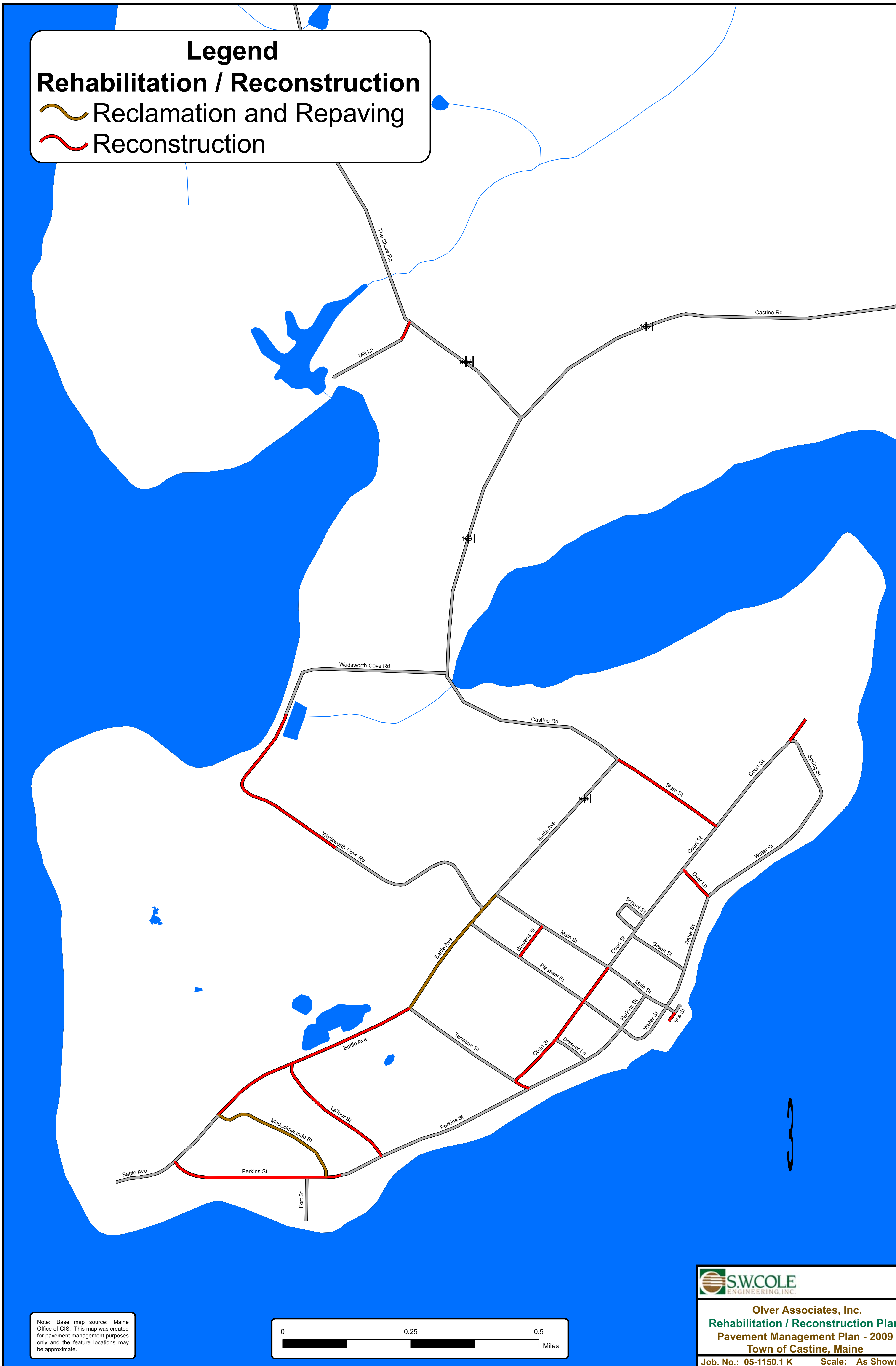
Job. No.: 05-1150.1 K	Scale: As Shown
Date: July 2009	Sheet: 4



S.W.COLE ENGINEERING, INC.

Olver Associates, Inc.
Potential 2012 Maintenance Plan
Pavement Management Plan - 2009
Town of Castine, Maine

Job. No.: 05-1150.1 K Scale: As Shown
Date: July 2009 Sheet: 5



S.W.COLE ENGINEERING, INC.

Olver Associates, Inc.
Rehabilitation / Reconstruction Plan
Pavement Management Plan - 2009
Town of Castine, Maine

Job. No.:	05-1150.1 K	Scale:	As Shown
Date:	July 2009	Sheet:	6

Battle Avenue 1

Battle Avenue 2

Battle Avenue 3

Battle Avenue 4

Court Street 1

Court Street 2

Court Street 3

Court Street 4

Court Street 5

Court Street 6

Court Street 7

Court Street 8

Dresser Lane

Dyer Lane

Fort Street

Green Street

LaTour Street

Madockawando Street

Main Street 1

Main Street 2

Main Street 3

Mill Lane 1

Mill Lane 2

Perkins Street 1

Perkins Street 2

Perkins Street 3

Perkins Street 4

Perkins Street 5

Pleasant Street 1

Pleasant Street 2

Pleasant Street 3

Pleasant Street 4

School Street

Sea Street 1

Sea Street 2

Spring Street

State Street

Stevens Street

Tarratine Street 1

Tarratine Street 2

Tarratine Street 3

Wadsworth Cove Road 1

Wadsworth Cove Road 2

Wadsworth Cove Road 3

Water Street 1

Water Street 2

Water Street 3

Water Street 4

3. CASTINE'S VILLAGE STORMWATER DRAINAGE INFRASTRUCTURE NEEDS

The collection and control of stormwater runoff and drainage is an essential public service provided by the Town of Castine. Rainfall occurring over the entire village area follows natural topographic features as it flows from high elevations toward Castine Harbor. As the water travels from upper reaches to its multiple discharge points, it converges with flow streams from other areas and intensifies in volume and velocity. To prevent widespread damage to property and the erosion of streets, the Town must maintain a system of open ditches, culverts, catchbasins and drainage swales to channel runoff to appropriate outlets. The Town's overall storm drainage system is a collection of manmade ditches and structures as well as natural streams and swales that collect the stormwater and convey it to the Harbor.

The public's perception of adequate stormwater drainage systems is often governed by visual appearances after a rainfall event. In general, the public demands that stormwater be adequately carried past their properties without causing erosion or ponding problems. There is an expectation that water will quickly drain away from street surfaces and not pond in traveled ways. The public also has an expectation that runoff from upstream areas will not collect on their property or contribute to the flooding of their lawns or cellars. As long as runoff appears to be moving in a reasonable fashion towards drainage system outlets, the public will generally be satisfied.

Beyond this public perception, which often drives budgetary decisions on how best to allocate limited funds for drainage system improvements, there are several additional concerns that the Town should address when considering a long-term capital plan. As discussed, the availability of adequate drainage systems alongside and under roadways is a critical factor on whether pavement surfaces will last and whether roadways will perform as expected. The ability of a roadway to withstand vehicular loadings without rutting and deformation is dependent on the quality of the pavement surface as well as on the strength of the underlying gravel base and subbase. The depth of the gravel structure is essential to allow the point loadings of overhead vehicle tires to be dissipated down to the poorer quality clay and silt subgrade below the gravel. The ability of the gravel to transmit these point loads, and to then spread them over a wider surface area below the gravel, is a function of the strength created by the interlocking of the discrete gravel particles.

When a roadbed is poorly drained and saturated with water, the gravel structure loses its ability to transfer loadings. This causes the weight of the vehicle tires to deform and rut the waterlogged gravel structure. The end result will be movement of the overlying pavement surface as characterized by cracking, rutting and deformation. As additional water enters the newly formed cracks, the saturation conditions will worsen and the deterioration of the pavement will accelerate. For this reason, poorly drained roadways are often associated with areas of pavement deterioration and failure. If the poor pavement condition is addressed simply by adding a new overlay surface to the road, the pavement overlay will eventually fail as well. For this reason, the most cost-effective approach for road improvement projects is to concurrently address drainage issues under the street at the same time that pavement is installed.

Drainage issues also impact the Town's sanitary sewer system which has sections that are well over 100 years old. When these lines were first installed, it was common to allow stormwater and sewage to be carried in the same pipes. It was also common to allow the public to discharge cellar drains and foundation drains into the same pipes that carried their sanitary sewage. This was because, before the treatment plant was built, all water ended up untreated in the harbor. With the installation of the wastewater treatment plant at the end of the sewer lines in 1973, the presence of excess runoff within these lines became an issue. At times, the treatment plant has historically been overloaded due to the presence of peak stormwater runoff that leaks into old sewer lines. Most of this leakage occurs in areas where old clay lines allow groundwater infiltration to enter. In addition, some private homes still have cellar drains and sump pumps that discharge stormwater inflow into the Town's sewer system. Where possible, drainage improvements to the Town's system should include installing storm stubs to each property to eventually allow private inflow sources to be disconnected. The Town has been proactively separating excess flow sources from its sewer system on previous infrastructure improvement projects conducted over the past twenty-five years.

Castine has a very limited existing stormwater drainage system. For the most part, runoff is collected in open ditches that are channeled under roadways and driveways through short sections of culverts. Some village streets, which have had recent reconstruction projects, have had upgraded drainage systems installed that include catchbasins and piped drain systems. However, many older streets that have catchbasins only collect water from small localized areas and discharge this water to the Harbor through multiple outlet points.

As future road reconstruction projects are conducted, it will be important to consider drainage needs on each street at the same time. Many streets currently utilize open ditches to convey stormwater. In areas with a low population density, this approach is acceptable. On more developed streets within the village, it may be beneficial to replace the old open ditches with closed pipe drain systems and catchbasins. In areas where localized catchbasins and drains exist, many of these pipes need to be upgraded in size in order to be able to properly convey current levels of design flows. In wet areas, perforated drain pipes should be installed below the street to help underdrain the road base.

In order to develop a preliminary assessment of future drainage system infrastructure needs, a hydraulic model of typical runoff patterns was conducted for each village street. Figure 6 shows the current overall runoff patterns throughout the village. Each drainage pathway is defined by the adjacent topography and ground conditions. A hydrogeological drainage

TOWN OF CASTINE, MAINE

STORM WATER SYSTEM

FIGURE 6

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model was developed for each drainage area in order to estimate the peak runoff in cubic feet per second (CFS) that is occurring on each street. The estimated in-place hydraulic capacity of each existing ditch or culvert was determined and compared to the estimated runoff volume for a twenty-five year frequency storm event. For Castine, such a storm would be equivalent to about 4.90 inches per day of rainfall over a twenty-four hour period. In general, municipal stormwater systems are typically designed to process up to a twenty-five year storm event.

The Hydrocad hydraulic model that was used generated estimates of peak runoff at the end of each drainage subarea on the basis of several specific site factors. These include the permeability of the soil as mapped for each area by the Soil Conservation Service (SCS), the size of the upstream drainage area, the slope of the watershed, the type of development or ground cover that is present, and the availability of upstream storage areas, such as ponds, along the drainage pathway of each system. The peak runoff volumes generated by the model were compared to the estimated in-place hydraulic capacity of each drainage system components as determined by Manning's Equation for open channel or pipe flow. Capacity deficiencies were noted for any area where the peak design flow exceeded the available drainage infrastructure capacity. This data is presented below in Table 4 for each village street:

TABLE 4: REVIEW OF EXISTING DRAINAGE SYSTEM CAPACITY

STREET/LOCATION	EXISTING SYSTEM	EXISTING CAPACITY (CFS)	25-YEAR DESIGN STORM (CFS)	RECOMMENDED ACTION
1. BATTLE AVENUE				
Perkins to Madockawando	Ditch	140	10	Reroute off priv. property
Madockawando to Latour	Ditch	80	5	Maintain ditches
Latour to Tarratine	Ditch	55	5	Maintain ditches
Tarratine to Pleasant	Ditch	30	5	Maintain ditches
Pleasant to Main	Ditch	60	10	Maintain ditches
2. COURT STREET				
Tarratine to Dresser	Piped	10	65	Upgrade drains
Dresser to Pleasant	Piped	6	20	Upgrade drains
Pleasant to Green	Piped	20	45	Upgrade drains
Green to Dyer	Piped	20	40	Upgrade drains
Dyer to State	Ditch	20	15	Maintain ditches
State to Spring	Ditch	55	35	Maintain ditches

STREET/LOCATION	EXISTING SYSTEM	EXISTING CAPACITY (CFS)	25-YEAR DESIGN STORM (CFS)	RECOMMENDED ACTION
3. DRESSER LANE				
Court to Perkins	Piped	13	2	Good condition
4. DYER LANE				
Court to Water	Piped	3	4	Upgrade drains
5. GREEN STREET				
Court to Water	Piped	10	6	Good condition
6. LATOUR STREET				
Battle to Midpoint	Ditch	4	3	Add piped system
Midpoint to Perkins	Ditch	5	10	Add piped system
7. MADOCKAWANDO ROAD				
Battle to Midpoint	Ditch	125	5	Add piped system
Midpoint	Ditch	135	10	Add piped system
Midpoint to Perkins	Ditch	100	15	Add piped system
8. MAIN STREET				
Battle to Stevens	Piped	10	5	Maintain drains
Stevens to Court	Piped	10	10	Maintain drains
Court to Water	Piped	25	35	Upgrade drains
9. PERKINS STREET				
Battle to Madockawando	Ditch	44	55	Add piped system
Madockawando to Latour	Ditch	5	25	Add piped system
Latour to Tarratine	Ditch	65	250	Add piped system
Tarratine to Dresser	Piped	10	25	Upgrade piped system
Dresser to Pleasant	Piped	25	65	Upgrade piped system
Pleasant to Main	Piped	10	5	Upgrade piped system

STREET/LOCATION	EXISTING SYSTEM	EXISTING CAPACITY (CFS)	25-YEAR DESIGN STORM (CFS)	RECOMMENDED ACTION
10. PLEASANT STREET				
Battle to Stevens	Piped	35	10	Good condition
Stevens to Court	Piped	30	30	Upgrade drains
Court to Perkins	Piped	35	45	Upgrade drains
11. SCHOOL STREET				
Court to Court	Piped	2	2	Good condition
12. SPRING STREET				
Court to Water	Ditch	5	2	Maintain ditches
13. STATE STREET				
Battle to Midpoint	Ditch	10	5	Maintain ditches
Midpoint to Court	Ditch	15	5	Maintain ditches
14. STEVENS STREET				
Pleasant to Main	Ditch	15	12	Add piped system
15. TARRATINE STREET				
Battle to Midpoint	Piped	20	10	Good condition
Midpoint to Perkins	Piped	15	30	Upgrade drains
16. WADSWORTH COVE ROAD				
Battle to Pump House	Ditch	550	30	Maintain ditches
Beach to Route 166	Ditch	100	40	Maintain ditches
17. WATER STREET				
Perkins to Main	Piped	10	10	Upgrade drains
Main to Dyer	Ditch	115	35	Maintain ditches
Dyer to Spring	Ditch	40	55	Add piped system

The data presented in Table 4 shows that some areas of the present drainage system have adequate capacity while others are undersized. Because many of Castine's streets have very steep slopes, the capacity of the drainage system can be misleading in some cases. Ditch and pipe capacity is a function of slope, ditch cross-sectional area or pipe diameter, and ditch bottom cover material or pipe material. On various steep streets, excess capacity is often available due to slope even though the velocity of flow in these areas can lead to erosion problems on adjacent properties. In general, it may be advantageous to install piped systems on some of the steeper streets, especially in densely populated residential areas, to control runoff and erosion even if sufficient capacity can be shown to exist in the ditches. In less densely populated areas of the village, existing ditches are still an acceptable method for drainage control provided that the ditch capacity is maintained in the future by periodic weed removal and regrading. In more densely developed areas, piped systems should be maintained or upgraded where now present or added in place of ditches, especially on steep streets.

With regard to the capacity summary of the present drainage system as presented above in Table 4, we offer the following comments and recommendations:

1. <u>BATTLE AVENUE</u> is presently served by a series of ditches. This area is not densely developed and ditches are an appropriate method for runoff control. In some areas, particularly towards the Perkins Street end, some of the Town's ditches drain onto private property for which poorly defined easements are available. To address the flooding issues that this creates between Battle Avenue and Perkins Street, the ditch area between Madockawando Road and Perkins Street should be connected to a piped drainage system at some point in the near future. In all other areas, the present ditch system should be maintained with periodic maintenance. As shown in Table 4, most of the ditches have sufficient capacity to handle a twenty-five year storm event.

2. <u>COURT STREET</u> is served by a combination of piped drains near the Tarratine Street end and by open ditches towards the Spring Street end. In general, most of the present piped drains between Tarratine Street and Dyer Lane are in poor condition and undersized. As part of any future roadway work, these drains should be upgraded. As Court Street progresses from Dyer Lane towards Spring Street, runoff is collected in open ditches. These ditches generally have sufficient capacity to carry flows from a twenty-five year storm event assuming that periodic maintenance is continued to preserve their hydraulic configuration.

3. <u>DRESSER LANE</u> had a major upgrade of its piped drainage system several years ago and is in good condition with no need for additional drainage improvements.

4. DYER LANE has a system of old 12"Ø drains in place that are at borderline capacity. At the time that any future upgrade work is conducted on this street, it would make sense to upgrade the drainage system at the same time.

5. GREEN STREET has a piped drainage system which was completely rebuilt several years ago. It is in good condition with no need of additional upgrade work.

6. LATOUR STREET has a series of open ditches to control runoff. These ditches have insufficient capacity to carry peak flows from this area. The steep slope of the streets makes these ditches prone to erosion during peak flow events. Whenever major street reconstruction work is done on Latour Street, it would be beneficial to add a piped drainage system.

7. MADOCKAWANDO ROAD has a more defined series of open ditches than Latour Street which provides greater peak flow capacity; however, the ditches are still prone to erosion given their steep slope. This is a relatively densely populated area that would benefit from having a piped drainage system at a point in the future when major repairs are done to the street.

8. MAIN STREET has had some upgrades to its drainage system in the past twenty years. This is a piped system along most of the street length. Sufficient capacity is in place at the upper end near Battle Avenue, but the present pipes are undersized at the lower end between Court Street and Water Street. Improvements to the piped drainage system should be considered whenever future repairs to this street are implemented at some point in the future.

9. PERKINS STREET is served by both an open ditch system at the Battle Avenue end and by a piped system near the Main Street end. The present ditches are in poor condition, poorly configured and generally inadequate to convey the peak flows from this area. In addition, these ditches are located at the bottom of a major hill from which all upstream runoff is directed. Excessive water from these upstream areas often floods the Perkins Street ditches and causes water to flow over the road or to pond on the roadway surface. This problem is severe near the Battle Avenue end. The present piped drainage system between Tarratine Street and Main Street is essentially a series of localized catchbasins and outlet pipes that are in poor condition. Many of these ditches and drains reach Castine Harbor through outlet pipes that are located in poorly defined easements. As work is conducted on Perkins Street in the future, a piped drainage system should be added to these areas. Proper outfalls to the Harbor should be constructed after obtaining easements from adjacent property owners.

10. PLEASANT STREET has a relatively new piped drainage system that was installed locally about fifteen years ago. The Utility Board at that time developed sizing and

plans for the project which included the replacement of most of the drain pipes. It does not appear that the hydraulic capacity of the drainage area was modeled in order to size the pipes. Some of these pipes, particularly down near Perkins Street, are undersized. As work is scheduled in this area in the future, some of the smaller drain lines should be upgraded to increase their peak flow capacity.

11. SCHOOL STREET has a new piped drainage system that was installed about fifteen years ago and remains in good condition. No immediate drainage system work is needed in this area.

12. SPRING STREET between Court Street and Water Street utilizes an open ditch system for runoff control. Given the slope of the street, this approach has been adequate in the past. With proper maintenance, the ditch system is appropriate for this area.

13. STATE STREET has a low development density and is served by an open ditch system. The ditches have sufficient hydraulic capacity to convey a twenty-five year storm event. With proper maintenance in the future, the continued use of open ditches in this area is appropriate.

14. STEVENS STREET has a poorly defined ditch drainage system that results in ponding of water on the roadway surface and deterioration of the pavement. A new piped drainage system should be constructed in this area when improvements are made to the roadway.

15. TARRATINE STREET utilizes a series of localized piped catchbasins and drains that convey runoff to several outlet points. The system is undersized in the Perkins to Court Street area at its lower end. Sufficient capacity is in place at the upper end near Battle Avenue. As future roadway improvements are constructed, specific improvements to the piped drainage system should be considered.

16. WADSWORTH COVE ROAD utilizes a series of open ditches and cross culverts to control runoff. On the steeper parts of the road beginning at Battle Avenue, the ditches generally have sufficient capacity, but are prone to erosion. On the flatter areas along the beach and approaching Route 166, additional capacity can be created by regrading and reshaping the ditches. Given the low development density in these areas, the continued use of open ditches for runoff control is appropriate provided that the ditches are properly maintained and stabilized with rip-rap.

17. WATER STREET utilizes a piped drainage system towards the Main Street end and has open ditches with some localized catchbasins and culverts towards Spring Street. Some recent repairs and upgrades have been made to several of these localized drainage subsystems while others are old and in poor condition. As with Perkins Street, Water

Street is located at the bottom of a major hill which serves as the outlet for adjacent upstream runoff. Many of the outlet drains to the Harbor cross below Water Street and pass through private property with poorly defined easements. As future repairs are made to the Water Street roadway, the entire system should be upgraded to a piped drainage network that has outfall pipes to the Harbor in well defined easements.

Based upon the above discussion, Table 5 summarizes the areas of the Castine drainage system where future upgrades should be considered:

TABLE 5: SUMMARY OF INITIAL DRAINAGE IMPROVEMENT RECOMMENDATIONS

PROPOSED ACTION	DRAINAGE AREAS
1. Add or upgrade piped drains	Battle Avenue (Perkins to Madockawando)
	Court Street (Tarratine to Green)
	Dyer Lane (Court to Water)
	Latour Street (Battle to Perkins)
	Madockawando Road (Battle to Perkins)
	Main Street (Court to Water)
	Perkins Street (Battle to Main)
	Pleasant Street (Court to Perkins)
	Stevens Street (Main to Pleasant)
	Tarratine Street (Court to Perkins)
2. Maintain or improve ditches	Battle Avenue (Madockawando to Main)
	Spring Street (Court to Water)
	State Street (Battle to Court)
	Wadsworth Cove Road (Battle to Route 166)
3. Current drainage system adequate	Dresser Lane (Court to Perkins)
	Green Street (Court to Water)
	Main Street (Battle to Court)
	Pleasant Street (Battle to Court)
	School Street (Court to Court)
	Tarratine Street (Battle to Court)

As the Town proceeds with roadway improvement work in the future, drainage needs should be considered for each street at the same time. Updated stormwater runoff calculations and hydraulic modeling should be conducted during the final design phase of each project to make final determinations of pipe and ditch sizes. The design should be based upon existing site features and field conditions that will be in place at that point in the future.

4. CASTINE'S VILLAGE SANITARY SEWER INFRASTRUCTURE IMPROVEMENTS

A schematic map of Castine's existing sanitary sewer system is shown in Figure 7. About 27,400 LF of gravity collector and interceptor sewers convey raw wastewater to the treatment plant site on Water Street. Some sections of the sewer system were constructed as far back as the 1890's. Other sections of the sewer system were added or replaced in 1973 when the treatment plant was constructed. Since then, the Town has been replacing sections of its sewer system with periodic capital improvement projects in an effort to upgrade old and leaking sections of pipe.

Table 6 summarizes the general composition of the current sewer system. At the present time, about eighteen percent of the system consists of leaking, small diameter clay sewers with high levels of excessive groundwater infiltration. The remaining eighty-two percent of the system has been reconstructed or replaced in a series of capital improvement projects conducted over the last thirty-five years:

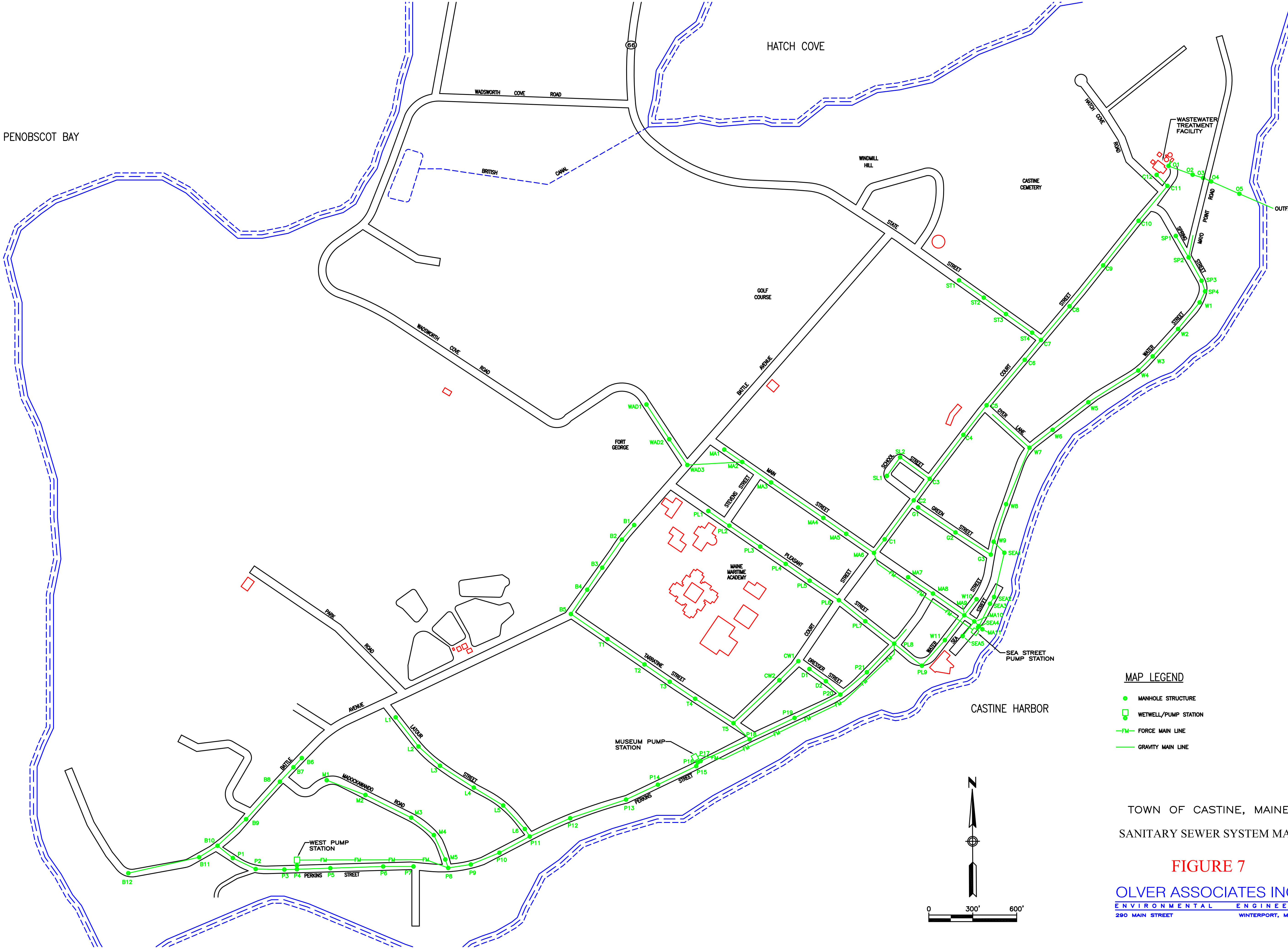
TABLE 6:

CASTINE'S SANITARY SEWER SYSTEM COMPONENTS

DESCRIPTION	LENGTH (LF)	PERCENT OF TOTAL
Original Clay Sewers (1894-1973)	4,900	18
New Interceptor Sewers (1973)	10,500	38
Upgraded Sewers (1983-2009)	12,000	44
Total Sewer System	27,400	100

Three major pump stations convey wastewater over topographical grade changes on its way to the treatment plant. The Town's major stations are the West pump station on Perkins Street, the Museum Pump Station on Perkins Street, and the Sea Street Pump Station near the Town Wharf at the foot of Main Street. The Town's experience has been that all three stations can process all peak flows in the sewer system provided that no mechanical malfunctions occur. This has not always been the case in the past, but the Town's sewer remediation efforts since 1983 have had a significant impact on reducing sewer system flows down to the available pump station capacity levels.

All flows in the sewer system are eventually pumped, or conveyed by gravity, to the treatment plant site at the end of Water Street. Treated effluent is discharged to the Bagaduce River and Castine Harbor through a 12" Ø concrete outfall sewer. There are no known combined sewer overflow (CSO) points in the sewer system that would allow



TOWN OF CASTINE, MAINE

SANITARY SEWER SYSTEM MAP

FIGURE 7

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290 MAIN STREET WINTERPORT, MAINE

untreated sewage to overflow to the Harbor during peak flow periods. Even though the sewer system is subject to occasional high excess groundwater infiltration and stormwater inflow events, the greatest impact of these flows is now observed at the wastewater treatment plant and not upstream in the sewer system.

The treatment plant was upgraded in 2008 which included an increase in its design capacity to 200,000 GPD (gallons per day) of average daily flow and 1.00 MGD (million gallons per day) of peak hourly flow. This allows the treatment plant to process the normal peak flows that are generated in the sewer system. At the time that the decision was made to upgrade the plant, DEP had requested that the Town continue to make significant improvements to its sanitary sewer system to reduce peak flows that were overloading the plant. After much discussion, it was decided that such an approach would result in significant sewer system expenditures to reduce these flows while still leaving the thirty-five year old treatment plant in place. Since the useful life of the plant when it was built was projected to be only twenty years, such an approach would have placed the Town at risk of having to eventually make significant repairs to the plant while still paying the debt service on the sewer system capital improvements that DEP was mandating. Instead, the Town requested a consent agreement where it agreed to upgrade the treatment plant to allow it to process peak sewer system flows. Repairs to the sewer system were kept off the DEP consent agreement requirements. This allows the Town the flexibility to continue making repairs to its sewer system in the future on its own schedule.

If sanitary sewer system repairs were to be viewed as stand alone projects, the Town would likely prioritize sewer system improvements on the basis of the following criteria:

1) Repair sewer sections with identified structural problems or continual maintenance issues.

2) Replace old 6”Ø clay sewer lines, many of which have been in the ground for well over 100 years.

3) Improve leaking areas of the sewer system that have been identified in numerous previous studies as being the source of the excess peak flows that reach the treatment plant during wet weather and high groundwater infiltration periods.

In previous studies, the Town has successfully identified the sources of most remaining major groundwater infiltration and stormwater inflow into the sewer system. Many of these sources have been removed and further projects have been proposed for the future to reduce additional excess flow levels. Previous sewer system remediation efforts have had a positive impact on the reduction of peak flows from the sewer system. While the plant still receives occasional high flows, these events have become less frequent and of shorter duration than they were prior to the Town’s sewer remediation work.

The Town has expended a considerable amount of capital and effort over the last twenty-five years on the removal of excess water from its sewer system. The remaining levels of excess groundwater infiltration generally are found in the old clay public sewers that have not yet been replaced and in leaking private building sewers from individual homes out to the street. Table 7 shows an overall assessment of the remaining problematic groundwater infiltration areas in the Castine sewer system:

TABLE 7:

BALANCED EXCESS INFILTRATION FLOW DISTRIBUTION IN CASTINE SEWER SYSTEM

STREET	SECTION	INFILTRATION VOLUME (GPD)	UNITIZED RATE (GPD/in-mi)
Dyer Lane	Water to Court	8,000	17,800
Main Street	Court to Battle	25,000	16,000
Maine Maritime	Tarratine St. to MMA	32,000	10,300
State Street	Court to Battle	12,000	10,000
Battle Avenue	Perkins to Latour	20,000	9,500
Perkins Street	Tarratine to Pleasant	12,000	7,100
Court Street	Tarratine to Pleasant	8,000	6,500
Perkins Street	Battle to Madockawando	5,000	6,300
Main Street	Water to Court	5,000	5,000
Court Street	Pleasant to State	22,000	3,400
Water Street	Green to Spring	4,000	1,000
Latour Street	Battle to Perkins	0	0
Madockawando Road	Perkins to Battle	0	0
Tarratine Street	Perkins to Battle	0	0
Pleasant Street	Water to Battle	0	0
School Street	Court to Court	0	0
Battle Avenue	Tarratine to Wadsworth	0	0
Totals	Overall System	150,000	3,600

The above data provides a relative ranking of the Castine sewer system's problem areas as they relate to peak groundwater infiltration. Some of the areas that were leaking badly in the initial studies conducted fifteen years ago have remained about the same while other areas have gotten worse. We offer the following comments on each of the specific streets listed above:

- Dyer Lane has a high leakage rate and represents 6"Ø original clay sewer main with old building sewers on a very steep street. The sewers on this street should be replaced.

- Main Street from Court Street to Battle Avenue remains a source of high leakage. This line is original 6”Ø clay pipe in poor condition with many old building sewers. Thirteen houses were found to have connected cellar drains in previous studies.

- Maine Maritime Academy (MMA) continues to contribute a large amount of excess flow that represents about twenty percent of the Town’s overall problem. A significant amount of campus sewers have been replaced over the last thirty-five years. It would be appropriate for MMA to assist the Town in locating its remaining excess flow areas.

- State Street’s sewer was replaced by the Town in 1983, but it still has a relatively high leakage rate. It is likely that most of these flows are the result of faulty private building sewers. Three homes were found to have connected cellar drains in a previous study.

- Battle Avenue from Perkins to Latour still shows high flow volumes. That sewer has been completely replaced, but old building sewer lines are still in place. Some of these lines are very long and believed to be in poor condition.

- Perkins Street from Tarratine to Pleasant Street is an old six inch clay line in poor condition. It continues to be the source of significant excess flow. At least twelve cellar drains are tied into the sewer on Perkins Street, not only on this old section, but elsewhere along the street.

- The Court Street sewer from Tarratine Street to Pleasant Street is also an old original clay sewer in poor condition. Some sections of pipe are in very poor structural condition. There are a total of twelve known cellar drain connections along this length of Court Street.

- The Perkins Street sewer section from Battle Avenue toward Madockawando has an old 6” Ø clay line in poor condition over 400 LF of its length. It continues to leak at a moderate rate.

The remaining Table 7 sewer lines in Castine have leakage rates below 5,000 GPD/in-mile and are in relatively good condition. There are several areas of the Town where groundwater infiltration into the sewer system is either zero or only a trace amount. The Town’s recent sewer improvement projects on Madockawando Road, Latour Street, Tarratine Street, Pleasant Street, School Street, Green Street, Dresser Lane and Battle Avenue have removed a significant amount of excess flows from groundwater leakage.

All of the remaining 6"Ø clay sewer lines in Castine appear on the Table 7 list of high leakage areas. As the Town moves forward over time to remove these remaining sources of groundwater entry into the sewer system, it will concurrently rehabilitate century old clay pipes that remain in the system. During rain events, stormwater inflow peaks are associated with private inflow sources upstream in the sewer system. Since the Town has no connected public catchbasins on its sewers, private sources including cellar drains, foundation drains and roof drains are the likely cause of this observed inflow. The Town should continue its past policy of requiring homeowners to separate their building sewers and cellar drains whenever work is constructed on the Town street. When new public storm drains are installed, the Town should continue its practice of installing a new storm sewer stub to each property line to allow homeowners to connect their cellar drains and sump pumps to the storm drain system.

Based upon the above discussion, the following areas of Castine's sanitary sewer system as shown on Table 8 should be upgraded in the future when roadway work is conducted in those areas:

TABLE 8: SUMMARY OF INITIAL SANITARY SEWER REMEDIATION RECOMMENDATIONS

PROPOSED ACTION	SEWER SYSTEM AREAS
1. Upgrade old clay sewer lines	Perkins Street (Battle to Madockowando)
	Court Street (Tarratine to Pleasant)
	Dyer Lane (Court to Water)
	Main Street (Battle to Water)
	Perkins Street (Tarratine to Pleasant)
2. Separate private inflow sources	Battle Avenue (Perkins to Latour)
	State Street (Battle to Court)
	Water Street (Green to Spring)

In addition to the remaining long term repairs that are needed throughout the sewer system, the Town will also likely need to address the location of its treatment plant outfall at some point in the very near future. The outfall conveys all of the treatment plant's final effluent to its discharge terminus in Castine Harbor. At low tide, the end of the outfall is exposed on the beach. This was considered acceptable back in 1973 when the plant was built; however, recent changes in DEP regulations require that all outfalls remain fully submerged at all times and that sufficient water velocity be available at the end of the outfall to adequately disperse the effluent. The Town is in the process of submitting an effluent dispersion study to DEP to define the appropriate location for an outfall extension into deeper water. Based on preliminary data, it is likely that DEP will require that the Town extend its outfall pipe by an additional 250 to 400 feet from its present terminus in order to reach a point of adequate dispersion. Communities throughout Maine with similar exposed outfalls are also being required to address this issue.

5. CASTINE'S VILLAGE WATER DISTRIBUTION INFRASTRUCTURE

The Town of Castine operates a municipal water department that provides potable water service to about 380 connected customers through nine miles of water mains. The water supply is obtained from a series of nine groundwater wells of which six are in normal operation. An additional six surface water ponds on Battle Avenue provide an emergency backup supply to the groundwater wells. Over the past twenty years, the Town has invested significant capital resources on the installation of new groundwater wells and treatment systems to comply with increasingly more stringent EPA water quality regulations. A new reservoir was added on Witherle Hill in 2006. Over the years, the Town has made improvements to its water treatment system as part of other roadway, sewer and drainage projects that were conducted throughout the village. In future years, the water distribution system should remain an important focus of the Town's ongoing water infrastructure improvement efforts.

The distribution system serves two equally important functions. First, it is essential that pipe sizes and pipe conditions be adequate to deliver a reliable and high quality supply of potable water to each customer's property at an appropriate volume and pressure. Second, the water distribution system must have sufficient peak flow capacity to deliver adequate fire flows throughout the community to assist the Fire Department in battling blazes. In both of these areas, the present water distribution system falls short.

Water pressure in the distribution system is created by the height of water stored in the reservoir as offset by various frictional and velocity headlosses that occur as water flows throughout the pipes. Water pressures will vary throughout the community depending on the location of each property, their elevation relative to the storage reservoir elevation, and the size of the pipes that the water must flow through between the reservoir and each building. As pipe sizes decrease, frictional and velocity headlosses increase which will result in a loss of available water pressure. This loss will intensify as the length of pipe between the reservoir and a subject property increases.

The preferable water pressure range for most distribution systems in between 65 and 75 psi (pounds per square inch). As a minimum, water pressures below 40 psi are seldom recommended during normal operating conditions. In most cases, water pressures below 20 psi at the highest elevations of the system should never be allowed. At the other end of the spectrum, the maximum water pressure that is recommended is 100 psi. Low water pressures result in customer complaints regarding their water delivery and volume. It also places the water system at risk of developing vacuum conditions should a large water draw occur elsewhere in the system such as might be the case during firefighting efforts. Excessive water pressure can result in accelerated water leakage throughout the community as well as in the plumbing fixtures of residential homes.

Fire flow needs often govern the sizing of the pipes in a water distribution system. As a minimum, fire flows should never decrease below 500 GPM (gallons per minute), although a lower range of 1,500 GPM for residential areas is typically recommended. Where possible, fire flows of 2,000 to 3,000 GPM are preferable, especially in developed commercial areas or densely populated residential areas. Exact fire flows for a community are typically developed by underwriters at the Insurance Service Office (ISO) for the purpose of fire insurance rating. In order to deliver typical fire flow water volumes, it is customary to provide water distribution mains no smaller than 8"Ø. Smaller lines often are unable to meet the desired fire flow volumes due to increased frictional losses. In addition, as pipes become older, they can lose portions of their available cross-sectional area due to corrosion and scale formation. This results in a rapid decrease in water delivery volume and pressure and flows that may not meet fire flow requirements. Smaller lines are more prone to a reduction in cross-sectional capacity since they begin with a smaller area when new.

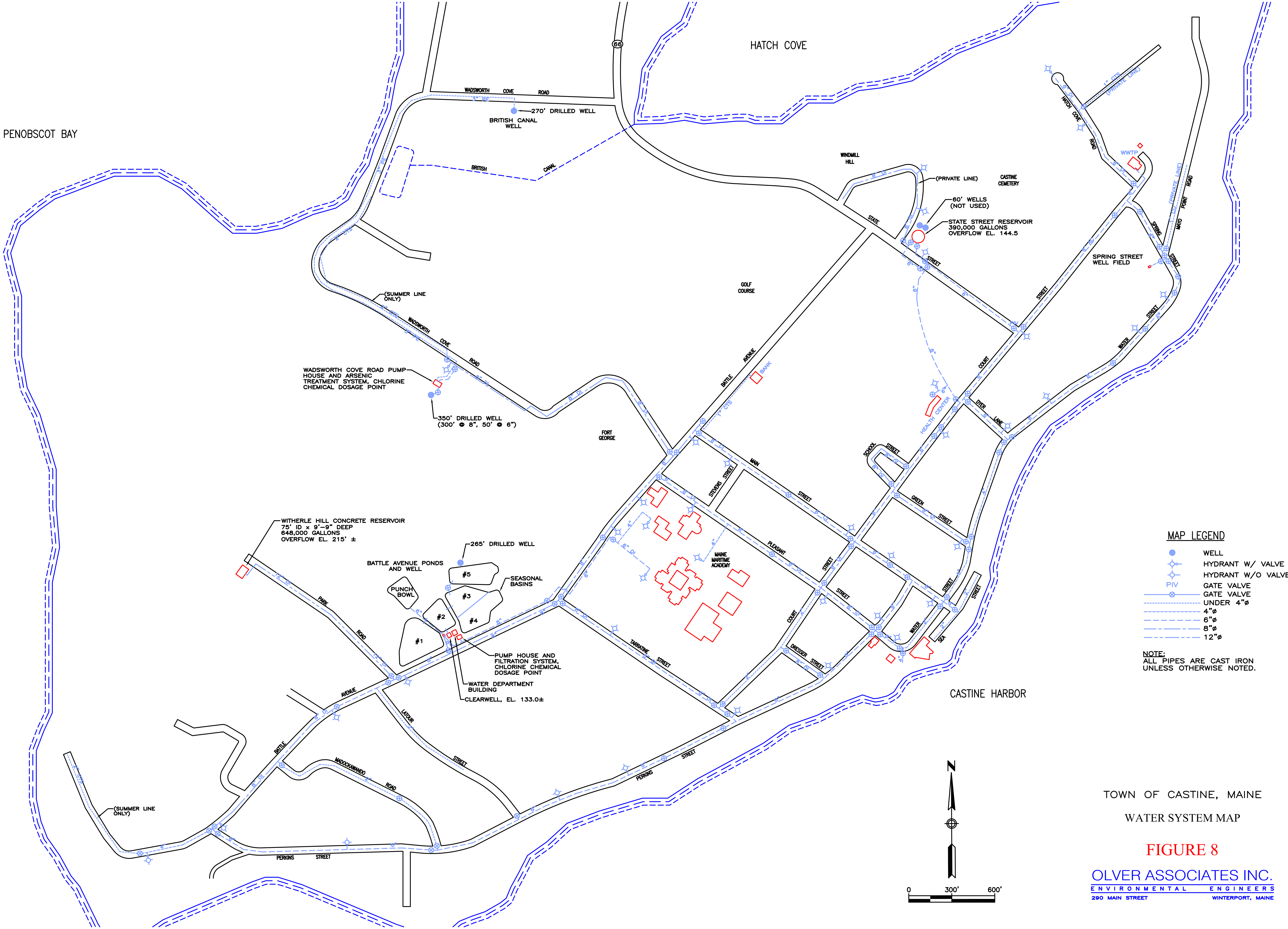
Water pressure and fire flow capacity throughout a water distribution system are determined by a combination of hydraulic modeling and hydrant testing. The Castine water system has been studied extensively over the past decade. Two detailed Watercad hydraulic models of the entire system were prepared by Dirigo Engineering for the recent installation of the new storage reservoir. Those models were reviewed as part of the current study. Modeling efforts to-date suggest that many areas of extremely low water pressure and inadequate fire flow volume presently exist throughout Castine's water system. While the addition of the new reservoir helped to improve the situation in some areas, the distribution system currently remains limited by the prevalent usage of extremely small diameter pipes throughout the village. In several areas, water mains as small as 2"Ø are still in use even though they are 100 years old.

During periods of high water demand, excessive friction and velocity losses occur in the small diameter piping sections throughout Castine. This results in very low water pressures on some streets. Pressures at or below 20 psi have been measured at the higher elevations of the system near Battle Avenue and the Wadsworth Cove Road during normal water use periods. Pressure measurement tends to improve at some of the lower elevation streets along the waterfront due to the increased elevation differences that are available between the reservoir and those areas. During periods of peak water use, most areas of the Castine system exhibit pressures greater than 20 psi which customers will generally find tolerable. These pressures will increase to as much as 70 psi down near the waterfront along Perkins Street and Water Street. However, should a sudden water demand develop during a fire, significant drops in water pressure will occur. Hydraulic modeling and field calibration shows that high elevations along Battle Avenue and Wadsworth Cove Road could experience water pressures below 10 psi, or even reach vacuum conditions, during extremely high demand periods.

The Castine water system is shown graphically in Figure 8. The presence of numerous small pipe sections throughout the system greatly limits available pressure and fire flow. Previous modeling work has shown that fire flows in the 450 to 550 GPM range are generally available at lower elevations of the village along Perkins Street and Water Street. These flows diminish to a 250 to 300 GPM range at higher elevations along Battle Avenue and Wadsworth Cove Road. The new reservoir alone did not address this significant fire flow deficiency. In order to improve water delivery throughout the system, it is important to remove the current hydraulic bottlenecks that are in place as follows:

1) The small 2”, 4” and 6”Ø cast iron and galvanized steel water mains that still exist throughout the community need to be upgraded to the minimum recommended pipe size of 8”Ø. In general, current design standards for public water mains do not allow any pipes less than 8”Ø to be used. Newer water pipe is now constructed of either lined ductile iron or inert PVC to minimize future corrosion and scaling. The older cast iron and galvanized steel pipes are reactive with the water and form corrosion by-products on the inner pipe surfaces that lead to scale formation and the loss of pipe cross-sectional area. This further diminishes fire flow and pressure in these lines.

2) Hydraulic bottlenecks in the present water system need to be removed. When the new reservoir was constructed, a 12”Ø ductile iron feeder main was installed between the reservoir and Battle Avenue. However, this line still feeds into smaller lines to the far west on Battle Avenue and to the Maine Maritime Academy campus off Pleasant Street and Main Street as well as to the downtown area along Main Street. Hydraulic modeling of the water system suggests that the extension of the 12”Ø water main along Battle Avenue and down through the center of the system along Main Street to Perkins Street and Water Street would significantly improve fire flow capacity. With this new main, the fire flows in the downtown commercial area would reach 2500 GPM and fire flows along higher elevations on Battle Avenue near Maine Maritime Academy could reach 2,000 GPM. A central 12”Ø water main would also serve as the distribution feeder from which future larger 8”Ø lines could be extended to other areas along the periphery of the system (Appendix B).



PENOBSCOT BAY
HATCH COVE
CASTINE HARBOR
WADSWORTH COVE ROAD
270' DRILLED WELL
BRITISH CANAL WELL
BRITISH CANAL
WINDMILL HILL
(PRIVATE LINE)
CASTINE CEMETERY
60' WELLS (NOT USED)
STATE STREET RESERVOIR 390,000 GALLONS OVERFLOW EL. 144.5
WWTP
SPRING STREET WELL FIELD
GOLF COURSE
(SUMMER LINE ONLY)
WADSWORTH COVE ROAD PUMP HOUSE AND ARSENIC TREATMENT SYSTEM, CHLORINE CHEMICAL DOSAGE POINT
350' DRILLED WELL (300' @ 8", 50' @ 6")
FORT GEORGE
BATTLE AVENUE
BANK
HEALTH CENTER
STATE STREET
COURT STREET
DYER LANE
SCHOOL STREET
GREEN STREET
MAIN STREET
STEVENS STREET
PLEASANT STREET
MAINE MARITIME ACADEMY
WATER STREET
SPRING STREET
HATCH COVE ROAD
MAYO POINT ROAD
SEA STREET
DRESSER STREET
TARRATINE STREET
WITHERLE HILL CONCRETE RESERVOIR 75' ID x 9'-9" DEEP 648,000 GALLONS OVERFLOW EL. 215' ±
265' DRILLED WELL
BATTLE AVENUE PONDS AND WELL
PUNCH BOWL
#1
#2
#3
#4
#5
SEASONAL BASINS
PUMP HOUSE AND FILTRATION SYSTEM, CHLORINE CHEMICAL DOSAGE POINT
WATER DEPARTMENT BUILDING
CLEARWELL, EL. 133.0±
PARK ROAD
LATOUR STREET
MADOCKAWANDO ROAD
PERKINS STREET
(SUMMER LINE ONLY)
MAP LEGEND
WELL
HYDRANT W/ VALVE
HYDRANT W/O VALVE
PIV
GATE VALVE
UNDER 4"ø
4"ø
6"ø
8"ø
12"ø
NOTE: ALL PIPES ARE CAST IRON UNLESS OTHERWISE NOTED.
N
0
300'
600'
TOWN OF CASTINE, MAINE
WATER SYSTEM MAP
FIGURE 8
OLVER ASSOCIATES INC.
ENVIRONMENTAL ENGINEERS
290 MAIN STREET
WINTERPORT, MAINE

In order to assess the long-term capital improvement needs of the Castine water distribution system, Table 9 presents a summary of the current line sizes on each village street:

TABLE 9: EXISTING CASTINE VILLAGE WATER DISTRIBUTION SYSTEM NEEDS

STREET/LOCATION	PIPE SIZE (IN.)	LONG TERM REQUIRED ACTION
1. BATTLE AVENUE		
Perkins to Madockawando	8"Ø	Good condition
Madockawando to Latour	8"Ø	Good condition
Latour to Tarratine	8"Ø	Increase to 12"Ø equivalent
Tarratine to Pleasant	8"Ø	Increase to 12"Ø equivalent
Pleasant to Main	8"Ø	Increase to 12"Ø equivalent
2. COURT STREET		
Tarratine to Dresser	2"Ø	Increase to 8"Ø
Dresser to Pleasant	2"Ø	Increase to 8"Ø
Pleasant to Main	8"Ø	Good condition
Main to Green	6"Ø	Increase to 8"Ø
Green to State	6"Ø	Increase to 8"Ø
State to Spring	6"Ø	Increase to 8"Ø
3. DRESSER LANE		
Court to Water	8"Ø	Good condition
4. DYER LANE		
Court to Water	6"Ø	Increase to 8"Ø
5. GREEN STREET		
Court to Perkins	8"Ø	Good condition
6. LATOUR STREET		
Battle to Midpoint	2"Ø	Increase to 8"Ø
Midpoint to Perkins	-	Loop dead end to Perkins St.

STREET/LOCATION	PIPE SIZE (IN.)	LONG TERM REQUIRED ACTION
7. MADOCKAWANDO ROAD		
Battle to Midpoint	2”Ø	Increase to 8”Ø
Midpoint to Perkins	2”Ø	Increase to 8”Ø
8. MAIN STREET		
Battle to Stevens	6”Ø	Increase to 12”Ø
Stevens to Court	6”Ø	Increase to 12”Ø
Court to Water	6”Ø	Increase to 12”Ø
9. PERKINS STREET		
Battle to Madockawando	6”Ø	Increase to 8”Ø
Madockawando to Latour	6”Ø	Increase to 8”Ø
Latour to Tarratine	6”Ø	Increase to 8”Ø
Tarratine to Dresser	6”Ø	Increase to 8”Ø
Dresser to Pleasant	6”Ø	Increase to 8”Ø
Pleasant to Main	6”Ø	Increase to 8”Ø
10. PLEASANT STREET		
Battle to Stevens	6”Ø	Increase to 8”Ø
Stevens to Court	6”Ø	Increase to 8”Ø
Court to Perkins	6”Ø	Increase to 8”Ø
11. SCHOOL STREET		
Court to Court	8”Ø	Good condition
12. SPRING STREET		
Court to Water	6”Ø	Increase to 8”Ø
13. STATE STREET		
Battle to Midpoint	6”Ø	Increase to 8”Ø
Midpoint to Court	6”Ø	Increase to 8”Ø

STREET/LOCATION	PIPE SIZE (IN.)	LONG TERM REQUIRED ACTION
14. TARRATINE STREET		
Battle to Midpoint	8”Ø	Good condition
Midpoint to Perkins	6”Ø	Increase to 8”Ø
15. WADSWORTH COVE ROAD		
Battle to Pump House	8”Ø	Good condition
16. WATER STREET		
Perkins to Main	2”Ø	Increase to 8”Ø
Main to Dyer	4”Ø	Increase to 8”Ø
Dyer to Spring	6”Ø	Increase to 8”Ø

As shown above in Table 9, a significant portion of the present water distribution system is in poor condition, undersized and does not meet current design standards. If water distribution projects were to be conducted on a stand alone basis, their overall priority for implementation might be:

1) Address deficient 2”Ø and 4”Ø lines first.

2) Provide 12”Ø distribution main feeder line down Main Street from reservoir to Perkins Street and Water Street.

3) Upgrade all remaining lines to 8”Ø over time as part of other work.

Since water distribution system needs will not be considered alone, but will likely be viewed in conjunction with the Town’s overall roadway, drainage and sewer system needs, it is suggested that water main projects be scheduled as part of other work planned for each area. In order to establish priorities between various areas of Town, if all other infrastructure conditions appear equal, the fact that one area might have a 2”Ø water main while another area might have a 6”Ø main should sway the decision towards the replacement of the smaller water main.

6. INITIAL RECOMMENDATIONS FOR LONG TERM INFRASTRUCTURE IMPROVEMENTS

The Town of Castine owns and operates four discrete, but also interrelated, public infrastructure systems that provide roadway access, runoff drainage and management, sanitary sewage collection and treatment, and potable water treatment and distribution for the village area. Each of these four infrastructure components has been reviewed in the previous four sections of this report. All four infrastructure systems have significant capital deficiencies that will eventually need to be addressed by the Town at substantial cost. The Town has been making improvements to each of these systems over the years, but the rate of these improvements has not kept pace with the increasing age and rate of deterioration of some of these components. A point in the future will come when the Town will need to take significant measures to modernize its infrastructure. To avoid the need to expend large amounts of limited financial resources all at once, it is best to phase these improvements in over time. In our opinion, the current state of many infrastructure components suggests that the time to begin this process is now before further deterioration can occur. The development of this Master Plan for infrastructure improvements is an important first step to begin the process of these long term remediation efforts.

The suggested infrastructure issues that Castine must address as it moves forward include the following:

1) Roadways throughout the village are in need of improvements. As discussed in Section 2 of this report, there are just under 40,000 LF of roadway in the village. Of these roads, 13,000 LF, or one-third, are currently rated as being in poor condition with severe pavement cracking, deformation and rutting. About 3,400 LF, or nearly ten percent, are rated as being very poor which means that the roadway has deteriorated to the point of near structural failure. These conditions are caused, in large part, by the lack of adequate gravel base below many paved roads and by the equal lack of proper roadbed drainage to remove water that is saturating the soils below the roadway. Another 3,500 LF of roads, or an additional ten percent, are rated as being fair which suggests that they are beginning to show signs of deterioration. They will likely reach the category of being in poor condition within the next three to five years after additional exposure to weathering and freeze/thaw cycles. In general, about forty percent of Castine's village roadway system requires attention.

2) Drainage systems around the village are a combination of open ditches and piped storm drains. Of Castine's four infrastructures, the drainage system is the most random in terms of its layout and configuration. As with many older systems, drainage in Castine appears to have evolved over the years without an overall plan or sizing method on how best to convey runoff out to the Harbor. As discussed in

Section 3 of this report, about 13,000 LF, or one-third, of all village areas have drainage systems that do not have sufficient capacity to meet the current design standard of passing a twenty-five year storm. Many of the open ditches throughout the village are poorly defined and subject to erosion. Many of the existing drain pipes and catchbasins are in poor structural condition. The easements for numerous outfall pipes to the Harbor are poorly defined. As Castine addresses its roadway issues, it is important to consider making improvements to the drainage systems within the same areas as well. As noted above, there is a strong correlation between poor roadway drainage and the accelerated deterioration of roadway structures and pavement.

3) Sanitary sewers throughout Castine have received significant attention over the past thirty-five years as the result of regulatory scrutiny from EPA and DEP. As discussed in Section 4 of this report, much of the sewer system was originally constructed of old, small 6"Ø vitrified clay pipes that have been in service for over 100 years. When the wastewater treatment plant was constructed in 1973, excessive leakage from groundwater infiltration and stormwater inflow hydraulically overloaded the facility and caused it to violate its discharge license. The Town has been making steady improvements since that time to replace its oldest and leakiest clay sewer sections with new 8"Ø PVC pipe. The Town also recently upgraded the treatment plant to give it the capacity to process the normal peak hourly flows that exist in the system. At this time, the Town will likely not receive any additional DEP mandates to repair its sewer collection system, at least in the near future. However, there are still about 5,000 LF of old 6"Ø vitrified clay pipe remaining within some areas of the village. Some of this pipe is in danger of insipient failure due to its poor structural condition. For example, attempts to flush some of the clay sewers a few years ago had to be stopped because the water pressure from the flusher truck began to demolish pieces of the clay pipe. As the Town's other infrastructure improvement needs are considered, the goal of completely eliminating the remaining 5,000 LF of clay pipe, which represents about twenty percent of the total sewer system, should be a long term goal. In addition, the Town also faces a DEP mandate to extend its treatment plant outfall out to deeper water to keep it submerged at low tide and to achieve proper effluent dispersion under all tidal conditions.

4) Water mains throughout Castine were discussed in Section 5 of this report. In order to achieve acceptable delivery pressure and fire flow capacity throughout the village, the Town needs to gradually eliminate some of the hydraulic bottlenecks that exist in the piping system and that limit its flow capacity. About 20,000 LF, or sixty percent, of Castine's water distribution system has pipe sizes smaller than the 8"Ø minimum required by current design standards to provide fire flow capacity. Fifteen percent of the system, representing about 4,500 LF, is constructed of water pipe in the 2"Ø to 4"Ø size range. Previous hydraulic models of the system have strongly

recommended that the 12”Ø main distribution line that now extends from the reservoir to Battle Avenue be further extended down Battle Avenue to Main Street and down Main Street to the commercial district. This would provide much needed fire flow capacity to the developed commercial area as well as to Maine Maritime Academy. It would also provide a conduit for increased water delivery capacity down through the center of the distribution system. Future water main upgrades could feed off this central line to improve the delivery capacity to peripheral areas of the system.

As the Town moves forward over the coming years and decades to improve its village area infrastructure, it is important to plan ahead with projects that continually address the multiple needs of Castine’s roadways, drainage, sewers and water systems. Each of these infrastructure areas has equal importance in its own regard and it would be easy to develop a list of priorities for each area that would justify moving forward with projects that address only that area’s needs while ignoring the needs of the other three infrastructure components. For example, the Pavement Management Plan presented in Section 2 focuses entirely on optimizing the surfaces of the Town’s roadways without regard for the utilities beneath the roads. It is important that the Town not proceed with roadway projects that could result in new pavement now, only to have the new pavement torn up in the future when utilities are replaced. The needs of all four utilities must be considered together in developing the most cost-effective capital improvements plan to be phased in over the next few decades.

Table 10 provides an overall summary of Castine’s infrastructure needs as presented in previous sections of this report. Areas of improvement that were noted for roadway, drainage, sewer and water works are listed for each area of the village:

TABLE 10: SUMMARY OF IDENTIFIED INFRASTRUCTURE REMEDIATION PROJECTS

STREET/LOCATION	ROADWAY	DRAINAGE	SEWERS	WATER
1. BATTLE AVENUE				
Perkins to Madockawando	Crack seal	Add pipes	Fix 400 LF	-
Madockawando to Latour	Reconstruct	-	-	-
Latour to Tarratine	Reconstruct	-	-	Upsize
Tarratine to Pleasant	Reclaim	-	-	Upsize
Pleasant to Main	Reclaim	-	-	Upsize

STREET/LOCATION	ROADWAY	DRAINAGE	SEWERS	WATER
2. COURT STREET				
Tarratine to Dresser	Reconstruct	Replace	Replace 6”VC	Upsize 2”Ø
Dresser to Pleasant	Reconstruct	Replace	Replace 6”VC	Upsize 2”Ø
Pleasant to Green	Reconstruct	Replace	-	Upsize 6”Ø
Green to Dyer	Overlay	Replace	-	Upsize 6”Ø
Dyer to State	Overlay	-	-	Upsize 6”Ø
State to Spring	Overlay	-	-	Upsize 6”Ø
3. DRESSER LANE				
Court to Perkins	-	-	-	-
4. DYER LANE				
Court to Water	Reconstruct	Replace	Replace 6”VC	Upsize 6”Ø
5. GREEN STREET				
Court to Water	-	-	-	-
6. LATOUR STREET				
Battle to Midpoint	Reconstruct	Add pipes	-	Upsize 2”Ø
Midpoint to Perkins	Reconstruct	Add pipes	-	Loop
7. MADOCKAWANDO ROAD				
Battle to Midpoint	Reclaim	Add pipes	-	Upsize 2”Ø
Midpoint to Perkins	Reclaim	Add pipes	-	Upsize 2”Ø
8. MAIN STREET				
Battle to Stevens	Crack seal	-	Replace 6”VC	Upsize 6”Ø
Stevens to Court	Crack seal	-	Replace 6”VC	Upsize 6”Ø
Court to Water	Overlay	Upsize	Replace 6”VC	Upsize 6”Ø
9. PERKINS STREET				
Battle to Madockawando	Reconstruct	Add pipes	-	Upsize 6”Ø
Madockawando to Latour	Crack seal	Add pipes	-	Upsize 6”Ø
Latour to Tarratine	Crack seal	Add pipes	-	Upsize 6”Ø
Tarratine to Dresser	Overlay	Upsize	Replace 6”VC	Upsize 6”Ø
Dresser to Pleasant	Overlay	Upsize	Replace 6”VC	Upsize 6”Ø
Pleasant to Main	Overlay	Upsize	-	Upsize 6”Ø

STREET/LOCATION	ROADWAY	DRAINAGE	SEWERS	WATER
10. PLEASANT STREET				
Battle to Stevens	Overlay	-	-	Upsize 6"Ø
Stevens to Court	Overlay	Upsize	-	Upsize 6"Ø
Court to Perkins	Overlay	Upsize	-	Upsize 6"Ø
11. SCHOOL STREET				
Court to Court	Crack seal	-	-	-
12. SPRING STREET				
Water to Court	Crack seal	-	-	Upsize 6"Ø
13. STATE STREET				
Battle to Midpoint	Reconstruct	-	Services	Upsize 6"Ø
Midpoint to Court	Reconstruct	-	Services	Upsize 6"Ø
14. STEVENS STREET				
Main to Pleasant	Reconstruct	Add pipes	-	-
15. TARRATINE STREET				
Battle to Midpoint	-	-	-	-
Midpoint to Perkins	-	Upsize	-	Upsize 6"Ø
16. WADSWORTH COVE ROAD				
Battle to Pump House	Overlay	-	-	-
Pump House Along Beach	Reconstruct	-	-	-
Beach to Route 166	-	-	-	-
17. WATER STREET				
Perkins to Main	Overlay	Upsize	Services	Upsize 2"Ø
Main to Dyer	Crack seal	-	Services	Upsize 4"Ø
Dyer to Spring	Crack seal	Add pipes	Services	Upsize 6"Ø
18. TREATMENT PLANT				
Outfall to Harbor	-	-	Extend	-

The infrastructure areas presented above in Table 10 summarize the overall needs of the village area. This data can be viewed in many different ways from various perspectives. Different priorities for phased infrastructure improvements can be developed depending on those perceptions. Given the significance of the Town's capital planning needs, we expect that the final development of priorities for phased improvements will occur only after considerable debate, public discussion and citizen input on how best to move forward. Towards that end, the need for public hearings and input for the final development of this plan cannot be overemphasized. It is also important to note that this capital planning program is a dynamic document that will extend many years into the future. The plan should be reviewed and modified periodically to reflect the changing needs of the community as well as changes that might take place in the condition of the infrastructure over time.

As an initial starting point for this discussion, we propose the following beginning rationale for the preliminary development of a framework to establish priorities for each infrastructure improvement project in Castine village:

- A few sections of roadway in Castine have been rated as being in very poor condition. This implies that the pavement and roadway structure has failed or is on the verge of failing. This can lead to safety issues for vehicular and pedestrian traffic. We would suggest that a high priority be placed on addressing those areas defined as being in very poor condition. If buried utilities in these very poor condition roadway areas are also present, the completion of utility projects should be done at the same time for the maximum benefit to the Town.

- The updated Pavement Management Plan suggested that several areas of newer roadway surfaces be protected by either crack sealing or a pavement overlay to extend their useful life. To the extent that no other utility improvement work will be constructed in those areas in the immediate future, we believe that it makes sense for the Town to initiate these proactive and protective measures early on in the planning process to preserve the condition of some of the roadways for as long as possible. In areas where the pavement management plan has recommended crack sealing or an overlay from strictly a pavement perspective, we would recommend delaying those efforts if it appears likely that there will be other utility work needed on those same streets in the foreseeable future. In addition, we would place the extension of the wastewater treatment plant's outfall sewer as an early priority in the capital plan because it is almost certain that this will be mandated by DEP as the result of their new effluent dispersion toxicity regulations.

- We would then suggest focusing efforts on areas of the infrastructure that prioritize immediate roadway improvements concurrent with necessary water system fire flow and capacity issues. Several detailed hydraulic studies of the Castine water system have strongly recommended that a 12”Ø water main be extended from the reservoir to Battle Avenue, down Battle Avenue and then down Main Street. As noted in previous sections of this report, there are numerous other roadway, drainage and sewer system infrastructure needs along those same areas. Because of the water system’s importance to the safety of the community, we recommend that a high priority be given to these types of projects which will also lay the foundation for future phased improvements to other areas of the water system.

- Several streets in Castine are in poor condition and also have underlying inadequate water lines as small as 2”Ø below the streets. Some areas also have concurrent sewer system and drainage deficiencies. We suggest that these areas be considered next in establishing project priorities.

- Once the above high priority issues are addressed, the remaining areas of the Town’s infrastructure can be considered based on the overall assessment of roadway conditions and utility improvement needs as discussed in this report.

Recognizing that the above rationale for project prioritization may be changed after additional public discussion and input is received, we will nonetheless proceed to develop a proposed Master Plan for preliminary discussion based upon the above rationale. In reviewing the overall conclusions previously presented for each infrastructure component, we would note the following:

1) Perkins Street from Battle Avenue to Madockawando Road was rated as one of the worst roads in Castine and is in very poor condition. The present roadbed consists of 2” of hot mix and 2.5” of cold mix over only 4” of gravel base. This is insufficient to support wheel loadings from vehicles which has led to the pumping of clay subgrade particles up into the shallow gravel layer. The drainage ditches beside the road are undersized which leaves the roadbed in a saturated condition. In addition, overland runoff from the Battle Avenue area between Perkins Street and Madockawando Road travels over private property to the north of Perkins Street and overloads the ditch on Perkins Street. The water line in this area is 6”Ø and contributes to high lead and copper corrosion problems that have been measured at this location in the water system. As an initial capital improvement project, we recommend that the Perkins Street roadway be rebuilt between Battle Avenue and Madockawando Road. At the same time, piped drainage should be properly sized and installed. The drains should be extended up Battle Avenue to collect the Town’s street runoff that now flows across private properties without easements and ends up on Perkins Street. The water line along Perkins Street should be upgraded at the same time to 8”Ø. The main sewer line in this area is mostly in good

condition, but service lines to each property should be upgraded. A short 400 LF section of old 6”Ø clay pipe should be replaced.

2) The Wadsworth Cove Road contains a section between the Pump House and the beach that is rated as being in very poor condition. It is one of the most deteriorated roadways in the village. This road was classified as being very poor because it is at the point of reaching complete pavement and road base failure. It should be fully reconstructed before the road becomes impassible. The roadway from Battle Avenue to the Pump House should be overlain with new pavement at the same time. Some minor ditch reshaping work should be conducted during this project, but no other buried utility work will be needed.

3) The Town’s 2009 Pavement Management Plan Update recommended several roadway areas that are in good condition to be preserved with crack seal. Other areas of roadway in fair condition were recommended to receive an overlay of pavement to prevent further deterioration. In areas where no immediate utility work is needed, we recommend that the Town undertake an early improvement project to address these areas by providing crack seal and overlays where indicated. This will preserve the useful life of these roads. Areas recommended in the Pavement Management Plan that would benefit from such an approach include:

   - Overlay Court Street from Main Street to Spring Street.
   - Overlay Pleasant Street from Battle Avenue to Perkins Street.
   - Crack seal Battle Avenue from Perkins Street to Madockawando Road.
   - Crack seal School Street from Court Street to Court Street.
   - Crack seal Water Street from Main Street to Spring Street.
   - Crack seal Tarratine Street from Battle Avenue to Perkins Street.

   Other areas were recommended for early overlay or crack sealing in the Pavement Management Plan including Main Street and Perkins Street. We would delay maintenance on those roadways because of significant utility needs that should be addressed in those areas in the near future.

4) DEP has enacted new regulations for treatment plant outfalls which will not allow the continued use of the Town’s current outfall since it is exposed on the beach at low tide. Dispersion studies are currently being conducted to determine how far the outfall must be extended. Preliminary data suggest that it will need to extend from 250 to 400 feet out into the Harbor. This project will be mandated by consent agreement if it is not initiated proactively by the Town.

5) The present Battle Avenue roadway between Madockawando Road and Main Street was rated to be in poor condition. Soils borings suggest that there is sufficient gravel present between Tarratine Street and Main Street to support a reclamation project. However, a deep layer of cold mix between Madockawando Road and Tarratine Street suggests that full reconstruction is needed in that area. The best long term result for the road, as well as a cost-effective approach for the Town, would be to do a combination approach where part of the street is reclaimed while the other part is reconstructed. The open ditches along Battle Avenue should be reshaped as part of the project. No sewer system repairs are needed. The water line along this roadway is 8"Ø ductile iron in good condition. Previous hydraulic studies have recommended that a 12"Ø line be installed between the Reservoir Road and Main Street to improve pressure and fire flow delivery throughout the village. The present 8"Ø ductile iron line can be left in place and a parallel water line installed next to this location. The exact sizing of the new line should be determined by hydraulic modeling during the final design of the project. Since Battle Avenue represents a major transportation route for traffic to numerous side streets and also for water from the reservoir, it makes sense to address this area early in the capital program.

6) As an early capital improvement project, we would suggest that the Town focus next on Main Street. While this road is in good condition compared to other roads in Castine, it has significant infrastructure deficiencies below the road. The 6"Ø water line below Main Street restricts fire flows to Maine Maritime Academy, the downtown commercial area and numerous side streets that connect to Main Street. In addition, the 6"Ø clay sewer below the road is one of the oldest and leakiest lines in the entire village. Many sewer services from older homes along Main Street have had plugging problems in the past. The upgrade and separation of these services would allow significant sources of private inflow to be removed from the sewer system. The drainage capacity along the street is substandard at its lower end. Since the pavement on Main Street is in good condition, it was recommended as a candidate for an immediate overlay in the Pavement Management Plan. We would suggest an alternate project scope that would consist of increasing the water main size to 12"Ø, replacing the clay sewers with 8"Ø PVC and installing properly sized storm drains which could be used later to also solve drainage problems on adjacent Court Street and Stevens Street. It is likely that the majority of the road base in this area could be reclaimed instead of fully reconstructing the street. The sidewalks on both sides of the street will also need to be upgraded to enhance the main gateway into the downtown area that this street represents.

7) We would recommend that the Town next focus on Court Street between Tarratine Street and Main Street. The roadway in this area is generally in poor condition with inadequate base gravel and a layer of cold mix. This road should be fully

reconstructed. At the same time, all of the deficient utilities below the road should be replaced. The drain pipes in this area are grossly undersized and need to be upgraded. The 6”Ø clay sanitary sewer line in this area is in extremely poor condition and in danger of failure. The area is served by an old 2”Ø water line which should be increased to 8”Ø. The larger water line would also increase the looping effect within the water distribution system between Main Street, Pleasant Street, Tarratine Street and Dresser Lane.

8) Latour Street would be a good candidate for the next infrastructure project. This street is served by a 2”Ø water line which only goes halfway down the street. The pipe size should be increased to 8”Ø and looped between Battle Avenue and Perkins Street. The present open drain system on the street is undersized and subject to erosion. It should be replaced by a piped drainage system. The pavement on the roadway is in poor condition with insufficient gravel that has previously been reclaimed. It should be fully reconstructed. No work on the sewer system is needed.

9) Madockawando Road has similar issues as Latour Street. The pavement is in fair to poor condition. It appears to have a deeper base material which may allow it to be reclaimed instead of reconstructed. The ditches along this steep street should be replaced by a piped drain system. No improvements to the sewer system are needed, but the inadequate 2”Ø water line should be replaced and upgraded to an 8”Ø size as soon as possible.

10) Water Street from Pleasant Street to Dyer Street represents a short section of road with some significant utility issues. The roadway has previously been reclaimed and is in fair condition. However, the water line in this area is only 2”Ø between Pleasant Street and Main Street and 4”Ø between Main Street and Dyer Street. The drains in this area are borderline to marginal between Main Street and Green Street. This area would be a good candidate for a water line upgrade project followed by the reconstruction of the roadway.

11) Dyer Lane has significant issues with most of its infrastructure. The roadway is in poor condition with an inadequate 4” gravel base and a 3” cold mix layer. The sewer line between Court Street and Water Street is 6”Ø clay pipe with a high leakage rate. The water line is 6”Ø and should be upgraded to 8”Ø. The piped drain lines along the street are not large enough to convey peak flows during a twenty-five year storm event. All of the utilities on Dyer Street should be upgraded followed by a full reconstruction project of the roadway.

12) State Street is presently in poor condition between Battle Avenue and Court Street. This roadway is heavily traveled and serves as a major transportation link between

Route 166 and Castine village. The road base has previously been reclaimed so any future work would require full reconstruction. The sewer on this road is relatively new, but services to each building are leaking and need to be inspected and separated. The present open ditch system should be retained. As part of the project, the 6”Ø water line should be upgraded to an 8”Ø size.

13) Perkins Street between Madockawando Road and Main Street is presently in good condition, but has significant areas of buried utility deficiencies. These utilities should be replaced. It may be possible to reclaim portions of this road versus full reconstruction. The street has a combination of open ditches and piped drains, most of which are undersized. New piped drainage systems should be installed over the entire street strength. The sanitary sewer system is in good condition, but some private services are prone to leakage and should be replaced. The water line along the entire street is 6”Ø and should be upgraded to 8”Ø when this work occurs. This would improve water delivery to the numerous sidestreets that abut Perkins Street.

14) Stevens Street would represent a relatively small infrastructure project to follow a larger project on Perkins Street. This would allow the Town a year to catch up on construction finances after completing Perkins Street. Stevens Street should have a full road reconstruction with improved drainage systems. No sewer or water utilities are present on the street.

15) At the conclusion of the above fourteen projects, the Town will have addressed most of its high priority infrastructure issues. Several areas of the roadway and infrastructure which are presently in good condition will likely need to be reviewed at this point in the plan implementation which could be fifteen to twenty years from now. These remaining areas include:

- Water Street between Dyer Lane and Spring Street, and also Spring Street between Water Street and Court Street, should be scheduled as a future project at the completion of the above higher priority work. These streets are presently in good condition since they were repaved in recent years. The drainage systems consist of localized piped drains, along with open ditches in some areas. This same configuration can be maintained, but additional piped drains in some areas will help to remove water in front of some properties where the ditches are not well defined. The sewer along this street is in good condition, but the 6”Ø water line should be upgraded to 8”Ø. Some building sewers may also need to be modified due to past leakage.

- Court Street from Pleasant Street to Spring Street was previously overlayed in an earlier phase project. By the time that the Town reaches this area again, it is likely that the pavement overlay will need to be replaced with a full rebuild. Whenever work is done on this street, the 6”Ø water line that is presently in place should be upgraded to 8”Ø. Improvements to the drainage system should be made at the same time.

- Pleasant Street is currently in good condition and will have received a recommended pavement overlay earlier in the schedule. In the future, the project will likely again need pavement work. At that time, it would appropriate to consider upsizing the 6”Ø water line on this street to at least 8”Ø. There are also several undersized storm drains which should be improved.

- Tarratine Street between Battle Avenue and Perkins Street is presently in good condition, but will need improvements in the future once the rest of the defined upgrade projects are completed. At that time, some drainage improvements should be considered at the lower end of the street to remove hydraulic limitations. The sewer line on this street is in good condition, but there are still areas where the old 6”Ø water line requires replacement.

The locations of these eighteen project priorities are shown on Figure 9 at the end of this section.

In order to assist the Town of Castine in implementing this long term plan for infrastructure improvements, order-of-magnitude preliminary cost estimates for each project priority were developed. These costs are summarized below in Table 11. Detailed costs estimates for each project are presented in Appendix A. These preliminary cost estimates represent typical price ranges for each work scope item based upon 2009 dollars. In order to prepare these estimates, the anticipated scope of work for each proposed project was developed at a very preliminary conceptual level. The estimates include allowance for construction, design, inspection and contingency. As each project is authorized over the next few years, these estimates should be updated to reflect typical construction market conditions at that time. In addition, more detailed estimates should be prepared for each project once final design has been completed and a takeoff from preliminary design plans can be made. Given the uncertainty of the future construction market and the different perspectives for each project that contractors may have as they prepare their future bids, these preliminary cost estimates should not be viewed as representing the exact low bid that will be received. These costs are intended to be used for preliminary planning purposes at the current concept level and are based on representative costs for similar work scopes in the current economy. Table 11 presents the estimated total cost for each project in 2009 dollars and then divides each project into the categories of roadway/drainage work, sewer work and water system work. It is assumed that the roadway/drainage work will be funded through general taxation while water and sewer work may be funded through user fees for these enterprise accounts.

TABLE 11: PRELIMINARY COST ESTIMATES FOR INFRASTRUCTURE IMPROVEMENTS

PRIORITY	PROJECT/AREA	TOTAL COST ($)	ROAD/ DRAIN COSTS ($)	SEWER COSTS ($)	WATER COSTS ($)
1.	Perkins St. (Battle to Madockowando)	850,000	535,000	99,000	216,000
2.	Wadsworth Cove Rd. (Battle to Beach)	400,000	400,000	-	-
3.	Miscellaneous Overlay/Crack Sealing	245,000	245,000	-	-
4.	Treatment Plant Outfall Extension	300,000	-	300,000	-
5.	Battle Avenue (Madockowando to Main)	760,000	465,000	-	295,000
6.	Main Street (Battle to Water)	1,915,000	1,051,000	435,000	429,000
7.	Court Street (Tarratine to Main)	1,070,000	646,000	212,000	212,000
8.	Latour Street (Battle to Perkins)	510,000	340,000	-	170,000
9.	Madockawando Road (Battle to Perkins)	495,000	300,000	-	195,000
10.	Water Street (Pleasant to Dyer)	540,000	373,000	-	167,000
11.	Dyer Street (Court to Water)	335,000	188,000	84,000	63,000
12.	State Street (Battle to Court)	355,000	185,000	25,000	145,000
13.	Perkins Street (Madockawando to Main)	1,920,000	1,136,000	227,000	557,000
14.	Stevens Street (Main to Pleasant)	100,000	100,000	-	-
15.	Water/Spring Street (Dyer to Court)	1,210,000	790,000	75,000	345,000
16.	Court Street (Pleasant to Spring)	1,715,000	1,255,000	-	460,000
17.	Pleasant Street (Battle to Water)	770,000	456,000	-	314,000
18.	Tarratine Street (Battle to Perkins)	535,000	425,000	-	110,000
	TOTALS	$14,025,000	$8,890,000	$1,457,000	$3,678,000

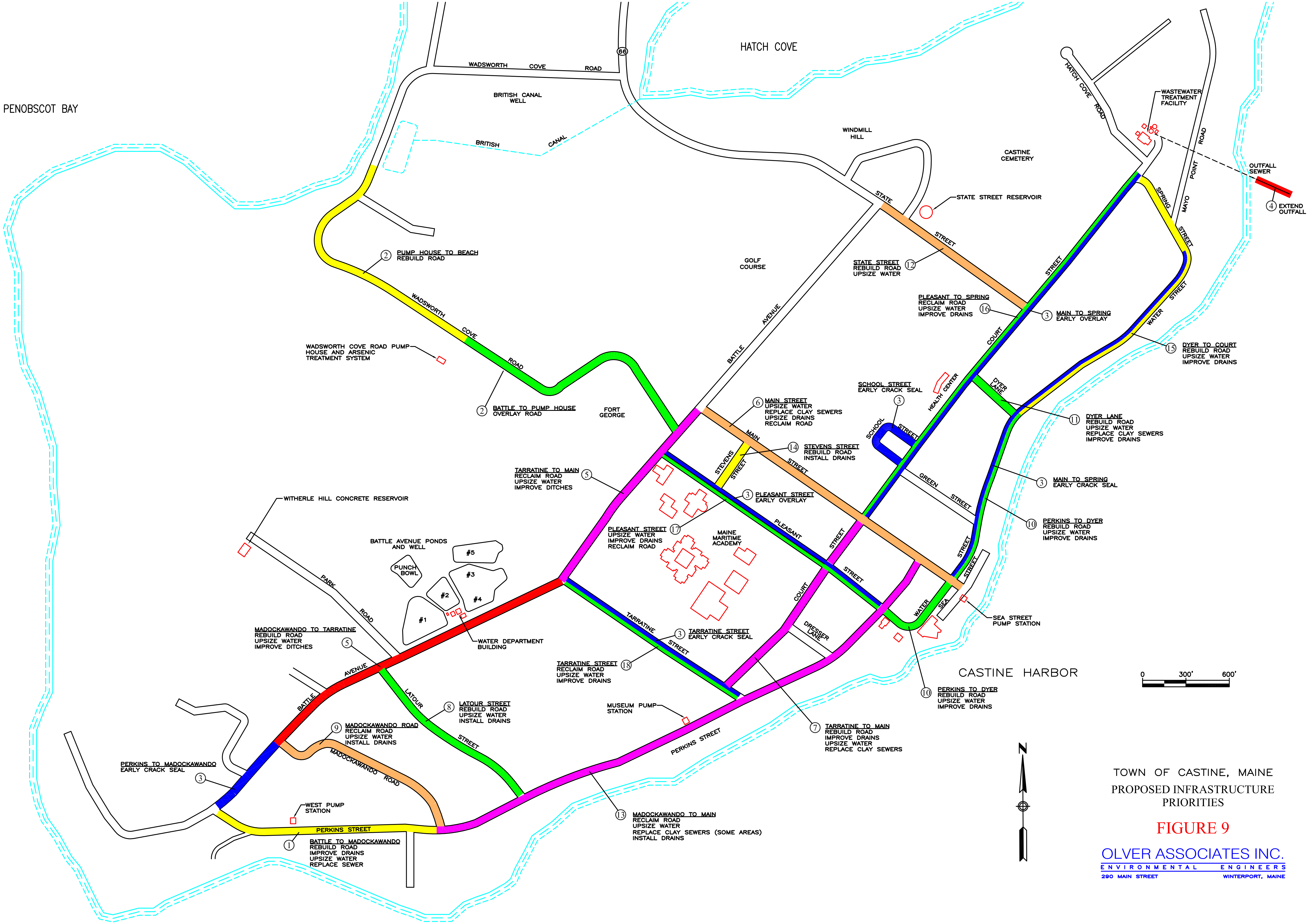
As shown above in Table 11, the Town would have to invest $14,025,000 to address the infrastructure needs identified in this study. This represents $8,890,000 of roadway pavement and drainage improvements, $1,457,000 in sewer system improvements, and $3,678,000 in water system improvements. At the completion of these projects, the Town will have addressed roadbed, pavement and drainage issues throughout the majority of its deficient roadways. Future repairs beyond that point would be periodic crack sealing and overlay for the next several cycles. However, when this occurs, the drainage systems that are needed to prolong the life of these roads would already be in place so that future road maintenance work would not be as extensive as at present. In addition, the Town would have finally eliminated all of its old 100 year, old 6"Ø clay sewers that have leaked profusely for the past century. The Town would also have upgraded its water system so that all distribution mains would meet the current design standard of 8"Ø for fire flow.

Implementing this type of extensive infrastructure improvement program represents a substantial undertaking for the Town. However, failure to begin addressing these infrastructure deficiencies will not make future costs any less. Eventually, these systems will need to be upgraded. It will be more cost-effective and beneficial to the Town in the long run to proactively plan these improvements in order to avoid having to make them at a future date under emergency conditions should a failure occur.

The challenge of implementing an infrastructure Master Plan is to develop a program schedule that is consistent with the Town's financial ability to fund the project. The priorities for these projects were established such that the early priorities represent the worst infrastructure deficiencies while the later projects can be delayed for many years. We recommend that the Town consider scheduling this work over perhaps a twenty year timeframe in order to spread the costs out over a reasonable time period. In addition, the public will be more tolerant of the projects if the entire community is not under construction all at once. If the project was scheduled over a twenty year cycle, the repavement of newly constructed streets will not reach the end of their useful life at the same time.

Communities facing similar infrastructure challenges generally bond the financing of their projects for long time periods in order to minimize their annual debt service payment. If the Town bonded the entire scope of work in five year increments, bonds would be retired every five years and the annual payments made for those bonds would be available to fund new projects. Longer bonding periods would result in lower annual payments, but would also result in higher interest expenditures.

As discussion takes place on the cost and priorities presented in this draft Master Plan over the coming weeks, a more precise project schedule can be developed that reflects the Town's input and public comments. At that time, a final plan will be published. Even then, the Master Plan should be viewed as a dynamic document that should be reviewed periodically and modified to reflect changing conditions in the community, changing construction prices and changes in the infrastructure’s condition that may occur.



TOWN OF CASTINE, MAINE

PROPOSED INFRASTRUCTURE PRIORITIES

FIGURE 9

OLVER ASSOCIATES INC.
ENVIRONMENTAL ENGINEERS
290 MAIN STREET WINTERPORT, MAINE

APPENDIX A

DETAILED PRELIMINARY COST ESTIMATES FOR PROPOSED INFRASTRUCTURE PROJECT PRIORITIES

APPENDIX A.1 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE PERKINS STREET INFRASTRUCTURE IMPROVEMENTS
(BATTLE TO MADOCKAWANDO)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $10,000/LS	$ 10,000
25 EA	Test pits @ $250/EA	6,000
LS	Temporary erosion control @ $3000/LS	3,000
3000 CY	Roadway excavation @ $10/CY	30,000
2200 CY	Roadway gravel base/subbase @ $20/CY	44,000
4200 SY	Filter fabric @ $2/SY	9,000
800 TONS	4” Roadway pavement @ $90/TON	72,000
2 EA	Manhole removal @ $200/EA	1,000
400 LF	8”Ø PVC sewer @ $90/LF	36,000
300 LF	4”Ø PVC building sewer @ $55/LF	17,000
2 EA	4’Ø PVC precast manholes @ $3500/EA	7,000
2 EA	Clay dams @ $1500/EA	3,000
1700 LF	8”Ø DI water main @ $70/LF	119,000
300 LF	¾”Ø Water service @ $50/LF	15,000
12 EA	Curb stop/corporation @ $200/EA	3,000
2 EA	Wedge valves @ $1500/EA	3,000
3 EA	Fire hydrants/valves @ $4000/EA	12,000
200 LF	12”Ø SICPE drain @ $55/LF	11,000
500 LF	15”Ø SICPE drain @ $65/LF	33,000
600 LF	18”Ø SICPE drain @ $70/LF	42,000
1000 LF	24”Ø SICPE drain @ $85/LF	85,000
300 LF	4”Ø Building drain stubs @ $45/LF	14,000
24 EA	4’Ø Precast catchbasins @ $2800/EA	67,000
2000 SF	Trench insulation @ $2/SF	4,000
LS	Loam and seed @ $20,000/LS	20,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$668,000
	Design allowance	45,000
	Inspection allowance	55,000
	Ledge removal allowance	15,000
	Contingency allowance	67,000
	ESTIMATE	$850,000
	Rounded	($850,000)

APPENDIX A.2 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE WADSWORTH COVE ROAD INFRASTRUCTURE IMPROVEMENTS (BATTLE TO BEACH)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $10,000/LS	$ 10,000
LS	Temporary erosion control @ $4000/LS	4,000
4200 CY	Roadway excavation @ $10/CY	42,000
3100 CY	Roadway gravel base/subbase @ $20/CY	62,000
6200 SY	Filter fabric @ $2/SY	12,000
600 TONS	1 ½” Pavement overlay @ $90/TON	54,000
1200 TONS	4” Roadway pavement @ $90/TON	108,000
4000 LF	Ditch excavation/grading @ $4/LF	16,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$320,000
	Design allowance	20,000
	Inspection allowance	25,000
	Contingency allowance	32,000
	ESTIMATE	$397,000
	Rounded	($400,000)

APPENDIX A.3 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE INITIAL OVERLAYS/SEALING INFRASTRUCTURE IMPROVEMENTS (COURT/PLEASANT/BATTLE/SCHOOL/WATER/TARRATINE)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $1000/LS	$ 1,000
1600 TONS	1 ½” Pavement overlay @ $90/TON	144,000
LS	Crack sealant @ $50,000/LS	50,000
6000 LF	Ditch excavation/grading @ $4/LF	24,000
	Subtotal	$219,000
	Design allowance	1,000
	Inspection allowance	1,000
	Contingency allowance	22,000
	ESTIMATE	$243,000
	Rounded	($245,000)

APPENDIX A.4 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE OUTFALL EXTENSION INFRASTRUCTURE IMPROVEMENTS (250' TO 400' INTO HARBOR)

DESCRIPTION	ESTIMATE
Existing outfall modification	$10,000
Mobilization of barge	10,000
Outfall extension	100,000
Precast collars	25,000
Rip-rap	50,000
General conditions	20,000
Subtotal	$215,000
Geotechnical exploration	20,000
Design allowance	15,000
Inspection allowance	17,000
Ledge removal allowance	10,000
Contingency allowance	22,000
ESTIMATE	$299,000
Rounded	($300,000)

APPENDIX A.5 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE BATTLE AVENUE INFRASTRUCTURE IMPROVEMENTS (MADOCKAWANDO TO MAIN)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $10,000/LS	$ 10,000
LS	Temporary erosion control @ $4,000/LS	4,000
4300 CY	Roadway excavation @ $10/CY	43,000
4600 SY	Roadway reclamation @ $4/SY	18,000
4000 CY	Roadway gravel base/subbase @ $20/CY	80,000
6300 SY	Filter fabric @ $2/SY	13,000
2100 TONS	4” Roadway pavement @ $90/TON	189,000
3000 LF	8”Ø DI water main @ $70/LF	210,000
2 EA	Wedge valves @ $1500/EA	3,000
4000 LF	Ditch excavation/grading @ $4/LF	16,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$598,000
	Design allowance	40,000
	Inspection allowance	48,000
	Ledge removal allowance	15,000
	Contingency allowance	60,000
	ESTIMATE	$761,000
	Rounded	($760,000)

APPENDIX A.6 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE MAIN STREET INFRASTRUCTURE IMPROVEMENTS
(BATTLE TO WATER)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $25,000/LS	$ 25,000
70 EA	Test pits @ $250/EA	18,000
LS	Temporary erosion control @ $5,000/LS	5,000
1500 CY	Roadway excavation @ $10/CY	15,000
7100 SY	Roadway reclamation @ $4/SY	28,000
2500 CY	Roadway gravel base/subbase @ $20/CY	50,000
2000 SY	Filter fabric @ $2/SY	4,000
2100 TONS	4” Roadway pavement @ $90/TON	189,000
1000 CY	Sidewalk excavation @ $10/CY	10,000
500 CY	Sidewalk base @ $20/CY	10,000
2300 SY	Concrete sidewalk @ $90/SY	207,000
4000 LF	Concrete curbing @ $30/LF	120,000
9 EA	Manhole removal @ $200/EA	2,000
2100 LF	8”Ø PVC sewer @ $90/LF	189,000
1600 LF	4”Ø PVC building sewer @ $55/LF	88,000
10 EA	4’Ø PVC precast manholes @ $3500/EA	35,000
2 EA	Clay dams @ $1500/EA	3,000
2100 LF	12”Ø DI water main @ $95/LF	200,000
1600 LF	¾”Ø Water service @ $50/LF	80,000
35 EA	Curb stop/corporation @ $200/EA	7,000
6 EA	Wedge valves @ $1500/EA	9,000
5 EA	Fire hydrants/valves @ $4000/EA	20,000
10 EA	Remove catchbasins @ $200/EA	2,000
200 LF	12”Ø SICPE drain @ $55/LF	11,000
800 LF	24”Ø SICPE drain @ $85/LF	68,000
1600 LF	4”Ø Building drain stubs @ $45/LF	72,000
10 EA	4’Ø Precast catchbasins @ $2800/EA	28,000
3000 SF	Trench insulation @ $2/SF	6,000
LS	Loam and seed @ $20,000/LS	20,000
LS	Owner’s testing allowance @ $5000/LS	5,000
	Subtotal	$1,526,000
	Design allowance	105,000
	Inspection allowance	120,000
	Ledge removal allowance	15,000
	Contingency allowance	150,000
	ESTIMATE	$1,916,000
	Rounded	($1,915,000)

APPENDIX A.7 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE COURT STREET INFRASTRUCTURE IMPROVEMENTS
(TARRATINE TO MAIN)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
25 EA	Test pits @ $250/EA	6,000
LS	Temporary erosion control @ $2000/LS	2,000
3100 CY	Roadway excavation @ $10/CY	31,000
2500 CY	Roadway gravel base/subbase @ $20/CY	50,000
4600 SY	Filter fabric @ $2/SY	9,000
900 TONS	4” Roadway pavement @ $90/TON	81,000
300 CY	Sidewalk excavation @ $10/CY	3,000
150 CY	Sidewalk base @ $20/CY	3,000
800 SY	Concrete sidewalk @ $90/SY	72,000
3000 LF	Concrete curbing @ $30/LF	90,000
5 EA	Manhole removal @ $200/EA	1,000
1200 LF	8”Ø PVC sewer @ $90/LF	108,000
600 LF	4”Ø PVC building sewer @ $55/LF	33,000
4 EA	4’Ø PVC precast manholes @ $3500/EA	14,000
1500 LF	8”Ø DI water main @ $70/LF	105,000
600 LF	¾”Ø Water service @ $50/LF	30,000
10 EA	Curb stop/corporation @ $200/EA	2,000
4 EA	Wedge valves @ $1500/EA	6,000
3 EA	Fire hydrants/valves @ $4000/EA	12,000
5 EA	Remove catchbasins @ $200/EA	1,000
1800 LF	12”Ø SICPE drain @ $55/LF	99,000
600 LF	4”Ø Building drain stubs @ $45/LF	27,000
15 EA	4’Ø Precast catchbasins @ $2800/EA	42,000
2000 SF	Trench insulation @ $2/SF	2,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$ 846,000
	Design allowance	60,000
	Inspection allowance	68,000
	Ledge removal allowance	10,000
	Contingency allowance	85,000
	ESTIMATE	$1,069,000
	Rounded	($1,070,000)

APPENDIX A.8 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE LATOUR STREET INFRASTRUCTURE IMPROVEMENTS
(BATTLE TO PERKINS)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
12 EA	Test pits @ $250/EA	3,000
LS	Temporary erosion control @ $4000/LS	4,000
2100 CY	Roadway excavation @ $10/CY	21,000
1600 CY	Roadway gravel base/subbase @ $20/CY	32,000
3000 SY	Filter fabric @ $2/SY	6,000
600 TONS	4” Roadway pavement @ $90/TON	54,000
1400 LF	8”Ø DI water main @ $70/LF	98,000
300 LF	¾”Ø Water service @ $50/LF	2,000
12 EA	Curb stop/corporation @ $200/EA	3,000
2 EA	Wedge valves @ $1500/EA	3,000
3 EA	Fire hydrants/valves @ $4000/EA	12,000
1600 LF	12”Ø SICPE drain @ $55/LF	88,000
300 LF	4”Ø Building drain stubs @ $45/LF	14,000
16 EA	4’Ø Precast catchbasins @ $2800/EA	45,000
1000 SF	Trench insulation @ $2/SF	2,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$404,000
	Design allowance	28,000
	Inspection allowance	32,000
	Ledge removal allowance	5,000
	Contingency allowance	40,000
	ESTIMATE	$509,000
	Rounded	($510,000)

APPENDIX A.9 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE MADOCKAWANDO ROAD INFRASTRUCTURE IMPROVEMENTS (BATTLE TO PERKINS)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
15 EA	Test pits @ $250/EA	4,000
LS	Temporary erosion control @ $4000/LS	4,000
3100 SY	Roadway reclamation @ $4/SY	12,000
600 CY	Roadway gravel base/subbase @ $20/CY	12,000
600 TONS	4” Roadway pavement @ $90/TON	54,000
1400 LF	8”Ø DI water main @ $70/LF	98,000
400 LF	¾”Ø Water service @ $50/LF	20,000
15 EA	Curb stop/corporation @ $200/EA	3,000
2 EA	Wedge valves @ $1500/EA	3,000
3 EA	Fire hydrants/valves @ $4000/EA	12,000
1600 LF	12”Ø SICPE drain @ $55/LF	88,000
400 LF	4”Ø Building drain stubs @ $45/LF	18,000
16 EA	4’Ø Precast catchbasins @ $2800/EA	45,000
1000 SF	Trench insulation @ $2/SF	2,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$392,000
	Design allowance	27,000
	Inspection allowance	31,000
	Ledge removal allowance	5,000
	Contingency allowance	39,000
	ESTIMATE	$494,000
	Rounded	($495,000)

APPENDIX A.10 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE WATER STREET INFRASTRUCTURE IMPROVEMENTS
(PLEASANT TO DYER)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
10 EA	Test pits @ $250/EA	3,000
LS	Temporary erosion control @ $2000/LS	2,000
2500 CY	Roadway excavation @ $10/CY	25,000
2000 CY	Roadway gravel base/subbase @ $20/CY	40,000
3700 SY	Filter fabric @ $2/SY	7,000
700 TONS	4” Roadway pavement @ $90/TON	63,000
1200 LF	8”Ø DI water main @ $70/LF	84,000
200 LF	¾”Ø Water service @ $50/LF	10,000
10 EA	Curb stop/corporation @ $200/EA	2,000
10 EA	Wedge valves @ $1500/EA	15,000
2 EA	Fire hydrants/valves @ $4000/EA	8,000
5 EA	Remove catchbasins @ $200/EA	1,000
100 LF	12”Ø SICPE drain @ $55/LF	6,000
1200 LF	24”Ø SICPE drain @ $85/LF	102,000
100 LF	30”Ø SICPE drain @ $95/LF	10,000
200 LF	4”Ø Building drain stubs @ $45/LF	9,000
10 EA	4’Ø Precast catchbasins @ $2800/EA	28,000
1000 SF	Trench insulation @ $2/SF	2,000
LS	Loam and seed @ $5000/LS	5,000
LS	Owner’s testing allowance @ $1000/LS	1,000
	Subtotal	$428,000
	Design allowance	30,000
	Inspection allowance	34,000
	Ledge removal allowance	5,000
	Contingency allowance	43,000
	ESTIMATE	$540,000
	Rounded	($540,000)

APPENDIX A.11– PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE DYER LANE INFRASTRUCTURE IMPROVEMENTS (COURT TO WATER)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $2000/LS	$ 2,000
8 EA	Test pits @ $250/EA	2,000
LS	Temporary erosion control @ $2000/LS	2,000
900 CY	Roadway excavation @ $10/CY	9,000
700 CY	Roadway gravel base/subbase @ $20/CY	14,000
1200 SY	Filter fabric @ $2/SY	3,000
250 TONS	4” Roadway pavement @ $90/TON	23,000
800 LF	Concrete curbing @ $30/LF	24,000
400 LF	8”Ø PVC sewer @ $90/LF	36,000
200 LF	4”Ø PVC building sewer @ $55/LF	11,000
3 EA	4’Ø PVC precast manholes @ $3500/EA	11,000
2 EA	Clay dams @ $1500/EA	3,000
400 LF	8”Ø DI water main @ $70/LF	28,000
200 LF	¾”Ø water service @ $50/LF	10,000
5 EA	Curb stop/corporation @ $200/EA	1,000
2 EA	Wedge valves @ $1500/EA	3,000
1 EA	Fire hydrants/valves @ $4000/EA	4,000
5 EA	Remove catchbasins @ $200/EA	1,000
500 LF	12”Ø SICPE drain @ $55/LF	28,000
200 LF	30”Ø SICPE drain @ $95/LF	19,000
200 LF	4”Ø Building drain stubs @ $45/LF	9,000
6 EA	4’Ø precast catchbasins @ $2800/EA	17,000
500 SF	Trench insulation @ $2/SF	1,000
LS	Loam and seed @ $3000/LS	3,000
LS	Owner’s testing allowance @ $1000/LS	1,000
	Subtotal	$265,000
	Design allowance	19,000
	Inspection allowance	21,000
	Ledge removal allowance	3,000
	Contingency allowance	27,000
	ESTIMATE	$335,000
	Rounded	($335,000)

APPENDIX A.12 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE STATE STREET INFRASTRUCTURE IMPROVEMENTS (BATTLE TO COURT)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
8 EA	Test pits @ $250/EA	2,000
LS	Temporary erosion control @ $/2000LS	2,000
2500 CY	Roadway excavation @ $10/CY	25,000
2000 CY	Roadway gravel base/subbase @ $20/CY	40,000
3700 SY	Filter fabric @ $2/SY	7,000
700 TONS	4” Roadway pavement @ $90/TON	63,000
300 LF	4”Ø PVC building sewer @ $55/LF	17,000
1200 LF	8”Ø DI water main @ $70/LF	84,000
300 LF	¾”Ø water service @ $50/LF	6,000
5 EA	Curb stop/corporation @ $200/EA	1,000
2 EA	Wedge valves @ $1500/EA	3,000
3 EA	Fire hydrants/valves @ $4000/EA	12,000
1200 LF	Ditch excavation/grading @ $4/LF	5,000
500 SF	Trench insulation @ $2/SF	1,000
LS	Loam and seed @ $5000/LS	5,000
LS	Owner’s testing allowance @ $1000/LS	1,000
	Subtotal	$279,000
	Design allowance	20,000
	Inspection allowance	22,000
	Ledge removal allowance	5,000
	Contingency allowance	28,000
	ESTIMATE	$354,000
	Rounded	($355,000)

APPENDIX A.13 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE PERKINS STREET INFRASTRUCTURE IMPROVEMENTS (MADOCKAWANDO TO MAIN)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $20,000/LS	$ 20,000
60 EA	Test pits @ $250/EA	15,000
LS	Temporary erosion control @ $5000/LS	5,000
11000 SY	Roadway reclamation @ $4/SY	44,000
1700 CY	Roadway gravel base/subbase @ $20/CY	34,000
2000 TONS	4” Roadway pavement @ $90/TON	180,000
5 EA	Manhole removal @ $200/EA	1,000
1200 LF	8”Ø PVC sewer @ $90/LF	108,000
500 LF	4”Ø PVC building sewer @ $55/LF	28,000
5 EA	4’Ø PVC precast manholes @ $3500/EA	18,000
4200 LF	8”Ø DI water main @ $70/LF	294,000
1500 LF	¾”Ø water service @ $50/LF	75,000
50 EA	Curb stop/corporation @ $200/EA	10,000
6 EA	Wedge valves @ $1500/EA	9,000
10 EA	Fire hydrants/valves @ $4000/EA	40,000
10 EA	Remove catchbasins @ $200/EA	2,000
1000 LF	12”Ø SICPE drain @ $55/LF	55,000
700 LF	15”Ø SICPE drain @ $65/LF	46,000
400 LF	18”Ø SICPE drain @ $70/LF	28,000
1700 LF	24”Ø SICPE drain @ $85/LF	145,000
1800 LF	30”Ø SICPE drain @ $95/LF	171,000
1500 LF	4”Ø Building drain stubs @ $45/LF	68,000
40 EA	4’Ø precast catchbasins @ $2800/EA	112,000
2000 SF	Trench insulation @ $2/SF	4,000
LS	Loam and seed @ $20,000/LS	20,000
LS	Owner’s testing allowance @ $4000/LS	4,000
	Subtotal	$1,536,000
	Design allowance	105,000
	Inspection allowance	120,000
	Ledge removal allowance	10,000
	Contingency allowance	150,000
	ESTIMATE	$1,921,000
	Rounded	($1,920,000)

APPENDIX A.14 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE STEVENS STREET INFRASTRUCTURE IMPROVEMENTS
(PLEASANT TO MAIN)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $1000/LS	$ 1,000
LS	Temporary erosion control @ $1000/LS	1,000
600 CY	Roadway excavation @ $10/CY	6,000
500 CY	Roadway gravel base/subbase @ $20/CY	10,000
1000 SY	Filter fabric @ $2/SY	2,000
200 TONS	4” Roadway pavement @ $90/TON	18,000
400 LF	12”Ø SICPE drain @ $55/LF	22,000
6 EA	4’Ø precast catchbasins @ $2800/EA	17,000
LS	Loam and seed @ $2000/LS	2,000
LS	Owner’s testing allowance @ $1000/LS	1,000
	Subtotal	$ 80,000
	Design allowance	6,000
	Inspection allowance	6,000
	Contingency allowance	8,000
	ESTIMATE	$100,000
	Rounded	($100,000)

APPENDIX A.15 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE WATER/SPRING STREETS INFRASTRUCTURE IMPROVEMENTS (DYER TO COURT)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
50 EA	Test pits @ $250/EA	12,000
LS	Temporary erosion control @ $5000/LS	5,000
4800 CY	Roadway excavation @ $10/CY	48,000
3600 CY	Roadway gravel base/subbase @ $20/CY	252,000
7000 SY	Filter fabric @ $2/SY	14,000
1400 TONS	4” Roadway pavement @ $90/TON	126,000
800 LF	4”Ø PVC building sewer @ $55/LF	44,000
2300 LF	8”Ø DI water main @ $70/LF	161,000
1200 LF	¾”Ø water service @ $50/LF	60,000
40 EA	Curb stop/corporation @ $200/EA	8,000
6 EA	Wedge valves @ $1500/EA	9,000
5 EA	Fire hydrants/valves @ $4000/EA	20,000
5 EA	Remove catchbasins @ $200/EA	1,000
800 LF	12”Ø SICPE drain @ $55/LF	44,000
800 LF	24”Ø SICPE drain @ $85/LF	68,000
800 LF	4”Ø Building drain stubs @ $45/LF	36,000
1200 LF	Ditch excavation/grading @ $4/LF	5,000
12 EA	4’Ø precast catchbasins @ $2800/EA	34,000
2000 SF	Trench insulation @ $2/SF	4,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$ 968,000
	Design allowance	65,000
	Inspection allowance	75,000
	Ledge removal allowance	5,000
	Contingency allowance	95,000
	ESTIMATE	$1,208,000
	Rounded	($1,210,000)

APPENDIX A.16 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE COURT STREET INFRASTRUCTURE IMPROVEMENTS (PLEASANT TO SPRING)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $20,000/LS	$ 20,000
30 EA	Test pits @ $250/EA	8,000
LS	Temporary erosion control @ $5000/LS	5,000
7000 CY	Roadway excavation @ $10/CY	70,000
5300 CY	Roadway gravel base/subbase @ $20/CY	106,000
11000 SY	Filter fabric @ $2/SY	22,000
2100 TONS	4” Roadway pavement @ $90/TON	189,000
500 CY	Sidewalk excavation @ $10/CY	5,000
250 CY	Sidewalk base @ $20/CY	5,000
1500 SY	Concrete sidewalk @ $90/SY	135,000
2500 LF	Concrete curbing @ $30/LF	75,000
3400 LF	8”Ø DI water main @ $70/LF	238,000
1000 LF	¾”Ø water service @ $50/LF	50,000
30 EA	Curb stop/corporation @ $200/EA	6,000
10 EA	Wedge valves @ $1500/EA	15,000
7 EA	Fire hydrants/valves @ $4000/EA	28,000
15 EA	Remove catchbasins @ $200/EA	3,000
500 LF	12”Ø SICPE drain @ $55/LF	28,000
2700 LF	24”Ø SICPE drain @ $85/LF	230,000
500 LF	4”Ø Building drain stubs @ $45/LF	23,000
1000 LF	Ditch excavation/grading @ $4/LF	4,000
30 EA	4’Ø precast catchbasins @ $2800/EA	84,000
1000 SF	Trench insulation @ $2/SF	2,000
LS	Loam and seed @ $15,000/LS	15,000
LS	Owner’s testing allowance @ $3000/LS	3,000
	Subtotal	$1,369,000
	Design allowance	95,000
	Inspection allowance	110,000
	Ledge removal allowance	5,000
	Contingency allowance	135,000
	ESTIMATE	$1,714,000
	Rounded	($1,715,000)

APPENDIX A.17 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE PLEASANT STREET INFRASTRUCTURE IMPROVEMENTS
(BATTLE TO WATER)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $10,000/LS	$ 10,000
30 EA	Test pits @ $250/EA	8,000
LS	Temporary erosion control @ $3000/LS	3,000
6500 SY	Roadway reclamation @ $4/SY	26,000
1000 CY	Roadway gravel base/subbase @ $20/CY	20,000
1400 TONS	4” Roadway pavement @ $90/TON	126,000
2100 LF	8”Ø DI water main @ $70/LF	147,000
1000 LF	¾”Ø water service @ $50/LF	50,000
30 EA	Curb stop/corporation @ $200/EA	6,000
6 EA	Wedge valves @ $1500/EA	9,000
5 EA	Fire hydrants/valves @ $4000/EA	20,000
200 LF	12”Ø SICPE drain @ $55/LF	11,000
1500 LF	24”Ø SICPE drain @ $85/LF	128,000
100 LF	30”Ø SICPE drain @ $95/LF	10,000
10 EA	4’Ø precast catchbasins @ $2800/EA	28,000
500 SF	Trench insulation @ $2/SF	1,000
LS	Loam and seed @ $10,000/LS	10,000
LS	Owner’s testing allowance @ $3000/LS	3,000
	Subtotal	$616,000
	Design allowance	40,000
	Inspection allowance	50,000
	Ledge removal allowance	5,000
	Contingency allowance	60,000
	ESTIMATE	$771,000
	Rounded	($770,000)

APPENDIX A.18 – PRELIMINARY ORDER-OF-MAGNITUDE PLANNING COST ESTIMATE FOR CASTINE TARRATINE STREET INFRASTRUCTURE IMPROVEMENTS (BATTLE TO PERKINS)

QUANTITY	DESCRIPTION	ESTIMATE
LS	Traffic control/mobilization @ $5000/LS	$ 5,000
8 EA	Test pits @ $250/EA	2,000
LS	Temporary erosion control @ $4000/LS	4,000
3800 CY	Roadway excavation @ $10/CY	38,000
2800 CY	Roadway gravel base/subbase @ $20/CY	56,000
5400 SY	Filter fabric @ $2/SY	11,000
1200 TONS	4” Roadway pavement @ $90/TON	108,000
700 LF	8”Ø DI water main @ $70/LF	49,000
200 LF	¾”Ø water service @ $50/LF	10,000
10 EA	Curb stop/corporation @ $200/EA	2,000
3 EA	Wedge valves @ $1500/EA	5,000
2 EA	Fire hydrants/valves @ $4000/EA	8,000
5 EA	Remove catchbasins @ $200/EA	1,000
200 LF	12”Ø SICPE drain @ $55/LF	11,000
700 LF	24”Ø SICPE drain @ $85/LF	60,000
100 LF	30”Ø SICPE drain @ $95/LF	10,000
200 LF	4”Ø Building drain stubs @ $45/LF	9,000
10 EA	4’Ø precast catchbasins @ $2800/EA	28,000
500 SF	Trench insulation @ $2/SF	1,000
LS	Loam and seed @ $5000/LS	5,000
LS	Owner’s testing allowance @ $2000/LS	2,000
	Subtotal	$425,000
	Design allowance	30,000
	Inspection allowance	35,000
	Ledge removal allowance	5,000
	Contingency allowance	42,000
	ESTIMATE	$537,000
	Rounded	($535,000)

APPENDIX B

SUMMARY OF DIRIGO WATER SYSTEM WATERCAD MODELING FOR FIRE FLOW CAPACITY

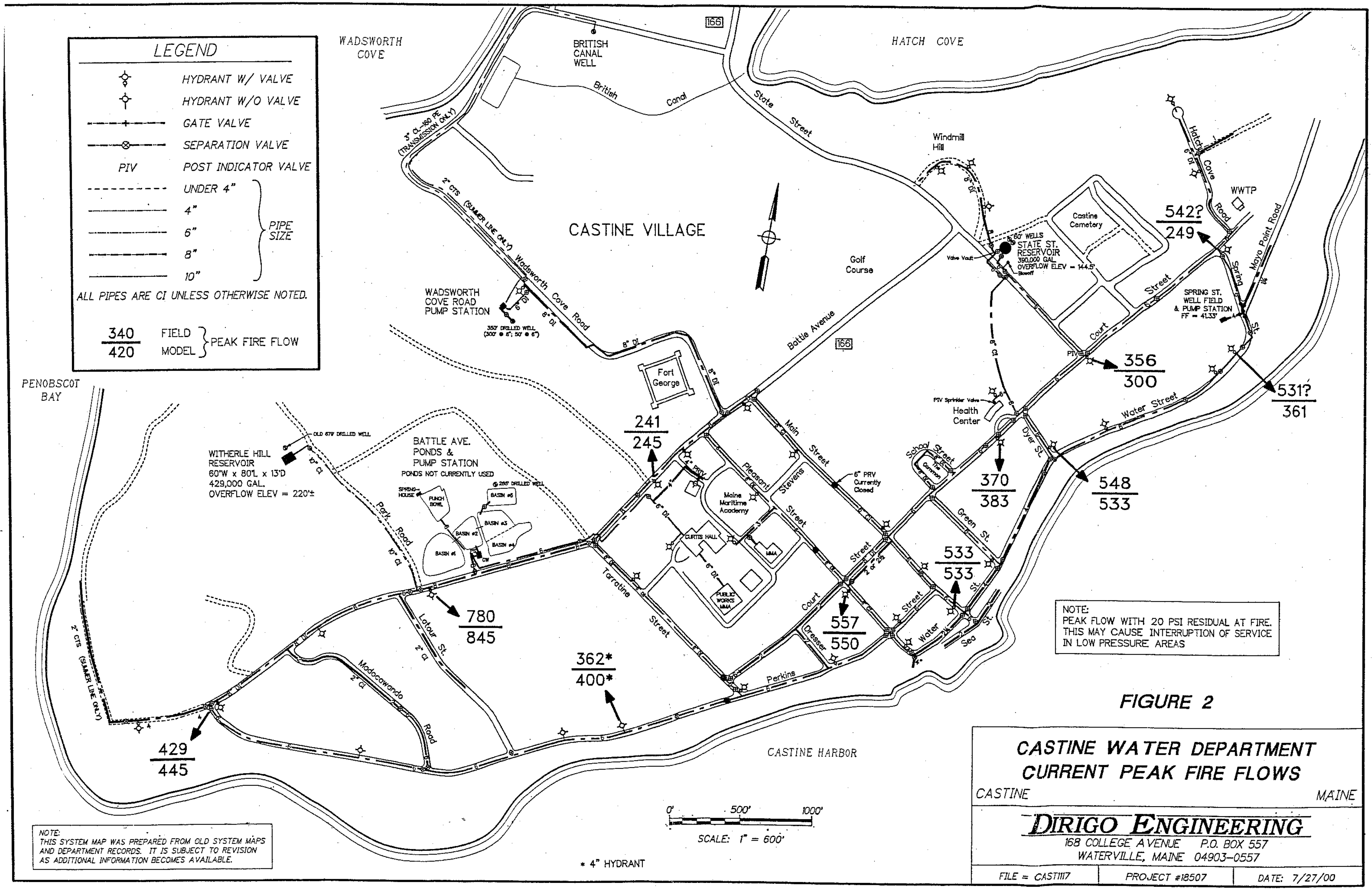


FIGURE 2

CASTINE WATER DEPARTMENT
CURRENT PEAK FIRE FLOWS

CASTINE MAINE

DIRIGO ENGINEERING
168 COLLEGE AVENUE P.O. BOX 557
WATERVILLE, MAINE 04903-0557

FILE = CAST1117 | PROJECT #18507 | DATE: 7/27/00

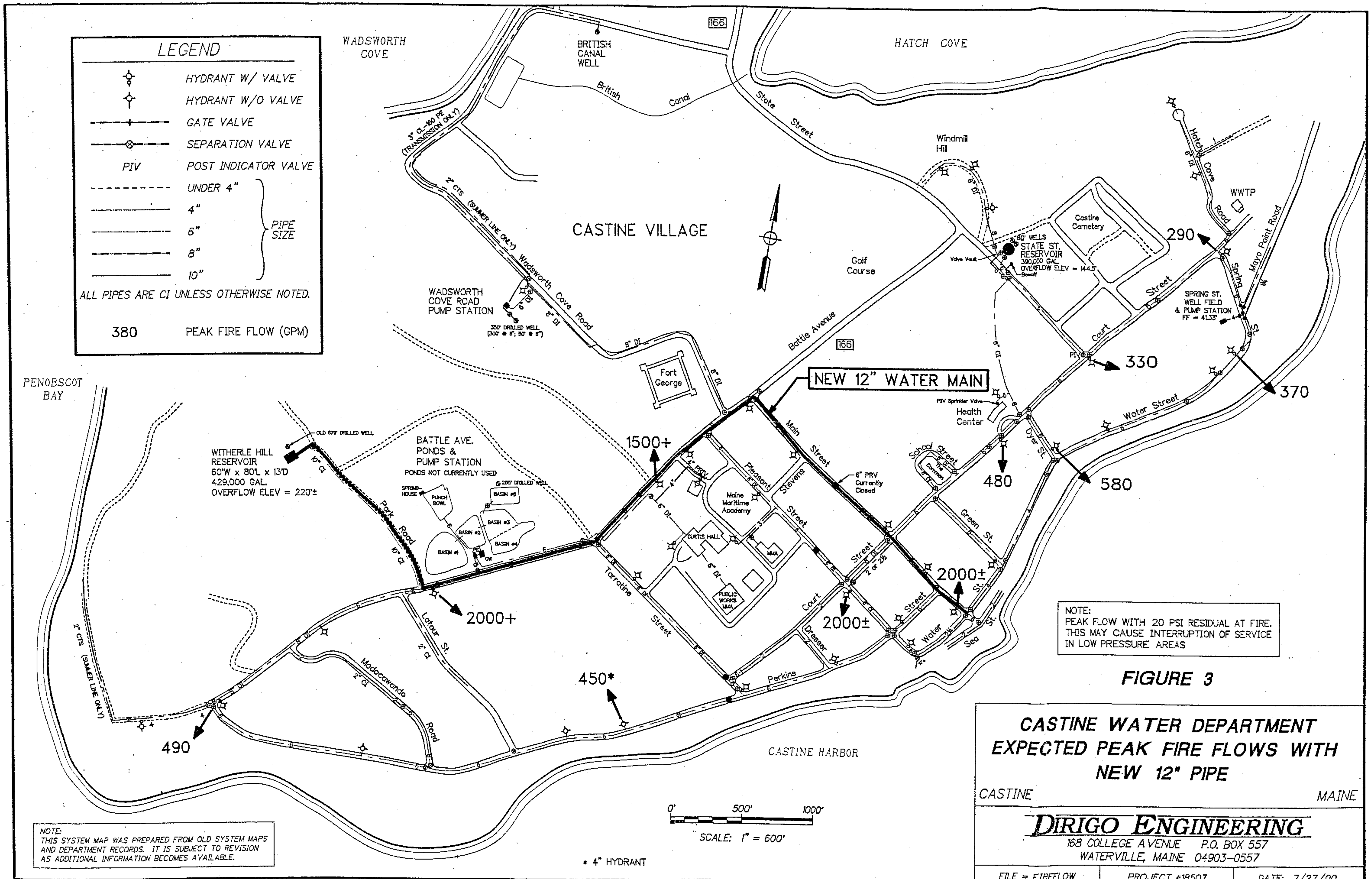


FIGURE 3

CASTINE WATER DEPARTMENT
EXPECTED PEAK FIRE FLOWS WITH NEW 12" PIPE

CASTINE MAINE

DIRIGO ENGINEERING
168 COLLEGE AVENUE P.O. BOX 557
WATERVILLE, MAINE 04903-0557

FILE = FIREFLOW | PROJECT #18507 | DATE: 7/27/00