City of Concord, NH

Storm Water Master Plan

April 2007

Final Report

Executive Summary

The City of Concord, New Hampshire, is developing a master plan to better manage storm water throughout the city as well as identify and plan various capital improvement projects. This report will be the basis for this effort.

Background

The City of Concord's drainage system handles all of the city's public storm water. This system stems from the early 1980s, when the City separated its combined sewer system. That project consisted largely of new sewer construction, in which the existing combined pipes were converted to drains.

Later, in the summer of 2000, Camp Dresser & McKee Inc. (CDM) prepared a Storm Water Master Plan for the City. The initial project intended to analyze all the city's drainage sub-basins, but the scope of work was later modified to reflect changing priorities for the City. The modified scope is considered Phase I. The project was also affected by information from initial field investigations, hydraulic modeling and other information generated by city-wide mapping.

In late 2004, the City of Concord and CDM signed an amendment to complete analysis of the remaining sub-basin and finalize the Storm Water Master Plan Report. The remaining work is considered Phase II. A revised report summarizing all work completed to date is included in this Final Submittal.

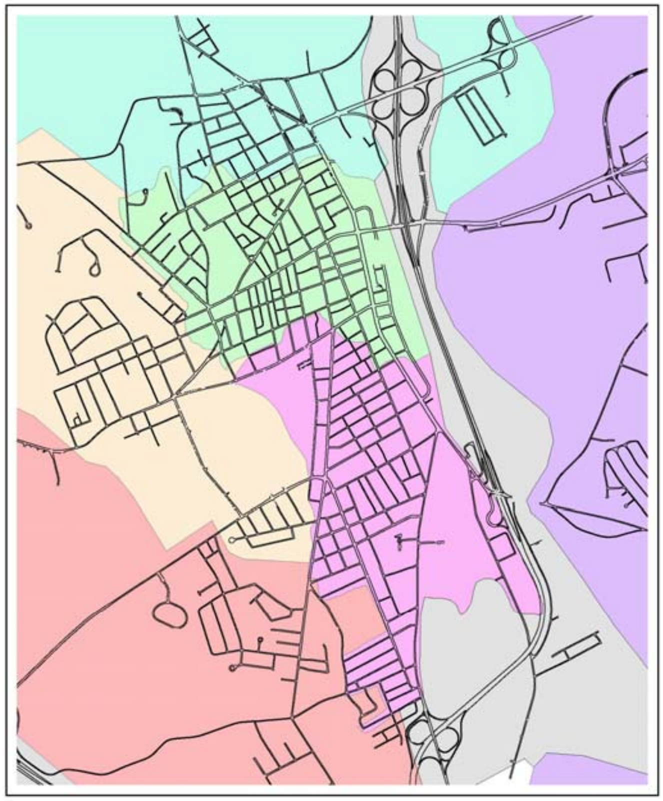
Purpose/Project Scope

The purpose of this report is to provide the City with a tool to better manage its drainage system. The report also includes a list of projects and a corresponding Capital Improvement Plan (CIP) for planning future projects. Other tasks include:

Task	Description
1. Data Collection	Collect plans, reports, and other information on the existing storm water system.
2. Field Survey	Collect additional system information where required, through field investigation.
3. Funding	Evaluate alternative methods of funding the City's storm water management program; apply for applicable grants.
4. Hydrology	Delineate select drainage basins in the City, and develop information about rainfall and runoff in these basins.
5. GIS	Develop a Geographic Information System (GIS) of the City's closed storm water system infrastructure.
6. Hydraulic Analysis	Create a computer simulation or spreadsheet model of select drainage basins in the City and/or perform TV or manhole inspections to evaluate the hydraulics of the system.
7. Develop Recommendations	Make recommendations to improve the system, based on the information collected and/or calculated through the above tasks, and based on input from the City.
8. Enterprise Fund	Evaluate the feasibility of funding the storm water capital improvements program with a storm water use fee.

Task	Description
9. NPDES Permitting	Discussion of EPA's Phase II Storm water permitting requirements; Prepare a storm water management plan suitable for fulfilling these requirements.
10. Project Meetings	Prepare for and attend meetings with Concord staff to present project progress and/or alternatives analysis.
11. Report Preparation	Prepare and distribute draft reports presenting results and analysis. Revise the reports based upon comments from Concord staff. Prepare and distribute final reports.
12. Public Meeting	Prepare for and present information at a public meeting to present information about the City's storm water plan and funding alternatives.

Two major tasks included detailed study (through either hydrologic and hydraulic modeling and/or field investigations) of two drainage basins – the Terrible Trapezoid and the Washington Street Basin. The report recommends several improvements within these basins. These two basins were intended to be "pilot areas" for determining a recommended approach for similar evaluations city-wide, ultimately resulting in a recommended storm water master plan for the entire city. However, the methods used in these sub-basins were time consuming and labor intensive. As a result, a different approach was used to evaluate the remaining sub-basins. These two areas were included in the July 2002 draft report submittal.



Terrible Trapezoid Area = Pink
Washington Street Area = Green

The report's third major task, resulting from the 2004 contract amendment, analyzes the remaining 10 drainage sub-basins. The approach used is more standardized across all the basins. Each sub-basin focused on its developed areas containing drain pipes. Smaller-diameter drain networks and outlying undeveloped areas were not investigated. A spreadsheet model incorporating the "Rational Method" was used to evaluate sub-basin physical characteristics and existing stormwater collection systems. These 10 areas are included in the report.

USEPA Storm Water Compliance

The Storm Water Master Plan was also prepared for the City of Concord to minimize storm water pollution from its system independent of the EPA regulations. EPA did not designate Concord as a regulated small Municipal Separate Storm Sewer System (MS4) community. Communities regulated as a small MS4 must:

SIX MINIMUM CONTROLS
1. Public education and outreach
2. Public participation and involvement
3. Illicit discharge detection and elimination
4. Construction site runoff control
5. Post-construction runoff control
6. Pollution prevention/good housekeeping

- Apply for a National Pollutant Discharge Elimination System (NPDES) permit
- Develop a storm water management program, including the "six minimum controls,"
- Implement the program using storm water management controls or best management practices (BMPs)
- Develop measurable goals and periodically evaluate the effectiveness of the program

If the Environmental Protection Agency (EPA) and New Hampshire Department of Environmental Services (DES) includes Concord in a Phase II program, the Storm Water Master Plan will help achieve compliance. Meanwhile, it will serve to direct Concord's storm water management and pollution minimization.

The following examples provide a BMP for two of the Six Minimum Controls, indicating the measurable goal and justification of the storm water management control:

BMP: Improve pet waste management in City parks by installing "pet waste stations" with waste receptacles, a supply of disposal waste collection bags, and scoops or shovels.
Measurable Goal: Reduce the amount of pet waste entering surface water bodies by 50 gallons during the 1st year.
Justification: When pet waste is not properly disposed of, it can wash into nearby waterbodies or can be carried by runoff into storm drains. Since storm drains do not connect to treatment facilities, but rather drain directly into lakes and streams, untreated animal feces can become a significant source of runoff pollution. Having designated places to dispose of the feces makes proper disposal more convenient for dog owners, and measuring the goal possible.

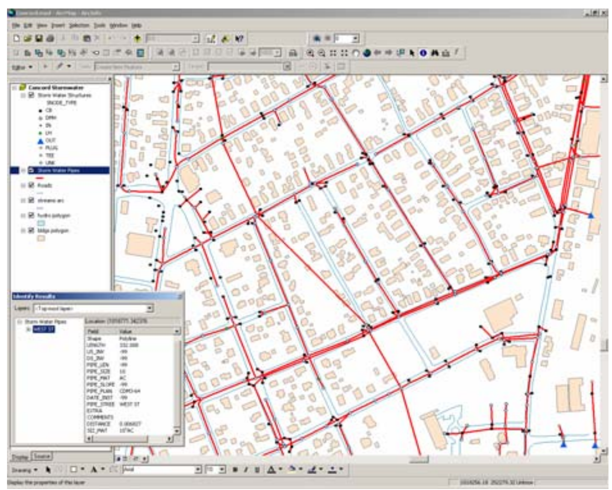
Example 1 - Minimum Control – Public Education and Outreach

BMP: Incorporate the use of road salt alternatives for roadway deicing.
Measurable Goals: During the 1st year, reduce the amount of road salt applied to roadways by 50% through the use of less-toxic alternatives, such as liquid calcium magnesium acetate (CMA).
Justification: CMA is just as effective as road salt at deicing, but it appears to be much less harmful to the environment and is less corrosive, causing less damage to roadways and vehicles.

Example 2 - Minimum Control - Pollution Prevention/Good Housekeeping

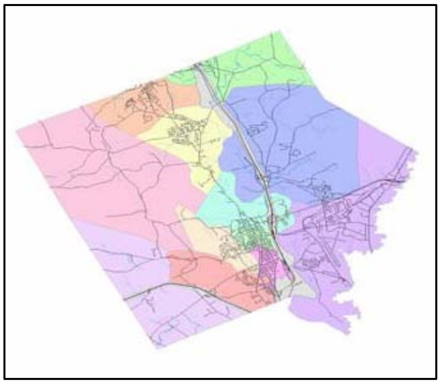
A detailed overview of the Phase II Storm Water Program, although not relevant to Concord at this time, is presented in the report. The EPA program can serve as a model of how to develop an effective storm water management plan, and can describe the steps other neighboring communities, such as Manchester, Hooksett, and Portsmouth, are taking towards storm water management. This section may also serve as guidance if Concord is designated in the future.

GIS System



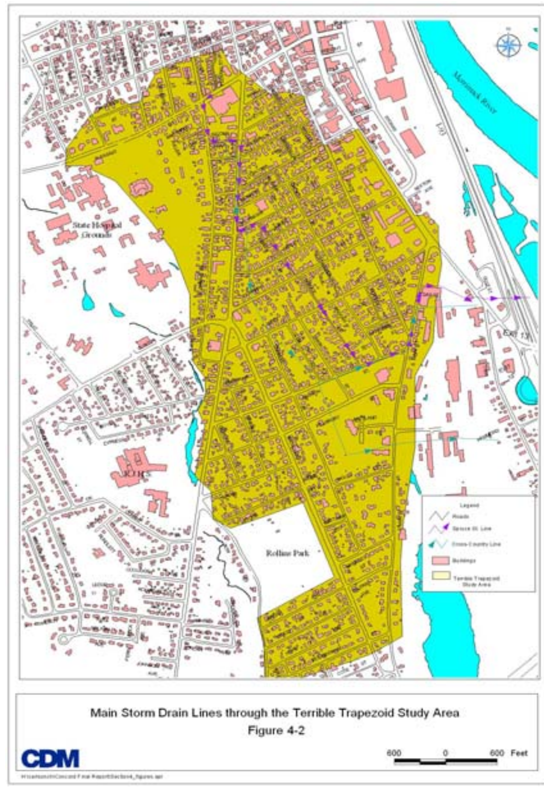
A Geographical Information System (GIS) is a common means of collecting and organizing geographically based information. The system is essentially a "smart" map, in that an electronic map on a desktop or laptop computer is linked to a database of information. The City maintains an extensive GIS database that includes information on parcels, zoning, utilities, aerial mapping, and many other layers. For this project, CDM has developed a GIS data layer consisting of storm water facilities. This storm water layer is supporting nearly all other aspects of the storm water master plan.

Custom applications have been developed for the City in addition to the standard applications built into the GIS software. These custom applications will allow easy access and analysis of the data. A field application for gathering manhole inspection data was also developed. This field application allows the City to locate and comment on structures in the field, and easily upload this information to the entire City's database.

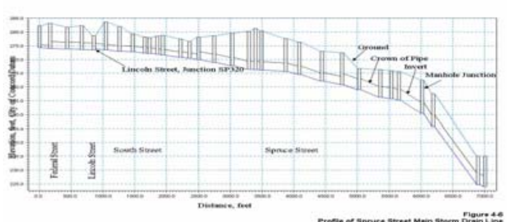


Sub-basin Analysis

Twelve drainage sub-basins were identified in Concord based on topography. For those twelve, three different methods of analysis were performed for this report:



Method #1 – This method focused on the Terrible Trapezoid sub-basin, which is an urban and densely populated downtown area with extensive drainage infrastructure. A detailed hydrologic and hydraulic study of the sub-basin resulted in a network model (SWMM) that plots the expected water levels within the system during four different rain events. The model also identifies problem areas or potential surcharging locations. From the model results, the report includes a discussion of the problems areas and recommended mitigation improvements.



Method #2 – This method focused on the Washington Street sub-basin, another urban and densely populated downtown area with extensive drainage infrastructure. Instead of a model/computer-based approach used in Method #1, this method focused on a physical approach. Manholes inspections and closed circuit television inspections were performed throughout the drainage pipe network. Each physical inspection was reviewed and summarized. From the summary, a list of recommendations was included.

Problem	Solution	Recommendation
Possible illicit connection on a cross country pipe west of Valley Street	TV 250 feet from Chestnut to Valley to pinpoint location; redirect illicit connection(s) to sanitary sewer line.	Investigate and redirect connection(s).
Small amount of grey-colored flow with a slight septic smell noticed on Valley Street between Forest Street and Liberty Street into White Park.	Repair of the above item may eliminate need for further investigation.	Investigate and redirect connection at Valley Street (above), and reassess.
Possible cross connection near North Main Street at Pearl Street	TV 350 feet along Pearl Street to pinpoint location; redirect illicit connection(s) to sewer in street.	Investigate and redirect connection(s).
Excess sedimentation in manholes	Schedule City vactor-truck to clean	Clean out excess sediment.

Priority Problems Identified During Manhole Inspection Program
Washington Street Drainage Basin

Method #3 – This method focused on the remaining ten sub-basins, which ranges in land use from downtown urban and very developed to rural and forested. The more developed areas containing existing drain pipes were the focus of each sub-basin. Smaller-diameter drain networks and outlying areas were not investigated. A "Rational Method" spreadsheet model was used to evaluate the sub-basins physical characteristics and existing stormwater collection systems. The expected pipe size resulting from the analysis was compared to the actual pipe in place. If the actual pipe sizes were too small, it was flagged (highlighted in blue as shown in the spreadsheet above) as a potential problem. Each sub-basin section summarizes the potential problems and recommends a solution.

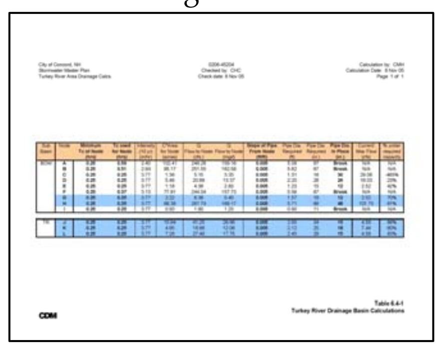
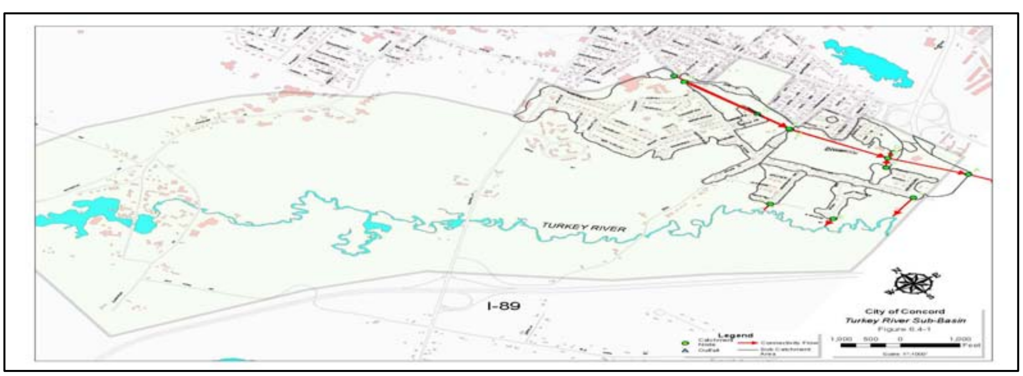


Table 6.4-1
Turkey River Drainage Basin Calculations
CDM



Outfall Inspections

An outfall inspection program was performed on all outfalls along the Merrimack River. The inspection program determined if illicit sewer connections were in the drainage system. As part of the analysis, water samples were also taken to measure contaminant levels. A map showing the location of each outfall and summary of the inspections are included in the report.

Outfall on the Merrimack River

Summary of Projects and Prioritization

A list of the problem areas identified in the twelve drainage basins throughout the City was formed. Each identified problem area was given a score based on eight types of criteria – property/traffic, pipe size, recurrence of problem, pipe age, stream impacts, constructability, impact on road projects and cost. The City and CDM agreed upon the criteria and associated score for each item. Once all the scores for each problem area was totaled, the list was sorted from highest score to lowest. The projects at the top of the list would be highest priority.

Criterion	Range	Maximum
Property/Traffic Impacts	0-5	5
Pipe Size	0-5	5
Percent Undersized	0-5	5
Recurrence of the Problem	0-5	5
Pipe Age	0-5	5
Stream Impacts	0-5	5
Constructability	0-5	5
Potential Road Projects	0-5	5
Project Cost	N/A	-
Total		**40**

Prioritization Criteria Summary

Capital Improvement Plan and Project Costs

A CIP was formed from the prioritized list mentioned above and will be the basis for selecting drainage projects in the City. The estimated project cost and fees are also listed with each problem area, to gauge the magnitude of each project.

Ninety-one projects were identified for the City. These projects included the problem areas and known problems for each of the 12 drainage basins throughout Concord. The estimated cost to complete all 89 projects is summarized in Section 10.

Total scores for the projects ranged from the lowest of 10 to the highest of 34. Fifteen projects scored 25 or more; 20 projects scored 20-24; 34 projects scored 15-19; and 20 projects scored 14 or less.

Evaluation of Funding Mechanisms

Alternative methods were evaluated for funding a storm water management program and implementing the recommendations in this report. Four funding mechanisms were evaluated: general fund, village districts, sewer user fees and storm water utility.

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Section 1
Introduction

1.1 Background

The City of Concord is undertaking a multi-purpose Storm Water Master Plan and Evaluation with the following objectives:

Concord wishes to improve the quality of storm water discharges

- This plan will be used as a tool the guide planned improvements to water quality of discharges from the City's storm water system, and if applicable, to meet the requirements of EPA's Phase II Storm Water permitting program. (Section 2).
- Developing a Geographic Information System (GIS) layer of the City's storm sewer system infrastructure to use as a tool in implementation of the Storm Water Master Plan. The GIS will act as a system inventory of the existing drainage system and a means to model the existing system for recommended improvements (Section 3).
- Conducting hydrologic and hydraulic analyses and field investigations of selected subbasins within the City, and recommending appropriate flood mitigation improvements (Sections 4. 5 and 6).
- Locating (for the GIS) and evaluating the conditions of drainage outfalls that discharge into the Merrimack River. This includes an evaluation of the water quality characteristics of dry weather discharges to prioritize detailed investigations of drainage systems tributary to outfalls in search of illicit connections to the storm sewer system (Section 7).
- Evaluating mechanisms for funding the operation and maintenance of storm water projects, including future capital projects (Section 8).
- Developing the basis of a Storm Water Capital Improvement Plan, based upon field investigations, hydrologic and hydraulic analyses, and the GIS database (Section 9).

The purpose of this report is to provide a summary of the work on this project to date.

At the beginning of the project, the City and CDM prepared a work plan to achieve the stated objectives. The work plan included the following tasks:

Task	Description
1. Data Collection	Collect plans, reports, and other information on the existing storm water system.
2. Field Survey	Collect additional system information where required, through field investigation.
3. Funding	Evaluate alternative methods of funding the City's storm water management program; apply for applicable grants.
4. Hydrology	Delineate select drainage basins in the City, and develop information about rainfall and runoff in these basins.
5. GIS	Develop a Geographic Information System (GIS) of the City's closed storm water system infrastructure.
6. Hydraulic Analysis	Create a computer simulation or spreadsheet model of select drainage basins in the City and/or perform TV or manhole inspections to evaluate the hydraulics of the system.
7. Develop Recommendations	Make recommendations to improve the system, based on the information collected and/or calculated through the above tasks, and based on input from the City.
8. Enterprise Fund	Evaluate the feasibility of funding the storm water capital improvements program with a storm water use fee.
9. NPDES Permitting	Determine whether the City will be a regulated community under EPA's Phase II Storm water permitting requirements; Prepare a storm water management plan suitable for fulfilling these requirements.
10. Project Meetings	Prepare for and attend meetings with Concord staff to present project progress and/or alternatives analysis. Prepare and distribute minutes for these meetings.
11. Report Preparation	Prepare and distribute draft reports presenting results and analysis. Revise the reports based upon comments from Concord staff. Prepare and distribute final reports.
12. Public Meeting	Prepare for and present information at a public meeting to present information about the City's storm water plan and funding alternatives. (This meeting has not yet taken place.)

Table 1-1

Project Tasks and Descriptions

1.2 Review of Project Tasks

Data Collection and Field Survey

Information gathered about the storm water system collected during task 1 and 2 was used to support all the other tasks. Field investigations included:

- Confirming pipe connectivity, delineating watershed basins, and estimating impervious surfaces in the Terrible Trapezoid. This is a drainage area located in downtown Concord. See Section 4 for more details.

- Dry weather screening of the outfalls discharging to the Merrimack River (CDM).

- Detailed manhole inspections in the Washington Street Basin (Severn Trent Pipeline Services under subcontract to CDM).
- TV Inspection of the "Spruce Street Brick Drain" in the Terrible Trapezoid (Severn Trent Pipeline Services under subcontract to CDM).
- TV Inspection of selected drains in the Terrible Trapezoid (City).
- Drainage area analysis performed on 10 other sections of the City. The drainage analysis consisted of existing pipe & culvery capacity analysis, connectivity, identified problems and recommendations. See Section 6 for more details.

Funding and Enterprise Fund

The first phase of tasks 3 and 8 was to produce a memorandum (Section 8) detailing the potential application of a storm water enterprise fund for the City of Concord, and to conduct preliminary discussions with City personnel.

Dry Weather Screening of Outfalls north of the I-93 Bridge was conducted in the Summer of 2002

In addition, grant applications were submitted to DES under the Non-Point Source Local Initiative Program and the Merrimack River Watershed Restoration Program for 2000 and 2001. These proposals did not receive funding.

The second phase has included further discussions with the City on funding its storm water management plan in the future. Section 8 summarizes the work done to date.

Hydrology and Hydraulics

Under the hydrology and hydraulics task, basins in the City were prioritized, and the higher priority basins were evaluated first. In this way, CDM and the City could tailor the evaluation to issues specific to each basin and adapt the evaluations as the task proceeded.

The City was broken into twelve basins, Fisherville, Heights, Horseshoe Pond, Hospital, Hoit, Oak Hill, Penacook, Terrible Trapezoid, Turkey Pond, Turkey River, Washington Street, and West Concord.

The first basin selected for evaluation was the area bounded by Pleasant Street, South Main Street, South Spring Street, and Allison Street. This area, informally known as the "Terrible Trapezoid", has experienced flooding complaints from several residents, and is characterized by older brick pipes that tend to back up. This area was hydraulically modeled and scenarios for mitigating flooding were examined. Methods and results of the study were presented in the report *"City of Concord, NH DRAFT Storm Water Master Plan Pilot Area – Terrible Trapezoid,"* dated May 2, 2001. Subsequent to the 2001 memo, the City and Severn Trent performed TV inspections of some of the pipes in this basin. The results and recommendations of the work in this basin are finalized in Section 4 of this present report.

The second basin selected for evaluation, informally known as the "Washington Street Basin," is the area roughly bounded by Franklin Street and Bishopsgate to the north, Ridge Road and Westbourne Street to the west, Warren Street and Concord Street to the south, and the river to the east. For this basin, a manhole field inspection program was conducted to assess sediment buildup and structural conditions within the basin. Severn Trent Pipeline Services, Inc, was retained to perform detailed manhole inspections. The information collected will also be useful to the GIS task. The findings and recommendations of the inspection program are found in Section 5 of this report.

After evaluation of these first two basins, a spreadsheet model was prepared to assess capacity issues in storm water collection pipes and culverts in the remaining City drainage basins. The model incorporated the rational method looking at the larger drainage basins in the 10 other sections of the City. The existing storm water pipes pipes were evaluated to determine their capacity as compared to the flows which they would encounter during a rain event. Under sized pipes were identified and determine to be an issue. Also, information regarding known potential problem locations in these basins was tabulated. These locations include observed periodic flooding, collapsed pipes, erosion, or blockage. The results and recommendations of the work to-date for these basins are found in Section 6 of this report.

All of the potential problem locations identified through the above analysis for all of the basins were then ranked based on criteria discussed with the City. The ranked locations form the basis for recommendations on system improvements, as summarized in Section 9 of this report.

Geographical Information Systems (GIS)
During the first phase of this task, CDM updated the City's GIS information to include all of the stormwater and sewer pipes shown on the 1983 sewer separation plans, which provide partial coverage of the City. CDM and the City field checked and updated the GIS mapping in the Terrible Trapezoid.

The second phase was field-checking the GIS database. This involved field-locating manholes, lamp-holes, and catchbasins and placing these structures as accurately as possible in the database. Accuracy is desirable when searching for a manhole under snow, for instance. Field checking was also necessary to determine that:

- The information on the 1983 sewer separation plans was accurately entered into the GIS database.
- The database reflects the system as it was built, not just as it was planned.

- Updates made to the system since 1983 are included in the database.

- Any system information not available on plans, but known by City staff, is included to the extent practicable in the GIS database.

To complete this phase, the City contracted separately with Chas Sells Inc. to conduct aerial photography and data entry. This will captured 80% of the structures in the field. CDM and the City used the Sells data to update the GIS mapping and performed inspections to verify that the data is accurately shown on the maps.

The final phase for this task is use of the GIS database by the City. The database is currently being used to schedule CIP projects, track catchbasin cleaning and pipe repair, etc.

NPDES Permit

To date, neither EPA nor NHDES has added Concord to the list of New Hampshire communities that will be required to apply for a Phase II NPDES Storm Water permit. However, the storm water management plan that would be the foundation for the permit is being prepared. This plan will be available if EPA or NHDES require the City to obtain a permit, and will also provide the foundation for solid storm water management whether or not the City is required to obtain a permit.

1.3 Summary of Work Completed

The work completed to date is summarized in Table 1-2 below. This work is detailed in Sections 2 through 9 of this report.

Table 1-2: Work Completed by Project Task

Task	Description
1. Data Collection	Collected plans, reports, and other information on the existing storm water system.
2. Field Survey	Collected additional system information in Terrible Trapezoid and Washington Street basins, through field investigations. Conducted dry weather screening of the outfalls to the Merrimack River.
3. Funding	Wrote and submitted four (2 in 2000; 2 in 2001) grant applications for the City's storm water management program.
4. Hydrology	Delineated drainage basins in the City, and collected information about soils, rainfall and runoff in these basins.
5. GIS	Developed a preliminary Geographic Information System (GIS) of the City's closed storm sewer system infrastructure based on information

Task	Description
	gathered to date.
6. Hydraulic Analysis	Created a computer simulation model of Terrible Trapezoid. Evaluated potential projects to mitigate flooding. Performed TV inspection and evaluation of storm water drains in the Terrible Trapezoid, including the cross-country Spruce drain. Conducted manhole inspections to evaluate the hydraulics of the Washington Street Basin. Conducted hydraulic analysis of the remaining basins in the City. Identified and ranked potential problem locations in the City. Compiled a list of prioritized potential problems.
7. Develop Recommendations	Made recommendations relevant to tasks completed to date.
8. Enterprise Fund	Evaluated and discussed an enterprise fund as a method of funding storm water system improvements.
10. Project Meetings	Prepared for and attended meetings with City of Concord personnel. Presented project progress and/or alternatives analysis. Prepared and distributed minutes for these meetings.
11. Report Preparation	Prepared and distributed draft reports presenting results and analysis including: • Pilot Area – Terrible Trapezoid, report dated May 2, 2001 • Dry Weather Screening Program, report dated October 2, 2001 • Evaluating Funding Mechanisms For a Storm Sewer Enterprise, memo dated June 2001 • Review of TV Tapes of Drains in Trapezoid, Concord, NH, memo dated January 9, 2002

Table 1-2 (cont'd)

Work Completed by Project Task

Section 2
USEPA Storm Water Compliance

As of this writing, Concord is under no statuary obligation to comply with the EPA's NPDES Phase II Storm Water Regulations. This section describes the Phase II regulations and the mechanisms by which Concord may become obligated to comply.

As described in Section 1, the City has decided to prepare a Storm Water Master Plan in order to minimize storm water pollution from its system independent of the EPA regulations.

EPA had until December 9, 2002 to designate small MS4s meeting the above criteria or until December 8, 2004, if a watershed plan is in place. EPA did not designate Concord as a regulated MS4 during this period. In the event EPA and NHDES include Concord in a future version of the Phase II program, the Storm Water Master Plan will be suitable to achieve compliance. In the meantime, the Storm Water Master Plan will serve to direct Concord's storm water management and pollution minimization.

An overview of the Phase II Storm Water Program, although not relevant to Concord at this time, is presented in this section. The EPA program can serve as a model of how to develop an effective storm water management plan, and can describe the steps other neighboring communities, such as Manchester, Hooksett, and Portsmouth, are taking towards storm water management. This section may also serve as guidance should Concord be designated in the future.

2.1 USEPA Phase II Storm Water Program

The Environmental Protection Agency (EPA) has finalized the storm water Phase II rule to control storm water runoff from municipal storm sewer systems in urbanized areas and from smaller construction sites. Phase II was signed on October 29, 1999, and published in the Federal Register in November 1999. Phase I of the storm water program, which was promulgated in November 1990, covered municipal storm sewer systems serving populations over 100,000, construction sites above five acres, and industrial activities.

Building on Phase I, Phase II requires Municipal Separate Storm Sewer Systems (MS4s) serving populations under 100,000 that are located in urbanized areas to obtain a National Pollution Discharge Elimination System (NPDES) permit under the Clean Water Act. Operators of construction sites disturbing one to five acres are also required to obtain a NPDES permit under the new rule.

2.2 Designation under the Phase II Program

According to EPA's definition, the City of Concord's Municipal Separate Storm Sewer System (MS4) is classified as a *small MS4.* Many small MS4s across the country were required to submit, before March 2003, a Notice of Intent to comply with EPA's Storm Water Phase II Final Rule. These are called *regulated small MS4s.* The Notice of Intent must include a Storm Water Management Plan. There are basically two categories of small MS4s that are regulated:

- Automatic Designation
- Potential Designation by the NPDES Permitting Authority (EPA Region I is the NPDES permitting authority in New Hampshire)

2.2.1 Automatic Designation

MS4s located in an *Urbanized Area* (as defined by the Bureau of the Census) are automatically designated as regulated small MS4s and required to comply with the regulations. An urbanized area is

> a land area comprising one or more places—central place(s)—and the adjacent densely settled surrounding area—urban fringe— that **together** have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile.

According to the 2000 census, Concord's population was 40,687. Therefore, Concord was not automatically designated.

2.2.2 Potential Designation

Physically Interconnected
A small MS4 outside of an urban area may be designated as a regulated small MS4 if its discharge contributes substantially to the pollutant loadings of a physically interconnected MS4 regulated by the NPDES storm water program. There is no deadline for designation of small MS4s meeting this criterion. Concord is not physically interconnected with any regulated MS4, so the City was not designated due to physical interconnectivity.

Required Evaluation
A small MS4 outside of an urban area may also be designated as a regulated small MS4 if the NPDES permitting authority (EPA Region I) determines that its discharge causes, or has the potential to cause, an adverse impact on water quality. EPA Region I is required to develop a set of designation criteria and apply them *at a minimum* to all small MS4s that are both located outside of urban areas and serving a jurisdiction with a population of at least 10,000 and a population density of at least 1,000 people per square mile. The recommended designation criteria are:

- Discharges to sensitive waters;
- High population density;
- High growth or growth potential;
- Contiguity to an Urban Area;

- Significant contributor of pollutants to the waters of the United States; and
- Ineffective protection of water quality concerns by other programs.

As mentioned above, EPA had until December 9, 2002 to designate small MS4s meeting the above criteria or until December 8, 2004, if a watershed plan is in place. EPA did not designate Concord as a regulated MS4 during this period.

2.2.3 Watershed Plan

NHDES Watershed Management Bureau administers the New Hampshire Rivers Management and Protection Program (RMPP). This program was established in 1988 with the passage of RSA 483 to recognize and designate rivers to be protected for their outstanding natural and cultural resources. Once designated, a management plan is developed and implemented by a volunteer local river advisory committee that also coordinates activities affecting the river on a regional basis.

The Upper Merrimack River is "designated" under the RMPP.

The Upper Merrimack River, from the confluence of the Winnipesaukee and Pemigewasset Rivers in Franklin to Garvins Falls in Bow, was identified as a "designated" river effective 6/26/90. This span includes the municipalities of Franklin, Northfield, Boscawen, Canterbury, Concord, and Bow. A plan has been developed and is available from the New Hampshire Department of Environmental Services website at: http://www.des.state.nh.us/rivers/plans/merrplan.htm

The EPA may consider this management plan to be a watershed plan. Recommendations in the plan include BMP installation, storm water management at construction sites, new construction storm water management, and land use management—recommendations typical of watershed plans. Subsequently, EPA Region I may have chosen to designate Concord before December 2002 (required evaluation) or may have taken until December 2004 (required evaluation, watershed plan noted). As of December 2007, the EPA has not designated Concord as a regulated MS4.

2.3 Overview of Phase II

If Concord was designated as a regulated MS4, the City would be subject to the new rule. Waivers are available for MS4 discharges that have been determined not to cause, or have the potential to cause, water quality problems. These waivers are based upon the system serving less than 1,000 people; the system being physically interconnected to and contributing non-substantial flow to another regulated MS4; or a "total maximum daily load" (TMDL) assessment or equivalent showing that storm water controls are not needed. If designated, it is unlikely that Concord will be granted a waiver.

2.3.1 Requirements

Under the Phase II rule operators of regulated small MS4s are required to:

- Apply for NPDES permit coverage (EPA general permits will be issued November 2002, and coverage will need to be obtained by March 2003);
- Develop a storm water management program which includes "six minimum controls" (listed below);
- Implement the storm water management program using appropriate storm water management controls or "best management practices" (BMPs), by the end of their first permit term (typically 5 years, or about March 2008);
- Develop measurable goals for the program; and
- Periodically evaluate the effectiveness of the program.

2.3.2 Schedule

The Schedule for the Phase II Rule was as follows:

- December 8, 1999 – The Phase II Final Rule is published in the *Federal Register* (64 *FR* 68722).
- December 9, 2002 – NPDES permitting authority is required to designate small MS4s meeting the "required evaluation" criteria (if no watershed plan is in place).
- December 9, 2002 – NPDES permitting authority to issue general permits for Phase II-designated small MS4s and small construction activity.
- March 9, 2003 – Operators of Phase II "automatically" designated regulated small MS4s and small construction activities must obtain permit coverage (within 90 days of permit issuance – expected on 12/9/02).
- After March 9, 2003 – The NPDES permitting authority may phase-in coverage for small MS4s serving jurisdictions with a population under 10,000. MS4s phased in under this option will have until March 8, 2007 to obtain permit coverage.
- December 8, 2004 - NPDES permitting authority is required to designate small MS4s meeting the "required evaluation" criteria (if a watershed plan is in place).

- March 9, 2008 or the end of the first permit term – Operators of regulated small MS4s must fully implement their storm water management program (by the end of the first permit term, typically a 5-year period).

2.4 Storm Water Management Program

Acceptable small MS4 operator's storm water management programs are designed to:

- Reduce the discharge of pollutants from its system to the "maximum extent practicable" (successful implementation of approved BMPs is considered compliance with the technical standard); and
- Protect water quality.

These goals are achieved through BMPs addressing each of the six minimum controls and measurable results associated with each of the selected BMPs.

Documents to assist municipalities with setting up and running storm water management programs are available from the EPA website assistance pages, such as: http://www.epa.gov/ebtpages/watestormwater.html

2.4.1 Six Minimum Controls

The "six minimum controls" are required storm water management program elements that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving waterbodies. These controls are:

1. Public Education and Outreach – about the impacts polluted storm water discharges can have on water quality.
2. Public Participation/Involvement – in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representatives to serve on a storm water management panel.
3. Illicit Discharge Detection and Elimination – including developing a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste.
4. Construction Site Runoff – developing, implementing and enforcing an erosion and sediment control program for construction activities disturbing 1 or more acres of land (controls could include for example, silt fences and temporary storm water detention ponds).
5. Post-Construction Runoff Control - developing, implementing and enforcing a program to address discharges of post-construction storm water runoff from new development and re-development areas (controls could include

preventative actions such as protecting sensitive areas, e.g. wetlands, or the use of structural BMPs, e.g. grassed swales or porous pavement).

6. Pollution Prevention/Good Housekeeping – developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch basin cleaning).

2.4.2 Selection of BMPs

A regulated MS4 operator will select BMPs (and/or acceptable existing programs) to address each of the six minimum controls. The EPA has provided a list or "menu" of BMPs to serve as guidance for the regulated small MS4 operators when developing their program. The menu is currently available on the Internet at
http://www.epa.gov/npdes/menuofbmps/menu.htm.

The BMPs and measurable goals selected by the municipality for each of the minimum control measures would become the required program. However, the NPDES permitting authority (EPA Region I) could require changes in the mix of selected BMPs and measurable goals if some or all of them are found to be inconsistent with the provisions of the Phase II rule. Likewise, the permittee could change their mix of selected BMPs if they determine that their program is not as effective as it could be.

2.4.3 Reference to Existing Programs

In the Phase II rule, the NPDES permitting authority will have the flexibility to "reference" an existing State, Tribal, or local program in the permit for regulated small MS4s. If the permit "references" an existing program for one or more of the minimum control measures, it means that the permittee is to follow the requirements of the referenced program (rather than any new permit requirements) for that particular measure or measures. The existing program needs to be at least as stringent as the minimum control it replaces. In short, this means that on-going non-profit, institutional, or public programs that meet one or more of the six minimum controls can be made to count towards compliance.

2.4.4 Measurable Goals

Phase II assumes the use of narrative, rather than numeric, effluent limitations in the form of measurable goals for each of the six minimum controls. A goal of "reduce metals in storm water by 50%" would be difficult to monitor, due to the number of outfalls a municipality may have, and may be difficult to achieve, given the non-point source nature of storm water. Therefore narrative, measurable goals will be used in the Phase II permitting process. Examples of potential BMPs and associated goals are presented below. Additional examples are found on EPA's website at
http://www.epa.gov/npdes/stormwater/measurablegoals/index.htm

BMP: Improve pet waste management in City parks by installing "pet waste stations" with waste receptacles, a supply of disposal waste collection bags, and scoops or shovels.
Measurable Goal: Reduce the amount of pet waste entering surface water bodies by 50 gallons during the 1st year.
Justification: When pet waste is not properly disposed of, it can wash into nearby waterbodies or can be carried by runoff into storm drains. Since storm drains do not connect to treatment facilities, but rather drain directly into lakes and streams, untreated animal feces can become a significant source of runoff pollution. Having designated places to dispose of the feces makes proper disposal more convenient for dog owners, and measuring the goal possible.

Example 1
Minimum Control – Public Education and Outreach

BMP: Incorporate the use of road salt alternatives for roadway deicing.
Measurable Goals: During the 1st year, reduce the amount of road salt applied to roadways by 50% through the use of less-toxic alternatives, such as liquid calcium magnesium acetate (CMA).
Justification: CMA is just as effective as road salt at deicing, but it appears to be much less harmful to the environment and is less corrosive, causing less damage to roadways and vehicles.

Example 2
Minimum Control - Pollution Prevention/Good Housekeeping

2.4.5 Applying for a Permit

Alternative deicers may be just as effective as road salt, but more in-line with Good Housekeeping measures.

To obtain a permit, a municipality can either submit a Notice of Intent (NOI) for a general permit, or apply for an individual permit. The NOI serves as an application for a general permit, and is encouraged by the EPA for the Phase II small MS4 program. The general permit establishes one set of requirements for all applicable permittees. An individual permit requires an application that is more comprehensive than the NOI, and establishes specific requirements tailored to the permittee. Either permit requires BMPs and measurable goals be listed for each of the six minimum control measures not covered by recognized existing programs. If an on-going program is referenced in the permit, the City will be required to follow the program's work plan, but not to list the minimum control measures to be implemented. The City will have the flexibility to choose the BMPs and measurable goals that are best suited for them. Implementation of approved BMPs and/or referenced, approved programs will constitute compliance.

Section 3
Geographic Information System Updates

3.1 Introduction and Scope

A Geographical Information System (GIS) is a common means of collecting and organizing geographically based information. The system is essentially a "smart" map, in the sense that an electronic map on a desktop or laptop computer is linked to a database of information. Simply "clicking" on a location on the electronic map will bring up information stored in the database about that location. The GIS software also allows users to perform spatial analysis and queries, and to display maps using the data stored in the GIS.

For example, if drainage manhole information is stored in the GIS a user can select a manhole on the map and view information that has been stored pertaining to the manhole. Attributes like size, material, and date installed are common types of information to be stored within a drainage system GIS. Other types of information such as images and maintenance history can also be related to a feature and stored in the GIS.

The City of Concord currently maintains an extensive GIS database that includes information on parcels, zoning, utilities, aerial mapping, and many other layers. For this project, CDM has developed a GIS data layer consisting of storm water facilities.

This storm water layer is being used to support nearly all other aspects of the storm water master plan.

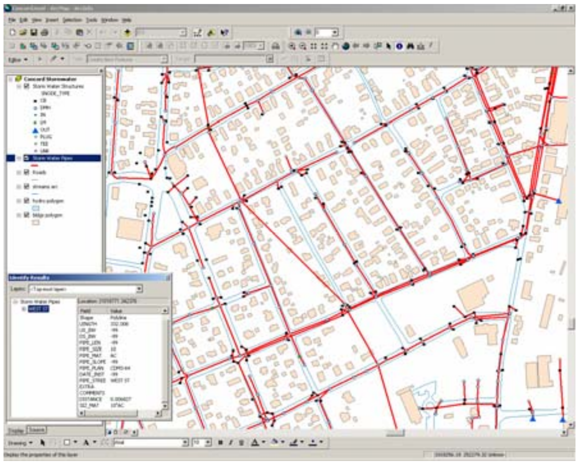
3.2 Study Area

Although other portions of the storm water project have focused on one area of the city at a time, a city-wide storm water layer is currently being developed using a combination of existing hard copy plans and field collection of storm water features using a GPS unit. It is anticipated that all major storm water systems will be mapped as part of this project.

In addition to the storm water GIS layer, a manhole inspection and large culvert applications have been developed. These applications will run on a lap top computer and will allow users to collect information in the field during manhole inspections (see Section 3.4). Information stored in the GIS can be verified and new information can be collected using the application. The application was used to collect detailed information during a manhole inspection project in the Washington Street area (see Section 5). In the future the application can be used by the City to collect information in other areas of the City as city workers perform work in those areas.

3.3 City-Wide Mapping

In an effort to develop an accurate storm water layer for the City of Concord, CDM collected all available source information as well as the city's existing base map. These source documents included record drawings maintained by the City, CDM plans from previous work with the City, sewer sheets, catch basin books, and other reports and studies. Any information related to the storm water system was entered into the GIS. All available attributes were captured from the source drawings and stored in the GIS. The City's existing base map compiled from aerial photography was initially used to spatially place the storm water features. Supplemental field investigations (visual, survey, and television) and GPS data were used to verify the placement of storm water features.



A storm water GIS data layer is being developed as part of this project

A pilot project was completed in the "Terrible Trapezoid" region of the city to test these methodologies. CDM produced check plots of the area that were submitted to the City for approval. These check plots were reviewed by the City with comments provided back to CDM. CDM incorporated this updated information into the storm water layer and continued to automate the rest of the City's storm water layer.

The City now has a comprehensive storm water facility inventory that can be used to manage the storm water system, maintain information related to the maintenance and upkeep of the system, and perform querying and GIS analysis, which is helpful for engineering purposes. All data developed is compatible with the City's existing GIS database.

3.4 Custom Applications for Concord GIS

Once the final GIS for the storm water system is complete, CDM will provide Concord with the GIS mapping and database. CDM will also provide custom applications developed for the City to easily access and analyze the data. These applications include:

- Query of drain line facilities by street, plan, material, or other data—helpful for finding information on given problem structures, etc.;
- Templates for map production;

- Tracing of upstream and downstream pipes (i.e., which lines contribute flow to a given manhole; which lines receive flow from a given source)—helpful in tracking down illicit connections and illegal dumping;
- Integration of scanned plan and profile images with GIS data so that source data can be viewed with the electronic data;
- Transfer of sewer data to AutoCAD DXF files that can be used in the creation of plans for new development, etc.;
- Generation of pipe statistics, including length, diameter, condition, etc.;
- Location of nearest feature (i.e., catch basin to an address)—helpful for use in addressing resident complaints or in managing fieldwork; and
- Linking of GIS to storm water maintenance management software.

The City will be able to access GIS information in the field using hardware, software, and applications provided.

To facilitate entry of additional manhole inspection data into the City's GIS, CDM created a field application. The application consists of a copy of the GIS mapping linked to a data sheet. Arriving at a manhole to be inspected, the field crew "clicks" on the structure on the computer map. The associated field sheet then requests information on the structure, such as depth of sediment, condition of cover, rim, walls, invert and corbel. The information entered can be added to the GIS database. Queries on the condition, location, photos, etc. can then be made on the entered information. This application is described in more detail in Section 5.

3.5 Recommendations and Next Steps

The City should continue to update their GIS database based on field verifications and new development plans. The City should also continue to clean up the existing pipe network (drain, water, sewer).

Section 4
Detailed Study Area No. 1: "Terrible Trapezoid"

4.1 Introduction

4.1.1 Study Area

This section describes a detailed hydrologic and hydraulic study completed in the pilot area of the "Terrible Trapezoid". The "Terrible Trapezoid" neighborhood of Concord is bounded on the north by Pleasant Street, on the east by South Main Street, on the west by South Spring Street, and on the south by Allison Street. In addition, Pleasant Street west of Spring Street, portions of the State Hospital grounds west of Spring Street, and several streets to the south of Allison Street contribute storm water to this basin. Figure 4-1 shows the study area.

4.1.2 Scope

The scope of the evaluation of this area, further explained below, was to:

- Determine appropriate design storms (rainfall events) to judge the effectiveness of the system. Evaluate a series of four design storms: the 6-month, 1-year, 5-year, and 10-year return period storms. Develop hyetographs for these storms.

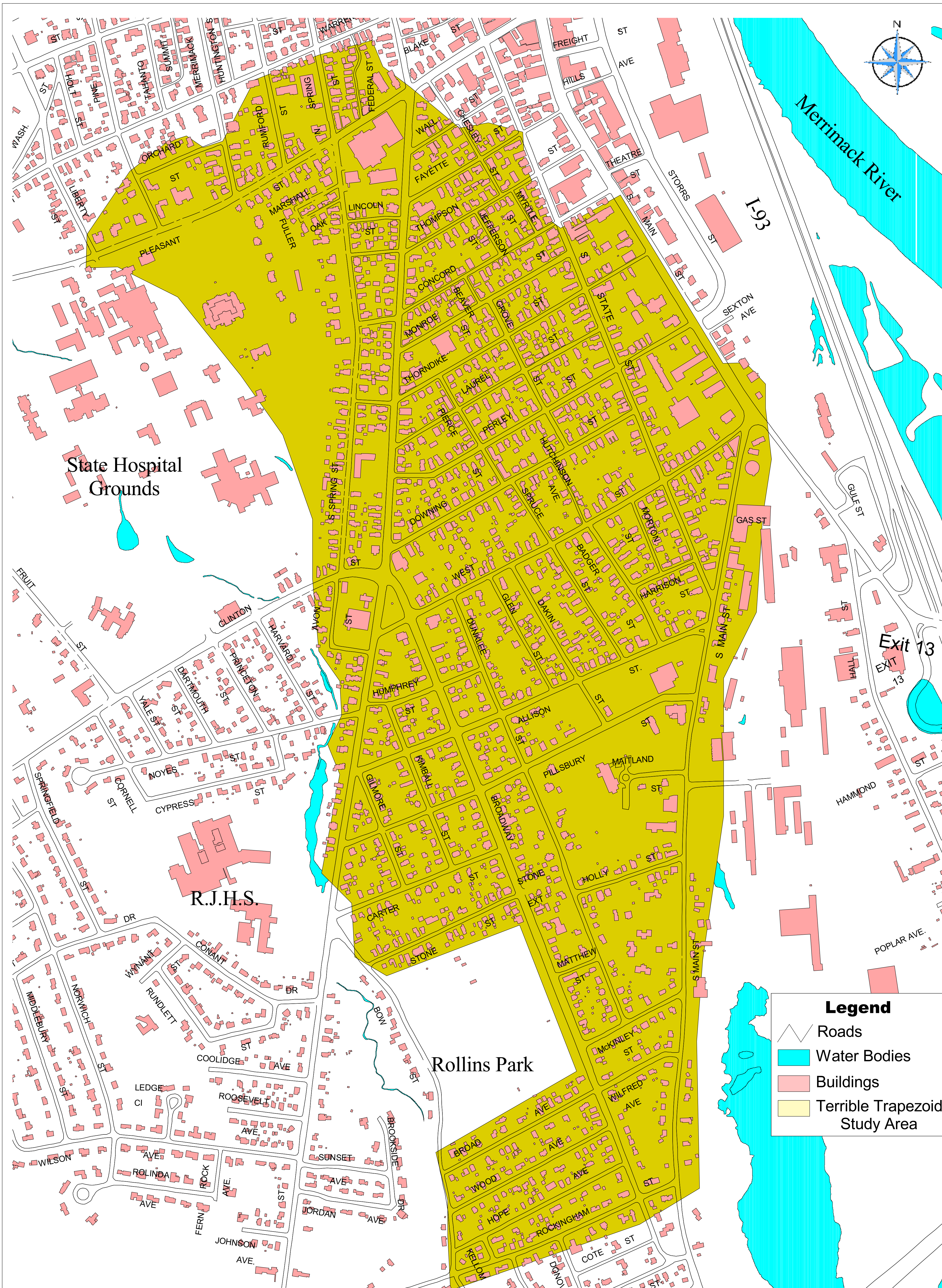
- In conjunction with preparation of the GIS (Section 3), collect system features of the storm sewer system within the Terrible Trapezoid. Conduct field visits to verify key system features.

- Divide the area into subbasins and collect appropriate hydrologic and hydraulic parameters for each subbasin.

- Based on review of the system data, select a method to analyze the system, and determine how it responds to the design storms. Create a network model (Section 4.2.4) representing the drainage system to determine the expected water levels within the system caused by the design storms.

- With the design storm hyetographs as input to the network model, calculate the resulting network hydrograph response at downstream locations.

- Identify problem areas, and use the network model to evaluate potential flood mitigation improvements. Conduct any additional field investigations (i.e. television inspection) required to develop a list of recommended improvements, considering the severity of the flooding problem, cost, and construction impacts.



Terrible Trapezoid Study Area

Figure 4-1

600 0 600 Feet

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4.1.3 Existing Storm Water System

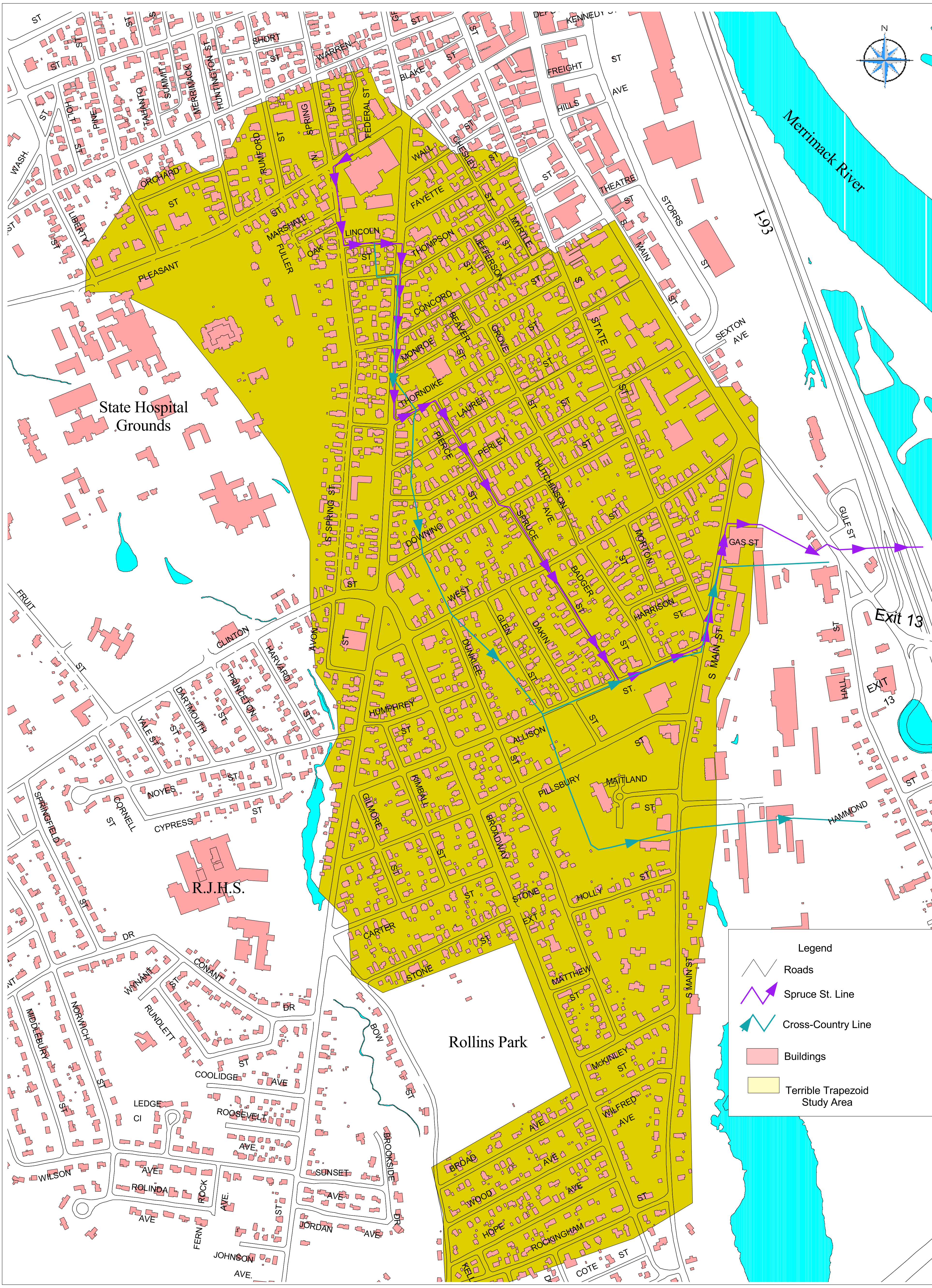
Two storm water drains handle the majority of the north to south flow through the study area which eventually discharges to the Merrimack River at Exit 13 off Route 93. Starting at the upper reaches of the drainage area, only one main drain exists near the new Federal Courthouse, flowing west on Pleasant Street, south for one block on Spring Street, and east onto Lincoln Street. Approximately 190 feet east of Spring Street, on Lincoln Street, one main drain splits off to the south, while the other continues along Lincoln Street. The pipe that splits off to the south will be called the "cross-country" pipe, while the one that continues on Lincoln Street (and later along Spruce Street) will be called the "Spruce Street" pipe. The Spruce Street pipe has a slightly lower invert than the cross-country pipe, so during very low flow conditions, the majority of flow from the upper part of the basin is directed towards Spruce Street.

The cross-country pipe is initially a 24″ diameter pipe, but becomes a 24″ by 36″ rectangular brick conduit before reaching South Street. At the corner of South Street and Monroe Street, the cross-country pipe again leaves the roadways to follow an old brook bed. At the corner of Allison Street and Glen Street, the flow splits into three pipes, one 38″ brick pipe that flows south towards Maitland Street, and two pipes traveling to the east along Allison Street (a 24″ by 36″ rectangle and a 36″ diameter). The invert of the southerly pipe is much lower (by 5.6′ and 6.6′, respectively) than the pipes along Allison Street. Only during large storms does flow enter the two smaller pipes along Allison Street.

The second main drain pipe in this area, the "Spruce Street" pipe, is a 24″ diameter pipe that generally runs in the roadways. The drainpipe is located along South Street to Thorndike Street, turns south at Pierce, and finally follows Spruce Street south to Allison Street. The Spruce Street pipe connects to the 36″ diameter pipe mentioned above in Allison Street, the joined flow entering a 48″ diameter pipe and flowing east towards Gas Street. Figure 4-2 shows the cross-country and Spruce Street pipes in the study area.

Flows from State Street (24″ diameter) and South Main Street (24″ diameter) travel south to join the Spruce Street pipe. Flows from Carter Street and Stone Street travel north on Broadway and connect to the drainage system on Allison Street and at the 38″ brick drain respectively. Flow from Holly Street and McKinley Street travels north on South Main Street in a 20″ pipe to connect to the 38″ brick drain near Maitland Street.

The Terrible Trapezoid system discharges to the Merrimack River in three locations. One outfall is at the end of the 38″ brick drain east of Maitland Street, and the two other outfalls, both 48″ diameter pipes, discharge in the vicinity of South State Street and Gas Street.



Main Storm Drain Lines through the Terrible Trapezoid Study Area

Figure 4-2

600 0 600 Feet

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4.2 Hydrologic and Hydraulic Analysis

4.2.1 Selection of Design Storm

Storm drainage systems are designed to carry runoff from developed areas to avoid flooding during heavy rainfall. Typically, snowmelt is sufficiently slow so that it does not tax storm drainage systems.

The major design parameter is the size of the storm to use in sizing storm drainage facilities. There are tradeoffs on selection of the appropriate design level. If too small a storm is selected, flooding is common. If too large a storm is selected, the size of the drainage system facilities becomes very large and can be cost prohibitive. However, many communities develop design standards after much of the storm drainage system infrastructure is already built. It is much more difficult to retrofit an existing system than to build a new system. Thus, areas of new development often have storm drainage systems that can handle larger storms than older areas.

The consequences of failure are an important factor in selecting the size of the design storm. Consequences can range from temporary nuisance flooding of side roads, to minor flooding of unfinished basements, to flooding of living areas and closing of major roadways. Design of a storm drainage system should consider capitol and maintenance costs of improvements as well as potential risk and damage costs.

In Concord, the 10-year storm has been selected as the basis of design for new drainage facilities, and for retrofitting existing drainage systems where practical. The 10-year design level is relatively common for many New England communities.

For this investigation, focusing on existing infrastructure in the Terrible Trapezoid basin, a range of design storms was used, including 6-month, 1-year, 5-year and 10-year storms. Using a range of design storms allowed for a comparative assessment to determine the frequency of drainage problems; drainage problems observed for the entire range of storms are likely to occur more frequently than problems observed for only the 10-year storm. Frequency of occurrence, as well as severity of flooding, will figure into decisions on prioritization of repairs. The 6-month storm, expected to occur on average about twice yearly, was the most common storm, while the 10-year storm, which has on average a 10 percent chance of occurring in any given year, was the most severe storm used.

Design storms may be developed using synthetic methods, or taken from the actual rainfall record. Storms from the actual rainfall record have the advantage of having actually happened, and so may be remembered by residents. Flooding predicted by the model can then be potentially corroborated anecdotally. Actual storms were used in this study.

Selecting the appropriate storms from the rainfall record is a two-step process. First, the most important characteristics in design storm selection are the total storm rainfall depth, peak rainfall intensity, and frequency. These characteristics were determined from intensity-duration-frequency data published in the *Atlas of Short-Duration Precipitation Extremes for the Northeastern Unites States and Southeastern Canada, Northeast Regional Climate Center, Cornell University, March 1995 ("Cornell Atlas").* These characteristics are shown in Table 4-1 below.

	Design Storm Frequency			
Duration	**6-month**	**1-year**	**5-year**	**10-year**
1-hour	0.42	0.64	1.15	1.37
3-hour	0.75	1.02	1.65	1.92
6-hour	1.03	1.35	2.09	2.41
12-hour	1.46	1.79	2.55	2.88
24-hour	1.56	2.00	3.02	3.46

Note: Rainfall depths (inches) of design storms – calculated from published IDF Curves.

Table 4-1

Rainfall Depths of Design Storms

Next, National Weather Service rainfall records collected from 1948 to 1999 at the Concord Airport were examined to select the storms with characteristics that most nearly match the rainfall statistics in Table 4-1. For rainfall depths less than one hour (the smallest duration in the Cornell Atlas), factors were applied based on the criterion in the atlas for establishing depths for these shorter durations.

This resulted in the selection of the following storms:

6-month	September 11, 1969
1-year	October 10, 1998
5-year	July 8, 1963
10-year	August 1, 1980

The resulting hyetographs are shown in Figure 4-3.

4.2.2 Study Area Delineation

As described above, a large part of the study area is drained by two main lines. Figure 4-4 shows the land area draining to each of these lines. Areas contributing to the system downstream of these lines are also shown in the figure, colored separately. The study area must include all areas that drain to the pipes being modeled to accurately assess the backwater conditions and the capacity required in the network.

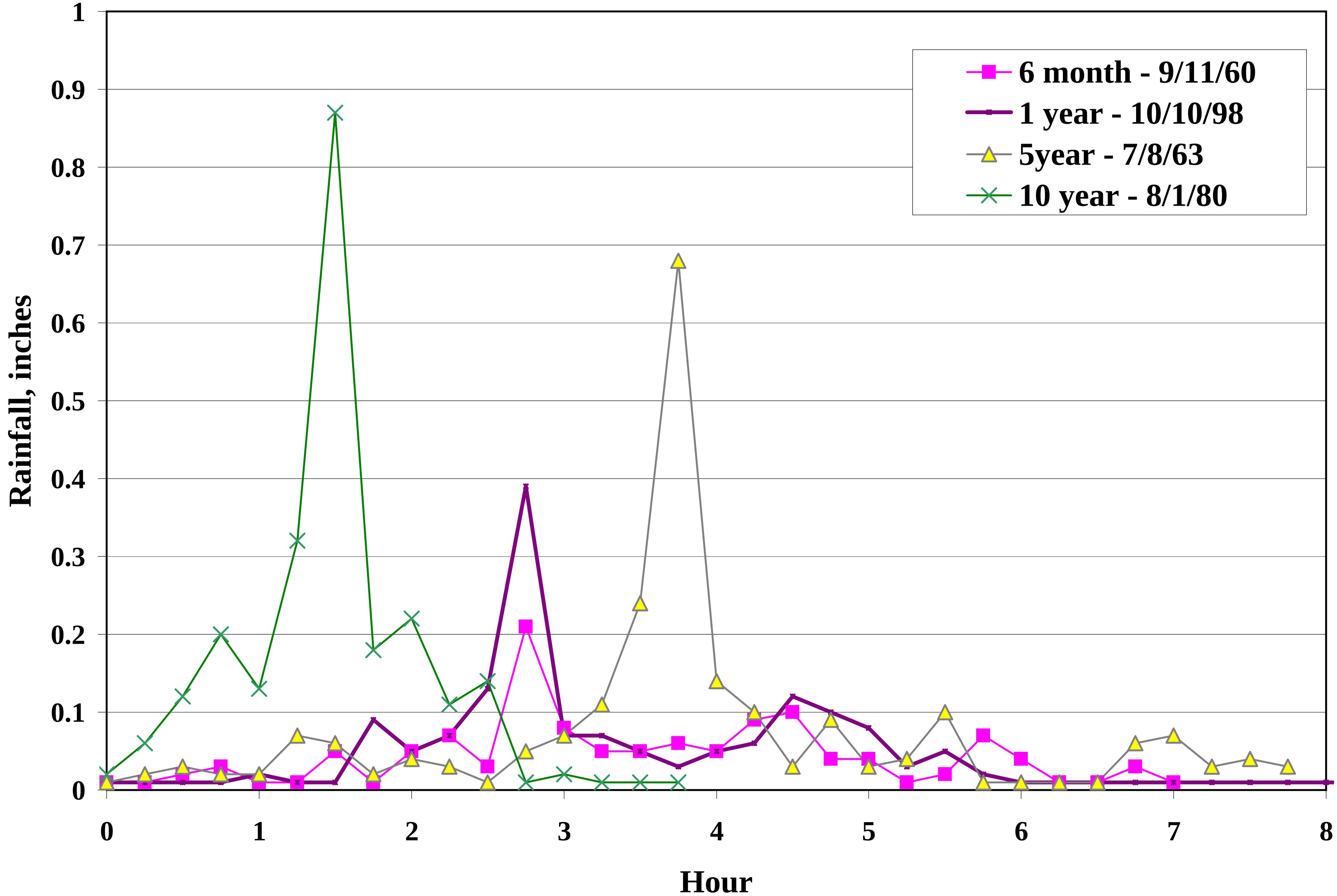

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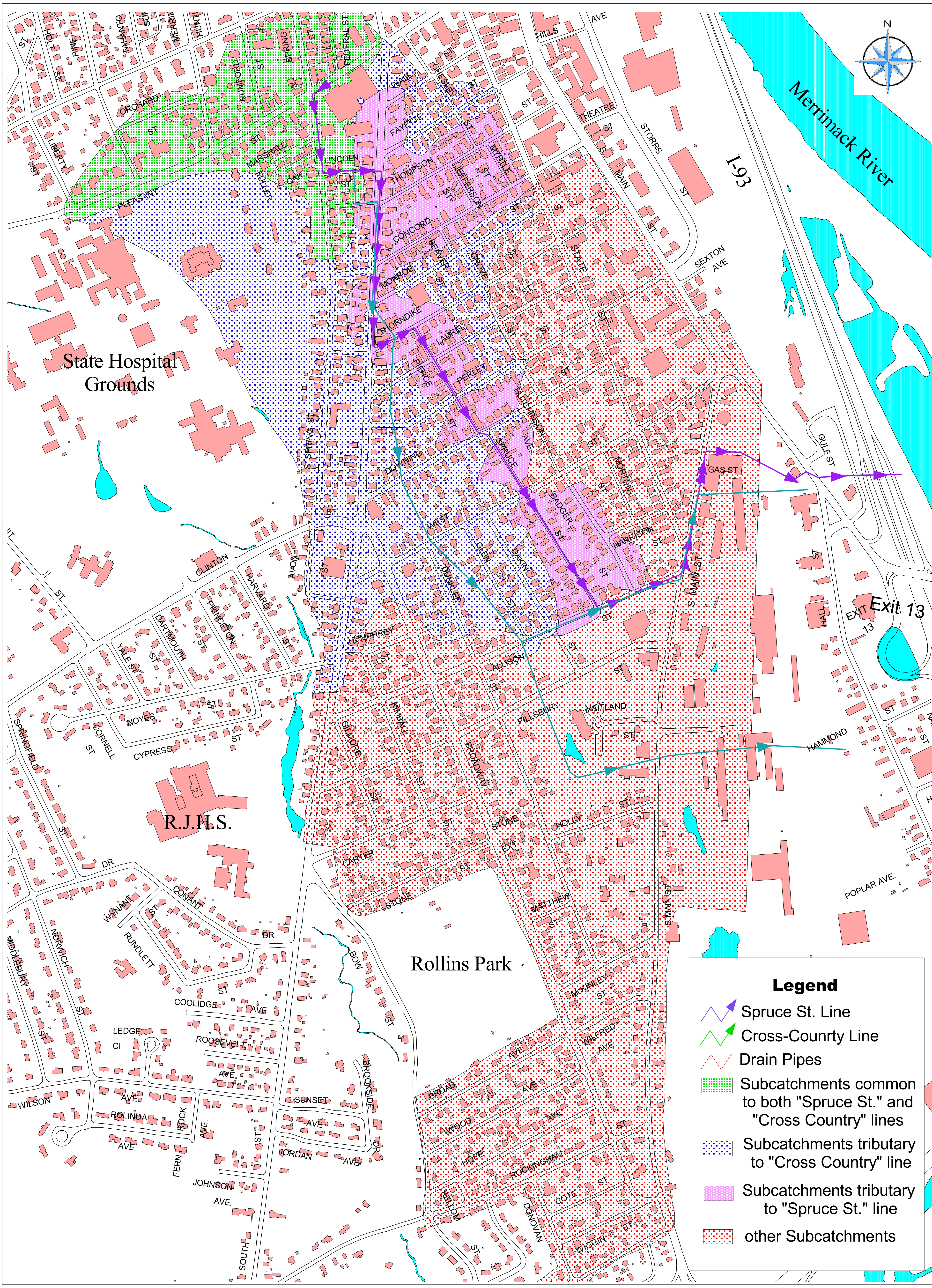
Figure 4-3
Hyetographs of Design Storms



Watersheds of Main Storm Drain Lines

Figure 4-4

600 0 600 Feet

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4.2.3 Subcatchment Development

Subcatchments divide the study area into smaller areas that drain into a particular section of pipe. In this way, the model can more accurately simulate the amount of flow along a section of pipe, and can better represent the actual system.

The subcatchments used are shown in Figure 4-4. They were developed using GIS data showing catchbasin locations and pipe directions, topographical information, sewer maps, and field visits.

Table 4-2 lists the subcatchments by name and shows the acreages and the line to which they are tributary. The lines were described previously in Section 4.1.3, named for modeling purposes as Cross-country (designated "CC" in Figure 4-4 and Table 4-2), Spruce Street (SP), State Street (STA), and Main Street (MA).

In addition, other lines are named after the streets they underlie, including Pleasant Street (PLE), Gas Street (GAS), Pillsbury Street (PILLSBUR), Allison Street (ALL), Holly Street (HOLLY), Stone Street (STONE), Hope Street (HOPE), and Wiggin Street (WIGGIN).

4.2.4 Model Selection

Computer modeling provides insights into the hydraulic behavior of a stormwater collection system and allows planners to quickly assess the impact of changes to that system. The model chosen should handle the complexities of the current pipe network and potential rehabilitation alternatives, but should be as simple as possible, and should not require any information that is not readily available.

EPA's Storm Water Management Model (SWMM) was used for this study. The SWMM model is a comprehensive suite of independent "modules" that are designed to simulate the rainfall-runoff process. The RUNOFF module was used to estimate runoff hydrographs (time-histories of flows) resulting from the design storms, and the EXTRAN (Extended Transport) Module was used to develop a dynamic representation of the storm drain system in the study area, showing the elevations resulting from the runoff hydrographs. SWMM is an EPA-sponsored model that is widely used for a variety of hydrologic/hydraulic applications.

SWMM was selected because of its ability to accurately simulate complex piped systems, a necessity to evaluate the Spruce Street and the cross-country drains that interconnect at two points (on Lincoln Street and again on Allison Street). Simpler models are not capable of evaluating these conditions. SWMM is a relatively complex, "high-end" computer model. Simpler methods may be appropriate in other areas in Concord to be studied in the future, which may have less complex hydraulic characteristics.

Subcatchment	Width, ft	Area, acres	%IMP	Slope
SP350	600	1.82	43.4	0.03
FED100	900	1.83	43.4	0.01
PLE110	8250	22.76	36.0	0.07
CC350	1500	8.71	24.8	0.07
CC340	1650	6.32	36.0	0.005
SP310	1050	3.48	36.0	0.005
SP320	675	1.76	43.4	0.07
SP300	2100	8.59	36.0	0.005
MA200	1200	2.09	43.4	0.07
STA180	5700	21.83	36.0	0.03
SP280	2100	6.56	36.0	0.005
SH	1475	29.12	18.0	0.005
CC270	3350	10.40	36.0	0.01
MA150	900	1.40	43.4	0.07
CC330	1125	4.42	24.8	0.03
STA150	1500	11.42	43.4	0.03
SP260	300	0.69	36.0	0.01
SP220	1200	4.68	36.0	0.01
MA100	900	4.67	43.4	0.07
CC290	2025	6.92	36.0	0.07
SP210	300	1.83	36.0	0.01
CC240	1800	4.20	36.0	0.03
SP200	300	1.40	36.0	0.01
SP190	450	3.01	36.0	0.005
AS100	900	3.04	43.4	0.005
CC220	3300	12.51	36.0	0.01
SP150	1500	5.70	39.7	0.005
STA100	2100	7.89	43.4	0.03
ALLISON	1500	8.21	42.0	0.005
CC210	5850	19.24	24.8	0.01
SP130	1350	3.74	43.4	0.005
SP140	675	3.52	39.7	0.005
CC170	1350	4.76	39.7	0.005
CC200	1500	4.36	24.8	0.01
PILLSBUR	5850	21.67	34.0	0.005
ALL1	5100	17.24	24.8	0.005
ALL2	2850	12.20	36.0	0.005
HOLLY	5700	40.26	18.0	0.008
ALL3	1350	4.95	25.0	0.005
STONE	1350	5.26	27.0	0.005
HOPE	5900	40.69	25.0	0.005
WIGGIN	4400	16.12	25.0	0.005

Table 4-2
EXTRAN Subcatchment Characteristics

4.3 RUNOFF Development

4.3.1 Percent Impervious

Impervious surfaces directly connected to the drainage system include streets, sidewalks, driveways, and roofs (with roof leaders that discharge to pavement). To calculate the percent impervious, representative city blocks in the study area were chosen. Allison Street, Badger Street, State Street and Harrison Street bound one block. This first block was the representative block chosen by Holden Engineering & Surveying in their "*Drainage Report for Interstate 93, Exit 13 and Water/South Main Streets*" Report. Thorndike Street, Pierce Street, Laurel Street, and Grove Street bound the second block. This block is more representative of the northwest side of the Terrible Trapezoid. Field crews examined both blocks for impervious surfaces, and roof leaders discharging to driveways. Orthophotos of the blocks were also consulted. Percent impervious was then calculated from the centerline of each bounding street.

The percent impervious for each subcatchment was estimated based on the similarity to one of the representative blocks discussed above, and on acreage of parks or open space in the given subcatchment. Table 4-2 lists the percent impervious used for each subcatchment.

4.3.2 Soil Parameters

The Terrible Trapezoid area in Concord rests on Windsor loamy sand with 3 to 8 percent slope (WdB). According to the Merrimack County New Hampshire Soil Survey, Series 1961, No. 22, the soil is deep, sandy, and excessively drained, with little or no gravel. This soil is most similar to U.S. Soil Conservation Service soil type B.

Soils of type B have an initial infiltration rate between 2.0 and 5.0 in/hr. As the soils become wet, water infiltrates more slowly. The soils have a minimum infiltration capacity between 0.15 and 0.30 in/hr. (USEPA SWMM Version 4 Manual, page 112 and 116). For this study, an initial rate of 4.0 in/hr and a minimum rate of 0.2 in/hr were used.

4.3.3 Slope

Slope for the subcatchments was determined from topographical data received from Chas E. Sells Engineering aerial photography flown for the City in the fall of 2000. Table 4-2 shows subcatchment slope.

4.3.4 Size of Subcatchments

The area of each of the subcatchments was calculated through the GIS database. Subcatchments were digitized into the system and acreages calculated for each.

The width of the subcatchments represents the width of overland sheet flow entering the system, while the length represents the average distance the flow must travel before entering the pipe. These parameters were estimated from maps of the study area similar to Figure 4-1. Table 4-2 summarizes the dimensions of all subcatchments in this study area.

4.4 EXTRAN Development

4.4.1 Pipe and System Characteristics

The characteristics of the pipes, diameter/dimensions, length, inverts, and rim elevations, were determined from design drawings of the study area. The information on these drawings was entered into the GIS system, so that the information will be easier to obtain for future studies.

4.4.2 Roughness

The Manning's roughness used for round pipes was 0.013, while for rectangular brick conduits 0.015 was used. The rectangular brick pipes tend to be older and hence slightly rougher.

4.4.3 Geometry of Main Drains

Figures 4-5 through 4-7 show profiles of the main drains. The profiles show the invert, (bottom) of the pipe, crown (top) of the pipe, and the ground surface. In addition, two vertical lines representing the modeled manhole junctions are shown. Note that not all manholes are shown, and that the manhole widths are not to scale. Street names are given on the profiles to provide a reference point.

Each of the profiles is oriented so that the outfall is on the right. Stormwater will flow from left to right.

Figure 4-5 is a profile of the cross-country line, from Federal Street to the outfall east of Maitland Street. From the upstream end of the modeled line to Lincoln Street, junction SP320, the cross-country line and the Spruce Street line are identical. The two main lines diverge at Lincoln Street. The cross-country line has a drop in invert downstream of this diversion, and proceeds south with a fairly steep slope. Lincoln Street is the location that the pipe has the shallowest amount of cover, approximately 3.1 feet. This profile includes two of the problem areas discussed in Section 4.5.2, labeled Lincoln Street and Rumford School on the figure.

Figure 4-6 is a profile of the Spruce Street line, from Federal Street to the outfall by Gas Street. Lincoln Street is again the shallow point. The Spruce Street line has a slight increase in elevation downstream from the diversion of the two main lines. Therefore, the Spruce Street line is not the preferred flow path for drainage from upstream of Lincoln Street because under low flow conditions the drainage will remain in the cross-country line. The upstream section of the Spruce Street line is in general slightly less steep than the cross-country pipe, but the line has a very steep outfall by Gas Street.

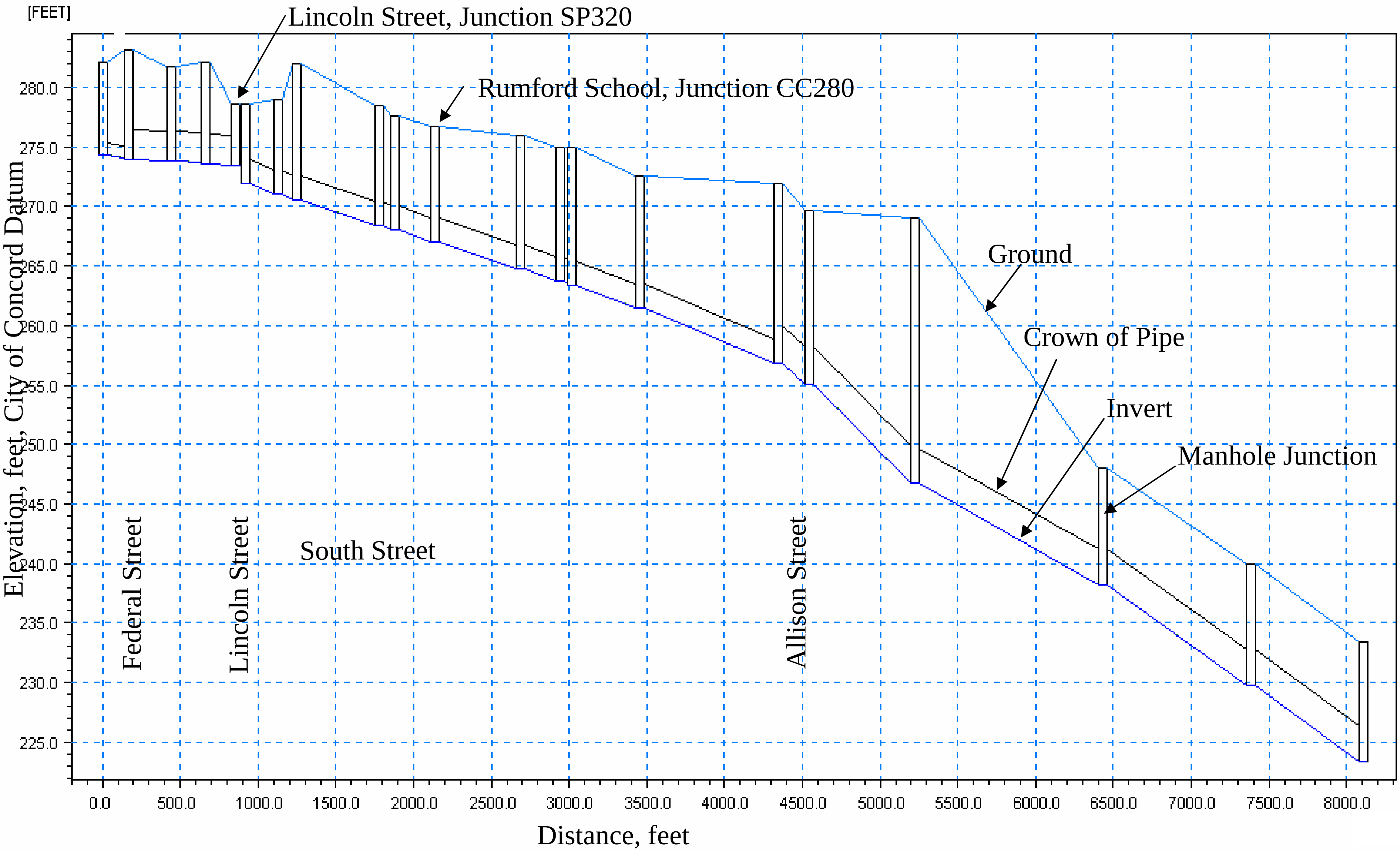


Figure 4-5
Profile of Cross Country Main Storm Drain Line

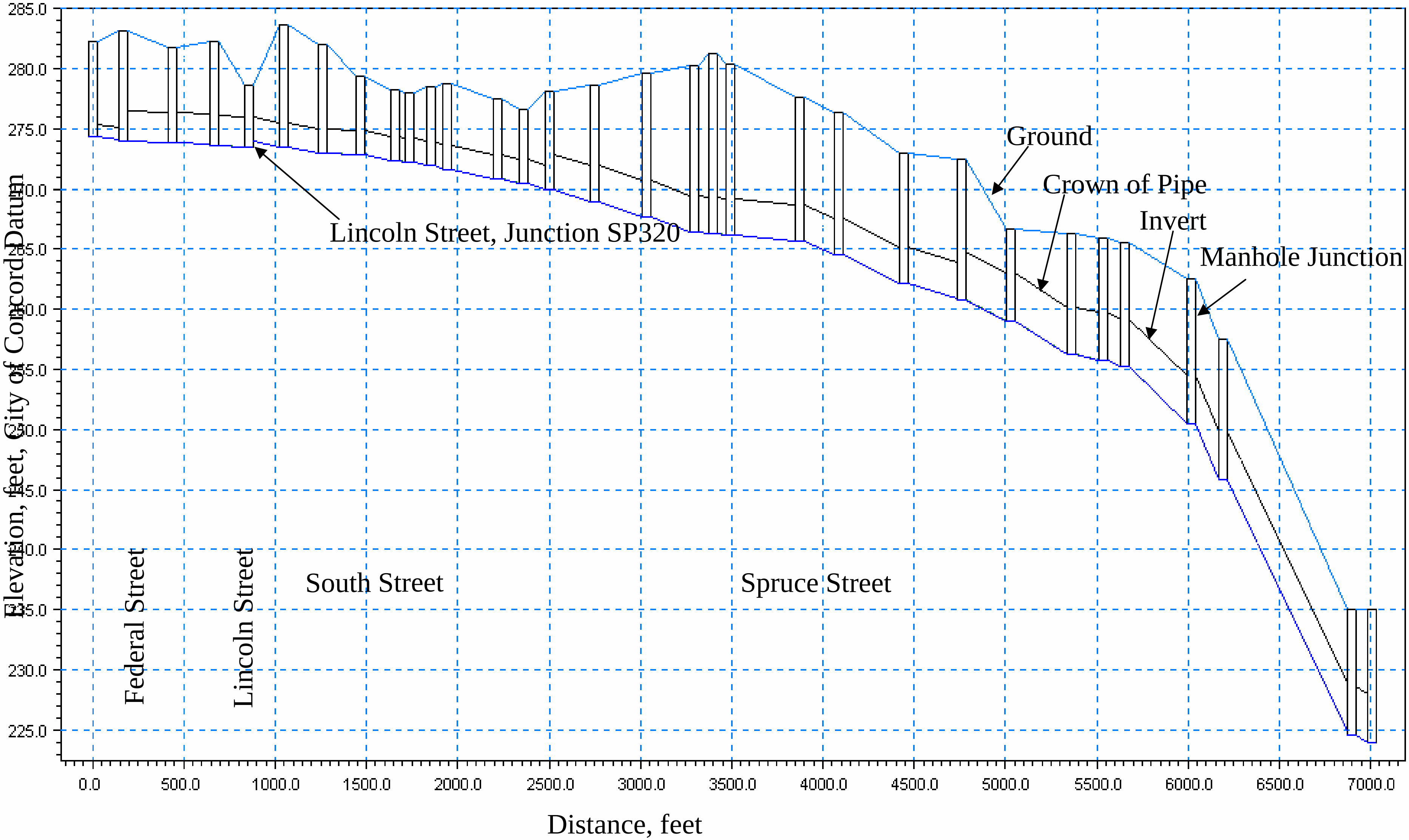


Figure 4-6
Profile of Spruce Street Main Storm Drain Line

The profile of the State Street line is shown in Figure 4-7. Note that the horizontal scale of this line is larger than on the other figures. This line has as steep a slope as the other two main lines. The problem area, labeled junction STA170, is at the upstream end of the line just downstream of Downing Street on State Street. This area is discussed further in Section 4.5.2. The stormwater drainage continues down State Street from that point, to an outfall south of that shown in the Spruce Street line.

4.5 Evaluation of Current Conditions

This section reports on the results from SWMM modeling during design storm conditions and summarizes problem areas. Several lengths were investigated further by TV inspection as a part of this study. Results of the TV inspection are discussed in Section 4.6.

4.5.1 Design Storms

Each design storm (6-month, 1-year, 5-year, and 10-year) was evaluated to determine the expected hydraulic grade lines resulting from the storms. The storms were evaluated assuming the storm drainage system was functioning properly and was relatively clean of sediment and debris. Appendix A lists the runoff and EXTRAN input files for the SWMM model in this drainage area. With the help of the City, problem areas highlighted in the model were compared to documented real-world problem areas to ensure that the model accurately depicts flooding under design storm conditions.

Results
Model runs were examined to determine locations where the hydraulic grade line exceeded manhole rims, indicating potential flooding. During the 6-month storm, the hydraulic grade line did not exceed any rims, showing that there are no extremely severe problems in the system. The 1-year storm also was conveyed through the system without exceeding manhole rims. Many older stormwater systems in New England are unable to convey the 1-year storm. The 5-year and 10-year storms were conveyed through the system causing flooding problems in three areas:

1) Lincoln Street, where the Spruce Street and cross-country drains diverge.

2) Cross-country drain in the vicinity of the Rumford School from the corner of South Street and Monroe Street, cross country to Thorndike Street, and south to Downing Street.

3) South State Street drain located south of the intersection with Downing Street.

The 5-year and 10-year storms also exceeded rim elevations downstream of Allison Street along the cross-country drain and some laterals entering the drain in that vicinity. This area was included in the model but is downstream of the Terrible Trapezoid, which is the focus of this study. Table 4-3 summarizes this information.

Example Results from Model

The outputs listed below were computed using the SWMM Model for the 48-inch diameter drain pipe at the end of Spruce Street. The design flows for the modeled pipe are estimated for three different design storms. To determine additional flows, the model can compute maximum flows at all nodes in the pipe network at the 1-year, 5-year and 10-year storm.

Design Storm	Maximum Computed Flow, cfs
1-Year	42.4
5-Year	81.5
10-Year	113

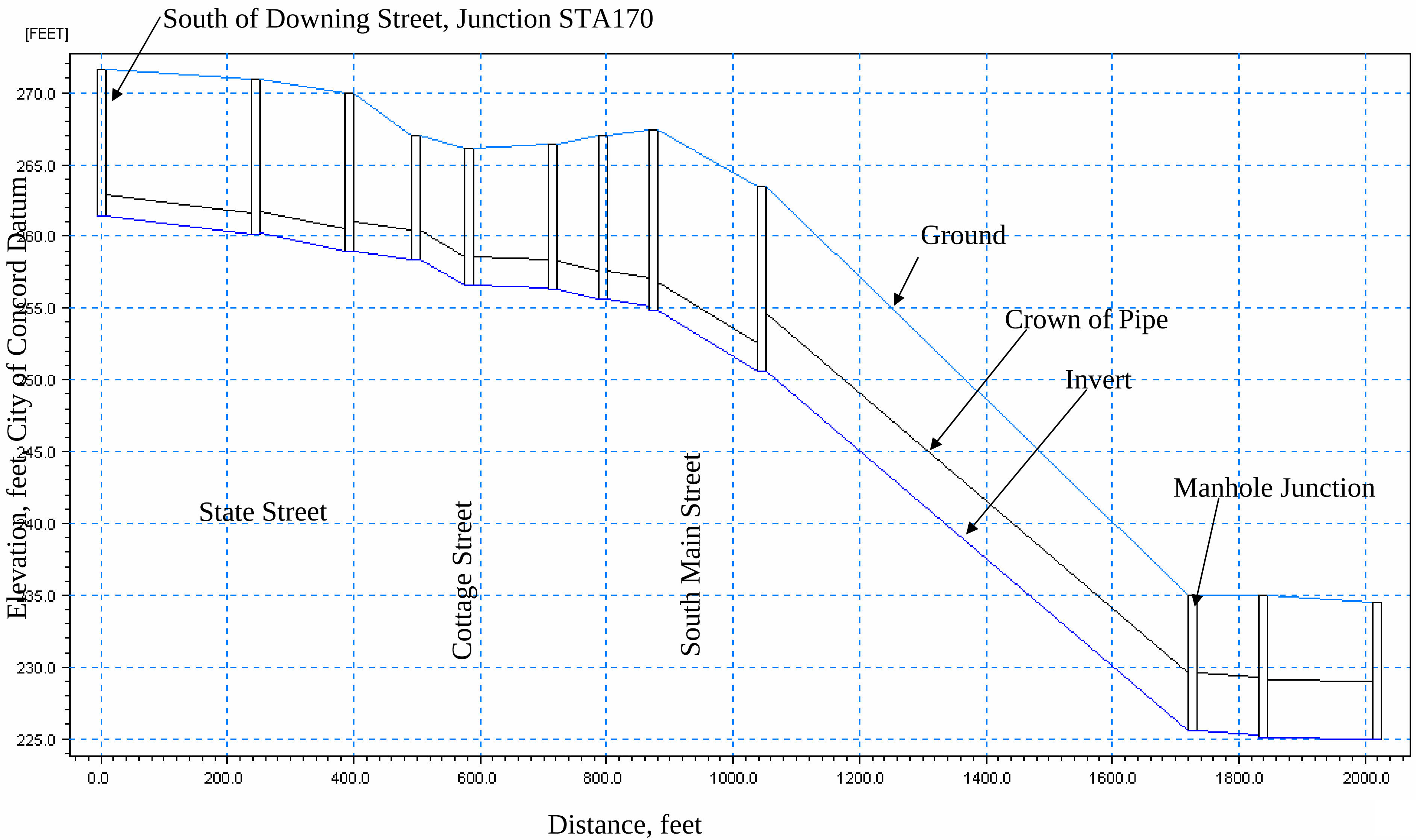


Figure 4-7
Profile of State Street Main Storm Drain Line

Location	Vicinity	Manhole Number	Rim Elevation, feet	Six Month Storm Surcharge Elev., feet	One Year Storm Surcharge Elev., feet	Five Year Storm Surcharge Elev., feet	Ten Year Storm Surcharge Elev., feet	Ten Year Est. Overflow, cubic feet
Lincoln Street	from Spring St. to South St.	SP320	278.60	274.68	276.50	278.60	278.60	4.11E+04
Rumford School	from Monroe St. to Downing St.	CC280	276.70	268.06	275.33	276.70	276.70	3.69E+02
State Street	south of Downing Street.	STA170	271.60	262.50	266.71	271.60	271.60	1.80E+04
South Main Street	near Holly Street.	Holly	260.50	246.55	255.77	260.50	260.50	2.57E+04

Shaded cells represent design storms so which the model predicts flooding at the given locations.
Note that the rim elevation is the maximum possible elevation to be reported.

Table 4-3
Model-Identified Problem Locations and Related Design Storm Elevations

4.5.2 Problem Areas

CDM and representatives of the City met to discuss the problem areas in the Terrible Trapezoid. Further information on the areas is provided below.

- Lincoln Street is located behind the Federal Building, with the two major drainage lines diverging at the lowest point along the street. During heavy rainfall, the capacity of the system is exceeded, causing surcharging. The surcharged conditions lift the manhole cover off one particular manhole (SP320, Figure 4-5), and residents in the vicinity have reported basement flooding. Long-time residents report having had recurring flooding problems for many years. The City has been unable to determine the causes of the flooding as problems do not occur consistently for storms of a certain size. A larger storm will fail to cause flooding, while a smaller storm a week before or after the large storm may cause flooding. While the modeling indicates that flooding will occur here during 1- and 5-year storms, in reality flooding appears to occur at this location more frequently. Since the modeling is based on a relatively clean system with little sediment buildup and few blockages, it is suspected that the area is subject to alternating episodes of sediment or debris build-up causing surcharging in the system, followed by "self-cleansing" when the pressure from the surcharged system is sufficient to clean out the debris.

- The cross-country pipe in the vicinity of the Rumford School to West Street is another problem area confirmed by the City. Flooding occurs at times in a depression above Thorndike Street, near the Rumford School. A low point on Laurel Street has sluggish flow that backs up occasionally. Flow occasionally discharges from catch basins on Pierce and South Street. Pre-development, a brook probably drained this area, and now the cross-country pipe (also known as the "South End Brook Sewer") serves this purpose. Thus, because it is in an old stream valley, it collects water even during dry periods. The water does not readily drain in this reach and in the reach just downstream to Allison Street. This section of pipe was part of the TV inspection program. Sags and cracks were found in this line, but fixing the identified problems will not necessarily alleviate flooding in this area. Section 4.6 summarizes findings.

- The model indicates flooding during 5-year and 10-year storms along South State Street in the Downing Street (STA170) vicinity, though this is not a known flood problem. This suggests that surcharging probably does occur in this reach, but does not result in damaging flooding.

- Areas south of Allison Street that may exceed rim elevations in 5- and 10-year floods include the depression between Maitland Street and Dunklee Street on the cross-country line and the storm drain in South State Street from Holly Street to Maitland Street. This area is outside of the terrible trapezoid and is not a focus for this study. In addition, the City believes that surcharged conditions in this vicinity do not result in flooding.

As a result of these findings, narrowing the problem areas down to several pipes, a TV inspection program was developed.

4.6 TV Inspection Program

A TV inspection program of local drains was undertaken in August 2001 by City personnel to record the structural condition of specific drains in the Terrible Trapezoid. In addition, Severn Trent Pipeline Services conducted a TV inspection program of the "Spruce Street" brick main line in December 2001 to record its structural condition. CDM reviewed the tapes of both inspections and evaluated the structural condition of the pipes. The results of the review indicate the following:

"Spruce Street" Brick Drain:

The drain was found to be in generally good condition. However, the following problems were identified that could be contributing to upstream flooding and pollution of the drain.

- Two pipes cross through the drain.
- There are heavy roots and light roots at several locations
- There was debris in the pipe at three locations.
- There were two sections of the drain, about 150 feet and 285 feet long, respectively, that were in poor condition (collapsed and crushed sections, major cracks, misalignments, etc.)
- There is one possible illicit connection, 151 from Manhole 2181.1-J14 in the easement.

Several sections of drain were identified as being in poor condition

- There are 12 other locations where water from service connections was entering. Since it was raining, this is probably clean water, but a follow-up inspection should be conducted during dry weather to ensure these are not illicit connections. In addition, there were 4 unplugged but dry service connections.

City TV Inspected Drains:

While generally in relatively good condition, there were a number of problems found in these drains:

- Drains in Thompson Street, Downing Street, Monroe Street, Fayette Street and Thorndike Street have severe structural problems;

- There are 15 sections of crushed and/or collapsed pipes in these areas;
- Major and minor cracks are common in drains in several streets including Thompson Street, Monroe Street, and Downing Street;
- Roots, primarily at pipe joints, are a problem in a few drains. Heavy roots were identified in drains in Downing Street, Perley Street and Thorndike Street.

One service connection was located which may be an illicit connection, on Downing Street between MH02 and MH01.

4.6.1 Discussion

Numbering Scheme

The numbering scheme used by the City assigned sequential numbers to manholes for each street beginning with the first manhole inspected. For these manholes, the City given number is used in this report.

The manholes in the Severn Trent TV inspection program were identified by a computer-generated scheme based upon a citywide grid. Figure 4-8 is a map showing the locations of some of the problem areas.

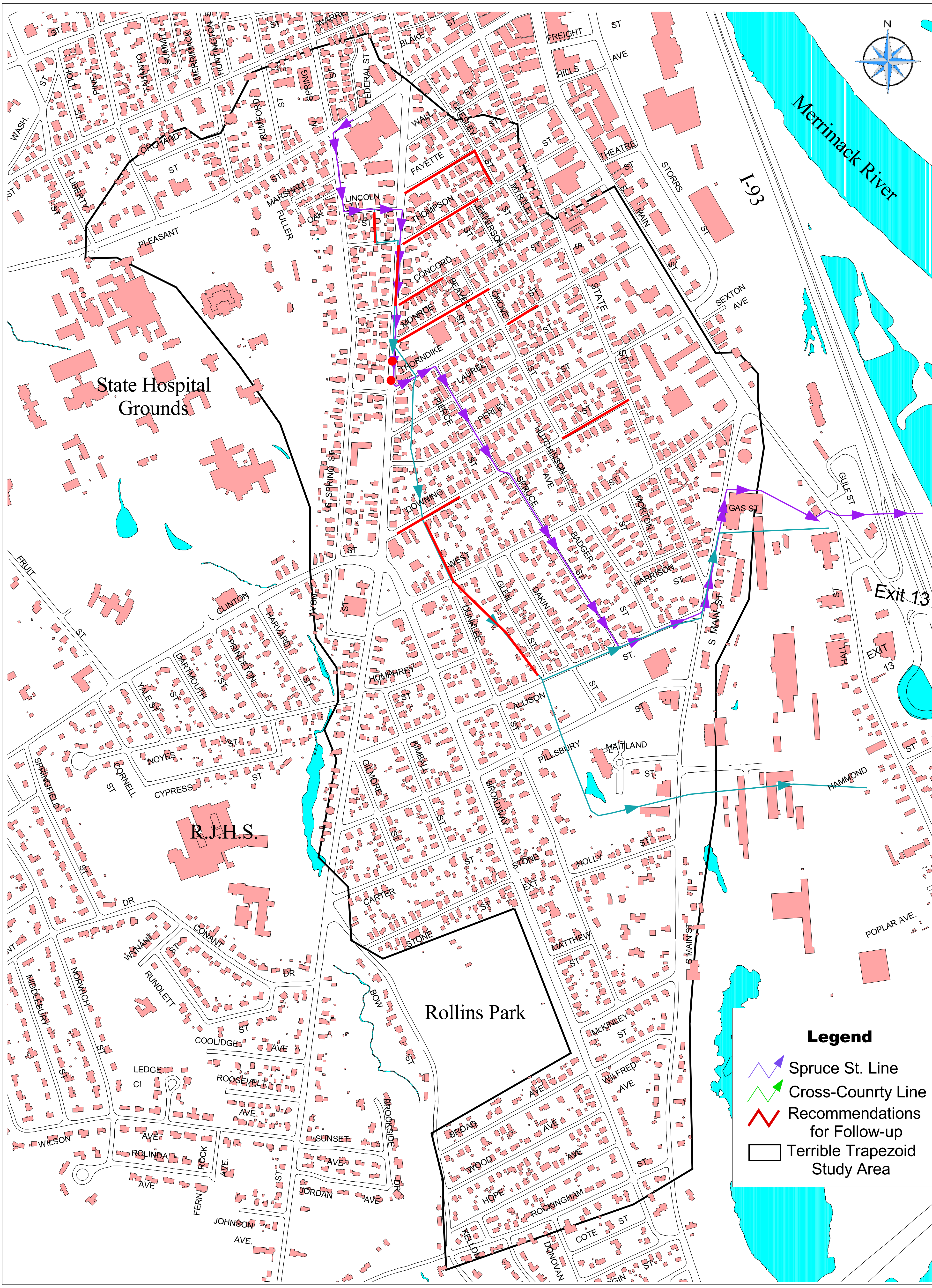
Scoring System

CDM developed a scoring system for the television inspection program to identify problems and rank their severity. For each manhole-to-manhole reach, each defect was scored on a structural scale, and totaled. The total manhole-to-manhole score was divided by the manhole-to-manhole length, giving a systematic way to rank the condition of the pipes. This scoring system has been successfully used in other projects to identify existing and potential drain problems. Recommendations are based upon the score of a pipe-reach, and also on the potential for rehabilitation to alleviate problems described in Section 4.5.

Note that the television inspection program scoring system is different than the ranking system used in Section 9 to prioritize the problem locations.

The television inspection scoring system characterizes defects in the pipe that may, over time, cause the pipe to fail. Defects affecting a continuous section of pipe were scored based on the affected length of pipe. These included defects such as major and minor cracks and roots. Cracks greater than 1/8 inch wide are classified as major cracks. In cases with localized structural defects such as crushed and/or collapsed pipes, scores were assigned for each occurrence. The complete list of structural defects scored in the program is presented in Table 4-4. At locations where multiple defects occurred, the higher scoring defect was used.

The scores were used to rank the condition of the pipes. Table 4-5 presents the pipes and their associated defects. These defects are aggregated for each pipe section and ranked in Table 4-6. Table 4-6 lists the pipes according to the severity of the structural defect.



Recommendations for Follow-up
Figure 4-8

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Defect	Points	Per Unit
Minor Crack (<1/8") - Bottom	1	per foot
Major Crack (>1/8") - Bottom	2	per foot
Minor Crack (<1/8") - Side	1	per foot
Major Crack (>1/8") - Side	3	per foot
Minor Crack (<1/8") - In-Between	1	per foot
Major Crack (>1/8") - In-Between	4	per foot
Minor Crack (<1/8") - Top	1	per foot
Major Crack (>1/8") - Top	5	per foot
Bow at Top	10	per foot
Minor Short Radial Crack (<1/2 pipe) (<1/8")	1	per incident
Major Short Radial Crack (<1/2 pipe) (>1/8")	3	per incident
Minor Long Radial Crack (> 1/2 pipe) (<1/8")	2	per incident
Major Long Radial Crack (> 1/2 pipe) (>1/8")	4	per incident
Pipe Collapse	175	per incident
Crushed Pipe	100	per incident
Misaligned Pipe/Offset Joint (major)	30	per incident
Hole in Pipe With Exposed Earth (Bottom)	55	per incident
Hole in Pipe With Exposed Earth (Side)	40	per incident
Hole in Pipe With Exposed Earth (In-Between)	55	per incident
Hole in Pipe With Exposed Earth (Top)	60	per incident
Missing Brick in First Ring (Bottom)	10	per brick
Missing Brick in First Ring (Side)	15	per brick
Missing Brick in First Ring (In-Between)	20	per brick
Missing Brick in First Ring (Top)	25	per brick
Missing Mortar	5	per incident
Hole around service	40	per incident
Infiltration (may be from service) - dripper	2	per incident
Infiltration (may be from service) - steady	5	per incident
Infiltration (may be from service) - gusher	10	per incident
Roots - Light	1	per foot
Roots - Heavy	3	per foot
Roots - Impassable	75	per incident
Sag > 25% of pipe diameter	10	per incident
Sag > 50% of pipe diameter	30	per incident

Table 4-4
Scoring System For Pipe Defects

Street	Manhole Number	Defect	Distance From Starting MH (feet)	Defect Length (feet)
City TV Inspection				
Chesley St	MH01 - MH04 Fayette	Major Crack - Bottom	16	3.7
Chesley St	MH01 - MH04 Fayette	Major Crack - Side	16	3.7
Chesley St	MH01 - MH04 Fayette	Major Crack - Top	16	3.7
Downing	MH02 - MH01	Collapsed Pipe	200	
Downing	MH02 - MH01	Hole around service	14.3	
Downing	MH02 - MH01	Hole around service	195.1	
Downing	MH02 - MH01	Major Crack - Bottom	70	2
Downing	MH02 - MH01	Major Crack - Top	97.3	3.9
Downing	MH02 - MH01	Minor Crack - Top	192.1	3
Downing	MH02 - MH01	Sag > 25% of pipe diameter	207	13
Downing	MH03 - MH02	Crushed Pipe	5.7	12.3
Downing	MH03 - MH02	Major Crack - Bottom	45	3
Downing	MH03 - MH02	Major Crack - Bottom	98	7
Downing	MH03 - MH02	Major Crack - Top	73	2
Downing	MH03 - MH02	Major Crack - Top	77	3
Downing	MH03 - MH02	Major Crack - Top	95.6	9.4
Downing	MH03 - MH02	Minor Crack - Bottom	80.2	1.8
Downing	MH03 - MH02	Minor Crack - Top	138.9	3.1
Downing	MH03 - MH02	Roots - Light	198	1
Downing	MH03 - MH02	Roots - Light	207	15
Downing	MH07 - MH08	Hole around service	49.6	
Downing	MH07 - MH08	Major Crack - Bottom	49.4	1.8
Downing	MH07 - MH08	Major Crack - Side	49.4	1.8
Downing	MH07 - MH08	Major Crack - Top	49.4	1.8
Downing	MH08 - MH09	Major Crack - Bottom	90.7	2.8
Downing	MH08 - MH09	Major Crack - Side	66	4
Downing	MH08 - MH09	Major Crack - Side	90.7	2.8
Downing	MH08 - MH09	Major Crack - Top	5	4
Downing	MH08 - MH09	Major Crack - Top	10	5
Downing	MH08 - MH09	Major Crack - Top	50.2	4.8
Downing	MH08 - MH09	Major Crack - Top	57	4
Downing	MH08 - MH09	Major Crack - Top	90.7	2.8
Downing	MH08 - MH09	Minor Crack - Side	5	4
Downing	MH08 - MH09	Minor Crack - Side	33.7	3.3
Downing	MH08 - MH09	Minor Crack - Side	51.9	4.1
Downing	MH08 - MH09	Minor Crack - Side	78	8
Downing	MH08 - MH09	Minor Crack - Top	24.5	2.7
Downing	MH08 - MH09	Minor Crack - Top	30	7
Downing	MH08 - MH09	Roots - Heavy	10.5	0.3
Downing	MH08 - MH09	Roots - Heavy	18.7	3.3
Downing	MH08 - MH09	Roots - Heavy	50.2	13.9
Downing	MH08 - MH09	Roots - Heavy	68.2	
Downing	MH08 - MH09	Roots - Light	27.2	6
Downing	MH08 - MH09	Roots - Light	45.5	4.5
Downing	MH08 - MH09	Roots - Light	78.3	
Downing	MH08 - Unknown	Hole around service	12.6	
Downing	MH08 - Unknown	Major Crack - Bottom	74	3
Downing	MH08 - Unknown	Major Crack - Bottom	80	2
Downing	MH08 - Unknown	Major Crack - Side	71	3
Downing	MH08 - Unknown	Major Crack - Top	68	3
Downing	MH08 - Unknown	Major Crack - Top	71	3
Downing	MH08 - Unknown	Major Crack - Top	74	3
Downing	MH08 - Unknown	Major Crack - Top	80	2
Downing	MH08 - Unknown	Major Crack - Top	119.4	3.6
Downing	MH08 - Unknown	Minor Crack - Bottom	82	8
Downing	MH08 - Unknown	Minor Crack - Bottom	135	4
Downing	MH08 - Unknown	Roots - Light	5	29
Downing	MH08 - Unknown	Roots - Light	44	3

Table 4-5
Drain Pipe Defects Found During TV Inspection

Street	Manhole Number	Defect	Distance From Starting MH (feet)	Defect Length (feet)
Fayette and South	MH01 - MH03	Collapsed Pipe	336	
Fayette and South	MH01 - MH03	Minor Crack - Side	287.8	0.9
Fayette and South	MH01 - MH03	Minor Crack - Side	301	2
Fayette and South	MH01 - MH03	Minor Crack - Top	301	2
Fayette and South	MH01 - MH03	Misalligned Pipe/Offset Joint	35	
Fayette St.	MH03 - MH01	Collapsed Pipe	29.7	
Fayette St.	MH03 - MH01	Major Crack - Bottom	20.4	3
Fayette St.	MH03 - MH01	Major Crack - Side	20.4	3
Fayette St.	MH03 - MH01	Major Crack - Top	20.4	3
Fayette St.	MH03 - MH01	Misalligned Pipe/Offset Joint	16	
Fayette St.	MH03 - MH01	Misalligned Pipe/Offset Joint	20	
Fayette St.	MH03 - MH05	Crushed Pipe	195.3	1.7
Fayette St.	MH03 - MH05	Major Crack - Bottom	18	4
Fayette St.	MH03 - MH05	Major Crack - Bottom	125	3
Fayette St.	MH03 - MH05	Major Crack - Bottom	163	4
Fayette St.	MH03 - MH05	Major Crack - Side	163	4
Fayette St.	MH03 - MH05	Major Crack - Side	197	2
Fayette St.	MH03 - MH05	Major Crack - Side	292	2
Fayette St.	MH03 - MH05	Major Crack - Top	18	4
Fayette St.	MH03 - MH05	Major Crack - Top	55	6.7
Fayette St.	MH03 - MH05	Major Crack - Top	61.7	2.7
Fayette St.	MH03 - MH05	Major Crack - Top	125	3
Fayette St.	MH03 - MH05	Major Crack - Top	128	1.4
Fayette St.	MH03 - MH05	Major Crack - Top	181	1
Fayette St.	MH03 - MH05	Major Crack - Top	197	2
Fayette St.	MH03 - MH05	Major Crack - Top	199	4
Fayette St.	MH03 - MH05	Major Crack - Top	342	2
Fayette St.	MH03 - MH05	Minor Crack - Bottom	128	1.4
Fayette St.	MH03 - MH05	Minor Crack - Bottom	129.4	3.6
Fayette St.	MH03 - MH05	Minor Crack - Side	55	6.7
Fayette St.	MH03 - MH05	Minor Crack - Side	128	1.4
Fayette St.	MH03 - MH05	Minor Crack - Side	155	3
Fayette St.	MH03 - MH05	Minor Crack - Top	193	2.3
Fayette St.	MH03 - MH05	Roots - Light	173.2	7.8
Fayette St.	MH03 - MH05	Roots - Light	286	5.5
Monroe St.	MH01 - Brick Main	Crushed Pipe	274.3	2.7
Monroe St.	MH01 - Brick Main	Major Crack - Side	110	4
Monroe St.	MH01 - Brick Main	Major Crack - Top	51	3
Monroe St.	MH01 - Brick Main	Major Long Radial Crack	274.2	
Monroe St.	MH01 - Brick Main	Minor Crack - Side	205	5
Monroe St.	MH01 - MH02	Crushed Pipe	210	2.7
Monroe St.	MH01 - MH02	Hole around service	79.6	
Monroe St.	MH01 - MH02	Major Crack - Bottom	102	3
Monroe St.	MH01 - MH02	Major Crack - Bottom	123	3
Monroe St.	MH01 - MH02	Major Crack - Bottom	126	3
Monroe St.	MH01 - MH02	Major Crack - Bottom	129	3
Monroe St.	MH01 - MH02	Major Crack - Bottom	147	17
Monroe St.	MH01 - MH02	Major Crack - Bottom	160	2
Monroe St.	MH01 - MH02	Major Crack - Bottom	212.7	5.3
Monroe St.	MH01 - MH02	Major Crack - Side	77.8	2.2
Monroe St.	MH01 - MH02	Major Crack - Side	126	3
Monroe St.	MH01 - MH02	Major Crack - Side	157	5
Monroe St.	MH01 - MH02	Major Crack - Top	61.6	6.4
Monroe St.	MH01 - MH02	Major Crack - Top	62.6	6.4
Monroe St.	MH01 - MH02	Major Crack - Top	74	3.8
Monroe St.	MH01 - MH02	Major Crack - Top	77.8	2.2
Monroe St.	MH01 - MH02	Major Crack - Top	120	12
Monroe St.	MH01 - MH02	Major Crack - Top	147	21
Monroe St.	MH01 - MH02	Major Crack - Top	157	5
Monroe St.	MH01 - MH02	Major Crack - Top	207	3

Table 4-5
Drain Pipe Defects Found During TV Inspection

Street	Manhole Number	Defect	Distance From Starting MH (feet)	Defect Length (feet)
Monroe St.	MH01 - MH02	Major Crack - Top	212.7	5.3
Monroe St.	MH01 - MH02	Minor Crack - Side	11	2
Monroe St.	MH01 - MH02	Minor Crack - Top	102	2
Monroe St.	MH01 - MH02	Roots - Impassable	160	6.3
Monroe St.	MH02 - MH03	Crushed Pipe	130	3.8
Monroe St.	MH02 - MH03	Hole around service	131.5	
Monroe St.	MH02 - MH03	Major Crack - Bottom	125.4	4.6
Monroe St.	MH02 - MH03	Major Crack - Side	6.5	2.7
Monroe St.	MH02 - MH03	Major Crack - Top	6.5	2.7
Monroe St.	MH02 - MH03	Major Crack - Top	125.4	4.6
Monroe St.	MH02 - MH03	Major Long Radial Crack	9	
Monroe St.	MH03 - Brick Main	Major Long Radial Crack	28.3	
Perley St.	MH02 - MH01	Roots - Heavy	67.2	2
Perley St.	MH02 - MH03	Minor Cracks - Side	32	3
Perley St.	MH02 - MH03	Sag > 50% of pipe diameter	18	10.7
Perley St.	MH03 - MH04	Roots - Heavy	10	4
Perley St.	MH03 - MH04	Roots - Light	14	6
Perley St.	MH03 - MH04	Roots - Light	41	10
Perley St.	MH04 - MH05	Roots - Heavy	61	6
Perley St.	MH04 - MH05	Roots - Heavy	101.8	1.2
South and Concord	Main - Buried MH01	Crushed Pipe	104.2	1.4
South and Concord	Main - Buried MH01	Major Crack - Bottom	99.8	4.4
South and Concord	Main - Buried MH01	Major Crack - Bottom	108.9	3
South and Concord	Main - Buried MH01	Major Crack - Bottom	244.2	6.7
South and Concord	Main - Buried MH01	Major Crack - Side	99.8	4.4
South and Concord	Main - Buried MH01	Major Crack - Top	99.8	4.4
South and Concord	Main - Buried MH01	Major Crack - Top	108.9	3
South and Concord	Main - Buried MH01	Major Crack - Top	111.9	3.1
South and Concord	Main - Buried MH01	Major Crack - Top	176.5	2.5
South and Concord	Main - Buried MH01	Major Crack - Top	244.2	6.7
South and Concord	Main - Buried MH01	Major Long Radial Crack	124	
South and Concord	Main - Buried MH01	Minor Crack - Side	111.9	3.1
Thompson St.	MH01 - MH02	Bow at Top	71	4.7
Thompson St.	MH01 - MH02	Crushed Pipe	50.9	2.1
Thompson St.	MH01 - MH02	Major Crack - Bottom	75.7	3.9
Thompson St.	MH01 - MH02	Major Crack - Top	75.7	3.9
Thompson St.	MH01 - MH02	Roots - Light	5	13.6
Thompson St.	MH01 - Unknown	Minor Crack - Top	22.3	0.7
Thompson St.	MH02 - MH01	Roots - Light	74	
Thompson St.	MH02 - MH01 MYTLE	Hole around service	200.2	
Thompson St.	MH02 - MH01 MYTLE	Minor Crack - Top	102	2
Thompson St.	MH02 - MH03	Bow at Top	78.3	7.7
Thompson St.	MH02 - MH03	Bow at Top	94	2
Thompson St.	MH02 - MH03	Crushed Pipe	86	
Thompson St.	MH02 - MH03	Major Crack - Top	64.5	13.8
Thompson St.	MH03 - MH02	Bow at Top	15.5	5.9
Thompson St.	MH03 - MH02	Collapsed Pipe	127.5	
Thompson St.	MH03 - MH02	Crushed Pipe	21.4	19.8
Thompson St.	MH03 - MH02	Crushed Pipe	59.7	9.4
Thompson St.	MH03 - MH02	Major Crack - Bottom	12	3.5
Thompson St.	MH03 - MH02	Major Crack - Bottom	44.4	3.2
Thompson St.	MH03 - MH02	Major Crack - Bottom	47.6	5.8
Thompson St.	MH03 - MH02	Major Crack - Bottom	69.1	3.5
Thompson St.	MH03 - MH02	Major Crack - Bottom	75.5	5.9
Thompson St.	MH03 - MH02	Major Crack - Bottom	90.5	15.5
Thompson St.	MH03 - MH02	Major Crack - Top	12	3.5
Thompson St.	MH03 - MH02	Major Crack - Top	44.4	3.2
Thompson St.	MH03 - MH02	Major Crack - Top	47.6	5.8
Thompson St.	MH03 - MH02	Major Crack - Top	69.1	3.5
Thompson St.	MH03 - MH02	Major Crack - Top	75.5	5.9

Table 4-5
Drain Pipe Defects Found During TV Inspection

Street	Manhole Number	Defect	Distance From Starting MH (feet)	Defect Length (feet)
Thompson St.	MH03 - MH02	Major Crack - Top	90.5	15.5
Thompson St.	MH03 - MH02	Minor Crack - Side	44.4	3.2
Thompson St.	MH03 - MH02	Minor Crack - Top	5	7
Thompson St.	MH03 - MH04	Crushed Pipe	21.5	6.4
Thompson St.	MH03 - MH04	Crushed Pipe	59.9	10.5
Thompson St.	MH03 - MH04	Hole In Pipe With Exposed Earth - Bottom	56.7	
Thompson St.	MH03 - MH04	Major Crack - Bottom	15.1	3.4
Thompson St.	MH03 - MH04	Major Crack - Bottom	27.9	7.8
Thompson St.	MH03 - MH04	Major Crack - Bottom	41.5	1.1
Thompson St.	MH03 - MH04	Major Crack - Bottom	47	12.9
Thompson St.	MH03 - MH04	Major Crack - Bottom	70.4	3
Thompson St.	MH03 - MH04	Major Crack - Bottom	164.4	5.9
Thompson St.	MH03 - MH04	Major Crack - Bottom	176.9	0.6
Thompson St.	MH03 - MH04	Major Crack - Side	15.1	3.4
Thompson St.	MH03 - MH04	Major Crack - Top	5	16.5
Thompson St.	MH03 - MH04	Major Crack - Top	27.9	7.8
Thompson St.	MH03 - MH04	Major Crack - Top	35.7	24.2
Thompson St.	MH03 - MH04	Major Crack - Top	70.4	3
Thompson St.	MH03 - MH04	Major Crack - Top	164.4	5.9
Thompson St.	MH03 - MH04	Major Crack - Top	176.9	0.6
Thompson St.	MH03 - MH04	Major Long Radial Crack	8.3	
Thompson St.	MH03 - MH04	Minor Crack - Bottom	173	3.9
Thompson St.	MH03 - MH04	Minor Crack - Side	12.2	2.9
Thompson St.	MH03 - MH04	Minor Crack - Side	15.1	3.4
Thompson St.	MH03 - MH04	Minor Crack - Side	27.9	14.7
Thompson St.	MH03 - MH04	Minor Crack - Side	42.6	4.4
Thompson St.	MH03 - MH04	Minor Crack - Side	176.9	0.6
Thompson St.	MH03 - MH04	Minor Crack - Top	173	3.9
Thorndike St	MH02 - MH01	Hole around service	117	
Thorndike St	MH02 - MH01	Roots - Heavy	53.8	4.9
Thorndike St	MH02 - MH01	Roots - Light	5	11
Thorndike St	MH03 - MH04	Major Crack - Bottom	5	7
Thorndike St	MH03 - MH04	Major Crack - Top	41.9	2.1
Thorndike St	MH03 - MH04	Minor Crack - Side	120	2
Thorndike St	MH03 - MH04	Roots - Light	146	5
Thorndike St	MH04 - MH05	Crushed Pipe	41.4	5
Thorndike St	MH04 - MH05	Major Crack - Side	20	14
Thorndike St	MH04 - MH05	Major Crack - Side	34	5.4
Thorndike St	MH04 - MH05	Major Crack - Side	39.4	2
Thorndike St	MH04 - MH05	Major Crack - Top	20	14
Thorndike St	MH04 - MH05	Major Crack - Top	34	5.4
Thorndike St	MH04 - MH05	Major Crack - Top	39.4	2
Thorndike St	MH04 - MH05	Minor Crack - Top	5	10
Thorndike St	MH04 - MH05	Roots - Heavy	20.9	1
Severn Trent TV Inspection				
South Street	2071-J14 - 2071.1-J14	Hole around service	81	
South Street	2071-J14 - 2071.1-J14	Minor Crack - Top	2	120
South Street	2071.1-J14 - 1844-J14	Hole around service	55	
South Street	2071.1-J14 - 1844-J14	Major Crack - Top	2	110
South Street	2071.1-J14 - 1844-J14	Minor Crack - Top	112	155
South Street	2074-J14 - 2071-J14	Minor Crack - Top	2	127
South Street	2181-J14 - 2074-J14	Minor Crack - Top	98	8
South Street Ease.	1840-J14 - 1846-J14	Minor Crack - Side	8	107
South Street Ease.	1840-J14 - 1846-J14	Minor Crack - Side	130	21
South Street Ease.	1840-J14 - 1846-J14	Minor Crack - Side	135	16
South Street Ease.	1840-J14 - 1846-J14	Minor Crack - Top	8	143
South Street Ease.	1840-J14 - 1846-J14	Roots - heavy	140	11
South Street Ease.	1840-J14 - 1846-J14	Roots - light	13	2
South Street Ease.	1840-J14 - 1846-J14	Roots - light	15	18

Table 4-5
Drain Pipe Defects Found During TV Inspection

Street	Manhole Number	Defect	Distance From Starting MH (feet)	Defect Length (feet)
South Street Ease.	2181-J14 - 2181.1-J14	Service - roots	52	
South Street Ease.	2181.1-J14 - 2212-J14	Hole around service	163	
South Street Ease.	2212-J14 - 2456-J15	Hole around service	72	
South Street Ease.	2212-J14 - 2456-J15	Infiltration - dripper	114	
South Street Ease.	2212-J14 - 2456-J15	Roots - heavy	135	5
South Street Ease.	2212-J14 - 2456-J15	Roots - light	127	8
South Street Ease.	2456-J15 - 2212-J14	Infiltration - steady	114	
South Street Ease.	2456-J15 - 2212-J14	Roots - heavy	235	19
South Street Ease.	2456-J15 - 2212-J14	Roots - light	213	4
South Street Ease.	2467-J15 - 2456-J15	Missing Brick in First Ring (top)	78	
South Street Ease.	2467-J15 - 2456-J15	Roots - heavy	115	25
South Street Ease.	2467-J15 - 2467.1-J15	Infiltration - steady	195	
South Street Ease.	2467-J15 - 2467.1-J15	Infiltration - steady	348	
South Street Ease.	2467-J15 - 2467.1-J15	Roots - heavy	80	27
South Street Ease.	2467-J15 - 2467.1-J15	Roots - light	40	40
South Street Ease.	2467-J15 - 2467.1-J15	Roots - light	114	81
South Street Ease.	2475-J15 - 2475.1-J15	Minor Crack - Top	274	86
South Street Ease.	2475-J15 - 2475.1-J15	Roots - light	128	
South Street Ease.	2475-J15 - 2475.1-J15	Sag >25%	45	30
South Street Ease.	2475-J15 - 2475.1-J15	Sag >50%	75	115
South Street Ease.	2475.1-J15 - 2493-J15	Minor Crack - Top	2	68
South Street Ease.	2493-J15 - 2493.1-J15	Roots - light	15.1	
South Street Ease.	2493-J15 - 2493.1-J15	Roots - light	28	
South Street Ease.	2493.1-J15 - 2691-J15	Minor Crack - Top	2	348
South Street Ease.	2493.1-J15 - 2691-J15	Roots - heavy	461	69
South Street Ease.	2493.1-J15 - 2691-J15	Roots - heavy	600	15
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	58	
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	224	
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	297	3
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	325	
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	336	
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	350	
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	370	
South Street Ease.	2493.1-J15 - 2691-J15	Roots - light	540	4
South Street Ease.	2691-J15 - 2776-J15	Infiltration - dripper	56	
South Street Ease.	2776-J15 - 2776.1-J15	Minor Crack - Top	99	128
South Street Ease.	2776.1-J15 - 888	Infiltration - dripper	112	
South Street Ease.	2776.1-J15 - 888	Minor Crack - Top	2	126
Thompson St	1846-J14 - 1840-J14	Roots - heavy	46	
Thompson St	1846-J14 - 1840-J14	Roots - heavy	50	
Thompson St	1846-J14 - 1840-J14	Roots - light	10	
Thompson St	1846-J14 - 1840-J14	Roots - light	17	
Thompson St	1846-J14 - 1840-J14	Roots - light	35	
Thompson St	1846-J14 - 1840-J14	Roots - light	41	

Table 4-5
Drain Pipe Defects Found During TV Inspection

Street	Manhole Numbers	Score/Length	Defect Summary*
South Street Easement	2475-J15 - 2475.1-J15	10.6	Pipe Sag
Fayette St.	MH03 - MH01	8.92	Collapsed pipe, major cracks, misalignment.
Thorndike St	MH04 - MH05	5.71	Crushed pipe, major cracks, some roots
Thompson St.	MH03 - MH02	5.56	Collapsed pipe, major and minor cracks
Monroe St.	MH01 - MH02	4.02	Crushed pipe, hole around service
Downing St.	MH08 - MH09	3.56	Major and minor cracks, roots
Thompson St.	MH03 - MH04	3.51	Crushed pipe, major and minor cracks
South Street Easement	1840-J14 - 1846-J14	2.9	Minor cracks
South St.	2071.1-J14 - 1844-J14	2.6	Major & minor cracks
Thompson St.	MH01 - MH02	2.25	Crushed pipe, major cracks
Monroe St.	MH02 - MH03	1.81	Crushed pipe, major cracks
Chesley St	MH01 - MH04 Fayette	1.80	Major cracks
South St.	2071-J14 - 2071.1-J14	1.3	Minor crack, hole around pipe
Downing St.	MH08 - Unknown	1.27	Major cracks
Downing St.	MH02 - MH01	1.25	Collapsed pipe, major cracks, pipe sag
South Street Easement	2776.1-J15 - 888	1.0	Minor crack, infiltration
South Street Easement	2493.1-J15 - 2691-J15	1.0	Minor crack, heavy roots
South and Concord	Main - Buried MH01	0.97	Crushed pipe, major cracks
South St.	2074-J14 - 2071-J14	1.0	Minor crack
Downing St.	MH03 - MH02	0.96	Major cracks
Perley St.	MH02 - MH03	0.93	Pipe sag, minor cracks
Fayette St.	MH03 - MH05	0.89	Crushed pipe, major and minor cracks
South Street Easement	2475.1-J15 - 2493-J15	0.9	Minor crack
South Street Easement	2467-J15 - 2456-J15	0.6	Missing brick, heavy roots
Fayette and South	MH01 - MH03	0.62	Misalligned pipe, minor cracks
South Street Easement	2467-J15 - 2467.1-J15	0.6	Light & heavy roots, infiltration
South Street Easement	2776-J15 - 2776.1-J15	0.6	Top crack
Monroe St.	MH01 - Brick Main	0.54	Crushed pipe, major and minor cracks
Thorndike St	MH02 - MH01	0.52	Roots, hole around service
South Street Easement	2212-J14 - 2456-J15	0.5	Roots, hole around service, infiltration
Downing St.	MH07 - MH08	0.43	Major cracks
South Street Easement	2456-J15 - 2212-J14	0.3	Light & heavy roots, infiltration
Thompson St	1846-J14 - 1840-J14	0.3	Light Roots, minor crack
South Street Easement	2181.1-J14 - 2212-J14	0.2	Hole around service
South St.	2181-J14 - 2074-J14	0.1	Minor crack
South Street Easement	2691-J15 - 2776-J15	0.0	Infiltration
South Street Easement	2181-J14 - 2181.1-J14	0.0	Light roots
South Street Easement	2493-J15 - 2493.1-J15	0.0	Light roots

*** Not all defects shown for each section**

Table 4-6
Drain Pipes Ranked in Order of Severity of Defects

Blockages

During the inspection tape review, blockages and other miscellaneous defects identified in the system were recorded. Table 4-7 lists these blockages and miscellaneous defects. Blockages identified in the City TV inspection tapes include a pipe that appears to have been transported by flow from service into the drain on Downing Street between manhole #6 and manhole #7. The piece of pipe is stuck protruding into the service. Also identified in the table is a plugged service on Downing Street that was active during the TV inspection. This service was the only active service identified during the review of the City's tapes. However, many unplugged services were also identified.

Blockages identified in the Spruce Street drain included several locations with pipes crossing the drain. This occurred on South Street between manholes 2181-J14 and 2074-J14 where two small pipes separately cross the top of the drain. They block less than 15 percent of the drain's effective area. Although not ideal, these blockages are not considered significant enough to warrant re-routing these pipes, which because of their gravity flow, would be very expensive. A pipe also crosses the drain on Thompson Street between manholes 1846-J14 and 1844-J14. An eight-inch pipe crosses the drain at this location. Pipes with debris and protruding taps were also identified.

Pipes crossing the drain impede flow directly and tend to accumulate debris increasing the effective impediment. Redirecting the offending pipes can be quite expensive.

Structural Problems

In the Spruce Street drain television inspection, a sag in the drain was identified between Downing and West Streets. In addition to the sag, other defects identified included cracked pipes, infiltration (not a severe problem for storm drains), and tree roots. Cracked pipes were identified in and along South Street. In total, over 1,000 feet of pipe were identified as having cracks. Of this total length, there was only one section with a major crack (>1/8"). This section was between manholes 2071.1-J14 and 1844-J14 and measured approximately 110 feet. In addition to cracked pipes, root intrusion was identified during the review. Roots were identified in and along South Street and in Thompson Street. The identified roots affect over 300 feet of pipe. Many of the roots occurred only at joints while others occurred in the pipe. Infiltration was identified during the tape review at six locations in the drain along South Street.

Street	Manhole	Item	Distance from Starting Manhole (feet)
Blockage			
Downing	MH07 - MH06	Pipe in sewer from service located 31' from MH07	32.1
Thompson St.	MH01 - Unknown	1/2 Pipe blocked from bottom	22.1
Thompson St.	MH03 - MH02	Debris in pipe, 1/4 from bottom	127.5
South St.	2181-J14 - 2074-J14	Pipe crossing drain	16
South St.	2181-J14 - 2074-J14	Pipe crossing drain	98
South Street Ease.	1840-J14 - 1846-J14	Service with debris	105
South Street Ease.	1840-J14 - 1846-J14	Service with debris	112
South Street Ease.	2475.1-J15 - 2493-J15	Service blocked with debris	70
South Street Ease.	2475-J15 - 2475.1-J15	Debris in pipe	156
South Street Ease.	2475-J15 - 2475.1-J15	Mineral Deposits	190
Miscellany			
Chesley St	MH01 - MH04 Fayette	Protruding Tap	12.2
Downing	MH02 - MH01	Plugged Service - Active	186
Downing	MH03 - MH02	Protruding Tap	22.3
Downing	MH07 - MH08	Protruding Tap	146.9
Downing	MH08 - Unknown	Protruding Tap	155.8
Fayette and South	MH01 - MH03	Encrustation at multiple pipe joints. Possible I/I problem	259.8
Fayette St.	MH03 - MH01	Protruding Tap	25
Fayette St.	MH03 - MH05	Protruding Tap	51.1
Monroe St.	MH01 - MH02	Protruding Tap	113
Monroe St.	MH01 - MH02	Protruding Tap	113.8
Monroe St.	MH02 - MH03	Debris in service	88.1
Monroe St.	MH03 - Brick Main	Protruding Tap	79.6
Monroe St.	MH03 - MH02	Broken Service	64.1
Monroe St.	MH03 - MH02	Protruding Tap	81.5
Perley St.	MH02 - MH03	Protruding Tap	11.5
Perley St.	MH04 - MH05	Collapsed Service	56.9
Perley St.	MH04 - MH05	Protruding Tap	14.9
South and Concord	Main - Buried MH01	Debri in 1/4 of pipe	235
South and Concord	Main - Buried MH01	Encrustation at multiple pipe joints. Possible I/I problem	30.5
Thompson St.	MH01 - MH02	Protruding Tap	83.1
Thompson St.	MH02 - MH01	Protruding Tap	51.8
Thompson St.	MH02 - MH03	Protruding Tap	118.6
Thorndike St	MH02 - MH01	Protruding Tap	127.1
South St.	2074-J14 - 2071-J14	Protruding Tap	78
South St.	2074-J14 - 2071-J14	Protruding Tap	88
South Street Ease.	2212-J14 - 2456-J15	Mineral Deposits	103
South Street Ease.	2456-J15 - 2212-J14	Mineral Deposits	87
South Street Ease.	2493.1-J15 - 2691-J15	Protruding Tap	186
South Street Ease.	2776.1-J15 - 888	Mineral Deposits	229
South Street Ease.	2776-J15 - 2776.1-J15	Mineral Deposits	100
Thompson St	1846-J14 - 1840-J14	Service with debris	9
Thompson St	1846-J14 - 1840-J14	Service with debris	40
Thompson St	1846-J14 - 1844-J14	Pipe in Pipe	14

Table 4-7
Drain Pipes with Blockage and Miscellaneous Defects

Though the cracked pipes identified during the review do not currently serve as an impediment to flow, their condition may over time deteriorate to the point where they fail and impede flow in the drain. Roots pose a similar problem as they may grow to impede flow and may eventually cause the pipes to fail.

Infiltration and Illicit Connections

Twelve active services were observed during the Spruce Street tape review, and five during the City's TV tapes review. However, because it rained during the Spruce Street TV inspections, these services could not be identified as conveying storm drainage or as illegal connections. The questionable sections are listed in Table 4-8. It is recommended that the City investigate these services during dry weather to determine if they are illegal connections. One service (discussed above) along South Street between 2467-J15 and 2467.1-J15 is identified as a potential sewer connection as there was toilet paper at the service.

4.6.2 TV Inspection Summary of Recommendations

City TV-Inspected Drains

Based on the scoring described above, the highest total defect scores in the City inspected drains were on Thompson, Fayette, Monroe, and Downing Streets. The high defect scores assigned to drains in Thompson Street, Fayette Street and Monroe Street were a result of cracked and crushed pipes. On Downing Street the high scores were due primarily to cracked pipes.

Crushed pipes may serve as an impediment to flow in the storm drain system. They also have a high risk of collapsing and causing more serious problems in the future. Fifteen sections of crushed pipes were identified and are listed in Table 4-6. Based on this review, we recommend that defects within all pipe sections with a score of 1.0 or higher be given highest priority for repair. In addition, we recommend the active service connection on Downing Street between MH02 and MH01 be removed from the drainage system and tied into the sewer system. Finally, although roots do not cause immediate structural concern, we recommend the heavy roots on Perley Street be removed. Although other defects identified in this review deserve attention, they are not as high a priority, or, in some cases, will not be cost effective to repair.

Spruce Street Drain

Based on the review of Severn Trent's TV inspection tapes, we recommend that defects within all pipe sections with a score of 1 or higher be given highest priority for repair. Addressing these sections should mitigate future problems associated with the roots and cracked pipes. Although other defects identified in this review deserve attention, they are not as high a priority or, in some cases, will not be cost-effective to repair. The highest priority recommendations are summarized in Table 4-6.

As discussed above, a total of seventeen active services were observed during the tape review. It is recommended that the City investigate these services during dry weather to determine if they are illegal connections.

4.7 Recommendations

The highest priority recommendations are summarized in Table 4-9 and presented in Figure 4-8. Recommendations from this list that potentially address problems identified in Section 4.5.2 should be given higher priority.

Recommendations for repair and replacement are summarized in Section 10.

Street	Manhole	Distance from Starting MH	Comment
Downing Street	MH07 - MH06	31.2	Unplugged Service
Downing Street	MH01 - MH02	186	Active
Perley Street	MH02 - MH01	9.3	Unplugged Service
Perley Street	MH04 - MH05	85.3	Unplugged Service
South and Concord	Main - Buried MH01	68.4	Unplugged Service
South Street Easement	2181-J14 - 2181.1-J14	10	
Thompson Street	1846-J14 - 1844-J14	7	
South Street Easement	2071.1-J14 - 1844-J14	260	
South Street Easement	2071.1-J14 - 1844-J14	266	
South Street Easement	2475.1-J15 - 2493-J15	80	In MH 2493
South Street Easement	2475-J15 - 2475.1-J15	28	
South Street Easement	2181.1-J14 - 2212-J14	151	Possible sewage connection, toilet paper
South Street Easement	2456-J15 - 2212-J14	111	
South Street Easement	2467-J15 - 2467.1-J15	8	Blocked but leaking
South Street Easement	2467-J15 - 2467.1-J15	8	
South Street Easement	2181-J14 - 2181.1-J14	60	
South Street Easement	2467-J15 - 2467.1-J15	21	

Table 4-8
Sections of Drain Pipe Identified as Possibly Having Active Services

Street	Manhole	Score	Defect Summary
South Street Easement	2475-J15 – 2475.1-J15	10.6	Pipe Sag
Fayette St.	MH03 – MH01	8.92	Collapsed pipe, major cracks, misaligned pipes, etc.
Thorndike St.	MH04 – MH05	5.71	Crushed pipe, major cracks, some roots
Thompson St.	MH03 – MH02	5.56	Collapsed pipe, major and minor cracks
Monroe St.	MH01 – MH02	4.02	Crushed pipe, hole around service
Downing St.	MH03 – MH09	3.56	Major and minor cracks, roots
Thompson St.	MH03 – MH04	3.51	Crushed pie, major and minor cracks
South Street Easement	1840-J14 – 1846-J14	2.9	Minor cracks
South St.	2071.1-J14 – 1844-J14	2.6	Major & minor cracks
Thompson St.	MH01 – MH02	2.25	Crushed pipe, major cracks
Monroe St.	MH02 – MH03	1.81	Crushed pipe, major cracks
Chesley St.	MH01 – MH04 Fayette	1.80	Major cracks
South St.	2071-J14 – 2071.1-J14	1.3	Minor crack, hole around pipe
Downing St.	MH03 – Unknown	1.27	Major cracks
Downing St.	MH02 – MH01	1.25	Collapsed pipe, major cracks, pipe sag
South Street Easement	2776.1-J15 – 888	1.0	Minor crack, infiltration
South Street Easement	2493.1-J15 – 2691-J15	1.0	Minor crack, heavy roots
South St.	2074-J14 – 2071-J14	1.0	Minor Crack

Table 4-9

Prioritized Recommendations Based Upon TV Inspection Score

Section 5
Detailed Study Area No. 2
"Washington Street"

5.1 Introduction

Although the hydraulic modeling of the Terrible Trapezoid area revealed important information about the nature and causes of flooding, the City and CDM discussed a different approach for the second study area. It was determined that the nature of hydraulics issues, including concerns about water quality, collapsed pipes and possible cross connections in this basin would be better investigated through a methodical manhole inspection field program rather than through hydraulic modeling.

Therefore, the approach used in the Washington Street area stressed field investigations over computer analysis. A subcontractor, Severn Trent Pipeline Services, Inc, was retained to perform detailed manhole inspections of many of the manholes in the basin. The inspections began on October 24, 2001 and continued for 8 ½ weeks.

The field program is also useful for the GIS task. Many drainage features not captured in previous mapping efforts were located, and the locations of existing mapped features were confirmed. This section describes the findings and recommendations of the Washington Street basin manhole inspection program.

5.2 Study Area

Washington Street basin is the area roughly bounded by Franklin Street and Bishopsgate to the north, Ridge Road and Westbourne Street to the west, Warren Street and Concord Street to the south, and the Merrimack River to the east (Figure 5-1). The study area includes White Park as well as a portion of the downtown area.

5.3 Scope and Methods

5.3.1 Mapping

CDM developed map books from the drainage GIS of the basin for use in the field. The 11"x17" books show streets, storm water pipes, manholes, catch basins and lamp holes in the basin. These map books were provided to Severn Trent and to the City.

A temporary manhole numbering scheme was developed for the inspection program, based on the structures in the map books. Manholes and catch basins located in the field were given a unique number at that time. At project close, the drainage manholes and catch basins were renumbered to produce a consistent number scheme incorporating the newly identified drainage facilities, once all structures had been entered into the GIS system.

5.3.2 Toughbook Computer

To accompany the hard copy maps during the field investigation, an electronic version was created. ArcView GIS mapping software was loaded onto a Panasonic Toughbook Computer (Pentium III) with touch screen. A data sheet similar to the hard copy shown in Figure 5-2 was created for use with the computer. Using the computer, the field team could enter this information for a manhole or catch basin that existed in the database, create a location for a manhole or catch basin that did not exist in the database, and/or move a manhole or catch basin. The software contained many quality control features including pull-down menus and error checking. The pull-down menus limited the field crews to certain well-defined choices. This avoids spelling errors and provides data consistency. The error checking prevented field crews from erroneously entering invalid data, by making sure the data was within reasonable values. Perhaps the most important quality control feature of the software is that data sheets do not need to be transcribed in the office, completely eliminating this source of error.

An ArcView application and Access database were created for use with the Arcview linked data collection software. The ArcView application pulls and sorts the data collected into a usable form, which is then used by the Access database to develop data reports. Using these tools, the data collected in the electronic data sheet can be summarized to provide information about problems in the system. For instance, reports can be prepared listing all manhole structures with cracked covers. Should additional covers be available, these manholes can be repaired. Appendices A and B contain reports created to detail findings of this inspection program in the Washington Street Basin. Appendix E contains a “manual” detailing the use of the ArcView application and Access database for report creation.

Both the Toughbook and the application/database are the property of the City of Concord, and have been provided to the City.

5.3.3 Scope of Inspections in Basin

In order to streamline the inspections, not every manhole in the basin was entered and inspected in detail, as described in section 3.4. If several inspections indicated that the nearby manholes were in good condition, the inspection team would either “pull” manhole covers but not enter all of the manholes, or open and enter only every second or third manhole on a line. If the team found evidence of a cross connection, illicit discharge, collapsing pipe, or other problem, additional manholes could be opened until the problem was pinpointed as closely as possible. Any problems found were reported to the City.

Once a week the field crew visited CDM’s offices in Manchester to download and backup their data. Copies of the field maps, notes and photos were also left with CDM staff and were turned over to the City.

5.3.4 Scope of Inspection

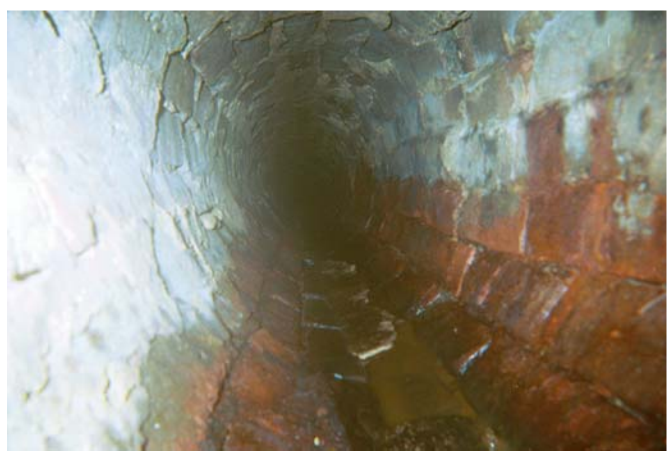
Upon reaching a manhole scheduled for inspection, the team first noted whether inspection was possible. If not, the manhole location and the reason preventing inspection were noted in the database, i.e., car parked, could not locate, paved over, etc. The manhole was located on the map, and in those cases where inspection may have been possible at a later time (car parked), the structure was revisited until the inspection was completed.

When an inspection could proceed, the cover was removed and a light lowered. Depths from rim to invert and sediment were recorded, as well as the condition of the rim and cover. Any other observations that could be made from the surface were recorded.

One member of the team entered the manhole to more closely inspect the condition of the structure. Material and condition were noted for the cover, rim, frame, steps, corbel, walls, shelf, and invert. In addition, any cracks, breaks, or offsets were described. The data was entered into the ArcView database.

Pipes entering and exiting the manhole were entered into the database, along with their diameter, shape, material, and invert. Pipes were numbered starting with the pipe just clockwise from the main outlet, continuing in the clockwise direction. The main outlet at each manhole is the pipe with the highest number.

During the inspection, pictures were taken of each pipe at each manhole inspected. These pictures were developed on photo paper as well as in electronic form on compact disk. Once the GIS database has been field checked, the pictures and the electronic data forms could be connected with the GIS mapping and database to provide visual user reference for condition, shape, and material of pipe. Several of these pictures are provided in Appendix C.



Typical Photo of Pipe Taken During Inspection

Sound testing was used to confirm connections between individual manholes. This involves one inspection team member pounding on a manhole cover with a sledge-hammer, while the second team member listens at an open manhole. Echoes will reverberate down pipes into connected manholes, while no such echoes will be audible at non-connected manholes.

The inspection team updated the ArcView database with new manholes and catch basins as appropriate. Pipe connectivity information and other relevant notes were marked on the hardcopy maps. Where necessary for additional detail, larger scale sketches were made of intersections, problem areas, or "spaghetti" piping to clarify the connectivity, structure identification, and conditions. These are provided as Appendix D.

Finally, any dry weather flow was described (odor, color, depth/flow-rate) along with any observations indicating water quality problems in the manhole, i.e., toilet paper, odor, excessive sediment, etc. As with the other information, this data was entered into the ArcView database.

The manhole was re-covered, and the next manhole was located.

5.3.5 Follow-up

Updating the City's GIS database and mapping to reflect the findings of the manhole inspection program was the ultimate goal of this task. However, to avoid duplication of effort, the GIS database was first updated to reflect the new aerial photography data. As the updates to reflect the aerial photography data were automated and most of the updates to reflect the inspection program (i.e., piping connectivity) were manual, this saved on staff time required to complete the work.

5.4 Findings

A total of 730 structures were visited during this program. A total of 460 structures were inspected, including:

- 394 manholes that were entered for a complete inspection;
- 17 manholes for which a partial inspection was completed;
- 46 catchbasins for which a complete inspection was done; and
- 3 catchbasins for which a partial inspection was completed.

A top-only partial inspection.

Field crews visited an additional 270 structures that appeared in the map books, but where no inspection was possible. These include mapping errors (no manhole at the mapped location, or the map incorrectly showed another map feature such as a sewer manhole or lamp pole as a drain manhole), manholes that were paved over, could not be opened, or were inaccessible (i.e., cars parked). Figure 5-3 shows the location of the fully and partially inspected structures in the Washington Street basin.

The field crew found that the mapping provided by the City's current GIS did not accurately portray the system. In many cases they found that existing manholes were not on the maps, stormdrain manholes were labeled as catch basins, sewer manholes were labeled as stormdrain manholes, etc. This underscores the need to move forward with the aerial photography information and the field checking of the data. The original purpose of the field investigations was to assess the condition of the drainage system. Once mobilized, the field crews determined that many mapping corrections were required. After consulting with the City, the field investigations became a multi-purpose program, designed to assess the condition of the drainage system and provide mapping corrections.

The manhole inspection program found that in general the manholes and pipes in the Washington Street basin are in good condition. Very few problems were found.

Pictures taken of the worst problem sites are reprinted in Appendix C. The locations with highest priority for follow-up, summarized in Table 5-1 and in Figure 5-4, are:

- Possible illicit connection near the corner of Concord Street and South State Street. The field crew noticed evidence of light sewage and a strong sewer smell on Concord Street flowing east from South State Street to South Main Street (manhole numbers 2033-J14 to 2031-J14).

- Possible illicit connection on a cross country pipe west of Valley Street (upstream of manhole number 3116-I13). Evidence of "dripping sewage" was found in the 8" line running from the end of Chestnut Street to just south of the corner of Valley Street and Orion Street, at the north end of White Park. This may be the cause of the following bulleted item.

- Small amount of gray-colored flow with a slight septic smell noticed on Valley Street between Forest Street and Liberty Street into White Park (manhole numbers 179-I13 to 808-I13). The flow was noticed just downstream of a location where a sewer line passes through the drain line. The preceding bulleted item may be the cause of this problem.

- Possible cross connection near North Main Street at Pearl Street (manhole 3898-J13). Flow containing floatables, including toilet paper, was found in the manhole.

Problem	Solution	Recommendation
Possible cross connection near the corner of Concord Street and South State Street.	TV 300' along South State and Concord to pinpoint location; redirect illicit connection(s) to sanitary sewer line in street.	Investigate and redirect connection(s).
Possible illicit connection on a cross country pipe west of Valley Street	TV 250' from Chestnut to Valley to pinpoint location; redirect illicit connection(s) to sanitary sewer line.	Investigate and redirect connection(s).
Small amount of grey-colored flow with a slight septic smell noticed on Valley Street between Forest Street and Liberty Street into White Park.	Repair of the above item may eliminate need for further investigation.	Investigate and redirect connection at Valley Street (above), and reassess.
Possible cross connection near North Main Street at Pearl Street	TV 350' along Pearl Street to pinpoint location; redirect illicit connection(s) to sewer in street.	Investigate and redirect connection(s).
Joint failure and possible cross connection on Liberty Street, north of Vernon Street	1. TV 400' of pipe to locate illicit connection; Redirect illicit connection, Replace 400' of pipe	Plug 8" pipe at manhole, if appropriate to do so.
	2. TV 400' of pipe to ensure hydraulics will not be affected. Plug pipe at manhole.	
Collapsed pipe at Celtic Street and Lyndon Street.	Replace 400' of 8" diameter clay pipe with similar diameter pipe. (One tee-connection on this stretch).	Replace pipe.
Excess sedimentation in manholes	Schedule City vactor-truck to clean	Clean out excess sediment.

Table 5-1

**Priority Problems Identified During Manhole Inspection Program
Washington Street Drainage Basin**

- Joint failure and a possible cross connection on Liberty Street, north of Vernon Street (manhole 213-I13). A section of 8-inch pipe about 4-feet upstream (south) of the manhole has settled 4" to 5", giving way at the joint. Although the exact source of flow in the settled pipe was not located, mapping indicates that it may be connected to the sewer system.

- Collapsed pipe at Celtic Street and Lyndon Street (8" vitrified clay pipe collapsed to 3", manhole number 3440-I13).

Other locations where attention may be needed, but are perhaps of lower priority as they do not involve raw sewage or complete pipe failure, include:

- Excessive amounts of debris, 90 to 100% full, in pipes on Blake Street (manhole number 1786-J14), Warren Street at Green Street (1891-J14), Summit Street (1606-I14), Celtic Street (3441-I13), and Valley Street (3116-I13). These locations are shown in Figure 5-5 and detailed in the debris report found in Appendix B.

- Drain manhole (I14-1) on Tahanto Street, south of Central Street sound-tests positive for cross connection with sewer system. There is also excessive debris in this area. This manhole is shown in Figure 5-4.

- The pipes or structures in fair to poor condition identified in Appendix B. Some of these locations are also summarized in Figure 5-6. Pictures taken during the inspection program of select pipes are presented in Appendix D.

5.5 Recommendations

- Complete aerial photography data reduction. Integrate this data into the GIS database. Check the database against findings from this inspection program. Field-check the final mapping and database.

- Monitor locations that accumulate excessive debris and clean out when full.

- Repair priority sites, as discussed in Section 10.

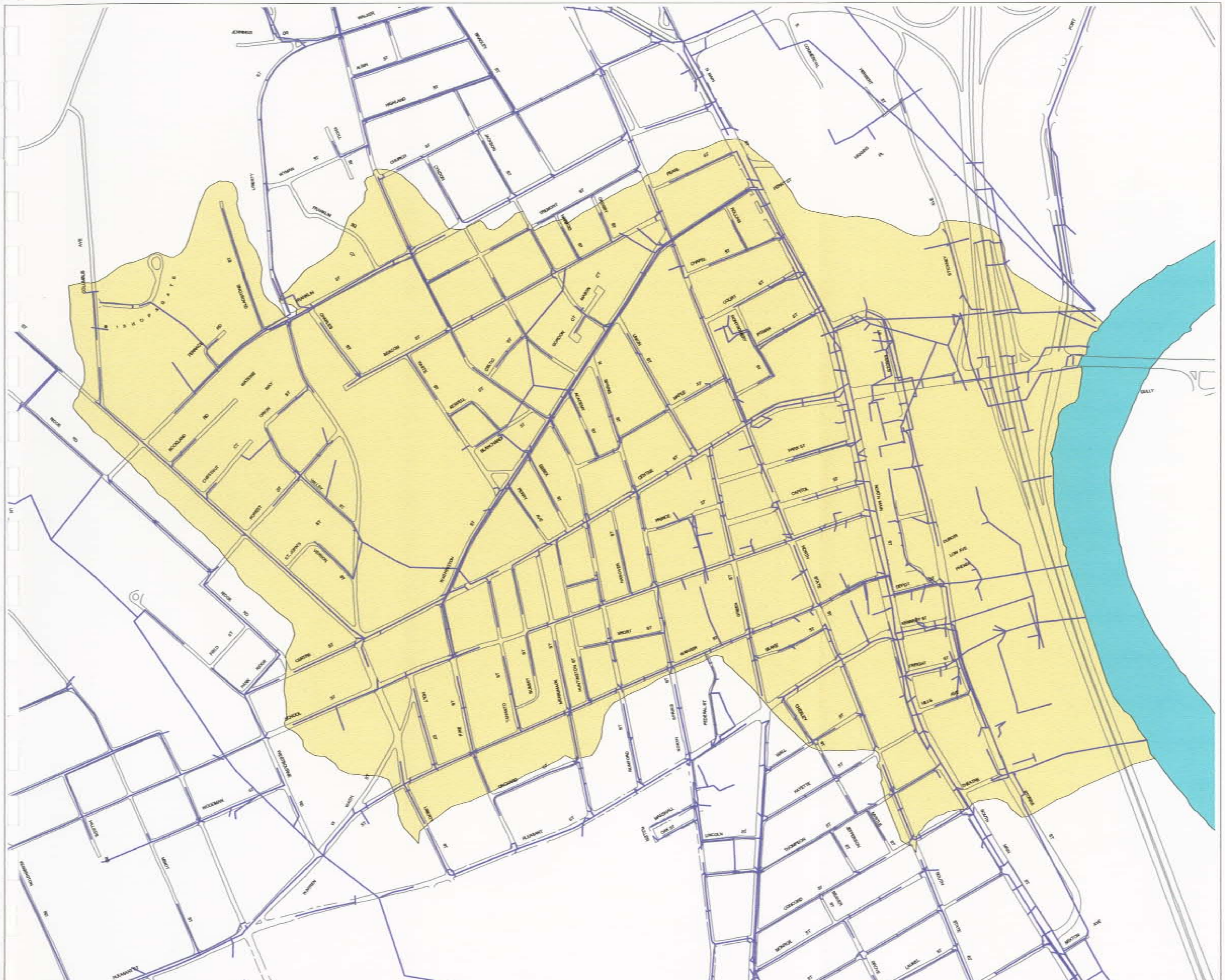


Figure 5-1: Washington St. Study Area

Concord, New Hampshire
Washington Street Drainage Area - Manhole Inspection Program

Inspectors: ______________________ Inspection Sheet No. ________

Time: ________

Date: ________

Weather: ________

Manhole Identifier: ________

A. Manhole Data:

Manhole size: 4' ________ 5' ________ Other: ________

Cover Size: 24" 30" Other:

Item	*Materials*		*Cracks*		*Breaks*		*Condition* Good	Fair	Poor
Cover							☐	☐	☐
Rim							☐	☐	☐
Frame							☐	☐	☐
Steps							☐	☐	☐
Corbel							☐	☐	☐
Walls							☐	☐	☐
Shelf							☐	☐	☐
Invert							☐	☐	☐

No. of holes in cover ________

Is cover subject to ponding? yes ________ no ________

Number of Manhole Grade Adjustments ________

Any there steps? yes ________ no ________

Sediment in pipe? yes ________ no ________

Any infiltration? yes ________ no ________

Location 1: ________ Flow Estimate: ________ gpm

Location 2: ________ Flow Estimate: ________ gpm

Location 3: ________ Flow Estimate: ________ gpm

Rim to top of sediment (feet) ________

Rim to invert (feet) ________

If evidence of surcharging, distance above invert (feet)

B. Pipe Data

	Incoming #1		*Incoming # 2*		*Incoming #3*		*Incoming #4*		*Exiting*
Photo Number									
Dimensions, Inches									
Rim to invert, feet									
Material									
Offsets observed?									
Breaks observed?									
Cracks observed?									
Condition (good, fair, poor)									
Flow?									
If yes:									
Depth of flow, inches									
Approximate discharge, gpm									
Evidence of floatables?									
Evidence of oil sheen?									
Smell									
Color									
Test kit used?									
Sediment in pipe?									

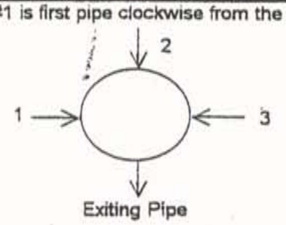
If yes:

Sediment character (circle one) sandy silty debris other if other: ________

Percent full? (circle one) <10 10 25 33 50 66 75 90 > 90 100

Comments:

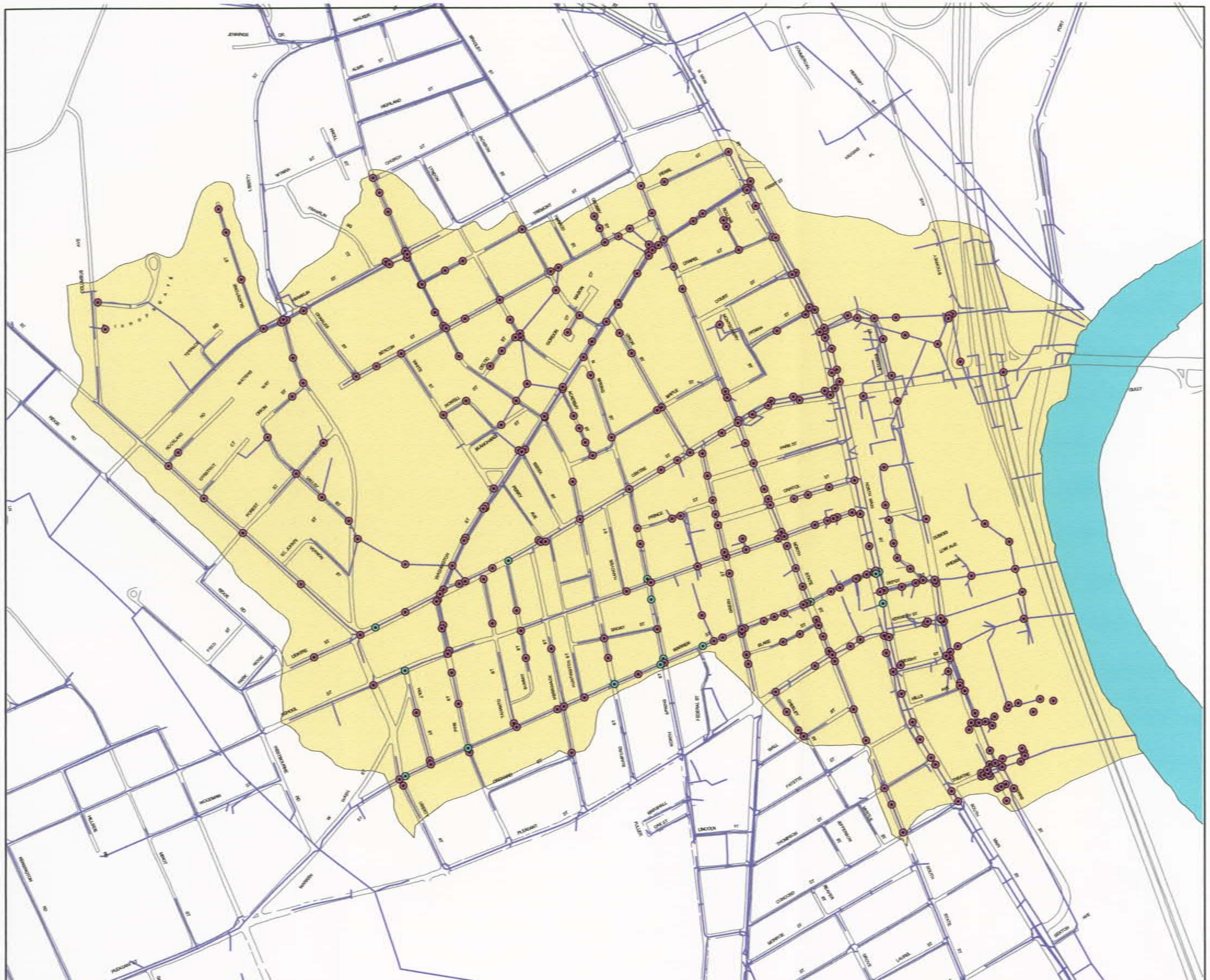
Note: Incoming #1 is first pipe clockwise from the exiting pipe when looking down



CDM

Figure 5-2
Datasheet for Manhole Inspections

Figure 5-3: Full and Partially inspected manholes.



CDM

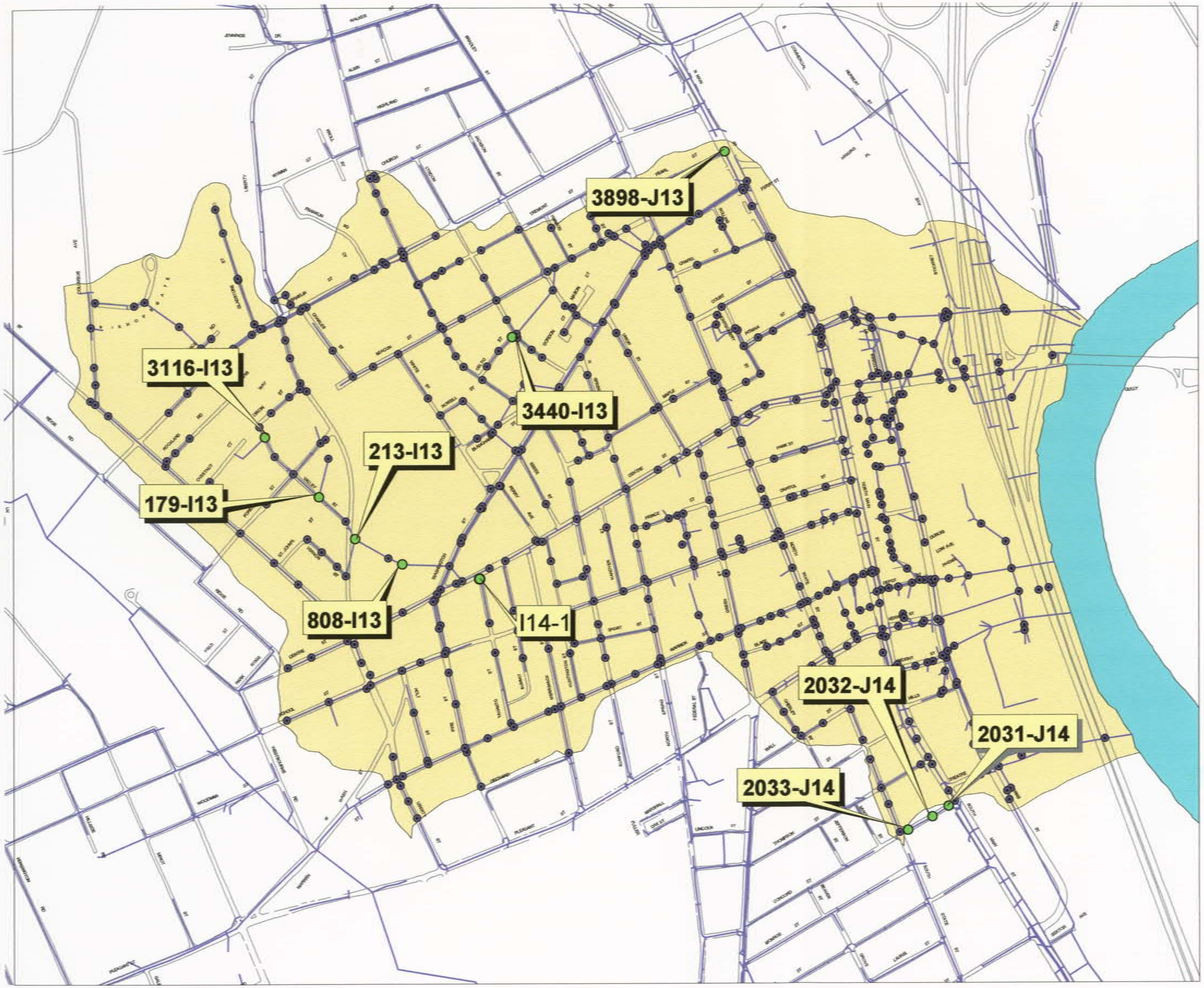


Figure 5-4: Manholes with Highest Priority for Follow-up. *

Legend

Features

- Drain Manhole
- Roads
- Drain Pipes
- Merrimack River
- Washington Street Drainage Area

N

500 0 500 1000 Feet

*Results summarized in Table 5-1

CDM

Figure 5-5: Manholes having pipes filled with 90-100 Percent debris.

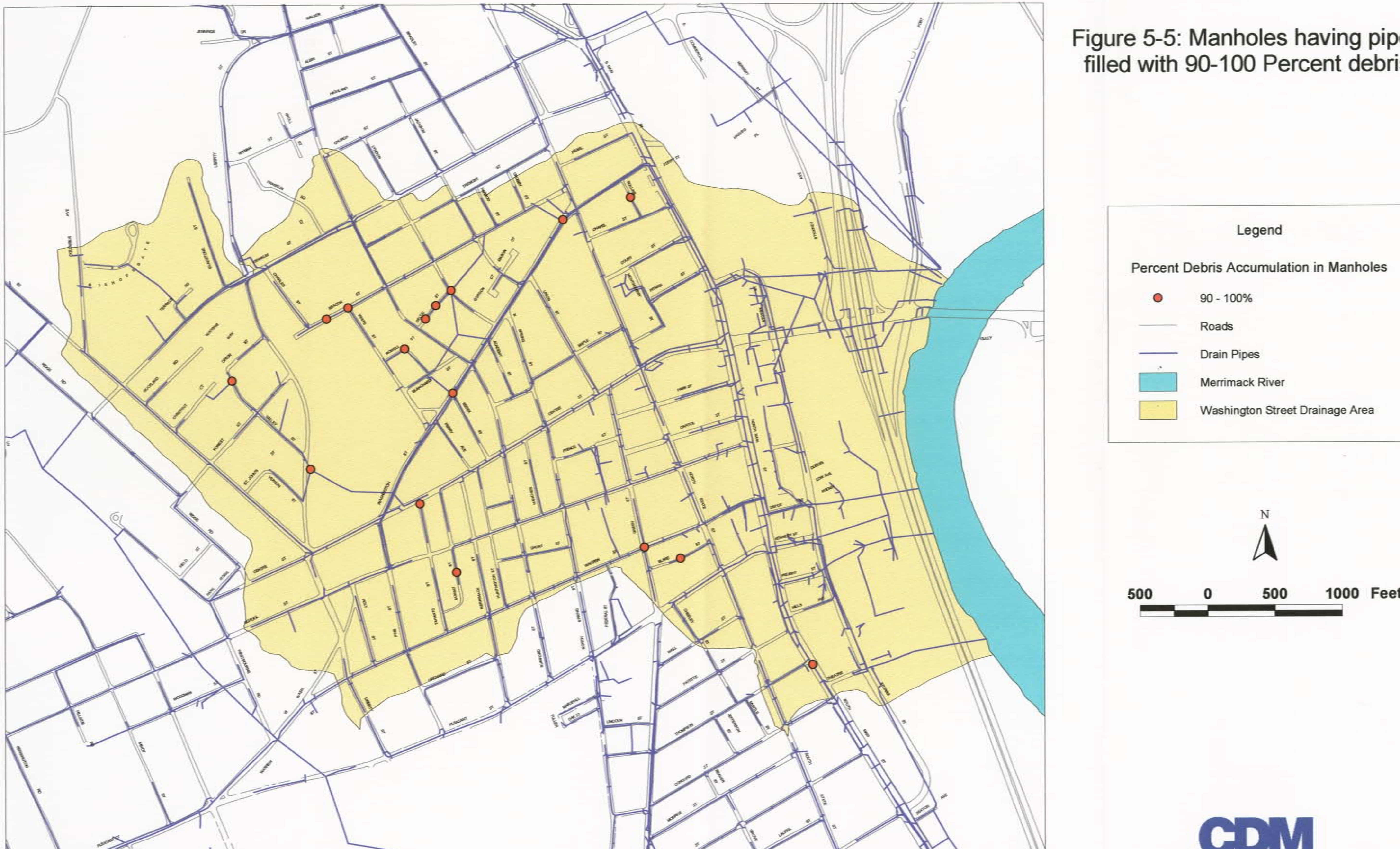
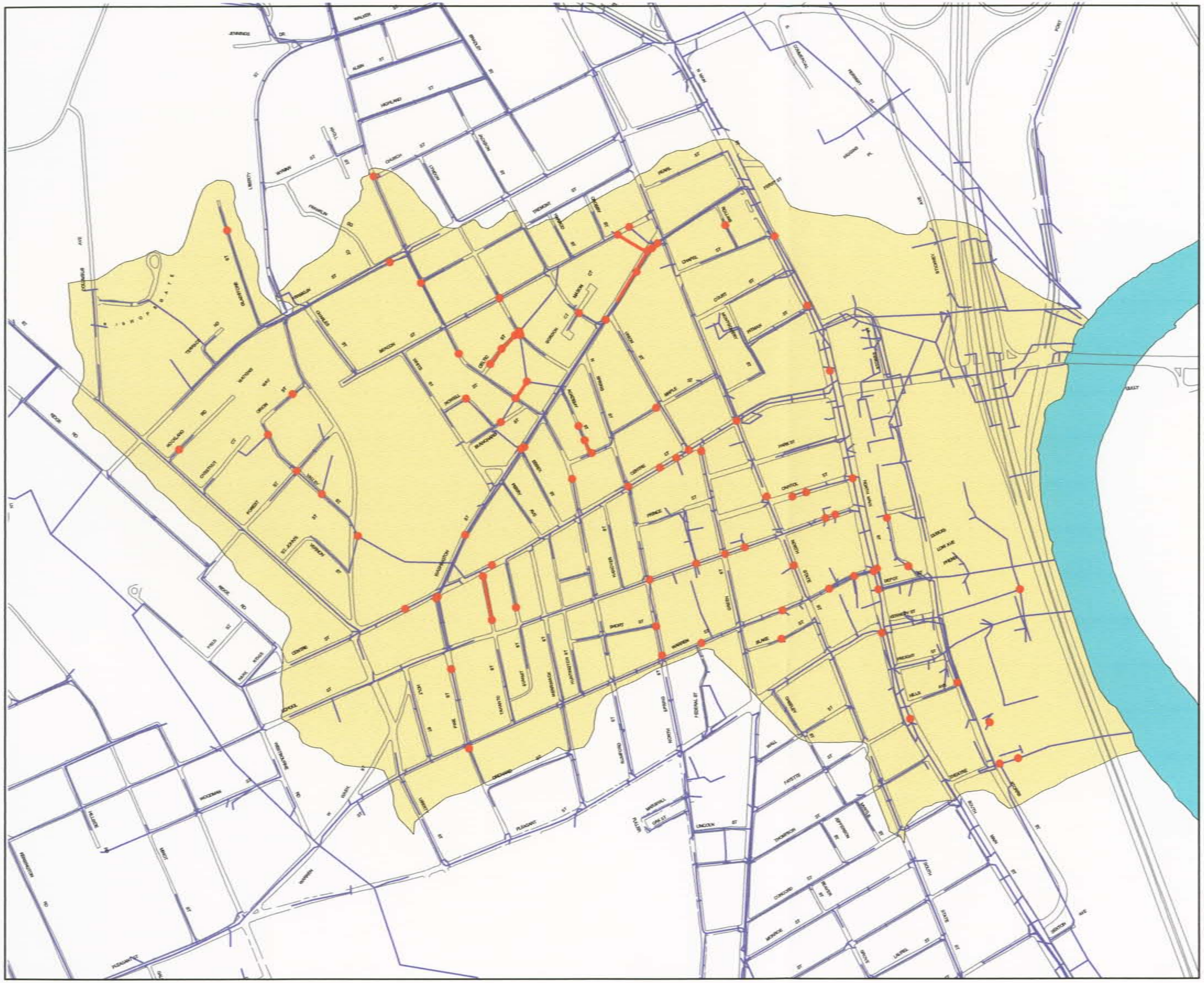


Figure 5-6: Pipes and Inverts/Shelves in Fair to Poor Condition



Legend

- Manholes with shelf and/or invert in Fair/Poor condition
- Fair/Poor Condition Pipes
- Roads
- Drain Pipes
- Merrimack River
- Washington Street Drainage Area

N

500 0 500 1000 Feet

CDM

Section 6
Remaining Sub-Basin Investigations

6.1 Introduction

The City of Concord has been separated into 12 sub-basins by topography. The two sub-basins discussed in Section 4 and 5 had different approaches for the sub-basin analysis. Both the hydraulic modeling of the Terrible Trapezoid sub-basin and the field inspections in the Washington Street sub-basin revealed valuable information about the drainage problems and issues facing the City in those areas. However, the methods used in these sub-basins were time consuming and rather labor intensive. Although detailed inspection of the rest of the City's stormwater system may be an ultimate goal, in the short term the City and CDM together developed a different approach for evaluating the remaining sub-basins.

The approach used for the remaining basins is a more standardized approach across all of the basins. The more developed areas containing existing drain pipes were the focus of each sub-basin. Smaller diameter drain networks and outlying areas were not investigated. A spreadsheet model using the "Rational Method" to evaluate sub-basin physical characteristics and existing stormwater collection systems. The method and model used for the evaluation are described in detail in Section 6.2.

The sub-basins established in this section, along with the corresponding subsection number in parentheses, are:

- Heights (6.3)
- Turkey River (6.4)
- Penacook (6.5)
- Fisherville (6.6)
- Oak Hill (6.7)
- Hospital (6.8)
- Horseshoe Pond (6.9)
- Turkey Pond (6.10)
- West Concord (6.11)
- Hoit (6.12)

A map showing all twelve (12) of the drainage basins are shown on Figure 9-1.

6.2 Rational Method Spreadsheet Model

The Rational Method is a widely accepted method of calculating peak rainfall runoff. The method, in widespread use since the 1900's, is applicable to small areas, but is seldom used for areas greater than 1 to 2 mi^2.[1]The Rational Method predicts the peak runoff according to the formula:

$$Q=CiA$$

where C is a runoff coefficient, i is the rainfall intensity (inches/hour), and A is the subcatchment area (square feet). The Rational Method was used, where appropriate, to calculate the peak discharge from sub-basins in Concord. Sub-basins Hoit, West Concord and Turkey Pond contain subcatchments larger than 1mi^2, so a USGS method was used instead of the Rational Method. This is explained in more detail in Sections 6.10 and 6.12.

The Rational Method spreadsheet model is described in further detail below. A sample sub-basin spreadsheet is used as an example case. The spreadsheet model workbook consists of two linked spreadsheets, "Tc Calcs" and "Project Area".

Table 6.2-1 shows the "Tc Calcs" spreadsheet and Table 6.2-2 shows the "Project Area" spreadsheet. Both are completed for the sample drainage sub-basin.

6.2.1 Characterization of Sub-Basin

Major manholes or junction points in the stormwater collection network are represented in the model by "nodes." Nodes accept flow from overland runoff and are connected by a pipe to other nodes in the network. The connectivity and timing of flow between these nodes is described in the model.

Within a drainage sub-basin, streets, neighborhoods and city blocks drain to individual nodes (catch basins) by gravity. The sub-basins were delineated into subcatchments, which is defined as a small area draining to a common location. These subcatchments get numbered and are listed in column 1 of the example sub-basin in Table 6.2-1. Each subcatchment is associated with a node in the model. The node represents the point of entry for that subcatchment area to the stormwater collection network.

6.2.2 Travel Time through Subcatchment (Tt)

Column 2 of Table 6.2-1 presents the pipe length (feet) between the point of entry node and downstream node. Column 3 presents the velocity (feet/second) between nodes. A conservative velocity value (5 ft/s) was agreed upon by CDM and the City. The velocity chosen falls between minimum flushing velocity (3 ft/s) and scouring velocity (10 ft/s). Column 4 calculates the travel time through the subcatchment, from

[1] Lindeburg, Michael R. Civil Engineering Reference Manual for the PE Exam. 8th Edition. Professional Publications, Inc. Belmont, CA. 2001.

the node at the upstream end of the subcatchment, to the node to which the subcatchment contributes. The formula in Column 4 is: Length/Velocity or Column2/Column3. The travel time is given in hours.

Some of the lengths are given as zero in Column 2. Subcatchments at the upstream end of the stormwater collection network have no node-to-node travel time, so the travel time is given as zero. If more than one node is upstream, the longer distance is used.

6.2.3 Time of Concentration for Subcatchment (Tc)

The Time of Concentration for a subcatchment is the time that it takes for a drop of water to flow from the farthest most point to the downstream end of the subcatchment. Generally, the path taken by this drop of water will consist of two phases:

- Overland flow – travel over the ground as runoff – Tc (1)

- In pipe flow – travel within the stormwater network pipes or impervious surface (roadways, driveways) – Tc (2).

The time taken during each of these two phases of travel is calculated separately.

Overland Flow

The length in Column 5 of Table 6.2-1 is from the farthest point in the subcatchment to the point where the flow enters the stormwater collection network or begins traveling on an impervious surface. Rain falling into the subcatchment will, at a maximum, travel the overland distance listed in Column 5 to enter the stormwater network.

Column 6 presents the elevation difference between the farthest point in the subcatchment and the location where the flow enters the stormwater collection network or begins traveling on an impervious surface. Slope, in Column 7, is then calculated as d(elev) (Column 6) divided by Length (Column 5), and is presented in units of feet per feet.

Using the slope from Column 7 and the known type of land use, the velocity is read from Figure 6.2-1. As an example, the first subcatchment H1 has a slope of approximately 0.005 ft/ft, or 0.5%, found along the lower left edge of Figure 6.2-1. Assume the example sub-basin is largely dense residential and urban land use; the line from the graph can be selected to be a grassed waterway and paved area sheet flow. Moving towards the right along the 0.5% line until approximately midway between grassed waterway and paved area, we find a velocity of 1.2 ft/sec. The rest of the subcatchment velocities are found in the same way.

Time of concentration for the overland flow, Tc(1), is calculated as the Length (Column 5) divided by the Velocity (Column 8), and is given in hours in Column 9.

Pipe Flow

Upon reaching the stormwater collection network, stormwater may still have a length of pipe or impervious surface to travel before reaching the downstream node of the subcatchment. The length (feet) from Column 10 may be greater than the length in Column 2 if the overland flow within the subcatchment reaches a secondary pipe before reaching the main trunk pipe. Node-to-node length in Column 2 only measures the distance along the main pipe from the upstream node to the downstream node.

Again, as in Column 3, the velocity in the pipe is assumed to be 5 ft/sec. The time of concentration or Tc(2) for in-pipe or impervious surface flow, is calculated as length (Column 10) divided by Velocity (Column 11) and given in hours.

The total time of concentration (Tc) of the subcatchment (Column 13) is calculated as the sum of overland flow (Column 9) and pipe flow (Column 12), in hours.

6.2.4 Runoff Coefficient and Area

The runoff coefficient is also based on the subcatchment land use. Coefficients used are related to land use of a particular subcatchment and are given in Table 6.2-3. These numbers serve as guidelines only. Subcatchments were assigned a number based on individual characteristics, which may fall between categories given below.

The area of each subcatchment, listed in Column 15 (acres), is measured digitally from the electronic subcatchment delineation in Autocad.

The final column, number 16, is the runoff coefficient (C) multiplied by the area (Column 15).

APPENDIX 20.A
Rational Method Runoff C-Coefficients

categorized by surface	
forested	0.059–0.2
asphalt	0.7–0.95
brick	0.7–0.85
concrete	0.8–0.95
shingle roof	0.75–0.95
lawns, well-drained (sandy soil)	
up to 2% slope	0.05–0.1
2% to 7% slope	0.10–0.15
over 7% slope	0.15–0.2
lawns, poor drainage (clay soil)	
up to 2% slope	0.13–0.17
2% to 7% slope	0.18–0.22
over 7% slope	0.25–0.35
driveways, walkways	0.75–0.85
categorized by use	
farmland	0.05–0.3
pasture	0.05–0.3
unimproved	0.1–0.3
parks	0.1–0.25
cemeteries	0.1–0.25
railroad yards	0.2–0.35
playgrounds (except asphalt or concrete)	0.2–0.35
business districts	
neighborhood	0.5–0.7
city (downtown)	0.7–0.95
residential	
single family	0.3–0.5
multiplexes, detached	0.4–0.6
multiplexes, attached	0.6–0.75
suburban	0.25–0.4
apartments, condominiums	0.5–0.7
industrial	
light	0.5–0.8
heavy	0.6–0.9

Support Material

Figure 6.2-1

Runoff Coefficients by Land Use.
Source: Civil Engineering Reference Manual, Eight Edition, Professional Publications.
Appendix 20-A, Page A-43.
Michael Lindeburg

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sub catchments	Travel Time Thru Subcatchmnt *(Node-to-Node Travel)*			Time of Concentration for Subcatchment Overland Flow					Pipe Flow			Tc of Subcatchment	**Runoff Coefficient "C"**	**Area**	"C"*Area
	Length (ft)	Velocity (ft/s)	Tt(sub) (hrs)	**Length (ft)**	**d(elev) (ft)**	slope (ft/ft)	**V (ft/sec)**	Tc(1) (hrs)	**Length (ft)**	Velocity (ft/s)	Tc(2) (hrs)	Tc(t)=Tc(1)+Tc(2) (hrs)		**(Acres)**	(acres)
S1	**0**	5	0.00	**55**	**0.3**	0.005	**1.20**	0.01	**1618**	5	0.09	0.10	**0.40**	**20.8**	8.32
S2	**1335**	5	0.07	**1288**	**20.6**	0.016	**2.10**	0.17	**1249**	5	0.07	0.24	**0.40**	**13.4**	5.36
S3	**0**	5	0.00	**1158**	**55.7**	0.048	**3.60**	0.09	**3412**	5	0.19	0.28	**0.40**	**50.5**	20.20
S4	**2825**	5	0.16	**607**	**29**	0.048	**3.60**	0.05	**1988**	5	0.11	0.16	**0.40**	**10.1**	4.04
S5	**2292**	5	0.13	**544**	**29.4**	0.054	**3.90**	0.04	**2131**	5	0.12	0.16	**0.40**	**58.3**	23.32
S6	**415**	5	0.02	**993**	**83**	0.084	**4.90**	0.06	**168**	5	0.01	0.07	**0.40**	**8.2**	3.28
S7	**0**	5	0.00	**733**	**60**	0.082	**4.90**	0.04	**1234**	5	0.07	0.11	**0.40**	**19.7**	7.88
S8	**938**	5	0.05	**826**	**42.5**	0.051	**3.70**	0.06	**1514**	5	0.08	0.15	**0.40**	**18.8**	7.52
S9	**0**	5	0.00	**410**	**24**	0.059	**4.00**	0.03	**590**	5	0.03	0.06	**0.40**	**13.8**	5.52
S10	**0**	5	0.00	**255**	**13**	0.051	**3.70**	0.02	**1665**	5	0.09	0.11	**0.40**	**15.8**	6.32
S11	**1775**	5	0.10	**620**	**46**	0.074	**3.50**	0.05	**1140**	5	0.06	0.11	**0.20**	**14.6**	2.92
S12	**1249**	5	0.07	**800**	**40**	0.050	**3.40**	0.07	**2026**	5	0.11	0.18	**0.20**	**34.5**	6.90
S13	**0**	5	0.00	**2310**	**132**	0.057	**3.60**	0.18	**220**	5	0.01	0.19	**0.20**	**44.6**	8.92
NULL1	**10**	5	0.00			0.000		0.00		5	0.00	0.00			0.00
NULL2	**873**	5	0.05			0.000		0.00		5	0.00	0.00			0.00
NULL3	**2658**	5	0.15			0.000		0.00		5	0.00	0.00			0.00
NULL4	**1334**	5	0.07			0.000		0.00		5	0.00	0.00			0.00
NULL	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.0*	*0*

City of Concord, NH
Stormwater Master Plan
Sample Area Drainage Calcs.

0206-45204
Checked by: CHC
Check date: 9 Nov 05

Calculation by: CMH
Calculation Date: 8 Nov 05

A	B	C	D	E	F	G	H	I	J	C	D	E	F	G	H	I	J
Sub Basin	Node	**Adj. Sub Sub**	Tc(sub) (hrs)	Tt(sub) (hrs)	Sub C*A (acres)	**Adj Node Node**	Tc (Adj Node) (hrs)	Tc (subarea) (hrs)	Node C*A (acres)	**Adj. Sub Sub**	Tc(sub) (hrs)	Tt(sub) (hrs)	Sub C*A (acres)	**Adj Node Node**	Tc (Adj Node) (hrs)	Tc (subarea) (hrs)	Node C*A (acres)
S	**A**	**NULL1**	0.00	0.00	0.00	**B**	0.10	0.10	8.32	**NULL2**	0.00	0.05	0.00	**C**	0.58	0.63	96.82
	B	**S1**	0.10	0.00	8.32	**NULL**	0.00	0.10	0.00	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	C	**S4**	0.16	0.16	4.04	**D**	0.28	0.44	20.20	**NULL3**	0.00	0.15	0.00	**E**	0.43	0.58	72.58
	D	**S3**	0.28	0.00	20.20	**NULL**	0.00	0.28	0.00	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	E	**S5**	0.16	0.13	23.32	**F**	0.13	0.26	11.16	**NULL4**	0.00	0.07	0.00	**H**	0.36	0.43	38.10
	F	**S6**	0.07	0.02	3.28	**G**	0.11	0.13	7.88	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	G	**S7**	0.11	0.00	7.88	**NULL**	0.00	0.11	0.00	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	H	**S9**	0.06	0.00	5.52	**J**	0.36	0.36	18.74	**S8**	0.15	0.05	7.52	**I**	0.11	0.16	6.32
	I	**S10**	0.11	0.00	6.32	**NULL**	0.00	0.11	0.00	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	J	**S11**	0.11	0.10	2.92	**K**	0.26	0.36	15.82	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	K	**S12**	0.18	0.07	6.90	**L**	0.19	0.26	8.92	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00
	L	**S13**	0.19	0.00	8.92	**NULL**	0.00	0.19	0.00	**NULL**	0.00	0.00	0.00	**NULL**	0.00	0.00	0.00

A	B	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Sub Basin	Node	Tc of Node (hrs)	**Minimum Tc of Node (hrs)**	**Tc used for Node (hrs)**	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	**Slope of Pipe From Node (ft/ft)**	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	**Pipe Dia. In Place (in.)**	Velocity in Pipe (ft/sec)	Current Max Flow (cfs)	% under required capacity
S	**A**	0.63	**0.25**	**0.63**	2.31	105.14	243.18	157.17	**0.005**	5.55	67	**60**	12.39	184.49	32%
	B	0.10	**0.25**	**0.25**	3.77	8.32	31.39	20.29	**0.005**	2.58	31	**36**	4.44	47.25	-51%
	C	0.58	**0.25**	**0.58**	2.44	96.82	236.24	152.68	**0.005**	5.49	66	**60**	12.03	184.49	22%
	D	0.28	**0.25**	**0.28**	3.60	20.20	72.71	46.99	**0.005**	3.53	42	**30**	14.81	29.06	60%
	E	0.43	**0.25**	**0.43**	2.90	72.58	210.83	136.26	**0.005**	5.26	63	**60**	10.74	184.49	12%
	F	0.13	**0.25**	**0.25**	3.77	11.16	42.10	27.21	**0.005**	2.88	35	**24**	13.40	16.03	62%
	G	0.11	**0.25**	**0.25**	3.77	7.88	29.73	19.21	**0.005**	2.52	30	**24**	9.46	16.03	46%
	H	0.36	**0.25**	**0.36**	3.20	38.10	122.00	78.85	**0.005**	4.29	51	**48**	9.71	101.75	17%
	I	0.11	**0.25**	**0.25**	3.77	6.32	23.84	15.41	**0.005**	2.32	28	**18**	13.49	7.44	69%
	J	0.36	**0.25**	**0.36**	3.20	18.74	60.01	38.79	**0.005**	2.53	30	**24**	19.10	32.05	47%
	K	0.26	**0.25**	**0.26**	3.71	15.82	58.71	37.95	**0.005**	3.26	39	**24**	18.69	16.03	73%
	L	0.19	**0.25**	**0.25**	3.77	8.92	33.65	21.75	**0.005**	2.64	32	**24**	10.71	16.03	52%

Table 6.2-2
Sample Model Output - "Project Area" Spreadsheet
Connectivity and Flow Calcuations

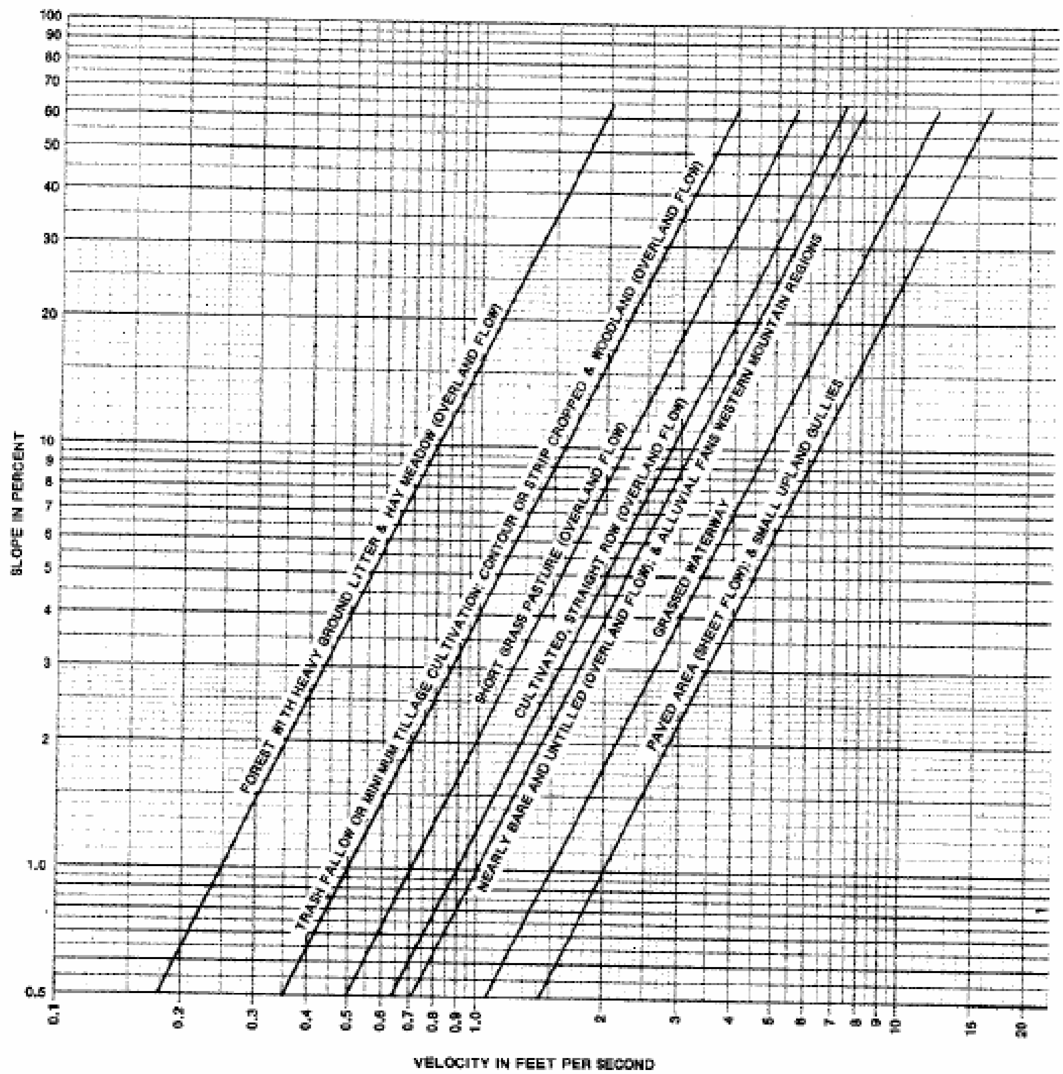


Figure 6.2-2

Upland method velocities for estimating time of concentration. Source: National Engineering Handbook, Section 4: Hydrology. Chapter 15: Travel Time, Time of Concentration and Lag. Kenneth M. Kent. 1972.

6.2.5 Connectivity

Table 6.2-2 is the second spreadsheet in the model workbook. Portions of this workbook are shown for each subbasin in the following sections, including all of the columns numbered at the top. The columns marked with a letter at the top are not included in the discussion of each subbasin, but are included here for further clarity on how the workbook operates.

Column A lists the subbasin code, here "S" for Sample basin. When the priority sites are listed together in one table, this column will help determine site location.

Column B lists the nodes in the subbasin. Nodes can connect to adjacent subcatchments and to adjacent nodes. All subcatchments and nodes directly connected to a node are listed in the same row of the spreadsheet.

Column C lists one adjacent contributing subcatchment. Subcatchments including the word "NULL" in their name are placeholders, used where no surface runoff reaches a node. Columns D, E and F refer back to the time of concentration table (Table 6.2-1) for the Tc, Tt and C*A, respectively, of the given subcatchment.

Column G lists a second adjacent contributing node, a node that is directly connected to the node listed in Column B. Column H lists the time of concentration (Tc) for the node in Column G.

Column I presents the greater of either:

- the subcatchment time of concentration (Column D), or
- the sum of the node time of concentration plus the subcatchment time of travel between nodes for the subcatchment (Column E plus Column H).

Additional columns C through F are repeated for additional subcatchments directly attached to the node listed in Column B. Columns G through J are repeated for additional nodes directly attached to the node listed in Column B.

6.2.6 Final Calculations

Column K is the maximum of all Column I's, which represents the maximum time of concentration calculated for each node.

Column M calculates the time of concentration to be used, either the maximum time of concentration calculated for the node (Column K) or 0.25 hours, whichever is greater. Fifteen minutes or 0.25 hours was selected as the shortest time of concentration used for these calculations. A smaller time of concentration would result in unreasonably sized drawing pipes.

Column N represents the intensity of the storm. The design storm selected by the City of Concord and CDM for analysis in this Section is expected to occur once every

10 years with duration equal to the time of concentration. This storm was selected because it provides reasonable protection from the majority of rain events, new designs require small diameter pipes than large storms (25, 50, 100-year), smaller pipes are more cost effective and smaller pipes are less disruptive to existing utilities.

A 10-year return frequency, 15-minute peak (hourly) precipitation rate design storm predicts an intensity of 3.77 inches/hour. The rainfall intensity is calculated from an empirical formula based on rainfall and duration data published by the National Oceanic and Atmospheric Administration (NOAA)[2].

A storm with duration equal to or greater than the time of concentration allows the flow from the farthest point in the watershed to reach the downstream end before the storm ends.

Column O sums each of the C*A columns for contributing subcatchments. Using the Rational Method, the flow in Column P is then calculated as

$$Q=c*i*A$$

Where c is the runoff coefficient, A is the area (c * A from Column O) and i is the intensity (Column N). Column P gives the flow (Q) estimated at the node from Column B for the 10-year return period storm, in cubic feet per second. Column Q gives this same flow in million gallons per day.

Column R gives the slope of each pipe. Note that a constant slope of 0.005 ft/ft was assumed for all of the pipes. This can be modified in future refinements of the model if desired.

Column S calculates the diameter of pipe required, at the given flow and slope, to pass the calculated storm for the given node. The formula used is:

$$\text{Diameter} = (2.16*Q*n/\text{Slope}^{1/2})^{(3/8)}$$

This formula is an alternate form of the Manning equation, for pipes flowing full, where n is the Manning roughness coefficient. Typical n values for cast iron or concrete are 0.013. This value is used in the spreadsheet. Column T converts the diameter required to inches.

Column U gives the actual diameter in place, where known. This number can be compared to the values in Column T to determine which pipes are undersized. CDM and the City reviewed existing plans and historical data to determine all existing pipe diameters listed in this column.

[2] NOAA Technical Memorandum NWS HYDRO-35. *Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States.* Silver Spring, MD. June 1977.

Column V shows the velocity (ft/sec) for the existing pipe in place. Velocities which are larger than 10 ft/s can cause scouring in the pipe.

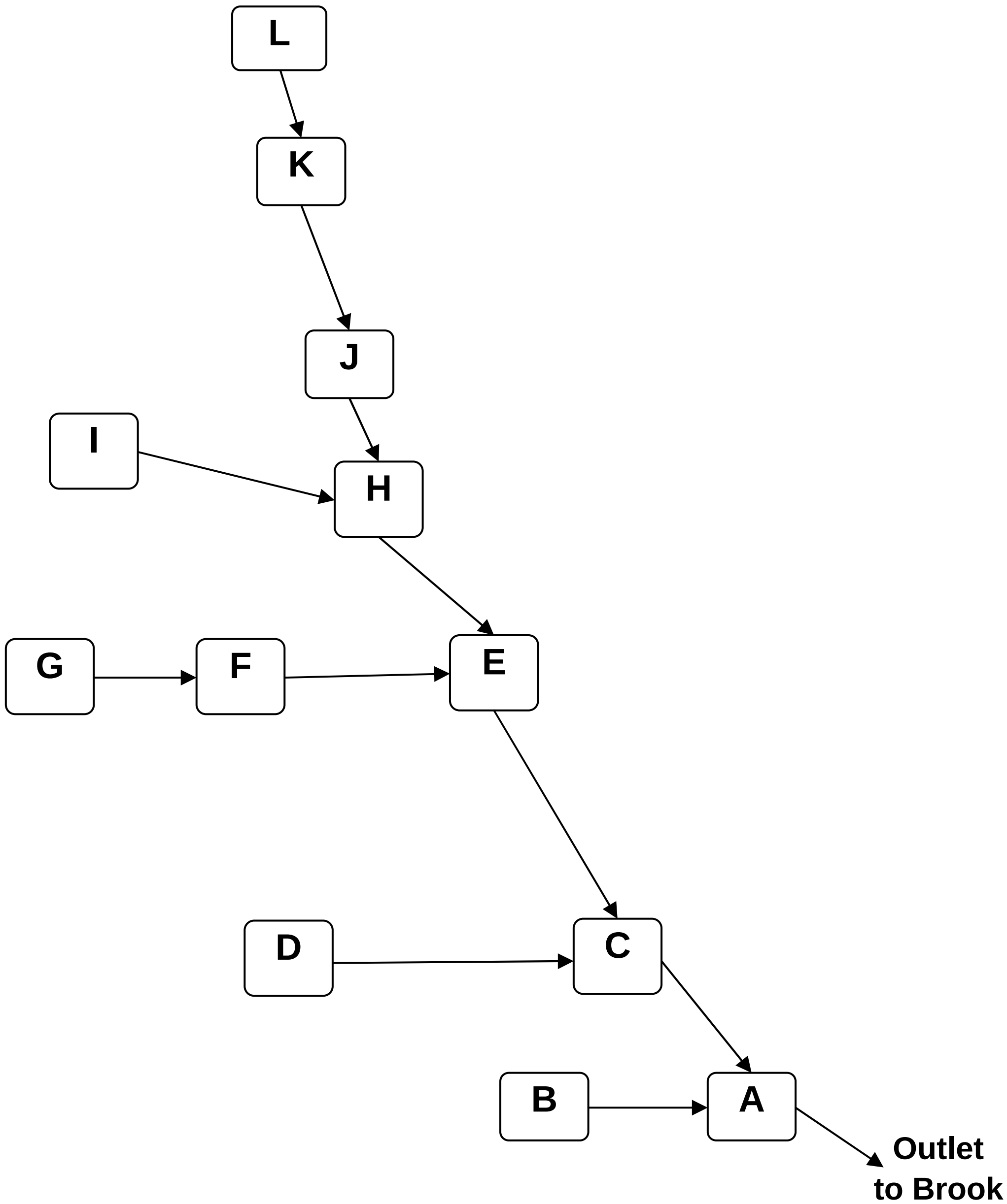
6.2.7 Summary

To determine if the size of the existing pipes are adequate, Column W calculates the maximum flow for the existing pipe at the determined storm intensity and slope. Column X calculates a ratio of expected pipe flow (Column P) versus existing pipe flow capacity (Column W). The City and CDM decided that any pipe ratio exceeding 50% of the existing pipe capacity should be listed as a problem area.

Figure 6.2-2 highlights the nodes which have an expected pipe flow exceeding 50% of the existing pipe capacity. Those nodes are D, F, I, K, and L.

The following chapters in Section 6 detail the 10 remaining drainage basins in the City of Concord that will identify these highlighted nodes as potential problem areas. Those problem areas will be summarized in Section 9 and 10. These nodes, along with identified problem areas from the City will comprise a complete list of future studies and projects in a Capital Improvements Plan.

Figure 6.2-2: Sample Drainage Basin - Connectivity Diagram



Section 6.3
Heights Drainage Basin Evaluation

6.3.1 Drainage Basin Description

Location

Figure 6.3-1 shows the Heights Drainage Basin located on the east side of the City of Concord. The drainage basin is bounded to the north by I-393 (Robert H. Whitaker Highway) and the Oak Hill Drainage Basin, to the west by the Merrimack River, and to the east by the Soucook River and the Town of Pembroke.

This drainage basin includes the Concord Municipal Airport, Concord's commercial district and Steeplegate Mall, the State Offices on Hazen Drive, and the New Hampshire National Guard State Armory on Pembroke Road.

Surface Water Drainage

The main surface water bodies in the Heights Basin are the Merrimack River, to the west, and the Soucook River, to the east. Several unnamed brooks and drainage ditches drain to these rivers. The basin is quite developed and there is an extensive stormwater pipe network.

The City requires new developments to manage stormwater on site in detention ponds. As a result, many neighborhoods in the Heights Basin contribute low stormwater flows to the collection system.

Drainage Sub-Basins

The Heights Basin is very large, and can be divided into several independent sub-basins. See Figure 6-3.1 for more details on the existing pipe network and subcatchment basins.

- Loudon – Along Loudon Road, from approximately Woodcrest Heights Drive to the west, including several neighborhoods on the north and south of Loudon Road. This sub-basin drains to the Merrimack River.

- Mall – Along Loudon Road, from approximately Woodcrest Heights Drive to the east, including the Steeplegate Mall and other shopping centers. This sub-basin drains ultimately to the Soucook River.

- Soucook – South and east of the Mall Sub-basin, the neighborhoods draining directly to the Soucook River, including much of Sheep Davis Road.

- Airport – South of the Loudon Sub-basin, including the National Guard facility and the Airport.

Major Drainage Pipes

Loudon

The main stormwater collection pipe for the Loudon area runs west along Loudon Road. The pipe is 30″ diameter until just west of the intersection with Airport Road, after which it is 36″ diameter to the outlet across from the eastern end of Gully Hill Road. Much of the drainage that would discharge to this main pipe is collected into detention ponds north of Loudon Road.

Mall

There is a 48″ pipe just west of the mall that runs along Loudon Road and discharges into the detention basin on the east side of the mall. A network of pipes throughout the commercial area around the mall feeds the detention pond and the 48″ pipe. Additionally, there is a 42″ pipe that discharges to the Soucook River under Sheep Davis Road.

Soucook

The roads and neighborhoods in the Soucook Sub-basin, such as Sheep Davis Road, are close to the river resulting in no major drainage pipes in this sub-basin.

Airport

The main pipe through the airport sub-basin is a 54″ diameter pipe running along Regional Drive and Regional Drive Extension. Approximately 670 feet northwest of Airport Road, along Regional Drive Extension, the 54″ pipe joins with a 30″ pipe. From this point to the discharge location off Old Turnpike Road the stormwater main is a 60″ diameter pipe.

Known Problems and Issues

Table 6.3-1 summarizes the known problems and issues as presented from the City to CDM.

Table 6.3-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
Mall	Woodcrest Heights Road at Loudon Road to Demante Dr.	12″ outflow from pond	Flow from Loudon Road occasionally backs up into detention basin on Woodcrest Heights Road.
Mall	Southwest of intersection of Loudon Road & Branch Turnpike	18″	30″ pipe discharges to an open channel with an 18″ outlet at a higher elevation at Branch Turnpike Rd.
Loudon	Fort Eddy Road, street crossing near Shaws	18″	Snow melt can overwhelm this pipe.

6.3.2 Model Development

Connectivity

Figure 6.3-2 shows the node connectivity for the spreadsheet models developed for the sub-basins of Heights Drainage Basin.

Detention/Storage

A number of detention ponds have been constructed in the basin to moderate storm flows. Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system as a whole. These are summarized in Table 6.3-2.

Table 6.3-2 – Detention Ponds

Subbasin	*Location*	*Max Discharge Rate*
Mall	Woodcrest Heights Road	Approx: 3 ft/s (12″ discharge pipe)
Mall	Large Detention Basin east of the Steeplegate Mall on Loudon Road	Approx: __ ft/s (Controlled discharge to wetlands)
Mall	Intersection of Loudon Road & Branch Turnpike	Approx: 7 ft/s (18″ discharge pipe)
Mall	Intersection of D'Amante Dr & Triangle Park Rd	Approx: 3 ft/s (12″ discharge pipe)

6.3.3 Recommendations

The existing pipes from Table 6.3-3 that are more than 50% under capacity are summarized below. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the undersized drainage pipes.

Replace Pipes

The pipes in the Heights area which are most severely under capacity are summarized in Table 6.3-3. The larger diameter pipes should receive higher priority because a larger area and greater number of people could be affected. For example, a 36″-diameter pipe which is 50% undersized is a higher priority problem than an 8″-diameter pipe 50% undersized.

Cleaning & Lining

Based upon the City's listing of known problems there are no recurring problem areas in the Heights Basin that require extensive cleaning or lining.

Other Work

All outfalls should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, stream bank stabilization or apron installation if necessary.

Table 6.3-4: Known and/or Suspected Problems in Heights

Sub Basin	*Location*	*Nature of Problem*	*Recommended Solution*
Mall	Woodcrest Heights Rd at Loudon Rd to Demante Dr.	Flow from Loudon Rd. occasionally backs up into detention basin on Woodcrest Heights Rd.	Consider flap valve on pipe, or upsizing drain pipe on Loudon St.
Mall	Southwest of intersection of Loudon Road & Branch Turnpike	30″ pipe discharges to an open channel with an 18″ outlet at a higher elevation at Branch Turnpike Rd.	Divert flow to a properly sized pipe on Branch Turnpike that connects to 42″ drain on Loudon Rd. Private Property owner to perform construction
Loudon	Fort Eddy Rd, street crossing near Shaws	18″diam pipe overwhelmed by snow melt	Maintain pipe to prevent blockage; Snow removal after heavy storms.
Loudon	Pipe along Loudon Rd. and East Side Dr. (Node "M" to "F")	30″ and 24″ dia. pipe on Loudon Rd. and 12″ dia. pipe on East Side Dr. undersized for 10-year storm	Consider additional detention or relief in system or replace pipes.
Loudon	Small dia. pipes at Nodes "U", "W" and "AA"	24″ thru 12″ dia. pipes undersized for 10-year storm	Consider replacing pipes with larger dia. pipes
Birdland	Small dia. pipes along Ormond St, Christian Ave, Oriole Rd, East Side Dr. and Partridge	12″ and 15″ dia. pipes undersized for 10-year storm	Consider more detailed study of drainage area and replacing pipes with larger dia. pipes

Sub Basin	Node	Tc of Node (hrs)	**Minimum Tc of Node (hrs)**	**Tc used for Node (hrs)**	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	**Slope of Pipe From Node (ft/ft)**	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	**Pipe Dia. In Place (in.)**	Current Max Flow (cfs)	% under capacity
Mall	**A**	0.20	**0.25**	**0.25**	3.77	7.32	27.60	17.84	**0.005**	2.45	29	**30**	29.06	-5%
	B	0.10	**0.25**	**0.25**	3.77	2.38	8.96	5.79	**0.005**	1.61	19	**30**	29.06	-224%
	C	0.17	**0.25**	**0.25**	3.77	20.34	76.74	49.60	**0.005**	3.60	43	**36**	47.25	38%
Mall	**D**	0.32	**0.25**	**0.32**	3.40	32.48	110.30	71.29	**0.005**	4.13	50	**40**	62.58	43%
	E	0.19	**0.25**	**0.25**	3.77	20.06	75.66	48.90	**0.005**	3.58	43	**60**	184.49	-144%
Loudon	**F**	0.08	**0.25**	**0.25**	3.77	13.12	49.48	31.98	**0.005**	3.06	37	**24**	16.03	68%
	G	0.15	**0.25**	**0.25**	3.77	22.31	84.18	54.41	**0.005**	3.73	45	**24**	16.03	81%
	XX	0.07	**0.25**	**0.25**	3.77	3.92	14.77	9.55	**0.005**	1.94	23	**12**	2.52	83%
	YY	0.04	**0.25**	**0.25**	3.77	1.68	6.34	4.10	**0.005**	1.41	17	**12**	2.52	60%
	G1	0.15	**0.25**	**0.25**	3.77	26.23	98.95	63.96	**0.005**	3.96	48	**24**	16.03	84%
	H	0.32	**0.25**	**0.32**	3.40	113.72	386.73	249.95	**0.005**	6.60	79	**30**	29.06	92%
	I	0.25	**0.25**	**0.25**	3.75	20.95	78.63	50.82	**0.005**	3.63	44	**12**	2.52	97%
	J	0.40	**0.25**	**0.40**	3.03	129.88	393.71	254.46	**0.005**	6.65	80	**30**	29.06	93%
	K	0.15	**0.25**	**0.25**	3.77	5.89	22.21	14.35	**0.005**	2.26	27	**30**	29.06	-31%
	L	0.17	**0.25**	**0.25**	3.77	8.65	32.61	21.08	**0.040**	1.77	21	**30**	82.18	-152%
	M	0.51	**0.25**	**0.51**	2.66	159.47	423.40	273.65	**0.005**	6.83	82	**30**	29.06	93%
Loudon	**N**	0.05	**0.25**	**0.25**	3.77	4.58	17.27	11.16	**0.005**	2.06	25	**36**	47.25	-174%
Airport	**O**	0.12	**0.25**	**0.25**	3.77	15.40	58.10	37.55	**0.005**	3.24	39	**30**	29.06	50%
	P	0.16	**0.25**	**0.25**	3.77	35.19	132.74	85.79	**0.005**	4.42	53	**54**	139.30	-5%
	Q	0.28	**0.25**	**0.28**	3.62	62.62	226.44	146.35	**0.010**	4.75	57	**54**	197.00	13%
	R	0.28	**0.25**	**0.28**	3.62	13.80	49.91	32.25	**0.005**	3.06	37	**54**	139.30	-179%
	S	0.10	**0.25**	**0.25**	3.77	2.69	10.13	6.55	**0.005**	1.69	20	**30**	29.06	-187%
	T	0.34	**0.25**	**0.34**	3.26	67.02	218.82	141.43	**0.010**	4.68	56	**60**	260.91	-19%
Soucook	**U**	0.14	**0.25**	**0.25**	3.77	5.74	21.65	14.00	**0.005**	2.24	27	**12**	2.52	88%
	V	0.24	**0.25**	**0.25**	3.77	13.17	49.67	32.10	**0.005**	3.06	37	**36**	47.25	5%
	W	0.09	**0.25**	**0.25**	3.77	13.80	52.05	33.64	**0.005**	3.11	37	**24**	16.03	69%
Soucook	**X**	0.18	**0.25**	**0.25**	3.77	16.85	63.56	41.08	**0.08**	2.00	24	**24**	64.10	-1%
	Y	0.24	**0.25**	**0.25**	3.77	50.93	192.14	124.18	**0.005**	5.08	61	**42**	71.27	63%
Soucook	**Z**	0.09	**0.25**	**0.25**	3.77	15.81	59.64	38.54	**0.005**	3.28	39	**36**	47.25	21%
	AA	0.04	**0.25**	**0.25**	3.77	7.82	29.51	19.07	**0.005**	2.52	30	**18**	7.44	75%
Birdland	**BB**	0.11	**0.25**	**0.25**	3.77	3.22	12.14	7.84	**0.005**	1.80	22	**15**	4.58	62%
	CC	0.06	**0.25**	**0.25**	3.77	0.84	3.15	2.04	**0.005**	1.09	13	**15**	4.58	-45%
	DD	0.32	**0.25**	**0.32**	3.40	42.34	143.97	93.05	**0.005**	4.56	55	**15**	4.58	97%
	EE	0.05	**0.25**	**0.25**	3.77	1.16	4.39	2.84	**0.005**	1.23	15	**12**	2.52	43%
	FF	0.30	**0.25**	**0.30**	3.49	40.06	139.66	90.26	**0.005**	4.51	54	**15**	4.58	97%
	GG	0.28	**0.25**	**0.28**	3.59	39.51	141.83	91.66	**0.005**	4.53	54	**15**	4.58	97%
	HH	0.26	**0.25**	**0.26**	3.69	38.03	140.21	90.62	**0.005**	4.51	54	**15**	4.58	97%
	II	0.25	**0.25**	**0.25**	3.77	32.36	122.10	78.91	**0.005**	4.29	51	**15**	4.58	96%
	JJ	0.23	**0.25**	**0.25**	3.77	29.72	112.14	72.48	**0.005**	4.15	50	**15**	4.58	96%
	KK	0.21	**0.25**	**0.25**	3.77	22.04	83.14	53.73	**0.005**	3.71	45	**15**	4.58	94%
	LL	0.20	**0.25**	**0.25**	3.77	19.72	74.38	48.07	**0.005**	3.56	43	**15**	4.58	94%
	MM	0.18	**0.25**	**0.25**	3.77	18.14	68.45	44.24	**0.005**	3.45	41	**15**	4.58	93%
	NN	0.16	**0.25**	**0.25**	3.77	16.83	63.49	41.04	**0.005**	3.35	40	**15**	4.58	93%
	OO	0.14	**0.25**	**0.25**	3.77	15.64	59.01	38.14	**0.005**	3.26	39	**15**	4.58	92%
	PP	0.12	**0.25**	**0.25**	3.77	10.91	41.17	26.61	**0.005**	2.85	34	**18**	7.44	82%
	QQ	0.10	**0.25**	**0.25**	3.77	6.29	23.72	15.33	**0.005**	2.32	28	**15**	4.58	81%
	RR	0.09	**0.25**	**0.25**	3.77	3.49	13.15	8.50	**0.005**	1.86	22	**12**	2.52	81%
	SS	0.03	**0.25**	**0.25**	3.77	0.59	2.24	1.45	**0.005**	0.96	11	**12**	2.52	-13%
	TT	0.11	**0.25**	**0.25**	3.77	3.80	14.35	9.28	**0.005**	1.92	23	**12**	2.52	82%
	UU	0.09	**0.25**	**0.25**	3.77	2.70	10.19	6.58	**0.005**	1.69	20	**12**	2.52	75%
	VV	0.07	**0.25**	**0.25**	3.77	2.25	8.49	5.49	**0.005**	1.58	19	**12**	2.52	70%
	WW	0.06	**0.25**	**0.25**	3.77	1.82	6.88	4.45	**0.005**	1.46	17	**12**	2.52	63%

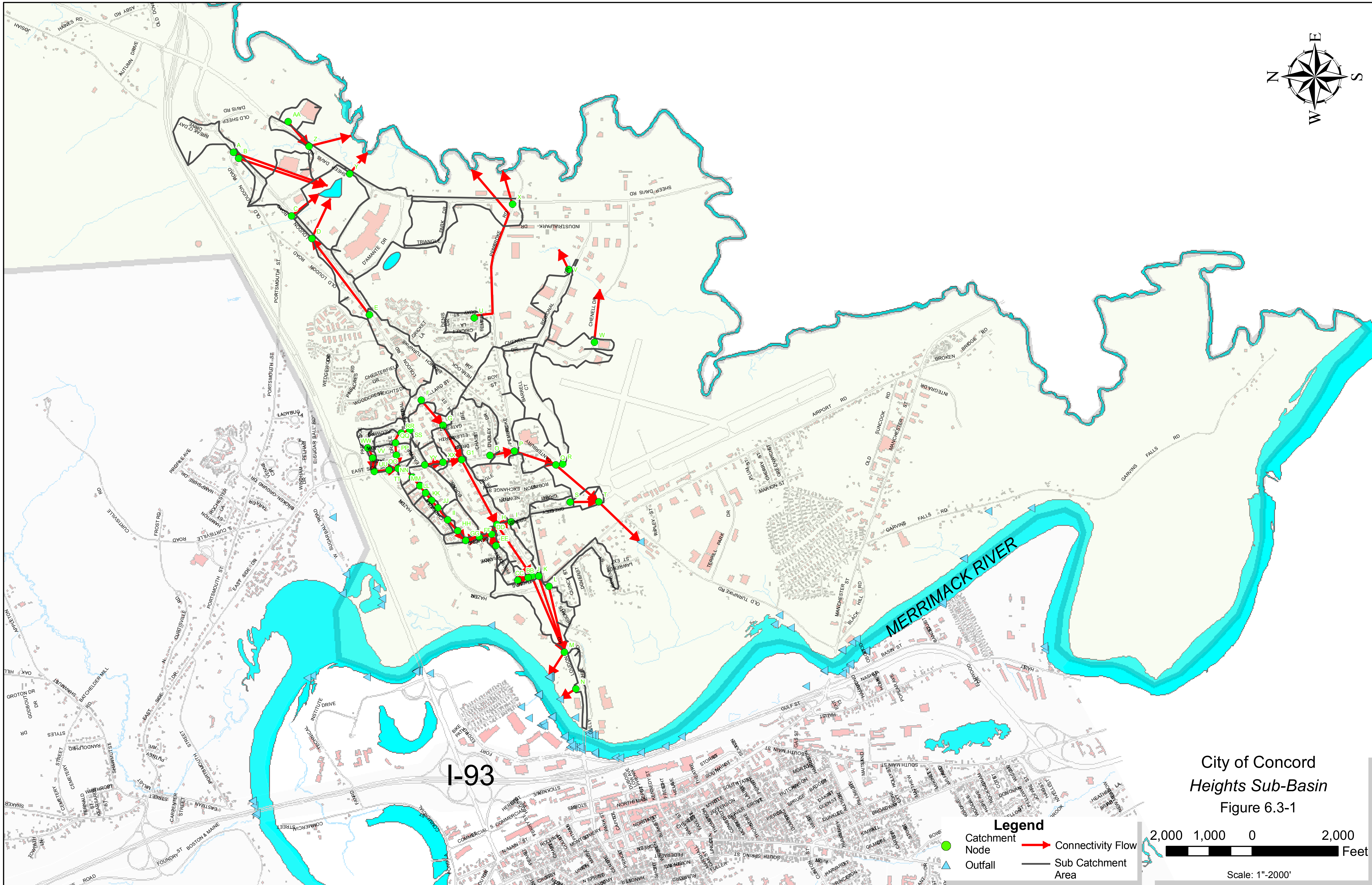

City of Concord
Heights Sub-Basin
Figure 6.3-1
Legend
Catchment Node
Outfall
Connectivity Flow
Sub Catchment Area
2,000 1,000 0 2,000
Feet
Scale: 1"-2000'
MERRIMACK RIVER
I-93
N
E
S
W

Figure 6.3-2: Concord Heights Drainage Basin - Connectivity Diagram

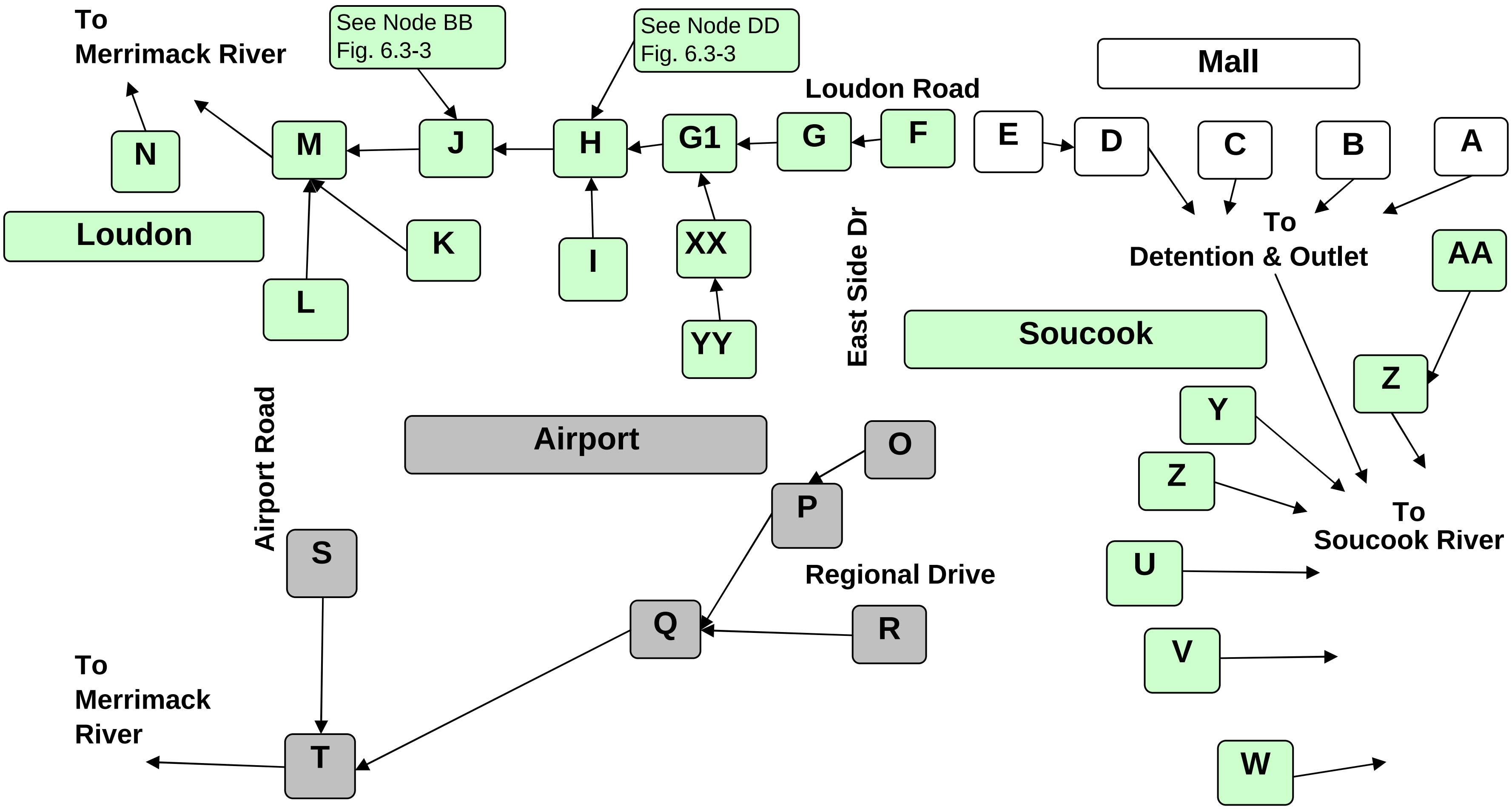
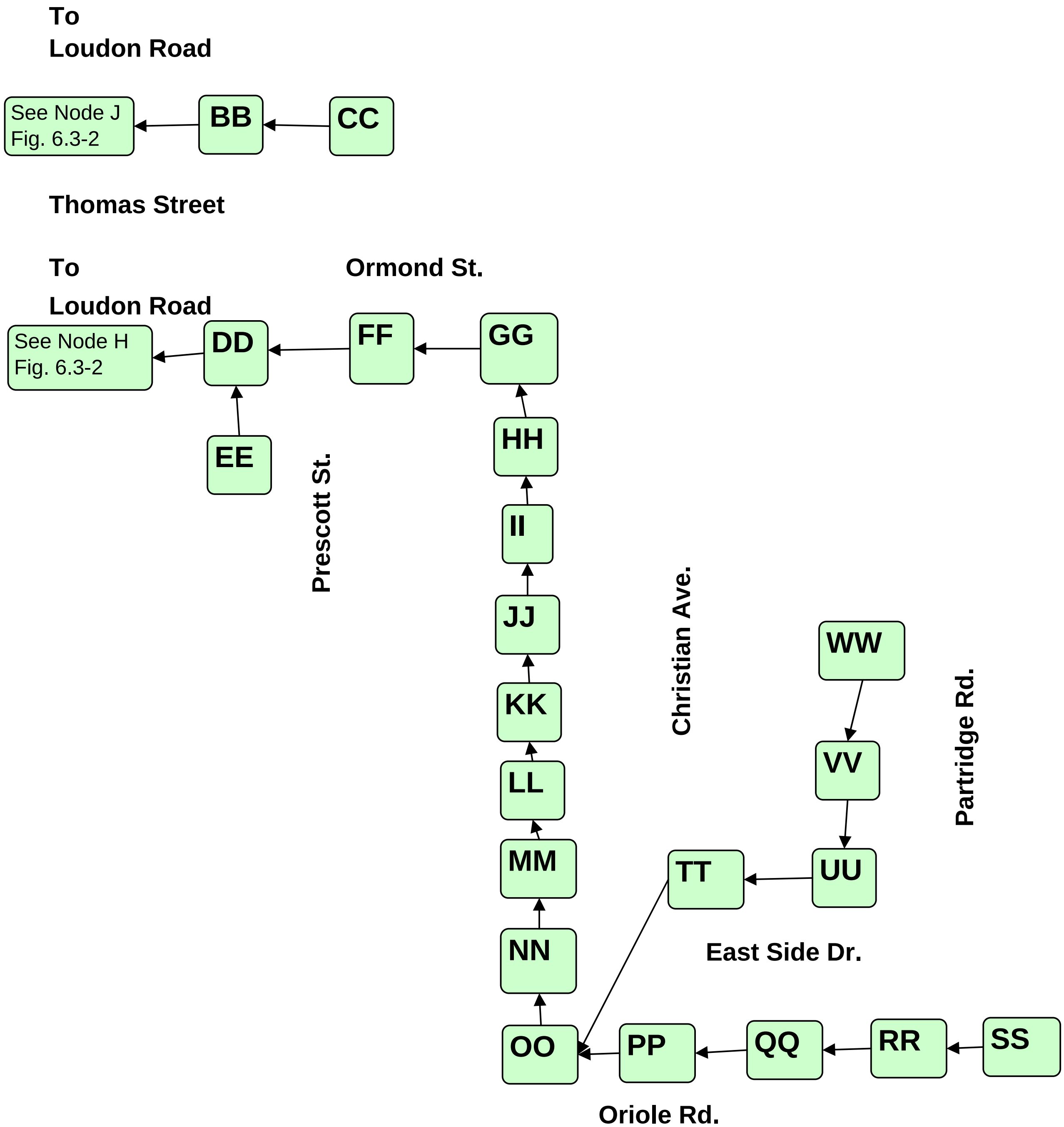


Figure 6.3-3: Concord Heights Drainage Basin - Connectivity Diagram



Section 6.4
Turkey River Drainage Basin Evaluation

6.4.1 Drainage Basin Description

Location

As shown in Figure 6.4-1, the Turkey River Drainage Basin is located south of the center of the City of Concord, on the west side of the Merrimack River. The drainage basin is bounded to the east by the Terrible Trapezoid drainage basin, to the south by the Town of Bow, and to the north by the Hospital drainage basin. The Turkey Pond drainage basin, along with Silver Hill and Route I-89, bound the Turkey River drainage basin to the west.

Portions of the Cilley State Forest, Russell-Shea State Forest, and White Farm are located within this drainage basin.

Surface Water Drainage

The Turkey River basin has two waterways that pass through it, Turkey River and Bow Brook. Turkey River begins at Turkey Pond, located in the Turkey Pond drainage basin to the west. Turkey River flows from the northwest corner of the Turkey River basin to the south, into the Town of Bow. The river ultimately discharges into the Merrimack River.

Bow Brook begins in the Horseshoe Pond basin to the north, and flows through the Hospital basin and Turkey River basin into the Town of Bow. In Bow, the brook converges with the Turkey River approximately 200′ before the junction with the Merrimack River.

Several small, unnamed brooks drain from Jerry Hill (hill south of Penacook Lake) and Silver Hill (ridge east of Turkey Pond) into the Turkey River.

Drainage Sub-Basins

The Turkey River Drainage Basin is effectively divided into three sub basins.

- Bow Brook - the sub-basin contributing to Bow Brook.
- Turkey River East – the sub-basin contributing to Turkey River from the east.
- Turkey River West – the sub-basin contributing to Turkey River from the west.

The Turkey River West sub-basin contains portions of the Cilley State Forest, Russell-Shea State Forest and the White Farm. This sub-basin contains very little development and stormwater infrastructure. This sub-basin will not be investigated in detail.

The Bow Brook and Turkey River East sub-basins include the urbanized development portion of the watershed. Bow Brook in particular is a small stream which has been impacted by poor quality stormwater runoff from the adjacent neighborhoods. Most recently both Turkey River and Bow Brook were severely affected by the heavy rain event in May 2006 causing stream flooding and road washouts.

All of the contributing areas to Bow Brook will be modeled to assess the amount of stormwater entering this brook. Only the urbanized areas contributing to the Turkey River will be modeled as most of the contributing watershed is undeveloped.

Major Drainage Pipes

The receiving waters in the Turkey River Sub-basin are Bow Brook and Turkey River. The majority of the drains in the basin are small diameter. Some flow passes through larger sized culverts and travels in Bow Brook as open channel flow. There are 15-inch diameter pipes along South Street that discharge to both Bow Brook and to Turkey River.

Known Problems and Issues

The City reports no known problems and issues in the Turkey River Drainage Basin.

6.4.2 Model Development

Connectivity

Figure 6.4-2 shows the node connectivity for the spreadsheet models developed for the Turkey River Drainage Basin (TR).

Detention/Storage

Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system. No large ponds are found in the Turkey River Basin with outlet to the stormwater collection system.

6.4.3 Recommendations

The pipes that are more than 50% undercapacity are summarized below in Table 6.4-2. There are only two for this area. The City may also wish to pursue additional detention/storage basins or other reduction in inflow to the Bow Brook or Turkey River for the pipes that are not undercapacity.

Cleaning & Lining

Based upon the City's listing of known problems, there are no pipes in the Turkey River area that need cleaning or lining at this time.

Replace Pipes

The pipes in the Turkey River area which are most severely under capacity are summarized in Table 6.4-2. The larger diameter pipes will receive higher priority in Section 9. For example, a 36" pipe which is 50% undersized is a higher priority problem than an 8" pipe 50% undersized.

Other Work

All outfalls in the Turkey River basin should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary.

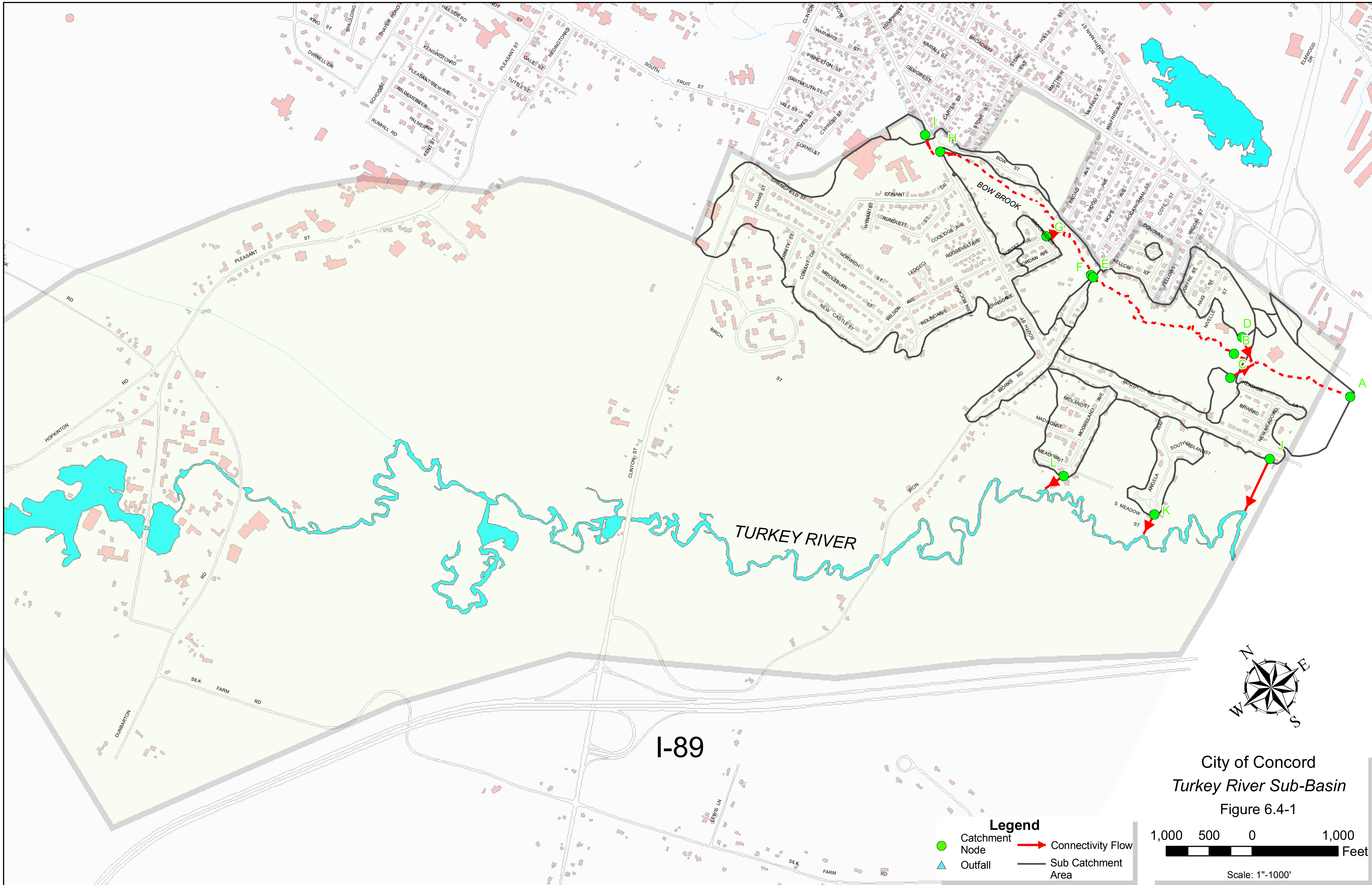
Table 6.4-2: Known and/or Suspected Problems in the Turkey River Basin

Basin	***Location***	***Nature of Problem***	***Recommended Solution***
TR	Into Bow Brook from South Street, at the intersection with Bow Street.	Pipe is undersized for flow from the South Street area.	An existing 24” overflow discharges to the brook south of this outlet. This may already resolve this issue.
TR	Into Turkey River from South Street, two houses south of the intersection with New Meadow Rd.	Pipe is undersized for flow from the South Street area.	Additional retention where possible in the system. Upsizing pipe as a less desirable solution.
TR	Pleasant St east of Miller’s Brook	Overland flow through undersized culvert	Replace existing culvert with large sized culvert.

Sub Basin	Node	**Minimum Tc of Node (hrs)**	**Tc used for Node (hrs)**	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	**Slope of Pipe From Node (ft/ft)**	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	**Pipe Dia. In Place (in.)**	Current Max Flow (cfs)	% under required capacity
BOW	**A**	**0.25**	**0.59**	2.40	102.41	246.26	159.16	**0.005**	5.58	67	**Brook**	N/A	N/A
	B	**0.25**	**0.51**	2.64	95.17	251.55	162.58	**0.005**	5.62	67	**Brook**	N/A	N/A
	C	**0.25**	**0.25**	3.77	1.36	5.15	3.33	**0.005**	1.31	16	**30**	29.06	-465%
	D	**0.25**	**0.25**	3.77	5.48	20.69	13.37	**0.005**	2.20	26	**24**	16.03	23%
	E	**0.25**	**0.25**	3.77	1.16	4.38	2.83	**0.005**	1.23	15	**12**	2.52	42%
	F	**0.25**	**0.37**	3.13	77.91	244.04	157.73	**0.005**	5.56	67	**Brook**	N/A	N/A
	G	**0.25**	**0.25**	3.77	2.22	8.36	5.40	**0.005**	1.57	19	**12**	2.52	70%
	H	**0.25**	**0.25**	3.77	69.38	261.74	169.17	**0.005**	5.71	68	**48**	101.75	61%
	I	**0.25**	**0.25**	3.77	0.50	1.90	1.23	**0.005**	0.90	11	**Brook**	N/A	N/A
TR	**J**	**0.25**	**0.25**	3.77	10.94	41.25	26.66	**0.005**	2.85	34	**15**	4.58	89%
	K	**0.25**	**0.25**	3.77	4.95	18.66	12.06	**0.005**	2.12	25	**18**	7.44	60%
	L	**0.25**	**0.25**	3.77	7.28	27.46	17.75	**0.005**	2.45	29	**15**	4.58	83%

Table 6.4-1
Turkey River Drainage Basin Calculations

CDM

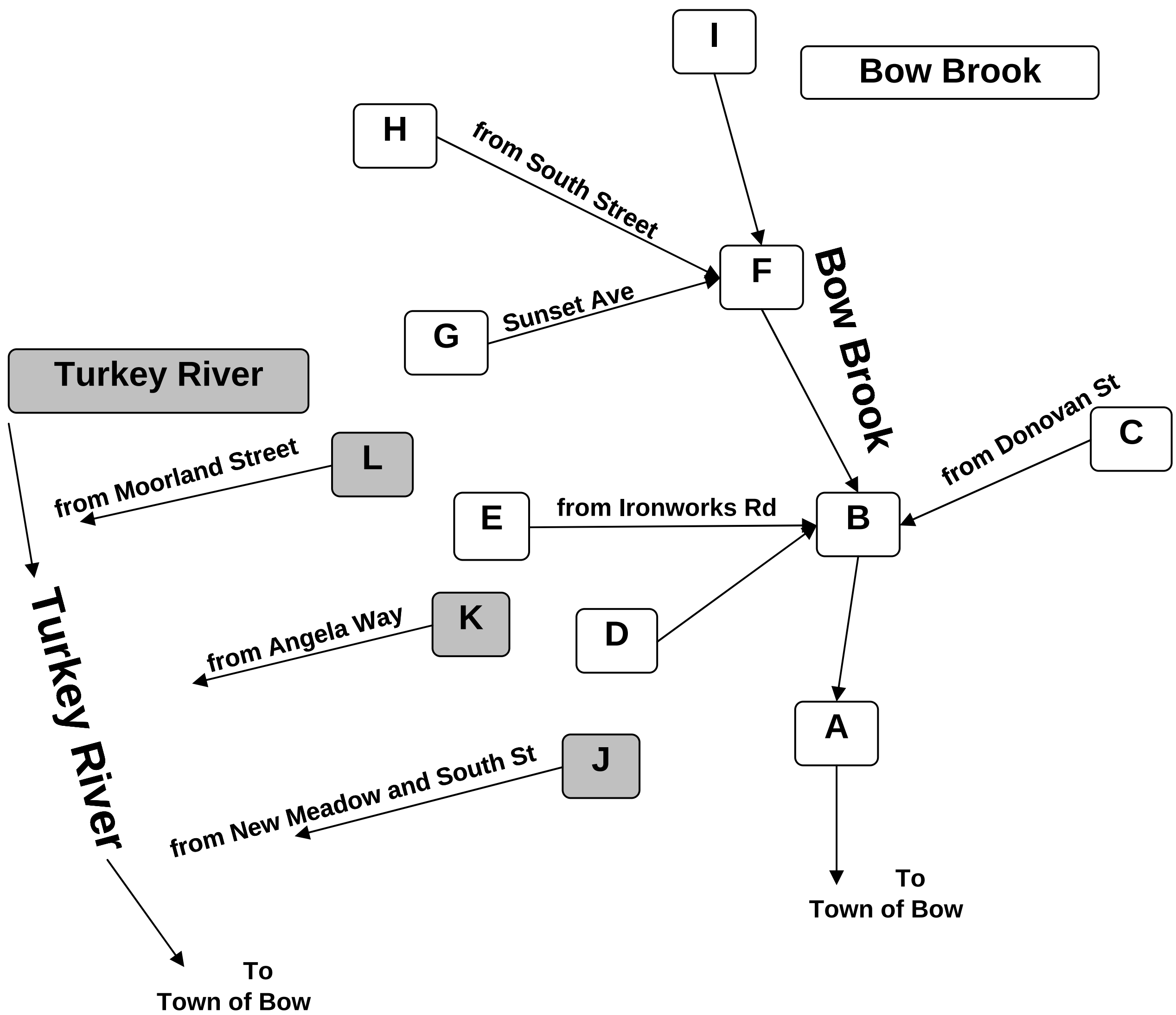


City of Concord

Turkey River Sub-Basin

Figure 6.4-1

Figure 6.4-2: Turkey River Drainage Basin - (TR)
- Connectivity Diagram



Section 6.5
Penacook Drainage Basin Evaluation

6.5.1 Drainage Basin Description

Location

As shown in Figure 6.5-1, the Penacook Drainage Basin is located northwest of the center of the City of Concord, on the west side of the Merrimack River. The drainage basin is bounded to the east by the Fisherville Drainage Basin, to the southwest by the West Concord basin, to the northwest by the Boscawen town line.

The Village of Penacook, a neighborhood within the City of Concord, is located within this drainage basin.

Surface Water Drainage

A small neighborhood in the northern corner of the drainage basin, including portions of Merrimack and Rolfe Streets, contributes to the Merrimack River directly. The Merrimack River runs across the northeastern edge of the Penacook Drainage Basin, adjacent to this neighborhood. The rest of the basin contributes to minor streams and canals which are tributary to the Merrimack.

The Contoocook River enters the drainage basin from the West Concord drainage basin. The river flows southwest to northeast through the Penacook drainage basin, exiting into the Town of Boscawen, to the north where it joins the Merrimack River.

Rolfe Canal begins at the Contoocook River approximately 1.5 miles upstream from the point where the Contoocook River leaves Concord. The canal continues parallel to the Contoocook River adjacent to the south (right) bank for approximately 1.2 miles before rejoining the river. Between the canal and the river is Tilton Island, a residential neighborhood draining partially to the river and partially to the canal. The canal is partially blocked by two dams, formerly used to power adjacent mills, but now serving no practical purpose.

Two small brooks also drain portions of the Penacook drainage basin. The first, Millstream Brook, is a tributary to Rolfe Canal. This brook begins southeast of Primrose Lane, and runs north under Borough Road entering Rolfe Canal south of Millstream Lane.

The second brook, Hoyt Brook, begins southeast of Primrose Lane and flows northeast to pass under Borough Road and Village Street. The brook flows through a 70-foot deep ravine parallel to Penacook Street and then turns east to go under Penacook Street. Hoyt Brook finally turns south to enter an oxbow lake west of the Merrimack River, near Goodwin Point.

Drainage Sub-Basins

The Penacook Drainage Basin is effectively divided into the following sub basins.

- Hoyt (H) - the sub-basin contributing to the Hoyt Brook directly. This sub-basin is the eastern most portion of the basin.

- Millstream Brook and Rolfe Canal (MS, RC) – the sub-basins contributing to the Millstream Brook and the Rolfe Canal. Millstream Brook contributes to Rolfe Canal.

- Contoocook (C) – the sub-basin contributing directly to the Contoocook River. The Millstream Brook and Rolfe Canal also contribute to the Contoocook River, but these water bodies are investigated separately to better understand the flow they accept. This will help to clarify any quality or quantity issues in the minor streams.

- Merrimack (M) – only two small neighborhoods contribute directly to the Merrimack River.

Of greatest concern here is the stormwater quality and quantity draining to Millstream Brook and Hoyt Brook. The areas draining to these brooks will be investigated in detail.

Major Drainage Pipes

The receiving waters in the Penacook Sub-basin are Hoyt Brook, Millstream Brook, Rolfe Canal, and Contoocook River. Many of the drainage pipes within the basin are smaller diameter pipes which discharge to the receiving waters. There are several short sections of 24" and 30" pipe, but no major stormwater collection mains.

Known Problems and Issues

Table 6.5-1 summarizes the known problems and issues in the Penacook Drainage Basin as presented from the City of Concord to CDM.

Table 6.5-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
PN	River Road at The Island Road	None	Road floods in heavy rain and spring conditions.
PN	River Road southwest of The Island Road	None	Road floods in heavy rain and spring conditions.
PN	Low Area at Borough/Washington/Fowler triangle	None	Low area in neighborhood experiences severe flooding in heavy rain and spring conditions

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems listed in Table 6.5-1 may not be identified through modeling, but will be included along with the model-identified problems in the summary table at section end.

6.5.2 Model Development

Connectivity

Figure 6.5-2 shows the node connectivity for the spreadsheet models developed for the Penacook Drainage Basin (PN).

Detention/Storage

Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system. The major detention basins in the drainage basin are listed in Table 6.5-2. Regular maintenance, either by the City or by a trusted contractor, is necessary for the continued proper operation of detention ponds.

Table 6.5-2 – Detention Ponds

Subbasin	*Location*	*Max Discharge Rate*
PN	Primrose Lane between Borough Road and Winterberry Lane	Approx. 3 cf/s (12″ outlet pipe)
PN	Tilton Island at Island Shores	Approx. 5 cf/s 2 ponds (12″ outlet pipes)
PN	Alice Drive at Borough Road	Approx. 4 ft/s (15″ outlet pipe)

6.5.3 Recommendations

The pipes that are more than 50% under capacity are summarized below in Table 6.5-4. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity drainage pipes.

Cleaning & Lining

The City did not identify any pipes in the Penacook area that need cleaning or lining at this time.

Replace Pipes

The pipes in the Penacook area which are most severely under capacity are summarized in Table 6.5-4. The larger diameter pipes should receive higher priority.

For example, a 36″ pipe which is 50% undersized is a higher priority problem than an 8″ pipe 50% undersized.

Other Work
All outfalls in the Penacook basin should be inspected. Those that discharge directly to the Merrimack River have been inspected, and are included in Section 7 of this report. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary.

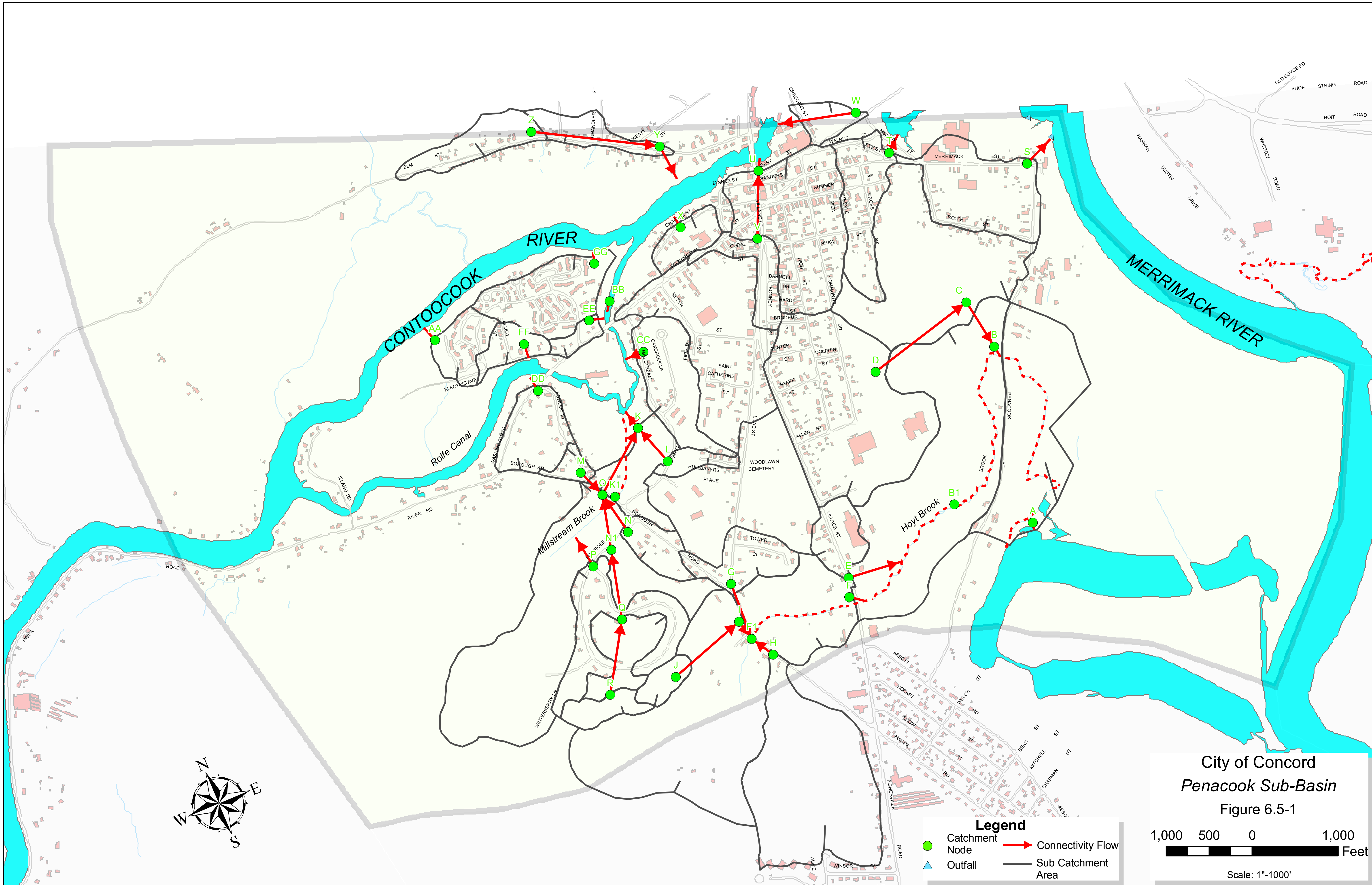
Table 6.5-4: Known and/or Suspected Problems in the Penacook Basin

Basin	*Location*	*Nature of Problem*	*Recommended Solution*
PN	River Road at The Island Road	Continued isolated flooding.	Design and construction completed by General Services
PN	River Road southwest of The Island Road	Continued isolated flooding.	Design and construction completed by General Services.
PN	Low Area at Borough/Washington/Fowler triangle	Low area in neighborhood experiences severe flooding in heavy rain and spring conditions	Install new drainage pipes and outfalls or drywells for an immediate solution
PN	Merrimack Street and Bye Street pipes, contributing to the Merrimack River (Sub-basin "M", Table 6.5-3)	12″ pipes are undersized and illicit sewer connection	Detention, storage, or increase in pipe size along with separating sewer connection
PN	Tanner Street and Village Street, contributing to the Contoocook (Sub-basin C, Table 6.5-3)	15″ and 12″ pipes are undersized	Detention, storage, or increase in pipe size.
PN	Charles Street, contributing to the Contoocook (Sub-basin C, Table 6.5-3)	12″ pipe is undersized	Detention, storage, or increase in pipe size.
PN	Washington Street, north of the Rolfe Canal (Sub-basin	12″ pipe is undersized	Detention, storage, or increase in pipe size.

	RC, Table 6.5-3)		
PN	Electric Ave, contributing to the Rolfe Canal (Sub-basin RC, Table 6.5-3)	12″ pipe is undersized	Detention, storage, or increase in pipe size.
PN	Penacook St culvert at Hoyt Brook crossing	Culvert is undersized	Install new larger dia. culvert
PN	Hoyt Brook crossings at Manor Rd. and Village St.	36″ culverts are undersized	Install new larger dia. culvert
PN	Lilac St, north of Hoyt Brook crossing	12″ drain pipe is undersized	Install new larger dia. pipe
PN	Local drainage from Millstream Lane, Primrose Lane and Fowler St.	12″, 15″ and 24″ pipes are undersized	Install new larger dia. pipes
PN	Elm St and Contoocook River	12″ pipe is undersized	Install new larger dia. pipes
PN	East St and Contoocook River	12″ pipe is undersized	Install new larger dia. pipes
PN	Electric Ave complex and Contoocook River	12″ pipe is undersized	Install new larger dia. pipes

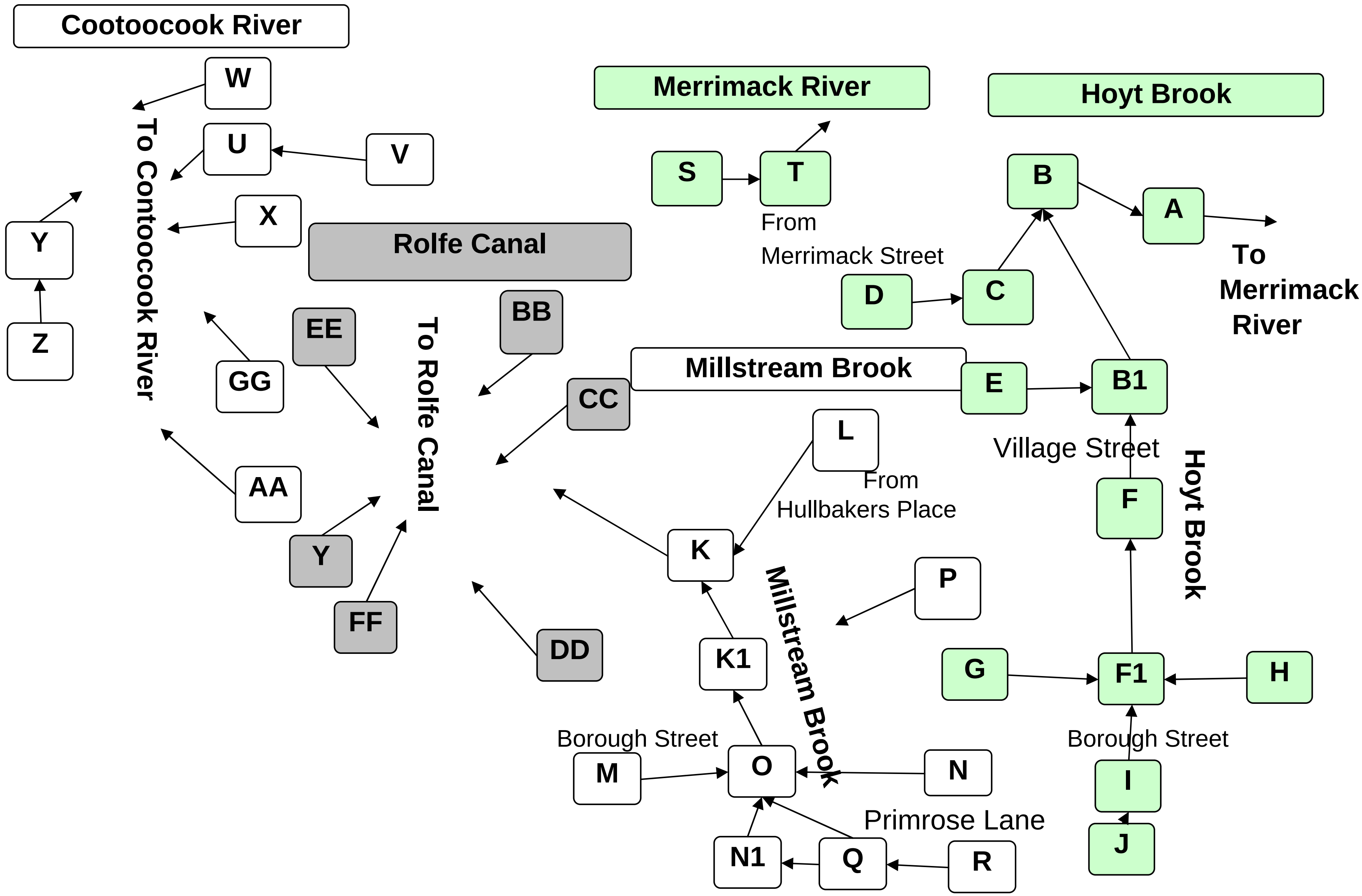
Sub Basin	Node	Minimum Tc of Node (hrs)	Tc used for Node (hrs)	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	Slope of Pipe From Node (ft/ft)	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	Pipe Dia. In Place (in.)	Current Max Flow (cfs)	% under capacity
H	A	0.25	1.07	1.47	130.26	191.86	124.00	0.005	5.08	61	Hoyt Br	N/A	N/A
	B	0.25	0.92	1.71	120.91	206.89	133.72	0.005	5.22	63	24	16.03	92%
	B1	0.25	0.51	2.64	67.05	176.76	114.24	0.005	4.92	59	24	16.03	91%
	C	0.25	0.71	2.13	11.41	24.29	15.70	0.005	2.34	28		0.00	N/A
	D	0.25	0.25	3.77	34.05	128.46	83.02	0.005	4.37	52		0.00	N/A
	E	0.25	0.25	3.77	4.93	18.58	12.01	0.005	2.12	25		0.00	N/A
	F	0.25	0.51	2.64	62.13	163.77	105.85	0.005	4.79	57	36	47.25	71%
	F1	0.25	0.44	2.89	55.28	159.74	103.24	0.005	4.74	57	36	47.25	70%
	G	0.25	0.25	3.77	6.40	24.13	15.59	0.005	2.33	28	12	2.52	90%
	H	0.25	0.33	3.33	24.18	80.62	52.11	0.005	3.67	44		0.00	100%
	I	0.25	0.44	2.89	24.70	71.38	46.13	0.005	3.50	42	Hoyt Br	N/A	N/A
	J	0.25	0.25	3.77	1.98	7.48	4.84	0.005	1.50	18	15	4.58	39%
MS	K	0.25	0.68	2.20	27.18	59.75	38.62	0.005	3.28	39		0.00	N/A
	K1	0.25	0.61	2.36	23.39	55.12	35.63	0.005	3.18	38		0.00	N/A
	L	0.25	0.25	3.77	1.72	6.47	4.18	0.005	1.42	17	12	2.52	61%
	M	0.25	0.25	3.77	1.27	4.80	3.10	0.005	1.27	15	12	2.52	47%
	N	0.25	0.25	3.77	3.26	12.28	7.94	0.005	1.81	22	15	4.58	63%
	N1	0.25	0.25	3.77	5.12	19.32	12.49	0.005	2.15	26	24	16.03	17%
	O	0.25	0.55	2.53	16.79	42.52	27.48	0.005	2.89	35	Stream	N/A	N/A
	P	0.25	0.25	3.77	11.06	41.72	26.97	0.005	2.87	34	24	16.03	62%
	Q	0.25	0.25	3.77	5.12	19.32	12.49	0.005	2.15	26	24	16.03	17%
	R	0.25	0.25	3.77	1.89	7.13	4.61	0.005	1.48	18	15	4.58	36%
M	S	0.25	0.25	3.77	20.07	75.70	48.92	0.005	3.58	43	12	2.52	97%
	T	0.25	0.25	3.77	8.43	31.81	20.56	0.005	2.59	31	12	2.52	92%
C	U	0.25	0.25	3.77	25.44	95.96	62.02	0.005	3.92	47	15	4.58	95%
	V	0.25	0.25	3.77	4.31	16.25	10.50	0.005	2.01	24	12	2.52	84%
	W	0.25	0.25	3.77	2.34	8.83	5.71	0.005	1.60	19	12	2.52	71%
	X	0.25	0.25	3.77	3.44	12.97	8.38	0.005	1.85	22	12	2.52	81%
	Y	0.25	0.26	3.70	8.68	32.10	20.75	0.005	2.60	31	12	2.52	92%
	Z	0.25	0.25	3.77	5.09	19.21	12.42	0.005	2.14	26	Drywells	#VALUE!	N/A
	GG	0.25	0.25	3.77	11.19	42.22	27.28	0.005	2.88	35	30	29.06	31%
	AA	0.25	0.25	3.77	3.91	14.74	9.53	0.005	1.94	23	12	2.52	83%
RC	BB	0.25	0.25	3.77	21.55	81.28	52.54	0.01	3.23	39	12	3.57	96%
	CC	0.25	0.25	3.77	8.03	30.29	19.57	0.005	2.54	30	24	16.03	47%
	DD	0.25	0.25	3.77	6.04	22.80	14.74	0.005	2.28	27	12	2.52	89%
	EE	0.25	0.25	3.77	1.33	5.01	3.24	0.005	1.29	16	18	7.44	-49%
	FF	0.25	0.25	3.77	2.72	10.25	6.62	0.01	1.49	18	12	3.57	65%

Table 6.5-3
Penacook Drainage Basin Calculations



CONTOOCOOK RIVER
MERRIMACK RIVER
Rolfe Canal
Millstream Brook
Hoyt Brook
WOODLAWN CEMETERY
SAINT CATHERINE ST
HULLBAKERS PLACE
TOWER CI
RIVER RD
ISLAND RD
ELECTRIC AVE
WINTERBERRY LN
ABBOTT RD
WINSOR AVE
DOUGLAS AVE
N
E
S
W
Legend
Catchment Node
Outfall
Connectivity Flow
Sub Catchment Area
City of Concord
Penacook Sub-Basin
Figure 6.5-1
1,000 500 0 1,000
Feet
Scale: 1"-1000'

Figure 6.5-2: Penacook Drainage Basin - (PN) - Connectivity Diagram



Section 6.6
Fisherville Drainage Basin Evaluation

6.6.1 Drainage Basin Description

Location

As shown in Figure 6.6-3, the Fisherville Drainage Basin is located north of the center of the City of Concord, on the west side of the Merrimack River. The drainage basin is bounded to the east by the Merrimack River and the Horseshoe Pond Drainage Basin. Fisherville Drainage Basin is bounded to the south by the Horseshoe Pond basin, to the north by the Penacook basin, and to the west by the West Concord basin.

The Village of Fisherville and the Beaver Meadow Golf Course are located within this drainage basin.

Surface Water Drainage

Beaver Meadow Brook runs through the basin from west to east, discharging to the Merrimack River. The brook starts near the western bank of Penacook Lake, and travels north, then northeast to pass through a mobile home park and under the Daniel Webster Highway (Route 3). The brook continues through a thin undeveloped corridor to the Beaver Meadow Golf Course and finally to the Merrimack River.

Rattlesnake Brook also drains a portion of the Fisherville basin. This brook discharges from the northern tip of Penacook Lake and travels west through the basin, under Daniel Webster Highway and to the Merrimack River.

Drainage Sub-Basins

The Fisherville Drainage Basin is effectively divided into three sub basins.

- Upper - This sub-basin contributes to the Merrimack River. The sub-basin includes the roads between Manor Road and Abbott Road, and discharges down Manor Road.

- Beaver Meadow Brook – This sub-basin includes the area just south of Manor Road south to Sylvester Street and Second Street. This area would naturally drain to Beaver Meadow Brook, however, several neighborhood pipe systems direct flow around the brook to the Merrimack River.

- Rattlesnake Brook – This sub-basin includes the area from Sylvester Street and Second Street southward along North State Street to just south of Abbotville Road and Hillcrest Avenue.

The stormwater quality and quantity draining to Beaver Meadow Brook and Rattlesnake Brook is a concern due to the sensitivity of these waterways. The areas draining to these brooks will be investigated in detail.

Major Drainage Pipes

The three largest drainage basins in the Fisherville Area contribute to Beaver Meadow Brook, Rattlesnake Brook and the Merrimack River. A 24" diameter pipe discharges to the Merrimack River from Manor Road and Sewalls Falls Road. The large trailer park off Fisherville Road drains to Beaver Meadow Brook along with a number of other smaller drainage systems. The southern part of the basin drains into Rattlesnake Brook. Rattlesnake Brook also receives overflow from Penacook Lake when the Lake elevations rise above the spillway height.

Quite a few pipes in the Fisherville drainage basin already have overflows or parallel outlets to provide relief. For example, the drainage on Lake Street can overflow into the ditch on the north side of the street. In cases where overflows or parallel relief structures already exist, the pipes are marked "overflow" in the table.

Rattlesnake Brook which connects Penacook Lake to the Merrimack River experiences fluxuations in flow based on lake elevations. The Concord Water Treatment Plant is located at the eastern edge of the Penacook Lake and retains water by a dam. When the water levels in the lake rise above a certain elevation, the lake water bypasses the influent channel and overflows through a spillway into Rattlesnake Brook.

Known Problems and Issues

Table 6.6-1 summarizes the known problems and issues in the Fisherville Drainage Basin as presented from the City of Concord to CDM.

Table 6.6-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
FV	Fisherville Road	2.5'x5.5' box culvert	Box culvert is undersized and creates wet area around road.
FV	Gallen Drive & Fisherville Road (between Nodes G an M)	Low Area	Surface elevations slope towards Gallen Drive but water outlets under Alder Creek Dr. causing backup

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems identified by the City may not be identified through modeling. Any problems flagged by the City will be included along with the model-identified problems in the summary table at section end.

Several locations in this drainage basin were impacted by the May 2006 rain event. An open channel passing Rattlesnake Brook just south of Quaker St spilled over and washed away top soil. Further downstream along Rattlesnake Brook a large 6-ft by 3-ft box culvert passes under North State Street. This culvert increases in slope and drops approximately 6 feet at the downstream end. This drop was formerly a water wheel and due to the high volume of water passing through this culvert significant materials eroded away downstream. Another smaller diameter pipe (15-inch) was discovered passing underneath North State St parallel to the 6-ft by 3-ft box culvert. This pipe enters a cross country manhole and blew a hole in the side.

6.6.2 Model Development

Connectivity

Figure 6.6-2 shows the node connectivity for the spreadsheet models developed for the Fisherville Drainage Basin (FV).

Detention/Storage

Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system. The major detention basins in the drainage basin are listed in Table 6.6-2.

Table 6.6-2 – Detention Basins

Subbasin	*Location*	*Max Discharge Rate*
Beaver Meadow Brook	On Fisherville Road, across from Cremin Street.	Approx. 4 ft/s (15″ discharge pipe)
Beaver Meadow Brook	Sandwood Crossing	Approx. 4 ft/s (15″ discharge pipe)

6.6.3 Recommendations

The pipes that are more than 50% undercapacity are summarized below in Table 6.6-4. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity drainage pipes.

Cleaning & Lining

Based upon the City's listing of known problems, there are no pipes in the Fisherville area that need cleaning or lining at this time.

Replace Pipes

The pipes in the Fisherville area which are most severely under capacity are summarized in Table 6.6-4. The larger diameter pipes should receive higher priority. For example, a 36″ pipe which is 50% undersized is a higher priority problem than an 8″ pipe 50% undersized.

Other Work

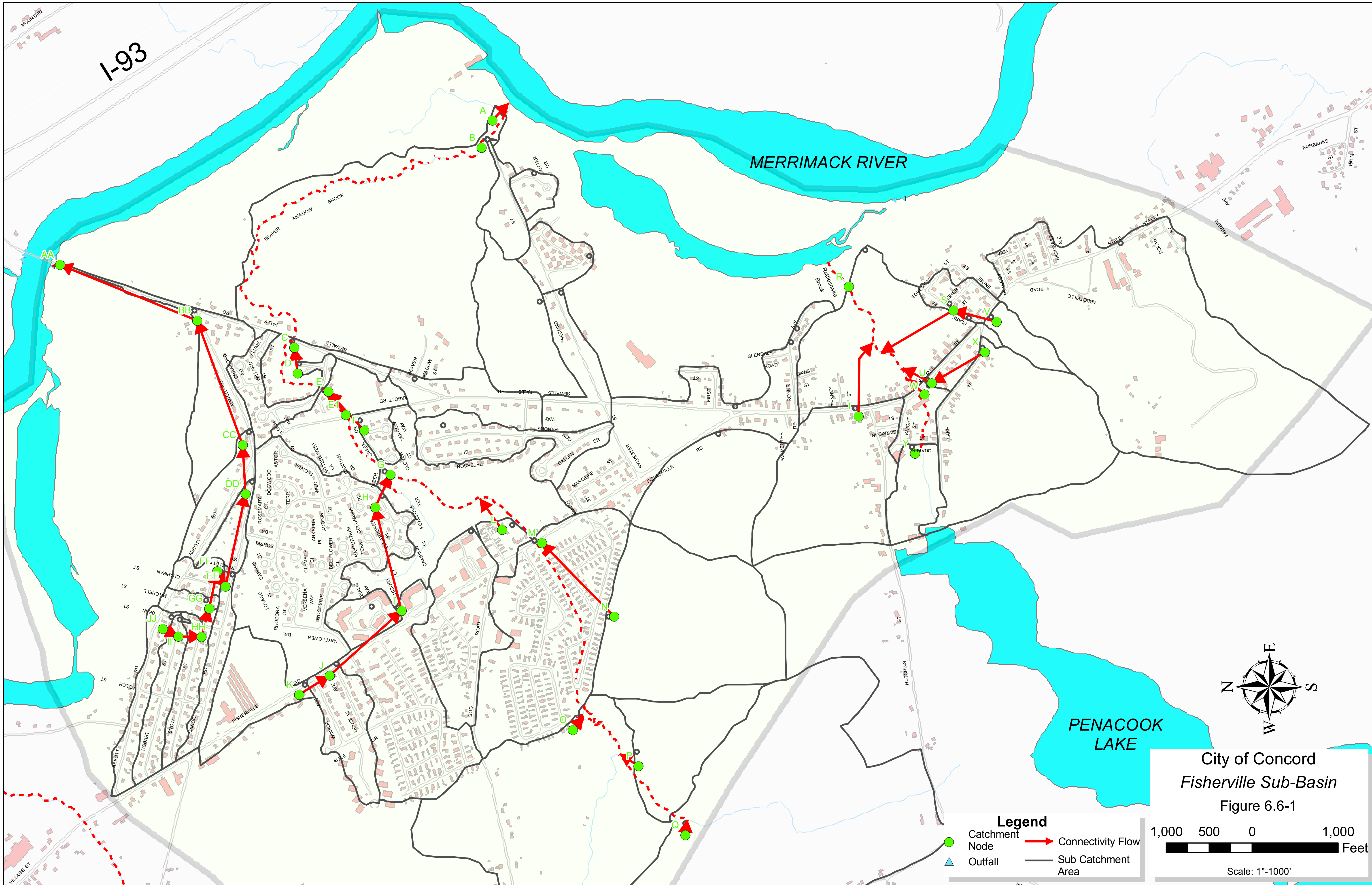
All outfalls in the Fisherville basin should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, stream bank stabilization or apron installation if necessary.

Table 6.6-4: Known and/or Suspected Problems in the Fisherville Basin

Basin	*Location*	*Nature of Problem*	*Recommended Solution*
Beaver Meadow Brook	From Douglas Ave to Fisherville Rd (node J)	24″ pipe is undersized for the flow expected.	Investigate possibility of retaining flow from Douglas Ave, or redirecting to Alice or Mayflower.
Upper	Along Snow Street and Randlett Street (nodes GG, FF, and EE)	24″ pipe is undersized for the flow expected.	Consider relief to the north side of Abbott Rd or Manor Rd. Possibly upsize pipe.
Upper	Along Manor Road to the Merrimack River (nodes AA - DD)	24″ pipe is undersized for the flow expected.	Consider relief to the north side of Abbott Rd or Manor Rd. Possibly upsize pipe.
Rattlesnake Brook	Quaker St, Knight St and North State St	Culverts undersized and not ideal hydraulically	Investigate size of culverts and large culvert elevation change at North State St
Rattlesnake Brook	Lake St	Need drain pipe, catch basins and curbing to handle water from large hill to the south	Existing drain pipe will be lined, new catch basins installed and road will be repaved by City.
Beaver Meadow Brook	Gallen Dr and Alder Creek Dr	Surface elevations slope towards Gallen Drive but water outlets under Alder Creek Dr. causing water backup	Inspect 48″ culvert for clogging or sediment build up.
Beaver Meadow Brook	Fisherville Rd	2.5′x5.5′ box culvert across from trailer park complex surcharges	Install properly sized culvert

Sub Basin	Node	Tc used for Node (hrs)	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	Slope of Pipe From Node (ft/ft)	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	Pipe Dia. In Place (in.)	Current Max Flow (cfs)	% under capacity
BM	**A**	**2.68**	0.02	171.01	3.51	2.27	**0.005**	1.13	14	**Brook**	N/A	N/A
	B	**0.25**	3.77	2.75	10.38	6.71	**0.005**	1.70	20	**36**	47.25	-355%
	C	**2.35**	0.23	153.96	34.71	22.44	**0.005**	2.67	32	**8x6 Box**	608.06	-1652%
	D	**0.25**	3.77	4.97	18.74	12.11	**0.02**	1.64	20	**18**	14.88	21%
	E	**2.30**	0.26	147.23	38.73	25.03	**0.005**	2.79	33	**48**	101.75	-163%
	E1	**2.22**	0.31	143.49	45.00	29.09	**0.005**	2.95	35	**48**	101.75	-126%
	F	**0.25**	3.77	1.93	7.27	4.70	**0.005**	1.49	18	**15**	4.58	37%
	G	**2.15**	0.37	141.56	51.80	33.48	**0.005**	3.11	37	**48**	101.75	-96%
	H	**0.55**	2.52	34.33	86.63	55.99	**0.005**	3.77	45	**Overflow**	N/A	N/A
	I	**0.32**	3.38	38.13	128.73	83.20	**0.005**	4.37	52	**Ditch**	N/A	N/A
	J	**0.25**	3.77	17.52	66.11	42.73	**0.005**	3.41	41	**24**	16.03	76%
	K	**0.25**	3.77	9.82	37.06	23.95	**0.005**	2.74	33	**Unknown**	N/A	Unknown
	L	**0.25**	3.77	2.58	9.74	6.30	**0.005**	1.66	20	**Unknown**	N/A	Unknown
	M	**2.04**	0.45	63.96	28.96	18.72	**0.005**	2.50	30	**2.5x5.5 Box**	114.79	-296%
	N	**0.56**	2.49	4.62	11.51	7.44	**0.005**	1.77	21	**Unknown**	N/A	Unknown
	O	**1.91**	0.55	25.84	14.27	9.22	**0.005**	1.92	23	**Brook**	N/A	N/A
	P	**0.47**	2.77	3.13	8.65	5.59	**0.005**	1.59	19	**Unknown**	N/A	Unknown
	Q	**0.66**	2.23	11.08	24.75	15.99	**0.005**	2.36	28	**Brook**	N/A	N/A
RS	**R**	**0.90**	1.74	48.83	84.82	54.82	**0.005**	3.74	45	**Brook**	N/A	Brook
	S	**0.25**	3.77	3.71	14.01	9.05	**0.05**	1.24	15	**12**	7.98	43%
	T	**0.80**	1.94	13.07	25.32	16.37	**0.05**	1.54	19	**15**	14.47	43%
	U	**0.47**	2.76	16.16	44.56	28.80	**0.005**	2.94	35	**Overflow**	N/A	N/A
	V	**0.25**	3.77	0.71	2.67	1.73	**0.005**	1.02	12	**Unknown**	N/A	Unknown
	W	**0.25**	3.77	2.99	11.27	7.29	**0.050**	1.14	14	**6x4 Box**	762.87	-6668%
	X	**0.42**	2.93	13.81	40.50	26.18	**0.005**	2.83	34	**6x4 Box**	241.24	-496%
	Y	**0.25**	3.77	4.57	17.26	11.15	**0.005**	2.06	25	**4x4 Channel**	140.54	-714%
Upper	**AA**	**0.45**	2.85	25.78	73.43	47.46	**0.010**	3.11	37	**24**	22.66	69%
	BB	**0.36**	3.20	24.90	79.77	51.56	**0.010**	3.21	39	**24**	22.66	72%
	CC	**0.27**	3.64	17.55	63.88	41.29	**0.040**	2.28	27	**24**	45.33	29%
	DD	**0.27**	3.66	14.64	53.62	34.66	**0.005**	3.15	38	**24**	16.03	70%
	EE	**0.25**	3.77	12.94	48.83	31.56	**0.005**	3.04	36	**24**	16.03	67%
	FF	**0.25**	3.77	10.56	39.83	25.74	**0.005**	2.82	34	**24**	16.03	60%
	GG	**0.25**	3.77	9.28	35.02	22.63	**0.005**	2.68	32	**24**	16.03	54%
	HH	**0.25**	3.77	8.35	31.49	20.35	**0.005**	2.58	31	**24**	16.03	49%
	II	**0.25**	3.77	5.62	21.20	13.70	**0.005**	2.22	27	**24**	16.03	24%
	JJ	**0.25**	3.77	2.70	10.19	6.58	**0.005**	1.69	20	**18**	7.44	27%

Table 6.6-3
Fisherville Drainage Basin Calculations

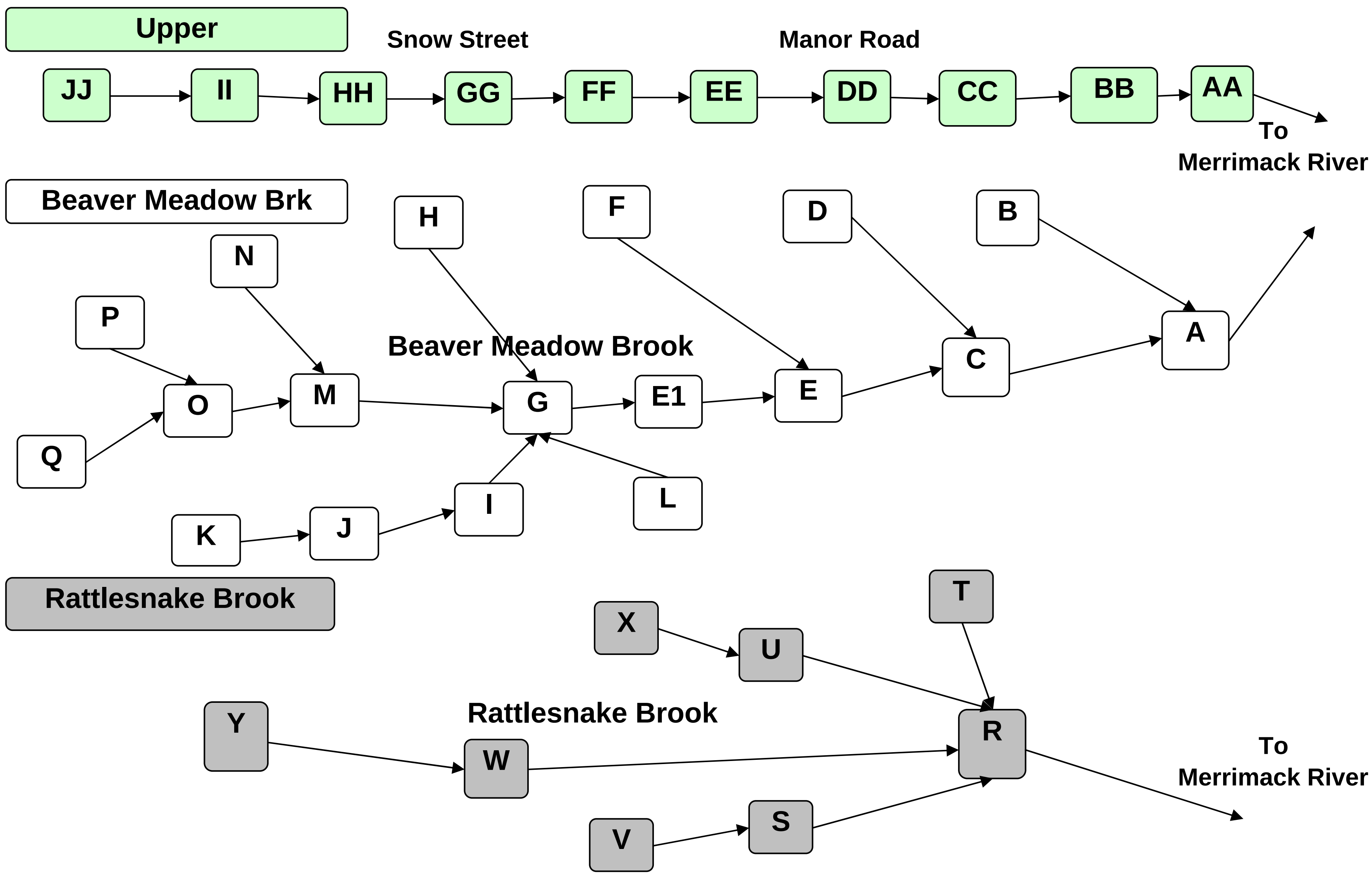


City of Concord

Fisherville Sub-Basin

Figure 6.6-1

Figure 6.6-2: Fisherville Drainage Basin - (FV) - Connectivity Diagram



Section 6.7
Oak Hill Drainage Basin Evaluation

6.7.1 Drainage Basin Description

Location

As shown in Figure 6.7-1, the Oak Hill drainage basin is located on the east side of the City of Concord. The drainage basin is bounded to the north east by the Town of Loudon, to the south by I-393 (Robert H. Whitaker Highway) and the Heights drainage basin, to the west by the Merrimack River, and to the north by the Hoit drainage basin.

This drainage basin includes the large undeveloped areas of the Concord Country Club and the Turtletown Wildlife Management Area.

Surface Water Drainage

Oak Hill, at approximately 920′ in elevation, lies on the border between the City of Concord and the Town of Loudon, forming part of the drainage divide between Oak Hill drainage basin and Hoit drainage basin. The north side of Oak Hill drains into Hackett Brook and into the "Hoit" drainage basin. While the east side of Oak Hill, including portions of Sanborn Road drain towards Snow Pond and into the "Oak Hill" drainage basin. The south side of Oak Hill, along with portions of the Concord Country Club, drain into Turtletown Pond, south of Snow Pond and also in the "Oak Hill" drainage basin.

Snow Pond lies in the north center of Oak Hill drainage basin between Snow Pond Road and Shaker Road. This pond drains north and west towards the Merrimack River. It formerly joined Haywood Brook just before discharging to the Merrimack River near the Sewalls Falls Road bridge crossing. However, now the streams join before passing under I-93 and the railroad tracks, and finally reaching the Merrimack.

A gentle saddleback south of Snow Pond prevents it from discharging towards the much larger Turtletown Pond, which feeds Mill Brook. Mill Brook discharges from the south of Turtletown Pond and runs southwest in a ravine lying largely parallel to Appleton Street and then Shawmut Street, taking a turn to the south to pass under East Side Drive near Eastman Street. The brook then flows southeast to drain into the Merrimack River at Merrill Park. The brook does not cross I-93.

Bowen Brook runs from north to south between I-93 and the Merrimack River, on the west side of I-93 in the Oak Hill drainage area. As discussed below, this portion of the drainage basin will not be discussed in detail.

Drainage Sub-Basins

Interstate 93 (I-93) runs through the Oak Hill drainage basin, dividing it into two distinct drainage basins. The portion of the Oak Hill basin lying to the west of I-93, the Bowen Brook area, has very little formal drainage and no known drainage problems. As a result, this portion will not be investigated or discussed at this time.

Much of the area of the Oak Hill basin east of I-93 is also undeveloped with no known drainage problems. This includes the areas surrounding both Turtletown and Snow Ponds.

Of the remaining developed areas, the associated stormwater drainage in the Oak Hill basin is concentrated in two main subbains (Figure 6.7-1)

- OH1 – From the north at Country Club Lane, north of the Concord Country Club, including Mountain Road and portions of Shaker Road. From the south, East Side Drive at Portsmouth Street, north to Eastman Street near Exit 16, I-93. This area is primarily single family residential units with several multi-family buildings. The main outfall of OH1 discharges into Merrimack River at Eastman Street. A secondary outfall discharges into Mill Brook from Eastman Street at East Side Drive. An active bypass from Eastman Street discharges just north of Carpenter Street.

- OH2 – From the north, East Side Drive at Portsmouth Road, south to West Sugar Ball Road, including portions of Curtisville Road, and Broken Ground Drive. From the east, including portions of Portsmouth Street, Pelham Lane and Ladybug Lane. This area is primarily single family residential units with several multi-family buildings. The main outfall of OH2 runs down West Sugar Ball Road and discharges into the Merrimack River.

Major Drainage Pipes

OH1

The main stormwater collection pipe for the OH1 area runs from north to south along Eastman Street. The pipe is an 18″ diameter along Mountain Road from the intersection of Mountain and Shaker Road to the three-way intersection of Mountain Road with Eastman Street and East Side Drive. The pipe then becomes a 24″ diameter south along Eastman Street to the outfall off Eastman Street.

OH2

The main stormwater collection pipe for the OH2 area is a 30″ diameter pipe on Curtisville Road, from the intersection with Portsmouth Street south along East Side Drive. The pipe turns into a 36″ pipe and runs southeast on East Side Drive to West Sugar Ball Drive. It remains a 36″ pipe along West Sugar Ball Road and outfalls to a wetland area and on to the Merrimack River.

Known Problems and Issues

Table 6.7-1 summarizes the known problems and issues as presented from the City of Concord to CDM.

Table 6.7-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
OH1	In Shaker Road between Pekoe Drive and Cemetery Street.	18″ Diam AC	Considerable roots in line. Pipe underdesigned for system inflow. Several residents complain of flooding. Large flat area with shallow groundwater.
OH1	East side of Eastman Street, south of East Side Drive.		Overflow to drainage ditch. Unknown condition of connection to closed drainage system.
OH1	West side of Eastman Street, north of Carpenter Street.	18″	Overflow to drainage ditch. Unknown condition of connection to closed drainage system.
OH2	West Sugar Ball Road to Outfall on Merrimack River		Severe washout and erosion at outfall.

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems listed in Table 6.7-1 may not be identified through modeling.

6.7.2 Model Development

Connectivity

Figures 6.7-2 and 6.7-3 show the node connectivity for the spreadsheet models developed for OH1 and OH2 respectively.

Detention/Storage

Several detention ponds have been constructed in the basin to moderate high storm flows. Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system. These are summarized in Table 6.7-2.

Table 6.7-2 – Detention Ponds

Subbasin	*Location*	*Max Discharge Rate*
OH1	North of Pekoe Drive, west of Max Lane. (Node K)	Approx. 4 cfs (12″ outlet)
OH2	East of South Curtisville Road, west of Hampton Street (Node LL)	Approx. 4 cfs (12″ outlet)
OH2	North of Portsmouth St., east of Cranmore Ridge Drive (Node CC)	Approx. 4 cfs (12″ outlet)
OH2	North of Portsmouth St., west of Cranmore Ridge Drive (Node BB)	Approx. 4 cfs (12″ outlet)

6.7.3 Recommendations

The pipes that are more than 50% undercapacity are summarized below. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity drainage pipes.

Cleaning & Lining

Based upon the City's listing of known problems, Shaker Road from north of Pekoe Drive to Cemetery Street has extensive roots and perhaps foreign objects lodged in the pipe. This section of pipe, while slightly under sized for the expected capacity, could benefit more immediately from cleaning and lining.

Replace Pipes

The pipes in the Oak Hill area which are most severely under capacity are summarized in Table 6.7-4. The larger diameter pipes should receive higher priority. For example, a 36″ pipe which is 50% undersized is a higher priority problem than an 8″ pipe 50% undersized.

Other Work

All outfalls, including the three in the OH1 area and the one in the OH2 area, should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary.

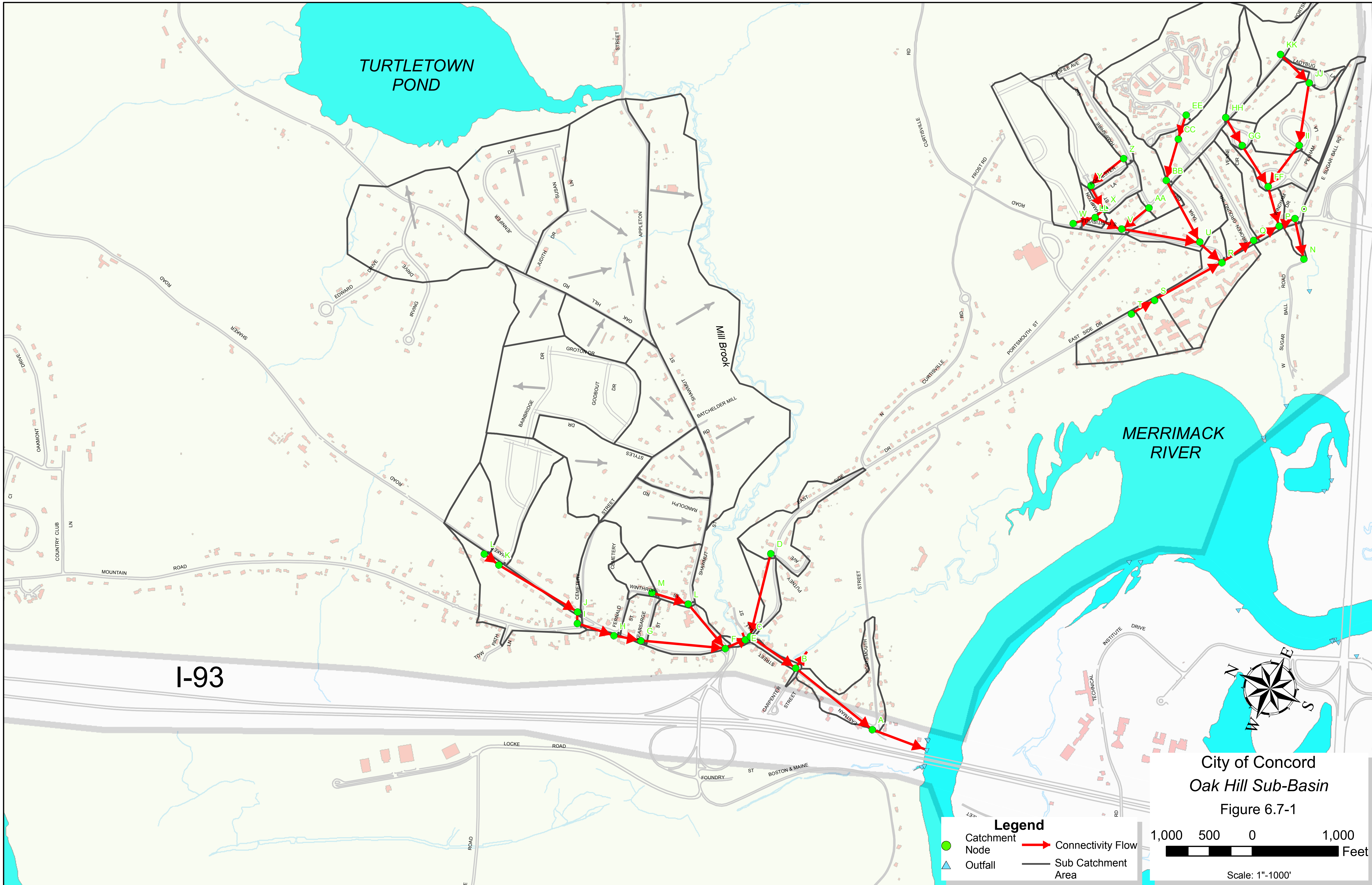
Table 6.7-4: Known and/or Suspected Problems in Oak Hill

Sub Basin	*Location*	*Nature of Problem*	*Recommended Solution*
OH1	Outfall at Eastman and Portsmouth (node A)	24″ pipe undersized for 10-year storm	Reducing incoming flow with detention, or increase size of pipe.
OH1	East Side Drive from Putney to Eastman (nodes C, D, E)	8″ and 18″ pipes undersized for 10-year storm	Redirect some flow in the basin to new detention or brook (with treatment). Or replace undersized pipes.
OH1	Winthrop Street and Shawmut Street (nodes M & L)	8″ and 12″ pipes undersized for 10-year storm	Redirect some flow in the basin to new detention. Or replace undersized pipe.
OH1	Shaker Road from Cemetery Street to Mountain Road (Node I)	Roots and other obstructions in the pipe, and undersized for 10-year storm.	Clean and line pipe or replace main in disrepair with new larger size pipe.
OH2	West Sugar Ball Rd to Outfall on Merrimack River (node N)	Severe washout and erosion	Repair/reconstruct drainage outfall facilities at this location.
OH2	East Side Drive from Heritage Heights Road to South Curtisville Rd (Nodes S & T)	Undersized pipe	Replace 12″ pipe large dia. pipe.
OH2	South Curtisville Rd north of Portsmouth St (nodes W & X)	Undersized pipes	Replace undersized pipes to detention pond (Node LL)
OH2	Pelham Lane (node II)	Undersized pipe	Redirect flow to detention. Or replace 18″ pipe with 30″ pipe.
OH1	Portsmouth St	Undersized culvert	Mill Brook 48″ culvert is undersized. Culvert washed out and flooded 200-feet on either side of road.

Sub Basin	Node	**Tc used for Node (hrs)**	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	**Slope of Pipe From Node (ft/ft)**	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	**Pipe Dia. In Place (in.)**	Current Max Flow (cfs)	% under capacity
OH1	**A**	**0.26**	3.68	11.18	41.13	26.58	**0.005**	2.85	34	**24**	16.03	61%
	B	**0.25**	3.77	6.96	26.24	16.96	**0.02**	1.86	22	**24**	32.05	-22%
	C	**0.25**	3.77	6.14	23.18	14.98	**0.005**	2.30	28	**18**	7.44	68%
	D	**0.25**	3.77	4.24	15.98	10.33	**0.005**	2.00	24	**8**	0.86	95%
	E	**1.12**	1.40	26.25	36.68	23.70	**0.02**	2.11	25	**18**	14.88	59%
	F	**1.11**	1.42	25.88	36.67	23.70	**0.04**	1.85	22	**18**	21.05	43%
	L	**0.25**	3.77	4.74	17.87	11.55	**0.005**	2.09	25	**12**	2.52	86%
	M	**0.25**	3.77	1.48	5.57	3.60	**0.005**	1.35	16	**8**	0.86	85%
	G	**1.05**	1.50	19.19	28.76	18.59	**0.04**	1.69	20	**18**	21.05	27%
	H	**1.03**	1.53	17.61	26.87	17.37	**0.02**	1.87	22	**18**	14.88	45%
	I	**1.01**	1.56	12.37	19.36	12.51	**0.005**	2.15	26	**18**	7.44	62%
	J	**1.00**	1.58	5.71	9.00	5.82	**0.005**	1.61	19	**15**	4.58	49%
	K	**0.53**	2.59	1.30	4.00	2.59	**0.005**	1.19	14	**12**	2.52	37%
	L	**0.78**	1.97	1.69	3.32	2.15	**0.005**	1.11	13	**12**	2.52	24%
OH2	**N**	**1.16**	1.35	51.73	69.70	45.05	**0.070**	2.12	25	**24**	59.96	14%
	O	**1.13**	1.38	51.48	70.99	45.88	**0.005**	3.50	42	**36**	47.25	33%
	P	**0.69**	2.16	50.43	109.02	70.46	**0.010**	3.61	43	**36**	66.82	39%
	Q	**0.67**	2.21	34.20	75.63	48.88	**0.005**	3.58	43	**36**	47.25	38%
	R	**0.65**	2.27	30.64	69.45	44.89	**0.005**	3.47	42	**36**	47.25	32%
	S	**0.34**	3.27	8.42	27.56	17.81	**0.005**	2.45	29	**12**	2.52	91%
	T	**0.33**	3.36	5.18	17.40	11.24	**0.005**	2.06	25	**12**	2.52	85%
	U	**0.63**	2.31	13.21	30.57	19.76	**0.005**	2.55	31	**30**	29.06	5%
	V	**0.25**	3.77	6.63	25.00	16.16	**0.005**	2.37	28	**30**	29.06	-16%
	W	**0.25**	3.77	7.96	30.03	19.41	**0.005**	2.53	30	**8**	0.86	97%
	X	**0.25**	3.77	9.32	35.16	22.72	**0.005**	2.69	32	**24**	16.03	54%
	Y	**0.25**	3.77	7.67	28.94	18.71	**0.005**	2.50	30	**24**	16.03	45%
	Z	**0.25**	3.77	2.71	10.23	6.61	**0.005**	1.69	20	**18**	7.44	27%
	AA	**0.25**	3.77	3.62	13.64	8.82	**0.005**	1.88	23	**18**	7.44	45%
	BB	**0.57**	2.46	1.30	4.00	2.59	**0.005**	1.19	14	**15**	4.58	-14%
	CC	**0.25**	3.77	1.30	4.00	2.59	**0.005**	1.19	14	**12**	2.52	37%
	EE	**0.25**	3.77	1.30	4.00	2.59	**0.005**	1.19	14	**12**	2.52	37%
	FF	**0.42**	2.95	13.16	38.85	25.11	**0.005**	2.79	33	**30**	29.06	25%
	GG	**0.37**	3.17	2.16	6.85	4.43	**0.005**	1.46	17	**24**	16.03	-134%
	HH	**0.34**	3.27	1.29	4.21	2.72	**0.005**	1.21	15	**18**	7.44	-77%
	II	**0.25**	3.77	8.20	30.94	19.99	**0.005**	2.56	31	**18**	7.44	76%
	JJ	**0.25**	3.77	2.06	7.76	5.01	**0.005**	1.52	18	**15**	4.58	41%
	KK	**0.25**	3.77	1.33	5.01	3.24	**0.005**	1.29	16	**15**	4.58	9%
	LL	**0.25**	3.77	1.30	4.00	2.59	**0.005**	1.19	14	**15**	4.58	-14%

CDM

Table 6.7-3
Oak Hill Drainage Basin Calculations



City of Concord

Oak Hill Sub-Basin

Figure 6.7-1

Figure 6.7-2: Oak Hill Drainage Basin (OH1)-Connectivity Diagram

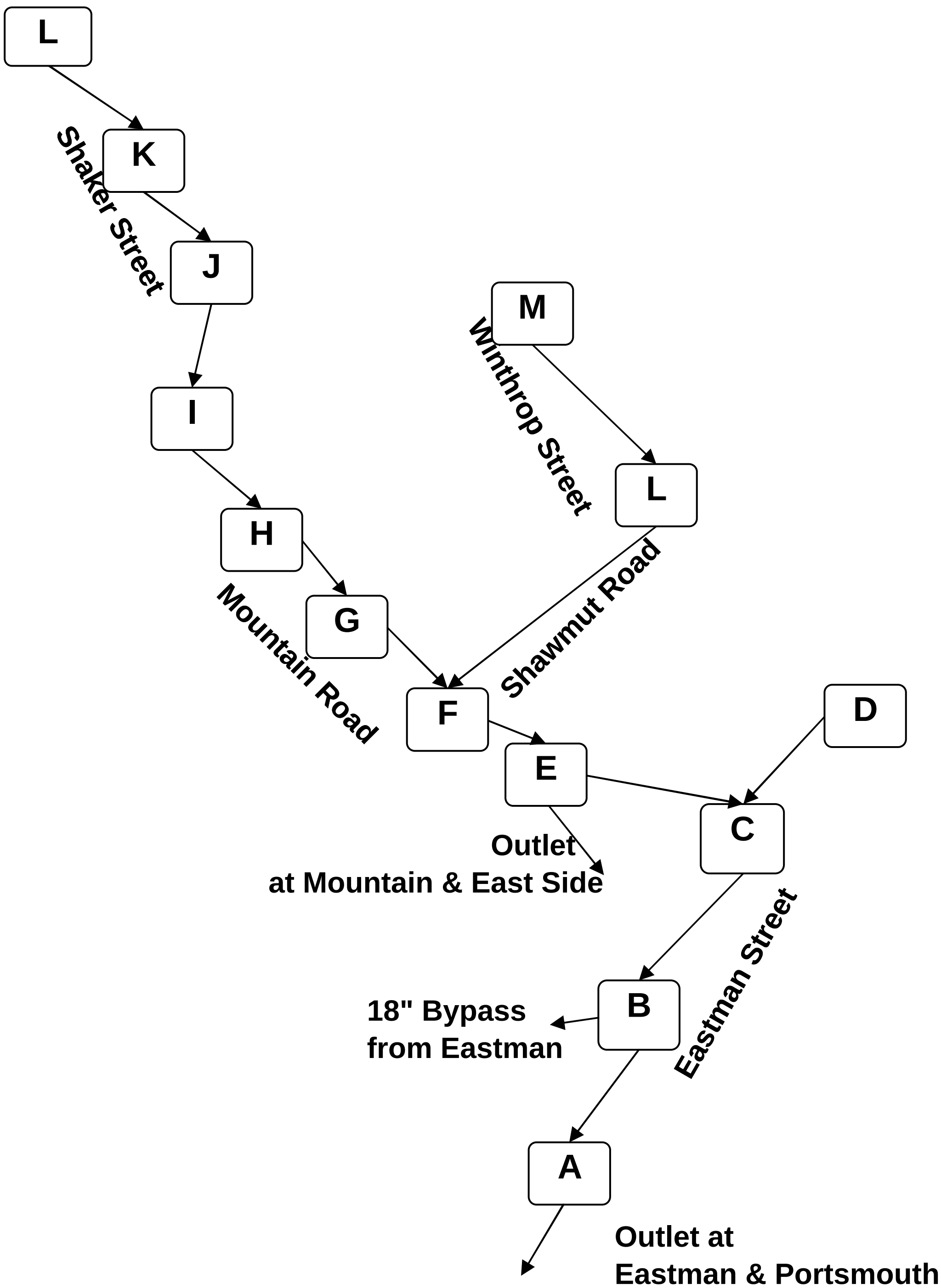
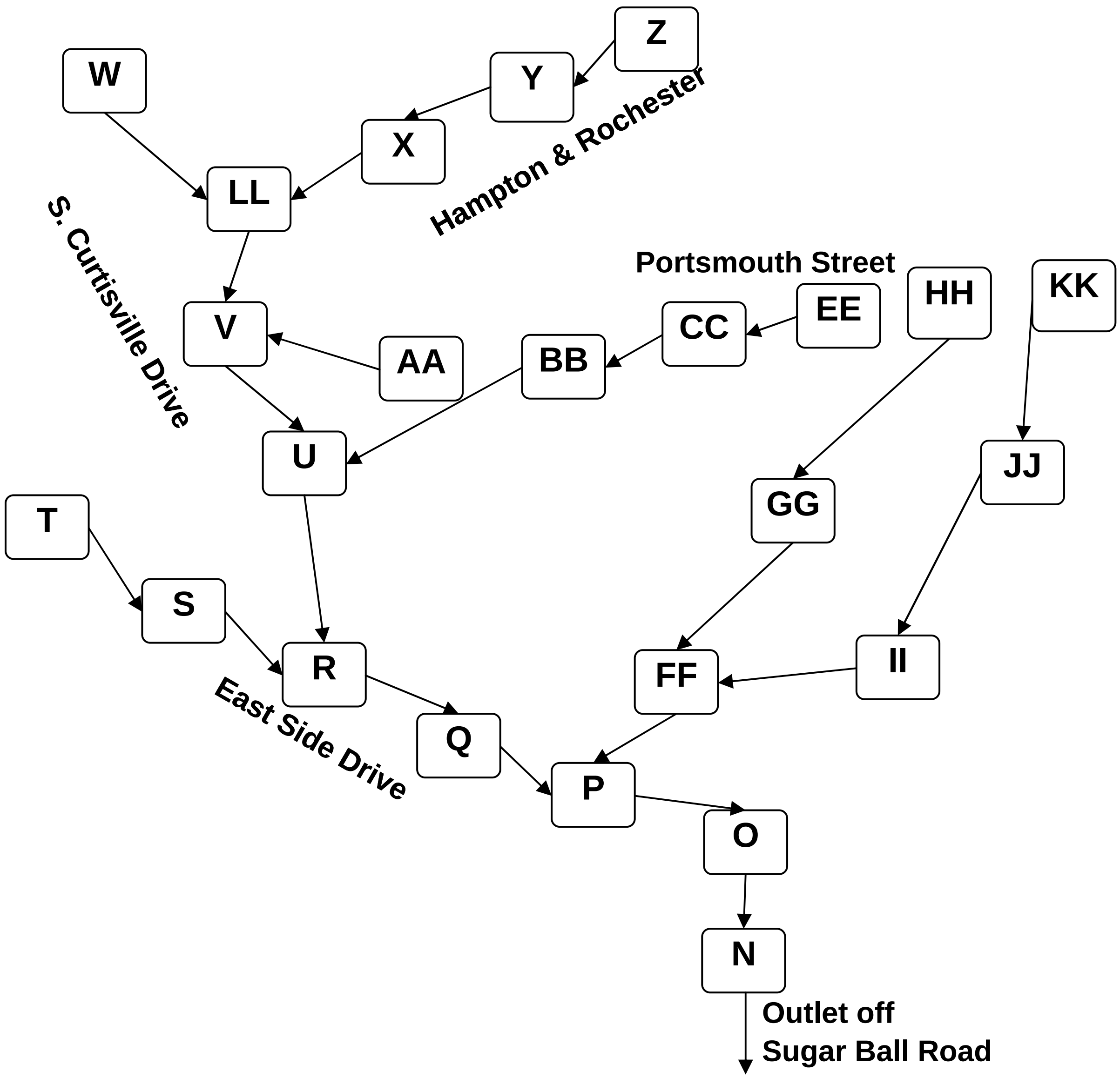


Figure 6.7-3: Oak Hill Drainage Basin - (OH2) - Connectivity Diagram



Section 6.8
Hospital Drainage Basin Evaluation

6.8.1 Drainage Basin Description

Location

As shown in Figure 6.8-1, the Hospital Drainage Basin is located west of the center of the City of Concord, on the west side of the Merrimack River. The drainage basin is bounded to the east by the Terrible Trapezoid drainage basin, to the south and west by the Turkey River drainage basin, and to the north by the Washington Street basin.

Concord Hospital, Concord High School, New Hampshire Hospital and portions of the State Office Park South, and the Concord District Court are all within the Hospital Drainage Basin.

Surface Water Drainage

Little Pond is contained within Hospital Drainage Basin, just east of Via Tranquila at the northern, upland edge of the basin. The outlet to Little Pond is to the east. According to USGS maps[1] the outlet stream splits into two brooks approximately 1500′ from Little Pond. One of the brooks, Woods Brook, continues to the east through Horseshoe Pond Drainage Basin. While the second brook, Bow Brook, turns south to pass under Little Pond Road and flow through the Hospital drainage basins.

Bow Brook runs through the Hospital Basin from North to South, at the southern end going underneath Noyes Street and continuing into the Turkey River drainage basin.

Drainage Sub-Basins

Most of the Hospital Drainage Basin is continuous, draining into one system which feeds a large cross country pipe through the New Hampshire State Hospital grounds. At the downstream end of the system, near Noyes Street, the pipe discharges into Bow Brook.

There are also a few minor pipes throughout the basin which drain directly to Bow Brook.

Major Drainage Pipe

Bow Brook crosses through the Hospital Drainage Basin through a series of closed pipes and open channel flow. At the upstream end of the sub basin, just north of School St, Bow Brook flows in Thayer Pond. After exiting Thayer Pond, Bow Brook then passes through a 4′x2′ box culvert under School St opening back up to open channel flow. It then passes through a 48″ reinforced concrete culvert under Woodman St, connects to a 7′x3′ box culvert passes under Warren St, then daylights

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[1] The majority of information in this section is from USGS, Concord NH Quadrangle 15 Minute Series (M300 – W7130/1b. AMS 6670II – Series V712), 1949. Available from the UNH Library Government Documents Department: http://docs.unh.edu/nhtopos/nhtopos.htm

again. The flow then passes into another 7′x3′ box culvert under Pleasant St before entering Hospital grounds. The flow continues to daylight and enter a closed system until finally connecting to the Washington St Sub-basin along Clinton St.

Known Problems and Issues

Table 6.8-1 summarizes the known problems and issues as presented from the City of Concord to CDM.

Table 6.8-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
H	South of Redington Road, west of Fruit Street	N/A	Flat area has poor drainage

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems listed in Table 6.8-1 may not be identified through modeling, but will be included along with the model-identified problems in the summary table at section end.

Three culverts in this drainage basin which Bow Brook flows through were washed out during the May 2006 rain event. The crossings occurred at Pleasant St (node E), School St (node H) and Warren St (node H2). Extensive damage to the culverts, road and subsurface resulted from the rain event. The City made temporary repairs to these three culverts and are currently under design for a permanent solution. The City may be granted funding from FEMA for 75% of the replacement costs.

6.8.2 Model Development

Connectivity

Figure 6.8-2 shows the node connectivity for the spreadsheet models developed for the Hospital Basin (H).

Detention/Storage

Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system. No large ponds are found in the Hospital Basin.

6.8.3 Recommendations

The pipes that are more than 50% undercapacity are summarized below in Table 6.8-3. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity drainage pipes.

Cleaning & Lining

Based upon the City's listing of known problems, there are no pipes in the Hospital area that need cleaning or lining at this time.

Replace Pipes

The pipes in the Hospital area which are most severely under capacity are summarized in Table 6.8-3. The larger diameter pipes should receive higher priority. For example, a 36″ pipe which is 50% undersized is a higher priority problem than an 8″ pipe 50% undersized.

Other Work

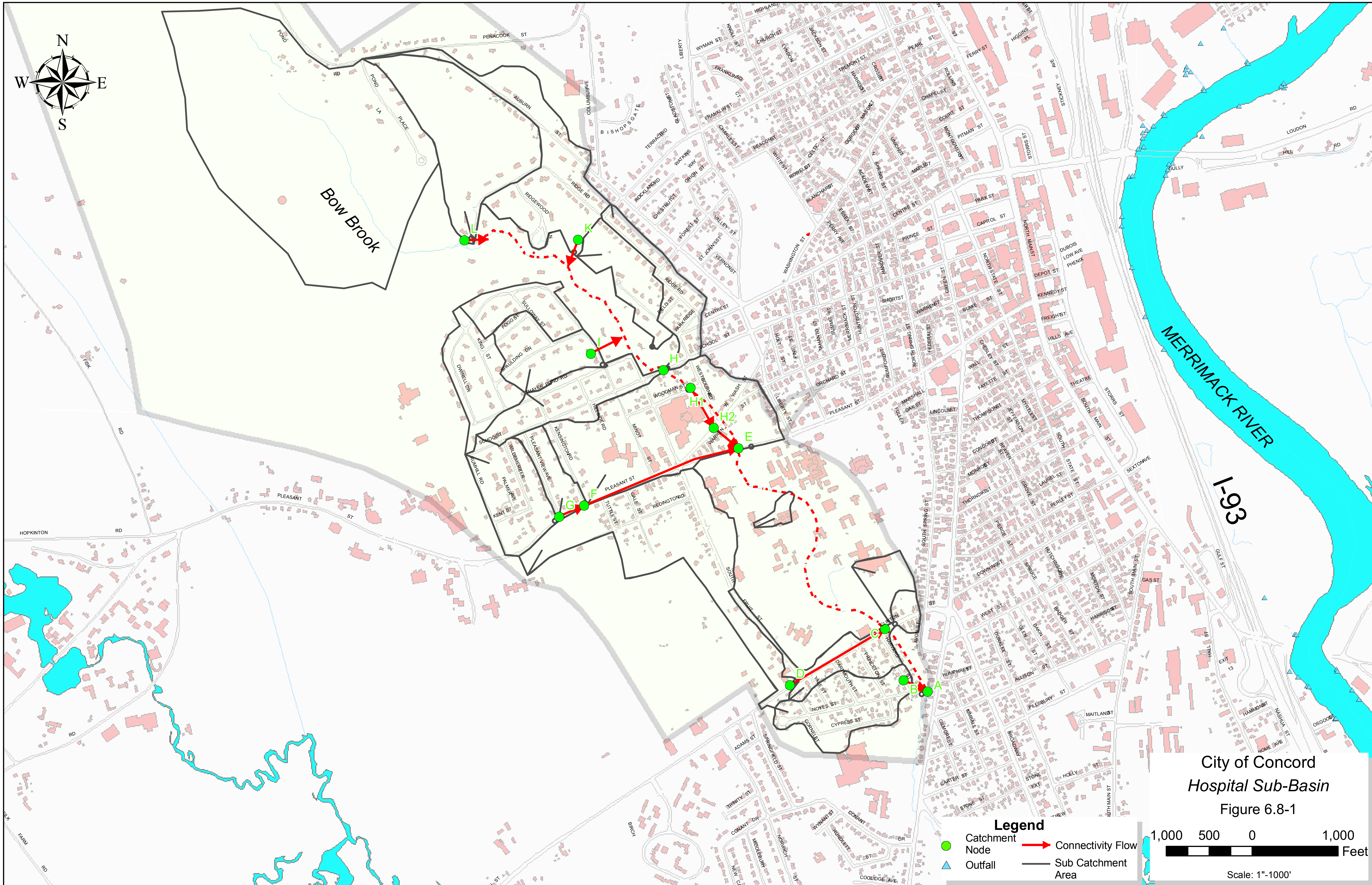
All outfalls in the Hospital basin should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary.

Table 6.8-3: Known and/or Suspected Problems in the Hospital Basin

Basin	***Location***	***Nature of Problem***	***Recommended Solution***
H	Noyes Street near Harvard Street (Node B)	18″ pipe undersized	Reduce flow through storage; or replace with a larger pipe.
H	South of Redington Road, west of Fruit Street (Node D)	Flat area has poor drainage, and 30″ pipe undersized	Consider installing larger pipes along flat area if possible.
H	Bow Brook culvert under Pleasant St as it enters State Hospital grounds (Node E).	Culvert was washed out during the May 2006 storm.	City currently under design to repair/replace culvert. FEMA & FHwA funded the project.
H	Pleasant St from Pleasant View to Kensington (Nodes F, G)	8″ pipe undersized	Replace with a larger pipe.
H	Minot st outlet to Thayer Pond/Bow Brook (node I)	12″ pipe undersized	Replace with a larger pipe.
H	Bow Brook culvert under School St and Warren St (node H and H2)	Culvert was washed out during the May 2006 storm. The School St culvert was undersized	City currently under design the repair/replace culverts. FEMA & FHwA funded the project.

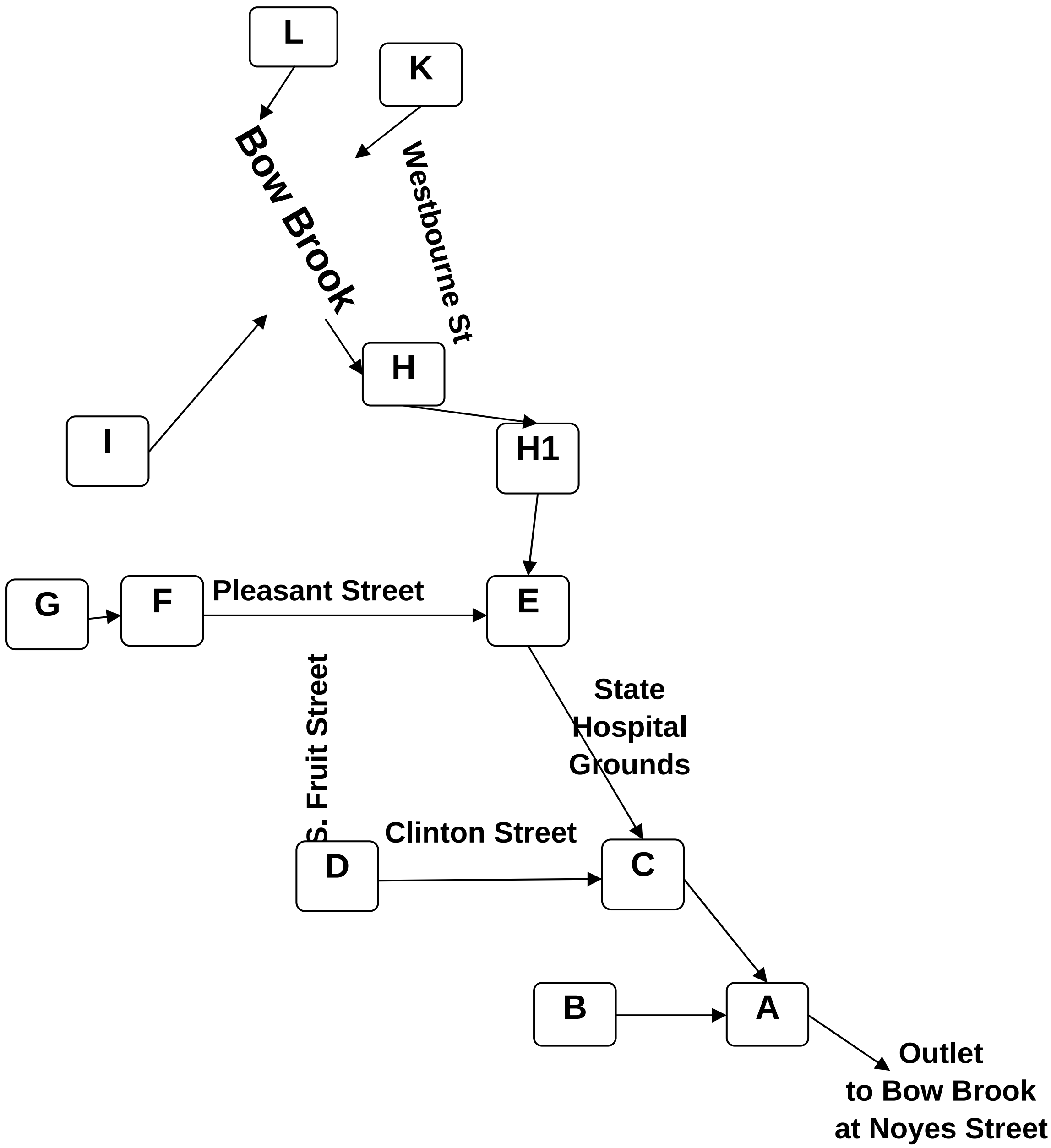
H	Bow Brook from Ridge Rd and Terrace Rd (node L and K)	Outlet pipes are undersized	Replace with larger pipes

Sub Basin	Node	**Tc used for Node (hrs)**	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	**Slope of Pipe From Node (ft/ft)**	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	**Pipe Dia. In Place (in.)**	Current Max Flow (cfs)	% under required capacity
H	**A**	**0.56**	2.50	105.14	262.64	169.75	**0.005**	5.71	69	**60**	184.49	42%
	B	**0.25**	3.77	8.32	31.39	20.29	**0.005**	2.58	31	**18**	7.44	76%
	C	**0.51**	2.64	96.82	255.75	165.30	**0.005**	5.66	68	**60**	184.49	28%
	D	**0.28**	3.60	20.20	72.71	46.99	**0.005**	3.53	42	**30**	29.06	60%
	E	**0.36**	3.18	72.58	230.91	149.24	**0.005**	5.44	65	**7x3 Box**	201.91	13%
	F	**0.25**	3.77	11.16	42.10	27.21	**0.070**	1.75	21	**12**	9.44	78%
	G	**0.25**	3.77	7.88	29.73	19.21	**0.070**	1.54	18	**8**	3.20	89%
	H	**0.29**	3.54	38.10	134.98	87.24	**0.005**	4.45	53	**4x2 Box**	55.75	59%
	H1	**0.29**	3.54	38.10	134.98	87.24	**0.005**	4.45	53	**48**	101.75	25%
	H2	**0.29**	3.54	38.10	134.98	87.24	**0.005**	4.45	53	**7x3 Box**	201.91	-50%
	I	**0.25**	3.77	6.32	23.84	15.41	**0.005**	2.32	28	**12**	2.52	89%
	K	**0.25**	3.77	6.90	26.03	16.82	**0.005**	2.40	29	**12**	2.52	90%
	L	**0.25**	3.77	8.92	33.65	21.75	**0.005**	2.64	32	**12**	2.52	93%



City of Concord
Hospital Sub-Basin
Figure 6.8-1

Figure 6.8-2: Hospital Drainage Basin - (H) - Connectivity Diagram



Section 6.9
Horseshoe Pond Drainage Basin Evaluation

6.9.1 Drainage Basin Description

Location

As shown in Figure 6.9-1, the Horseshoe Pond drainage basin is located near the center of the City of Concord, on the west side of the Merrimack River. The drainage basin is bounded to the north east by drainage basins Fisherville and West Concord, to the south by Hospital and Washington Street drainage basins, and to the west by the Merrimack River.

Exit 15 of Interstate-93 is within the Horseshoe Pond basin, as are New Hampshire Technical Institute and the Calvary Cemetery. The Concord Bus Station at 30 Stickney Avenue is near the downstream end of the watershed. Horseshoe Pond (west of I-93), Fort Eddy Pond (east of I-93) and the Merrimack River (crossing under I-93 near the north end of the basin) are the main water features in the basin.

Surface Water Drainage

The east side of the drainage basin, between I-93 and the Merrimack River, drains to the Merrimack River and to Fort Eddy Pond. This portion of the basin includes New Hampshire Technical Institute and the beginning of I-393, east as far as Exit 1. There is very little other development in this area, and minimal stormwater infrastructure.

The west side of the drainage basin, west of I-93 drains through several small streams eventually to Horseshoe Pond and the Merrimack River. The Boston-Maine railroad tracks lie on the west side of I-93 also running north/south.

Rattlesnake Hill is a ridge approximately 2000′ in length which runs roughly north/south at the western side of the drainage basin, along the boundary with the West Concord and Fisherville drainage basins. The hill has a maximum elevation of approximately 714′. At the southern end of the ridge, at an elevation of approximately 643′, is Little Pond.

The outlet to Little Pond is to the east. According to USGS maps[1] approximately 1500′ from Little Pond the outlet stream splits into two brooks. Woods Brook continues to the east through Horseshoe Pond Drainage Basin, skirting the southern edge of Calvary Cemetery, passing under North State Street and the railroad, and eventually discharging into the northeast corner of Horseshoe Pond. At the divergence point, Bow Brook turns south to pass under Little Pond Road and flow through the Terrible Triangle and Hospital drainage basins.

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[1] The majority of information in this section is from USGS, Concord NH Quadrangle 15 Minute Series (M300 – W7130/1b. AMS 6670II – Series V712), 1949. Available from the UNH Library Government Documents Department: http://docs.unh.edu/nhtopos/nhtopos.htm

West of Rattlesnake Hill lies Pennacook Lake, also known as Long Pond, a drinking water source for the City of Concord. The lake is 359 acres in area and 74′ deep[2]. Rattlesnake Brook discharges from the north end of Penacook Lake, northwest of Rattlesnake Hill. The brook flows approximately 3000′ toward the Merrimack River, then turns south and runs parallel to the larger river. Rattlesnake Brook enters Horseshoe Pond Drainage Basin from the north, crosses under the railroad and enters the Merrimack River directly east of the state prison.

Drainage Sub-Basins

East

Interstate 93 runs through the Horseshoe Pond drainage basin, dividing it into two distinct drainage basins. The portion of the basin lying to the east of I-93, the Fort Eddy Pond area and New Hampshire Technical Institute, has very little formal drainage and no known drainage problems. As a result, this area will not be investigated or discussed at this time.

Northwest

Much of the area of the Horseshoe Pond basin west of I-93 is undeveloped and has no known drainage problems. This includes the areas of the Calvary Cemetery and Rattlesnake Hill to the west, and State Prison and Rattlesnake Brook to the north. These areas also are sparsely developed without extensive drainage and with no known problems. These areas will not be investigated at this time.

Southwest

The main developed portion of the basin is bounded

- to the north by Horseshoe Pond, North State Street and Curtice Street;
- to the east by I-93;
- to the south by portions of Franklin Street and Tremont Street; and
- to the west by portions of Rumford Street, Liberty Street and the reservoir-topped hill south west of Penacook Street.

The southwest portion of the basin includes Bouton Street, East Penacook Street, and Church Street, as well as North Main Street from Pennacook Street to Franklin Street. The main bus station by I-93 is also included in this area to the east near the downstream end. This area has the majority of the drainage and development and will be the focus of the investigation in this drainage basin.

The southwest portion of the Horseshoe Pond area is the only portion of the basin that will be investigated in detail through this study. This area is delineated in Figure 6.9-1.

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[2] The Laker: https://www.thelaker.com/boating/lake_info.html

Major Drainage Pipes

The drainage in the southwest portion of the Horseshoe Pond Drainage Basin enters three main systems which intertwine slightly. A schematic of the three systems is shown in Figure 6.9-2.

1. The smallest of the three sub-basins collects stormwater drainage from Curtice Street, Granite Avenue, and runs in a 12" to 15" pipe from the corner of Rumsfield Street and Curtice Street to the head of Horseshoe Pond Lane. The stormline runs southeast towards to the corner of Walker Lane, and then turns north to run cross country back to Horseshoe Pond Lane. This section of pipe is scheduled for improvements by the NHDOT according to plans sent to the City of Concord. This NHDOT project is currently on hold until a private property issue for the proposed outfall is resolved. The now 18" pipe turns east onto Horseshoe Pond lane, travels straight for approximately 500 feet before discharging to the Horseshoe Pond on the north side of Horseshoe Pond Lane.

2. The largest drainage sub-basin in the Horseshoe Pond area collects flow from the south side of the reservoir-topped hill west of the northern end of Liberty Street. This drainage enters the stormwater system on Gladstone Street and flows north on Liberty Street. Drainage from Liberty Street and Jennings Drive enter the stormwater system and flow east on Walker Street. Drainage from Albin Street, Highland Street, and Church Street flows east to Bradley Street and then north along Bradley Street to Walker Street. The combined flow drains east on Walker Street to State Street (Route 3), north to Horseshoe Pond Lane, and east towards Commercial Street. The pipe turns to the south just east of Commercial Street, passes under Route I-393/202, Fort Eddy Road and I-93 and discharges to the Merrimack River.

At the corner of Horseshoe Pond Lane and North Main Street, there is an overflow to a 30" diameter pipe. This overflow pipe also collects some overflow from the drainage area to the south (3, below) and discharges to Horseshoe Pond to the north.

3. The third drainage sub-basin in the southwestern portion of the Horseshoe Pond basin lies along the southern edge of the drainage basin, just north of the Washington Street basin. South of Church Street, both Lyndon Street and Jackson Street drain south to Franklin Street. Flow from Tremont Street east of Jackson Street travels east on Tremont Street, joins flow from Franklin and flows north on North State Street to Church Street. Bradley Street, Church Street, Bouton Street and portions of North Main Street join this flow as it continues east. The flow collects into a 20" diameter pipe on I-393/202 which turns south just before Commercial Street, then crosses Commercial Street, Stickney Avenue and I-93 to discharge to the Merrimack River.

At the corner of North Main Street and I-393/202 there is an overflow to a 30" diameter pipe. This overflow drains north along North Main to collect from the drainage area to the north (2, above) and discharge to Horseshoe Pond.

Known Problems and Issues

Table 6.9-1 summarizes the known problems and issues as presented by the City of Concord to CDM during meetings held in the fall of 2005.

Table 6.9-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
HP1 and HP2	East end of Walker Street, corner of Walker and North State Street.	20″ and 18″ Diameter	This small area contains a lot of pipes including some 90° turns and a turn upwards of 135°. The NHDOT is designing a reworked piping scheme here.
HP2	I393/202 at Railroad Track, west of the southbound offramp for I-93.	20″ Diameter	This area floods. A new pipe design to direct excess flow up North Main Street is planned upstream of this pipe. This should alleviate this condition.

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems listed in Table 6.9-1 may not be identified through modeling, but will be included along with the model-identified problems in the summary table at section end.

6.9.2 Model Development

Connectivity

Figure 6.9-2 shows a schematic of the node connectivity for the spreadsheet models developed for the horseshoe pond basin (HP).

Detention/Storage

Several detention ponds have been constructed in the basin to moderate high storm flows. Although small to medium sized ponds are certainly beneficial, only larger ponds have a noticeable effect on the stormwater system.

6.9.3 Recommendations

The pipes that are more than 50% undercapacity are summarized below in Table 6.9-3. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity drainage pipes.

Cleaning & Lining
Based upon the City's listing of known problems, clogged pipes do not seem to be causing the majority of problems in this drainage basin. Capacity issues seem to be the majority of the problems here.

Redirect Flow, Replace Pipes
The pipes in the Horseshoe Pond area which are most severely under capacity are summarized in Table 6.9-2. The larger diameter pipes should receive higher priority. For example, a 36″ pipe which is 50% undersized is a higher priority problem than an 8″ pipe 50% undersized.

Table 6.9-2: Summary of known and/or Suspected Problems in the Horseshoe Pond Basin[3]

Sub Basin	*Location*	*Nature of Problem*	*Recommended Solution*
HP1	East end of Walker Street, corner of Walker and North State Street. (Nodes JJ, CC and FF)	15″ and 18″ pipes that turn 90° and approx 135°. Undersized pipes as well.	The NHDOT is designing a new piping scheme here.
HP2	East end of Walker Street, corner of Walker and North State Street. (Nodes A and B)	20″ and 24″ dia. with a few 90° turns and some capacity issues.	The NHDOT is designing a new piping scheme here.
HP2	Walker Street from North State Street to Liberty Street (Nodes C, D, E and F)	8″, 15″ and 20″ Diam; Excess flow causes capacity problems, especially near Liberty St.	Replace with a larger pipe
HP2	Liberty Sreet and Franklin St (Nodes HH, II & FHH)	8″ Diameter; Excess flow causes capacity problems, especially near Wyman St.	Consider pipe replacement

[3] This table includes problems identified by the City (Table 6.9-1) and problems identified through modeling (Table 6.9-2)

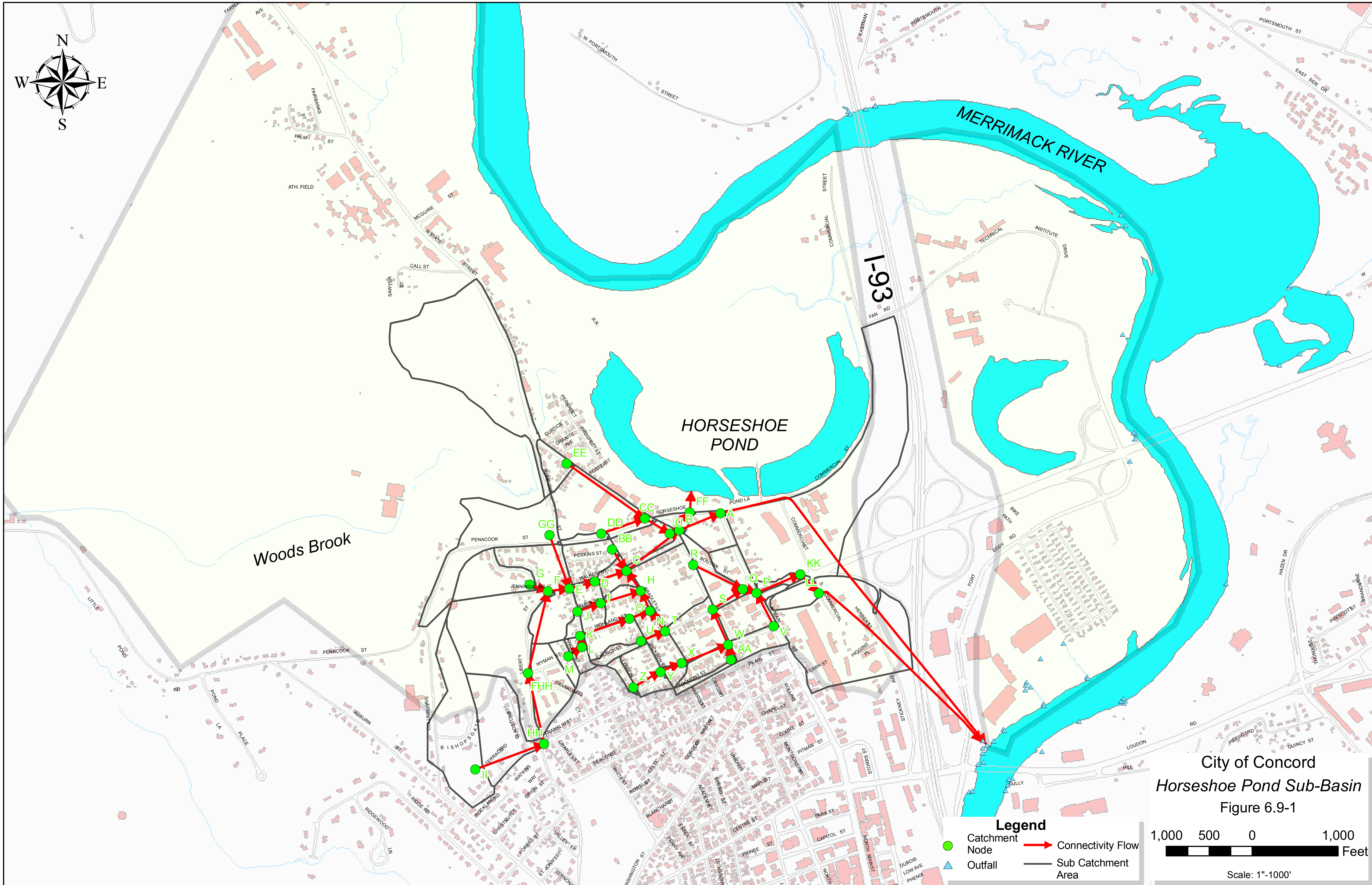
HP2	Rumford St, between Penacook St and Jennings St (Node GG)	Undersized 8″ dia. pipe from large area to Walker St	Consider pipe replacement .
HP2	Wyman St and Rumford St to Highland St (Node L and M)	6″ and 10″ dia. pipe is undersized	Consider pipe replacement
HP3	I393/202 at RR Track, west of southbound offramp for I-93. (Nodes P, LL and KK)	20″ Diameter; This pipe is undersized.	NHDOT new pipe design to direct excess flow up North Main Street (from node P) is planned, but currently on hold.
HP3	Church St between Bouton and State, (Node Q)	18″ Diameter, Excess flow to the pipe, causes capacity problems.	The planned overflow at node P should alleviate some of these issues if constructed.
HP2	Bradley St from Albn St to Perkins St	12″ and 20″ dia. pipe is undersized	Consider pipe replacement

Other Work

All outfalls in the Horseshoe Pond basin should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary. There are four main outfalls for the areas listed: the outfall for HP1 area (to Horseshoe Pond), outfalls for HP2 and HP3 (both to Merrimack River), and the overflow pipe from HP2 and HP3 (to Horseshoe Pond).

Node	**Adj. Sub Basin**	**Tc used for Node (hrs)**	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	**Slope of Pipe From Node (ft/ft)**	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	**Pipe Dia. Installed (in.)**	Velocity in Pipe (ft/sec)	Current Max Flow (cfs)	% under capacity
FF	**HP35**	**0.25**	3.77	8.65	32.63	21.09	**0.005**	2.61	31	**18**	18.46	7.44	65%
JJ	**HP2**	**0.25**	3.77	8.09	30.52	19.72	**0.005**	2.55	31	**15**	24.87	4.58	77%
CC	**HP29**	**0.25**	3.77	6.09	22.97	14.85	**0.01**	2.01	24	**15**	18.72	6.47	56%
DD	**HP30**	**0.25**	3.77	0.79	2.98	1.93	**0.01**	0.94	11	**15**	2.43	6.47	-236%
EE	**HP32**	**0.25**	3.77	1.22	4.62	2.98	**0.01**	1.10	13	**15**	3.76	6.47	-117%
A	**HP1**	**0.59**	2.41	43.28	104.23	67.37	**0.005**	4.04	48	**24**	33.18	16.03	76%
B	**HP2**	**0.55**	2.53	41.40	104.95	67.83	**0.04**	2.74	33	**24**	33.41	45.33	33%
C	**HP3**	**0.53**	2.59	39.40	101.88	65.85	**0.02**	3.09	37	**20**	46.70	19.71	70%
D	**HP4**	**0.51**	2.65	27.71	73.40	47.44	**0.02**	2.73	33	**15**	59.81	9.15	81%
E	**HP5**	**0.49**	2.70	26.88	72.70	46.99	**0.04**	2.39	29	**15**	59.24	12.94	72%
F	**HP6**	**0.48**	2.74	19.45	53.33	34.47	**0.04**	2.13	26	**8**	152.79	2.42	93%
G	**HP7**	**0.25**	3.77	1.62	6.11	3.95	**0.04**	0.94	11	**8**	17.51	2.42	39%
HH	**HP33**	**0.37**	3.14	8.38	26.28	16.99	**0.04**	1.63	20	**8**	75.29	2.42	86%
FHH	**HP13a**	**0.42**	2.94	13.13	38.66	24.99	**0.04**	1.89	23	**8**	110.75	2.42	90%
II	**HP34**	**0.32**	3.39	5.66	19.19	12.40	**0.04**	1.45	17	**8**	54.98	2.42	80%
GG	**HP31**	**0.25**	3.77	3.60	13.57	8.77	**0.04**	1.27	15	**8**	38.86	2.42	72%
BB	**HP28**	**0.25**	3.77	2.14	8.06	5.21	**0.005**	1.55	19	**12**	10.26	2.52	52%
H	**HP8**	**0.25**	3.77	8.50	32.07	20.73	**0.005**	2.60	31	**20**	14.70	9.85	52%
I	**HP9**	**0.25**	3.77	1.08	4.09	2.64	**0.005**	1.20	14	**10**	7.50	1.55	41%
J	**HP10**	**0.25**	3.77	0.30	1.13	0.73	**0.005**	0.74	9	**10**	2.08	1.55	-112%
N	**HP14**	**0.25**	3.77	5.79	21.85	14.12	**0.005**	2.25	27	**15**	17.81	4.58	68%
O	**HP15**	**0.25**	3.77	3.39	12.77	8.25	**0.005**	1.84	22	**15**	10.41	4.58	45%
K	**HP11**	**0.25**	3.77	1.68	6.33	4.09	**0.005**	1.41	17	**12**	8.06	2.52	38%
L	**HP12**	**0.25**	3.77	1.45	5.48	3.54	**0.005**	1.34	16	**10**	10.04	1.55	56%
M	**HP13**	**0.25**	3.77	1.10	4.16	2.69	**0.005**	1.21	14	**6**	21.21	0.40	85%
T	**HP20**	**0.25**	3.77	1.73	6.52	4.21	**0.005**	1.43	17	**15**	5.31	4.58	-9%
U	**HP21**	**0.25**	3.77	0.62	2.34	1.51	**0.005**	0.97	12	**10**	4.29	1.55	-3%
LL	**HP38**	**0.41**	2.98	18.97	56.60	36.58	**0.005**	3.21	39	**20**	25.94	9.85	73%
KK	**HP37**	**0.39**	3.06	17.69	54.07	34.95	**0.005**	3.16	38	**20**	24.78	9.85	72%
P	**HP16**	**0.36**	3.18	17.21	54.79	35.41	**0.005**	3.17	38	**18**	31.00	7.44	79%
V	**HP22**	**0.25**	3.77	1.41	5.33	3.44	**0.005**	1.32	16	**24**	1.70	16.03	-365%
Q	**HP17**	**0.36**	3.22	12.11	38.92	25.15	**0.005**	2.79	34	**18**	22.02	7.44	70%
R	**HP18**	**0.33**	3.31	3.42	11.33	7.32	**0.030**	1.26	15	**12**	14.42	6.18	16%
S	**HP19**	**0.25**	3.77	6.67	25.17	16.27	**0.020**	1.83	22	**18**	14.25	14.88	9%
W	**HP23**	**0.25**	3.77	3.86	14.55	9.40	**0.070**	1.18	14	**15**	11.86	17.12	-82%
AA	**HP27**	**0.25**	3.77	0.67	2.51	1.62	**0.005**	1.00	12	**12**	3.19	2.52	-56%
X	**HP24**	**0.25**	3.77	2.81	10.61	6.86	**0.070**	1.05	13	**12**	13.51	9.44	-38%
Y	**HP25**	**0.25**	3.77	2.36	8.92	5.76	**0.070**	0.98	12	**12**	11.36	9.44	-64%
Z	**HP26**	**0.25**	3.77	0.46	1.75	1.13	**0.005**	0.87	10	**10**	3.21	1.55	-37%

Table 6.9-2
Horseshoe Pond Drainage Basin Calculations

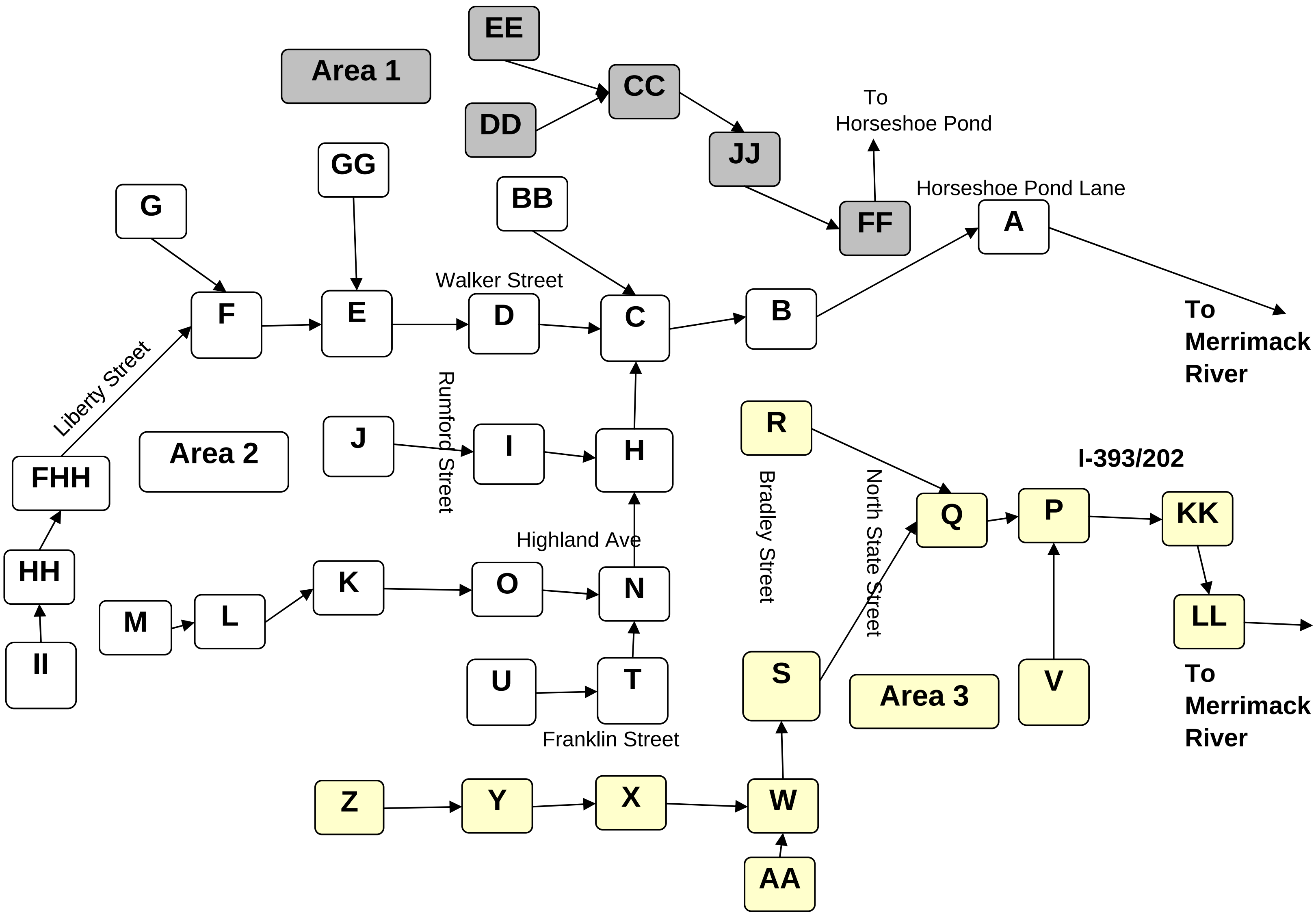


City of Concord

Horseshoe Pond Sub-Basin

Figure 6.9-1

Figure 6.9-2: Horseshoe Pond Drainage Basin - (HP1, HP2 & HP3) - Connectivity Diagram



Section 6.10
Turkey Pond Drainage Basin Evaluation

Note that for the Turkey Pond Drainage Basin, as for the West Concord and Hoit Basins, the analysis and modeling will focus on culvert sizing rather than pipe size. As these three basins have minimal stormwater collection infrastructure, the pipe-size analysis done for the other basins in Concord is not as relevant here.

These three basins on the outskirts of the City are expected to have additional development in the coming years, and therefore increased runoff and "flashier" streamflow (quicker response to rainfall) is a concern. So, as discussed below, analysis is done to determine the required culvert diameter under current conditions and under future buildout conditions.

6.10.1 Drainage Basin Description

Location

As shown in Figure 6.10-1, the Turkey Pond Drainage Basin is located in the southwest corner of the City of Concord. The drainage basin is bounded to the north by the West Concord drainage basin. Turkey Pond drainage basin is separated from the Turkey River drainage basin to the east by Silver Hill. The basin is bounded to west by the Town of Hopkinton and to the south by the Town of Bow.

Saint Paul's School is located within the West Concord drainage basin, as are Little Turkey Pond and Turkey Pond.

Surface Water Drainage

Turee Brook, White Brook, and Bela Brook all enter the southeast corner of Concord from the Town of Bow, to feed Turkey Pond. The pond lies just south of Route I-89 and to the west of Silver Hill. Flow out of Turkey Pond discharges to the north, under Route I-89 and into Little Turkey Pond. A stream, approximately 2500 feet in length separates Turkey Pond from Little Turkey Pond.

Little Turkey Pond lies north of Turkey Pond, across Route I-89. The smaller pond is approximately 7 feet lower in elevation than the larger. Turkey River discharges from the northern end of Little Turkey Pond.

Turkey River travels north from Little Turkey Pond, then east to enter the Turkey River drainage basin. Ash Brook and several unnamed brooks are tributary to the Turkey River within the Turkey Pond drainage basin.

Ash Brook enters the Turkey Pond drainage basin from the West Concord drainage basin to the north. The brook travels south to go under Currier Road, and then east and southeast to go under Pleasant Street, Route 202. Ash Brook enters the Turkey River approximately 2000 feet downstream of Little Turkey Pond, upstream from the impoundment on Turkey River near the St Paul's School.

Drainage Sub-Basins

The Turkey Pond Drainage Basin has no sub-basins. The entire drainage basin is contiguous, from the small streams feeding into the system, through Turkey Pond and Little Turkey Pond, to the Turkey River.

Major Drainage Pipes

With the receiving waters, Turkey Pond, Little Turkey Pond, and Turkey River, running so close to the majority of the drainage basin and taking up so much of the actual land area, no large drainage pipes are necessary. Small areas generally drain directly to the ponds and streams. Culvert size is of more concern for this basin.

Known Problems and Issues

The City of Concord did not identify any known problems in the Turkey Pond Sub-basin.

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems may not be identified through modeling, but will be included along with the model-identified problems in the summary table at section end.

6.10.2 Model Development

Connectivity

Figure 6.10-2 shows the node connectivity for the spreadsheet model developed for the Turkey Pond Drainage Basin (TP).

Detention/Storage

Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system.

Method

Table 6.10-1 summarizes the model results. As discussed in Section 6.2, the Rational Method is appropriate for basins of 1mi^2 and smaller. The Turkey Pond Drainage Basin contains several brooks with watersheds much larger than 1mi^2. A slightly different method was used for this basin. The method, published by the United States Geological Survey[1], uses regression formulas for various regions around the country. The formula for the ten year peak discharge, developed for New Hampshire, is:

$$Q10 = 0.84*A^{1.05}*S^{0.46}*(I2.24)^{1.98}$$

Where Q10 is the peak discharge expected every 10-years (cubic feet per second), A is drainage area (square miles), S is the channel slope (feet per mile), and I2.24 is the 2-year 24-hour storm depth (inches) as read from charts provided in the USGS

[1] U.S. Geological Survey Water-Resources Investigations Report 94-4002: *Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1999.* http://water.usgs.gov/software/nff_manual/nh/index.html

document. This method offers one equation for all of New Hampshire, and is not Concord-specific, but is a better choice for larger watersheds.

Columns 1 and 2 of Table 6.10-1 present the subcatchment and node in the Turkey Pond basin (Figure 6.10-1, 6.10-2).

Connectivity and Areas
Column 3 of Table 6.10-1 presents the node connectivity for the Turkey Pond Drainage Basin. Figure 6.10-2 shows a simplified diagram of the connectivity. Please note that in the Turkey Pond basin the nodes represent culverts, connected by brooks. In other basins, the culverts represent manholes connected by pipes.

Column 4 shows the distance through the subcatchment to each node in miles. Column 5 lists the elevation difference from the upstream end of the subcatchment to the downstream end in feet. Column 6 then calculates the slope (elevation/distance, Col 5/Col 4) for the subcatchment, in feet/mile. This slope represents the path runoff must take to get to the brook. The slope in column 9 represents the path water takes once it is in the brook.

Column 7 is the area for each subcatchment in square miles. Column 8 is the cumulative area contributing to each node, the sum of the areas of the subcatchments upstream of each node.

Column 9 is the slope assumed for the brook in feet/foot.

Estimated Flows and Required Pipe Sizes
Columns 10, 11 and 12 give the results for the current condition, while columns 13, 14 and 15 give the results for the buildout/future condition. Columns 10 and 13 are the peak discharge expected every 10-years (cubic feet per second), as calculated by the formula above from the USGS method.

Columns 11 and 14 give the approximate pipe diameter required to carry the estimated flow to this node. The actual culvert diameter that is installed in this location, where known, is given in column 16. As only the larger culverts were inspected, where the culvert size is unknown, a diameter of 24" is assumed. Pipes that appear to be severely undersized for the current condition are highlighted in the table. Additional inspections to determine the remaining culvert sizes are recommended.

6.10.3 Recommendations

The City inspected all the larger culverts in the Turkey Pond area. Only one such culvert was identified, a 16' by 3.7' bridge opening for Bela Brook at Hooksett Turnpike. All other pipes are assumed to be 24" or under. Therefore, in Table 6.10-1, the existing capacity is based on a 24" diameter.

Table 6.10-1 calculates both the existing capacity required for the 10-year storm, and the future "build-out" capacity that would be required if the entire basin was developed. Both the current required capacity and the future theoretical required capacity are compared to the current existing capacity, assuming 24" pipe where the diameter is not available.

Culverts that are more than 50% undercapacity compared to current required capacity are summarized below in Table 6.10-2. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity culverts.

Cleaning & Lining

Based upon the City's listing of known problems, there are no pipes in the Turkey Pond area that need cleaning or lining at this time.

Replace Pipes

The culverts in the Turkey Pond area which are most severely under capacity are summarized in Table 6.10-2. The larger diameter pipes should receive higher priority. For example, a 36" pipe which is 50% undersized is a higher priority problem than an 8" pipe 50% undersized.

Other Work

All outfalls in the Turkey Pond basin should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary, and the diameters can be compared with the recommended sizes from Table 6.10-1.

Table 6.10-2: Culverts Potentially under Capacity for Current Conditions[2]

Basin	***Location***
TP	Stickney Hill Road at unnamed brook (node F)
TP	Milestone Drive at unnamed brook (node G)
TP	Turee Brook at junction with unnamed brook (node L)
TP	Hopkington Road at unnamed brook, near Loop Road & Armour Place (node M)
TP	Miller's Brook at Pleasant Street (node N)

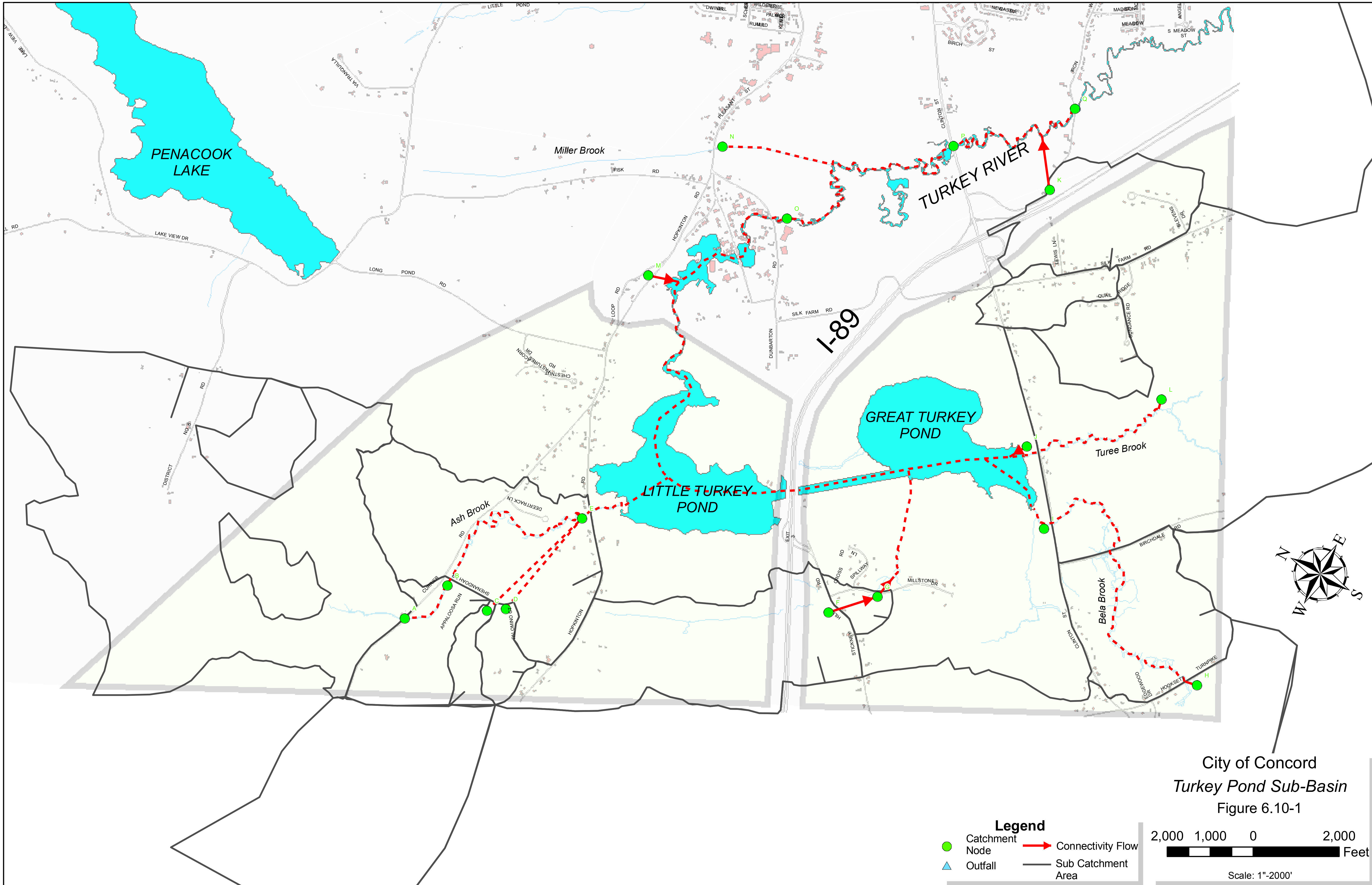
[2] Note: In most cases the culverts are assumed to be 24" in the absence of detailed information on culvert diameters. If any culvert is in actuality larger than 24", the actual current capacity will need to be compared with required capacity to determine if the culvert should be presented in Table 6.10-1.

Sub Basin	Node	Upstream Nodes	Dist (mi)	Elev (ft)	S (ft/mi)	A per Node (mi^2)	A Sum (mi^2)	Slope (ft/ft)	Q10 USGS Rural (cfs)	Pipe Dia. Rural (ft)	Pipe Dia. Rural (in.)	% under capacity (see 16)	Q10 USGS Buildout (cfs) (1)	Pipe Dia. Buildout (in.)	% under capacity (see 16)	Equiv D In Place (in.) (2)	Location
TP1	**A**	-	2.54	398	156.7	1.630	1.630	**0.005**	126.92	4.35	52	-2058%	177.69	59	-1441%	**16.5x6 Arch**	Ash Brook at Currier Road
TP2	**B**	A	2.85	436	153.2	0.207	1.837	**0.005**	142.63	4.54	55	-326%	199.68	62	-205%	**8x6 Box**	Ash Brook at Shenandoah Dr., north of Palomino Ct.
TP3	**C**	-	0.59	238	406.7	0.055	0.055	**0.005**	5.44	1.33	16	-195%	7.61	18	-110%		Unnamed Brk; Shenandoah Dr near Palomino Ct.
TP4	**D**	-	0.55	229	414.4	0.069	0.069	**0.005**	6.90	1.46	18	-132%	9.66	20	-66%		Unnamed Brk; Shenandoah Dr near Palomino Ct.
TP5	**E**	B, C, D	3.82	471	123.3	0.577	2.538	**0.005**	181.79	4.98	60	-2386%	254.51	68	-1675%	**Three 72**	Ash Brook at Hopkinton Road
TP6	**F**	-	1.55	210	135.2	0.618	0.618	**0.005**	42.43	2.88	35	62%	59.41	39	73%		Stickney Hill Drive, unnamed brook
TP7	**G**	F	1.75	255	145.8	0.044	0.662	**0.005**	47.23	3.00	36	66%	66.12	41	76%		Millstone Drive, unnamed brook
TP8	**H**	-	5.85	231	39.5	11.339	11.339	**0.005**	526.27	7.41	89	-53%	736.78	101	-9%	104	Bela Brook at Hooksett Turnpike (16' x 3.7')
TP9	**I**	H	7.08	240	33.9	0.380	11.720	**0.005**	507.90	7.32	88	-286%	711.06	100	-176%	**16.5x7 Box**	Bela Brook at Clinton Street
TP10	**J**	L	5.11	560	109.7	0.140	7.654	**0.005**	555.14	7.56	91	-373%	777.20	103	-238%	**16x9 Box**	Turee Brook at Clinton Street
TP11	**K**	-	1.00	90	89.9	0.329	0.329	**0.005**	18.03	2.09	25	11%	25.25	28	37%		Unnamed Brook at Ironworks Road near I89
TP12	**L**	-	4.51	557	123.5	7.514	7.514	**0.005**	574.85	7.66	92	97%	804.79	104	98%		Turee Brook at junction with unnamed brook
TP13	**M**	-	1.59	420	264.4	0.791	0.791	**0.005**	75.00	3.57	43	79%	105.00	49	85%		Unnamed Brk at Hopkinton Rd, near Loop Rd & Armour Pl
TP14	**N**	-	1.66	330	198.3	0.622	0.622	**0.005**	50.94	3.09	37	69%	71.32	42	78%		Millers Brook at Pleasant Street
Null	**O**	E,I,G,J,M	10.70	280	26.2	0.000	23.365	**0.005**	937.02	9.20	110	-1376%	1311.83	125	-955%	**25 foot Bridge**	Turkey River at Dunbarton Road
TP15	**P**	N, O	11.95	291	24.3	1.336	25.322	**0.005**	987.35	9.39	113	-259%	1382.29	128	-156%	**20x9 Box**	Turkey River at Clinton Street
TP16	**Q**	P	12.56	295	23.5	0.370	49.057	**0.005**	1957.27	12.13	146	-81%	2740.17	165	-29%	**20x9 Box**	Turkey River at Clinton Street

(1) - Buildout assumes 10% impervious, i.e. 10% of land at 100% runoff, and 90% at 20% runoff. Current condition is 100% of land at 0.20.
Buildout is thus = 0.1(1.0) + 0.9(0.2) = 0.28; and so is more than current condition by 0.28/0.2
(2) - Culvert diameters not given are assumed to be equal tc 24 inches

Slope & Area Figures for Columns 4 and 5

	Distance through catchment			Elevation	
	One area	Contrib.	Total	upstream	downstr
A	13411	-	13411	790	392
B	1613	A	15024	A	354
C	3090	-	3090	614	376
D	2918	-	2918	615	386
E	5151	B, C, D	20175	A	319
F	8201	-	8201	590	380
G	1034	F	9235	F	335
H	30887	-	30887	560	329
I	6519	H	37406	H	320
J	3140	L	26956	L	320
K	5284	-	5284	406	316
L	23816	-	23816	880	323
M	8388	-	8388	720	300
N	8786	-	8786	650	320
O	19112	E,I,G,J,M	56518	H	280
P	6586	N,O	63104	H	269
Q	3232	P	66336	H	265

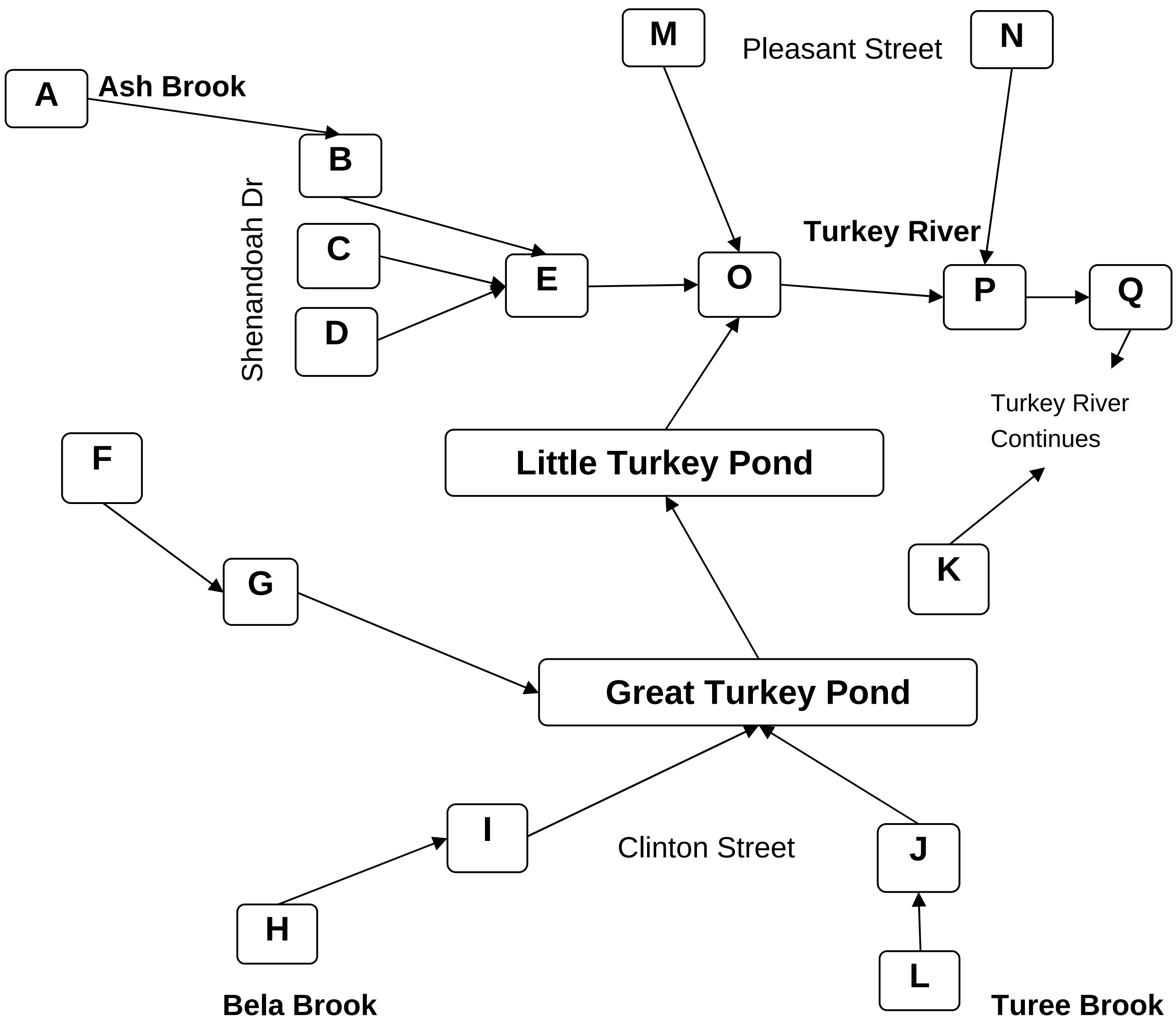


City of Concord

Turkey Pond Sub-Basin

Figure 6.10-1

Figure 6.10-2: Turkey Pond Drainage Basin - (TP) - Connectivity Diagram



Section 6.11
West Concord Drainage Basin Evaluation

For the West Concord Drainage Basin, as is for the Turkey Pond and Hoit Basins, the analysis and modeling will focus on culvert sizing rather than pipe size. The focus will be slightly different because these three rural basins have minimal stormwater collection infrastructure and the pipe-size analysis done for the other basins in Concord is not as relevant here.

These three basins located on the outskirts of the City are expected to have increased development in the coming years, resulting in increasing runoff and stormwater entering streams at a faster rate. The analysis will determine the required culvert diameter under current conditions and under future buildout conditions.

6.11.1 Drainage Basin Description

Location

As shown in Figure 6.11-1, the West Concord Drainage Basin is located west of the center of the City of Concord and the Merrimack River. The drainage basin is bounded to the east by the Fisherville, Horseshoe Pond, and Hospital Drainage Basins. The basin is bounded to north by the Penacook basin, the Town of Boscawen and the Town of Webster, to the west by the Town of Hopkinton, and to the south by the Turkey Pond and Turkey River Drainage Basins.

Penacook Lake, the main drinking water supply for the City of Concord, is located within the West Concord Drainage Basin, as is the village of Riverhill.

Surface Water Drainage

Besides Penacook Lake, the other surface waters within the West Concord Basin are Contoocook River, Millers Brook and Ash Brook.

The Contoocook River enters the basin from Hopkinton, near the western most corner of the City. The river travels southwest, joining Dolf Brook and turning towards the northeast at Broad Cove. The Contoocook continues to wind through the basin, passing by Horse Cemetery and the YMCA Camp, and passing under Horse Hill Road near the Village of Riverhill. It travels around the base of Horse Hill, and then leaves the West Concord Drainage Basin to enter the Penacook Drainage Basin, and ultimately joining the Merrimack River.

Ash Brook begins just north of the unimproved portion of District Five Road. The brook passes under District Five Road, and travels south to enter the Turkey Pond Drainage Basin.

Dolf Brook enters Concord from Hopkinton, but flows only approximately 2000 feet through the basin before joining the Contoocook River. It does not pass under any roads within the City of Concord.

There are numerous other unnamed brooks and streams that are tributary to the Contoocook River, Penacook Lake and Ash Brook. Some of these cross under roads in culverts that will be investigated further in this section.

Drainage Sub-Basins

The West Concord Drainage Basin is effectively divided into four sub basins.

- Penacook (P) - the sub-basin contributing to Penacook Lake, in the central and eastern portion of the West Concord.
- Contoocook (C) – the sub-basin contributing to the Contoocook River, the north section of West Concord
- Ash (A) – the sub-basin contributing to Ash Brook, the southwest portion of West Concord.
- Millers Brook (B) – contributing to Millers Brook, along Fiskill Road in the southeast portion of the basin.

As discussed above, the analysis will focus on capacity of culverts and stream crossings. The stormwater quality draining to the Penacook Lake may also be of concern, but is out of the scope of this study.

Major Drainage Pipes

With the receiving waters, the Contoocook River, Penacook Lake, Ash Brook and Miller's Brook and their tributaries, running so close to the majority of the drainage basin, no large drainage pipes are necessary. Culvert size is of more concern for this basin.

Known Problems and Issues

Table 6.11-1 summarizes the known problems and issues in the West Concord Drainage Basin as presented from the City of Concord to CDM.

Table 6.11-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
Millers Brook	Millers Brook near intersection of Fisk Road and Pleasant Street	Private	Concern for potential of brook flooding public road.
Contoocook River & Penacook Lake	Road side ditches along Carter Hill Road	N/A	Steep road with high velocity runoff, large riprap pushed to bottom of hill.
Millers	Intersection of Fisk Road	12"	Isolated flooding at small

Brook	and Little Pond Road		diameter culverts

As the model is designed to find simple capacity problems, i.e. too much flow for the installed pipe, the types of problems listed in Table 6.11-1 may not be identified through modeling, but will be included along with the model-identified problems in the summary table at section end.

6.11.2 Model Development

Connectivity

In the other basins, where stormwater collection networks are well developed, connectivity between the modeled nodes is quite important to the accuracy of the model. However, this basin has little to no collection network, and therefore, no connectivity diagram is necessary.

Detention/Storage

Although small to medium sized ponds are certainly beneficial, only the larger ponds have a noticeable effect on the stormwater system. The major detention basins in the drainage basin are listed in Table 6.11-2.

Table 6.11-2 – Detention Ponds

Subbasin	*Location*	*Max Discharge Rate*
Millers Brook	Off Thackeray Road	4.22 cfs
Millers Brook	Off Emerson Road	0.40 cfs

Method

Table 6.11-3 summarizes the model results. The first and second columns give the sub-basin and node (as listed above in Section 6.11.1 – Drainage Sub-Basins). The third column gives the time of concentration calculated for the node, i.e., the time in hours it would take for stormwater to travel from the farthest contributing point, to the node. With a minimum of 0.25 hours used, the fourth column gives the time of concentration used for each node.

Column 5 lists the peak intensity, in inches per hour, for the 10-year return period storm. The 10-year storm intensity is the peak rainfall intensity expected to occur on average once every 10-years. As discussed in Section 2, larger areas with longer times of concentration will have lower 10-year intensities as higher intensities will not be sustained throughout the time of concentration.

The runoff coefficient times the cumulative area (C*A) for each node's contributing area is given in the sixth column. This is, as presented in Section 2, the equivalent area contributing runoff to the stormwater collection network. The intensity (column 5) multiplied by the C*Area (column 6), results in the flow to node (Q, columns 7 and 8). Generally, a constant slope of 0.005 ft/ft was estimated for pipes and stream lengths. [1]

Estimated Flows and Required Pipe Sizes
The approximate pipe diameter required to carry the estimated flow to this node is given in column 10 and 11. The pipe that is installed in this location is given in column 12 [Note that we do not have this information for the West Concord Drainage Basin]. Pipes that appear to be severely undersized are highlighted in the table.

The flow that each pipe was designed to carry, based upon the installed pipe size, and the flow that might theoretically reach that pipe during the 10-year return period storm, are compared in the far right columns of Table 6.11-3.

6.11.3 Recommendations

The City inspected all the larger culverts in the West Concord area. Through these inspections and information from plans, only one culvert larger than 24″ was identified, a 36″ diameter culvert under Lake View Drive, approximately 780′ south of Carter Hill Road. All other pipes are assumed to be 24″ or under.

Table 6.11-3 calculates both the existing capacity required for the 10-year storm, and the future "build-out" capacity that would be required. Both the current required capacity and the future theoretical required capacity are compared to the current existing capacity, assuming 24″ pipe where the diameter is not available.

There are no culverts which exceed 50% under capacity for the 10-year storm when compared to existing culvert capacity. There are, however, eight culverts which exceed 50% under capacity for the future build out. See Table 6.11-3 for a list of the under capacity nodes.

Cleaning & Lining
Based upon the City's list of known problems, there is a culvert under District Five Road and several under Fisk Road that need investigation and may need repair.

Replace Pipes
Where flooding is caused by low culvert capacity, replacement may be appropriate.

[1] Note that this is the approximation with the largest potential for error. For the broad brush scope of this analysis, a constant slope is used to simply highlight serious pipe capacity issues. For a more detailed investigation of the pipe capacity, the slope of each pipe could be entered in the spreadsheet. A slope of 0.005 ft/ft was selected as a representative, conservative slope for Concord, as a typical minimum slope is 0.003 ft/ft.

Other Work

All outfalls in the West Concord basin should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the outfalls can be prioritized for cleaning, streambank stabilization or apron installation if necessary.

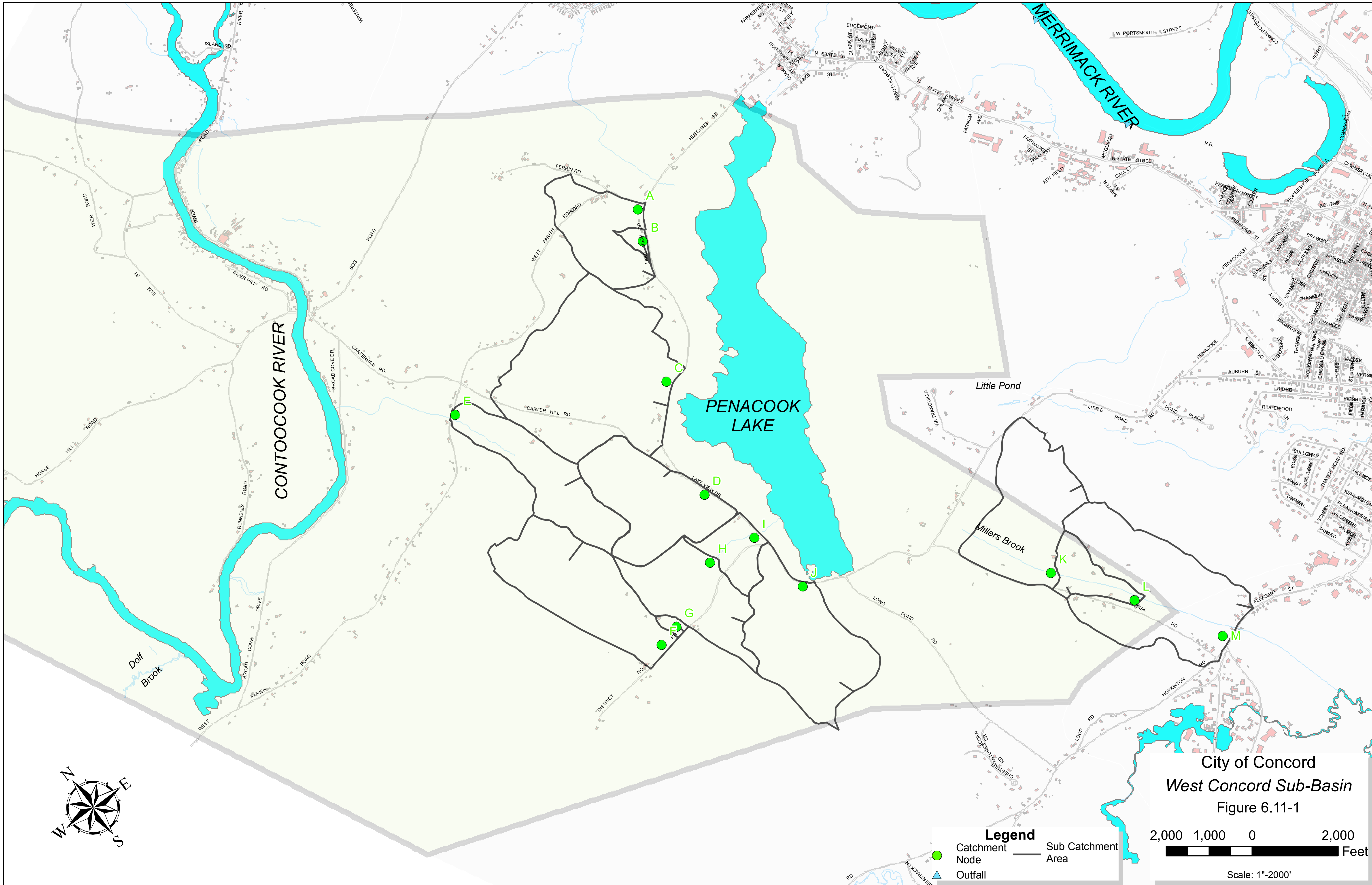
Table 6.11-4: Known and/or Suspected Problems in the West Concord Basin

Sub-Basin	*Location*	*Nature of Problem*	*Recommended Solution*
Millers Brook	Intersection of Little Pond Rd and Fisk Rd	Limited pipe capacity creates flooding problem.	Inspect culverts. Compare to recommended diameter. Consider replacement.
Penacook Lake, Contoocook River	Road side ditches along Carter Hill Road	Steep with high velocity runoff, large riprap pushed to bottom of hill.	City completed a design for this known problem. Construction to begin in 2007.
Millers Brook	Private Drive off Fisk Road at Millers Brk	Brook periodically floods private drive.	Recommend correct pipe size to owner.

Sub Basin	Node	Minimum Tc of Node (hrs)	Tc used for Node (hrs)	Intensity (10 yr) (in/hr)	C*Area for Node (acres)	Q Flow to Node (cfs)	Q Flow to Node (mgd)	Slope of Pipe From Node (ft/ft)	Pipe Dia. Required (ft)	Pipe Dia. Required (in.)	Pipe Dia. In Place (in.)	Current Max Flow (cfs)	% under capacity (2)	Location
Current Condition, Rural Area (1)														
P	**A**	**0.25**	**1.15**	1.36	8.86	12.00	7.76	**0.005**	1.80	22		0.00	-33%	Lake View Dr at West Parish Road
P	**B**	**0.25**	**0.25**	3.77	0.97	3.64	2.36	**0.005**	1.15	14		0.00	-340%	Lake View Dr, 750' south of W.Parish Road
P	**C**	**0.25**	**1.62**	0.81	27.74	22.52	14.56	**0.005**	2.27	27		0.00	29%	Lake View Dr, 2000' north of Carter Hill Rd at Penacook Lake cove
P	**D**	**0.25**	**0.86**	1.82	10.52	19.09	12.34	**0.005**	2.14	26	**36**	47.25	-147%	Lake View Dr. 780' south of Carter Hill Rd
C	**E**	**0.25**	**1.63**	0.81	9.55	7.72	4.99	**0.005**	1.52	18		0.00	-107%	West Parish Rd; 840' west of Carter Hill Rd.
A	**F**	**0.25**	**2.20**	0.33	15.62	5.14	3.32	**0.005**	1.31	16		0.00	-212%	District Five Rd; 615' east of Pine Ridge
A	**G**	**0.25**	**0.25**	3.77	0.48	1.83	1.18	**0.005**	0.89	11		0.00	-778%	District Five Rd; 940' east of Pine Ridge
P	**H**	**0.25**	**1.19**	1.31	9.32	12.21	7.89	**0.005**	1.81	22		0.00	-31%	Stream from culvert "I" at Lake View Rd; North of District Five Rd
P	**I**	**0.25**	**1.19**	1.31	12.79	16.74	10.82	**0.005**	2.03	24		0.00	4%	Lake View Dr; 400' north of District Five Rd
P	**J**	**0.25**	**0.71**	2.11	12.81	27.08	17.50	**0.005**	2.44	29		0.00	41%	Lake View Dr; 840' northwest of Long Pond Rd.
Future Condition, Buildout (1)														
P	**A'**	**0.25**	**0.68**	2.18	24.80	54.08	34.95	**0.005**	3.16	38		0.00	70%	Lake View Dr at West Parish Road
P	**B'**	**0.25**	**0.25**	3.77	1.80	6.80	4.40	**0.005**	1.45	17		0.00	-136%	Lake View Dr, 750' south of W.Parish Road
P	**C'**	**0.25**	**0.97**	1.62	77.68	125.87	81.35	**0.005**	4.34	52		0.00	87%	Lake View Dr, 2000' north of Carter Hill Rd at Penacook Lake cove
P	**D'**	**0.25**	**0.52**	2.62	36.81	96.58	62.42	**0.005**	3.93	47	**36**	47.25	51%	Lake View Dr. 780' south of Carter Hill Rd
C	**E'**	**0.25**	**0.98**	1.62	29.70	48.04	31.05	**0.005**	3.02	36		0.00	67%	West Parish Rd; 840' west of Carter Hill Rd.
A	**F'**	**0.25**	**1.28**	1.18	43.73	51.69	33.41	**0.005**	3.11	37		0.00	69%	District Five Rd; 615' east of Pine Ridge
A	**G'**	**0.25**	**0.25**	3.77	1.36	5.11	3.30	**0.005**	1.30	16		0.00	-213%	District Five Rd; 940' east of Pine Ridge
P	**H'**	**0.25**	**0.72**	2.10	29.01	60.81	39.30	**0.005**	3.30	40		0.00	74%	Stream from culvert "I" at Lake View Rd; North of District Five Rd
P	**I'**	**0.25**	**1.19**	1.31	20.10	26.32	17.01	**0.005**	2.41	29		0.00	39%	Lake View Dr; 400' north of District Five Rd
P	**J'**	**0.25**	**0.42**	2.95	44.84	132.10	85.38	**0.005**	4.42	53		0.00	88%	Lake View Dr; 840' northwest of Long Pond Rd.
Current Condition, Rural Area														
M	**K**	**0.25**	**1.98**	0.50	14.70	7.33	4.74	**0.005**	1.49	18		0.00	-119%	Millers Brook at Private Drive
M	**L**	**0.25**	**1.98**	0.50	18.45	9.20	5.95	**0.005**	1.63	20		0.00	-74%	Millers Brook at Fisk Hill Drive
M	**M**	**0.25**	**1.98**	0.50	38.50	19.20	12.41	**0.005**	2.14	26		0.00	17%	Millers Brook at Pleasant Street
Future Condition, Buildout														
M	**K'**	**0.25**	**1.17**	1.33	36.75	48.89	31.60	**0.005**	3.04	36		0.00	67%	Millers Brook at Private Drive
M	**L'**	**0.25**	**1.98**	0.50	24.08	12.01	7.76	**0.005**	1.80	22		0.00	-33%	Millers Brook at Fisk Hill Drive
M	**M'**	**0.25**	**1.98**	0.50	68.56	34.19	22.10	**0.005**	2.66	32		0.00	53%	Millers Brook at Pleasant Street

(1) - Buildout assumes 10% impervious, i.e. 10% of land at 100% runoff, and 90% at 20% runoff. Current condition is 100% of land at 20% runoff.
Buildout is thus = 0.1(1.0) + 0.9(0.2) = 0.28; and so is more than current condition by a factor of 0.28/0.20.

(2) - Culvert diameters not given are assumed to be 24 inches.
Diameters of culverts greater than 24 inch were provided by field crews.


City of Concord
West Concord Sub-Basin
Figure 6.11-1
2,000 1,000 0 2,000
Feet
Scale: 1"-2000'
Legend
Catchment Node
Sub Catchment Area
Outfall
PENACOOK LAKE
CONTOOCOOK RIVER
MERRIMACK RIVER
Little Pond
Millers Brook
Dolf Brook
A
B
C
D
E
F
G
H
I
J
K
L
M
N
E
S
W

Section 6.12
Hoit Drainage Basin Evaluation

For the Hoit Drainage Basin, as for the Turkey Pond and West Concord Basins, the analysis and modeling will focus on culvert size rather than pipe size. The focus will be slightly different because these three rural basins have minimal stormwater collection infrastructure and the pipe-size analysis done for the other basins in Concord is not as relevant here.

These three basins located on the outskirts of the City are expected to have increased development in the coming years, resulting in increasing runoff and stormwater entering streams at a faster rate. The analysis will determine the required culvert diameter under current conditions and under future buildout conditions.

6.12.1 Drainage Basin Description

Location

As shown in Figure 6.12-1, the Hoit drainage basin is located in the northeast corner of the City of Concord. The drainage basin is bounded to the north by the town of Canterbury, to the east by the Town of Loudon and to the west by the Merrimack River. The basin is bounded to the south by Oak Hill and the Oak Hill drainage basin.

Surface Water Drainage

Oak Hill, at approximately 920' in elevation, lies on the border between the City of Concord and the Town of Loudon. The hill forms part of the drainage divide between Oak Hill drainage basin and Hoit drainage basin. The north side of Oak Hill drains into Hackett Brook and into the Hoit drainage basin. While the east side of Oak Hill, along with Merullo Park and portions of Sanborn Road drain towards the Oak Hill drainage basin.

A complex series of interconnected brooks drain Hoit Drainage Basin. Hayward Brook is the main brook and originates in a series of ponds in the Town of Canterbury. The brook flows southerly into Concord just under a mile from the northernmost corner of the City. Hayward Brook continues south and west, passing under Hoit Road, Mountain Road, and the northbound lanes of Route I-93. It then flows south approximately 0.25 miles in the median of the highway before crossing the southbound lanes of Route I-93 and continuing southwest to join the Merrimack River north of Sewell's Falls Road.

Hackett Brook discharges from the western end of Hothole Pond on the border of Concord and the Town of Loudon. The brook flows under Hothole Pond Road, Shaker Road and Hoit Road, before joining Hayward Brook.

Snow Pond lies in the north center of Oak Hill drainage basin between Snow Pond Road and Shaker Road. This pond drains into Snow Pond Outlet Brook which flows north and west into the Hoit Drainage Basin and towards the Merrimack River. Snow

Pond Outlet Brook joins Hayward Brook in the median of Route I-93. Hayward Brook then flows under the southbound lanes of Route I-93 and onto the Merrimack River.

Numerous other unnamed brooks enter Hayward Brook throughout basin.

Burnham Brook, located to the east, is not connected to the Hayward Brook system. The brook begins in the Town of Canterbury in a series of small ponds, and flows south into the City of Concord. The brook crosses under Hoit Road and Route I-93 before joining the Merrimack River.

Drainage Sub-Basins
As the brooks in the Hoit basin are largely interconnected, there is no benefit to delineating sub-basins within the Hoit basin. The entire basin will be investigated together.

Major Drainage Pipes
With the receiving waters, the Hayward Brook, Hackett Brook and Burnham Brook and their tributaries, running so close to the majority of the drainage basin, no large drainage pipes are necessary. Culvert size is of more concern for this basin.

Known Problems and Issues
Table 6.12-1 summarizes the known problems and issues as presented from the City of Concord to CDM.

Table 6.12-1: Known Problems and Issues

Sub-Basin	*Street Location*	*Pipe*	*Description*
Hoit	Freedom Acres, between Hoit Road and Mountain Rd	12”	Poor design. Does not permit access for cleaning & maintenance.

As the model is designed to find simple capacity problems, i.e. too much flow for the culvert, the types of problems listed in Table 6.12-1 may not be identified through modeling.

6.12.2 Model Development

Connectivity
Figure 6.12-2 shows the node connectivity for the spreadsheet models developed for the Hoit drainage basin.

Detention/Storage
Several detention ponds have been constructed in the basin to moderate high storm flows. Although small to medium sized ponds are certainly beneficial, only the larger

ponds have a noticeable effect on the stormwater system. These are summarized in Table 6.12-2.

Table 6.12-2 – Detention Ponds

Subbasin	*Location*	*Max Discharge Rate*
Hoit	Freedom Acres, between Hoit Rd and Mountain Rd	
Hoit	Mountain Road Development	
Hoit	Acres of Wildlife Development	

Method

Table 6.12-3 summarizes the model results. As discussed in Section 6.2, the Rational Method is appropriate for basins of $1mi^2$ and smaller. The Hoit Drainage Basin contains several brooks with watersheds much larger than $1mi^2$. A slightly different method was used for this basin. The method, published by the United States Geological Survey[1], uses regression formulas for various regions around the country. The formula for the ten year peak discharge, developed for New Hampshire, is:

$$Q10 = 0.84*A^{1.05}*S^{0.46}*(I2.24)^{1.98}$$

Where Q10 is the peak discharge expected every 10-years (cubic feet per second), A is drainage area (square miles), S is the channel slope (feet per mile), and I2.24 is the 2-year 24-hour storm depth (inches) as read from charts provided in the USGS document. This method offers one equation for all of New Hampshire, and is not Concord-specific, but is a better choice for larger watersheds.

Columns 1 and 2 of Table 6.12-3 present the subcatchment and node in the Hoit basin (Figure 6.12-1, 6.12-2).

Connectivity and Areas

Column 3 of Table 6.12-3 presents the node connectivity for the Hoit Drainage Basin. Figure 6.12-2 shows a simplified diagram of the connectivity. Please note that in the Hoit basin the nodes represent culverts, connected by brooks. In other basins, the culverts represent manholes connected by pipes.

Column 4 shows the distance through the subcatchment to each node in miles. Column 5 lists the elevation difference from the upstream end of the subcatchment to the downstream end in feet. Column 6 then calculates the slope (elevation/distance,

[1] U.S. Geological Survey Water-Resources Investigations Report 94-4002: *Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1999.* http://water.usgs.gov/software/nff_manual/nh/index.html

Col5/Col4) for the subcatchment, in feet/mile. This slope represents the path runoff must take to get to the brook. The slope in column 9 represents the path water takes once it is in the brook.

Column 7 is the area for each subcatchment in square miles. Column 8 is the cumulative area contributing to each node, the sum of the areas of the subcatchments upstream of each node.

Column 9 is the slope assumed for the brook in feet/foot.

Estimated Flows and Required Pipe Sizes
Columns 10, 11 and 12 give the results for the current condition, while columns 13, 14 and 15 give the results for the buildout/future condition. Columns 10 and 13 are the peak discharge expected every 10-years (cubic feet per second), as calculated by the formula above from the USGS method.

Columns 11 and 14 give the approximate pipe diameter required to carry the estimated flow to this node. The actual culvert diameter that is installed in this location, where known, is given in column 16. As only the larger culverts were inspected, where the culvert size is unknown, a diameter of 24″ is assumed. Pipes that appear to be severely undersized for the current condition are highlighted in the table.

6.12.3 Recommendations

The City inspected all the larger culverts in the Hoit area. Three culverts larger than 24″ diameter were identified:

- A 6′ by 6′ culvert under Hoit Road for the West/Main Branch of Hayward Brook;
- A 96″ diameter culvert under Hoit Road for Burnham Brook at Hoit Road; and
- A 6′ by 3′8″ culvert under Hoit Road for the Hoit Road Marsh outlet.

All other pipes are assumed to be 24″ or under. Therefore, in Table 6.12-3, the existing capacity for all other culverts is based on a 24″ diameter.

Table 6.12-3 calculates both the existing capacity required for the 10-year storm, and the future "build-out" capacity that would be required if the basin was completely developed. Both the current required capacity and the future theoretical required capacity are compared to the current existing capacity, assuming 24″ pipe where the diameter is not available.

Culverts that are more than 50% undercapacity compared to current required capacity are summarized below in Table 6.12-4. The larger diameter pipes on this list are the highest priority for replacement. The City may also wish to pursue additional detention/storage basins, additional discharges of clean stormwater to local streams, or other reduction in inflow to the overcapacity culverts.

Cleaning & Lining

Based upon the City's listing of known problems, no pipe cleaning or lining is required at this time in the Hoit area.

Replace Pipes

The pipes in the Hoit area which are most severely under capacity are summarized in Table 6.12-4. The larger diameter pipes should receive higher priority. For example, a 36" pipe which is 50% undersized is a higher priority problem than an 8" pipe 50% undersized. The minimum culvert diameter calculated in Table 6.12-4 is 13 inches, as this is not a standard pipe size, a pipe size of 15 to 18 inches is recommended as the minimum diameter to be installed in this area.

Other Work

All culverts in the Hoit area should be inspected. Potential problems at the outfalls include clogging, blockage and erosion. Once inspected, the culverts can be prioritized for cleaning, streambank stabilization or apron installation if necessary.

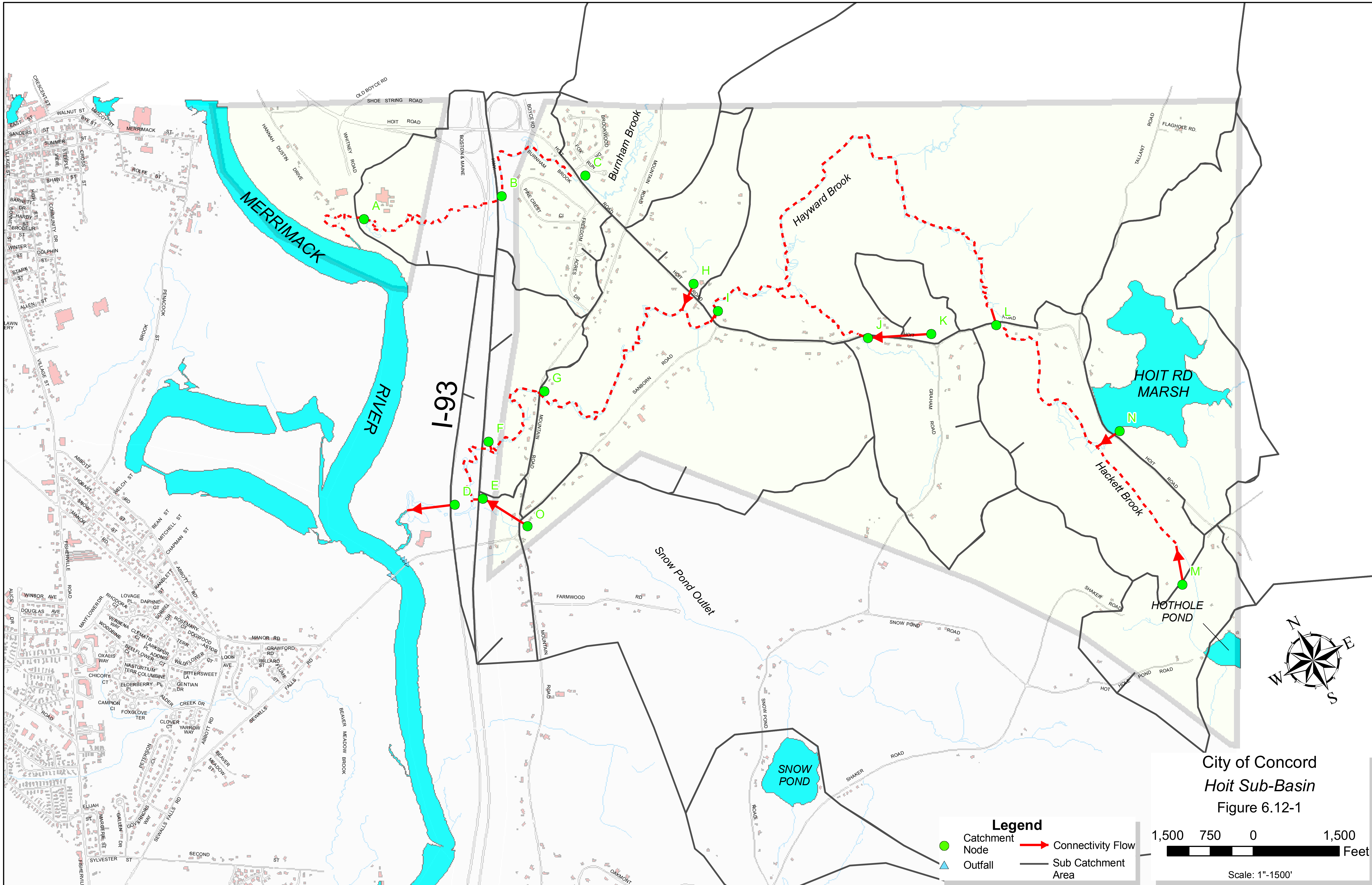
Table 6.12-4: Known and/or Suspected Problems in Hoit

Sub Basin	***Location***	***Nature of Problem***	***Recommended Solution***
Hoit	Freedom Acres, between Hoit Road and Mountain Rd	Poor design. Does not permit access for cleaning & maintenance.	Recommend regular maintenance of detention pond.

Sub Basin	Node	Upstrm Nodes	Dist (mi)	Elev (ft)	Slope (ft/mi)	Area per Node (mi^2)	Area Sum (mi^2)	Pipe Slope (ft/ft)	Q10 USGS Rural (cfs)	Pipe Dia. Rural (in.)	% under capacity (see 16)	Q10 USGS Buildout (cfs) (1)	Pipe Dia. Buildout (in.)	% under capacity (see 16)	Equiv D in place (in.) (2)	Location
H1	**A**	B	6.70	570	85.05	0.19	4.29	**0.005**	267.29	69	-104%	374.21	78	-45%	90	Burnham Brk at Hannah Dustin
H2	**B**	C	6.12	536	87.54	0.19	4.10	**0.005**	257.99	68	-700%	361.18	77	-471%	15'x8' Bridge	Burnham Brk at I93 Northbound (NHDOT Bridge)
H3	**C**	-	5.63	492	87.38	3.90	3.90	**0.005**	244.87	67	-164%	342.82	76	-88%	96	Burnham Brook at Hoit Road
H4	**D**	F, E	7.92	266	33.58	0.08	11.56	**0.005**	498.56	87	-314%	697.98	99	-196%	15'x8' Bridge	Hayward Brk at I93 Southbound (NHDOT Bridge)
H5	**E**	O	2.64	212	80.31	0.10	2.07	**0.005**	120.12	51	-1617%	168.17	58	-1127%	15'x8' Bridge	Snow Pond Outlet at I93 Northbound (NHDOT Bridge)
H6	**F**	G	7.51	260	34.64	0.15	9.41	**0.005**	406.59	81	-407%	569.23	92	-262%	15'x8' Bridge	Hayward Brk at I93 Northbound (NHDOT)
H7	**G**	H, I	7.06	253	35.83	0.62	9.26	**0.005**	405.94	81	-548%	568.31	92	-363%	18'x8' Box	Hayward Brook at Mountain Rd
H8	**H**	-	0.17	126	720.78	0.12	0.12	**0.005**	16.15	24	1%	22.62	27	29%		East Branch of Hayward Brk at Hoit Road
H9	**I**	J, L	6.02	224	37.19	3.83	8.52	**0.005**	378.07	79	-10%	529.30	89	22%	81	West/Main Branch of Hayward Brk at Hoit Rd (6'x6')
H10	**J**	K	0.56	46	82.30	0.26	0.32	**0.005**	16.59	24	3%	23.22	28	31%		Unnamed Brk at Hoit Rd, east of Sanborn Rd
H11	**K**	-	0.04	5	132.00	0.06	0.06	**0.005**	3.41	13	-370%	4.77	15	-236%		Unnamed Brk at Hoit Rd, west of Graham Rd
H12	**L**	N, M	4.18	162	38.75	0.34	4.37	**0.005**	189.90	61	-118%	265.87	69	-56%	6' x 6' Box	Hackett Brk, Hoit Rd between Graham & Tallant
H13	**M**	-	0.12	1	8.37	0.19	0.19	**0.005**	3.36	13	-376%	4.71	15	-240%		Hackett Brook at Shaker Road
H14	**N**	-	3.53	10	2.83	3.84	3.84	**0.005**	49.74	37	-332%	69.64	42	-209%	64	Hoit Road Marsh outlet at Hoit Rd (6'x3'8")
H15	**O**	-	2.44	234	95.75	1.97	1.97	**0.005**	123.72	52	-405%	173.20	59	-261%	7' x 7' Box	Snow Pond Outlet at Mountain Rd

(1) - Buildout assumes 10% impervious, i.e. 10% of land at 100% runoff, and 90% at 20% runoff.
Buildout is thus = 0.1(1.0) + 0.9(0.2) = 0.28.
Current condition is 100% of land at 0.20
Therefore, buildout is more than current condition by 0.28/0.2

(2) - Culvert diameters not given are assumed to be 24 inches
For current capacity problems, compare the existing pipe diameter (col 13) with the rural pipe diam required (col 12).
Note that there are no known problems.

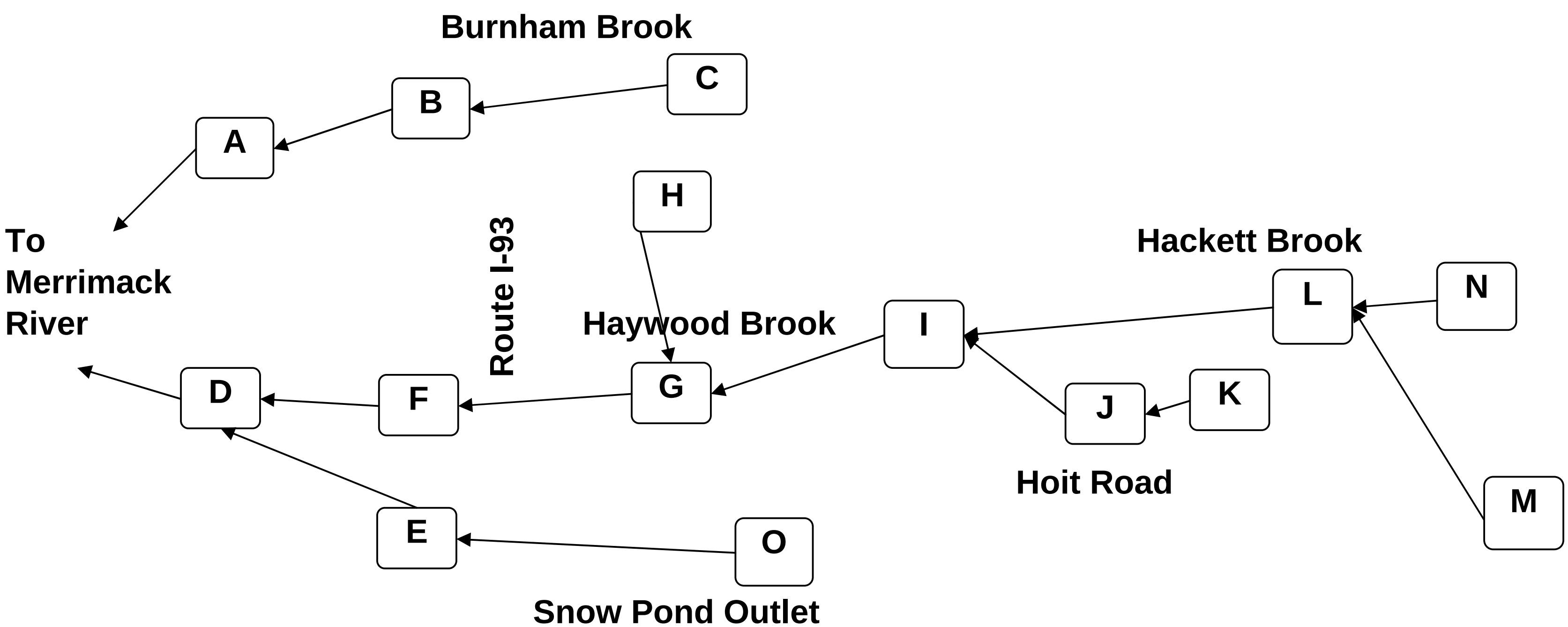


City of Concord

Hoit Sub-Basin

Figure 6.12-1

Figure 6.12-2: Hoit Drainage Basin - Connectivity Diagram



Section 7
Outfall Screening

7.1 Introduction

Illicit connections are defined as service connections meant for the sanitary sewer but are inadvertently connected to the storm system. These illicit connections can be a major source of pollution in receiving streams. Locating illicit connections can be difficult and costly, but redirecting the connection to a sanitary sewer takes care of a major pollution source. An illicit connection detection and elimination program is essential to any effective storm water management program and generally includes the following steps:

- Mapping outfalls and streams to receiving waters;
- Field visits to the outfalls and streams to conduct a "dry-weather field screening program"; and
- Follow-up work within the drainage system based on the results of the dry-weather field-screening program.

To simplify this procedure, on August 30 and September 7, 2001, CDM completed dry weather screening of the outfalls and streams to the Merrimack River in Concord, south of the Route 93 Bridge. On September 21, 2005 CDM completed dry weather screening of the Merrimack River outfalls, north of the Route 93 Bridge. Both screenings were done during dry weather and during the period of the year when groundwater is typically lowest

Outfall on the Merrimack River

The procedures used to locate and document the outfalls, as well as the results of those procedures, were discussed in a draft memorandum *Dry Weather Screening Program*, dated October 2, 2001. The memorandum identified drainage systems that required follow up work to pinpoint sources of contamination. The information provided in the memorandum is summarized here and updated to include the 2005 screening results.

7.2 Background

Ideally, storm drainage systems convey storm water runoff, and only storm water runoff, to receiving streams. Thus, the purpose of the dry weather field-screening program is to observe outfalls during dry periods when there should be little to no storm water runoff. Flow during these periods is suspect and could represent cross connections and a source of pollution to the receiving waters. Flow during dry weather is not necessarily contaminated however. For example, storm drains can convey uncontaminated groundwater and small natural streams through urbanized areas. Therefore, for outfalls with flow, observations are made to help determine if the flow is contaminated. If contamination is suspected, the drainage system tributary to the outfall will be identified for further investigations.

Outfall screening is not a one-time activity. Intermittent sources of pollution may be present so revisits to the outfall are recommended over the course of the permit term.

7.3 Screening Procedure

As described above, screening is done during dry weather periods with low groundwater. On the Merrimack River, August and September are historically the low flow months. The field days were therefore scheduled for days in August and September following at least 72 hours with no rainfall.

The City provided CDM maps of all known outfalls into the Merrimack River. These maps were used to identify pipes and help field locate individual outfalls. Outfalls and streams were located and screened by boat and by land by a two-person CDM team.

CDM Staff with Global Positioning System (GPS) and other field equipment

As each outfall or stream was located, a Global Positioning System (GPS) coordinate was taken in order to locate the outfall in the GIS database. Figures 7-1 (a through g) shows these locations on a map of the drainage system.

To judge whether dry weather flow is contaminated, CDM relies on physical evidence of contamination supplemented with field-testing results. The field tests are used as gross indicators of pollution as trends are more important than absolute numbers which are subject to interpretation. Though absolute numbers are presented, determining sources of contamination is generally based on physical evidence and observed trends.

For outfalls with dry weather flow, physical evidence (smell, staining, evidence of solids or floatables, local sediment characteristics, and color) was recorded. In situ field tests were conducted for pH, temperature, dissolved oxygen, and conductivity. Additionally, samples of the flow were taken to measure nutrients (nitrate, nitrite, and orthophosphorus).

As each pipe or stream was located, a field sheet was completed documenting the pipe description and any physical evidence of illicit flow. The field sheet was developed based on EPA document 600R92238 "*Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems: A User's Guide*." The blank form used is shown in Figure 7-2. Completed sheets for both sampling rounds are provided in Appendix G. In addition, photos were taken of the outfalls and streams. These photos are found in Appendix F.

The identification scheme for the pipes and streams uses two numbers. The first indicates the order in which the pipes were encountered. For instance, outfall 13.44 was the thirteenth pipe encountered on the river. Numbering is not necessarily consecutive and numbers were skipped where the City data showed a pipe that we did not find. For example, we located outfall 7.42 and the City maps indicated another outfall nearby that CDM was not able to find. Therefore, the next pipe that we did find was numbered outfall 9.24 rather than 8.24.

The second value in the numbering scheme refers to the diameter of the pipe or other characteristic when diameter is not applicable. For instance, outfall 9.24 has a diameter of 24 inches. Outfall 17.chan was a large concrete channel; outfall 14.egg was a brick egg-shaped pipe; and 29.trough is an asphalt trough. The streams were numbered in the order they were located, followed by the word stream, i.e., 4.stream. This outfall numbering scheme should be modified when the GIS system is completed.

7.4 Results of CDM Investigation

All pipes found in the investigation area are listed in Table 7-1 and Figures 7-1a through g. Eighteen outfalls had no flow during dry weather, including two pipes, 4.24 and 23.48, which contained stagnant flow but were not flowing at the time of investigation. It is unlikely that there are illicit connections in the drainage systems tributary to these pipes. Eleven pipes had flow, while one pipe and a rectangular channel were submerged so flow could not be confirmed. Seven streams were found having regular sandy streambeds entering the main river stem. Five of these streams were flowing, one was not flowing, and flow could not be confirmed at one.

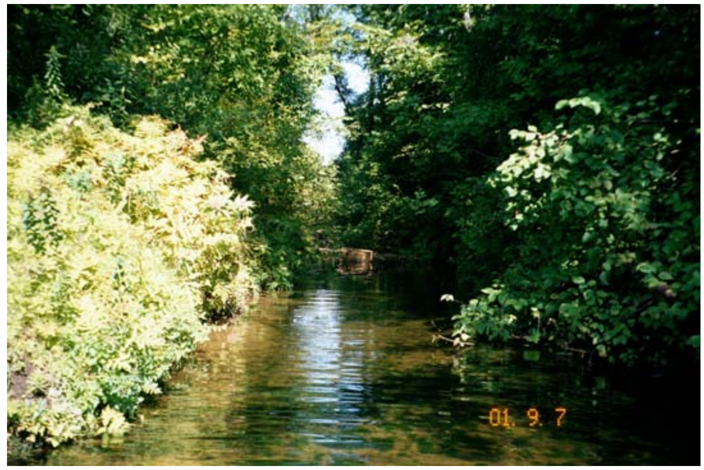
Physical observations and in situ quality measurements were taken at each of the flowing pipes and at the streams. Samples were also taken for nutrient analysis from the flowing pipes where possible. Nutrient measurements were made only if there was sufficient flow. No nutrient measurements were made for stream discharges.

	Location #	Bank	U/S Bridge	D/S Bridge	Pipe Mat'l	Diam/width (in)	Headwall	Flow	Figure #
2001 Screening. South of I-93.	1.14	Right	Manch St.		Concrete	14	Concrete	no	7-1f&g
	2.54	Right	Manch St.		Concrete	54	Concrete	yes	7-1f&g
	3.84	Right	Manch St.		Concrete	84	Concrete	no	7-1f&g
	4.24	Right	Manch St.		Concrete	24	Stone Block	no	7-1g
	1.stream	Left	Manch St.		Sand	60	-	yes, stream	7-1g
	5	Could not find outfall							-
	6.30	Left	Manch St.		Cor. Metal	30	Stone Pile	yes	7-1f&g
	7.42	Left	Manch St.		Concrete	42	Stone Wall	no	7-1f&g
	2.stream	Left	Loudon Rd	Manch St	Sediment		-	yes, stream	-
	8	Could not find outfall							-
	9.24	Left	Loudon Rd	Manch St	Concrete	24	Concrete	no	7-1f
	10.24	Left	Loudon Rd	Manch St	Concrete	24	Not found	unknown	7-1f
	11.12		Loudon Rd	Manch St	Cor. Metal	12	Not found	no	7-1f
	12.24	Right	Loudon Rd	Manch St	Concrete	24	Stone Pile	no	7-1f
	13.44	Right	Loudon Rd	Manch St	Concrete	44	Stone Wall	yes	7-1f
	14.egg	Right	Loudon Rd	Manch St	Brick	24 x 42	Stone Wall	yes	-
	15.44	Right	Loudon Rd	Manch St	Concrete	44	Concrete	yes	-
	16.18	Right	Loudon Rd	Manch St	Concrete	18	Concrete	no	-
	17.chan	Right	Loudon Rd	Manch St	Concrete	72 x 48	Concrete	unknown	7-1f&g
	18.36	Right	93	393	Concrete	36	Concrete	no	7-1e
	19	Could not find outfall							-
	3.stream	Right	393	Loudon Rd	Sand	10' wide	-	unknown	7-1e
	20.30	Could not find outfall							-
	4.stream	Right	393	Loudon Rd	Sand	15' wide	-	yes, stream	-
	21.30	Right	393	Loudon Rd	Cor. Metal	30		no	7-1e
	22.30	Right	393	Loudon Rd	Cor. Metal	30		no	7-1e
	23.48	Right	393	Loudon Rd	Cor. Metal	48	Metal Apron	no	7-1f
	24.54	Right	393	Loudon Rd	Concrete	54	Concrete	yes	7-1f
	25.54	Right	393	Loudon Rd	Brick	54	Brick	yes	7-1f
	26.18	Right	393	Loudon Rd	Concrete	18	None	no	7-1f
	27.24	Could not find outfall							-
	28.5	Left	393	Loudon Rd	Iron?	5	None	no	7-1e
	29.trough	Left	393	Loudon Rd	Asphalt/Conc	1' to 7' wide	None	no	7-1e
	5.stream	Left	393	Loudon Rd	Sand	4' wide	-	yes, stream	7-1e
	6.stream	Left	RR Bridge	93	Rock	3' wide	-	no, stream	7-1e
	31.24*	Left	93	393	Concrete	24	Not found	yes	7-1e
2005 Screening. North of I-93.	1.18	Right	RR Trestle		PVC	18		yes	7-1a
	2.24	Right		RR Trestle	Concrete	24		no	7-1a
	3.24	Right		Sewells Falls	Cast Iron	24		yes	7-1b
	4.chute	Left		Sewells Falls	Concrete	18		yes	7-1b
	5.18	Left		Sewells Falls	Steel	18		no	7-1b
	6.12	Right	Sewells Falls		Galvanized	12	Not found		7-1b
	7.4	Left	Sewells Falls		PVC	4	Not found		7-1b
	8.box	Right	Island		Concrete	Twin 6' Culverts		yes, stream	7-1c
	9.Flap	Right	Island		Unknown	~24			7-1c
	10.24	Right	Across from Dolan Street		RCP	24/30	Not found		-
	11.12	Right	Off End of McGuire Street		PVC	12	Not found		7-1d
	12.12	Right	Off End of McGuire Street		VC	12	Not found		7-1d

*Pipe 30 was an apparent intake, not an outfall, and is thus not included in this table.

Table 7-1
Outfalls Located during Dry Weather Screening
Merrimack River, Concord NH

Results are shown in Table 7-2. The pH readings appear quite high, therefore we focused on the difference between Merrimack River pH and pH from the storm drains rather than the absolute numbers. High pH readings, typically over 7.5, mean the water can cause scaling of pipes and affect the fish living in streams and rivers.



Seven streams were found tributary to the Merrimack in the study area

The temperature found at the outfalls shows a great deal of variation. The outfall temperatures ranged from 14.6°C to 25.5°C. The river was a relatively constant 24.1°C on August 30 and 23.5°C on September 7. One explanation for the wide variety of temperatures at the outfalls is that groundwater tends to be much colder than surface water, with much less seasonal variation. Therefore, pipes discharging groundwater will generally be cooler than pipes discharging surface water. Stream flow will tend to be slightly warmer than pipe flow, but cooler than the main river. Streams are smaller than rivers, have more tree-cover and shade resulting in lower temperatures.

Similar to the temperature results, dissolved oxygen (DO) levels varied at all the outfalls. DO is defined as a gaseous oxygen dissolved in an aqueous solution. Understanding the DO level in a waterway is important because fish cannot survive when levels drop below 5 mg/L for too long. The DO measured during this analysis did not yield any immediate results of concern. Dissolved oxygen of groundwater varies depending upon the time since recharge (*Study and Interpretation of the Chemical Characteristics of Natural Water*, USGS Water-Supply Paper 2254, 1989).

Conductivity of the water at each outfall was also measured. Conductivity in pure water is very low. Water which contains other constituents tends to increase the conductivity, meaning the higher the conductivity reading, the more constituents or potential contaminants in the water. A conductivity reading over 1000 ms/cm shall be considered a concern and three outfalls exceeded this limit.

The final field measurement of the sample program was nutrients (nitrate and phosphate). Both nitrate and phosphate can be existent in surface waters because of runoff or illicit sewer connections. The runoff from open agricultural fields or wooded areas can transfer the fertilizers and wastes to the surface water. Illicit sewer connections also supply the surface waters with nutrients once outfalled. Nitrate and phosphate both contribute to the growth of aquatic plants and can make humans sick at high doses. The drinking water standards for nitrate is 10 mg/L and for phosphorous 20 mg/L.

Based on the results shown in Table 7-2, we prepared Table 7-3, which ranks the eight outfalls we believe deserve further investigation. The bases for these recommendations are shown in the table.

Sample Location	Estimated Flow Rate	Smell	Color	pH	pHriver-pHflow	Temp, deg C	Conduct, ms/cm	DO, mg/l	Nitrate, mg/l	Orthophos, mg/l
Merrimack River				9.44		24.1	118	9.2		
2.54	1 gpm	Septic	Brown flakes	9.20	-0.24	18.2	242	8.6	1.00	0.08
4.24	stagnant	Oil	Brown/Green	9.30	-0.14	15.2	300	5.1	bdl*	bdl
6.30	2 gpm	Organic	Brown	9.73	0.29	17.1	550	9.4	2.00	0.04
10.24	low (submerged)	Slight Septic	Slight Grey	9.45	0.01	25.5	120	8.8		
13.44	8 gpm	Slight Septic	Grey	8.88	-0.56	23.7	1360	6.2	2.50	3.00
14.egg	2 gpm	Slight Septic	Sudsy	9.70	0.26	22.2	509	6.5	bdl	1.00
15.44	0.5 gpm	None	Clear						Not taken - Sheet Flow	
Merrimack River				7.35		23.5	111	14.1		
23.48	stagnant	Musty	Brown						Not taken - Too Shallow	
24.54	7 gpm	Woodsy	Clear	6.53	-0.82	16.2	1400	10.7	Not taken	
25.54	10 gpm	Musty	Grey	7.06	-0.29	19.1	985	12.8	2.00	0.01
31.24	1.5 gpm	None	Clear	6.64	-0.71	14.6	1557	15.2	5.50	bdl

* bdlL below detection limit. Nutrient concentration did not register in the test kits.

1.stream	5 gpm	None	Clear							
2.stream	1 gpm	None	Clear	9.84	0.40	22.5	230	8.6	Not taken - Stream	
17.chan	(submerged)	None	Brown, as river	9.36	-0.08	23.9	290	9.0	Not taken - Stream	
3.stream	low (submerged)	Faint	Clear	6.94	-0.41	21.3			Not taken - Stream	
4.stream	low (submerged)	None	Clear	7.33	-0.02	21.2	109	11.0	Not taken - Stream	
5.stream	low (submerged)	None	Slight Brown						Not taken - Stream	

1.18	low	chlorine	clear	7.42		20.4	232	8.2		
3.24	0.7 gpm	none	none			12.0				
4.chute	low	none	none						Not taken - Too Shallow	
8. box	low (submerged)	none	Brown, as river						Not taken - Stream	

Table 7-2
Results of Dry Weather Screening - In-situ and Nutrient Testing
Merrimack River, Concord NH

Ranking	Sample Location	Estimated Flow Rate	Smell	Color	Divergence from Ambient pH	Conduct, ms/cm	DO, mg/l	Reason further investigations are warranted
1	13.44	8 gpm	**Slight Septic**	**Grey**	**-0.56**	**1360**	**6.2**	Smell, color, divergence from ambient pH, high conductivity, low dissolved oxygen, and high flow rate
2	2.54	1 gpm	**Septic**	**Brown flakes**	-0.24	242	8.6	Smell and texture of discharge
3	25.54	10 gpm	**Musty**	**Grey**	-0.29	985	12.8	High flow rate, fairly high conductivity, odor and color
4	14.egg	2 gpm	**Slight Septic**	**Sudsy**	0.26	509	**6.5**	Smell, color, "sudsiness", low dissolved oxygen
5	24.54	7 gpm	Woodsy	Clear	0.29	**1400**	10.7	Divergence from ambient pH and high conductivity
6	31.24	1.5 gpm	None	Clear	**-0.71**	**1557**	15.2	Divergence from ambient pH and high conductivity
7	6.30	2 gpm	Organic	**Brown**	**-0.82**	550	9.4	Slight odor, color
8	4.24	stagnant	**Oil**	**Brown/Green**	-0.14	300	**5.1**	Oil odor and low dissolved oxygen

Table 7-3
Ranking of Outfalls Recommended for Further Investigations
Merrimack River, Concord NH

7.5 City Investigation

CDM could not locate eleven outfalls that appeared on outfall mapping (six in the 2001 investigation and five in 2005). City staff conducted investigations at the six locations of missing outfalls from 2001. The outfalls identified by the City are shown on Figure 7-1, and photos are included at the end of Appendix F. Several of these appear to be flowing, but no field-testing was performed.

7.6 Conclusions and Recommendations

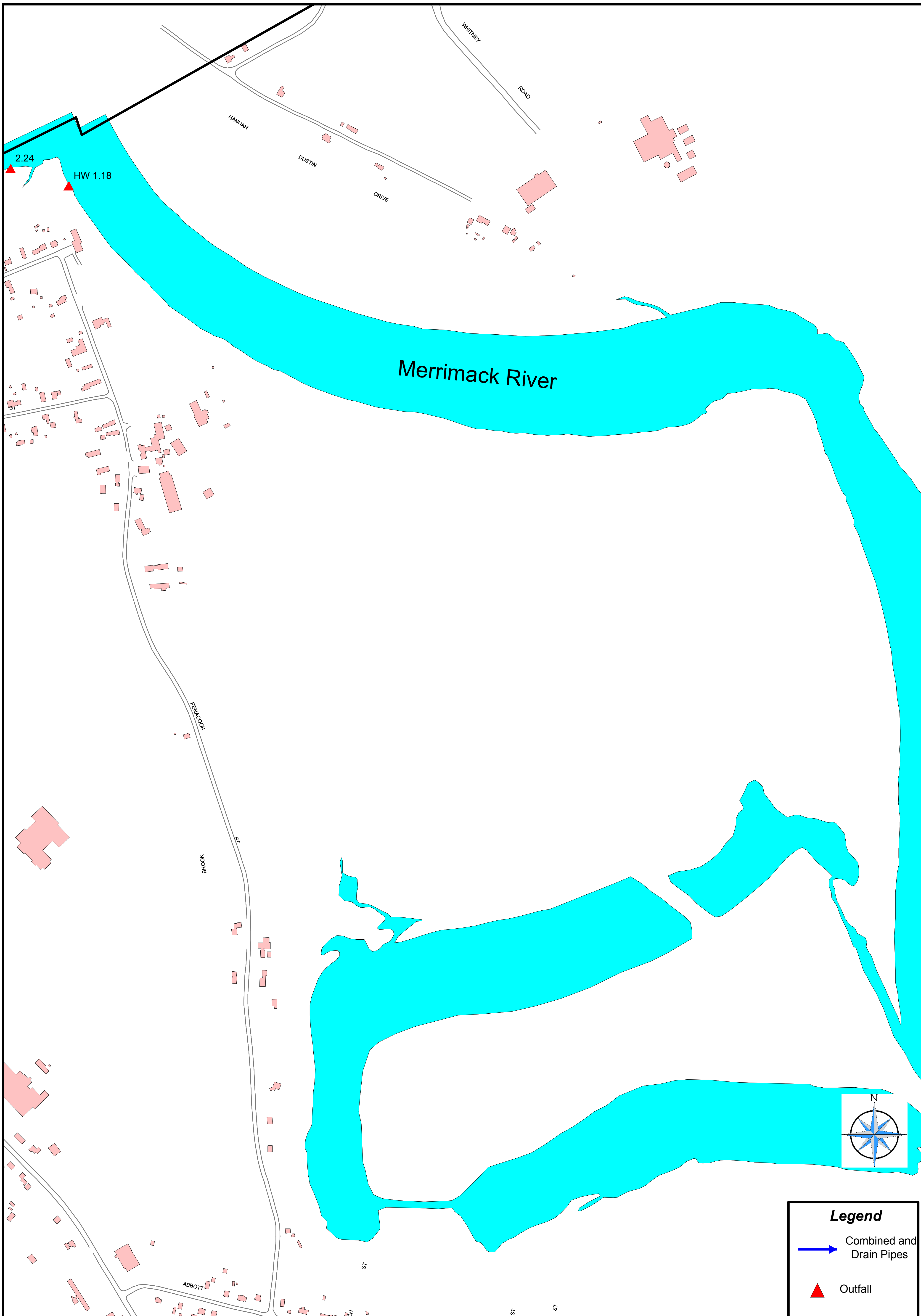
Based upon our field investigations, the following conclusions and recommendations are made:

- The drainage systems tributary to the 8 outfalls shown in Table 7-3 are recommended for further investigation. The outfalls are ranked in order from most likely to least likely to have illicit connections. CDM has designed a field investigation program for pipes tributary to outfall 13.44, the highest ranked outfall. This investigation occurred as part of the Washington Street basin study, see Section 5.

- Of the 30 outfalls located, 18 were dry, with no evidence of illicit connections. Since some illicit connections are intermittent, these outfalls should be re-visited in the future to confirm these drainage systems have no illicit connections.

- We made observations at seven tributary streams, some of which had upstream storm drainage systems. No evidence of contamination was observed at the seven streams.

- We recommend that the drain systems for outfall 17.chan and 10.24 undergo further investigation. These two outfalls were submerged and it was unclear weather either system had dry weather flow. A future investigation should venture upstream in the pipe network to make the determination.

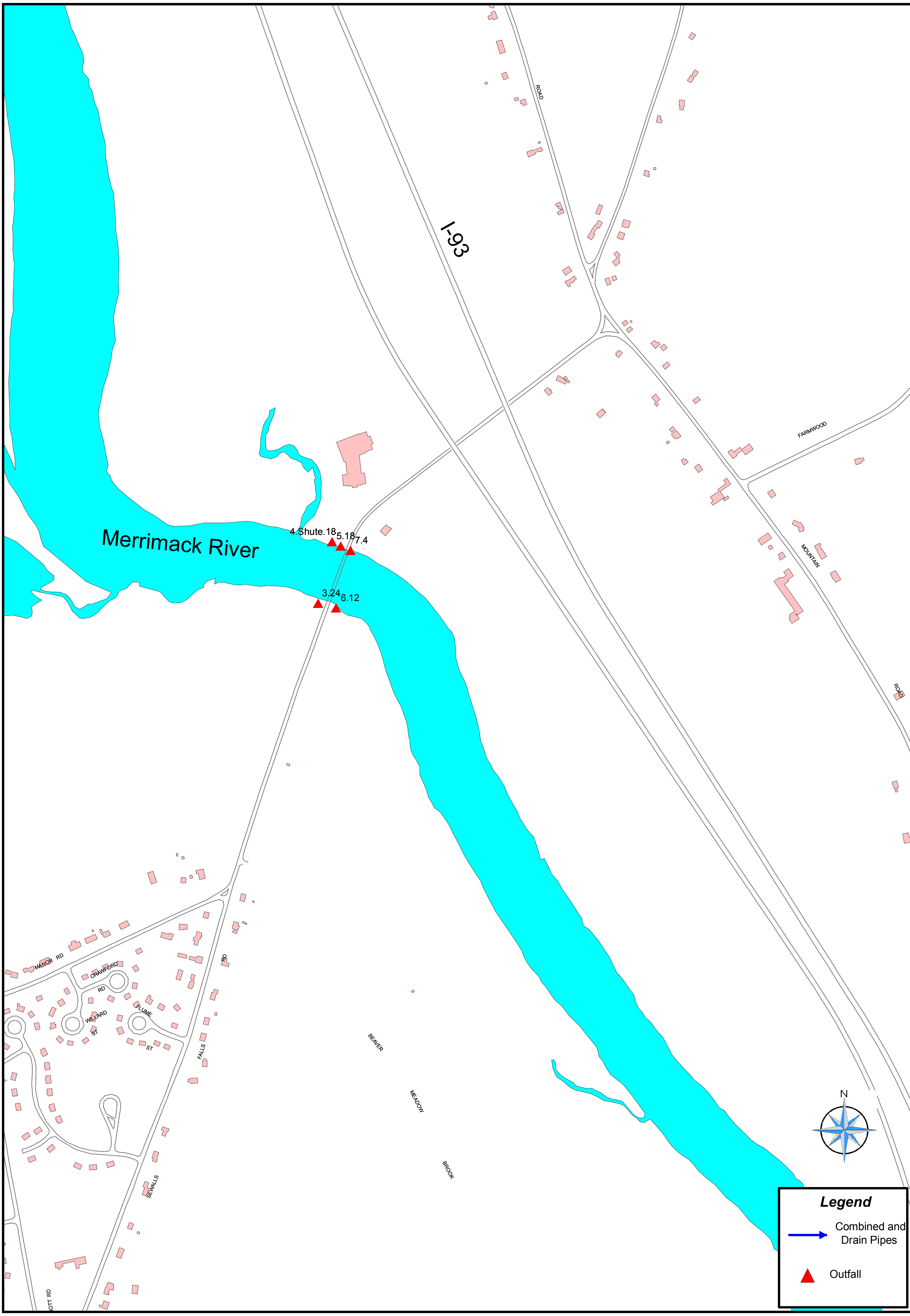


Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

500 0 500 Feet

1 = 500'

Figure 7-1a



CDM

Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

500 0 500 Feet
1 = 500'

Figure 7-1b

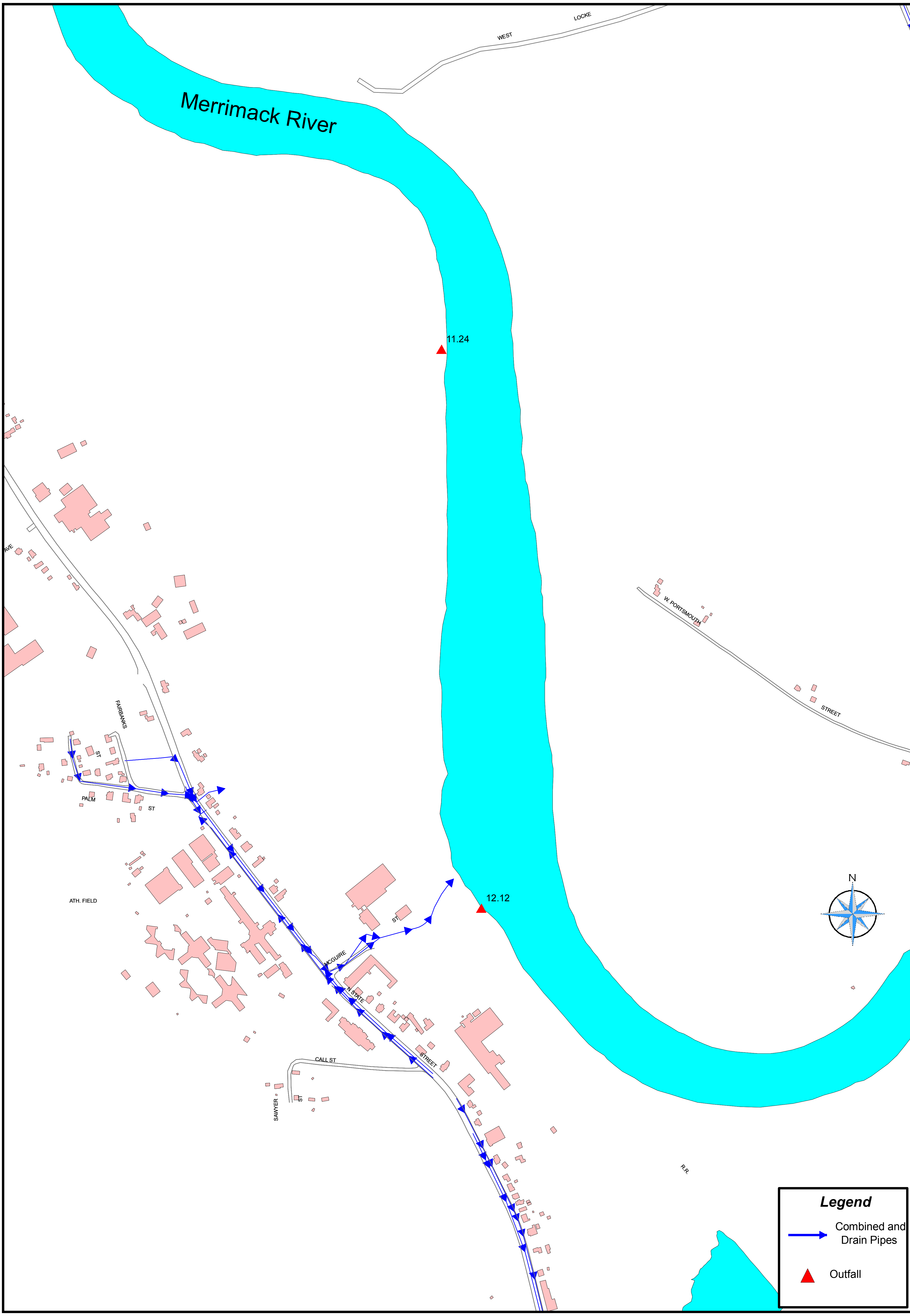
Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

CDM

500 0 500 Feet

1 = 500'

Figure 7-1c



Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

CDM

500 0 500 Feet
1 = 500'

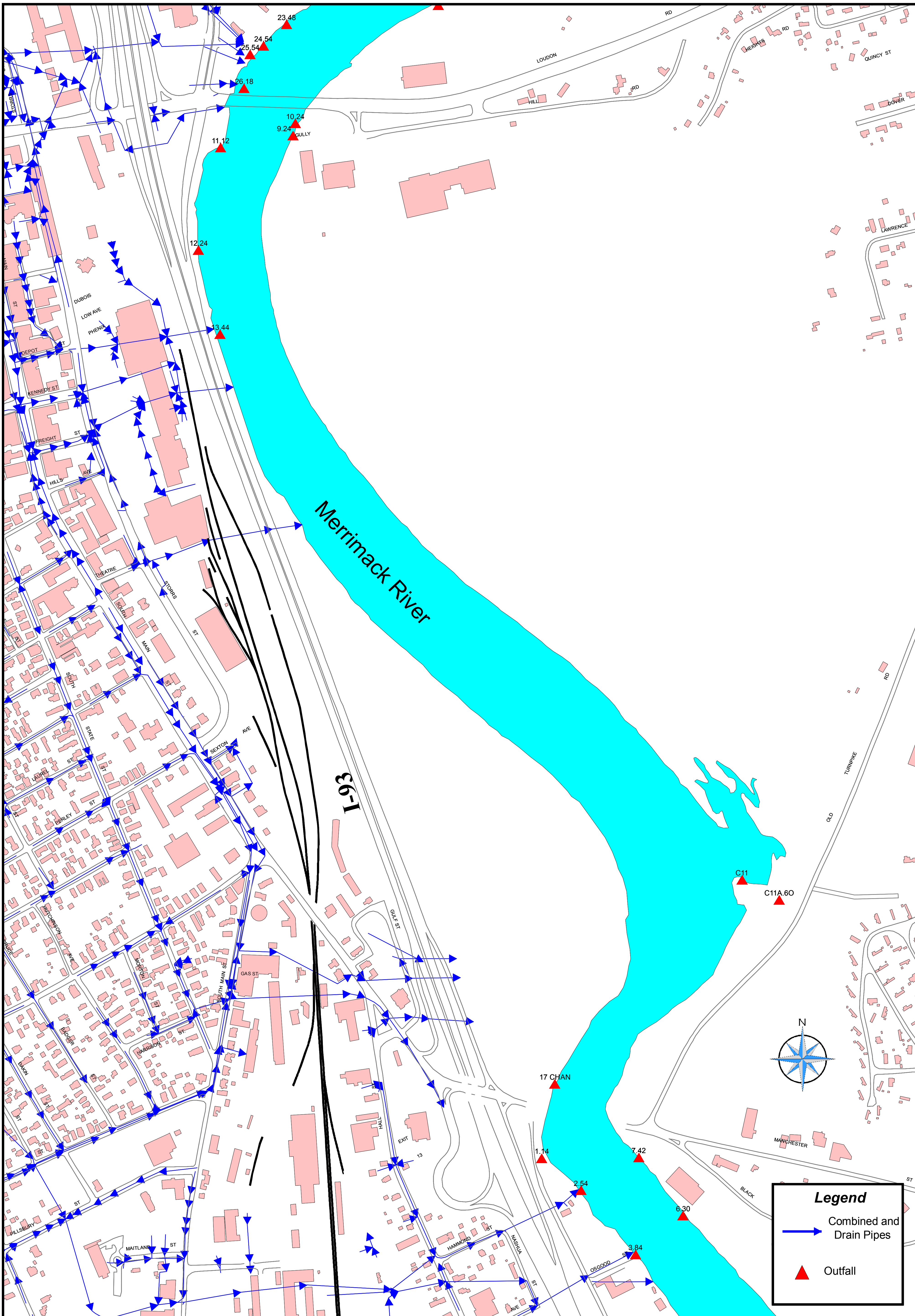
Figure 7-1d

CDM

Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

500 0 500 Feet
1 = 500'

Figure 7-1e

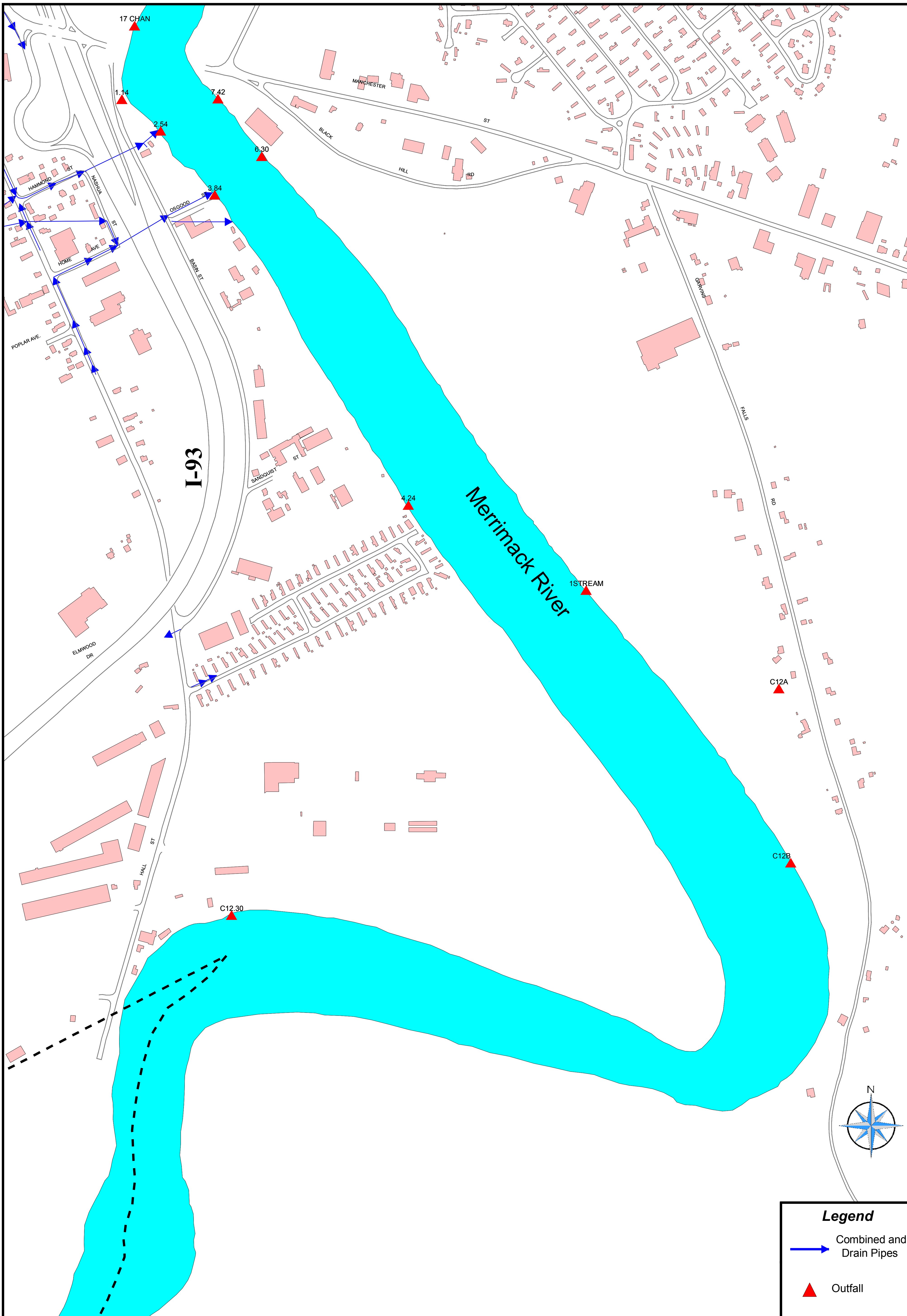


Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

500 0 500 Feet

1 = 500'

Figure 7-1f



CDM

Drainage System Map Showing GPS Located Outfalls
Merrimack River
Concord, NH

500 0 500 Feet

1 = 500'

Figure 7-1g

Outfall Data Sheet

Time, Date: ____________________

Outfall Location/Number:

____

Pipe Diameter: __________________________________

Pipe Material: __________________________________

Photo Number: _______________________________

Site Description:

Sediment below pipe: __________________________

Ambient Sediment (same?): ______________________

Evidence of floatables: ___________________________

Evidence of solids: ____________________________

Oil Sheen: ___________________________________

Smell: _______________________________________

Stains, corrosion, concrete damage: _______________

____

Plants (excess, absence): ________________________

Other? ____

____

Discharging Currently? No Yes

If yes: Approximate discharge rate: _______________

Smell: _______________________

Color: _______________________

pH: __________________ Temp: _______________

Conductivity: _________ Turbidity: ____________

Test Kit Results:

Ammonia: __________

Surfactants: _____________

Notes: ___________________________________

Figure 7-2
Field Sheet for Outfall Investigation

Section 8
Evaluating Funding Mechanisms for a Storm Sewer Enterprise

8.1 Introduction

The City of Concord is evaluating alternative methods of funding its storm water management program. Storm water management programs enable municipalities to comply with complex surface water quality regulations imposed by the Federal government. At this time, the full impact to comply with these regulations is unknown. However, the goal of this task is to evaluate the advantages and disadvantages of alternative funding mechanisms. We evaluate alternatives in terms of the five criteria:

- Ease and cost of implementation;
- Equity, including applicability to all customers;
- Revenue stability;
- Customer acceptability; and
- Legal authority.

There are also a number of policy decisions the City will need to consider regarding their pursuit of equity and encouraging private sector entities to invest in solutions affecting their business properties. Equity issues will include determining whether non-taxable properties should be paying for storm water management. In addition, the City will need to evaluate whether it can or should provide incentives to private entities to invest in storm water management facilities, such as detention ponds, to reduce the public investment.

A comprehensive approach to storm water management planning is a multi-year process. The implementation of such a program takes extensive strategic planning up-front and a major commitment to fund operations and maintenance for the life of the program. As we understand it, the General Services Department is presently responsible for most storm water management functions. The primary funding source for these activities is general tax revenue, although certain functions, such as catch-basin cleaning, may be paid through other fees.

The purpose of this section is to address the various rate and financial issues associated with a storm water management program.

8.2 Funding Alternatives

The scope of services performed by a storm water management program is diverse. The services generally include:

- **Program Administration –** oversight, management, billing, customer service, etc.
- **Engineering –** storm water master planning, protecting water quality of surface waters, design, permitting, construction management, inspections, etc.
- **Operations and Maintenance –** flushing, jet vactoring, erosion control maintenance, minor repair work, etc.
- **Capital Improvements –** scheduling, prioritizing, and construction of major primary and secondary systems.

Four principal funding options are available to the City. They include:

- General Fund revenues with the storm water management program paid for primarily with property taxes.
- Village Districts with the primary source of revenues being property taxes on residents of the District.
- Sewer use fees with the costs of the storm system included in the wastewater user fee.
- Storm Sewer Enterprise/Storm Water Utility with the program paid with a storm water use fee.

Municipalities frequently supplement these principal sources with miscellaneous fees and other mechanisms. These may include permit review fees, fines for non-compliance, and developer contributions for constructing required infrastructure. These supplemental sources are not discussed in this section.

Each of the principal funding options is discussed below.

8.3 General Fund

The General Fund receives revenue from many sources, primarily local property tax receipts, license and permits, Federal and State shared taxes, payments-in-lieu of taxes (PILOTs), fines and penalties. Most municipal services are funded from the General Fund with the balance funded through fees, such as the water or sewer use fee. When considering the capacity of a General Fund to effectively support a City's storm water management program, the analysis must look to evaluate three issues: fairness, equity, and competition for scarce dollars.

There are several advantages to administering a storm water management program through a General Fund:

- Existing source of revenue;

- Billing system is in place and cost effective;
- Payments made by residents are fully tax-deductible on federal income taxes;
- Collection rates are high and stable; and
- Requires minimal incremental implementation and administrative costs.

The obvious benefit of using the General Fund is that it serves as an account for depositing receipts from which multiple municipal services are funded and relies on relatively stable revenue sources. Funding storm water management requirements through municipal taxes places little or no additional burden on the existing property tax billing system. Property owners do benefit since the total tax payment is deductible for federal tax purposes. Finally, property tax collections are generally high, relatively stable and fully enforceable as a lien on a property.

There are disadvantages to using the general fund. First, the storm water management programs must compete for funding with other municipal needs that have more political appeal. Frequently infrastructure related programs are not seen as priority programs against other municipal needs, such as schools, police and fire. Second, the use of general fund taxes does not assess costs to residents based on their impacts on the storm water system. There is no relationship between the value of a particular parcel and the amount of run-off from that parcel that the storm water system must accommodate. The actual amount of run-off from a parcel is more highly correlated with the amount of impervious surface on the parcel and not its value.

8.4 Village Districts

New Hampshire has created enabling legislation, Revised Statutes Annotated (RSA) 52, et. al., to allow the formation of village districts to provide special "needs" services. These districts include flood control, fire, drainage, irrigation systems, shade tree maintenance, sanitary collection and wastewater treatment, roads, impoundment of water, potable water, and others. Funding for these special needs districts comes from *ad valorem* taxes or a special use tax assessment based on a property's total assessed value.

The role of the village district is to provide a particular service function for a specified area. In this case, the service would be drainage to control flooding, minimize water quality degradation and to eliminate sanitary sewer overflow conditions if they exist. Under the statute, each property owner within the district is eligible to vote when a special election is called for to establish a village district, adopt a budget, issue debt, establish a tax rate, and/or make an amendment to the district's size, rules of incorporation, or services provided through the district. A majority of the eligible voters within the district is required to pass any proposal. The voters determine a ruling body of representative members and the appointment of a village district manager. A village district may issue tax anticipation notes to meet expenditure obligations based on anticipated revenues from the current tax assessment.

If the intent of a Storm Sewer Enterprise is to focus solely on issuing Village District Assessment Bonds for capital construction purposes, then a village district or, as it is sometimes called, a special assessment district may be considered. These districts are established according to the area benefiting from a particular improvement or service and assessments are made against property owners that fall within those district boundaries. These districts may include one or more or a portion of multiple communities or towns. All properties that fall within the district must receive a direct benefit.

The disadvantages of this funding option are:

- Districts may include only a portion of the City. The size of the District is limited only by those property owners wanting to join. However, given the geographical lay-out of Concord's storm water management system, this limitation may be an advantage. Concord's storm water system serves a relatively small portion of the City and thus the Village District would target the appropriate geographical area.
- Revenues generated within the district must be spent for the benefit of those within the district which may not be where the money is most needed.
- Assessments are based on property value and not impact or demand on the storm water management system.
- Decision-making would be complicated given the need to "poll" all residents of the village.

The ease and cost of implementing a village district would not be difficult; however, there would be a cost to organize. The formulation of a village district requires meeting all the requirements of the act (RSA 52) which may require the use of an attorney to formulate the form, language, mission and scope into a service agreement. An engineering consultant may be necessary to establish the district boundaries based on basin-wide drainage studies and the specific legal language of a district agreement.

A Village District raises some of the same equity issues discussed under the General Fund. The primary point is that fees are assessed based on property value rather than on a determination of runoff contribution to the drainage system. Residents will not be paying in proportion to their impact on the system. The benefit of this approach is that revenues would be very stable since they are tied to the regular tax bill for the community at large that has a high collection rate. In addition, customers affected by the formation of a special district would know that the funds generated through the district tax levy are for projects specifically targeted to benefit them.

8.5 Storm Water Funding Through Sewer Use Fees

Most municipalities including Concord manage and operate storm sewer operations through general fund departments of the city. In Concord, the General Services Department is responsible for administering storm sewer activities with funding from general taxes.

An alternative approach used by a number of communities is to include the expenses of the storm water system within the sewer user fee revenue requirement. Under this alternative, Concord's sewer department, which is an enterprise fund and generates revenues, would include in its expenses the costs of storm water management. This would then result in the sewer rates to be increased to meet the additional expenses.

This approach frequently fits within the operations of the utility as well because the sewer department's staff is responsible for the maintenance of the storm water system infrastructure. Many communities also do not like to take on the added burden of tracking storm sewer related activities separate and apart from sanitary collection and treatment because it is easier to capture those expenditures under the umbrella of sewer services. As a result, storm water service costs are captured in the enterprise fund's annual expenditure budget. These expenditures are then incorporated into the annual review of sewer rates used to support the utilities annual expenditure needs.

There are many similarities between the requirements of a sanitary sewer management program and that of a storm water sewer management program, including, but not limited to:

- Master planning, engineering, capital improvement design and construction;
- Flushing and televising of pipes;
- Staff that are assigned to collector system maintenance;
- Administrative, budgetary and financial services; and
- Billing and collections services.

The requirements for storm water systems in Concord that differ from sanitary sewer operations include:

- Maintenance of drainage swales since not all collection elements are below ground; and
- Maintenance of catch basins that are designed to capture solids suspended in storm water.

The obvious advantages of funding storm water activities under the umbrella of a sewer utility or department is the assignment of maintenance crews to perform semiannual maintenance functions on a seasonal basis associated with spring rains and fall cleanup of leaves from storm drains and catch-basins. A second advantage is that simplicity of organization with similar operational and system requirements "housed" within a single funding and managerial structure.

There are several disadvantages. First, sewer use fees can be instable related to variations in the sale of water. In wet years, when storm water operating and maintenance requirements may be there highest, revenues will likely decline because Concord's sewer use fees are based on metered water consumption.

In addition, there is an equity problem associated with funding storm water activities through water use fees or consumption based billing. Storm water runoff during rain events has no relationship to water sales based on consumption. High water users will carry the bulk of the expense for storm sewer charges as opposed to those properties that have a high percentage of impervious surfaces.

The costs to fund a storm water program within a sanitary sewer fund would be relatively simple because the system of funding and staffing a sewer enterprise is already in place. It essentially requires including within the sewer budget or enterprise fund the expenses associated with storm water management and then making appropriate adjustments in the rate calculation.

8.6 Storm Sewer Enterprise Fund/Storm Water Utility

An enterprise fund is generally the choice of a local government to create a separate revenue fund to capture the assets, administrative, operations and capital construction activity associated with a specific service or department. The department, enterprise program or storm water utility remains a department of the City but no longer relies on general tax revenues to support its operations. The difference with this approach from that described in Section 8.5 is that the revenue source is directly related to storm water management. Nationally, approximately 300 communities have established storm water utilities with specialized fee structures.

The storm water utility provides funding for local storm water management programs and includes funding to cover operations and maintenance, basin planning, facility construction, and program administration. Storm water utilities allocate costs among "customers" based on estimates of the relative amount of run-off that comes from each parcel. In addition, a principal advantage of a storm water utility compared to a general fund revenue source is that tax-exempt properties (federal, state, local and other tax-exempt buildings) are assessed a user fee or cost of service fee that reflects their relative storm water contribution. This is comparable to how other public utilities bill tax-exempt properties based on usage (e.g., electricity, water consumption).

Storm water utilities generally all use a methodology that estimates the amount of impervious area on a particular parcel as a percentage of the total impervious area and allocates fees on that basis. A number of alternative methods have been developed that seek to simplify this process and reduce the initial administrative burden associated with determining each customer's bill. Nearly 70 percent of existing storm water utilities base the bills on some type of equivalent residential unit basis. In these systems, all residential properties or some subset of residential properties become the base billing unit. All other customers are then billed based on the amount of impervious area relative to the average impervious area per equivalent residential unit (ERU). Depending on the system, the ERU may reflect the average amount of impervious area per dwelling unit for all housing, for all single family housing or for all multi-family housing. This approach reduces the administrative burden of determining the actual impervious areas for every residential property. There are many permutations of this approach including multiple residential class systems, credit policies, and lifeline rate policies. For simplicity of discussion, we use the term ERU to include all of these various approaches.

The advantages of the storm water utility approach include:

- The utility can be structured so that it relies on an evaluation of a representative sample of residential properties in the community to determine a standard impervious area for all residential properties as a class (single family, apartment, condominium) which significantly reduces the up-front implementation burden and costs.

- Costs are allocated to properties based on their relative contribution to the storm water problem.

- Revenues are relatively stable, since impervious area (the basis of the charge) does not change rapidly over time.

The disadvantages of a storm water utility approach include:

- The City may incur a significant up-front effort to define a billing unit, determine the amount of impervious area on each parcel in the City, and to establish a new billing system.

- The City will also need to educate its residents regarding the benefits of the storm water program and the basis of the new charge that they are paying. It is frequently challenging to get public support for this fee, since opponents characterize it as a "tax on rain".

- Under an impervious charge system, there are administrative complications necessary for maintaining accurate records of impervious areas for all citywide parcels, including both residential and commercial.

As an incentive to the private sector to participate aggressively in a storm water management program, the City can consider providing credits or differential rates to businesses that operate and maintain detention and other water quality facilities that provide a higher level of protection than that required by ordinance.

Transitioning to a new full service fee can be difficult. Therefore, many communities have considered a combination of revenue sources that allows for the gradual transition from the General Fund to a full enterprise fee structure to fund a storm water management program. The transition period may range between one and five years. Initiating a program that is partially offset by General Fund revenues allows an immediate effort to address problems while at the same time gradually adjusting the public to a full cost program. Taxes rarely fall even with the transfer of an expenditure obligation to a new funding strategy. Therefore, a gradual effort that relieves the municipalities tax burden for new general purpose demands offers two benefits: (1) relief on the politically charged issue of higher taxes; and (2) creating a business model for administering a program that has an established market and growing services needs.

8.7 Summary

The City of Concord may choose to fund its storm water program from the four primary alternatives outlined in this section. Selecting the best alternative requires balancing a number of frequently conflicting goals and objectives. For example, an administratively simple fee structure is preferable because it reduces the burden of maintaining the system. However, the most simple fee structure (general taxes) is the most inequitable rate structure.

Each system has advantages and disadvantages:

- A general tax system is the easiest to administer and provides very stable revenues, at least in the short-term. However, this system presents equity issues and over time may represent instable revenues, as storm water management must compete with high priority and visibility municipal issues, such as police and fire protection and schools.

- The use of sewer use fees is also a relatively easy to administer funding source since the use fee is well established and collection rates are high. Again, this alternative source presents equity issues.

- The Village District is very similar to general tax supports. The key distinctions are that (i) a Village District targets the tax payment as the strategy for improving overall equity and (ii) the Village District will complicate tax payments since not all Concord residents will be subject to the District tax.

- Storm water user fees provide an independent revenue source that is allocated to residents/customers based on their estimated contribution to the storm water management problem. However, this autonomy and equity must be balanced against the up-front implementation costs, ongoing maintenance of the billing system and effort required to educate customers and policy-makers on the basis of the charge.

The City's selection of the appropriate funding mechanism will result in the cost burden being shifted among various customer classes. We have not developed a detailed budget for the City's storm water management program, nor is it the scope of this assignment to undertake a detailed feasibility evaluation of the alternative systems. However, it is important to understand how the alternatives shift the burden among customers.

The following table is based on work that was undertaken for Manchester, New Hampshire that was evaluating implementing a wet weather charge based on impervious area. As part of that evaluation, we compared what various typical customers would be required to pay for wet weather management under three funding alternatives:

- General Taxes based on property values;
- Sewer Use Charges based on metered water consumption; and
- Storm Water Charges based on impervious area.

Table 8-1 shows what the estimated annual bills would be under each funding source for a variety of customer types. This information reflects actual data in Manchester (for value of properties, amount of impervious area, and annual water consumption) at the time of that analysis. We believe it is illustrative of the impact in Concord and is useful in understanding the real implications of adopting any of the principal funding approaches.

Customer Type	General Taxes	Sewer User Charges	Storm Water Charges
Single Family	$120	$94	$48
Apartment Building	$3,046	$2,033	$1,440
Strip Mall	$4,858	$3,250	$6,626
Regional Mall	$22,030	$15,506	$38,282
Manufacturing Facility	$2,878	$8,717	$4,368
Parking Lot	$216	$0	$528
Laundromat	$386	$2,364	$360

Table 8-1

Estimated Annual Bills
Alternative Storm Water Funding Approaches

As can be seen from the table, an impervious area charge shifts the burden away from residential properties and towards commercial developments. General tax systems place much of the burden on residential properties. While the table does not include it, under the general tax system, tax-exempt properties would pay nothing, while under the other two systems tax-exempt properties would be required to pay something. The sewer use charge alternative is most favorable to commercial properties because their relative water use is less than the value of the property or the amount of impervious area.

Section 9
Project Prioritization, BMPs and Rehabilitation Measures

This section includes a description of the eight categories that each problem area and known problem were evaluated on. The categories are explained in detail and number rankings are given to measure the severity of the problem with regard to each criterion. This section also presents best management practices (BMPs) to improve operation of the existing storm water system and rehabilitation measures to help resolve the identified problems.

BMPs assist with the operation and maintenance of Concord's storm water system. These recommendations are general in nature and are intended to be implemented system wide and initiated as an ongoing management task.

9.1 Prioritization Criteria

The City allocates funds to spend on its Capitol Improvements Plan (CIP) for stormwater projects which is further discussed in Section 10. A method was developed to help prioritize projects by identifying the highest priority and most effective projects for consideration within the allocated budget of funds. The projects or known problem areas identified from Section 4, 5 and 6 were evaluated.

For the purpose of prioritization, CDM and the City identified eight criteria to rate the individual projects. These criteria include:

- Property/Traffic Impacts
- Pipe Size
- Percent Undersized
- Recurrence of the Problem
- Pipe Age
- Stream Impacts
- Constructability
- Potential Road Projects

Each project is assigned a score between 0 and 5 for each criterion and the scores are summed to give each project a total score. Projects with a high total score are ranked higher on the priority list. Each of the eight criterion were weighted the same. The resulting projects/scores matrix is used to identify the priority projects that the City should implement as discussed below.

9.1.1 Property/Traffic Impacts

The first criterion considered is property/traffic impacts. This criterion attempts to identify projects that are potentially disruptive to the general public, including impacts to public or private property due to flooding or pipe collapse, and impacts to traffic patterns. Impacts are likely to be more severe in more congested areas such as downtown, urban areas or near schools.

The property/traffic impact criterion is broken down in Table 9-1. Projects with a higher point value are judged of higher priority under this criterion.

Land Use	Score
Urban/Downtown/Schools Nearby	5
Mixed Residential/Semi-Urban	3
Residential/No Schools	0

Table 9-1

Property/Traffic Impact

9.1.2 Pipe Size

The second criterion used is the pipe size. The need for installing a larger pipe indicates a greater need to convey larger volumes of storm water. A pipe equal to or over 48-inches in diameter shall be given a score of 5 points. Also, if no drainage exists at a certain area which the City considers a problem area, that will also be given a score of 5 points. As pipe sizes decrease, the score decreases. See Table 9-2 for the entire pipe size criteria.

Pipe Size	Score
48” Diameter and Greater; No formal drainage piping	5
30”, 36” Diameter	4
21”, 24” Diameter	3
15”, 18” Diameter	2
8”, 12” Diameter	1
6” Diameter and Less	0

Table 9-2

Pipe Size

9.1.3 Percent Undersized

The third criterion used is the relative percent that pipe is under capacity. This percentage compares the actual pipe size in place to the proposed pipe size based on a 10-year storm event. An impact is likely to be more severe for an 8-inch pipe that is 75 percent undersized than for a same sized pipe that is 25 percent undersized. The percent undersized criterion is presented in Table 9-3.

Percent Undersized	Score
81% and Greater	5
61% to 80%	4
41% to 60%	3
21% to 40%	2
11% to 20%	1
10% and Less	0

Table 9-3

Percent Undersized

9.1.4 Recurrence of the Problem

This criterion attempts to identify projects that will address problems that consistently recur in the City. For example, problems that trigger resident complaints or that cause property damage on a regular basis.

The recurrence criterion is presented in Table 9-4. Projects with a higher point value are judged of higher priority under this criterion.

Recurrence of the Problem	Score
City identifies this as a critical and frequent recurrence	5
City identifies this as an infrequent, occasional occurrence	3
City has not identified this as a current problem	0

Table 9-4

Recurrence of the Problem

9.1.5 Pipe Age

The age of the pipe or when the pipe was last replaced generally is a good indicator of the condition of the pipe. Although some very old pipes are still in good condition, in general, older pipes are more likely to need repair or replacement. This criterion measures the age of the pipe present.

Pipe Age	Score
Before 1960	5
1960 to 1975 Construction	3
1975 to 1995 Construction	2
1995 to New Construction	0

Table 9-5

Pipe Age

9.1.6 Stream Impacts

The main receiving waters in Concord are the Merrimack River and the Contoocook River. Many other smaller receiving waters also exist in the City, such as Beaver Meadow Brook and Bow Brook. Stormwater quantity and quality impacts from the City to these rivers and streams can be significant. This criterion attempts to measure the relative impact to a stream by a project. For instance, a very large, urbanized area contributing flow directly to a small, sensitive brook would be a significant impact. A very small residential street, contributing flow to a large river, would be slight to no impact.

The impact to receiving water criterion is presented in Table 9-6. Projects with a higher point value are judged of higher priority under this criterion.

Impact to Receiving Water	Score
Significant impact to sensitive or important brook	5
Moderate impact to receiving water body	3
Slight impact to receiving water body	2
No impact to sensitive brook or waterway	0

Table 9-6

Impact to Receiving Water

9.1.7 Constructability

The constructability criterion ranks projects based on an assessment of construction difficulty. Constructability is a composite rating based on pipe size, depth of construction and density of land use. Quite simply, smaller-diameter, shallow drain systems in residential neighborhoods are easier to construct than large-diameter, deep drain systems in busy urban neighborhoods. The areas with less difficult construction impacts were assigned a higher score, and thus higher priority under this criterion.

Some judgment was used if for example a 30-inch pipe was to be constructed at 2-6 feet depth in a residential area. The constructability criterion is summarized in Table 9-7.

Pipe Size	Depth of Construction	Density, Land Use	Score
15" or Less	0-2 feet	Residential	5
18" to 24"	2-6 feet	Mixed Residential/ Urban	3
>24"	> 6 feet	Urban/Downtown	0

Table 9-7

Constructability

9.1.8 Potential Road Projects

If a majority of the roads in the proposed project area were scheduled to be paved soon, it would be to the City's advantage to complete the stormwater system improvements at the same time as the paving. Alternatively, if a majority of the roads in a drainage area have been recently paved, it would not be desirable for the City to remove the new pavement, repair the drainage and consequently re-pave these streets. A 5-year paving plan prepared by the City was used to help identify which streets are to be paved in the near future. Thus, a project in an area scheduled for pavement will receive a higher score. The Potential Road Projects are summarized in Table 9-8.

Paved Last	Paving Plans	Score
Scheduled for pavement in 2006 or 2007, and dirt roads	Pending	5
Scheduled for pavement in 2008 or 2009	Two to three years	4
Scheduled for pavement in 2010 or 2011	Four to five years	3
Any road scheduled for repavement after 2011, or not on the pavement schedule	Greater than five years	0

Table 9-8

Potential Road Projects

9.1.9 Prioritization Criteria Summary

The highest score that a project could receive based on the evaluated criteria is 40. A project receiving this score would have received a 5 in each of 8 categories. A ninth category, project cost, receives no ranking but the estimated cost is provided in the priority table for comparison. The prioritization systems developed here will be used in Section 10 to rank projects in the Capital Improvement Program. Table 9-9 summarizes all of the criteria.

Criterion	Range	Maximum
Property/Traffic Impacts	0-5	5
Pipe Size	0-5	5
Percent Undersized	0-5	5
Recurrence of the Problem	0-5	5
Pipe Age	0-5	5
Stream Impacts	0-5	5
Constructability	0-5	5
Potential Road Projects	0-5	5
Project Cost	N/A	-
Total		**40**

Table 9-9

Prioritization Criteria Summary

9.2 Best Management Practices (BMPs)

BMPs are an integral part of EPA's Phase II storm water management initiative. Generally, BMPs are low cost measures that reduce pollution to the storm drainage system and receiving waters and assist the City with maintenance of the infrastructure. Several BMPs are already practiced by Concord, while others are recommended to be implemented as long-term programs. A partial listing of BMP's are presented below:

Television Inspection (TV)

Some areas of the City's drainage network have been TV inspected as part of this report. It is recommended that the City perform TV inspections of the storm water system before beginning any new drainage projects. TV inspection is done to assess the structural condition of pipelines, evaluate maintenance needs such as sediment and debris removal, and to identify potential illicit connections to the drainage system. TV inspection will allow the City to systematically evaluate the condition of the pipelines and identify problem areas in a proactive manner. The City currently conducts a similar very successful program on its sewer system. This same program can be implemented for the storm water system.

For example, in Table 5-1 of this report there are several problem areas identified in the Washington Street Basin that require television inspection to further quantify possible illicit connections and/or cross connections from the sewer system.

Street Sweeping

Regular street sweeping reduces the amount of sediment, nutrients, heavy metals, floatable materials, sand, litter, large particulate matter, and oxygen demanding substances that enters the storm water system. This practice greatly reduces negative impacts to the receiving waters.

The City currently has a well established street sweeping program. The City owns one street sweeper and contracts out for the heavy sweeping. A logical sequence for sweeping streets has been established and is followed every spring. It is recommended that the City continue this successful street sweeping program.

Catch Basin Cleaning

Catch basin cleaning removes debris before it enters the storm drain system. If catch basins are not cleaned on a regular basis, the debris can build up until it reaches the elevation of the discharge pipe where it will travel down stream and ultimately to receiving waters. Currently approximately 90 to 95 percent of the City's catch basins have sumps which should be cleaned regularly.

Several drainage manholes were identified in Section 5 of the report as having excess sediment. Catch basins in these areas as well as others that accumulate debris will require more frequent cleaning.

The City of Concord is developing a formal catch basin cleaning program with the goal of cleaning each basin every 3 years. We recommend that the City continue with the development of this program while maximizing the benefits of the GIS. The GIS will allow the City to prepare a data base of cleaning history for each catch basin and prioritize frequency of cleaning. Examples of pertinent data that may be tracked include: date cleaned, volume removed, and general condition of the catch basin.

Public Involvement and Participation BMPs

Stormwater runoff is generated from various land surfaces such as pavement, grass lawns, driveways and roofs. An important step to improving discharge to receiving waters is to inform the public of ways they can individually help improve runoff quality. A few ways to do this are disposing of pet-waste, minimizing the application lawn chemicals, limit washing cars, changing motor oil on impervious driveways and proper disposal of household chemicals (paint, cleaning products).

Another BMP to consider involves the help of active groups or outreach programs in the community. With their help, the City can consider moving forward with stormwater related activities such as adopt a stream, reforestation, storm drain marking, stream cleanup and monitoring, volunteer monitoring and wetland plantings. Outreach programs of this type are inexpensive and can produce positive results.

Illicit Discharge Detection and Elimination BMPs

Illicit discharges to the drainage system have a negative effect on the receiving waters because they can contain harmful pathogens, nutrients, surfactants and various toxic pollutants. Section 7 identifies some potential illicit sewer connections as evidenced by the outfall discharge smell and color during inspection. The first step to eliminate this problem is to create an Illicit Discharge Detection and Elimination Program (IDDE). This program will outline practical, low cost and effective techniques for eliminating illicit discharges. Other BMP programs to consider are developing used oil recycling program, illegal dumping control, trash management, preventing septic system failure, sewage from recreational activities and community hotlines.

Construction BMPs

Sediment from construction sites which enter receiving waters can have a negative effect on the aquatic plants, fish, aquatic habitats, spawning areas and impede navigation. To mitigate these issues the contractor can utilize the following BMPs; municipal program oversight, construction site planning and management, erosion control, runoff control, sediment control and good housekeeping/materials management.

Post Construction BMPs

As land development continues across the city the increase in impervious surfaces increase. When rain events occur on larger impervious surfaces the stormwater volume increases and degrades the water quality that harms lakes, rivers, streams and coastal areas. To mitigate these impacts BMPs should be performed which treat, store and infiltrate runoff on site before it can affect receiving waters. Such BMPs include municipal program elements, innovative BMPs for site plans, infiltration, filtration and retention/detention.

9.3 Rehabilitation Measures

Section 10 summarizes the problem areas in Concord's storm water system that were identified during our investigations and recommended rehabilitation measures to correct deficiencies. Figure 9-1 summarizes all of the projects and presents the geographical location of these identified issues. The following paragraphs present typical rehabilitation measures that are used in storm drainage systems. Some rehabilitation measures require excavation while others can be accomplished internally with little disruption to surrounding areas.

Pipe Replacement

Pipe replacement is a common solution to aging infrastructure. Most pipe replacement is performed using conventional "open cut" construction methods. This method can provide immediate benefit to the hydraulic capacity of the storm water system, prevent potential flooding from blockages, replace any collapsed pipes, remove infiltration from cracks in old pipe, remove root intrusion leaks and eliminate situations that might deteriorate further.

Cured in Place Pipe (CIPP) and Grout Treatment

Cured in place pipe (CIPP), also know as pipe lining, and grout treatment are two other rehabilitation measures to consider for resolving problems with existing pipes. Over time, existing pipes will crack longitudinally and circumferentially allowing infiltration and structural instability. CIPP is the most dependable and cost effective "trenchless technology" rehabilitation measure because it provides structural strength in addition to sealing cracks. CIPP is cost effective and best installed for long stretches of pipe between one or multiple manholes.

Grout treatment is more applicable to point repairs. If existing pipes have specific infiltration locations, applying a grout treatment can reduce the leak. To do this, a grouting machine can be sent into the pipe at the source of the problem, fill the void with grout and dig a trench on the outside of the pipe for further sealing.

9.4 Summary

The eight criteria described in this Section are used to rank all projects (problem areas) identified in Section 4, 5 and 6. The scores for each project's criteria are totaled and sorted from highest to lowest. A list of the sorted projects by total score is presented in Section 10.

Best Management Practices (BMPs) are important remedies for a municipality to ensure cleaner receiving waters and upkeep of their existing storm water system. The City of Concord utilizes some BMPs and should consider implementing several others mentioned above.

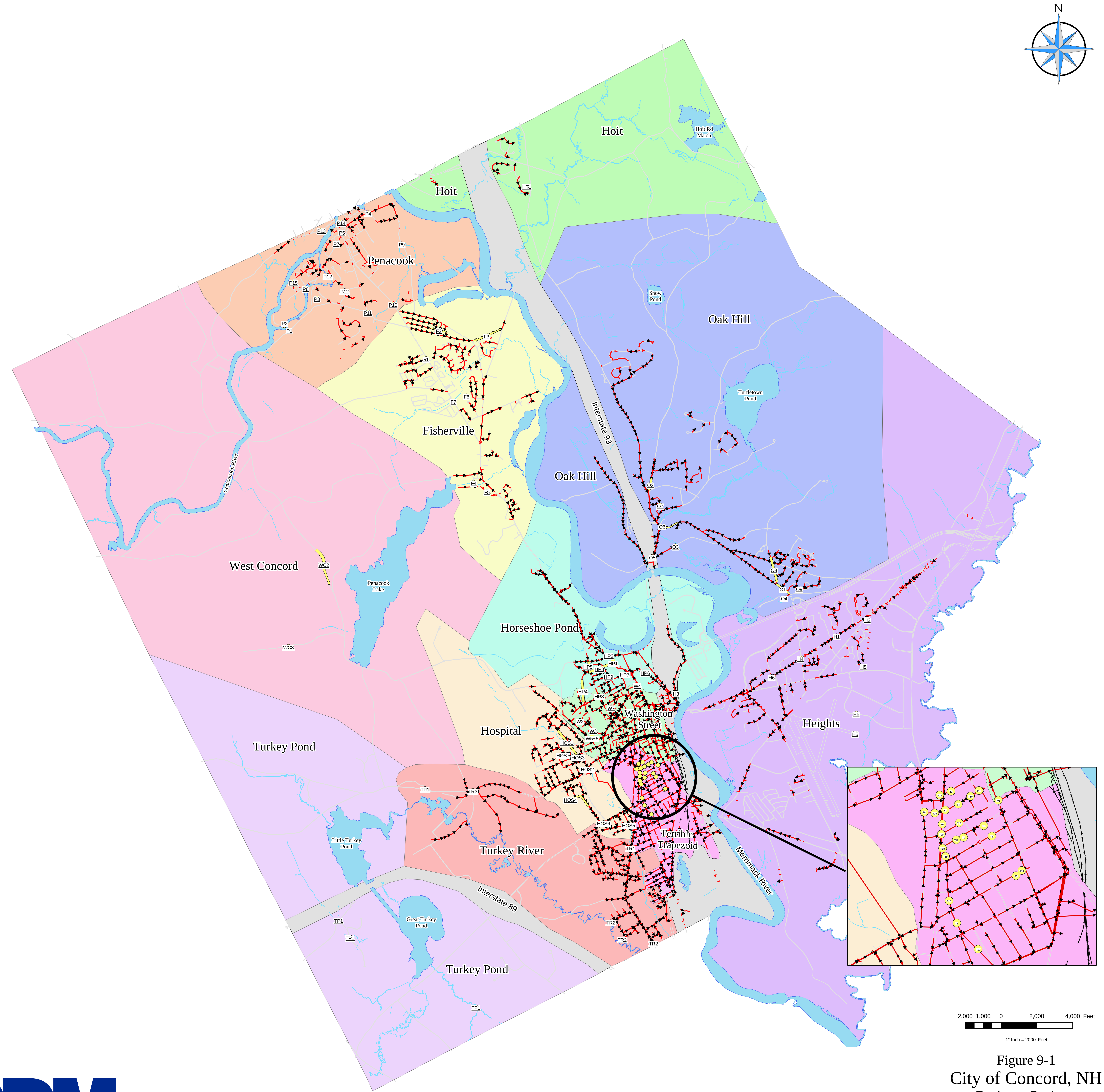


Figure 9-1
City of Concord, NH
Drainage Projects
and Sub-basin Areas
March 2007

CDM

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Section 10
Capital Improvements Plan (CIP)

Identified problem areas and known problem areas, now referred to as projects are summarized in this section. Each project has been given a score based on the eight criteria discussed in Section 9. The list of projects will be used by the City to formulate a Capital Improvements Plan (CIP) that will be the basis for selecting drainage projects in the City for the present and future. The projects that score the highest will be considered a top priority. Table 10-1 and 10-2 list all the projects and their associated total score.

10.1 Summary of Projects

A total of 89 projects were identified based on the evaluation and analysis of the twelve drainage basins throughout the City of Concord. The total scores for the projects ranged from the lowest of 10 to the highest of 34. The summary below lists the number of projects that fall within a certain range of total score:

Total Score	Number of Projects
14 and under	20
15-19	34
20-24	20
25 and above	15

The projects have also been separated by their respective drainage areas. Two drainage areas stand out with the greatest number of projects: the Terrible Trapezoid and Penacook. These two drainage areas make up 35 of the 89 projects (39%). Three outlying drainage areas (West Concord, Turkey Pond, Hoit) with limited development make up only 5 of the 89 projects (6%). The remaining seven drainage areas have approximately the same number of projects, with Turkey River being the only exception. The summary below lists the number of projects by drainage area:

Drainage Area	Number of Projects
Washington	8
Terrible Trapezoid	20
Heights	6
Turkey River	3
Penacook	15
Fisherville	7
Oak Hill	9
Hospital	7
Horseshoe Pond	9
Turkey Pond	1
West Concord	3
Hoit	1

10.2 Project Costs

Cost is an important factor in project selection, as the City planned expenditures must be in-line with the budget allotted for this work. The goal of this Storm Water Master Plan is to provide the City a general idea of the financial expenditures needed for the upkeep and upgrade of their storm water infrastructure for the future. A CIP (Capital Improvements Plan) for the next 5 years and future years will be formed based on this project list.

Planning level construction and engineering cost estimates are included for each project. These costs should be re-evaluated for each project that gets added to the CIP before preliminary design begins. The assumptions made for new construction work for each project are listed in Table 10-1 under the "Description" column. The cost for the engineering services of each project was determined to be 10 percent the construction cost and provides a planning level estimate. Once projects are selected and a better feel for the tasks are identified, the engineering cost can be revised.

The project list is sorted by total score based on the eight criteria discussed above. For scores within a few numbers of each other, the costs must also be considered. The projects with the greatest impact for the lowest cost should be considered first.

Note that the presented costs are planning stage only. The construction costs are based upon other similar work done in the region recently. An approximate cost per linear foot was determined for each size/material of new pipe. The cost per linear foot includes pipe, manholes, catch basin connections, gravel sub-base, temporary pavement, full width pavement, police details, miscellaneous items and work, mobilization and a planning level multiplying factor. The given project costs are suitable only for comparison between projects in this analysis and do not include escalation.

10.3 Recommendations

It is recommended that all projects which scored 20 total points or higher be included in the Capital Improvements Plan (CIP). There are 35 projects that fall within this total point range, of which 28 should be included in the CIP. The remaining 7 projects have either been addressed by the City, are awaiting NHDOT approval or are currently under design. Table 10-1 presents more detailed information. The summary below lists the 28 recommended projects by drainage area:

Drainage Area	# of Projects
Hospital	4
Heights	4
Oak Hill	6
Penacook	5
Turkey River	2

Washington	1
Fisherville	3
Horseshoe Pond	2
West Concord	1

There are three major projects greater than $1M in total cost included in the list of 28 recommended projects. Two of the projects are located in the Heights Sub-basin and the other is located in Fisherville Sub-basin. The following is a description of each major project:

- Heights Sub-basin – this project is in the Birdland neighborhood. The drainage pipes in this neighborhood have undersized pipes along Ormond Street, Christian Avenue, Oriole Road, East Side Drive and Partridge Road. It is recommended that all existing drain pipe be replaced with larger more appropriately sized drain pipes.

- Heights Sub-basin – this project had the highest total cost. The drainage pipes along Loudon Road and East Side Drive that flow westerly to the Merrimack River are undersized. It is recommended that all existing drain pipe be replaced with larger more appropriately sized drain pipes.

- Fisherville Sub-basin - this project includes a long stretch of drain work (approximately 3,900 linear feet). The drainage pipes along Manor Road and Sewalls Falls Road that flow north to the Merrimack River are undersized. It is recommended that all existing drain pipes be replaced with larger more appropriately sized drain pipes.

The remaining 25 recommended projects are all less than $1M in total cost. It is recommended that the City evaluate these projects and spread them evenly over the course of a 5-year CIP. This will effectively address the address all of the highest priority drainage projects for the City throughout its 12 sub-basins.

10.4 Summary and Conclusions

This report serves as a guide to the City of Concord for future storm water planning. It is recommended that many of the issues detailed in this report be included in the upcoming 5-year CIP. Those issues are:

1. Perform the 28 storm water improvement projects listed in Section 10.3 above.

2. Investigation of potential illicit sewer connections identified in Section 7.

3. Feasibility study for a Storm Water Utility to provide funding for projects.

4. Continue performing storm water best management practices.

It is recommended that all remaining storm water projects listed in Table 10-1 be considered for inclusion in future CIPs. Performing this work would allow the City to maintain and upgrade their storm water infrastructure.

Sect	Drainage Basin	Sub Basin	Location	On Map	Project #	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
							Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
6.9	Horseshoe Pond	HP2	East end of Walker St, corner of Walker and North State St.	HP2	77	18" and 24" Diameter; Pipes with 90° turns & capacity issues.	The NHDOT is designing a new piping scheme here.	**4**	**3**	**4**	**5**	**5**	**3**	**5**	**5**	**34**	**NHDOT project**	**$0**	**$0**	**NHDOT design of these pipes have begun but is currently on hold**	*1*
6.9	Horseshoe Pond	HP1	East end of Walker Street, corner of Walker & North State	HP1	76	18" and 20" Diameter; Pipes with 90° turns & capacity issues.	The NHDOT is designing a new piping scheme here.	**4**	**2**	**4**	**5**	**5**	**3**	**5**	**5**	**33**	**NHDOT project**	**$0**	**$0**	**NHDOT design of these pipes have begun but is currently on hold**	*2*
6.5	Penacook	Rolfe Canal	River Road at The Island Road	P1	38	Continued Isolated Flooding; No existing piping	Improved drainage, storage, or re-grading.	**1**	**5**	**5**	**3**	**5**	**1**	**5**	**5**	**30**	**Completed**	**$0**	**$0**	**Construction completed by General Services Division**	*3*
6.5	Penacook	Contoo cook	River Rd southwest Island Rd	P2	39	Continued Isolated Flooding; No existing piping	Improved drainage, storage, or re-grading.	**1**	**5**	**5**	**3**	**5**	**1**	**5**	**5**	**30**	**Completed**	**$0**	**$0**	**Construction completed by General Services Division**	*4*
6.4	Turkey River	Bow Brk	Bow Brook passing under both South St and Bow St. and Sunset Ave flow into Bow Brook	TR1	35	48" (South Street) and 12" (Sunset Ave) pipes are undersized for flow from the South Street area.	Existing 24" overflow discharges to brook south of this outlet. May have already resolved this issue.	**4**	**3**	**4**	**2**	**5**	**4**	**3**	**4**	**29**	**$118,325**	**$11,833**	**$130,158**	**Installation includes new 24" RC pipe for 300 LF and 18" PVC for 125 LF**	*5*
6.8	Hospital	H	Bow Brook culverts under School St and Warren St	HOS3	71	Culverts were washed out during the May 2006 storm. The School St culvert was undersized	City currently under design to repair/replace culvert	**5**	**5**	**4**	**3**	**5**	**3**	**0**	**4**	**29**	**$171,000**	**$19,000**	**$190,000**	**City temporarily repaired wash out. City to prepare design for new permanent culvert. FEMA and FHwA (Federal Highway Administration) paid for project.**	*6*
6.6	Fisherville	Upper	Lake St	F5	57	Road is poor conditions, limited catch basins and drain pipes	Line existing pipe, install new pipes & catch basins and repave road	**3**	**3**	**3**	**3**	**5**	**2**	**3**	**5**	**27**	**$380,550**	**$38,055**	**$418,605**	**Installation of new 18" PVC pipe for 1,350 LF and line 12" pipe for 650 LF**	*7*
6.11	West Concord	Penna cook Lake	Road side ditches along Carter Hill Road	WC2	87	Steep with high velocity runoff, large riprap pushed to bottom of hill.	Consider veins or other means to break velocity, or detention near top of hill.	**0**	**5**	**5**	**5**	**5**	**2**	**5**	**0**	**27**	**$90,000**	**$10,000**	**$100,000**	**City design of this problem is complete. Construction to begin in 2007.**	*8*
6.3	Heights	Loudon	Small dia. pipes a Nodes "U", "W" and "AA"	H5	33	24" thru 12" dia. pipes undersized for 10-year storm	Consider replacing pipes with large dia. pipes	**5**	**4**	**5**	**0**	**5**	**2**	**0**	**5**	**26**	**$467,900**	**$46,790**	**$514,690**	**Installation includes new 36" RC pipe for 560 LF, 30" RC pipe for 930 LF**	*9*
6.3	Heights	Birdland	Small dia. pipes along Ormond St. Christian Ave, Oriole Rd, East Side Dr and Partridge Rd	H6	34	12" and 15" dia. pipes undersized for 10-year storm	Consider more detailed study of drainage area and replace pipes with larger dia. pipes	**3**	**5**	**5**	**3**	**3**	**2**	**0**	**5**	**26**	**$1,998,340**	**$199,834**	**$2,198,174**	**Installation includes new 54" RC pipe for 1,305 LF, 48" RC pipe for 940 LF, 42" RC pipe for 1,145 LF, 30" RC pipe for 605 LF, 24" RC pipe for 500 LF and 18" PVC pipe for 925 LF**	*10*
6.7	Oak Hill	OH2	West Sugarball Road to outfall on Merrimack River	O4	63	Severe washout and erosion	Repair/Reconstruct drainage outfall	**2**	**2**	**4**	**5**	**5**	**5**	**0**	**3**	**26**	**$133,600**	**$13,360**	**$146,960**	**Installation of new 36" RC pipe for 400 LF and repair existing outfall structure.**	*11*
6.8	Hospital	H	South of Redington Road, west of Fruit Street, 30" pipe	HOS4	72	Flat area has poor drainage	Consider installing larger pipes.	**0**	**4**	**3**	**3**	**5**	**2**	**5**	**4**	**26**	**$549,000**	**$54,900**	**$603,900**	**Installation of new 42" RC pipe for 1,500 LF**	*12*
6.5	Penacook	Contoo cook	Charles Street and Contoocook River	P6	43	12" pipe is undersized	Detention, storage, or increase in pipe size.	**3**	**1**	**5**	**1**	**5**	**2**	**3**	**5**	**25**	**$57,800**	**$5,780**	**$63,580**	**Installation of new 24" RC pipe for 200 LF**	*13*
6.8	Hospital	H	Bow Brook culvert under Pleasant St as the pipe enters State Hospital grounds	HOS2	70	Culvert was washed out during the May 2006 storm.	City currently under design to repair/replace culvert	**5**	**5**	**0**	**3**	**5**	**3**	**0**	**4**	**25**	**$126,000**	**$14,000**	**$140,000**	**City temporarily repaired wash out. City to prepare design for new permanent culvert. FEMA and FHwA (Federal Highway Administration) paid for project.**	*14*
6.11	West Concord	Miller's Brook	Intersection of Pleasant Street and Miller's Brook	WC1	86	Undersized culvert causing backups	Consider culvert replacement or storage/retention.	**3**	**3**	**1**	**3**	**5**	**0**	**5**	**5**	**25**	**$20,040**	**$2,004**	**$22,044**	**Installation of new 36" RC pipe for 60 LF**	*15*
6.5	Penacook	Merri mack	Merrimack St and Bye St pipes	P4	41	12" pipes are undersized and illicit sewer connection	Detention, storage, or increase in pipe size along with separating sewer connection	**3**	**1**	**5**	**2**	**5**	**2**	**3**	**3**	**24**	**$558,200**	**$55,820**	**$614,020**	**Installation of new 30" RC pipe for 1,000 LF and 42" RC pipe for 700 LF**	*16*
6.5	Penacook	Contoo cook	Tanner Street and Village Street	P5	42	15" and 12" pipes are undersized	Detention, storage, or increase in pipe size.	**3**	**2**	**5**	**1**	**5**	**2**	**3**	**3**	**24**	**$306,550**	**$30,655**	**$337,205**	**Installation of new 24" RC pipe for 700 LF and 48" RC pipe for 250 LF**	*17*
6.8	Hospital	H	Noyes Street near Harvard Street	HOS5	73	18" pipe undersized	Reduce flow through retention or storage; or replace with a larger pipe	**3**	**2**	**5**	**0**	**5**	**5**	**0**	**4**	**24**	**$57,800**	**$5,780**	**$63,580**	**Installation of new 24" RC pipe for 200 LF**	*18*
6.9	Horseshoe Pond	HP2	Rumford St, between Penacook St and Jennings St	HP5	80	Undersized 8" Diam pipe from large area to Walker St	Consider pipe replacement	**2**	**1**	**5**	**1**	**5**	**0**	**5**	**5**	**24**	**$134,750**	**$13,475**	**$148,225**	**Installation of new 15" PVC pipe for 550 LF**	*19*
6.5	Penacook	Rolfe Canal	Low Area at Borough, Washington and Fowler triangle	P3	40	Low area in neighborhood experiences severe flooding in heavy rain and spring conditions	Install new drainage pipes and outfalls or drywells for an immediate solution	**0**	**3**	**5**	**3**	**2**	**2**	**3**	**5**	**23**	**$385,500**	**$38,550**	**$424,050**	**Installation of new 12" and 15" PVC drainage for 1000 LF and 24' RC pipe for 500 LF**	*20*
6.7	Oak Hill	OH2	East Side Dr from Heritage Heights Road to South Curtisville Rd	O1	60	12" pipes are undersized	Replace 12" pipe with larger dia. pipe.	**3**	**3**	**4**	**1**	**3**	**1**	**3**	**5**	**23**	**$352,070**	**$35,207**	**$387,277**	**Installation of new 24" RC pipe for 330 LF and 30" RC pipe for 850 LF**	*21*
6.7	Oak Hill	OH1	Outfall at Eastman and Portsmouth	O5	64	24" pipe undersized for 10-year storm	Reducing incoming flow with detention, or increase size of pipe.	**0**	**3**	**4**	**0**	**5**	**5**	**3**	**3**	**23**	**$200,400**	**$20,040**	**$220,440**	**Installation of new 36" RC pipe for 600 LF**	*22*
6.7	Oak Hill	OH2	South Curtisville Rd from East Side Dr to north of Portsmouth St	O8	67	24" and 8" pipes feeding detention pond at Node LL are undersized	Redirect some flow in the basin to alternate detention. Or replace with larger pipes.	**3**	**4**	**4**	**0**	**5**	**1**	**3**	**3**	**23**	**$75,500**	**$7,550**	**$83,050**	**Installation of new 30" RC pipe for 250 LF**	*23*
6.9	Horseshoe Pond	HP2	Walker St from North State St to Liberty St	HP3	78	8", 15" and 20" Diameter, Excess flow & severe capacity problems	Replace with a larger pipe	**2**	**2**	**5**	**1**	**5**	**0**	**3**	**5**	**23**	**$553,645**	**$55,365**	**$609,010**	**Installation of new 24" RC pipe for 225 LF, 30" RC pipe for 700 LF and 36" RC pipe for 830 LF**	*24*
6.3	Heights	Mall	Southwest of intersection of Loudon Rd & Branch Turnpike	H2	30	30" pipe discharges to a detention basin with an 18" outlet across Branch Turnpike. 18" backs up.	Replace with 36" pipe along Branch Turnpike to exsting 42" on Loudon Rd. Private Property owner to perform work	**5**	**4**	**5**	**4**	**0**	**1**	**3**	**0**	**22**	**Private Project**	**$0**	**$0**	**Installation of new 36" RC pipe for 800 LF on Branch Turnpike and Loudon Rd.**	*25*

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Project #*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
							Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.6	Fisherville	Upper	Along Manor Road, Sewalls Falls Rd to the Merrimack River.	F3	55	24" pipe undersized for flow expected.	Investigate relief to the north side of Abbott Rd or Manor Rd or upsize pipe.	**3**	**3**	**5**	**1**	**2**	**0**	**3**	**5**	**22**	**$1,630,470**	**$163,047**	**$1,793,517**	**Installation of new 48" RC pipe for 3,910 LF**	*26*
6.6	Fisherville	Rattlesnake Brook	Quaker St, Knight St, and North State St	F4	56	Culverts undersized and not ideal hydraulically	Investigate size of culverts and large culvert elevation changes under North State St	**3**	**5**	**3**	**3**	**5**	**0**	**0**	**3**	**22**	**$33,360**	**$3,336**	**$36,696**	**Installation of new 48' RC culvert for 80 LF**	*27*
6.8	Hospital	H	Bow Brook from Ridge Rd and Terrace Rd	HOS1	69	Outlet pipes are undersized	Replace existing pipes with larger dia. pipes	**0**	**4**	**5**	**0**	**5**	**3**	**0**	**5**	**22**	**$140,560**	**$14,056**	**$154,616**	**Installation of new 30" RC pipe for 200\ LF ad 36" RC pipe for 240 LF**	*28*
4	Washington	Wash	North Main Street at Pearl Street	W4	4	Possible Cross Connection	TV 350' along Pearl Street to pinpoint location; redirect illicit connection(s) to sewer	**5**	**3**	**0**	**3**	**5**	**0**	**0**	**5**	**21**	**$5,700**	**$570**	**$6,270**	**TV inspect 350 LF and disconnect two illicit sewer connections**	*29*
6.4	Turkey River	Turkey River	Separate drainage from South St, Angela Way and Mooreland Ave into Turkey River	TR2	36	15" and 18" pipe is undersized for flow from the three area.	Consider replacing pipes with large dia. pipes	**3**	**2**	**3**	**0**	**3**	**5**	**5**	**0**	**21**	**$442,200**	**$44,220**	**$486,420**	**Installation includes new 30" RC pipe for 1,225 LF and 24' RC pipe for 250 LF**	*30*
6.5	Penacook	Hoyt Brook	Elm St and Contoocook River	P13	50	12" is undersized and removal of temporary drywells	Install new larger dia. pipe and removal drywells	**0**	**4**	**5**	**0**	**3**	**2**	**3**	**4**	**21**	**$469,200**	**$46,920**	**$516,120**	**Installation of new 30" RC pipe for 350 LF, 18" PVC pipe for 500 LF and 12" PVC pipe for 1,000 LF**	*31*
6.7	Oak Hill	OH2	Portsmouth St culvert at Mill Brook crossing	O3	62	Undersized culvert (48" existing). Substantial flooding during May 2006 storm	Replace culvert with larger dia. pipe or box culvert. New size assumed to be 60"	**3**	**1**	**5**	**2**	**2**	**0**	**5**	**3**	**21**	**$20,240**	**$2,024**	**$22,264**	**Installation of new 60' RC pipe for 40 LF**	*32*
6.7	Oak Hill	OH1	East Side Drive from Putney to Eastman	O6	65	8" and 18" pipes undersized for 10-year storm	Redirect some flow in the basin to new detention or brook (with treatment). Or replace undersized pipes.	**3**	**2**	**4**	**0**	**3**	**1**	**3**	**5**	**21**	**$511,310**	**$51,131**	**$562,441**	**Installation of new 30" RC pipe for 650 LF and 24" RC pipe for 1,090 LF**	*33*
6.3	Heights	Loudon	Pipe along Loudon Rd. and East Side Dr.	H4	32	30" and 24" dia. pipe on Loudon Rd and 12' dia. pipe on East Side Dr. undersized for 10-year storm	Consider additional detention or relief in system or replace pipe.	**2**	**4**	**5**	**1**	**2**	**3**	**3**	**0**	**20**	**$7,515,425**	**$751,543**	**$8,266,968**	**Installation includes new 84" RC pipe for 2,400 LF, 72" RC pipe for 1,500 LF, 48' RC pipe for 2,620 LF, 36" RC pipe for 680 LF and 24" RC pipe for 885 LF**	*34*
6.8	Hospital	H	Minot St outlet to Thayer Pond/Bow Brook	HOS7	75	12" pipe is undersized	Replace with a larger pipe.	**0**	**1**	**5**	**0**	**5**	**2**	**3**	**4**	**20**	**$173,400**	**$17,340**	**$190,740**	**Installation of new 24" RC pipe for 600 LF**	*35*
4	Washington	Wash	Celtic St and Lyndon St	W7	7	Collapsed pipe	Replace 400' of 8" diam clay pipe (and one tee-connection)	**5**	**1**	**0**	**3**	**5**	**0**	**0**	**5**	**19**	**$94,800**	**$9,480**	**$104,280**	**Installation of new 8" PVC pipe for 400 LF**	*36*
6.5	Penacook	Rolfe Canal	Washington Street, north of the Rolfe Canal	P7	44	12" pipe is undersized	Detention, storage, or increase in pipe size.	**2**	**1**	**5**	**1**	**3**	**2**	**5**	**0**	**19**	**$200,400**	**$20,040**	**$220,440**	**Installation of new 36" RC pipe for 600 LF**	*37*
6.5	Penacook	Hoyt Brook	Penacook St. culvert at Hoyt Brook	P9	46	24" culvert is undersized	Install new larger dia. culvert	**0**	**3**	**5**	**0**	**3**	**0**	**3**	**5**	**19**	**$17,710**	**$1,771**	**$19,481**	**Installation of new 60" RC culvert for 35 LF**	*38*
6.5	Penacook	Hoyt Brook	East St and Contoocook River	P14	51	12" pipe is undersized	Install new larger dia. pipe	**3**	**1**	**4**	**0**	**3**	**2**	**3**	**3**	**19**	**$50,600**	**$5,060**	**$55,660**	**Installation of new 18" PVC pipe for 200 LF**	*39*
6.9	Horseshoe Pond	HP3	I393/202 at RR Track, west of the southbound I93 offramp	HP6	81	20" Diameter; Undersized.	NHDOT is designing a new pipe to direct excess flow north on North Main St to Horseshoe Pond	**5**	**3**	**4**	**0**	**5**	**2**	**0**	**0**	**19**	**NHDOT project**	**$0**	**$0**	**NHDOT design of these pipes have begun but is currently on hold**	*40*
6.10	Turkey Pond	TP	Five culverts apparently undersized for current conditions.	TP1	85	Culverts potentially undersized, potential for flooding of roads.	Detailed inspection of all culverts, compare culvert size with recommended.	**0**	**3**	**1**	**0**	**5**	**5**	**5**	**0**	**19**	**Inspect**	**$0**	**$0**	**Inspect the five culverts for blockage and sediment build up. Replace with larger culvert if necessary.**	*41*
6.3	Heights	Loudon	Fort Eddy Rd, street crossing near Shaws	H3	31	18"diam pipe overwhelmed by snow melt	Maintain pipe to prevent blockage; Consider snow removal after heavy snow storms.	**4**	**2**	**3**	**3**	**5**	**1**	**0**	**0**	**18**	**Regular Maintenance**	**$0**	**$0**	**Regular maintenance of area should relieve seasonal issues.**	*42*
6.5	Penacook	Hoyt Brook	Local drainage from Millstream Ln, Primrose Ln and Fowler St to Millsteam Brook	P12	49	12", 15" and 24" pipes are undersized	Install new larger dia. pipe	**0**	**3**	**4**	**0**	**3**	**2**	**3**	**3**	**18**	**$189,250**	**$18,925**	**$208,175**	**Installation of new 36" RC pipe for 150 LF and 18" PVC pipe for 550 LF**	*43*
6.8	Hospital	H	Pleasant St from Pleasant View to Kensington Rd	HOS6	74	8" pipe undersized	Replace with a larger pipe.	**3**	**1**	**5**	**0**	**5**	**0**	**0**	**4**	**18**	**$120,800**	**$12,080**	**$132,880**	**Installation of new 30" RC pipe for 400 LF**	*44*
5	Trapezoid	Trap	Downing Street; MH08 - MH09	T6	14	Major and minor cracks, roots	Lining or chemical grouting	**5**	**1**	**0**	**3**	**5**	**0**	**0**	**3**	**17**	**$4,000**	**$400**	**$4,400**	**Line 8" pipe for 100 LF**	*45*
5	Trapezoid	Trap	Downing Street; MH08 - Unknown	T14	22	Major cracks	Lining or chemical grouting	**5**	**1**	**0**	**3**	**5**	**0**	**0**	**3**	**17**	**$9,600**	**$960**	**$10,560**	**Line 12" pipe for 160 LF**	*46*
5	Trapezoid	Trap	Downing Street; MH02 - MH01	T15	23	Collapsed pipe, major cracks, pipe sag, active sewer connection	Replace Pipe	**5**	**1**	**0**	**3**	**5**	**0**	**0**	**3**	**17**	**$53,325**	**$5,333**	**$58,658**	**Installation of new 12" PVC pipe for 225 LF**	*47*
5	Trapezoid	Trap	South and Concord; Main to buried MH1	T20	28	Collapsed pipe, major and minor cracks	Replace Pipe	**5**	**4**	**0**	**3**	**5**	**0**	**0**	**0**	**17**	**$60,435**	**$6,044**	**$66,479**	**Installation of new 12" PVC pipe for 255 LF**	*48*
6.4	Turkey River	Turkey River	Pleasant St , east of Miller's Brook crossing	TR3	37	Overland flow through undersized culvert	Replace existing culvert with larger sized culvert	**0**	**3**	**3**	**3**	**5**	**0**	**3**	**0**	**17**	**$14,450**	**$1,445**	**$15,895**	**Installation of new 24" RC culvert under Pleasant St**	*49*
6.7	Oak Hill	OH1	Shaker Rd from Pekoe Dr to Mountain Rd	O2	6	Roots and other obstructions in the pipe.	Clean and line pipe or replace with larger dia. pipe.	**2**	**2**	**4**	**3**	**3**	**0**	**3**	**0**	**17**	**$130,050**	**$13,005**	**$143,055**	**Installation of new 24" RC pipe for 450 LF**	*50*
6.9	Horseshoe Pond	HP2	Bradley St from Albin St to Perkins St	HP9	84	12" and 20" dia. pipe is undersized	Consider pipe replacement	**5**	**4**	**3**	**0**	**5**	**0**	**0**	**0**	**17**	**$224,250**	**$22,425**	**$246,675**	**Installation of new 18" PVC pipe for 200 LF and 30" RC pipe for 575 LF**	*51*
4	Washington	Wash	Cross Country pipe west of Valley Street	W2	2	Possible Illicit Connection	TV 250' from Chestnut to Valley to pinpoint illicit; redirect to sewer	**3**	**2**	**0**	**3**	**5**	**0**	**3**	**0**	**16**	**$5,500**	**$550**	**$6,050**	**TV inspect 250 LF and disconnect two illicit sewer connections.**	*52*
5	Trapezoid	Trap	South Street Easement; 2475-J15 - 2475.1-J15	T1	9	Pipe Sag (approximately 20" vertical drop)	Replace pipe	**5**	**3**	**0**	**3**	**5**	**0**	**0**	**0**	**16**	**$120,240**	**$12,024**	**$132,264**	**Installation of new 36" RC pipe for 360 LF**	*53*
5	Trapezoid	Trap	South Street Easement (Lincoln St); 1840-J14 - 1846-J14	T8	16	Minor cracks	Lining or chemical grouting	**5**	**3**	**0**	**3**	**5**	**0**	**0**	**0**	**16**	**$18,000**	**$1,800**	**$19,800**	**Line 24" pipe for 150 LF**	*54*

Sect	Drainage Basin	Sub Basin	Location	On Map	Project #	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
							Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
5	Trapezoid	Trap	South Street; 2071.1-J14 - 1844-J14, from Concord to Thompson	T9	17	Major & minor cracks	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$51,300	$5,130	$56,430	Line 36" pipe for 285 LF	55
5	Trapezoid	Trap	South Street; 2071-J14 - 2071.1-J14	T13	21	Minor crack, hole around pipe	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$19,800	$1,980	$21,780	Line 36" pipe for 110 LF	56
5	Trapezoid	Trap	South Street Easement; 2776.1-J15 - 888	T16	24	Minor crack, infiltration	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$23,400	$2,340	$25,740	Line 36" pipe for 130 LF	57
5	Trapezoid	Trap	South Street Easement; 2493.1-J15 - 2691-J15	T17	25	Minor crack, heavy roots	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$113,400	$11,340	$124,740	Line 36" pipe for 630 LF	58
5	Trapezoid	Trap	South Street; 2074-J14 - 2071-J14, near Concord St	T18	26	Minor crack	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$23,580	$2,358	$25,938	Line 36" pipe for 130 LF	59
5	Trapezoid	Trap	Cross Country (Spruce Street) Drain; 2181.1-J14 - 2212-J14	T19	27	Active sewer connections	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$31,500	$3,150	$34,650	Line 36" pipe for 175 LF	60
6.5	Penacook	Rolfe Canal	Electric Ave, contributing to the Rolfe Canal	P8	45	12" pipe is undersized	Detention, storage, or increase in pipe size.	2	1	4	1	3	2	3	0	16	$37,950	$3,795	$41,745	Installation of new 18" PVC pipe for 150 LF	61
6.9	Horseshoe Pond	HP3	Church St between Bouton & State	HP7	82	18" Diameter; Excess flow & capacity problems	Planned overflow should alleviate these issues if constructed	2	2	4	0	5	0	3	0	16	$151,000	$15,100	$166,100	Installation of new 30" RC pipe for 500 LF	62
6.12	Hoit	Hoit	Freedom Acres, between Hoit Rd and Mountain Rd	HT1	89	Back up of detention basin. Poor design. Does not permit access for cleaning & maintenance.	Maintain detention pond	1	2	1	3	2	2	5	0	16	$10,000	$0	$0	Regular maintenance of detention pond.	63
4	Washington	Wash	Concord Street and South State Street	W1	1	Possible Cross Connection	TV 300' along South State and Concord to pinpoint location; redirect illicit connection(s) to sewer.	5	2	0	3	5	0	0	0	15	$5,600	$560	$6,160	TV inspect 300 LF and disconnect two illicit sewer connections.	64
4	Washington	Wash	Liberty Street, north of Vernon St	W5	5	1. Possible cross connection	TV 400' of pipe to located illicit connection; redirect	3	1	0	3	5	0	3	0	15	$5,800	$580	$6,380	TV inspect 400 LF and disconnect two illicit sewer connections	65
4	Washington	Wash	Liberty Street, north of Vernon St	W6	6	2. Joint Failure	Check hydraulics to ensure they will not be affected; if appropriate, plug 8" pipe at manhole.	3	1	0	3	5	0	3	0	15	$800	$80	$880	TV inspect 400 LF	66
4	Washington	Wash	Manholes throughout the subbasin	N/A	8	Excess sedimentation noted in manholes	Schedule City Vactor-Truck to clean regularly	5	2	0	0	5	0	0	3	15	Regular Maintenance	$0	$0	Regular maintenance of the system to remove sediment and debris.	67
6.5	Penacook	Hoyt Brook	Electric Ave complex and Contoocook River	P15	52	12" pipe is undersized	Install new larger dia. pipe	0	3	5	0	2	2	3	0	15	$115,600	$11,560	$127,160	Installation of new 24" RC pipe for 400 LF	68
6.6	Fisherville	Upper	Along Snow Street and Randlett Street.	F2	54	24" pipe undersized for flow expected.	Investigate relief to the north side of Abbott Rd or Manor Rd, or upsize pipe.	1	3	4	1	3	0	3	0	15	$677,580	$67,758	$745,338	Installation of new 36" RC pipe for 480 LF, 42" RC pipe for 160 LF and 48" RC pipe for 1,100 LF	69
5	Trapezoid	Trap	Fayette Street; MH03 - MH01	T2	10	Collapsed pipe, major cracks, misaligned pipes, etc.	Replace pipe	5	1	0	3	5	0	0	0	14	$7,110	$711	$7,821	Installation of new 12" PVC pipe for 30 LF	70
5	Trapezoid	Trap	Thorndike Street; MH04 - MH05	T3	11	Crushed pipe, major cracks, some roots	Replace pipe	5	1	0	3	5	0	0	0	14	$14,220	$1,422	$15,642	Installation of new 12" PVC pipe for 60 LF	71
5	Trapezoid	Trap	Thompson Street; MH03 - MH02	T4	12	Collapsed pipe, major and minor cracks	Replace pipe	5	1	0	3	5	0	0	0	14	$30,810	$3,081	$33,891	Installation of new 12" PVC pipe for 130 LF	72
5	Trapezoid	Trap	Monroe Street; MH01 - MH02	T5	13	Crushed pipe, hole around service	Replace pipe	5	1	0	3	5	0	0	0	14	$40,290	$4,029	$44,319	Installation of new 12" PVC pipe for 170 LF	73
5	Trapezoid	Trap	Thompson Street; MH03 - MH04	T7	15	Crushed pipe, major and minor cracks	Replace pipe	5	1	0	3	5	0	0	0	14	$47,400	$4,740	$52,140	Installation of new 12" PVC pipe for 200 LF	74
5	Trapezoid	Trap	Thompson Street; MH01 - MH02	T10	18	Crushed pipe, major cracks	Replace pipe	5	1	0	3	5	0	0	0	14	$54,510	$5,451	$59,961	Installation of new 12" PVC pipe for 230 LF	75
5	Trapezoid	Trap	Monroe Street; MH02 - MH03	T11	19	Crushed pipe, major cracks	Replace Pipe	5	1	0	3	5	0	0	0	14	$31,995	$3,200	$35,195	Installation of new 12" PVC pipe for 135 LF	76
5	Trapezoid	Trap	Chesley Street; MH01 - MH04 Fayette	T12	20	Major cracks	Lining or chemical grouting	5	1	0	3	5	0	0	0	14	$1,000	$100	$1,100	Line 8" pipe for 25 LF	77
6.5	Penacook	Hoyt Brook	Lilac St , north of Hoyt Brook	P11	48	12" pipe is undersized	Install new larger dia. pipe	0	4	5	0	3	2	0	0	14	$151,000	$15,100	$166,100	Installation of new 30" RC pipe for 500 LF	78
6.6	Fisherville	Beaver Meadow	Douglas Ave to Fisherville Rd	F1	53	24" pipe is undersized for the flow expected.	Investigate retaining flow from Douglas Ave, or redirect to Alice or Mayflower.	1	3	4	1	2	0	3	0	14	$417,500	$41,750	$459,250	Installation of new 36" RC pipe for 1,250 LF	79
6.9	Horseshoe Pond	HP2	Liberty St and Franklin St	HP4	79	8" Diam; Excess flow/capacity problems, especially near Wyman St	Consider pipe replacement	2	1	5	1	2	0	3	0	14	$709,700	$70,970	$780,670	Installation of new 18" PVC pipe for 1,640 LF and 24" RC pipe for 1,020 LF	80
6.6	Fisherville	Upper	Fisherville Rd and Beaver Meadow Brook	F7	59	2.5'x5.5' box culvert surcharges	Install new culvert	0	5	0	5	3	0	0	0	13	$24,250	$2,425	$26,675	Installation of new 54" RC culvert for 50 LF	81
6.7	Oak Hill	OH1	Winthrop Street and Shawmut st	O7	66	8" and 12" pipes undersized for 10-year storm	Redirect some flow in the basin to new detention. Or replace undersized pipe.	0	1	5	0	3	1	3	0	13	$298,100	$29,810	$327,910	Installation of new 15" PVC pipe for 450 LF and 24" RC pipe for 650 LF	82
6.7	Oak Hill	OH2	Pelham Lane	O9	68	Undersized pipe (18" existing)	Redirect flow to detention. Or replace 18" pipe with 30" pipe.	0	2	5	0	0	1	5	0	13	$105,700	$10,570	$116,270	Installation of new 30" RC pipe for 350 LF	83
6.9	Horseshoe Pond	HP2	Wyman Street and Rumford St to Highland St	HP8	83	6" and 10" dia. pipe is undersized	Consider pipe replacement	0	0	5	0	5	0	3	0	13	$85,750	$8,575	$94,325	Installation of new 15" PVC pipe for 350 LF	84
4	Washington	Wash	Valley Street, between Forest Street & Liberty Street, into White Park	W3	3	Small amount of grey-colored flow with a slight septic smell noticed.	Repair of pipe on Valley Street may solve this problem. If not, continue investigation & repairs	3	1	0	0	5	0	3	0	12	$6,400	$640	$7,040	TV inspect 700 LF and disconnect two illicit sewer connections	85
6.5	Penacook	Hoyt Brook	Hoyt Brook crossings at Manor Rd and Village St	P10	47	36" culverts are undersized	Install new larger dia. culvert	0	5	4	0	3	0	0	0	12	$35,420	$3,542	$38,962	Installation of two new 60" RC culverts for 70 LF	86

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Project #*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
							Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.6	Fisherville	Upper	Gallen Dr. and Alder Creek Dr	F6	58	Surface elevations slope towards Gallen Dr but water outlets under Alder Creek Rd causing water backup	Inspect 48" culvert for clogging or sediment build up. Remediate as needed	**0**	**5**	**0**	**3**	**3**	**0**	**0**	**0**	**11**	**Culvert Inspection**	**$0**	**$0**	**Inspect large culvert and look for sediment build up or other blockages**	*87*
6.11	West Concord	Miller's Brook	***Private*** Drive off Fisk Road at Millers Brook - NOT CITY PRIORITY, SINCE PRIVATE ROAD	WC3	88	Brook periodically floods private drive.	Consider culvert replacement or storage/retention.	**0**	**2**	**1**	**2**	**2**	**4**	**0**	**0**	**11**	**$0**	**$0**	**$0**	**N/A - Private driveway**	*88*
6.3	Heights	Mall	Woodcrest Heights Rd at Loudon Rd to D'Amante Dr.	H1	29	Flow from Loudon Rd occasionally backs up into 12" pipe of detention basin on Woodcrest Heights Rd.	Consider flap valve on pipe, or alternative relief into another detention basin or upsizing of drain pipe along Loudon Rd.	**3**	**1**	**0**	**3**	**2**	**1**	**0**	**0**	**10**	**$820,800**	**$82,080**	**$902,880**	**Installation of new 36" RC pipe for 1,800 LF and new 42" RC pipe for 600 LF on Loudon Rd.**	*89*

Sect	Drainage Basin	Sub Basin	Location	On Map	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
						Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
4	Washington	Wash	North Main Street at Pearl Street	W4	Possible Cross Connection	TV 350' along Pearl Street to pinpoint location; redirect illicit connection(s) to sewer	5	3	0	3	5	0	0	5	21	$5,700	$570	$6,270	TV inspect 350 LF and disconnect two illicit sewer connections	29
4	Washington	Wash	Celtic St and Lyndon St	W7	Collapsed pipe	Replace 400' of 8" diam clay pipe (and one tee-connection)	5	1	0	3	5	0	0	5	19	$94,800	$9,480	$104,280	Installation of new 8" PVC pipe for 400 LF	36
4	Washington	Wash	Cross Country pipe west of Valley Street	W2	Possible Illicit Connection	TV 250' from Chestnut to Valley to pinpoint illicit; redirect to sewer	3	2	0	3	5	0	3	0	16	$5,500	$550	$6,050	TV inspect 250 LF and disconnect two illicit sewer connections.	52
4	Washington	Wash	Concord Street and South State Street	W1	Possible Cross Connection	TV 300' along South State and Concord to pinpoint location; redirect illicit connection(s) to sewer.	5	2	0	3	5	0	0	0	15	$5,600	$560	$6,160	TV inspect 300 LF and disconnect two illicit sewer connections.	64
4	Washington	Wash	Liberty Street, north of Vernon St	W5	1. Possible cross connection	TV 400' of pipe to located illicit connection; redirect	3	1	0	3	5	0	3	0	15	$5,800	$580	$6,380	TV inspect 400 LF and disconnect two illicit sewer connections	65
4	Washington	Wash	Liberty Street, north of Vernon St	W6	2. Joint Failure	Check hydraulics to ensure they will not be affected; if appropriate, plug 8" pipe at manhole.	3	1	0	3	5	0	3	0	15	$800	$80	$880	TV inspect 400 LF	66
4	Washington	Wash	Manholes throughout the subbasin	N/A	Excess sedimentation noted in manholes	Schedule City Vactor-Truck to clean regularly	5	2	0	0	5	0	0	3	15	Regular Maintenance	$0	$0	Regular maintenance of the system to remove sediment and debris.	67
4	Washington	Wash	Valley Street, between Forest Street & Liberty Street, into White Park	W3	Small amount of grey-colored flow with a slight septic smell noticed.	Repair of pipe on Valley Street may solve this problem. If not, continue investigation & repairs	3	1	0	0	5	0	3	0	12	$6,400	$640	$7,040	TV inspect 700 LF and disconnect two illicit sewer connections	85

Sect	Drainage Basin	Sub Basin	Location	On Map	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
						Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
5	Trapezoid	Trap	Downing Street; MH08 - MH09	T6	Major and minor cracks, roots	Lining or chemical grouting	5	1	0	3	5	0	0	3	17	$4,000	$400	$4,400	Line 8" pipe for 100 LF	45
5	Trapezoid	Trap	Downing Street; MH08 - Unknown	T14	Major cracks	Lining or chemical grouting	5	1	0	3	5	0	0	3	17	$9,600	$960	$10,560	Line 12" pipe for 160 LF	46
5	Trapezoid	Trap	Downing Street; MH02 - MH01	T15	Collapsed pipe, major cracks, pipe sag, active sewer connection	Replace Pipe	5	1	0	3	5	0	0	3	17	$53,325	$5,333	$58,658	Installation of new 12" PVC pipe for 225 LF	47
5	Trapezoid	Trap	South and Concord; Main to buried MH1	T20	Collapsed pipe, major and minor cracks	Replace Pipe	5	4	0	3	5	0	0	0	17	$60,435	$6,044	$66,479	Installation of new 12" PVC pipe for 255 LF	48
5	Trapezoid	Trap	South Street Easement; 2475-J15 - 2475.1-J15	T1	Pipe Sag (approximately 20" vertical drop)	Replace pipe	5	3	0	3	5	0	0	0	16	$120,240	$12,024	$132,264	Installation of new 36" RC pipe for 360 LF	53
5	Trapezoid	Trap	South Street Easement (Lincoln St); 1840-J14 - 1846-J14	T8	Minor cracks	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$18,000	$1,800	$19,800	Line 24" pipe for 150 LF	54
5	Trapezoid	Trap	South Street; 2071.1-J14 - 1844-J14, from Concord to Thompson	T9	Major & minor cracks	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$51,300	$5,130	$56,430	Line 36" pipe for 285 LF	55
5	Trapezoid	Trap	South Street; 2071-J14 - 2071.1-J14	T13	Minor crack, hole around pipe	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$19,800	$1,980	$21,780	Line 36" pipe for 110 LF	56
5	Trapezoid	Trap	South Street Easement; 2776.1-J15 - 888	T16	Minor crack, infiltration	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$23,400	$2,340	$25,740	Line 36" pipe for 130 LF	57
5	Trapezoid	Trap	South Street Easement; 2493.1-J15 - 2691-J15	T17	Minor crack, heavy roots	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$113,400	$11,340	$124,740	Line 36" pipe for 630 LF	58
5	Trapezoid	Trap	South Street; 2074-J14 - 2071-J14, near Concord St	T18	Minor crack	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$23,580	$2,358	$25,938	Line 36" pipe for 130 LF	59
5	Trapezoid	Trap	Cross Country (Spruce Street) Drain; 2181.1-J14 - 2212-J14	T19	Active sewer connections	Lining or chemical grouting	5	3	0	3	5	0	0	0	16	$31,500	$3,150	$34,650	Line 36" pipe for 175 LF	60
5	Trapezoid	Trap	Fayette Street; MH03 - MH01	T2	Collapsed pipe, major cracks, misaligned pipes, etc.	Replace pipe	5	1	0	3	5	0	0	0	14	$7,110	$711	$7,821	Installation of new 12" PVC pipe for 30 LF	70
5	Trapezoid	Trap	Thorndike Street; MH04 - MH05	T3	Crushed pipe, major cracks, some roots	Replace pipe	5	1	0	3	5	0	0	0	14	$14,220	$1,422	$15,642	Installation of new 12" PVC pipe for 60 LF	71
5	Trapezoid	Trap	Thompson Street; MH03 - MH02	T4	Collapsed pipe, major and minor cracks	Replace pipe	5	1	0	3	5	0	0	0	14	$30,810	$3,081	$33,891	Installation of new 12" PVC pipe for 130 LF	72
5	Trapezoid	Trap	Monroe Street; MH01 - MH02	T5	Crushed pipe, hole around service	Replace pipe	5	1	0	3	5	0	0	0	14	$40,290	$4,029	$44,319	Installation of new 12" PVC pipe for 170 LF	73
5	Trapezoid	Trap	Thompson Street; MH03 - MH04	T7	Crushed pipe, major and minor cracks	Replace pipe	5	1	0	3	5	0	0	0	14	$47,400	$4,740	$52,140	Installation of new 12" PVC pipe for 200 LF	74
5	Trapezoid	Trap	Thompson Street; MH01 - MH02	T10	Crushed pipe, major cracks	Replace pipe	5	1	0	3	5	0	0	0	14	$54,510	$5,451	$59,961	Installation of new 12" PVC pipe for 230 LF	75
5	Trapezoid	Trap	Monroe Street; MH02 - MH03	T11	Crushed pipe, major cracks	Replace Pipe	5	1	0	3	5	0	0	0	14	$31,995	$3,200	$35,195	Installation of new 12" PVC pipe for 135 LF	76
5	Trapezoid	Trap	Chesley Street; MH01 - MH04 Fayette	T12	Major cracks	Lining or chemical grouting	5	1	0	3	5	0	0	0	14	$1,000	$100	$1,100	Line 8" pipe for 25 LF	77

Sect	Drainage Basin	Sub Basin	Location	On Map	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
						Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
6.3	Heights	Loudon	Small dia. pipes a Nodes "U", "W" and "AA"	H5	24" thru 12" dia. pipes undersized for 10-year storm	Consider replacing pipes with large dia. pipes	5	4	5	0	5	2	0	5	26	$467,900	$46,790	$514,690	Installation includes new 36" RC pipe for 560 LF, 30" RC pipe for 930 LF	9
6.3	Heights	Birdland	Small dia. pipes along Ormond St. Christian Ave, Oriole Rd, East Side Dr and Partridge Rd	H6	12" and 15" dia. pipes undersized for 10-year storm	Consider more detailed study of drainage area and replace pipes with larger dia. pipes	3	5	5	3	3	2	0	5	26	$1,998,340	$199,834	$2,198,174	Installation includes new 54" RC pipe for 1,305 LF, 48" RC pipe for 940 LF, 42" RC pipe for 1,145 LF, 30" RC pipe for 605 LF, 24" RC pipe for 500 LF and 18" PVC pipe for 925 LF	10

6.3	Heights	Mall	Southwest of intersection of Loudon Rd & Branch Turnpike	H2	30" pipe discharges to a detention basin with an 18" outlet across Branch Turnpike. 18" backs up.	Replace with 36" pipe along Branch Turnpike to exsting 42" on Loudon Rd. Private Property owner to perform work	5	4	5	4	0	1	3	0	22	Private Project	$0	$0	**Installation of new 36" RC pipe for 800 LF on Branch Turnpike and Loudon Rd.**	**25**
6.3	Heights	Loudon	Pipe along Loudon Rd. and East Side Dr.	H4	30" and 24" dia. pipe on Loudon Rd and 12' dia. pipe on East Side Dr. undersized for 10-year storm	Consider additional detention or relief in system or replace pipe.	2	4	5	1	2	3	3	0	20	$7,515,425	$751,543	$8,266,968	**Installation includes new 84" RC pipe for 2,400 LF, 72" RC pipe for 1,500 LF, 48' RC pipe for 2,620 LF, 36" RC pipe for 680 LF and 24" RC pipe for 885 LF**	**34**
6.3	Heights	Loudon	Fort Eddy Rd, street crossing near Shaws	H3	18"diam pipe overwhelmed by snow melt	Maintain pipe to prevent blockage; Consider snow removal after heavy snow storms.	4	2	3	3	5	1	0	0	18	Regular Maintenance	$0	$0	**Regular maintenance of area should relieve seasonal issues.**	**42**
6.3	Heights	Mall	Woodcrest Heights Rd at Loudon Rd to D'Amante Dr.	H1	Flow from Loudon Rd occasionally backs up into 12" pipe of detention basin on Woodcrest Heights Rd.	Consider flap valve on pipe, or alternative relief into another detention basin or upsizing of drain pipe along Loudon Rd.	3	1	0	3	2	1	0	0	10	$820,800	$82,080	$902,880	**Installation of new 36" RC pipe for 1,800 LF and new 42" RC pipe for 600 LF on Loudon Rd.**	**89**

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.4	Turkey River	Bow Brk	Bow Brook passing under both South St and Bow St. and Sunset Ave flow into Bow Brook	TR1	48" (South Street) and 12" (Sunset Ave) pipes are undersized for flow from the South Street area.	Existing 24" overflow discharges to brook south of this outlet. May have already resolved this issue.	4	3	4	2	5	4	3	4	29	$118,325	$11,833	$130,158	**Installation includes new 24" RC pipe for 300 LF and 18" PVC for 125 LF**	**5**
6.4	Turkey River	Turkey River	Separate drainage from South St, Angela Way and Mooreland Ave into Turkey River	TR2	15" and 18" pipe is undersized for flow from the three area.	Consider replacing pipes with large dia. pipes	3	2	3	0	3	5	5	0	21	$442,200	$44,220	$486,420	**Installation includes new 30" RC pipe for 1,225 LF and 24' RC pipe for 250 LF**	**30**
6.4	Turkey River	Turkey River	Pleasant St , east of Miller's Brook crossing	TR3	Overland flow through undersized culvert	Replace existing culvert with larger sized culvert	0	3	3	3	5	0	3	0	17	$14,450	$1,445	$15,895	**Installation of new 24" RC culvert under Pleasant St**	**49**

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.5	Penacook	Rolfe Canal	River Road at The Island Road	P1	Continued Isolated Flooding; No existing piping	Improved drainage, storage, or re-grading.	1	5	5	3	5	1	5	5	30	Completed	$0	$0	**Construction completed by General Services Division**	**3**
6.5	Penacook	Contoocook	River Rd southwest Island Rd	P2	Continued Isolated Flooding; No existing piping	Improved drainage, storage, or re-grading.	1	5	5	3	5	1	5	5	30	Completed	$0	$0	**Construction completed by General Services Division**	**4**
6.5	Penacook	Contoocook	Charles Street and Contoocook River	P6	12" pipe is undersized	Detention, storage, or increase in pipe size.	3	1	5	1	5	2	3	5	25	$57,800	$5,780	$63,580	**Installation of new 24" RC pipe for 200 LF**	**13**
6.5	Penacook	Merrimack	Merrimack St and Bye St pipes	P4	12" pipes are undersized and illicit sewer connection	Detention, storage, or increase in pipe size along with separating sewer connection	3	1	5	2	5	2	3	3	24	$558,200	$55,820	$614,020	**Installation of new 30" RC pipe for 1,000 LF and 42" RC pipe for 700 LF**	**16**
6.5	Penacook	Contoocook	Tanner Street and Village Street	P5	15" and 12" pipes are undersized	Detention, storage, or increase in pipe size.	3	2	5	1	5	2	3	3	24	$306,550	$30,655	$337,205	**Installation of new 24" RC pipe for 700 LF and 48" RC pipe for 250 LF**	**17**
6.5	Penacook	Rolfe Canal	Low Area at Borough, Washington and Fowler triangle	P3	Low area in neighborhood experiences severe flooding in heavy rain and spring conditions	Install new drainage pipes and outfalls or drywells for an immediate solution	0	3	5	3	2	2	3	5	23	$385,500	$38,550	$424,050	**Installation of new 12" and 15" PVC drainage for 1000 LF and 24' RC pipe for 500 LF**	**20**
6.5	Penacook	Hoyt Brook	Elm St and Contoocook River	P13	12" is undersized and removal of temporary drywells	Install new larger dia. pipe and removal drywells	0	4	5	0	3	2	3	4	21	$469,200	$46,920	$516,120	**Installation of new 30" RC pipe for 350 LF, 18" PVC pipe for 500 LF and 12" PVC pipe for 1,000 LF**	**31**
6.5	Penacook	Rolfe Canal	Washington Street, north of the Rolfe Canal	P7	12" pipe is undersized	Detention, storage, or increase in pipe size.	2	1	5	1	3	2	5	0	19	$200,400	$20,040	$220,440	**Installation of new 36" RC pipe for 600 LF**	**37**
6.5	Penacook	Hoyt Brook	Penacook St. culvert at Hoyt Brook	P9	24" culvert is undersized	Install new larger dia. culvert	0	3	5	0	3	0	3	5	19	$17,710	$1,771	$19,481	**Installation of new 60" RC culvert for 35 LF**	**38**
6.5	Penacook	Hoyt Brook	East St and Contoocook River	P14	12" pipe is undersized	Install new larger dia. pipe	3	1	4	0	3	2	3	3	19	$50,600	$5,060	$55,660	**Installation of new 18" PVC pipe for 200 LF**	**39**
6.5	Penacook	Hoyt Brook	Local drainage from Millstream Ln, Primrose Ln and Fowler St to Millsteam Brook	P12	12", 15" and 24" pipes are undersized	Install new larger dia. pipe	0	3	4	0	3	2	3	3	18	$189,250	$18,925	$208,175	**Installation of new 36" RC pipe for 150 LF and 18" PVC pipe for 550 LF**	**43**
6.5	Penacook	Rolfe Canal	Electric Ave, contributing to the Rolfe Canal	P8	12" pipe is undersized	Detention, storage, or increase in pipe size.	2	1	4	1	3	2	3	0	16	$37,950	$3,795	$41,745	**Installation of new 18" PVC pipe for 150 LF**	**61**
6.5	Penacook	Hoyt Brook	Electric Ave complex and Contoocook River	P15	12" pipe is undersized	Install new larger dia. pipe	0	3	5	0	2	2	3	0	15	$115,600	$11,560	$127,160	**Installation of new 24" RC pipe for 400 LF**	**68**
6.5	Penacook	Hoyt Brook	Lilac St , north of Hoyt Brook	P11	12" pipe is undersized	Install new larger dia. pipe	0	4	5	0	3	2	0	0	14	$151,000	$15,100	$166,100	**Installation of new 30" RC pipe for 500 LF**	**78**
6.5	Penacook	Hoyt Brook	Hoyt Brook crossings at Manor Rd and Village St	P10	36" culverts are undersized	Install new larger dia. culvert	0	5	4	0	3	0	0	0	12	$35,420	$3,542	$38,962	**Installation of two new 60" RC culverts for 70 LF**	**86**

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		

6.6	Fisherville	Upper	Lake St	F5	Road is poor conditions, limited catch basins and drain pipes	Line existing pipe, install new pipes & catch basins and repave road	3	3	3	3	5	2	3	5	27	$380,550	$38,055	$418,605	Installation of new 18" PVC pipe for 1,350 LF and line 12" pipe for 650 LF	7
6.6	Fisherville	Upper	Along Manor Road to the Merrimack River.	F3	24" pipe undersized for flow expected.	Investigate relief to the north side of Abbott Rd or Manor Rd or upsize pipe.	3	3	5	1	2	0	3	5	22	$1,630,470	$163,047	$1,793,517	Installation of new 48" RC pipe for 3,910 LF	26
6.6	Fisherville	Rattlesnake Brook	Quaker St, Knight St, and North State St	F4	Culverts undersized and not ideal hydraulically	Investigate size of culverts and large culvert elevation changes under North State St	3	5	3	3	5	0	0	3	22	$33,360	$3,336	$36,696	Installation of new 48' RC culvert for 80 LF	27
6.6	Fisherville	Upper	Along Snow Street and Randlett Street.	F2	24" pipe undersized for flow expected.	Investigate relief to the north side of Abbott Rd or Manor Rd, or upsize pipe.	1	3	4	1	3	0	3	0	15	$677,580	$67,758	$745,338	Installation of new 36" RC pipe for 480 LF, 42" RC pipe for 160 LF and 48" RC pipe for 1,100 LF	69
6.6	Fisherville	Beaver Meadow	Douglas Ave to Fisherville Rd	F1	24" pipe is undersized for the flow expected.	Investigate retaining flow from Douglas Ave, or redirect to Alice or Mayflower.	1	3	4	1	2	0	3	0	14	$417,500	$41,750	$459,250	Installation of new 36" RC pipe for 1,250 LF	79
6.6	Fisherville	Upper	Fisherville Rd and Beaver Meadow Brook	F7	2.5'x5.5' box culvert surcharges	Install new culvert	0	5	0	5	3	0	0	0	13	$24,250	$2,425	$26,675	Installation of new 54" RC culvert for 50 LF	81
6.6	Fisherville	Upper	Gallen Dr. and Alder Creek Dr	F6	Surface elevations slope towards Gallen Dr but water outlets under Alder Creek Rd causing water backup	Inspect 48" culvert for clogging or sediment build up. Remediate as needed	0	5	0	3	3	0	0	0	11	Culvert Inspection	$0	$0	Inspect large culvert and look for sediment build up or other blockages	87

Sect	Drainage Basin	Sub Basin	Location	On Map	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
						Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
6.7	Oak Hill	OH2	West Sugarball Road to outfall on Merrimack River	O4	Severe washout and erosion	Repair/Reconstruct drainage outfall	2	2	4	5	5	5	0	3	26	$133,600	$13,360	$146,960	Installation of new 36" RC pipe for 400 LF and repair existing outfall structure.	11
6.7	Oak Hill	OH2	East Side Dr from Heritage Heights Road to South Curtisville Rd	O1	12" pipes are undersized	Replace 12" pipe with larger dia. pipe.	3	3	4	1	3	1	3	5	23	$352,070	$35,207	$387,277	Installation of new 24" RC pipe for 330 LF and 30" RC pipe for 850 LF	21
6.7	Oak Hill	OH1	Outfall at Eastman and Portsmouth	O5	24" pipe undersized for 10-year storm	Reducing incoming flow with detention, or increase size of pipe.	0	3	4	0	5	5	3	3	23	$200,400	$20,040	$220,440	Installation of new 36" RC pipe for 600 LF	22
6.7	Oak Hill	OH2	South Curtisville Rd from East Side Dr to north of Portsmouth St	O8	24" and 8" pipes feeding detention pond at Node LL are undersized	Redirect some flow in the basin to alternate detention. Or replace with larger pipes.	3	4	4	0	5	1	3	3	23	$75,500	$7,550	$83,050	Installation of new 30" RC pipe for 250 LF	23
6.7	Oak Hill	OH2	Portsmouth St culvert at Mill Brook crossing	O3	Undersized culvert (48" existing). Substantial flooding during May 2006 storm	Replace culvert with larger dia. pipe or box culvert. New size assumed to be 60"	3	1	5	2	2	0	5	3	21	$20,240	$2,024	$22,264	Installation of new 60' RC pipe for 40 LF	32
6.7	Oak Hill	OH1	East Side Drive from Putney to Eastman	O6	8" and 18" pipes undersized for 10-year storm	Redirect some flow in the basin to new detention or brook (with treatment). Or replace undersized pipes.	3	2	4	0	3	1	3	5	21	$511,310	$51,131	$562,441	Installation of new 30" RC pipe for 650 LF and 24" RC pipe for 1,090 LF	33
6.7	Oak Hill	OH1	Shaker Rd from Pekoe Dr to Mountain Rd	O2	Roots and other obstructions in the pipe.	Clean and line pipe or replace with larger dia. pipe.	2	2	4	3	3	0	3	0	17	$130,050	$13,005	$143,055	Installation of new 24" RC pipe for 450 LF	50
6.7	Oak Hill	OH1	Winthrop Street and Shawmut st	O7	8" and 12" pipes undersized for 10-year storm	Redirect some flow in the basin to new detention. Or replace undersized pipe.	0	1	5	0	3	1	3	0	13	$298,100	$29,810	$327,910	Installation of new 15" PVC pipe for 450 LF and 24" RC pipe for 650 LF	82
6.7	Oak Hill	OH2	Pelham Lane	O9	Undersized pipe (18" existing)	Redirect flow to detention. Or replace 18" pipe with 30" pipe.	0	2	5	0	0	1	5	0	13	$105,700	$10,570	$116,270	Installation of new 30" RC pipe for 350 LF	83

Sect	Drainage Basin	Sub Basin	Location	On Map	Nature of Problem	Recommended Solution	Property & Traffic	Pipe Size	% Undersized	Recur.	Pipe Age	Stream Impacts	Construct ability	Road Projects	Total Score	Construction Cost	Engineering Cost	Total Cost	Description	Rank
						Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-40	Estimate	Estimate	Estimate		
6.8	Hospital	H	Bow Brook culverts under School St and Warren St	HOS3	Culverts were washed out during the May 2006 storm. The School St culvert was undersized	City currently under design to repair/replace culvert	5	5	4	3	5	3	0	4	29	$171,000	$19,000	$190,000	City temporarily repaired wash out. City to prepare design for new permanent culvert. FEMA and FHwA (Federal Highway Administration) paid for project.	6
6.8	Hospital	H	South of Redington Road, west of Fruit Street, 30" pipe	HOS4	Flat area has poor drainage	Consider installing larger pipes.	0	4	3	3	5	2	5	4	26	$549,000	$54,900	$603,900	Installation of new 42" RC pipe for 1,500 LF	12
6.8	Hospital	H	Bow Brook culvert under Pleasant St as the pipe enters State Hospital grounds	HOS2	Culvert was washed out during the May 2006 storm.	City currently under design to repair/replace culvert	5	5	0	3	5	3	0	4	25	$126,000	$14,000	$140,000	City temporarily repaired wash out. City to prepare design for new permanent culvert. FEMA and FHwA (Federal Highway Administration) paid for project.	14
6.8	Hospital	H	Noyes Street near Harvard Street	HOS5	18" pipe undersized	Reduce flow through retention or storage; or replace with a larger pipe	3	2	5	0	5	5	0	4	24	$57,800	$5,780	$63,580	Installation of new 24" RC pipe for 200 LF	18
6.8	Hospital	H	Bow Brook from Ridge Rd and Terrace Rd	HOS1	Outlet pipes are undersized	Replace existing pipes with larger dia. pipes	0	4	5	0	5	3	0	5	22	$140,560	$14,056	$154,616	Installation of new 30" RC pipe for 200\ LF ad 36" RC pipe for 240 LF	28
6.8	Hospital	H	Minot St outlet to Thayer Pond/Bow Brook	HOS7	12" pipe is undersized	Replace with a larger pipe.	0	1	5	0	5	2	3	4	20	$173,400	$17,340	$190,740	Installation of new 24" RC pipe for 600 LF	35
6.8	Hospital	H	Pleasant St from Pleasant View to Kensington Rd	HOS6	8" pipe undersized	Replace with a larger pipe.	3	1	5	0	5	0	0	4	18	$120,800	$12,080	$132,880	Installation of new 30" RC pipe for 400 LF	44

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.9	Horseshoe Pond	HP2	East end of Walker St, corner of Walker and North State St.	HP2	18″ and 24″ Diameter; Pipes with 90° turns & capacity issues.	The NHDOT is designing a new piping scheme here.	**4**	**3**	**4**	**5**	**5**	**3**	**5**	**5**	**34**	**NHDOT project**	**$0**	**$0**	**NHDOT design of these pipes have begun but is currently on hold**	***1***
6.9	Horseshoe Pond	HP1	East end of Walker Street, corner of Walker & North State	HP1	18″ and 20″ Diameter; Pipes with 90° turns & capacity issues.	The NHDOT is designing a new piping scheme here.	**4**	**2**	**4**	**5**	**5**	**3**	**5**	**5**	**33**	**NHDOT project**	**$0**	**$0**	**NHDOT design of these pipes have begun but is currently on hold**	***2***
6.9	Horseshoe Pond	HP2	Rumford St, between Penacook St and Jennings St	HP5	Undersized 8″ Diam pipe from large area to Walker St	Consider pipe replacement	**2**	**1**	**5**	**1**	**5**	**0**	**5**	**5**	**24**	**$134,750**	**$13,475**	**$148,225**	**Installation of new 15" PVC pipe for 550 LF**	***19***
6.9	Horseshoe Pond	HP2	Walker St from North State St to Liberty St	HP3	8″, 15″ and 20″ Diameter, Excess flow & severe capacity problems	Replace with a larger pipe	**2**	**2**	**5**	**1**	**5**	**0**	**3**	**5**	**23**	**$553,645**	**$55,365**	**$609,010**	**Installation of new 24" RC pipe for 225 LF, 30" RC pipe for 700 LF and 36" RC pipe for 830 LF**	***24***
6.9	Horseshoe Pond	HP3	I393/202 at RR Track, west of the southbound I93 offramp	HP6	20″ Diameter; Undersized.	NHDOT is designing a new pipe to direct excess flow north on North Main St to Horseshoe Pond	**5**	**3**	**4**	**0**	**5**	**2**	**0**	**0**	**19**	**NHDOT project**	**$0**	**$0**	**NHDOT design of these pipes have begun but is currently on hold**	***40***
6.9	Horseshoe Pond	HP2	Bradley St from Albin St to Perkins St	HP9	12″ and 20" dia. pipe is undersized	Consider pipe replacement	**5**	**4**	**3**	**0**	**5**	**0**	**0**	**0**	**17**	**$224,250**	**$22,425**	**$246,675**	**Installation of new 18" PVC pipe for 200 LF and 30" RC pipe for 575 LF**	***51***
6.9	Horseshoe Pond	HP3	Church St between Bouton & State	HP7	18″ Diameter; Excess flow & capacity problems	Planned overflow should alleviate these issues if constructed	**2**	**2**	**4**	**0**	**5**	**0**	**3**	**0**	**16**	**$151,000**	**$15,100**	**$166,100**	**Installation of new 30" RC pipe for 500 LF**	***62***
6.9	Horseshoe Pond	HP2	Liberty St and Franklin St	HP4	8″ Diam; Excess flow/capacity problems, especially near Wyman St	Consider pipe replacement	**2**	**1**	**5**	**1**	**2**	**0**	**3**	**0**	**14**	**$709,700**	**$70,970**	**$780,670**	**Installation of new 18" PVC pipe for 1,640 LF and 24" RC pipe for 1,020 LF**	***80***
6.9	Horseshoe Pond	HP2	Wyman Street and Rumford St to Highland St	HP8	6″ and 10" dia. pipe is undersized	Consider pipe replacement	**0**	**0**	**5**	**0**	**5**	**0**	**3**	**0**	**13**	**$85,750**	**$8,575**	**$94,325**	**Installation of new 15" PVC pipe for 350 LF**	***84***

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.10	Turkey Pond	TP	Five culverts apparently undersized for current conditions.	TP1	Culverts potentially undersized, potential for flooding of roads.	Detailed inspection of all culverts, compare culvert size with recommended.	**0**	**3**	**1**	**0**	**5**	**5**	**5**	**0**	**19**	**Inspect**	**$0**	**$0**	**Inspect the five culverts for blockage and sediment build up. Replace with larger culvert if necessary.**	***41***

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.11	West Concord	Penna cook Lake	Road side ditches along Carter Hill Road	WC2	Steep with high velocity runoff, large riprap pushed to bottom of hill.	Consider veins or other means to break velocity, or detention near top of hill.	**0**	**5**	**5**	**5**	**5**	**2**	**5**	**0**	**27**	**$90,000**	**$10,000**	**$100,000**	**City design of this problem is complete. Construction to begin in 2007.**	***8***
6.11	West Concord	Miller's Brook	Intersection of Pleasant Street and Miller's Brook	WC1	Undersized culvert causing backups	Consider culvert replacement or storage/retention.	**3**	**3**	**1**	**3**	**5**	**0**	**5**	**5**	**25**	**$20,040**	**$2,004**	**$22,044**	**Installation of new 36" RC pipe for 60 LF**	***15***
6.11	West Concord	Miller's Brook	***Private*** Drive off Fisk Road at Millers Brook - NOT CITY PRIORITY, SINCE PRIVATE ROAD	WC3	Brook periodically floods private drive.	Consider culvert replacement or storage/retention.	**0**	**2**	**1**	**2**	**2**	**4**	**0**	**0**	**11**	**$0**	**$0**	**$0**	**N/A - Private driveway**	***88***

Sect	*Drainage Basin*	*Sub Basin*	*Location*	*On Map*	*Nature of Problem*	*Recommended Solution*	*Property & Traffic*	*Pipe Size*	*% Undersized*	*Recur.*	*Pipe Age*	*Stream Impacts*	*Construct ability*	*Road Projects*	*Total Score*	*Construction Cost*	*Engineering Cost*	*Total Cost*	*Description*	*Rank*
						Range	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-5*	*0-40*	*Estimate*	*Estimate*	*Estimate*		
6.12	Hoit	Hoit	Freedom Acres, between Hoit Rd and Mountain Rd	HT1	Back up of detention basin. Poor design. Does not permit access for cleaning & maintenance.	Maintain detention pond	**1**	**2**	**1**	**3**	**2**	**2**	**5**	**0**	**16**	**$10,000**	**$0**	**$0**	**Regular maintenance of detention pond.**	***63***

```
*Concord, NH - Storm water study Pilot Area.
*Cynthia Carlson, Winter 00/01
*Vertical datum:  Mean Sea Level (Off sewer plans of 1978)
*Horizontal datum:  NAD 1983
*Ten-year return period storm.
*
***  NBLOCK  JIN(1)  JOUT(1)
SW     1       0        9
MM   8   1     2       3      10      11     12    13    14
* Generate interface file for Extran block
@ 9 'run10yri.int'
$ANUM
$NOQUOTE
$RUNOFF      Call the RUNOFF block with a '$' in first column.
A1  'Concord, NH:  Terrible Trapezoid'
A1  '10yr Year storm'
*
*  METRIC ISNOW NRGAG INFILM KWALTY IVAP NHR NMN NDAY MONTH IYRSTR  [IVCHAN]
B1    0       0    2      0       0       0   00   0   1    10    1989
*   IPRN(1) IPRN(2) IPRN(3)  IRPNGW
B2     0       0       1
*
*    WET    WET/DRY  DRY    LUNIT LONG
B3   60.    120.0   720.   3     9.0
*        Line D1 is the first rainfall control line.
*==========================================================================
*       D1 Line       :
*          ROPT       :  Precipitation input option.
*                        = 0, Read NRGAG hyetographs on E1, E2 and E3
*                        data groups.  (Rain data can be saved permanently
*                        on NSCRAT(1) using the @ function.)
D1       0
*==========================================================================
* KTYPE KINC KPRINT KTHIS KTIME KPREP NHISTO THISTO TZRAIN
E1    2    1      0     0     1     1 .  38   0.25      0
*
*       E3 Line      :
*     REIN(1)        :  Time of precipitation.  Units of KTIME.
*     REIN(2)        :  Precipitation, first raingage, in./hr [mm/hr].
*        .                                .
*     REIN(NRGAG+1) :  Precipitation, last raingage, in./hr [mm/hr].
*==========================================================================
*  Rainfall from stochastic disaggregation Mitch Heineman did on real rainfall data.
```

Runoff Input File

```
*  Then table 2 from Cornell report gives conversions from 1-day to short duration depths
*     (based on work done at the Midwestern Climate Center).
*
E3          0.00       0        0
E3          0.25    0.02     0.02
E3          0.50    0.06     0.06
E3          0.75    0.12     0.12
E3          1.00     0.2      0.2
E3          1.25    0.13     0.13
E3          1.50    0.32     0.32
E3          1.75    0.87     0.87
E3          2.00    0.18     0.18
E3          2.25    0.22     0.22
E3          2.50    0.11     0.11
E3          2.75    0.14     0.14
E3          3.00    0.01     0.01
E3          3.25    0.02     0.02
E3          3.50    0.01     0.01
E3          3.75    0.01     0.01
E3          4.00    0.01     0.01
E3          4.25    0.14     0.14
E3          4.50       0        0
E3          4.75       0        0
E3          5.00       0        0
E3          5.25       0        0
E3          5.50       0        0
E3          5.75       0        0
E3          6.00       0        0
E3          6.25       0        0
E3          6.50       0        0
E3          6.75       0        0
E3          7.00       0        0
E3          7.25       0        0
E3          7.50       0        0
E3          7.75       0        0
E3          8.00       0        0
E3          8.25       0        0
E3          8.50       0        0
E3          8.75       0        0
E3          9.00       0        0
E3          9.25       0        0
*
*
```

```
*=====================================================================
*   NAMEG         NGTO          NPG GWIDTH GLEN    G3     GS1 GS2    G6      DFULL GDEPTH
*G1  'Runholly'   'Brook30'     2    1.67  500   0.0085   0   0    0.013     0      0
*G1  'Runholly1' 'Runholly'     2    1.67  875   0.0083   0   0    0.013     0      0
*G1  'Runhope'    'Runholly1'   2    1.50  363   0.0050   0   0    0.013     0      0
G1  'Pill10'     'Brook20'     2    1.25  897   0.0067   0   0    0.013     0      0
G1  'Pill15'     'Pill10'      2    1.50  389   0.0072   0   0    0.013     0      0
G1  'Pill20'     'Pill15'      2    1.00  305   0.0190   0   0    0.013     0      0
*
*========================================================================
*                 'NGOTO'  W,ft  Area,ac %IMP    SLOPE   Ruff-i  Ruff-p i-sto p-sto MAX MIN  DECAY
H1  1  'SP350'  'SP350'  600   1.82    43.4    0.03    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'FED100' 'SP370'  900   1.83    43.4    0.01    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'PLE100' 'PLE100' 8250  22.76   36.0    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'CC350'  'CC350'  1500  8.71    24.8    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP310'  'SP310'  1050  3.48    36.0    0.005   0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP320'  'SP320'  675   1.76    43.4    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP300'  'SP300'  2100  8.59    36.0    0.005   0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'MA200'  'MA200'  1200  2.09    43.4    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'STA180' 'STA180' 3700  21.83   36.0    0.03    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP280'  'SP280'  2100  6.56    36.0    0.005   0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SH'     'CC210'  1475  29.12   18.0    0.005   0.03    0.2    0.1   0.2   4  0.45  0.00115
*
*used to drain into 'Monroe', but too much flow for that little pipe, put right into system
H1  1  'CC270'  'CC300'  1000  10.40   36.0    0.009   0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'MA150'  'MA150'  900   1.40    43.4    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'CC340'  'CC320'  1650  6.32    36.0    0.005   0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'CC330'  'CC320'  1125  4.42    24.8    0.03    0.03    0.2    0.1   0.2   4  0.45  0.00115
*
*spliting the original STA150 into 2 pieces, one drains to State st. the other to main.
*H1  1 'STA150' 'STA140' 1500  16.04   43.4    0.03    0.03    0.2   0.1  0.2   4  0.45  0.00115
H1  1  'MA125'  'MA160'  1200   4.61   43.4    0.03    0.03    0.2   0.1  0.2   4  0.45  0.00115
H1  1  'STA150' 'STA140' 1500  11.42   43.4    0.03    0.03    0.2   0.1  0.2   4  0.45  0.00115
*
H1  1  'SP260'  'SP260'  300    0.69   36.0    0.01    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP220'  'SP220'  1200   4.68   36.0    0.01    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'MA100'  'MA100'  900    4.67   43.4    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
*
H1  1  'CC290'  'CC280'  2025   6.92   36.0    0.07    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP210'  'SP210'  300    1.83   36.0    0.01    0.03    0.2    0.1   0.2   4  0.45  0.00115
*
H1  1  'CC240'  'CC230'  1800  4.20    36.0    0.03    0.03    0.2    0.1   0.2   4  0.45  0.00115
H1  1  'SP200'  'SP200'  300   1.40    36.0    0.01    0.03    0.2    0.1   0.2   4  0.45  0.00115
```

```
H1  1  'SP190'    'SP190'   450   3.01    36.0    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'AS100'    'MA100'   900   3.04    43.4    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'CC220'    'CC220'   3300  12.51   36.0    0.01    0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'SP150'    'SP150'   1500  5.70    39.7    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'STA100'   'STA100'  2100  7.89    43.4    0.03    0.03   0.2    0.1  0.2   4  0.45    0.00115
*
H1  1  'ALLISON'  'CC130'   1500  8.21    42.0    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'CC210'    'CC210'   5850  19.24   24.8    0.01    0.03   0.2    0.1  0.2   4  0.45    0.00115
*
H1  1  'SP130'    'ALL130'  1350  3.74    43.4    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'SP140'    'ALL140'  675   3.52    39.7    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'CC170'    'CC170'   1350  4.76    39.7    0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'CC200'    'CC190'   1500  4.36    24.8    0.01    0.03   0.2    0.1  0.2   4  0.45    0.00115
*
H1  1  'PILLSBUR' 'Brook20'   5850  21.67   34.0  0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'ALL1'     'All2x3us'  5100  17.24   24.8  0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'ALL2'     'All2us'    2850  12.20   36.0  0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'HOLLY'    'Holly'     5700  40.26   18.0  0.008   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'Carter'   'All2us'    1350  4.95    25.0  0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'STONE'    'Pill20'    1350  5.26    27.0  0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
H1  1  'HOPE'     'McKinley'  3900  40.69   20.0  0.005   0.03   0.2    0.1  0.2   4  0.45    0.00115
*
*Wiggin discharges into the pond.
*H1  1  'WIGGIN' 'Brook20'  4400  16.12   25.0    0.005   0.03   0.2    0.1  0.2   4  0.45
0.00115
*==========================================================================
*   Enter Subcatchment Snow Input Data on data groups I1 and I2 (if modeled).
*==========================================================================
*
*                Note: If ISNOW = 0, skip to group J1.
*                      If ISNOW = 1, read only group I1.
*                      If ISNOW = 2, read both groups I1 and I2, in pairs.
*
*##########################################################################
*              Enter General Quality Control on data group J1.
*==========================================================================
*==========================================================================
*      Enter data for Channel/Inlet Print Control on data group M1.
*==========================================================================
*       M1 Line    :
*        NPRNT     :  Total number of channels/pipes/inlets for which
*                     non-zero flows (and concentrations) are
*                     to be printed (maximum = NG).
```

```
*        INTERV    :  Print Control.
*                       = 0, Print statistical summary only.
*                       = 1, Print every time step.
*                       = K, Print every K time steps.
*============================================================================
*  NPRNT  INTERV
M1     0      0
*============================================================================
*============================================================================
*                End your input data set with a $ENDPROGRAM.
$ENDPROGRAM
```

```
*Concord, NH - Storm water study Pilot Area.
*"Terrible Trapezoid" from Pleasant street to Allison Street"
*Cynthia Carlson, Winter 00/01
*Vertical datum:  Mean Sea Level (Off sewer plans of 1978)
*Horizontal datum: NAD 1983
*Ten-year return period storm.
*
SW 1 7 8 0 0
MM 5 12 13 14 15 16
@ 7 'run10yri.int'
@ 8 '10yeari.out'
$ANUM
$NOQUOTE
*==========================================================================
$EXTRAN
*==========================================================================
*==========================================================================
*==========================================================================
*==========================================================================
*==========================================================================
*==========================================================================
A1 'Concord Stormdrain - Terrible Trapezoid'
A1 'XYS=Concord.XYS '
B0 0 0
BB 0 0 0 0
*#steps  sec
*B1 5000  10     0 0 -20 20 0 19990101
B1 8000 10 0 0 -20 20 0 19990101
B2 0 1 12.57 100 0.01
B3 0 0 0 0 0
*C1 'FED120' 'FED120' 'FED110' 0 1 0 1.25 0 25 0 0 0.013 0 0
*
*C1 'FED110' 'FED110' 'FED100' 0 1 0 1.25 0 58 0 0 0.013  0 0
*
*ROUND PIPES ROUGH=0.013;  OTHER PIPES ROUGH=0.015
C1 'SP370' 'SP370' 'SP360' 0 1 0 1 0 61 0 0.01 0.013 0 0
C1 'SP360' 'SP360' 'SP350' 0 1 0 1 0 170 0 0.1 0.013 0 0
C1 'SP350' 'SP350' 'SP340' 0 1 0 2.5 0 270 0 0 0.013 0 0
C1 'SP340' 'SP340' 'SP330' 0 1 0 2.5 0 227 0 0.1 0.013 0 0
C1 'SP330' 'SP330' 'SP320' 0 1 0 2.5 0 191 0 0 0.013 0 0
```

Extran Input File

```
C1 'SP320' 'SP320' 'SP310' 0 1 0 2 0 187 0.44 0 0.013 0 0
C1 'CC370' 'CC370' 'CC360' 0 1 0 2 0 209 0 0 0.013 0 0
C1 'CC360' 'CC360' 'CC350' 0 2 0 2 3 120 0 0 0.015 0 0
C1 'SP310' 'SP310' 'SP300' 0 1 0 2 0 215 0 0 0.013 0 0
C1 'SP315' 'SP315' 'SP310' 0 1 0 1 0 110 0 0 0.013 0 0
C1 'SP300' 'SP300' 'SP290' 0 1 0 2 0 208 0 0 0.013 0 0
C1 'SP290' 'SP290' 'SP280' 0 1 0 2 0 188 0 0 0.013 0 0
C1 'SP280' 'SP280' 'SP270' 0 1 0 2 0 68 0 0 0.013 0 0
C1 'SP270' 'SP270' 'SP260' 0 1 0 2 0 120 0 0 0.013 0 0
C1 'SP260' 'SP260' 'SP250' 0 1 0 2 0 83 0 0 0.013 0 0
C1 'SP250' 'SP250' 'SP240' 0 1 0 2 0 280 0 0 0.013 0 0
*C1 'Monroe' 'Monroe' 'CC300' 0 1 0 1 0 299 0 0 0.013 0 0
C1 'CC350' 'CC350' 'CC320' 0 2 0 2 3 530 0 0 0.015 0 0
C1 'CC320' 'CC320' 'CC300' 0 2 0 2 3 101 0 0 0.015 0 0
C1 'SP240' 'SP240' 'SP230' 0 1 0 2 0 143 0 0 0.013 0 0
C1 'SP230' 'SP230' 'SP220' 0 1 0 2 0 142 0 0 0.013 0 0
*C1 'Thorn' 'Thorn' 'CC280' 0 1 0 1 0 205 0 0 0.013  0 0
C1 'CC300' 'CC300' 'CC280' 0 2 0 2 3 257 0 0 0.015 0 0
C1 'SP220' 'SP220' 'SP210' 0 1 0 3 0 245 0 0 0.013 0 0
C1 'SP210' 'SP210' 'SP200' 0 1 0 3 0 282 0 0 0.013 0 0
C1 'SP200' 'SP200' 'SP190' 0 1 0 3 0 265 0 0 0.013 0 0
C1 'SP190' 'SP190' 'SP180' 0 1 0 3 0 77 0 0 0.013 0 0
C1 'CC280' 'CC280' 'CC250' 0 2 0 2 3 550 0 0 0.015 0 0
C1 'CC250' 'CC250' 'CC230' 0 2 0 2 3 250 0 0 0.015 0 0
C1 'CC230' 'CC230' 'CC220' 0 2 0 2 3 24 0 0.1 0.015 0 0
C1 'CC220' 'CC220' 'CC210' 0 2 0 2 3 440 0 0 0.015 0 0
*C1 'West' 'West' 'CC210' 0 1 0 1 0 57 0 0 0.013  0 0
C1 'SP180' 'SP180' 'SP170' 0 1 0 3 0 71 0 0 0.013 0 0
C1 'SP170' 'SP170' 'SP160' 0 1 0 3 0 377 0 0 0.013 0 0
C1 'CC210' 'CC210' 'CC190' 0 2 0 2 3 882 0 0 0.015 0 0
*
*equivalent pipe for stability.
C1 'CC190' 'CC190' 'CC180' 0 2 0 2 3 100 6.6 0 0.0051 0 0
***C1 'CC190' 'CC190' 'CC180' 0 2 0 2 3 34 0 0 0.013 0 0
C1 'CC180' 'CC180' 'CC170' 0 1 0 2 0 184 0 0 0.013 0 0
C1 'CC170' 'CC170' 'CC160' 0 1 0 2 0 215 0 0.1 0.013 0 0
C1 'CC160' 'CC160' 'CC150' 0 1 0 2 0 112 0 0 0.013 0 0
C1 'SP160' 'SP160' 'SP155' 0 1 0 3 0 218 0 0 0.013 0 0
C1 'SP155' 'SP155' 'SP150' 0 1 0 3 0 352 0 0 0.013 0 0
C1 'ALL150' 'ALL150' 'ALL140' 0 1 0 3 0 265 0 0.2 0.013 0 0
```

```
C1 'CC150' 'CC150' 'CC140' 0 1 0 4 0 274 0 0 0.013 0 0
C1 'CC140' 'CC140' 'CC130' 0 1 0 4 0 329 0 0 0.013 0 0
*C1 'SP130' 'SP130' 'ALL130' 0 1 0 3 0 274 0 0 0.013  0 0
C1 'ALL130' 'ALL130' 'ALL110' 0 1 0 3 0 70 0 0 0.013 0 0
C1 'ALL110' 'ALL110' 'ALL100' 0 1 0 3 0 216 0 0 0.013 0 0
C1 'CC130' 'CC130' 'CC110' 0 1 0 4 0 180 0 0 0.013 0 0
C1 'CC110' 'CC110' 'CC100' 0 1 0 4 0 116 0 0 0.013 0 0
C1 'CC100' 'CC100' 'MA080' 0 1 0 4 0 364 0 0 0.013 0 0
C1 'MA110' 'MA110' 'MA100' 0 1 0 2 0 105 0 0 0.013 0 0
C1 'MA100' 'MA100' 'GAS100' 0 1 0 2 0 466 0 0 0.013 0 0
C1 'GAS100' 'GAS100' 'MA080' 0 1 0 4 0 174 0 0 0.013 0 0
C1 'MA170' 'MA170' 'MA160' 0 1 0 1.5 0 128 0 0.02 0.013 0 0
C1 'MA160' 'MA160' 'MA150' 0 1 0 1.5 0 48 0 0.08 0.013 0 0
C1 'MA150' 'MA150' 'MA140' 0 1 0 2 0 140 0 0.1 0.013 0 0
C1 'MA140' 'MA140' 'MA130' 0 1 0 2 0 71 0 0 0.013 0 0
C1 'MA130' 'MA130' 'MA110' 0 1 0 2 0 386 0 0 0.013 0 0
C1 'MA200' 'MA200' 'MA190' 0 1 0 1.5 0 175 0 0.05 0.013 0 0
C1 'MA190' 'MA190' 'MA170' 0 1 0 1.5 0 351 0 0 0.013 0 0
C1 'STA180' 'STA180' 'STA170' 0 1 0 1.5 0 202 0 0 0.013 0 0
C1 'STA170' 'STA170' 'STA160' 0 1 0 1.5 0 244 0 0 0.013 0 0
*
*remove STA150 for stability.
*C1 'STA160' 'STA160' 'STA150' 0 1 0 1.5 0 53 0 0 0.013 0 0
*C1 'STA150' 'STA150' 'STA140' 0 1 0 1.5 0 95 0.1 0 0.013 0 0
C1 'STA150' 'STA160' 'STA140' 0 1 0 1.5 0 148 0.1 0 0.013 0 0
*
C1 'ALL100' 'ALL100' 'SP090' 0 2 0 3 2 244 0 0 0.015 0 0
C1 'SP090' 'SP090' 'GAS200' 0 2 0 2 3 40 0 0 0.015 0 0
C1 'STA140' 'STA140' 'STA130' 0 1 0 2 0 106 0 0 0.013 0 0
*
*remove STA125 for stability
*C1 'STA130' 'STA130' 'STA125' 0 1 0 2 0 25 0 0.5 0.013 0 0
*C1 'STA125' 'STA125' 'STA120' 0 1 0 2 0 60 0 0 0.013 0 0
C1 'STA125' 'STA130' 'STA120' 0 1 0 2 0 85 0 0 0.013 0 0
*
C1 'STA120' 'STA120' 'STA115' 0 1 0 2 0 131 0 0.1 0.013 0 0
C1 'STA115' 'STA115' 'STA110' 0 1 0 2 0 32 0 0 0.013 0 0
C1 'STA110' 'STA110' 'STA100' 0 1 0 2 0 27 0 0.3 0.013 0 0
C1 'STA100' 'STA100' 'GAS200' 0 1 0 2 0 170 0 0 0.013 0 0
C1 'Allups1' 'All2x3us' 'CC190' 0 2 0 2 3 353 0 0.4 0.015 0 0
```

```
C1 'Allups2' 'All2us'   'CC180' 0 1 0 2 0 390 0 0 0.013 0 0
C1 'CC190a' 'CC190' 'ALL170' 0 1 0 3 0 182 5.6 0 0.013 0 0
C1 'ALL140' 'ALL140' 'ALL130' 0 1 0 3 0 274 0 0 0.013 0 0
C1 'ALL170' 'ALL170' 'ALL150' 0 1 0 3 0 604 0 0 0.013 0 0
C1 'SP150' 'SP150' 'CC150' 0 1 0 3 0 316 0 0.1 0.013 0 0
C1 'Water100' 'GAS100' 'Water100' 0 1 0 4 0 704 0 0.2 0.013 0 0
C1 'Water200' 'GAS200' 'Water200' 0 1 0 4 0 682 0 0 0.013 0 0
C1 'Water110' 'Water100' 'Water110' 0 1 0 4 0 88 0 0 0.013 0 0
C1 'Water210' 'Water200' 'Water210' 0 1 0 4 0 80 0 0.2 0.013 0 0
C1 'Water220' 'Water210' 'Water220' 0 1 0 4 0 180 0 0 0.013 0 0
*C1 'NEW10' 'FED100' 'NEW10' 0 1 0 1.5 0 150 0 0 0.013 0 0
*C1 'NEW20' 'NEW10' 'SP350' 0 1 0 2.5 0 15 0 0 0.013 0 0
*
*C1 'NEW30' 'PLE100' 'NEW10' 0 1 0 1.25 0 9.8 0 0 0.013 0 0
C1 'NEW30' 'PLE100' 'SP350' 0 1 0 1.25 0 9.8 0 0 0.013 0 0
C1 'NEW40' 'SP320' 'CC370' 0 1 0 1.25 0 4 0 1.45 0.013 0 0
C1 'Brook10' 'CC190' 'Brook10' 0 1 0 3.2 0 200 0 0 0.013 0 0
C1 'Brook20' 'Brook10' 'Brook20' 0 1 0 3.2 0 685 0 0 0.013 0 0
C1 'Brook30' 'Brook20' 'Brook30' 0 1 0 3 0 1210 0 0 0.013 0 0
C1 'Brook40' 'Brook30' 'Brook40' 0 1 0 3 0 950 0 0 0.013 0 0
C1 'Brook50' 'Brook40' 'Brook50' 0 1 0 3 0 725 0 0 0.013 0 0
*
C1 'Holly' 'Holly' 'Brook30' 0 1 0 1.67 0 270 0 0 0.013 0 0
C1 'McKinley' 'McKinley' 'Holly' 0 1 0 1.67 0 875 0 0 0.013 0 0
*
*    JUN   GRELEV   Z   QINST  Y    [XLOC YLOC IWHICH ]
D1 'PLE100' 293.5 275.38 0 0 6135.807235 -2689.413512
*D1 'FED100' 282.2 274.2 0 0 6443.210843 -2542.340032
*D1 'FED110' 282 274.8 0 0 6587.776367 -2397.774508
*D1 'FED120' 281.6 300 0 0 6584.67 -2417.04
D1 'SP370' 292.1 274.65 0 0 6779.228007 -2534.525679
D1 'SP360' 282.2 274.3 0 0 6540.890251 -2663.462498
D1 'SP350' 283.1 274.01 0 0 6161.894148 -2854.914137
*D1 'edge' 283.1 276.3 0 0 15000 -14000
D1 'SP340' 281.78 273.84 0 0 6288.08285 -3613.11803
D1 'SP330' 282.2 273.6 0 0 6350.068525 -4213.514594
D1 'SP320' 278.6 273.48 0 0 6841.697913 -4157.78795
D1 'CC370' 278.6 271.9 0 0 6915.979178 -4269.311964
D1 'SP310' 283.6 273.5 0 0 7362.043543 -4165.939579
D1 'CC360' 279 271.1 0 0 6914.680463 -4749.332962
```

```
D1 'SP300' 282 273 0 0 7319.721211 -4739.838664
D1 'CC350' 282 270.6 0 0 7267.534281 -4754.273347
D1 'SP315' 285.3 274.1 0 0 7388.610447 -3812.742386
D1 'SP290' 279.4 272.9 0 0 7297.524968 -5292.501163
D1 'SP280' 278.3 272.3 0 0 7269.297144 -5785.402396
D1 'SP270' 278 272.2 0 0 7256.268917 -5965.626194
D1 'CC320' 278.5 268.4 0 0 7172.092517 -6124.592005
D1 'SP260' 278.5 272 0 0 7238.069033 -6255.044014
D1 'SP250' 278.8 271.6 0 0 7221.483904 -6487.235827
D1 'SP240' 277.5 270.8 0 0 7238.069033 -7194.86802
D1 'CC300' 277.6 268.1 0 0 7288.141384 -6456.160195
*D1 'Monroe' 292.5 273.6 0 0 7940.23 -6025.12
D1 'CC280' 276.7 267 0 0 7500.15115 -7065.710304
D1 'SP230' 276.6 270.5 0 0 7587.41 -7053.03
D1 'SP220' 278.1 269.9 0 0 7923.5 -6859.96
*D1 'Thorn' 279.5 272.2 0 0 7979.619039 -6804.591642
D1 'SP210' 278.6 268.9 0 0 8231.67 -7369.64
D1 'SP200' 279.6 267.7 0 0 8620.08426 -8067.584885
D1 'SP190' 280.3 266.4 0 0 8995.690303 -8644.408451
D1 'SP180' 281.2 266.3 0 0 9207.23246 -8715.960108
D1 'CC210' 272.6 261.5 0 0 8221.708297 -10538.76268
*D1 'West' 275.2 267.1 0 0 8064.474194 -10639.84174
D1 'CC250' 276 264.8 0 0 7601.96 -8492.52
D1 'CC230' 275 263.8 0 0 7703.93 -9280.46
D1 'CC220' 275 263.4 0 0 7685.388873 -9614.173835
D1 'SP170' 280.4 266.2 0 0 9316.891165 -8881.851783
D1 'SP160' 277.6 265.7 0 0 9789.656034 -9688.33303
D1 'SP150' 273 262.2 0 0 10704.9335 -11099.63281
*
*move the invert down to put it more in line.
D1 'ALL150' 272.1 256.58 0 0 11095.86637 -11614.45821
*D1 'ALL150' 272.1 260.8 0 0 11095.86637 -11614.45821
D1 'CC190' 271.9 256.8 0 0 9824.618324 -12118.00622
D1 'CC180' 272.1 263.2 0 0 10199.2742 -12169.57347
D1 'CC170' 274.3 262.6 0 0 10461.73135 -12088.81742
D1 'CC160' 272.5 261.7 0 0 10852.05225 -11886.9273
D1 'CC150' 272.4 260.8 0 0 11114.50941 -11806.17126
D1 'SP155' 276.4 264.6 0 0 10061.41 -10071.46
D1 'CC140' 266.7 259 0 0 11780.7468 -11516.79542
D1 'CC130' 266.3 256.2 0 0 12602.88805 -11106.97299
```

```
D1 'ALL140' 266.9 255.6 0 0 11721.56714 -11352.75527
D1 'CC110' 265.9 255.8 0 0 12709.93804 -10547.01919
D1 'CC100' 265.6 255.2 0 0 12718.17265 -9921.012917
D1 'ALL130' 266 254.6 0 0 12421.72652 -11041.09607
D1 'ALL110' 266.1 254.2 0 0 12512.30728 -10901.10762
D1 'ALL100' 265.6 253.2 0 0 12593.70193 -10408.21745
D1 'MA080' 262.5 250.5 0 0 12784.04957 -9484.578339
D1 'GAS100' 257.5 245.8 0 0 12849.92649 -8891.686081
D1 'MA100' 267.6 255.7 0 0 13072.26108 -7722.370796
D1 'MA110' 267 256.5 0 0 13278.12645 -7532.974658
D1 'MA130' 269.8 257.5 0 0 12866.4 -6635.4
D1 'MA140' 269.3 257.8 0 0 12635.83 -6404.83
D1 'MA160' 268 258.52 0 0 12422.19 -6059.18
D1 'MA150' 268 258.05 0 0 12529.24 -6240.34
D1 'MA170' 268 259.18 0 0 12224.56 -5770.97
D1 'MA190' 268 260.28 0 0 11795.9 -4974.62
D1 'MA200' 278.2 261.09 0 0 11557.09 -4595.82
D1 'STA180' 291.5 262.7 0 0 11263.43 -7440.31
D1 'STA170' 271.6 261.4 0 0 11487.01 -7986.82
D1 'STA160' 270.9 260.1 0 0 11694.02 -8541.61
*D1 'STA150' 270.5 259.8 0 0 11751.98 -8665.82
D1 'STA140' 270 259 0 0 11834.79 -8914.23
D1 'SP090' 264 251.5 0 0 12579.06576 -10017.08554
D1 'GAS200' 263.5 250.6 0 0 12654.686 -9770.709911
D1 'STA130' 267.01 258.4 0 0 11949.35933 -9169.56765
*D1 'STA125' 267.1 257.7 0 0 11975.3823 -9226.348428
D1 'STA120' 266.1 256.6 0 0 12038.23132 -9370.90118
D1 'STA115' 266.4 256.3 0 0 12167.68285 -9689.125279
D1 'STA110' 267 255.6 0 0 12224.06 -9767.32
D1 'STA100' 267.4 254.8 0 0 12278.61 -9825.52
D1 'All2us' 282 269.3 0 0 8886.928495 -12738.08345
D1 'All2x3us' 281.8 259.7 0 0 8772.530282 -12443.91662
D1 'ALL170' 274.3 258.8 0 0 10280.03025 -11934.035
D1 'Water100' 235 224.6 0 0 14193.73581 -9300.0514
D1 'Water200' 235 225.6 0 0 13934.44875 -10300.15863
D1 'Water110' 235 224 0 0 14737.00393 -9670.461483
D1 'Water210' 235 225.1 0 0 14638.22791 -10287.81162
D1 'Water220' 234.5 225 0 0 14860.47396 -10794.03874
*D1 'NEW10' 283.21 271.11 0 0 6144.01 -2770.9
D1 'Brook10' 269.67 255.02 0 0 10211.88 -12499.13
```

```
*
*brook20 is on pillsbury street
D1 'Brook20' 269 246.7 0 0 10860.2 -12933.88
D1 'Brook30' 248 238.23 0 0 11672.7 -12911.46
D1 'Brook40' 240 229.82 0 0 12310.7 -12893.9
D1 'Brook50' 233.44 223.39 0 0 12797.52 -12880.49
*
*running south on main street passed holly and hope streets.
D1 'Holly' 260.5 245.7 0 0 11672.7   -13367.49
D1 'McKinley' 287.1 253.0 0 0 11672.7   -13854.49
**
*
*    JFREE  NBCF
I1 'Water110' 1
I1 'Water220' 1
I1 'Brook50' 1
J1 1

*
*
*
$ENDPROGRAM
```

City of Concord - Stormwater Master Plan

Washington Street Drainage Basin - Inspection Status Report

Contains data from 11/2/01 9:18:00 AM through 12/20/01 4:24:00 AM

A. Inspection Counts

Number of Structures Visited: 730

Number of Unobstructed Structures: 460

	Complete Inspections	Partial Inspections	Total
Number of MH Inspections:	394	17	411
Number of CB Inspections:	46	3	49
Total:	440	20	460

Number of Inspected Pipes: 1,554.00

Number of New Pipes Found & Inspected: 85

B. Location Status Counts (*of completed inspections only)

LOCATION STATUS	STRUCTURE TYPE	COUNT	TOTAL
Mapped/Found	Catchbasin	25	371
	Manhole	346	
Moved**	Catchbasin	2	10
	Manhole	8	
New	Catchbasin	21	77
	Manhole	56	
Not Found	Catchbasin	1	2
	Manhole	1	

*** Discrepancy between field-observed location and mapped location.*

Separator Sheet

City of Concord - Stormwater Master Plan

Washington Street Drainage Basin - Pipe Condition Report

Contains data from 11/3/01 through 12/19/01 11:14:00 PM

A. Number of Pipes in Fair to Poor Condition 74

B. Pipe Condition Description:

MHID	PIPE #	PIPE TYPE	SHAPE	WIDTH (in.)	HEIGHT (in.)	RIM TO INVERT (ft.)	OFFSET DESC.	OFFSET DISTANCE	BREAK DESC.	BREAK DISTANCE	CRACKS	CONDITION
113-J13												
	4	Out	Circular	-99	15	55	None	-99	Crown crushed	10	☐	Fair
1601-I14												
	1	In	Circular	-99	4	91	None	-99	None	-99	☐	Fair
1681-J14												
	1	In	Circular	-99	8	36	None	-99	None	-99	☐	Fair
1711-J14												
	2	In	Circular	-99	18	161	None	-99	None	-99	☐	Fair
	5	Out	Circular	-99	18	162	None	-99	minor	4	☐	Fair
182-I13												
	2	In	Circular	-99	8	121	None	-99	None	-99	☐	Plugged
1895-J14												
	2	In	Circular	-99	12	92	None	-99	None	-99	☐	Plugged
1927-J14												
	2	In	Circular	-99	12	60	None	-99	None	-99	☐	Fair
2109-J14												
	1	In	Circular	-99	8	42	None	-99	None	-99	☐	Plugged
213-I13												
	1	In	Circular	-99	8	98	Settle 5" at joint	4	None	-99	☐	Poor
	2	In	Circular	-99	10	136	None	-99	None	-99	☐	Poor
2190-J14												
	1	In	Circular	-99	6	73	None	-99	None	-99	☐	Plugged
	2	In	Circular	-99	6	73	None	-99	None	-99	☐	Plugged
222-I13												
	1	In	Circular	-99	4	108	None	-99	None	-99	☐	Fair

B. Pipe Condition Description:

MHID	PIPE #	PIPE TYPE	SHAPE	WIDTH (in.)	HEIGHT (in.)	RIM TO INVERT (ft.)	OFFSET DESC.	OFFSET DISTANCE	BREAK DESC.	BREAK DISTANCE	CRACKS	CONDITION
277-J13												
	3	In	Circular	-99	8	100	None	-99	None	-99	☐	Plugged
2788-I13												
	1	Out	Circular	-99	8	106	None	-99	None	-99	☐	Fair
2802-J14												
	1	In	Circular	-99	6	74	None	-99	None	-99	☐	Plugged
2849-J14												
	1	In	Egg	18	21	100	None	-99	None	-99	☐	Fair
2897-I13												
	2	In	Circular	-99	8	78	None	-99	None	-99	☐	Fair
2901-I13												
	2	In	Circular	-99	4	66	None	-99	None	-99	☐	Fair
2965-I13												
	2	In	Circular	-99	24	86	None	-99	LC	20	☐	Fair
3116-I13												
	2	In	Circular	-99	12	105	None	-99	None	-99	☐	Plugged
	3	In	Circular	-99	6	91	None	-99	None	-99	☐	Plugged
3159-I13												
	1	In	Circular	-99	6	65	None	-99	None	-99	☐	Plugged
	3	In	Circular	-99	6	64	None	-99	None	-99	☐	Plugged
3161-I13												
	1	In	Circular	-99	6	81	None	-99	None	-99	☐	Plugged
3174-I13												
	2	In	Circular	-99	4	56	None	-99	None	-99	☐	Fair
3179-I13												
	2	In	Circular	-99	6	76	None	-99	None	-99	☐	Plugged
3304-I13												
	1	In	Circular	-99	8	46	None	-99	None	-99	☑	Fair
	2	In	Circular	-99	15	51	None	-99	Crown fallen	6	☐	Fair
	5	In	Circular	-99	8	54	None	-99	None	-99	☐	Plugged
3316-I13												
	3	In	Circular	-99	10	106	None	-99	None	-99	☐	Plugged

Separator Sheet

City of Concord - Stormwater Master Plan

Washington Street Drainage Basin - Flow Characteristics Report

A. Number of Pipes with Flow: 66

B. Flow Description:

MHID	PIPE #	DEPTH OF FLOW (IN.)	VOL. FLOW (GPM) [-99 = Could not quantify]	FLOATABLES	SHEEN	SMELL	COLOR
130-J13							
	1	0.1	-99	None	☐	None	None
1555-J14							
	5	1	10	None	☐	None	None
1745-J14							
	1	25	3	None	☐	None	None
	2	25	0	None	☐	None	None
178-I13							
	2	0.1	-99	None	☐	Weak Septic	Grey
	4	0.1	-99	None	☐	Weak Septic	Grey
179-I13							
	2	0.1	-99	None	☐	Weak Septic	Grey
	5	0.1	-99	None	☐	Weak Septic	Grey
1815-J14							
	2	0.5	-99	None	☐	None	None
1957-J14							
	1	0.1	-99	None	☐	None	Grey
	3	0.1	-99	None	☐	None	Sudsy
1962-J14							
	3	0.25	-99	None	☐	None	Grey
	6	0.25	-99	None	☐	None	Grey

B. Flow Description:

MHID	PIPE #	DEPTH OF FLOW (IN.)	VOL. FLOW (GPM) [-99 = Could not quantify]	FLOATABLES	SHEEN	SMELL	COLOR'
1963-J14							
	1	0.25	-99	None	☐	None	Grey
	3	0.25	-99	None	☐	None	Grey
1964-J14							
	2	0.25	-99	None	☐	None	Grey
	4	0.25	-99	None	☐	None	Grey
1967-J14							
	2	0.1	-99	None	☐	None	Grey
	3	0.1	-99	None	☐	None	Grey
1971-J14							
	3	1	1	None	☐	None	Grey
	4	1	1	None	☐	None	Grey
2033-J14							
	6	3	-99	None	☐	Strong Septic	Clear
2107-J14							
	4	0.05	-99	None	☐	None	None
2114-J14							
	1	0.1	-99	None	☐	None	None
213-I13							
	5	0.1	-99	None	☐	Weak Septic	Grey
	6	0.1	-99	None	☐	Weak Septic	Grey
2143-J14							
	1	0.1	-99	None	☐	None	Grey
	3	0.25	-99	None	☐	None	Grey

B. Flow Description:

MHID	PIPE #	DEPTH OF FLOW (IN.)	VOL. FLOW (GPM) [-99 = Could not quantify]	FLOATABLES	SHEEN	SMELL	COLOR
233-J13							
	1	0.2	-99	None	☐	None	None
	2	0.2	-99	None	☐	None	None
2820-J14							
	1	1	-99	None	☐	None	Grey
2826-J13							
	1	30	-99	None	☐	None	None
	3	10	-99	None	☐	None	None
	5	5	-99	None	☐	None	None
	6	20	-99	None	☐	None	None
2854-J13							
	1	0.25	-99	None	☐	None	Grey
295-I14							
	4	1	-99	None	☐	None	None
2972-I13							
	1	2	-99	YES	☐	Weak Septic	Grey
	2	2	-99	YES	☐	Weak Septic	Grey
3116-I13							
	1	0.1	-99	YES	☐	Weak Septic	Grey
	4	0.1	-99	YES	☐	Weak Septic	Grey
362-I14							
	5	1	-99	None	☐	None	None
371-I14							
	2	1	-99	None	☐	None	None

B. Flow Description:

MHID	PIPE #	DEPTH OF FLOW (IN.)	VOL. FLOW (GPM) [-99 = Could not quantify]	FLOATABLES	SHEEN	SMELL	COLOR
3828-J13							
	1	3	-99	None	☐	None	Brown
	3	3	-99	None	☐	None	Brown
3879-J13							
	4	-1	-99	None	☐	None	None
3881-J13							
	1	2	-99	None	☐	None	None
3885-J13							
	3	1	-99	None	☐	None	None
3898-J13							
	1	5	-99	YES	☐	None	Grey
	3	5	-99	YES	☐	None	Grey
3930-J13							
	2	5	-99	None	☐	None	Grey
3996-J13							
	3	0.5	-99	None	☐	None	Grey
4013-J13							
	1	0.25	-99	None	☐	None	Grey
	2	0.25	-99	None	☐	None	Grey
799-I14							
	5	1	-99	None	☐	None	None
808-I13							
	1	0.1	-99	None	☐	Weak Septic	Grey
	2	0.1	-99	None	☐	Weak Septic	Grey

B. Flow Description:

MHID	PIPE #	DEPTH OF FLOW (IN.)	VOL. FLOW (GPM) [-99 = Could not quantify]	FLOATABLES	SHEEN	SMELL	COLOR
85-I13							
	1	2	-99	None	☐	None	None
J13-28							
	1	0.1	-99	None	☐	None	Grey
	3	0.1	-99	None	☐	None	Grey
J13-5							
	3	1	-99	None	☐	None	None
J14-1							
	1	0.2	-99	None	☐	None	None
J14-2							
	1	0.2	-99	None	☐	None	None
J14-9							
	2	25	-99	None	☐	None	None
J14-909							
	1	0.25	-99	None	☐	None	None
	2	0.25	-99	None	☐	None	None

Separator Sheet

City of Concord - Stormwater Master Plan

Washington Street Drainage Basin - Obstruction Summary Report

Contains data from 11/4/01 through 12/20/01 3:34:00 AM

OBSTRUCTION TYPE	MH ID	TILE #	STREET ADDRESS	CROSS STREET	INSPECTION DATE	TOTAL COUNT BY OBSTRUCTION TYPE
BRK OVER IN WALKWAY						
	1697-J14		HILLS AV	None	16-Nov-01	
						1
Car Parked						
	2852-J14		WARREN ST	None	19-Dec-01	
	3663-J13		STICKNEY AV	None	08-Nov-01	
						2
CATCH BASIN						
	3310-I13		CHURCH ST	None	30-Nov-01	
	3311-I13		CHURCH ST	None	30-Nov-01	
	3618-J13		LOUDON RD	None	15-Nov-01	
	3832-J13		N STATE ST	None	08-Nov-01	
	574-I14		None	None	06-Dec-01	
	786-I14		LIBERTY ST	None	06-Dec-01	
						6
CNI						
	153-J13		CENTRE ST	None	12-Dec-01	
	1966-J14		S MAIN ST	THEATRE ST	14-Dec-01	
	247-J13		N STATE ST	None	19-Dec-01	
	2851-J14		WARREN ST	None	19-Dec-01	
	2861-J13		WARREN ST	None	20-Dec-01	
						5
CNL						
	1721-J14		STORRS ST	None	04-Nov-01	
	1956-J14		N MAIN ST	PLEASANT ST	20-Dec-01	
	1958-J14		S MAIN ST	None	17-Dec-01	
	1959-J14		S MAIN ST	None	17-Dec-01	
	2314-J14		N MAIN ST	None	20-Dec-01	
	580-I14		CENTRE ST	None	10-Dec-01	
						6
COULD NOT INSPECT						
	2889-I13		BLANCHARD ST	None	05-Dec-01	
	3010-I13		BEACON ST	None	03-Dec-01	
	3492-J13		N STATE ST	None	07-Dec-01	
	497-I14		SCHOOL ST	None	06-Dec-01	
						4
COULD NOT LOCATE						
	1598-J14		PLEASANT ST EXT	None	12-Nov-01	

OBSTRUCTION TYPE	MH ID	TILE #	STREET ADDRESS	CROSS STREET	INSPECTION DATE	TOTAL COUNT BY OBSTRUCTION TYPE
	1607-I14		SUMMIT ST	None	19-Nov-01	
	1620-I14		WARREN ST	None	19-Nov-01	
	1628-J14		STORRS ST ROW	None	05-Nov-01	
	1629-J14		STORRS ST ROW	None	05-Nov-01	
	1630-J14		STORRS ST ROW	None	05-Nov-01	
	1710-J14		Storrs Street	None	06-Nov-01	
	1713-J14		STORRS ST	None	06-Nov-01	
	1714-J14		Storrs Street	None	06-Nov-01	
	1746-J14		STORRS ST	FREIGHT ST	13-Nov-01	
	1749-J14		FREIGHT ST	None	12-Nov-01	
	180-I13		FOREST ST	None	04-Dec-01	
	181-I13		CHESTNUT CT	None	06-Dec-01	
	188-I13		LIBERTY ST. EASEMENT	None	05-Dec-01	
	189-I13		AUBURN ST	None	05-Dec-01	
	1955-J14		FREIGHT ST	None	16-Nov-01	
	1974-J14		S MAIN ST	None	06-Nov-01	
	199-J13		LOW AV	None	12-Nov-01	
	2031-J14		None	None	15-Nov-01	
	205-J13		RUMFORD ST	None	20-Nov-01	
	207-I13		VERNON ST	None	05-Dec-01	
	2268-I14		MERRIMACK ST	None	19-Nov-01	
	2291-J14		WARREN ST	None	19-Nov-01	
	231-J13		SCHOOL ST	None	19-Nov-01	
	2319-J14		SCHOOL ST	RUMFORD ST	20-Nov-01	
	239-J13		LOW AV	None	12-Nov-01	
	2789-J13		GREENWOOD AV	None	19-Nov-01	
	2790-J13		GREENWOOD AV	None	19-Nov-01	
	2804-J13		None	None	05-Nov-01	
	2818-J13		DEPOT ST	STORRS ST	12-Nov-01	
	2887-J13		STORRS ST	DEPOT ST	13-Nov-01	
	2890-I13		WHITE ST	None	05-Dec-01	
	2895-I13		WHITE ST	None	03-Dec-01	
	2896-I13		ROWELL ST	None	03-Dec-01	
	2898-I13		BLANCHARD ST	None	05-Dec-01	
	3028-I13		CHESTNUT CT	None	06-Dec-01	
	3038-I13		COLUMBUS AV	None	06-Dec-01	
	3119-I13		VALLEY ST	None	04-Dec-01	
	3152-I13		FRANKLIN ST	GLADSTONE ST	04-Dec-01	
	3166-I13		FRANKLIN ST	None	04-Dec-01	
	3171-I13		GLADSTONE ST	None	04-Dec-01	
	3173-I13		GLADSTONE ST	None	06-Dec-01	
	3181-I13		CHARLES ST	None	03-Dec-01	
	3186-I13		ROCKLAND RD	None	06-Dec-01	
	3294-I13		BEACON ST	WHITE ST	03-Dec-01	
	3418-I13		LYNDON ST	None	27-Nov-01	
	3494-J13		MONTGOMERY ST	None	15-Nov-01	
	351-I14		PINE ST	None	05-Dec-01	

OBSTRUCTION TYPE	MH ID	TILE #	STREET ADDRESS	CROSS STREET	INSPECTION DATE	TOTAL COUNT BY OBSTRUCTION TYPE
	3522-J13		STORRS ST	None	07-Nov-01	
	356-I14		SCHOOL ST	None	05-Dec-01	
	3573-J13		STICKNEY AV	None	08-Nov-01	
	3577-J13		MONTGOMERY ST	None	08-Nov-01	
	3607-J13		STORRS ST	None	12-Nov-01	
	3616-J13		STORRS ST	None	08-Nov-01	
	3617-J13		STORRS ST	None	08-Nov-01	
	3619-J13		STORRS ST	None	07-Nov-01	
	3620-J13		STORRS ST	None	07-Nov-01	
	3621-J13		STORRS ST	None	07-Nov-01	
	3643-J13		LOUDON RD	None	21-Nov-01	
	3644-J13		LOUDON RD	None	21-Nov-01	
	3645-J13		LOUDON RD	None	15-Nov-01	
	3646-J13		LOUDON RD	STICKNEY AV	15-Nov-01	
	3666-J13		I-93	None	06-Nov-01	
	3700-J13		LOW AV	None	12-Nov-01	
	3712-J13		STORRS ST	None	08-Nov-01	
	3793-J13		CHAPEL ST	None	28-Nov-01	
	3803-J13		N MAIN ST	None	08-Nov-01	
	3827-J13		N STATE ST	None	21-Nov-01	
	3940-J13		BEACON ST	None	28-Nov-01	
	3942-J13		WASHINGTON ST	ACADEMY ST	27-Nov-01	
	3993-J13		BEACON ST	None	28-Nov-01	
	3997-J13		BEACON ST	None	30-Nov-01	
	782-I14		HOLT ST	None	06-Dec-01	
	806-I13		VERNON ST	LIBERTY ST	05-Dec-01	
						74
COULD NOT OPEN						
	3856-J13		CENTRE ST	N STATE ST	14-Nov-01	
						1
LAMP HOLE - COULD NOT IN						
	155-J13		ESSEX ST	None	26-Nov-01	
	1600-J14		RUMFORD ST	None	19-Nov-01	
	2108-J14		WALL ST	None	19-Nov-01	
	2256-J14		None	None	19-Nov-01	
	2885-J13		RUMFORD ST	None	20-Nov-01	
	2899-I13		RUMFORD ST	CELTIC ST	03-Dec-01	
	2900-I13		RUMFORD ST	None	03-Dec-01	
	292-I14		PINE ST	None	05-Dec-01	
	296-I14		SCHOOL ST	None	05-Dec-01	
	3118-I13		VALLEY ST	None	04-Dec-01	
	3126-I13		FOREST ST.	None	04-Dec-01	
	3139-I13		FRANKLIN ST	None	04-Dec-01	
	3158-I13		LIBERTY ST	None	03-Dec-01	
	3163-I13		ORION ST	None	03-Dec-01	
	3165-I13		ORION ST	None	03-Dec-01	
	3419-I13		RUMFORD ST	None	27-Nov-01	

OBSTRUCTION TYPE	MH ID	TILE #	STREET ADDRESS	CROSS STREET	INSPECTION DATE	TOTAL COUNT BY OBSTRUCTION TYPE
	3842-J13		MAPLE ST	None	26-Nov-01	
	3941-J13		RUMFORD ST	None	26-Nov-01	
	3944-J13		JACKSON ST	None	27-Nov-01	
	3961-J13		CAMBRIDGE ST	None	20-Nov-01	
	3969-I13		LYNDON ST	None	27-Nov-01	
	3973-J13		JACKSON ST	None	27-Nov-01	
	583-I14		LIBERTY ST	None	05-Dec-01	
						23
LAMP HOLE - COULD NOT L						
	2798-J14		GREENWOOD AV	None	19-Nov-01	
						1
LH - CNI						
	2036-J14		S STATE ST	None	14-Dec-01	
	800-I14		WARREN ST	None	11-Dec-01	
	J13-30		SCHOOL ST	None	12-Dec-01	
	J14-13		PLEASANT ST	None	19-Dec-01	
						4
NO CATCH BASIN						
	237-J13		LOW AV	None	12-Nov-01	
						1
NOT EXPOSED ON SURFAC						
	3746-J13		N MAIN ST	None	14-Nov-01	
						1
Other						
	3117-I13		VALLEY ST	None	04-Dec-01	
						1
Paved Over						
	1748-J14		FREIGHT ST	None	12-Nov-01	
	2189-J14		THORNDIKE ST	None	05-Nov-01	
	2287-J14		WARREN ST	WARREN ST	12-Dec-01	
	2918-I13		RUMFORD ST	None	03-Dec-01	
	2960-I13		TREMONT ST	None	04-Dec-01	
	3149-I13		FRANKLIN ST	None	30-Nov-01	
	3178-I13		FRANKLIN ST	None	30-Nov-01	
	3187-I13		ROCKLAND RD	None	06-Dec-01	
	3305-I13		FRANKLIN ST	None	04-Dec-01	
	3611-J13		DIXON AV	None	07-Nov-01	
	3922-J13		N STATE ST	None	13-Dec-01	
	3998-J13		BEACON ST	None	28-Nov-01	
	494-I14		AUBURN ST	None	05-Dec-01	
	J14-8		N SPRING ST	None	12-Dec-01	
						14
PLUG						
	3897-J13		PEARL ST	None	28-Nov-01	

OBSTRUCTION TYPE	MH ID	TILE #	STREET ADDRESS	CROSS STREET	INSPECTION DATE	TOTAL COUNT BY OBSTRUCTION TYPE
						1
Police Detail Req'd						
	118-J13		CAPITOL ST	None	08-Nov-01	
	119-J13		CAPITOL ST	None	08-Nov-01	
	120-J13		CAPITOL ST	None	08-Nov-01	
	1969-J14		S MAIN ST	None	06-Nov-01	
	1970-J14		S MAIN ST	None	06-Nov-01	
	1977-J14		S MAIN ST	None	06-Nov-01	
	1986-J14		S MAIN ST	None	06-Nov-01	
	3670-J13		LOUDON RD	None	06-Nov-01	
	3685-J13		LOUDON RD	None	06-Nov-01	
						9
STEAM MANHOLE						
	1724-J14		THEATRE ST	STORRS ST	15-Nov-01	
	2313-J14		CENTRAL AVE.	None	19-Nov-01	
	3610-J13		DIXON AV	None	12-Nov-01	
						3
UNKNOWN						
	3447-I13		BLANCHARD ST	None	26-Nov-01	
						1

Separator Sheet

City of Concord - Stormwater Master Plan

Washington Street Drainage Basin - Sediment Accumulation Report >10% Full

Contains data from 11/2/01 10:23:00 AM through 12/20/01 4:24:00 AM

A. Number of Pipes with >10% Sediment Accumulation 112

B. Sediment Accumulation Description

MHID	Pipe Number	Tile Number	Percent Full of Sediment (%)
151-J13	5	15	20
1592-J14	2	20	20
1720-J14	2	24	20
1893-J14	1	21	20
1957-J14	2	20	20
2289-J14	2	26	20
2315-J14	2	20	20
2315-J14	3	20	20
295-I14	3	22	20
2964-I13	1	12	20
3179-I13	3	12	20
3304-I13	7	7	20
3307-I13	1	7	20
3416-I13	1	11	20
3416-I13	2	11	20
3426-I13	5	16	20
352-I14	2	22	20
362-I14	2	27	20
3799-J13	1	10	20
3914-J13	1	6	20
3964-J13	2	16	20
3972-J13	1	11	20
4020-I13	5	11	20
799-I14	1	27	20
J14-12	1	20	20
J14-12	1	20	20

B. Sediment Accumulation Description

MHID	Pipe Number	Tile Number	Percent Full of Sediment (%)
J14-903	1	24	20
1552-J14	2	21	30
1684-J14	1	20	30
1685-J14	1	24	30
2033-J14	3	29	30
2270-J14	2	26	30
2288-J14	1	26	30
2788-I13	1	21	30
3179-I13	5	12	30
3304-I13	4	7	30
3304-I13	6	7	30
3798-J13	3	10	30
3933-J13	1	6	30
3933-J13	2	6	30
4020-I13	6	11	30
85-I13	2	16	30
J14-16	1	20	30
J14-16	2	20	30
J14-16	3	20	30
J14-9	4	25	30
J14-9	4	25	30
2841-J13	6	21	40
J14-3	3	19	40
1601-I14	1	21	50
1705-J14	1	24	50
1712-J14	2	24	50
1720-J14	1	24	50
1971-J14	2	28	50
2038-J14	1	25	50
2038-J14	4	25	50
2114-J14	2	25	50
222-I13	1	17	50
2299-I14	1	21	50
2901-I13	1	12	50

B. Sediment Accumulation Description

MHID	Pipe Number	Tile Number	Percent Full of Sediment (%)
2901-I13	3	12	50
2953-I13	1	12	50
3127-I13	1	17	50
3127-I13	2	17	50
3127-I13	3	17	50
3313-I13	1	7	50
3313-I13	2	7	50
3441-I13	3	11	50
3740-J13	3	15	50
3848-J13	2	11	50
3848-J13	3	11	50
3889-J13	2	5	50
3963-J13	3	16	50
4017-J13	4	11	50
788-I14	1	27	50
809-I14	2	22	50
85-I13	3	16	50
I14-2	1	21	50
I14-2	2	21	50
1785-J14	2	20	60
3440-I13	2	11	60
3914-J13	2	6	60
411-I13	3	22	60
3161-I13	2	12	70
3442-I13	3	11	70
778-I14	1	22	70
1971-J14	1	28	75
799-I14	2	27	75
1892-J14	4	20	80
3995-J13	1	6	80
412-I13	1	22	80
788-I14	2	27	80
J14-907	1	24	80
1965-J14	2	25	90

B. Sediment Accumulation Description

MHID	Pipe Number	Tile Number	Percent Full of Sediment (%)
3116-I13	3	17	90
3441-I13	1	11	90
1606-I14	1	21	100
1786-J14	3	20	100
1786-J14	4	20	100
1891-J14	3	20	100
1891-J14	5	20	100
213-I13	2	17	100
2897-I13	2	12	100
3317-I13	1	12	100
3318-I13	2	12	100
3439-I13	1	11	100
3442-I13	1	11	100
3442-I13	2	11	100
3490-I13	1	16	100
3790-J13	3	5	100
3933-J13	4	6	100
406-I13	2	22	100

Preparing Data Reports from Inspection Data

Using the "Integrate.apr" and "Concord.mdb" Applications

1. Collect and Store Data

1.1 Collect data using the Arc View application on the field computer.

1.2 Data is generally stored on the field computer in a folder "database" as files called
-inspmh.dbf (containing manhole information)
-insppipes.dbf (containing pipe information)
-infiltration.dbf (containing infiltration information, if any)

1.3 Copy data from the field computer to the analysis computer (or simply move data to the analysis folder if the same computer is to be used). You may wish to start a folder called DATA, inside which you have stored downloaded data in folders entitled "WE 12-31-01", where the date is the week-ending date for the data collected. Also within the DATA folder, you will need a folder called TEST, empty for now, but used in step 3 below.

2. Convert Files (Integrate.apr application)

2.1 Open Integrate.apr application, by double-clicking on icon. If program begins with "Where is '...'" dialog box, click "cancel all".

2.2 On window titled "integrate.apr", click "tables". Delete any tables shown by selecting (they will turn blue) and pushing keyboard "delete".

2.4 On window titled "integrate.apr", push "add". Locate your data files to be added - the latest versions of inspmh.dbf, insppipes.dbf and infiltration.dbf. Click on files and "ok".

2.5 Open (or click on) the Manhole data table. Click on the "mhid" column heading (it will turn a darker grey). On the tool bar at the top of the screen click "field", then "summarize". You will get another window with a file to save. Save it as sum1.dbf in the same folder as your data. Click "ok".

2.6 Click on the "mhid" column heading in sum1.dbf. THEN click on "mhid" column heading in inspmh.dbf (the order of this is important). On the toolbar at the top of the screen click "table," then "join". This adds a column called "count" to inspmh.dbf.

2.7 Click on the inspmh.dbf window. On the toolbar, click "edit" then "select all". Table will turn yellow. Click "File" and "Export". Export in Dbase format ("ok"). Save as inspmh2.dbf in same folder as your data.

2.8 In the Integrate.apr window, click "tables", "add", and add in inspmh2.dbf.

2.9 Open inspmh2.dbf, on the toolbar at the top of the screen click "table," then "start editing." Click the hand icon on the tool bar. This will search for duplicates in the table.

2.10 Click "table," then "stop editing." Save edits. Close the tables and close the application.

3. Pull New Data into Database (Concord.mdb application)

3.1 Move the files (inspmh2.dbf, insppipes.dbf, and infiltration.dbf) into folder called TEST. Rename files as inspmh.dbf, inspp.dbf,.and inspii.dbf respectively. These files will be used to update the Access database.

3.2 Open the Access application titled Concord.mdb.

3.3 On the toolbar at the top of the screen, click "tools", "addins", "linked table manager update". Select all. Click Ok. This lets the database see the new data you will be adding.

3.1 On the main switchboard window, click "import data". Import manhole data; click "yes" to the warning windows. Import pipe data; click "yes" to the warning windows. Enter a date before any of the data to be entered, i.e. the Sunday before work began.

3.2 On the main switchboard window, click "check for duplicates and integrate obstructions". If either manhole or pipe inspections show more than zero duplicates, click the folder icon after the number to investigate/resolve the error. When finished and both numbers read 0, click "no".

3.3 On the main switchboard window, click "integrate new manhole inspections". The number of new manhole records (from the latest table inspmh.dbf) should match the number of manhole records to integrate (=number to update + number to append). To see details behind any of the numbers, click the folder icon to the right. When ready, click "yes". On the Process MH Data window that appears, click "update new mh data" (respond yes to any messages), then "append new mh data" (respond yes to messages).

3.4 On the main switchboard window, click "integrate new pipe inspections". The number of new pipe records (from the latest table inspp.dbf) should match the number of pipe records to integrate (=number to update + number to append). To see details, click the folder icon to the right. When ready, click "yes". On the Process MH Data window that appears, click "update new pipe data" (respond yes to any messages), then "append new pipe data" (respond yes to any messages).

3.5 On the main switchboard window, click "add tile numbers". This will allow you to enter map page numbers for manholes added during the field inspection program.

4. Create Reports (summarizing the data)

4.1 On the main switchboard window, click "generate reports". Select the type of report to be generated using the beginning date and ending date for the report or the complete record.

4.2 Print reports by clicking "file" on the toolbar, and "print".

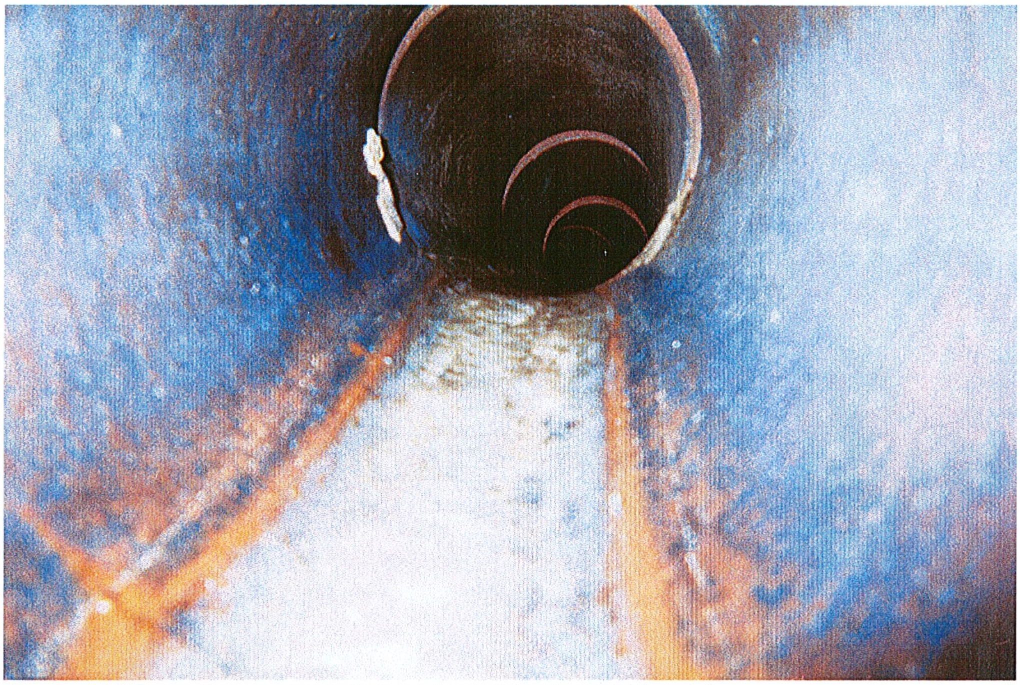
5.0 Miscellaneous Notes

-Any necessary adjustments or edits to the inspection data may be made either before integration (in the case of new data), or within the concord.mdb file (for all data). In Concord.mdb, click on the "database window" icon (looks like 3 small sheets). A "Concord:Database" window will appear, click the "tables" tab. Tables pipe_insp, MH_insp, and II_insp contain the final data - any necessary changes should be made to these tables so the reports will reflect the desired changes.

-

Appendix D
Photos of Select Manholes and Pipes from Washington Street Basin

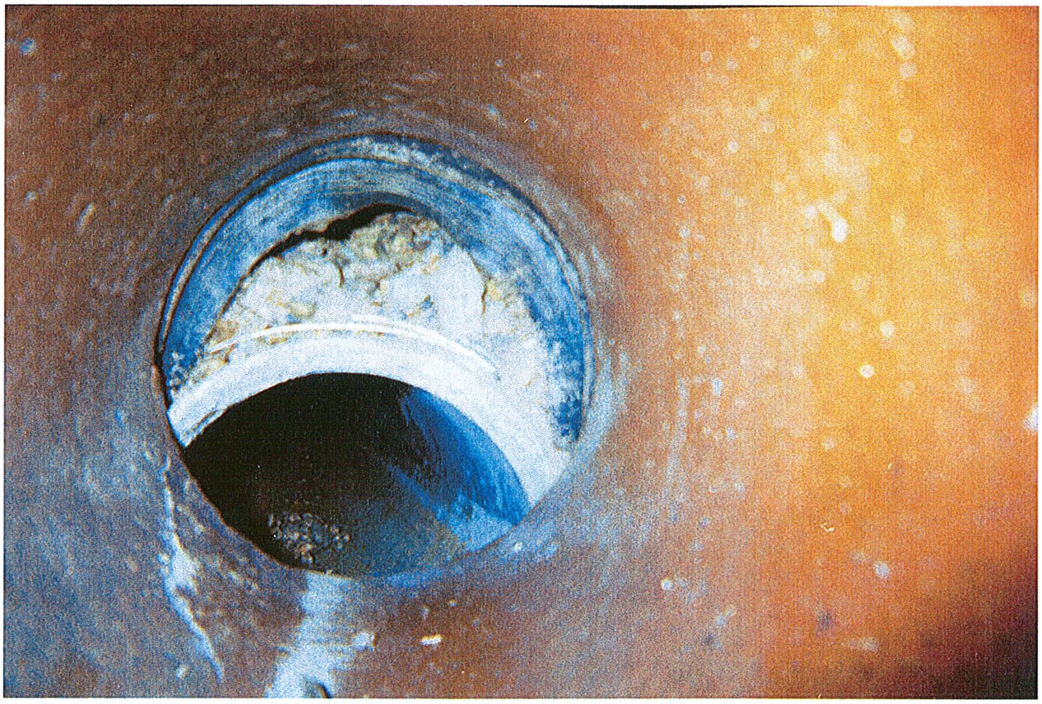
Possible cross connection near the corner of Concord Street and South State Street. The field crew noticed evidence of light sewage and a strong sewer smell on Concord Street flowing east from South State Street to South Main Street (manhole numbers 2033-J14 – above, to 2031-J14). Pipe out of manhole 2032-J14 (towards 2031-J14) is shown below.



Evidence of "dripping sewage" was found in the 8" line (above, upstream of manhole number 3116-I13) running from the end of Chestnut Street to just south of the corner of Valley Street and Orion Street, near the north end of White Park.

Sewer line runs through storm drain about 6' upstream from manhole 179-I13, on Valley Street between Forest Street and Liberty Street. Small amount of grey-colored flow with a slight septic smell noticed here (manhole numbers 179-I13 to 808-I13). This is also downstream of the above-mentioned "dripping sewage".

Possible sewage in the drain line running south on Rumford Street from Franklin to Beacon (manholes 3316-I13 to 2973-I13). Pipe leaving manhole 2972-I13, corner of Rumford and Beacon is shown above. Floatables, color and odor all suggest sewage in this line.

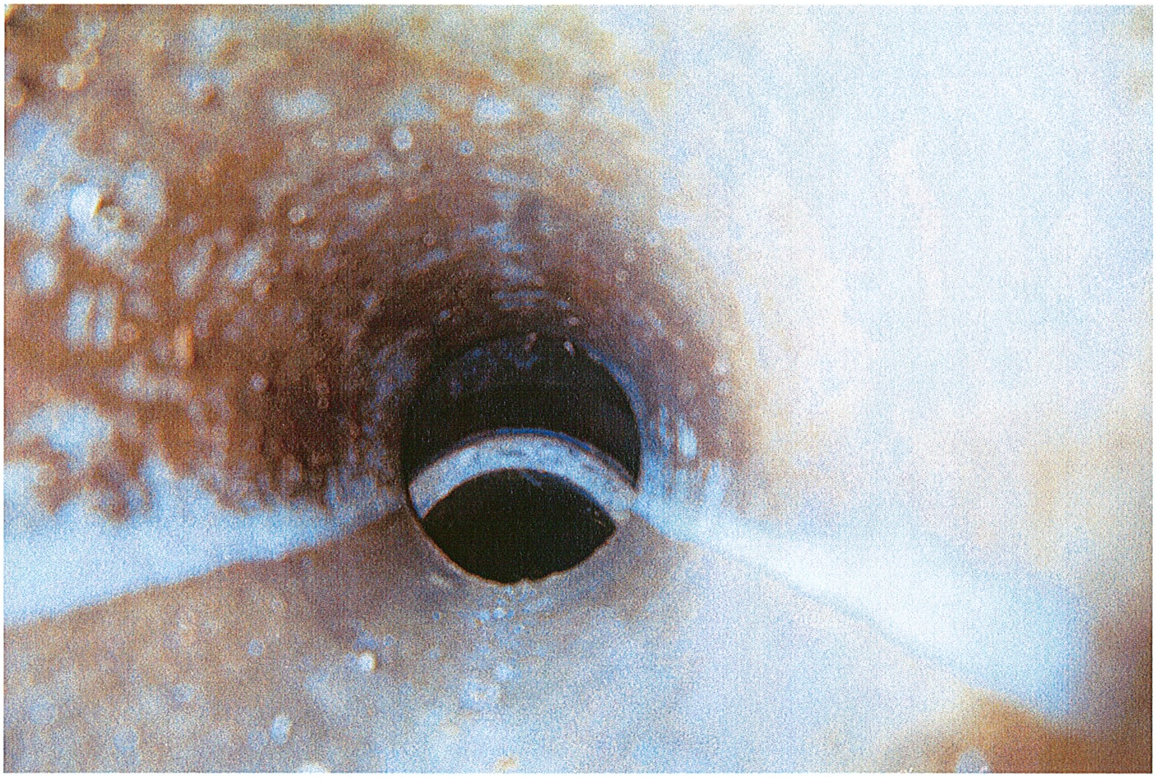


Joint failure and possible cross connection on Liberty St, north of Vernon St (manhole 213-I13). A section of 8″ pipe about 4′ upstream (south) of the manhole settled 4″ to 5″, giving way at the joint. The source of any flow in the settled pipe was not located, but mapping indicates it may be connected to the sewer system.

8" vcp on Celtic Street is 50% full of debris flowing into manhole 3440-I13.
The 8"vcp flowing out of this manhole is collapsed to 3".
No picture was available of the collapsed pipe.

Possible cross connection near North Main Street at Pearl Street (manhole 3898-J13).
Flow containing floatables, including toilet paper, were found in the manhole.

Manhole 213-I13 (Liberty Street, west of White Park), 10″ pipe 100% full of debris.



Manhole 3480-I13, Beacon Street at Lyndon Street.
4″ catchbasin lateral experiencing differential settling at joint.

Appendix E
Detail Sketches from Washington Street Manhole Inspection

PITOMETER UTILITY PIPELINE

SEVERN TRENT SERVICES

72 PRISCILLA LANE • AUBURN, NH 03032
603/625-1212 • FAX 603/623-6680

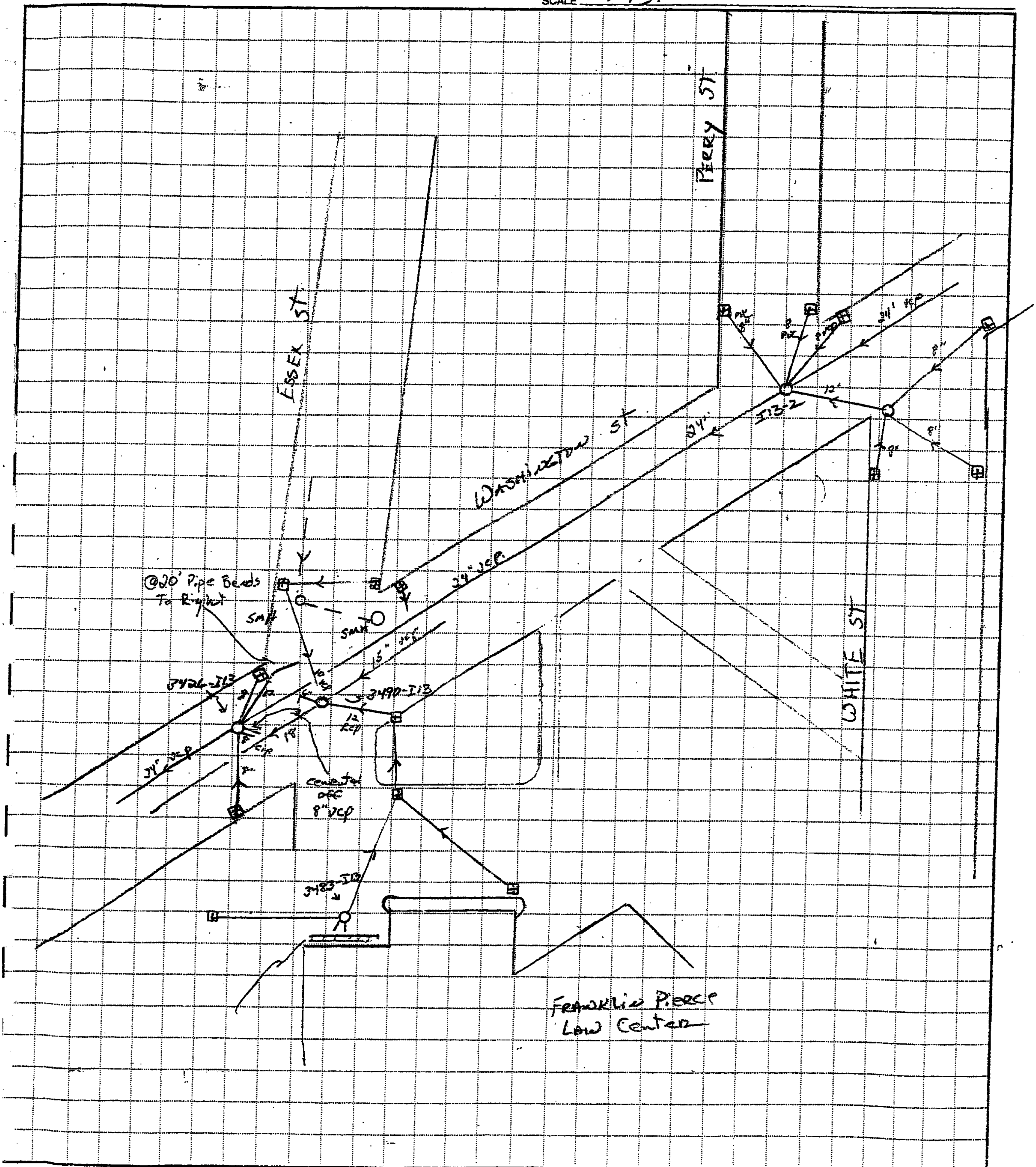
JOB Concord NH 01108

SHEET NO. Sketch 1 OF Tile 16

CALCULATED BY JAH DATE 11-26-0

CHECKED BY ______ DATE ______

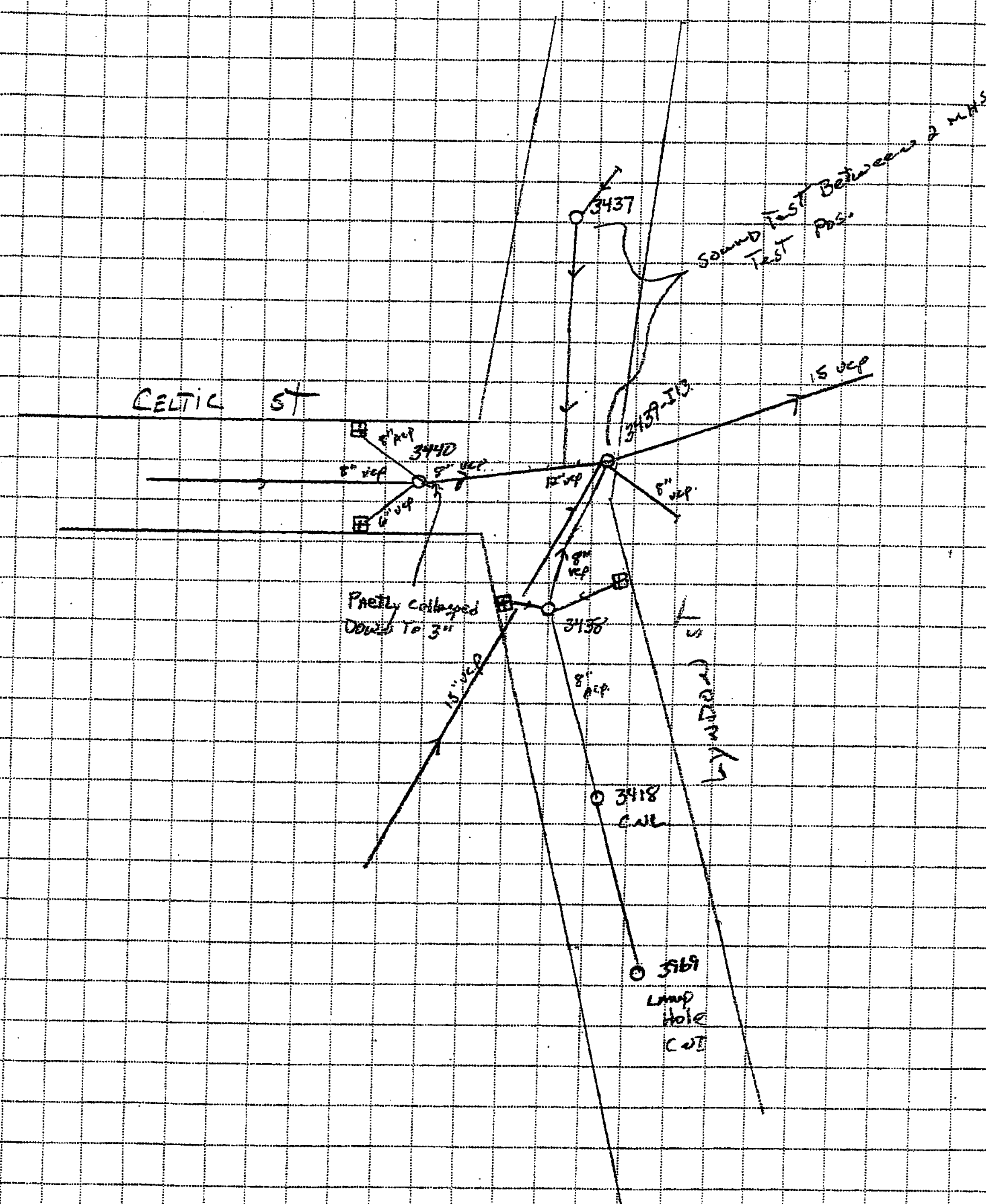
SCALE NTS.



PITOMETER UTILITY PIPELINE SEVERN TRENT SERVICES

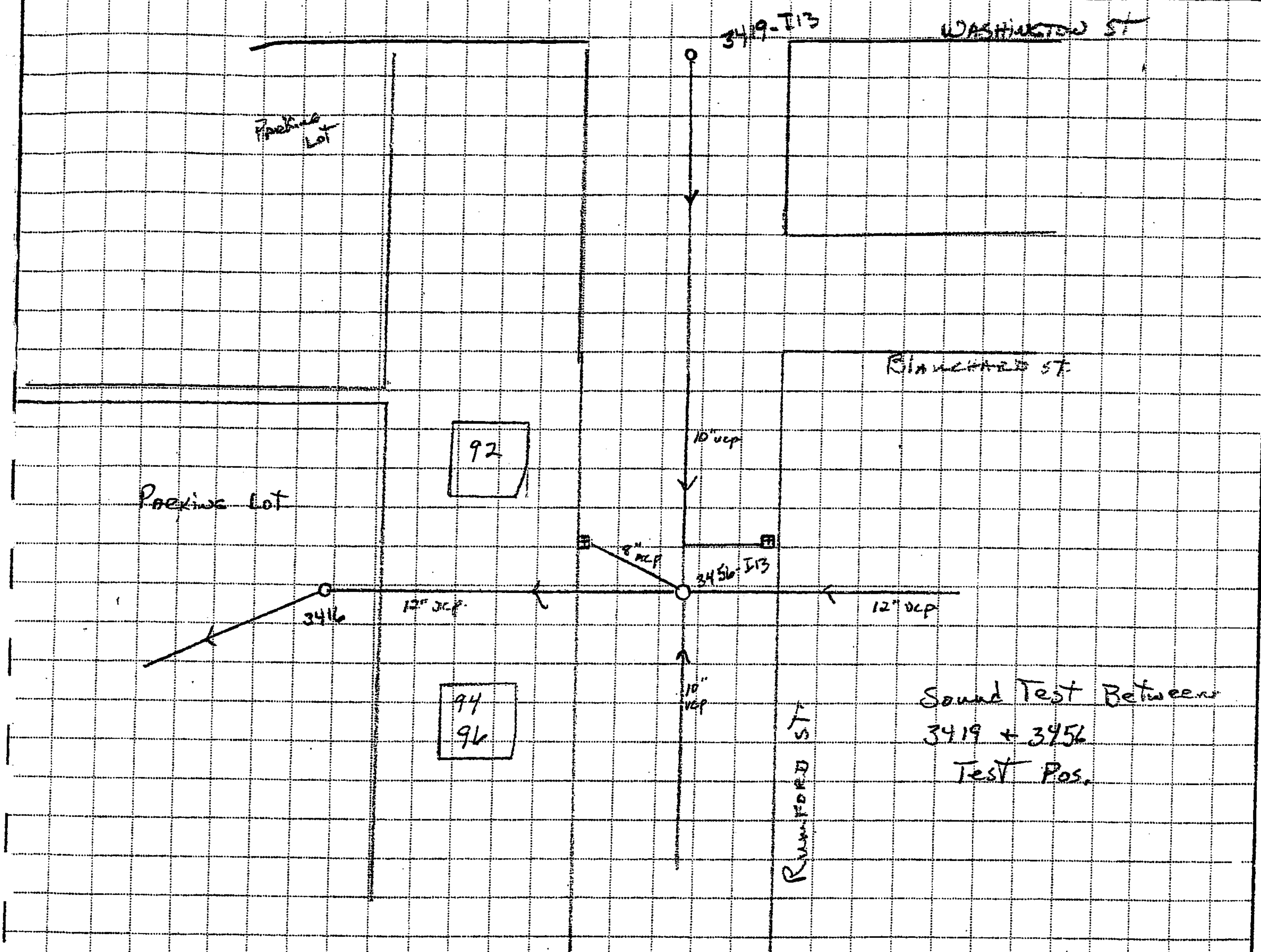
72 PRISCILLA LANE · AUBURN, NH 03032
603/625-1212 * FAX 603/623-6680

JOB: Concord NH Data
SHEET NO.: Sketch 2 OF: Tile 11
CALCULATED BY: JAH DATE: 11-27-01
CHECKED BY: DATE:
SCALE: NTS.



PITOMETER UTILITY PIPELINE
SEVERN TRENT SERVICES
72 PRISCILLA LANE - AUBURN, NH 03032
603/625-1212 * FAX 603/623-6680

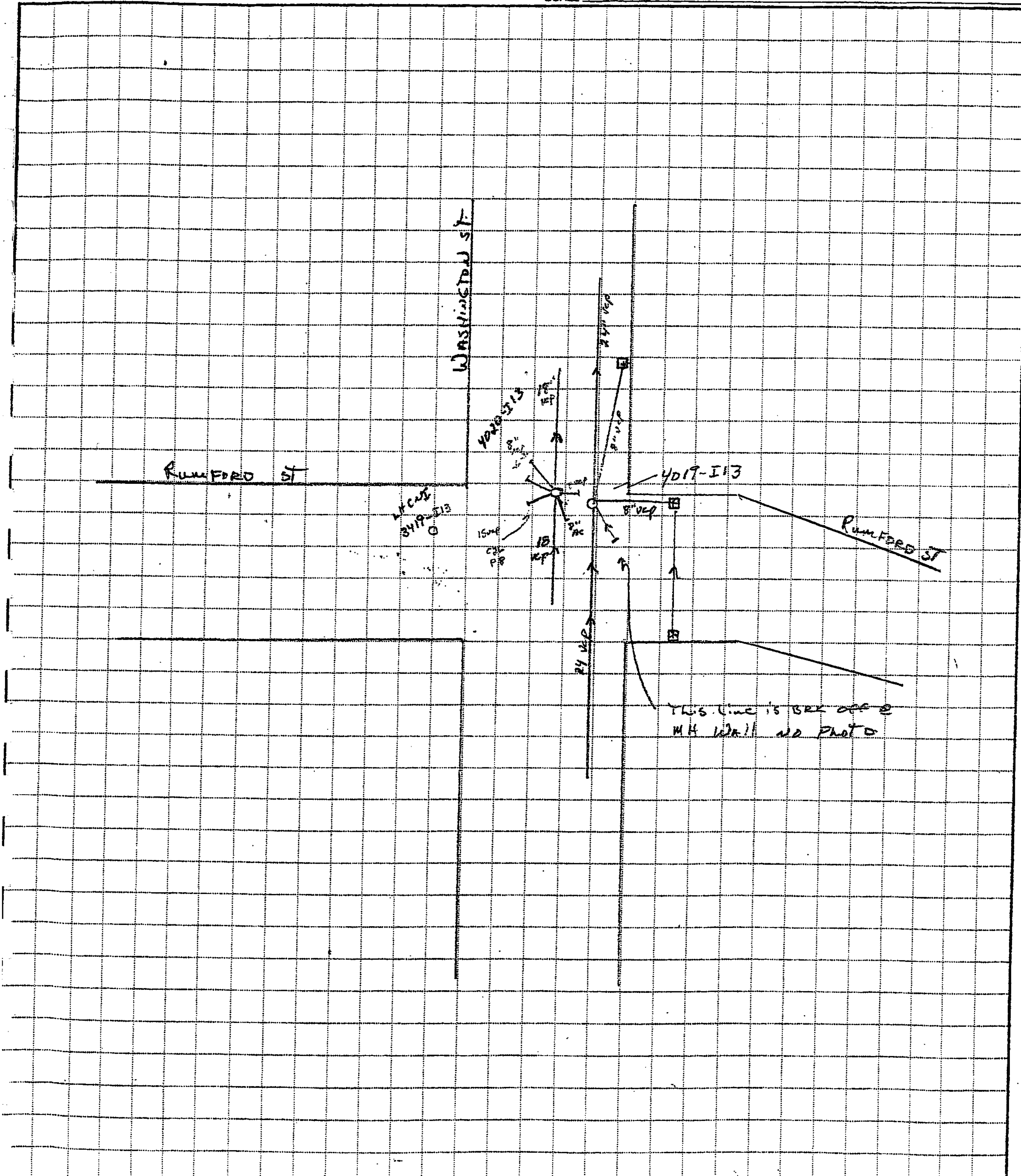
JOB Concord NH. DMH
SHEET NO. Sketch 3 OF Tile 11
CALCULATED BY JAH DATE 11-27-01
CHECKED BY ______ DATE ______
SCALE NTS



Sound Test Between
3419 + 3456
Test Pos.

PITOMETER UTILITY PIPELINE
SEVERN TRENT SERVICES
72 PRISCILLA LANE • AUBURN, NH 03032
603/625-1212 • FAX 603/623-6680

JOB Concord NH Durh
SHEET NO. Sketch 4 OF Tile 11
CALCULATED BY JAH DATE 11-27-01
CHECKED BY ______ DATE ______
SCALE NTS



PITOMETER UTILITY PIPELINE

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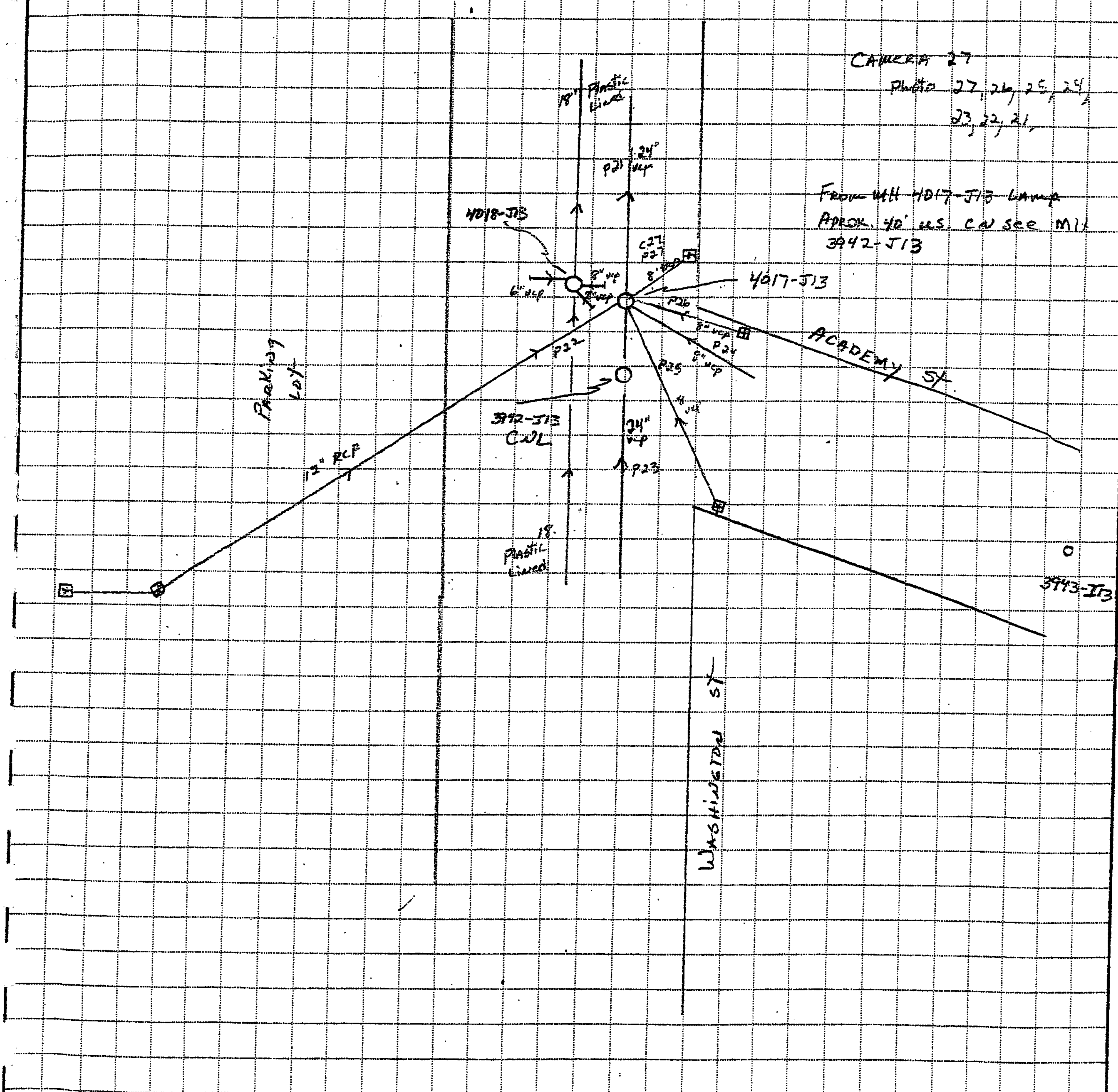
SHEET NO. Sketch 5. OF Tile 11

CALCULATED BY JAH DATE 11-27-01

CHECKED BY ______ DATE ______

SCALE NTS.



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JOB: Concord NH DPW
SHEET NO.: Sketch 6 OF: Tile 6
CALCULATED BY: JAH DATE: 11-28-01
CHECKED BY: DATE:
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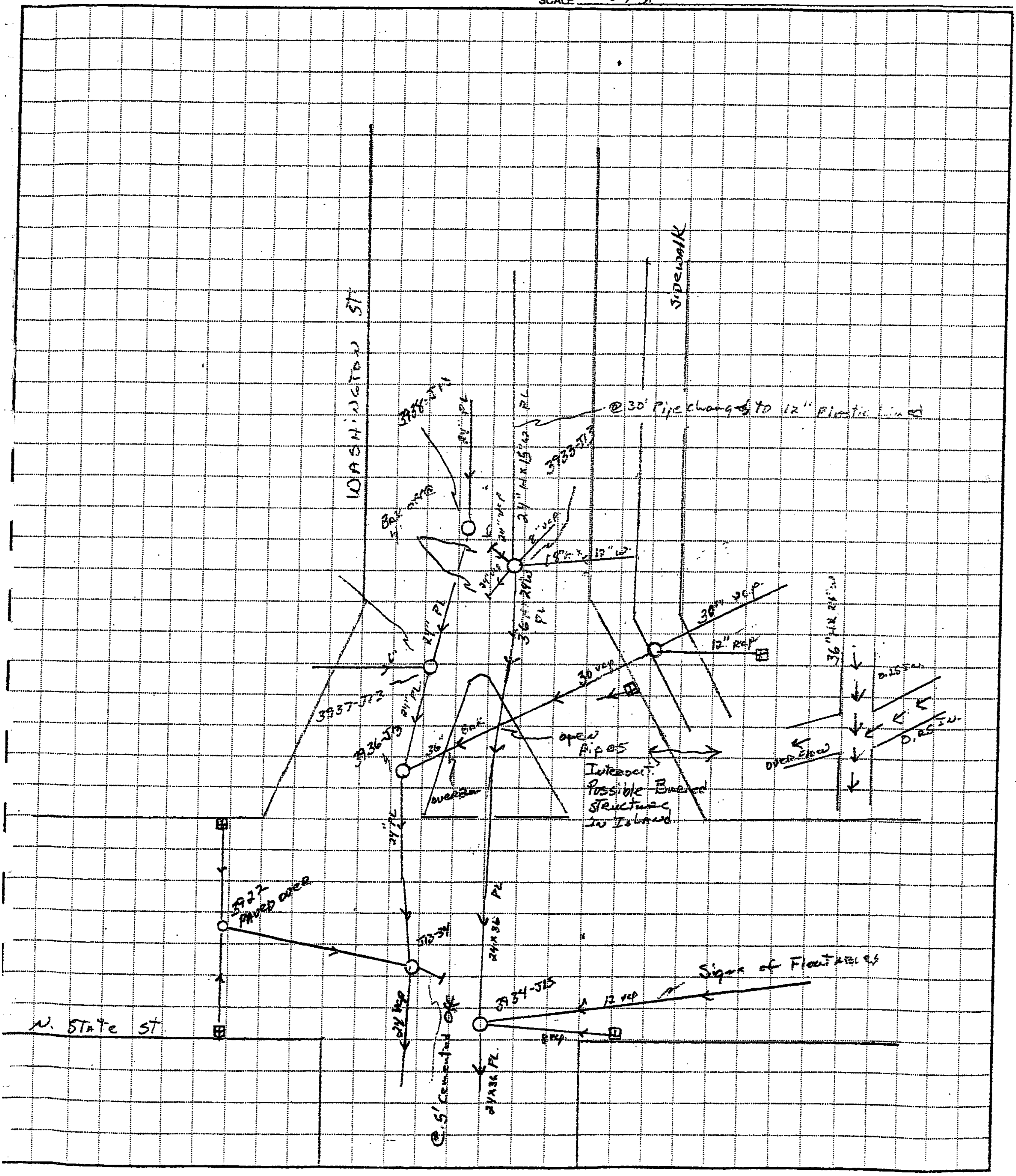

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JOB: CONCORD NH DRAFT

SHEET NO.: Sketch 7 OF: Tile 6

CALCULATED BY: JAH DATE:

CHECKED BY: DATE: 11-28-01

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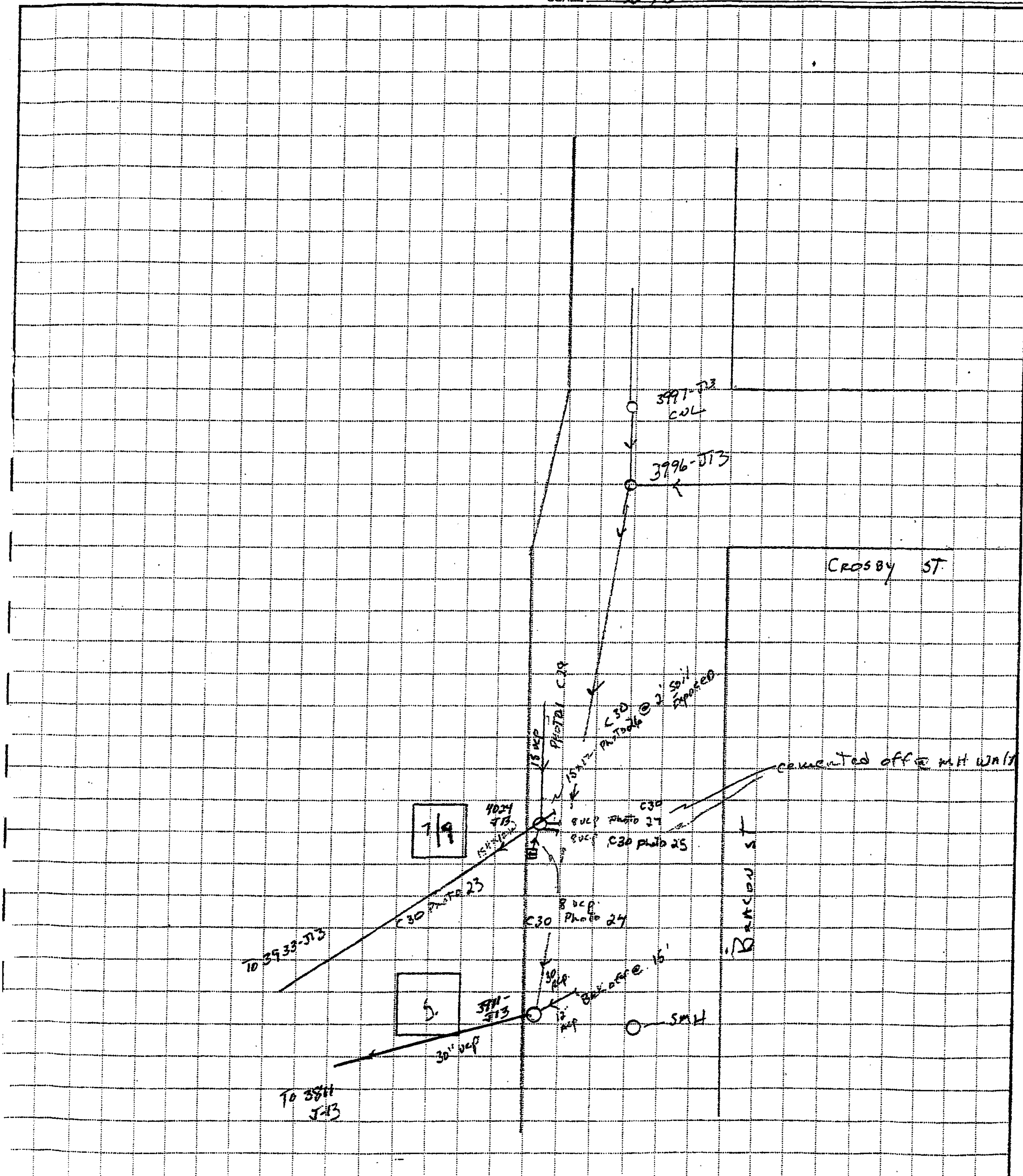

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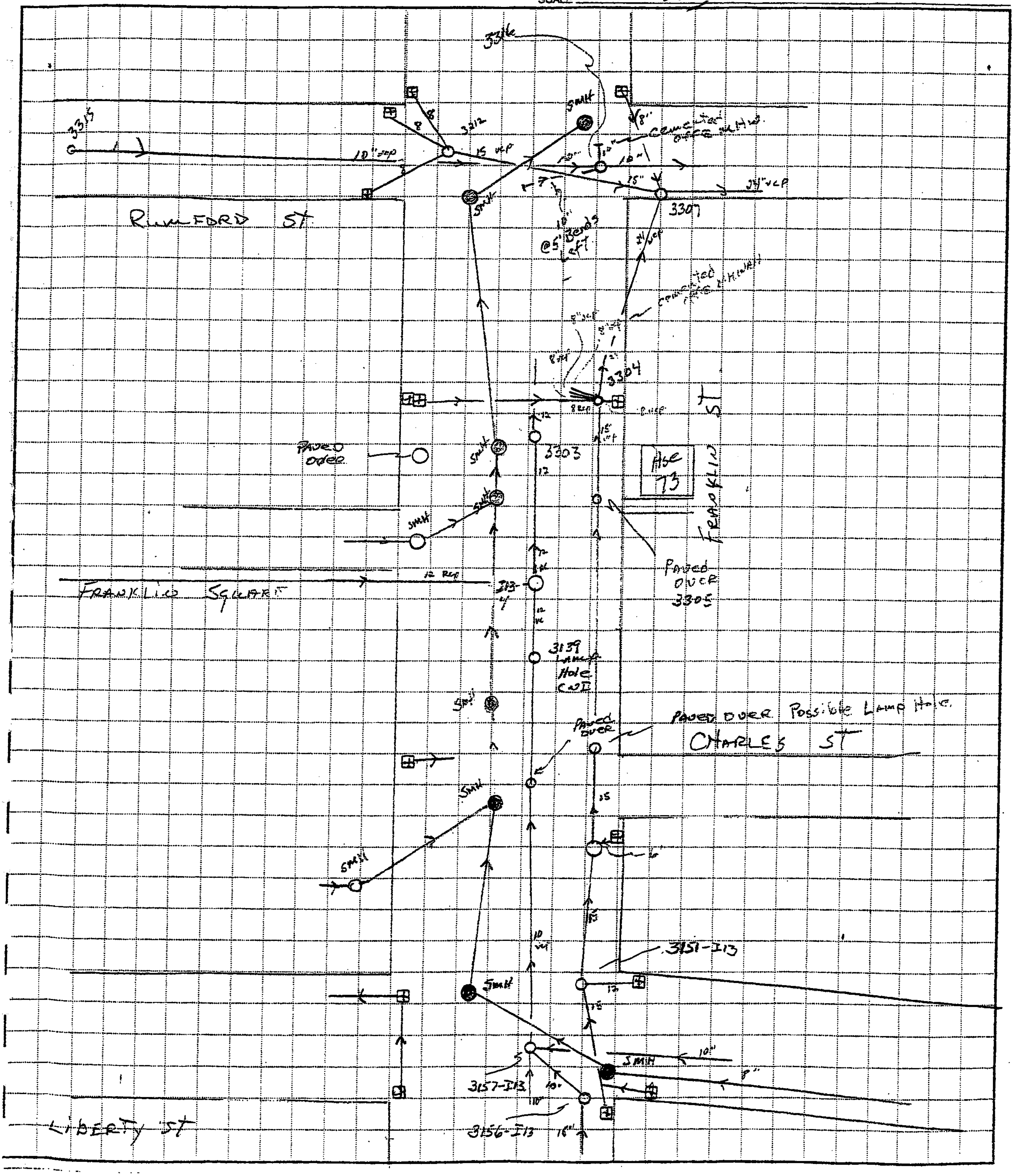
JOB Concord NH Daily
SHEET NO. Sketch 8. OF Tile 7
CALCULATED BY JAH DATE 11-30-01
CHECKED BY DATE
SCALE NTS



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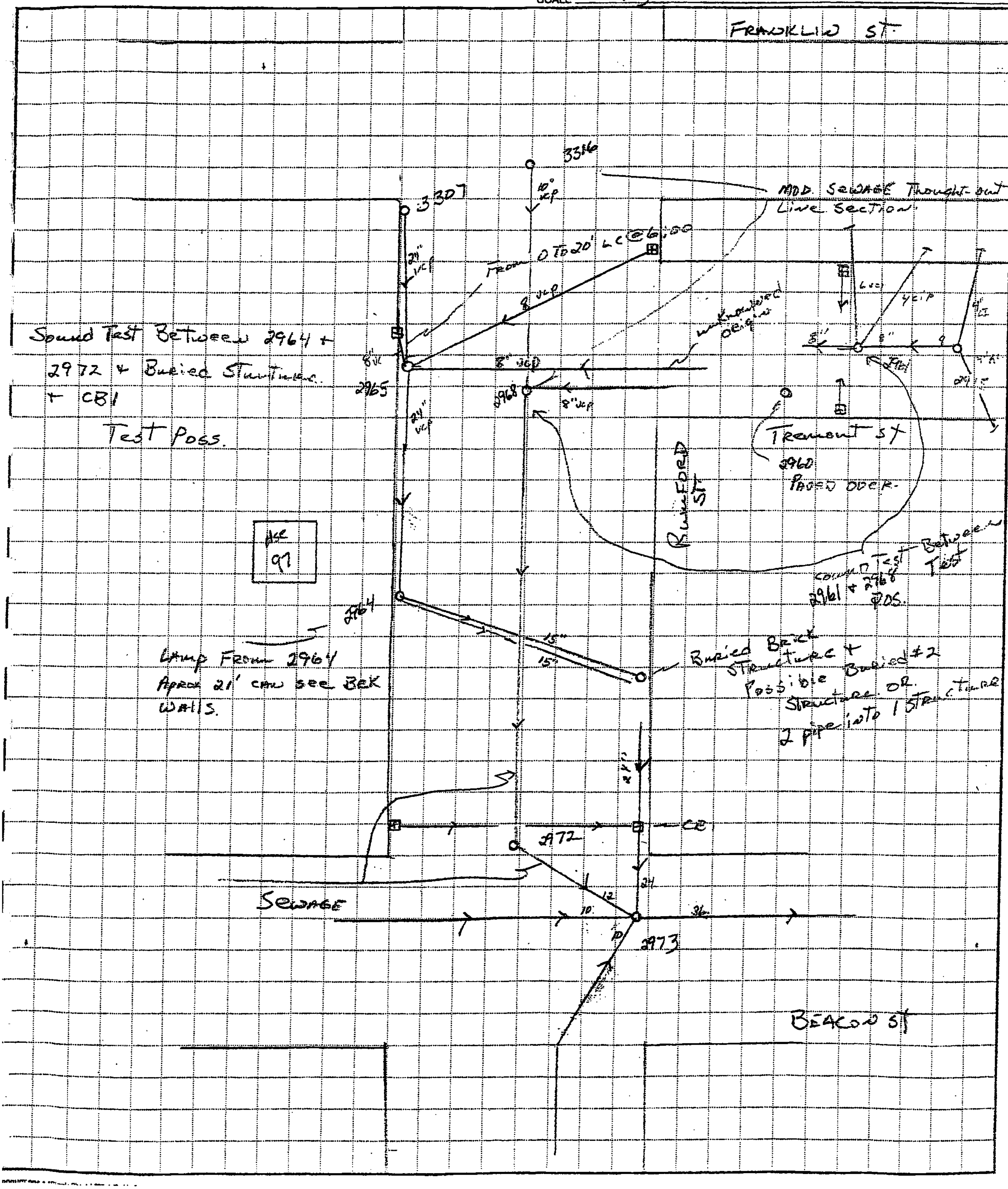
JOB Concord NH DMH

SHEET NO. Sketch 9 OF Tile 12, 7

CALCULATED BY JXH DATE 12-3-01

CHECKED BY DATE

SCALE NTS



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SHEET NO. Sketch 10 OF T/le 12

CALCULATED BY JAH DATE 12-4-01

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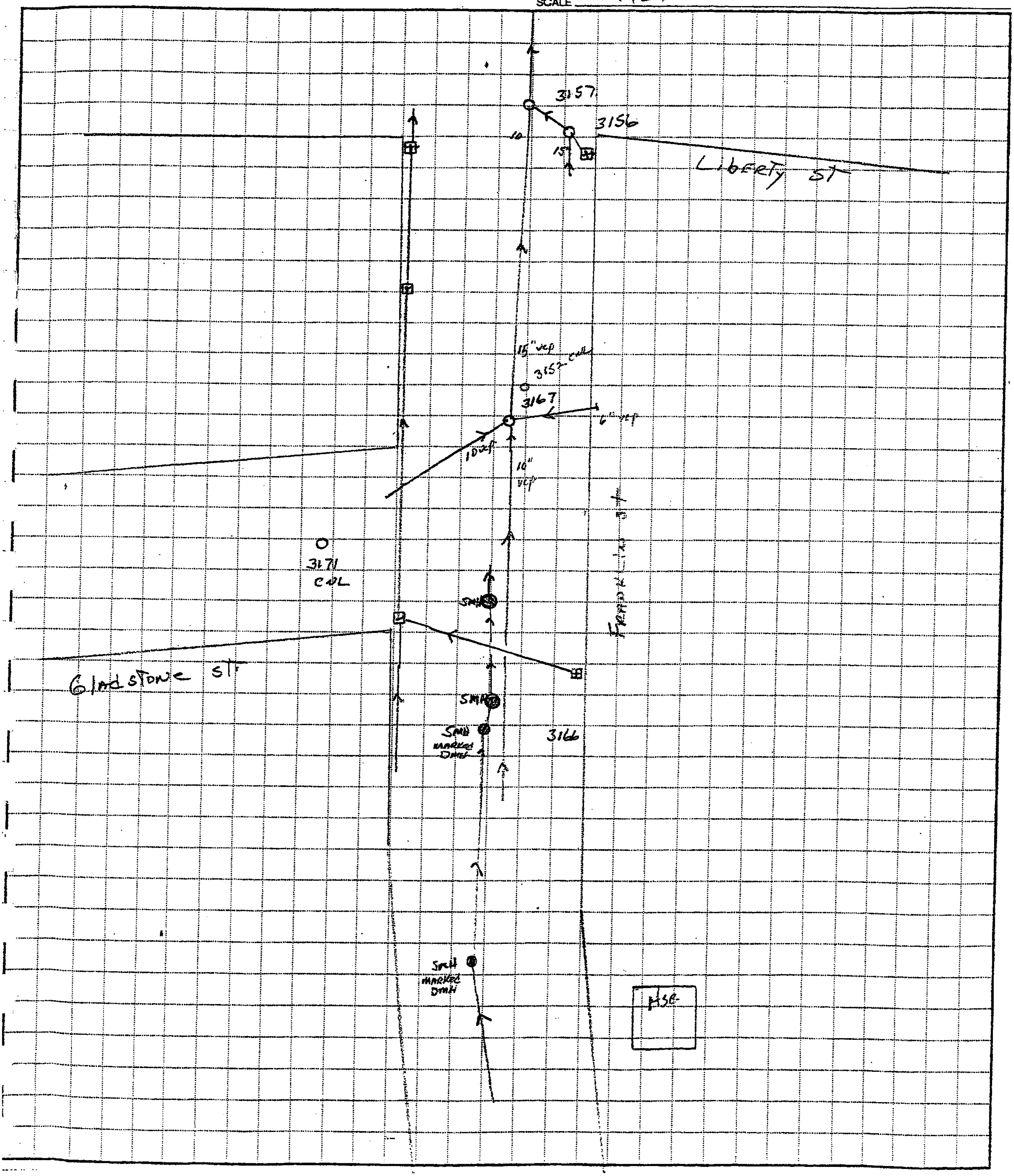
SCALE N.T.S.



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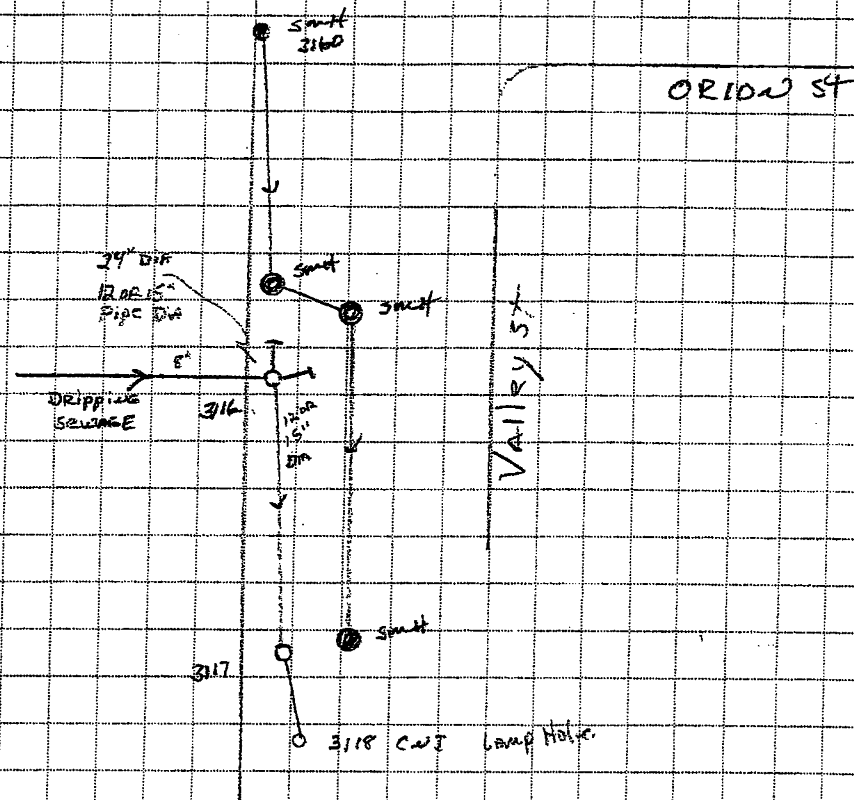
JOB Concord NH Drait

SHEET NO. Sketch 11 OF Tile 17

CALCULATED BY JAL DATE 12-3-01

CHECKED BY DATE

SCALE NTS



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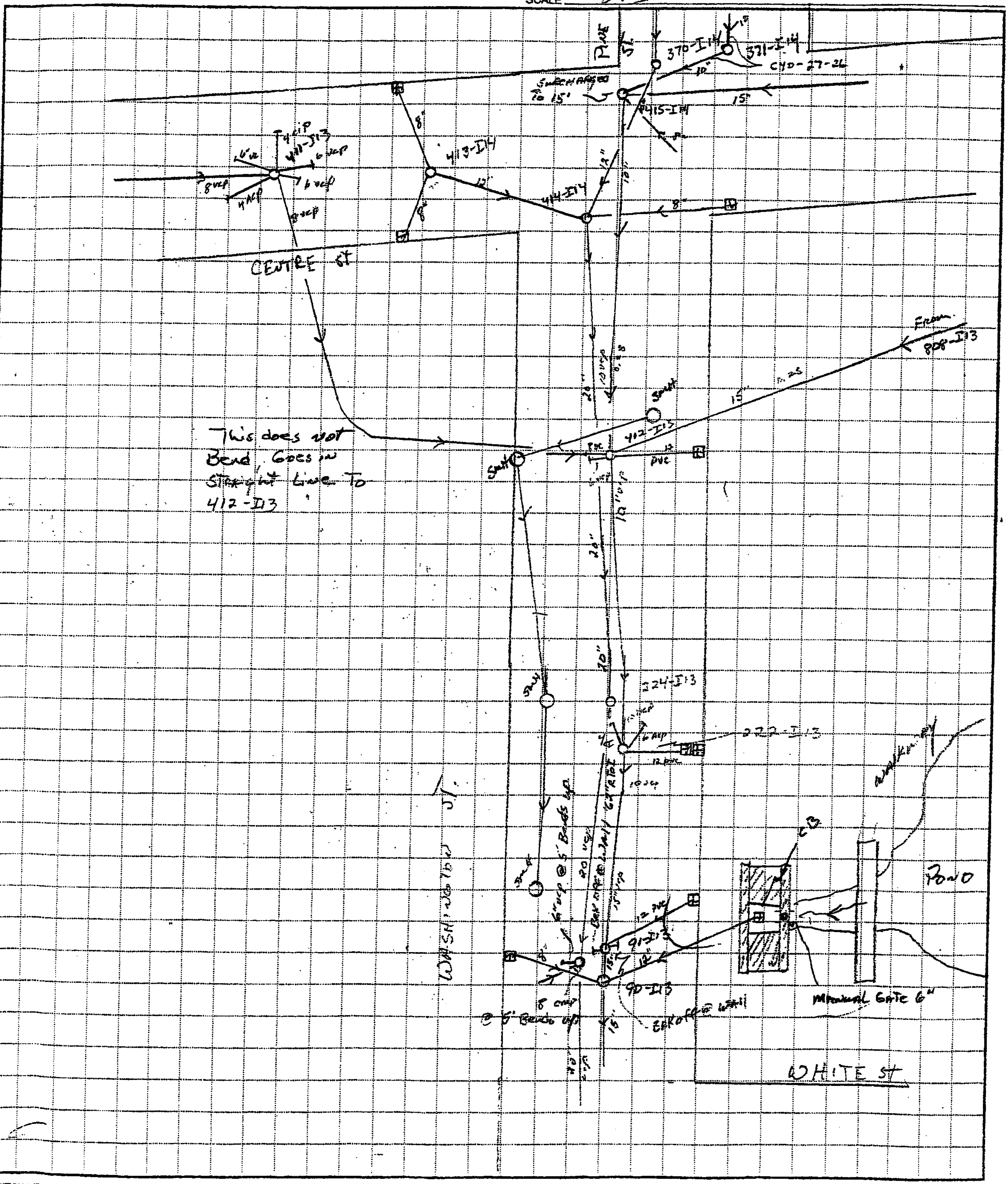
JOB Concord NH DMH

SHEET NO. Sketch # 12 OF Tile 17, 22,

CALCULATED BY JAH DATE 12-5-01

CHECKED BY ______ DATE ______

SCALE NTS



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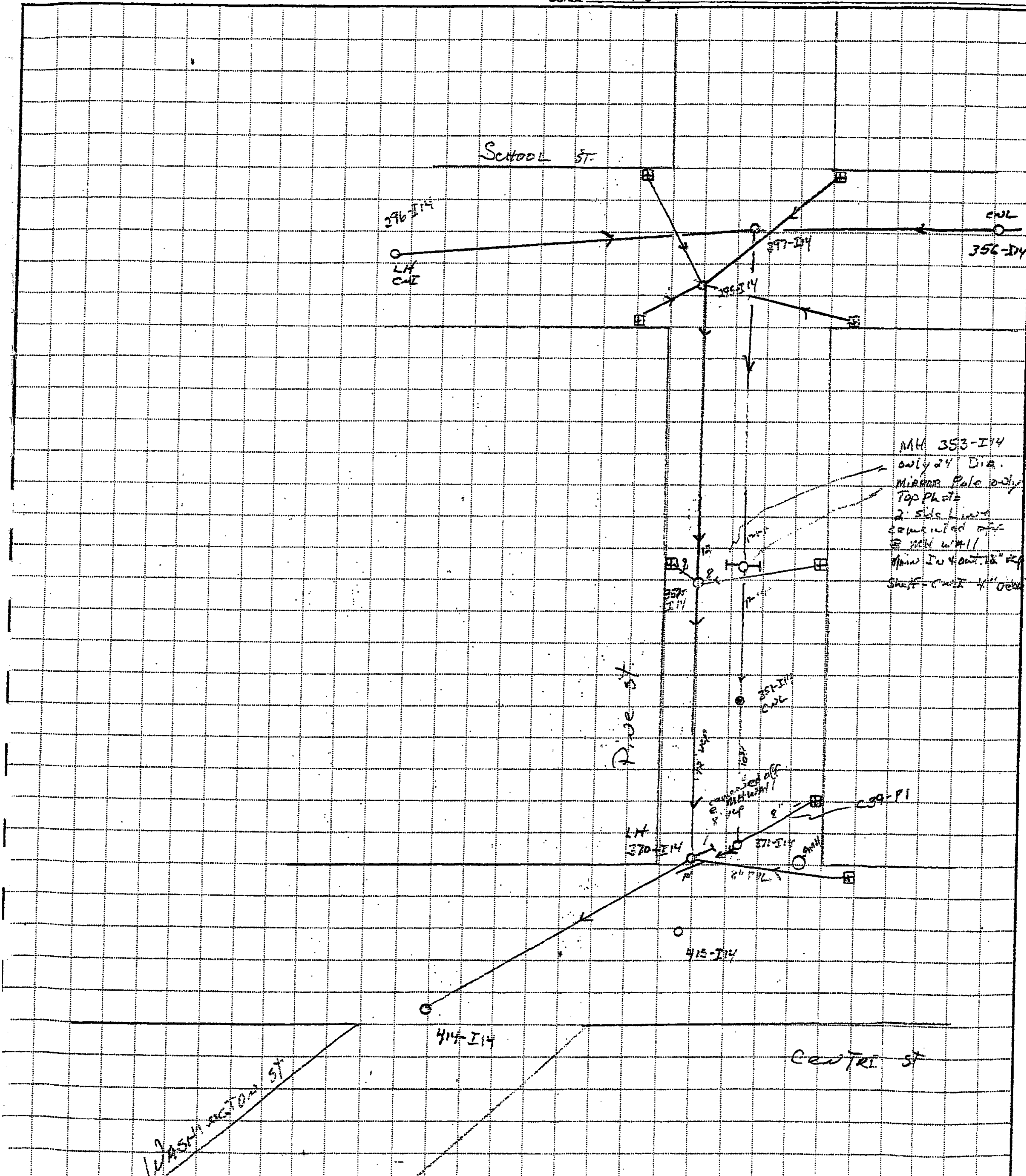
JOB Concord WW ...
SHEET NO. Sketch 13 OF Tile 22
CALCULATED BY JAH DATE 12-5-01
CHECKED BY DATE
SCALE NTS



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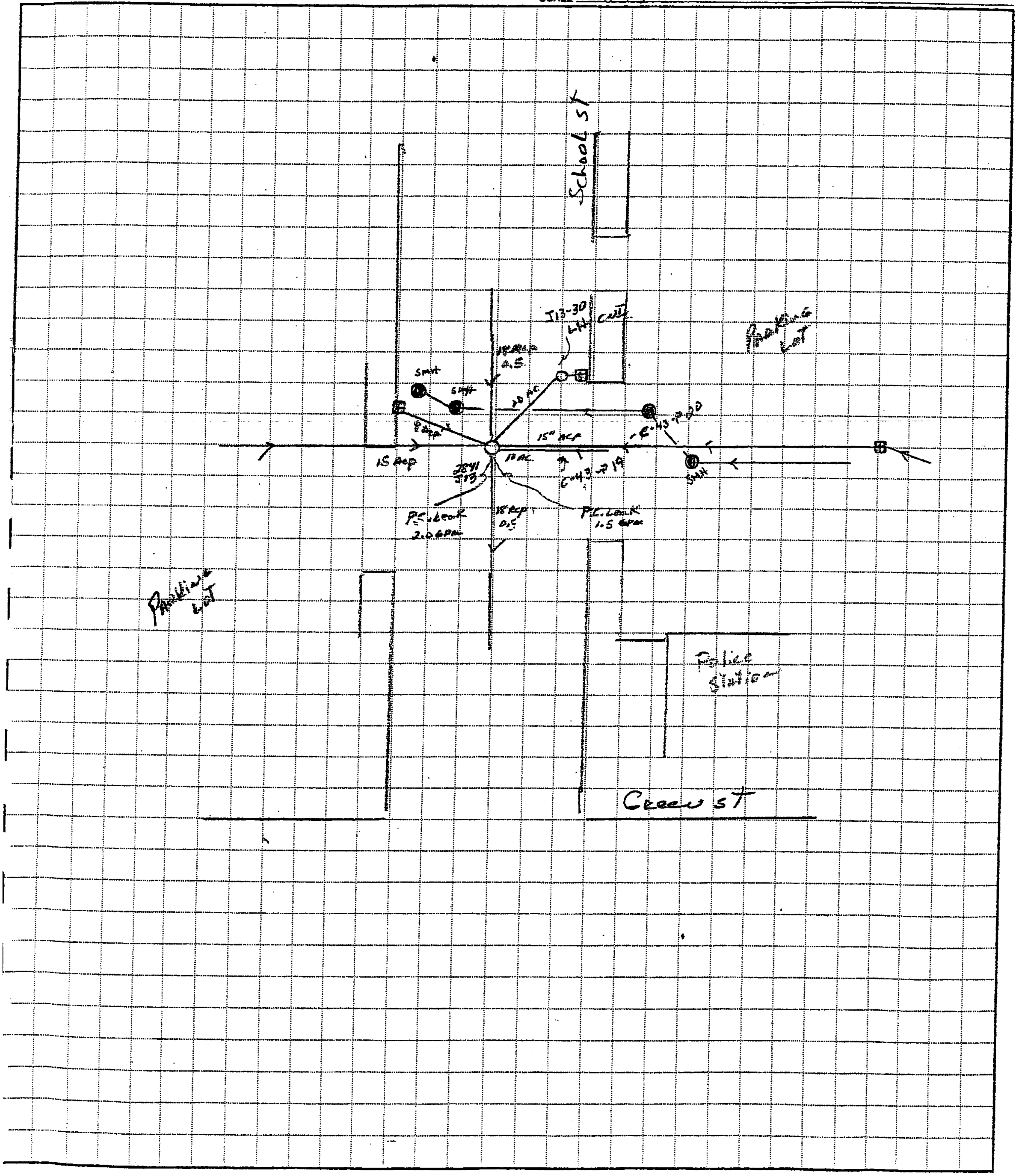
JOB Concord NH DMH

SHEET NO. SK 14 OF Tile 21

CALCULATED BY JMH DATE 12-12-01

CHECKED BY ______ DATE ______

SCALE NTS



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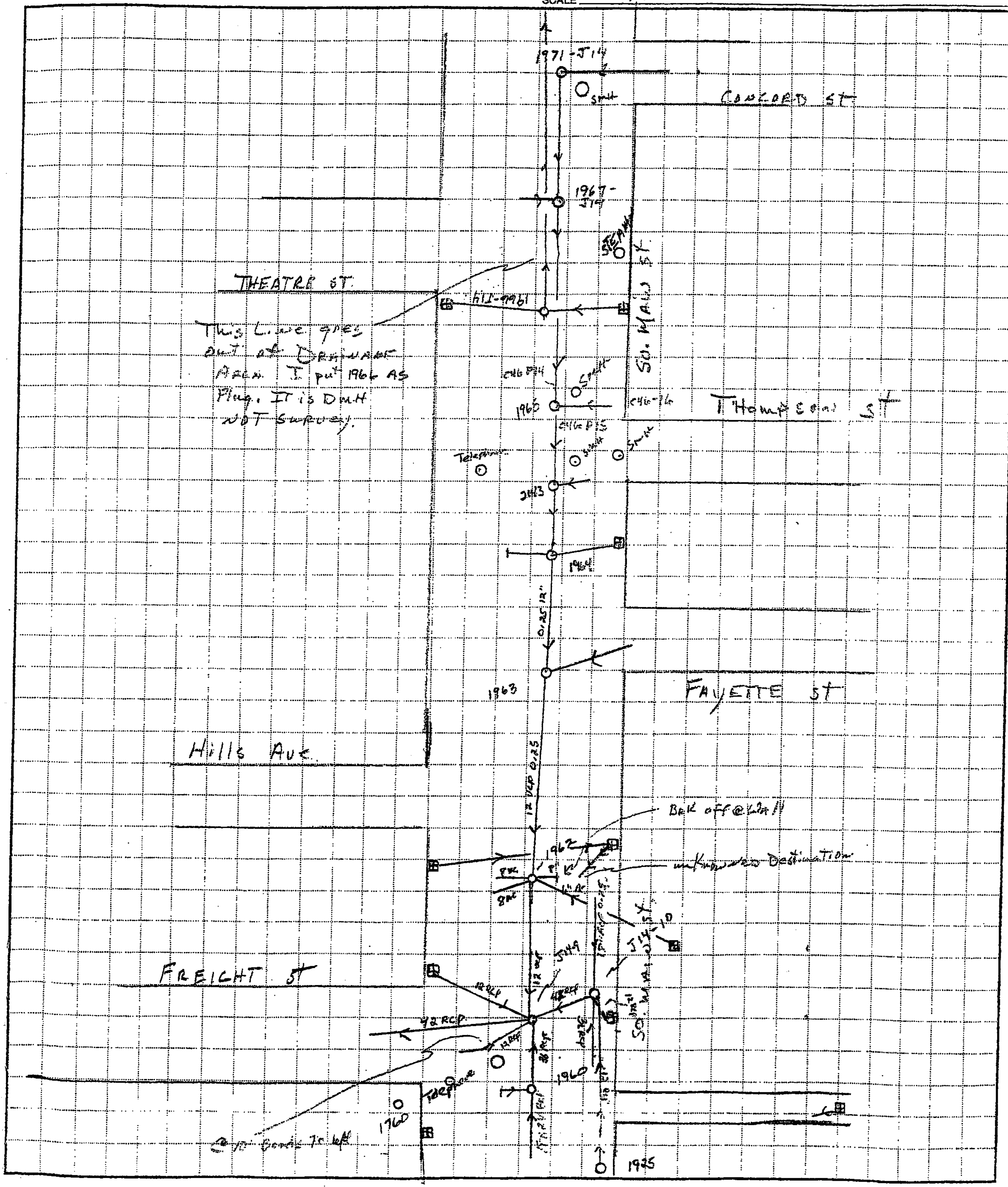
JOB: Concord NH

SHEET NO.: Sketch 15 OF: Tile 29, 25

CALCULATED BY: JAH DATE: 12-13-01

CHECKED BY: DATE:

SCALE: NTS



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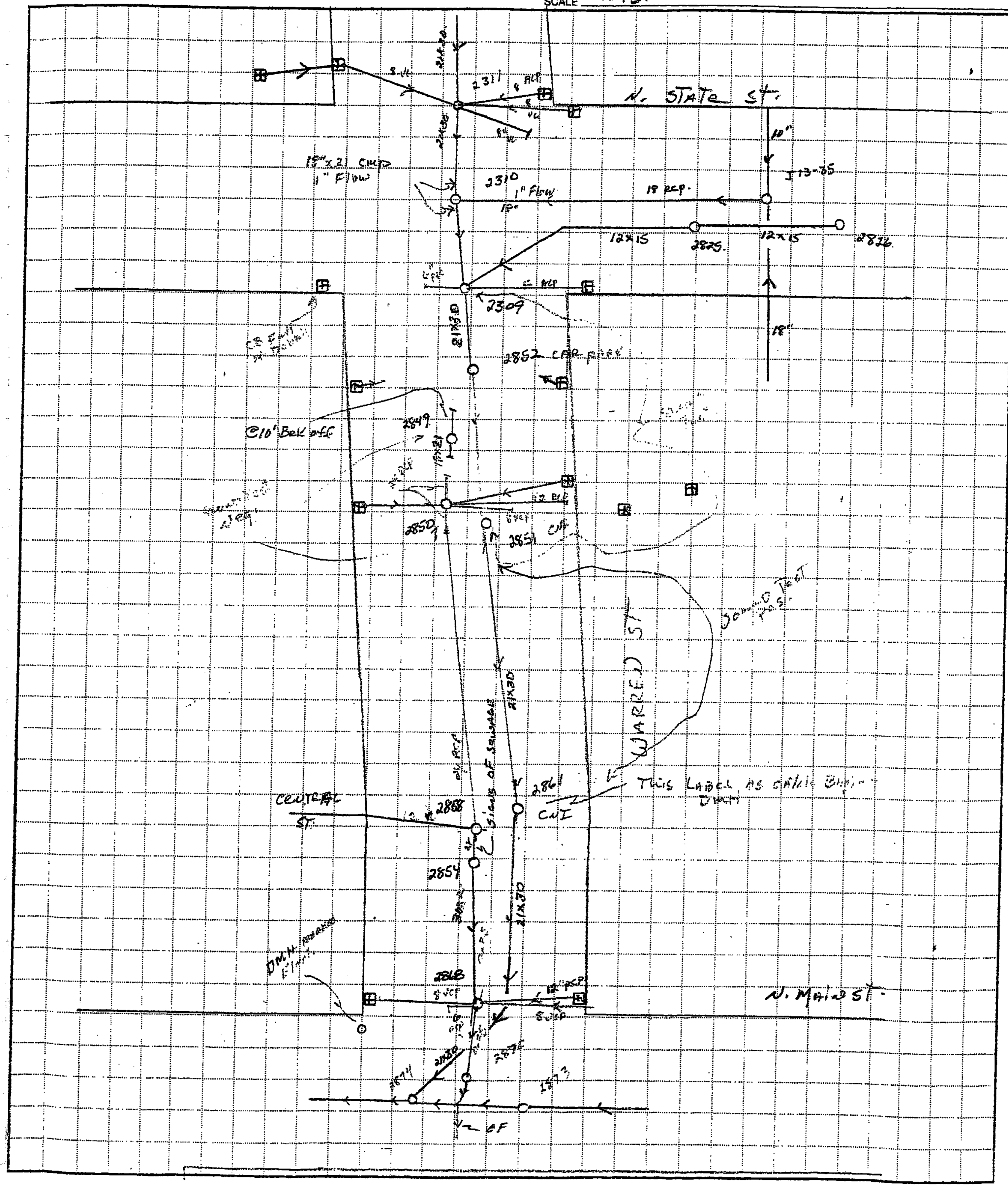
JOB Concord NH

SHEET NO. Sketch 16 OF Tile 20

CALCULATED BY JAH DATE 12-20-01

CHECKED BY ______ DATE ______

SCALE NTS



SEVERN TRENT PIPELINE SERVICES

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JOB Concord NH

SHEET NO. Sketch 17 OF Tile 20

CALCULATED BY JAH DATE 12-20-01

CHECKED BY ________ DATE ________

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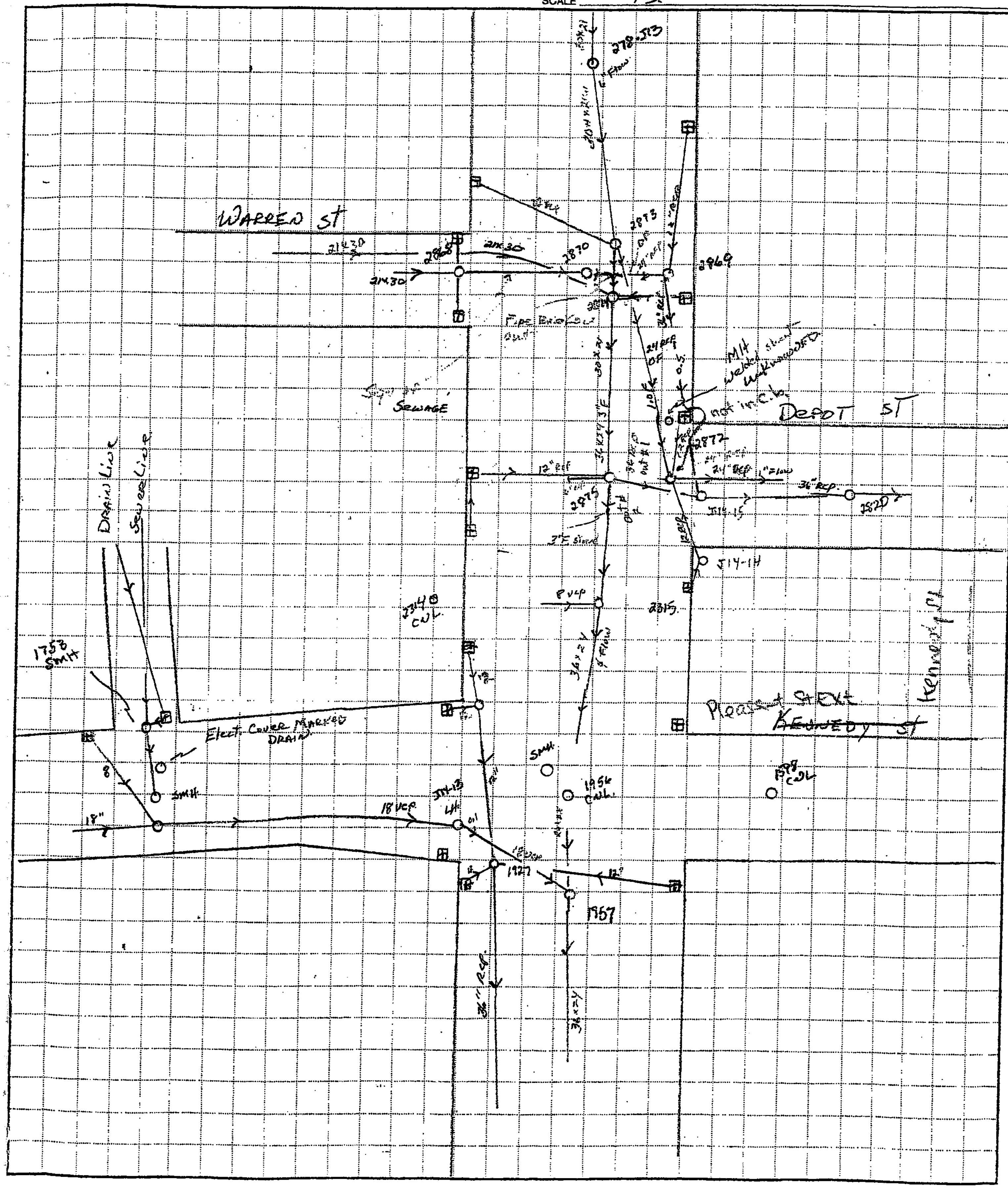
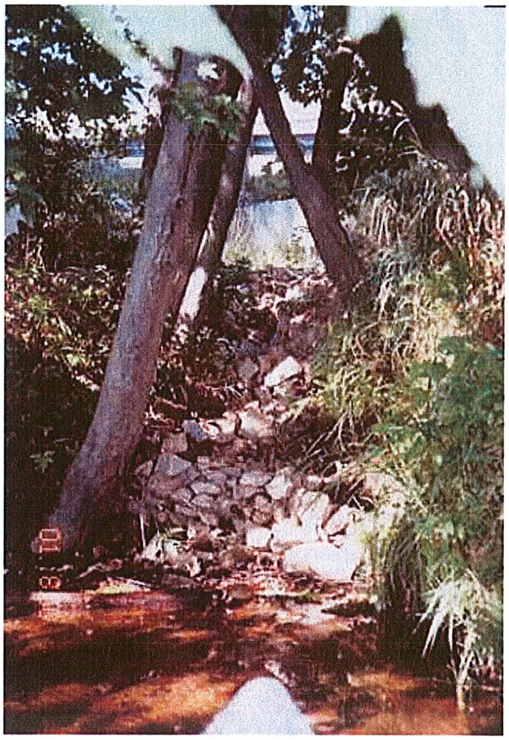
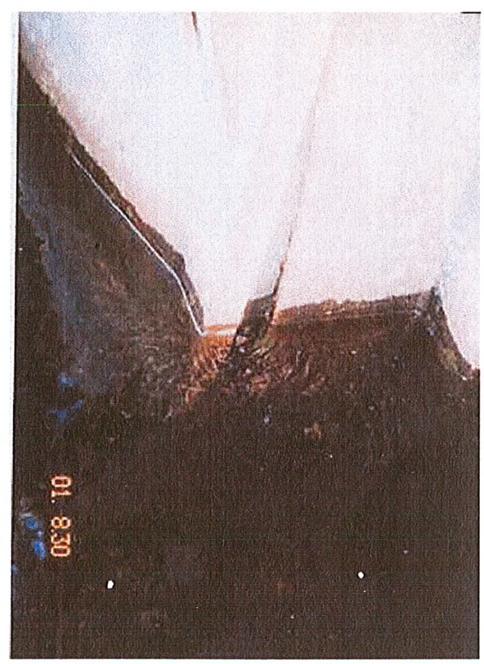


Appendix F
Photos of Select Outfalls from Merrimack River Study

Pictures from First Field Day, Thursday, 8/30/01

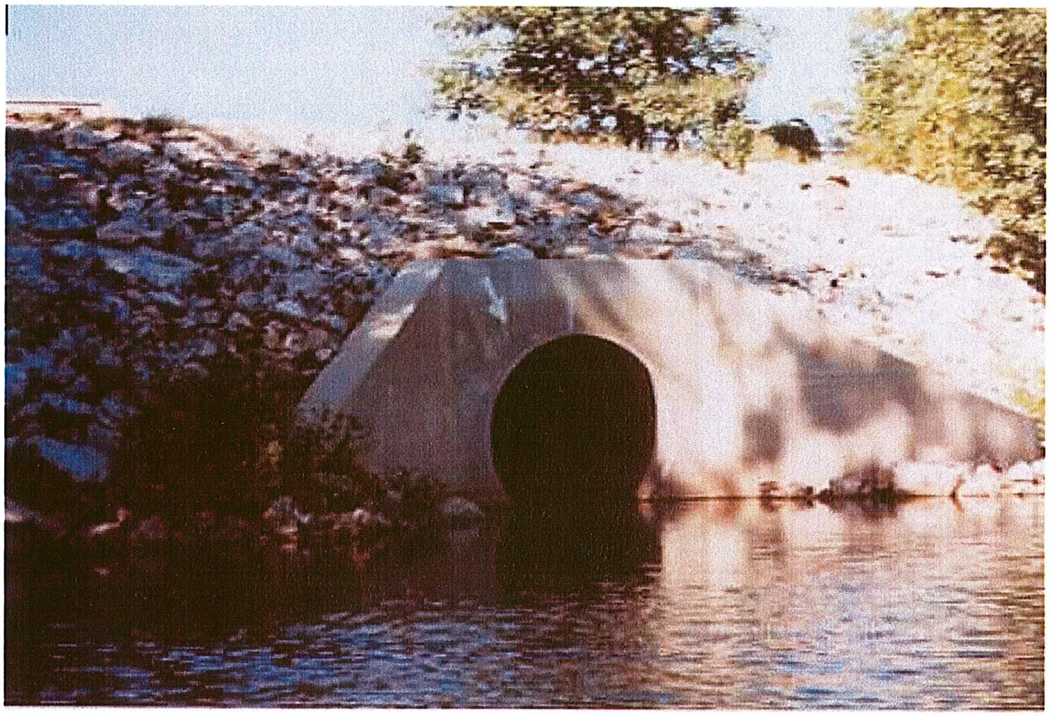


Pipe 1.14 14-inch pipe, d/s of Manch St.
From the River. From the shore.



Pipe 2.54 54-inch pipe with flapgate.
From the River.

Pipe 2.54
Close up of flapgate edge.
Surface disturbance indicates flow.



Pipe 3.84 From the River

Pipe 4.24 From the River.

Pipe 4.24 Showing stagnant water.

Mouth of stream 1, from the Merrimack River.

Pipe 6.30 Showing flow.

Pipe 6.30 From River.

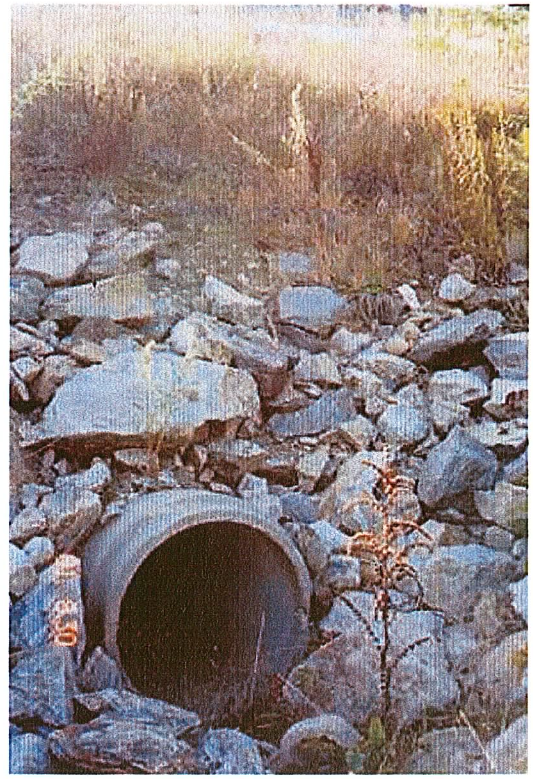
Pipe 3.45, 45-inch pipe, left bank just d/s of Manch St. Bridge.

Stream 2: Left bank upstream of Manch St Bridge, and inlet cove.

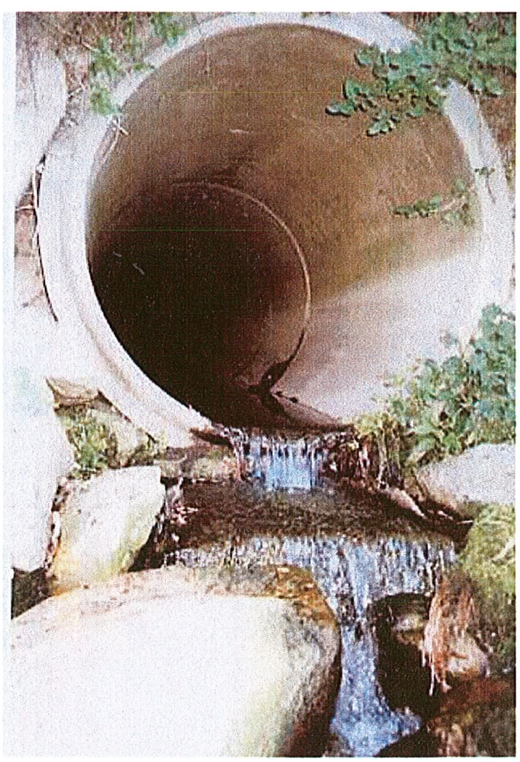
Pipe 9.24, 24-inch pipe. Left bank, d/s of Loudon Road.

Pipe 10.24, 24-inch pipe. Left bank, d/s of Loudon Road. Discharge could not be confirmed due to submergence.

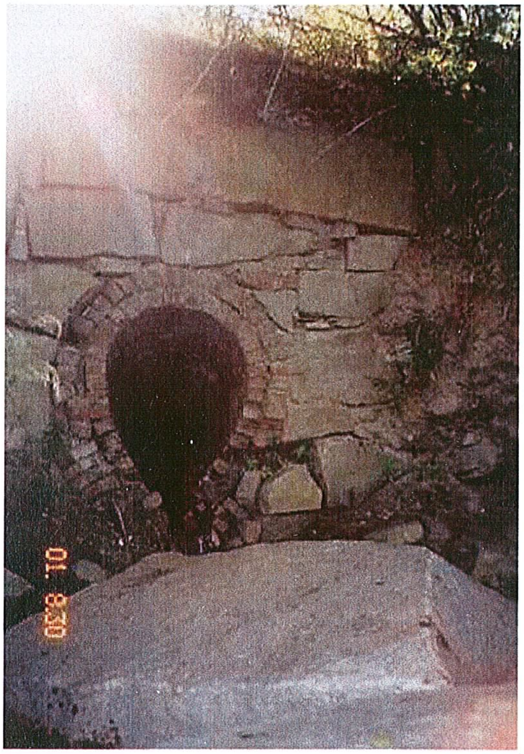
Pipe 11.12, 12-inch pipe
Right bank, d/s of Loudon Rd.



Pipe 12.24, 24-inch pipe
Right bank, d/s of Loudon Rd.

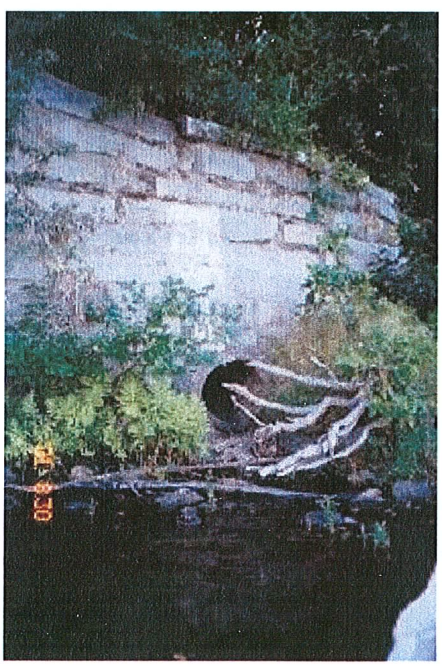


Pipe 13.44, 44-inch pipe.
Right bank, d/s of Loudon Road.

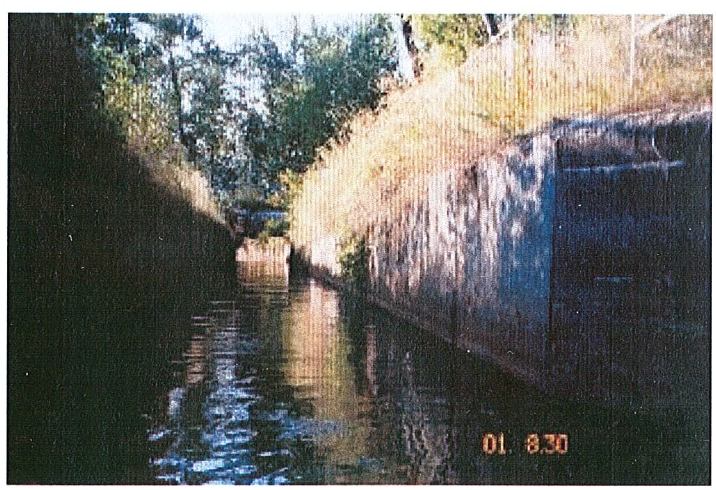


14.egg – 2'wide by 3' high brick

14.egg – Flow approx. 2gpm



Pipe 16.18 – 18-inch pipe
d/s of Loudon Road
On Right bank.



17.chan
~6' wide, walls ~4'high.
Right bank. U/s of Manchester St.

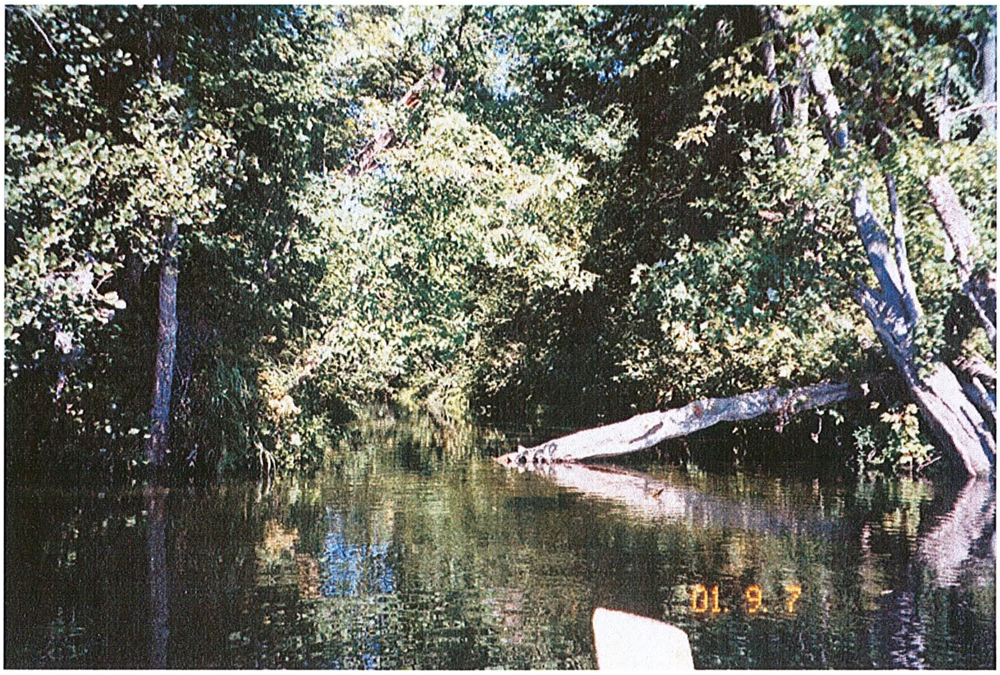
End of 8/30/01 pictures.

Start of 9/7/01 pictures.

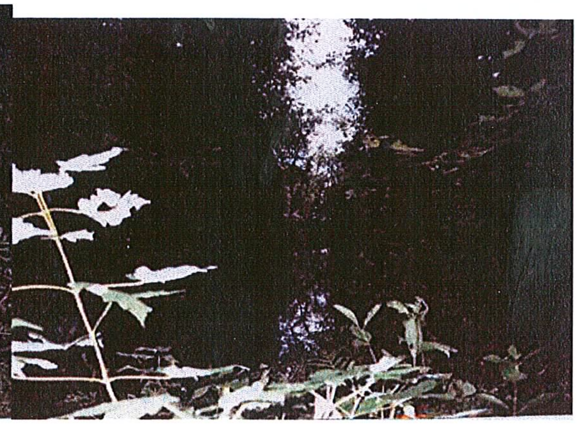
Boat ramp off Technical Institute Drive.
Right bank, upstream of 393 Bridge.

Pipe 18.36 – 36-inch pipe. Right bank, upstream of 393 Bridge.
Just a short length of pipe, overgrown, but not flowing.

Stream 3 – shopping carts make it impassible by boat.



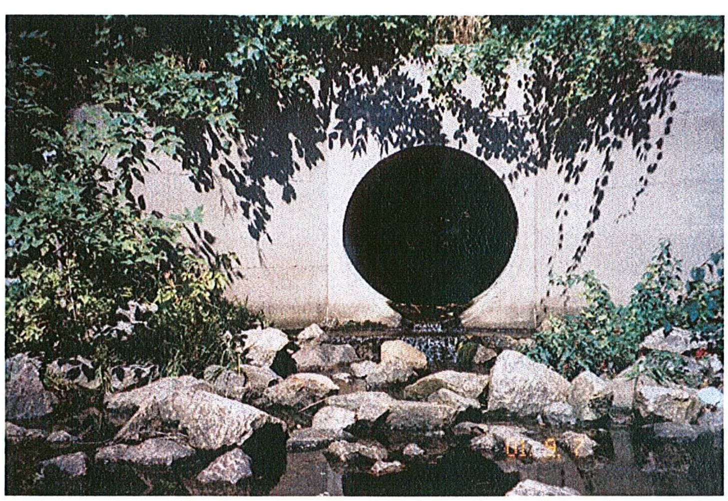
Stream 4 – downed logs make it impassible by boat.
Pipes 21.30 and 22.30 which discharge upstream were located on foot.

Pipe 21.30 – 30 inch outfall into Stream 4.

D/S from 21.30.

Pipe 23.48 – 48"
Flow too shallow to sample.



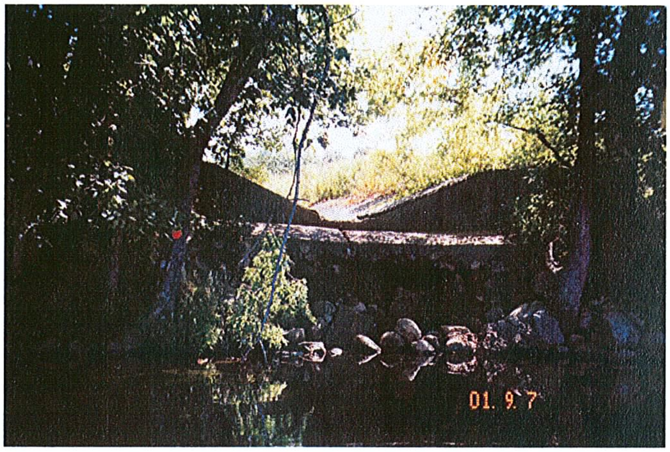
Pipe 24.54 – 54-inch pipe. Right bank u/s of Loudon Road.

Pipe 25.54 – 54-inch brick pipe. Evidence of stormwater (debris). Outfall is located at edge of Boston Market parking lot, under stone lintel.

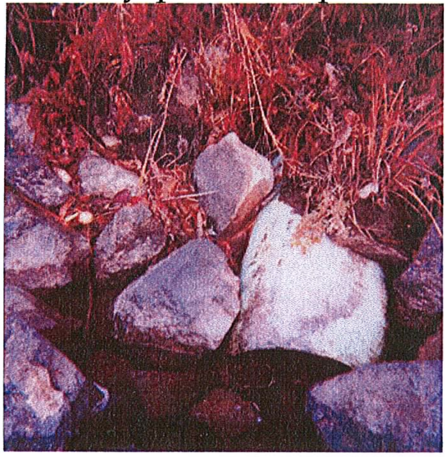
Pipe 26.18 – 18-inch concrete. Right bank upstream of Loudon Road.

Pipe 28.5 Left bank. Iron pipe near fire station's practice building.

29.trough
Paved trough of asphalt. Upstream of Loudon Road on left bank.

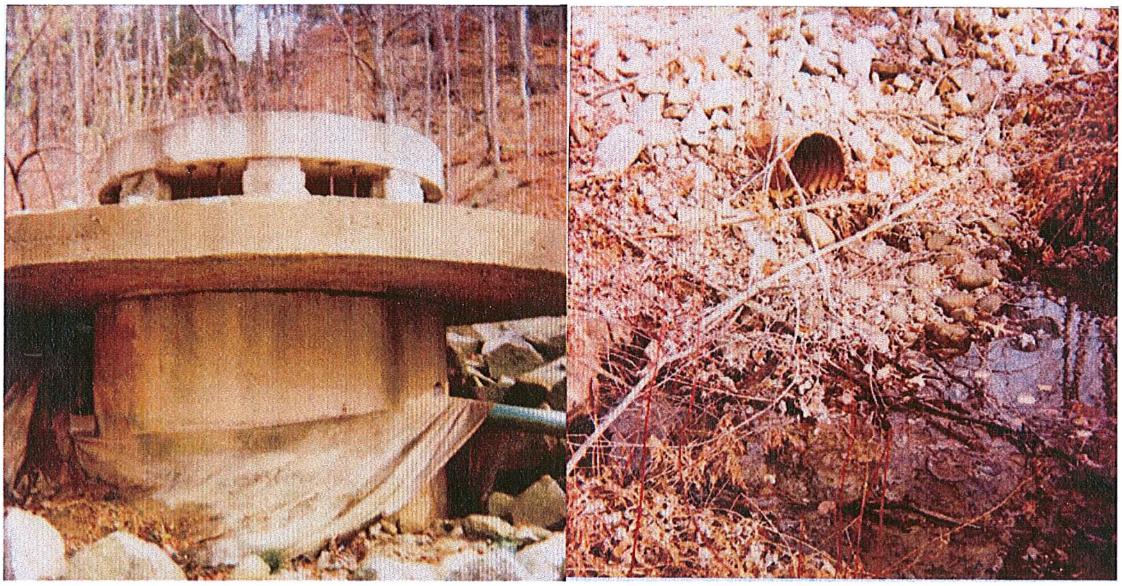


End of 9/7/01 pictures.
Start of City-provided pictures.

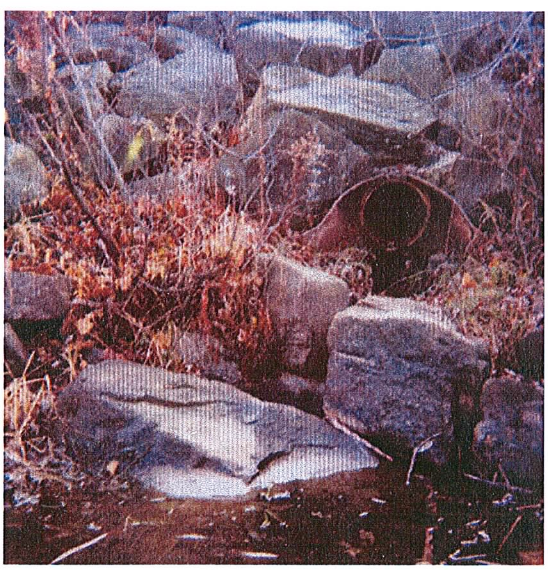


C1.15
15"PVC
from East Concord Pump Station

C3.48
48" galvanized pipe
under I393 from Sugar Ball Rd.

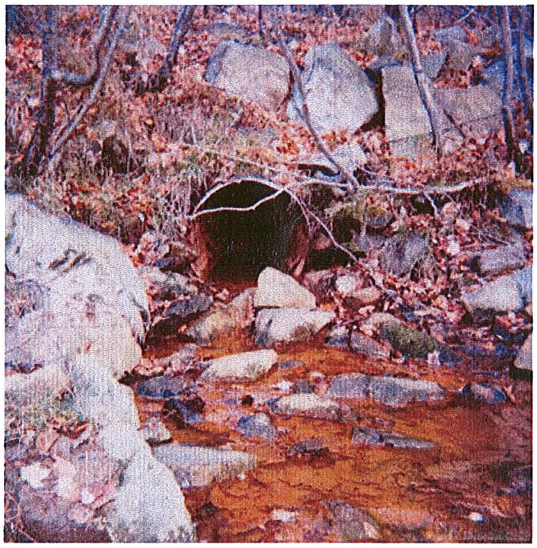


C2.18
West Sugar Ball Diffuser and 18″ galvanized pipe from Sugar Ball Road into the backwater of the river.



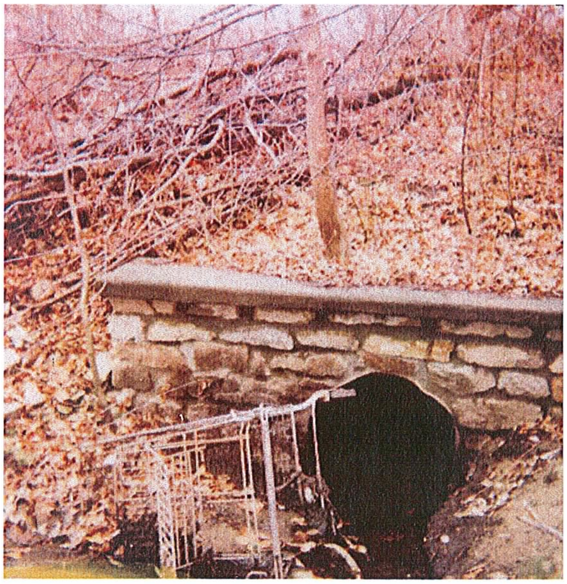
C4.12
12″ Galvanized pipe
Near Sugar Ball Road and I393

C5.4
48″ Galvanized pipe
under I393



C6.30
30" galvanized.
South of I393, north of the fire area.
By Fish and Game

C7.24
24" RCP
By Everett Arena



C8.24
24" galvanized pipe
Between Bradleys and Trailer park
Headway of Stream 3.

C9.15
15" galvanized pipe
~ 90' behind Bradleys
Part of Stream 3.

C11A.60
60″ RCP
Under Old Turnpike Road
by Park

C11.60
60″ RCP
By Old Turnpike Road
Behind Commercial Bldgs.

C12A
Twin concrete pipes
Garvin Falls Road Outlet

C13.30
30″ RCP
Hall Street Outfall

Appendix G
Field Sheets for Outfall Inspections

Attachment 1
Pipe data sheet

Time, Date: 9/07/01 8:20
Pipe Location/GIS Number: "1.14", right bank d/s of Manch bridge
Pipe Dimensions: 14"
Pipe Material: concrete
the one we missed last time.

Site Description:

Sediment below pipe (mound/delta, depth, etc):
gravel

Ambient Sediment (depth, character of sediment not affected by outfall): soil + gravel

Evidence of floatables: leaves

Evidence of solids: none

Oil Sheen: none

Smell in area?: none

Stains, corrosion, concrete damage:
slight corrosion at pipe top

Plants (excess, absence): weeds in gravel not unusual

Other? Sediment + gravel fill pipe 1/3 full back quite a ways

Discharging Currently? ~~(No)~~ (No) Yes

If yes: Approximate discharge rate: ______

~~Smell of discharge: ______~~

~~Color: ______~~

~~pH: ______ Temp: ______~~

~~Conductivity: ______ Turbidity: ______~~

~~Test Kit Results:~~

~~TKN: ______ P: ______ Other: ______~~

Attachment 1
Pipe data sheet

Time, Date: 8/30/01 10:13am
Pipe Location/GIS Number: d/s right bank of March bridge 2-S
Pipe Dimensions: 4.25' flap → can't measure pipe directly
Pipe Material: concrete headwall, metal flap gate

Site Description:
Sediment below pipe (mound/delta, depth, etc): rocky
Ambient Sediment (depth, character of sediment not affected by outfall): rocky, some vegetation
Evidence of floatables: less organic looking periodically from
Evidence of solids: no trash, thin layer of mud on rocks/pipe.
Oil Sheen: slight organic smell
Smell in area?: slight organic smell
Stains, corrosion, concrete damage: no.

Plants (excess, absence): algae + moss on concrete. not excessive
Other? bolt + pins look new.
flow out both sides of flap gate

Discharging Currently? No (Yes) - constant flow with periodic organics
If yes: Approximate discharge rate: 1gpm, increases when flap disturbed
Smell of discharge: not at first. REAL strong sewage smell later
Color: intermittent brown flakes.
pH: 9.2 Temp: 18.2
Conductivity: 242 Turbidity: - brown organics floatables.
Test Kit Results:
TKN: 5mg/L N as nitrite P: 1.3 mg/L Other: 1mg/L N as nitrate.
D.O. = 8.58 mg/L salinity = 0.1 ppt

ambient pH = 8.92
temp = 23.3°C
D.O. = 8.4 mg/l

Attachment 1
Pipe data sheet

Time, Date: 10:30am, 8/30/01
Pipe Location/GIS Number: 3-84
Pipe Dimensions: ~78", rock riprap + concrete headwall
Pipe Material: concrete.
beneath a parking lot.

Site Description:

Sediment below pipe (mound/delta, depth, etc): Sand on rock, sand in lip of pipe.

Ambient Sediment (depth, character of sediment not affected by outfall): Sand on rocks out as far as can see

Evidence of floatables: yes - paper + can trash at outlet

Evidence of solids: Sand, trash.

Oil Sheen: no.

Smell in area?: no.

Stains, corrosion, concrete damage: no.

Plants (excess, absence): no plants, no ambient plants.

Other? none.

Discharging Currently? (No) Yes - submerged by 1.15'

If yes: Approximate discharge rate: ______

Smell of discharge: ~~1.15~~

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 8/30/01
Pipe Location/GIS Number: 4-24th
Pipe Dimensions: 24"
Pipe Material: concrete

Site Description:
Sediment below pipe (mound/delta, depth, etc): Some black oil smelling sediment between rocks.
Ambient Sediment (depth, character of sediment not affected by outfall):
Evidence of floatables: black plastic bag, 1 pepsi can.
Evidence of solids:
Oil Sheen: no.
Smell in area?: no ambient smell
Stains, corrosion, concrete damage: slight corrision & pitting
Plants (excess, absence): nothing unusual
Other? Black staining on riprap

Discharging Currently? (No) Yes – sampled stagnent water in pipe
If yes: Approximate discharge rate: 0 flow
Smell of discharge: smells like motoroil
Color: brown, black, green sediment in pipe smells like motor oil
pH: 9.30 Temp: 15.2 °c
Conductivity: APPROXIMATELY 300 Turbidity:
Test Kit Results: DO 5.12 mg/L
TKN: P: Other:

measured stagnant water in pipe

Attachment 1
Pipe data sheet

Time, Date: 8/30 12:50pm
Pipe Location/GIS Number: 6-30 directly across from 84"
Pipe Dimensions: 30" pipe
Pipe Material? corrugated metal

Site Description:
Sediment below pipe (mound/delta, depth, etc):
tan sediment ~4" deep
Ambient Sediment (depth, character of sediment not affected by outfall): ~~tan sediment 4" deep~~
Evidence of floatables: plastic bags
Evidence of solids:
Oil Sheen:
Smell in area?: warm, organic
Stains, corrosion, concrete damage: tan pipe lining worn away 3' into pipe
Plants (excess, absence): no plants to right of disc. plants to left.
Other?
this is discharge from detention pond kitty corner from Carlson

Discharging Currently? No (Yes) took measurements in splash pool beneath pipe lip
If yes: Approximate discharge rate: 1 gallon per 30 sec.
Smell of discharge: organic smell
Color: brown.
pH: 7.73 Temp: 17.1 °c
Conductivity: 550 Turbidity:
Test Kit Results: DO 9.40 mg/L
TKN: 0 mg/L NO_2 nitrite ~~P~~: 0 mg/L NO_3 nitrate Other: 0.67 mg/L P

Attachment 1
Pipe data sheet

Time, Date: 1:09 8/30
Pipe Location/GIS Number: left bank d/s of Merrick St. 7-42
Pipe Dimensions: 3.45'
Pipe Material: concrete w/stone headwall

Site Description:

Sediment below pipe (mound/delta, depth, etc): thin layer of sed on rock

Ambient Sediment (depth, character of sediment not affected by outfall): ______

Evidence of floatables: only 1 beercan

Evidence of solids: Some sed on rocks.

Oil Sheen: none

Smell in area?: none.

Stains, corrosion, concrete damage: none.

Plants (excess, absence): Some plants not unusual

Other? perfectly clear, new pipe

Discharging Currently? (No) Yes

If yes: Approximate discharge rate: ______

Smell of discharge: ______

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 2:48 8/30
Pipe Location/GIS Number: 2 Stream
Pipe Dimensions: Stream
Pipe Material:

Site Description:

Sediment below pipe (mound/delta, depth, etc): ~ 1 in of brown sediment

Ambient Sediment (depth, character of sediment not affected by outfall): Sandier than in mouth

Evidence of floatables: none

Evidence of solids: none

Oil Sheen: none

Smell in area?: none

Stains, corrosion, concrete damage: no

Plants (excess, absence): —

Other? — Sediment red when stirred. 1 dead fish.

Discharging Currently? No (Yes) ~ 1 gal/min

If yes: Approximate discharge rate:

Smell of discharge: none

Color: Clear - brown at mouth

pH: 9.84 Temp: 22.5

Conductivity: 230 uS Turbidity:

Test Kit Results:

TKN: P: Other:

D.O ~ 8.6 mg/L

Attachment 1
Pipe data sheet

left bank before gully ~~~ of ~~~

Time, Date: 3:30pm 8/30
Pipe Location/GIS Number: 9-24
Pipe Dimensions: 24"
Pipe Material: concrete w/concrete headwall

Site Description:

Sediment below pipe (mound/delta, depth, etc): ~3" of sandy sediment

Ambient Sediment (depth, character of sediment not affected by outfall): ______

Evidence of floatables: none - 8' piece of metal ⊥ to pipe in river

Evidence of solids: none

Oil Sheen: none

Smell in area?: none

Stains, corrosion, concrete damage: none

Plants (excess, absence): not much in river, not much ambient

Other? cold breeze coming from pipe

Discharging Currently? (No) Yes

If yes: Approximate discharge rate: ______

Smell of discharge: ______

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

pre- has ~~~ of sand + grass on headwall

Attachment 1
Pipe data sheet

Time, Date: (10-24) 3:40 8/30
Pipe Location/GIS Number: ↓
Pipe Dimensions: 24"
Pipe Material: concrete reinforced with metal

Site Description:
Sediment below pipe (mound/delta, depth, etc):
dug out below pipe,
Ambient Sediment (depth, character of sediment not affected by outfall): similar to in front of pipe.
Evidence of floatables: no
Evidence of solids: no
Oil Sheen: no
Smell in area?: slight sewage
Stains, corrosion, concrete damage:
metal exposed on top of pipe
Plants (excess, absence): none directly infront
Other? lots around.
weird small flat bugs everywhere

Discharging Currently? No Yes ? Submerged. maybe slight flow.
If yes: Approximate discharge rate: real slight
Smell of discharge: slight sewage
Color: slightly more grey than surrounding
pH: 9.45 Temp: 25.5°c
Conductivity: 120 Turbidity:
Test Kit Results: DO: 8.80
TKN: not taken: due to submerged + low flow

Ambient: 25.4 TEMP DO: 9.3
9.25 pH COND: 120

Attachment 1
Pipe data sheet

Time, Date: 3:55pm 8/30/01
Pipe Location/GIS Number: 11-12
Pipe Dimensions: 12"
Pipe Material: corrugated metal

Site Description:

Sediment below pipe (mound/delta, depth, etc): asphalt pieces.

Ambient Sediment (depth, character of sediment not affected by outfall): asphalt pieces

Evidence of floatables: no

Evidence of solids: no

Oil Sheen: no

Smell in area?: none

Stains, corrosion, concrete damage: some wear to lining

Plants (excess, absence):

Other? pipe located well up from water. ~6' off water.

Discharging Currently? (No) Yes

If yes: ~~Approximate discharge rate:~~

~~Smell of discharge:~~

~~Color:~~

~~pH:~~ Temp:

~~Conductivity:~~ Turbidity:

~~Test Kit Results:~~

TKN: P: Other:

Attachment 1
Pipe data sheet

Time, Date: 8/30 4:09
Pipe Location/GIS Number: 12-24
Pipe Dimensions: 24'
Pipe Material: CONCRETE

Site Description:
Sediment below pipe (mound/delta, depth, etc): Sandy. vegetated.
Ambient Sediment (depth, character of sediment not affected by outfall): Same.
Evidence of floatables: YARD WASTE/PLASTICS
Evidence of solids: None
Oil Sheen: None
Smell in area?: None
Stains, corrosion, concrete damage: NONE
Plants (excess, absence): not unusual
Other? ______

Discharging Currently? (No) Yes
If yes: Approximate discharge rate: NONE 12' ABOVE RIVER
Smell of discharge: NO SMELL
Color: ______
pH: ______ Temp: ______
Conductivity: ______ Turbidity: ______
Test Kit Results:
TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 8/30
Pipe Location/GIS Number: 13-44 – tree cover. had to GPS into river a bit to get signal
Pipe Dimensions: 3.75 44"
Pipe Material: concrete

Site Description:

Sediment below pipe (mound/delta, depth, etc): rock w/slight sediment

Ambient Sediment (depth, character of sediment not affected by outfall): Same

Evidence of floatables: 1 cup, 1 cig butt

Evidence of solids: organic matter in flow/organic matter on base of pipe

Oil Sheen: no

Smell in area?: slight sewage

Stains, corrosion, concrete damage: Slight AT pipe lip

Plants (excess, absence): moss, algae not unusual

Other? gray colored water. slightly soapy

Discharging Currently? No (Yes)

If yes: Approximate discharge rate: 8 gallons per minute

Smell of discharge: Slight sewage

Color: gray

pH: 8.88 Temp: 23.7 °C

Conductivity: 1360 Turbidity: —

Test Kit Results: DO: 6.2 mg/L

TKN: ______ P: ______ Other: ______

Salinity 0.6 ppt

Attachment 1
Pipe data sheet

Time, Date: 8/30/01
Pipe Location/GIS Number: 14-EGG
Pipe Dimensions: EGG 2' WIDE, 3.5' HIGH
Pipe Material: BRICK

Site Description:

Sediment below pipe (mound/delta, depth, etc): rocky

Ambient Sediment (depth, character of sediment not affected by outfall): rocky - same, no cig butts.

Evidence of floatables: lots of cigarettes

Evidence of solids: none

Oil Sheen: none

Smell in area?: slight sewerage smell

Stains, corrosion, concrete damage: none / brick deterioration (bricks falling in)

Plants (excess, absence): nothing unusual

Other? WATER SOAPY

Discharging Currently? No (Yes)

If yes: Approximate discharge rate: 2 gallons per minute

Smell of discharge: slight sewage

Color: none - soapy

pH: 9.70 Temp: 22.2 °C

Conductivity: 509 Turbidity: —

Test Kit Results: DO: 6.51

TKN: ______ P: ______ Other: ______

Salinity: 0.3 ppt

ambient temp 24.2 pH 9.7 Sal 0.1 D.O. 8.93 cond 116

Attachment 1
Pipe data sheet

Time, Date: 4:30 8/30
Pipe Location/GIS Number: 15-44
Pipe Dimensions: 44"
Pipe Material: concrete

Site Description:
Sediment below pipe (mound/delta, depth, etc): rock, some sediment
Ambient Sediment (depth, character of sediment not affected by outfall): Same
Evidence of floatables: no
Evidence of solids: no
Oil Sheen: no
Smell in area?: no
Stains, corrosion, concrete damage: no

Plants (excess, absence): pink roots on apron
Other? ______

Discharging Currently? No (Yes)
If yes: Approximate discharge rate: 0.5 gpm
Smell of discharge: none
Color: clear
pH: ______ Temp: ______
Conductivity: ______ Turbidity: ______
Test Kit Results:
TKN: ______ P: ______ Other: ______

Sheet flow - hard to get reading from meters.

Attachment 1
Pipe data sheet

Time, Date: 4:59 8/30/01
Pipe Location/GIS Number: 16*18
Pipe Dimensions: 18"
Pipe Material: concrete w/ concrete slab headwall

Site Description:
Sediment below pipe (mound/delta, depth, etc): rock lip.
Ambient Sediment (depth, character of sediment not affected by outfall): rock
Evidence of floatables: no
Evidence of solids: pine needles, wood in channel
Oil Sheen: no
Smell in area?: no
Stains, corrosion, concrete damage: some staining in pipe - dark
Plants (excess, absence): Sensitive fern
Other? ______

Discharging Currently? (No) Yes dry
If yes: Approximate discharge rate: ______
Smell of discharge: ______
Color: ______
pH: ______ Temp: ______
Conductivity: ______ Turbidity: ______
Test Kit Results:
TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 5:35 pm 8/30

Pipe Location/GIS Number: 17·chan, channel rt side of river u/s from merr. bridge

Pipe Dimensions: 6' wide 4' high

Pipe Material: concrete channel

Site Description:

Sediment below pipe (mound/delta, depth, etc): Sandy sedi. in chan.

Ambient Sediment (depth, character of sediment not affected by outfall): Same

Evidence of floatables: none

Evidence of solids: none

Oil Sheen: none

Smell in area?: none

Stains, corrosion, concrete damage: none

Plants (excess, absence): some in outlet

Other? trash boom collapsed in middle

Discharging Currently? No Yes ? - 18 inches deep 6' wide

If yes: Approximate discharge rate: —

Smell of discharge: none

Color: brownish, same as river

pH: 9.36 Temp: 23.9°C

Conductivity: 290 u/s Turbidity: —

Test Kit Results: Salinity 0.1ppt

TKN: ______ P: ______ Other: ______

D.O. 9.02 mg/l

ambient u/s of merch St bridge:
pH. 9.44; temp 24.1; D.O. 9.2 mg/l; cond 118.4 sal 0.1

Attachment 1
Pipe data sheet

Time, Date: 9:45a, 9/7/01 u/s of 393 bridge.
Pipe Location/GIS Number: d/s of boat launch "18.36" right bank
Pipe Dimensions: 36'
Pipe Material: concrete

Site Description:
Sediment below pipe (mound/delta, depth, etc): sand in pipe, rocks d/s.
Ambient Sediment (depth, character of sediment not affected by outfall): sand + rocks
Evidence of floatables: perscription bottle, leaves.
Evidence of solids: —
Oil Sheen: —
Smell in area?: no
Stains, corrosion, concrete damage: no.
Plants (excess, absence): not unusual
Other? pipe is only 5' length + rock open on other side.

Discharging Currently? (No) Yes
If yes: Approximate discharge rate: ____
Smell of discharge: ____
Color: ____
pH: ____ Temp: ____
Conductivity: ____ Turbidity: ____
Test Kit Results:
TKN: ____ P: ____ Other: ____

Attachment 1
Pipe data sheet

Time, Date: 10:26a, 9/7/01

Pipe Location/GIS Number: 3stream. right bank d/s of 393 (d/s) u/s of La

Pipe Dimensions: stream 10' wide

Pipe Material: sand bottom.

Site Description:

Sediment below pipe (mound/delta, depth, etc): sand

Ambient Sediment (depth, character of sediment not affected by outfall): sand

Evidence of floatables: 2 shopping carts.

Evidence of solids: —

Oil Sheen: —

Smell in area?: Swampy. faint oil smell

Stains, corrosion, concrete damage: none.

Plants (excess, absence): Sensitive ferns on bank

Other?

Discharging Currently? No Yes — not noticable.

If yes: Approximate discharge rate: —

Smell of discharge: faint smell

Color: clear to sand

pH: 6.94 Temp: 21.3

Conductivity: Turbidity:

Test Kit Results:

TKN: — P: — Other: —

D.O.

Attachment 1

Pipe data sheet

Time, Date: 10:52 9/7

Pipe Location/GIS Number: 4 stream, 15' wide.

Pipe Dimensions: 18" deep.

Pipe Material: Sand + wood bottom.

Site Description:

Sediment below pipe (mound/delta, depth, etc): sand, wood. metal bike parts.

Ambient Sediment (depth, character of sediment not affected by outfall): Sand

Evidence of floatables:

Evidence of solids: —

Oil Sheen: —

Smell in area?: no

Stains, corrosion, concrete damage: no

Plants (excess, absence): not unusual.

Other?

Discharging Currently? No (Yes) – slight movement on surface.

If yes: Approximate discharge rate:

Smell of discharge: —

Color: —

pH: 7.33 Temp: 21.2° C

Conductivity: 109.4 uS Turbidity:

Test Kit Results:

TKN: — P: — Other: —

Sal. : 0.1 ppt

D.O. = ? 11 mg/l – not reliable.

Attachment 1
Pipe data sheet

Time, Date: 11:21am 9/07
Pipe Location/GIS Number: 23.48
Pipe Dimensions: 48"
Pipe Material: corrugated metal w/ metal apron

Site Description:
Sediment below pipe (mound/delta, depth, etc): rock + brown mud. geotech fabric
Ambient Sediment (depth, character of sediment not affected by outfall): Sand + rock
Evidence of floatables: none
Evidence of solids: paper towels, brown sed. cig. underwear
Oil Sheen: no
Smell in area?: musty, stale
Stains, corrosion, concrete damage: Metal apron badly corroded
Plants (excess, absence):
Other? pipe wet, arc ≈ 2.5 ft.

Discharging Currently? (No) Yes → stagnant 6" width
If yes: Approximate discharge rate: none.
Smell of discharge: musty
Color: brown
too shallow: pH: Temp:
Conductivity: Turbidity:
Test Kit Results:
TKN: P: Other:

Attachment 1
Pipe data sheet

Time, Date: 9/7/01 11:40.
Pipe Location/GIS Number: 24.54
Pipe Dimensions: 54" concrete.
Pipe Material: concrete

Site Description:
Sediment below pipe (mound/delta, depth, etc):
rocky. some dirt.
Ambient Sediment (depth, character of sediment not affected by outfall): Sand + wood.
Evidence of floatables: cans + trash.
Evidence of solids: —
Oil Sheen: no.
Smell in area?: woodsy.
Stains, corrosion, concrete damage:
none.
Plants (excess, absence): not unusual
Other? Stream enters pipe 20' upstream.

Discharging Currently? No Yes (circled)
If yes: Approximate discharge rate: 7 gal/min
Smell of discharge: woodsy
Color: Clear
pH: 6.53 Temp: 16.2
Conductivity: 1400 Turbidity:
Test Kit Results:
~~TKN: P:~~ Other:

Sal: 0.9
DO: 10.7

Attachment 1
Pipe data sheet

Time, Date: 9/7/01 11:45am.
Pipe Location/GIS Number: 25.54
Pipe Dimensions: 54"
Pipe Material: brick

Site Description:
Sediment below pipe (mound/delta, depth, etc):

Ambient Sediment (depth, character of sediment not affected by outfall):
Evidence of floatables: trash & cigs
Evidence of solids:
Oil Sheen:
Smell in area?: faint musty
Stains, corrosion, concrete damage: ~~none~~ may have had trash rack
Plants (excess, absence):
Other? Evidence of surcharging greater than 2 feet.

Discharging Currently? No (Yes)
If yes: Approximate discharge rate: 10 gal/min
Smell of discharge:
Color: greyish
pH: 7.06 Temp: 19.1
Conductivity: 985 Turbidity:
Test Kit Results:
TKN: P: Other:

took sample.

SAL: 0.6
DO: 12.8 ?

Attachment 1
Pipe data sheet

Time, Date: 9/7/01, 12:06

Pipe Location/GIS Number: 26.18 u/s right bank of Harden bridge.

Pipe Dimensions: ~~18~~ 24

Pipe Material: concrete

Site Description:

Sediment below pipe (mound/delta, depth, etc): rock + sand

Ambient Sediment (depth, character of sediment not affected by outfall): rock + sand

Evidence of floatables: some trash paper

Evidence of solids: —

Oil Sheen: —

Smell in area?: —

Stains, corrosion, concrete damage: no stains, concrete slightly corroded

Plants (excess, absence): not unusual

Other? —

Discharging Currently? (No) Yes

If yes: Approximate discharge rate: ____

Smell of discharge: ____

Color: ____

pH: ____ Temp: ____

Conductivity: ____ Turbidity: ____

Test Kit Results:

TKN: ____ P: ____ Other: ____

river stage ~ 2.8.
(from left pier on
Linden Rd
bridge.)

Attachment 1
Pipe data sheet

Time, Date: ____________ freshwater mussels under
Pipe Location/GIS Number: ____________ bridge.
Pipe Dimensions: ____________
Pipe Material: ____________

Site Description: boat ramp + rope swing at area.

Sediment below pipe (mound/delta, depth, etc):

____

Ambient Sediment (depth, character of sediment not affected by outfall): ____________

Evidence of floatables: ____________

Evidence of solids: ____________

Oil Sheen: ____________

Smell in area?: ____________

Stains, corrosion, concrete damage: ____________

____

Plants (excess, absence): ____________

Other? ____________

____

ambient in river
between 393 & water.
pH = 7.35
temp = 23.5°C.
cond = 111.4 uS
sal = 0.1 ppt
DO: 14.11 mg/L ?.
took sample

Discharging Currently? No Yes

If yes: Approximate discharge rate: ____________

Smell of discharge: ____________

Color: ____________

pH: ____________ Temp: ____________

Conductivity: ____________ Turbidity: ____________

Test Kit Results:

TKN: ____________ P: ____________ Other: ____________

Attachment 1
Pipe data sheet

Time, Date: 12:38 9/7
Pipe Location/GIS Number: 28-5 back of fire practice building.
Pipe Dimensions: ~5"
Pipe Material: iron.

Site Description:
Sediment below pipe (mound/delta, depth, etc): rocks + sand.
Ambient Sediment (depth, character of sediment not affected by outfall): rocks + sand.
Evidence of floatables: no
Evidence of solids: no
Oil Sheen: no
Smell in area?: no
Stains, corrosion, concrete damage: no
Plants (excess, absence):
Other? pipe seems unhooked- broken.

Discharging Currently? (No) Yes
If yes: Approximate discharge rate:
Smell of discharge:
Color:
pH: Temp:
Conductivity: Turbidity:
Test Kit Results:
TKN: P: Other:

Attachment 1
Pipe data sheet

Time, Date: 12:40 9/7
Pipe Location/GIS Number: ~~28~~ 29 - trough
Pipe Dimensions: paved trough
Pipe Material: asphalt, concrete.

Site Description:

Sediment below pipe (mound/delta, depth, etc): rock.

Ambient Sediment (depth, character of sediment not affected by outfall): rock, sand

Evidence of floatables: no

Evidence of solids: no

Oil Sheen: — no.

Smell in area?: no

Stains, corrosion, concrete damage: concrete lip in poor condition.

Plants (excess, absence): not unusual.

Other? —

Discharging Currently? (No) Yes

If yes: Approximate discharge rate: ______

Smell of discharge: ______

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 1:36 9/7/01
Pipe Location/GIS Number: S. Stream
Pipe Dimensions: ~4'
Pipe Material: Sand, grav.

Site Description:

Sediment below pipe (mound/delta, depth, etc): Sand

Ambient Sediment (depth, character of sediment not affected by outfall): Sand

Evidence of floatables: —

Evidence of solids: —

Oil Sheen: —

Smell in area?: —

Stains, corrosion, concrete damage: —

Plants (excess, absence): not unusual.

Other? no picture.

Discharging Currently? No Yes – slow.

If yes: Approximate discharge rate: ____

Smell of discharge: None

Color: clear, brown.

pH: ____ Temp: ____

Conductivity: ____ Turbidity: ____

Test Kit Results:

TKN: ____ P: ____ Other: ____

Attachment 1
Pipe data sheet

Time, Date: 2pm 9/7
Pipe Location/GIS Number: 30-6
Pipe Dimensions: 6"
Pipe Material: rubber/plastic

Site Description: by "end" (center pier of RR bridge) inlet side.

Sediment below pipe (mound, delta, depth, etc): —

Ambient Sediment (depth, character of sediment not affected by outfall): ____
Evidence of floatables: ____
Evidence of solids: ____
Oil Sheen: ____
Smell in area?: no
Stains, corrosion, concrete damage: n/a
Plants (excess, absence): no
Other? pumping out of river periodically.

Discharging Currently? No (Yes)
If yes: Approximate discharge rate: pumping out of river.
Smell of discharge: ____
Color: ____
pH: ____ Temp: ____
Conductivity: ____ Turbidity: ____
Test Kit Results:
TKN: ____ P: ____ Other: ____

Attachment 1
Pipe data sheet

Time, Date: 2:11 9/7.
Pipe Location/GIS Number: 6 stream.
Pipe Dimensions: ~3' wide
Pipe Material: rocky stream

Site Description:
Sediment below pipe (mound/delta, depth, etc): rock + sand
Ambient Sediment (depth, character of sediment not affected by outfall): Sand.
Evidence of floatables: none
Evidence of solids: no
Oil Sheen: no
Smell in area?: no
Stains, corrosion, concrete damage: no
Plants (excess, absence): not unusual
Other? no.

Discharging Currently? (No) Yes doesn't seem to be.
If yes: Approximate discharge rate: ______
Smell of discharge: ______
Color: ______
pH: ______ Temp: ______
Conductivity: ______ Turbidity: ______
Test Kit Results:
TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 3:47p 9/7/01
Pipe Location/GIS Number: 21.30?
Pipe Dimensions: 30'
Pipe Material: corrogated metal

Site Description:

Sediment below pipe (mound/delta, depth, etc): Sand rock. some sed did come from pipe it seems

Ambient Sediment (depth, character of sediment not affected by outfall): sand. rock

Evidence of floatables: — 1 can

Evidence of solids: —

Oil Sheen: no. film on top

Smell in area?:

Stains, corrosion, concrete damage: bottom of pipe corroded out

Plants (excess, absence): not unusual

Other?

9/11 - flowing ~1 gpm

flowing dks. seems to be due to g.w. additions after pipe

Discharging Currently? (No) Yes film remains still

If yes: Approximate discharge rate: —

Smell of discharge: no

Color: no

pH: 5.8 Temp: ~~14.6~~ ~~13.8°C~~ 14.4°C

Conductivity: 538 uS Turbidity:

Test Kit Results:

TKN: P: Other: stagnant.

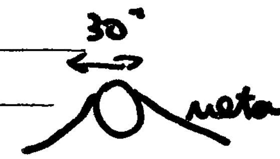
Sal 0.4 ppt

D.O. 10.30 mg/l ?

couldn't get GPS in tree cover.
GPS'ed p.lot corner.

Attachment 1
Pipe data sheet

Time, Date: 3:54 9/7.
Pipe Location/GIS Number: 2230
Pipe Dimensions: 30"
Pipe Material: corrugated metal with expansion



Site Description:

Sediment below pipe (mound/delta, depth, etc): black organic. muddy.

Ambient Sediment (depth, character of sediment not affected by outfall): pine needles

Evidence of floatables: no

Evidence of solids: no

Oil Sheen: no

Smell in area?: no.

Stains, corrosion, concrete damage: brown dirt stains on pipe

Plants (excess, absence): no plants in area - sometimes wet

Other? ______

Discharging Currently? (No) Yes - but muddy does get flow in wet weather.

If yes: Approximate discharge rate: ______

Smell of discharge: ______

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Elev = 249 ft.

Time, Date: 9:45am 21 Sept 05.
N 43°17.155'
Pipe Location/GIS Number: HW1-18 ; W 071° 35.362'
Pipe Dimensions: new concrete headwall, South of RR trestle on right bank
Pipe Material: PVC pipe

Site Description:
Sediment below pipe (mound/delta, depth, etc): rock, + sand
Ambient Sediment (depth, character sediment not affected by outfall): Sand + rock
Evidence of floatables: no.
Evidence of solids: no.
Oil Sheen: no
Smell in area?: slight chlorine from discharge.
Stains, corrosion, concrete damage: new headwall.
Plants (excess, absence): some grass.
Other? Small mildew on concrete, metal pieces below outfall.

Ambient

Ambient Water Characteristics measured upstream of outfall from bank near submerged grasses.
Temp: 19.63 pH: 7.50 D.O.: 11.60 Salinity: 0.04
Conductivity: 82 Turbidity: ~~0.2~~ ~~...~~ 1.01
Color: clear to slight turbid Smell: none.

Discharge

Outfall Discharging Currently? No (Yes)
If yes: Approximate discharge rate: (weir - 1458) -
Smell of discharge: ~~none~~. chlorine - pool water.
Color: clear
pH: 7.42 Temp: 20.4°C.
Conductivity: 232 µS/cm Turbidity: ~~...~~ 0.21
D.O.: ~~*~~ 8.16 mg/L Salinity: 0.11
90.6%.

Test Kit Results:
TKN: X P: X Other: X

Attachment 1
Pipe data sheet

Time, Date: 10am, 21 Sept 05.
Pipe Location/GIS Number: 2.24.
Pipe Dimensions: 24"
Pipe Material: concrete.

Site Description:

Sediment below pipe (mound/delta, depth, etc):
rocks + a little sand

Ambient Sediment (depth, character sediment not affected by outfall):
rocks + a little sand.

Evidence of floatables: none
Evidence of solids: none
Oil Sheen: none.
Smell in area?: none.
Stains, corrosion, concrete damage: none
some sediment in pipe.
Plants (excess, absence): grasses - as in ambient.
Other? ______

Ambient Water Characteristics as HW1-18.

Temp: ______ pH: ______ D.O.: ______ Salinity: ______
Conductivity: ______ Turbidity: ______
Color: ______ Smell: ______

Outfall Discharging Currently? (No) Yes

If yes: Approximate discharge rate: ______
Smell of discharge: ______
Color: ______
pH: ______ Temp: ______
Conductivity: ______ Turbidity: ______
D.O.: ______ Salinity: ______

Test Kit Results:
TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 11:30am 21 Sept 05. 3:24
Pipe Location/GIS Number: right bank north of [illegible] bridge
Pipe Dimensions: 24"
Pipe Material: cast iron in a concrete wall

Site Description:

Sediment below pipe (mound/delta, depth, etc): rock + sand.

Ambient Sediment (depth, character sediment not affected by outfall): rock + sand

Evidence of floatables: none

Evidence of solids: none

Oil Sheen: none

Smell in area?: mud smell

Stains, corrosion, concrete damage: top 20% of [illegible]

Plants (excess, absence): [illegible]

Other? 3 [illegible]

Ambient Water Characteristics

Temp: ________ pH: ________ D.O.: ________ Salinity: ________

Conductivity: ________ Turbidity: ________

Color: ________ Smell: ________

Outfall Discharging Currently? No (Yes)

If yes: Approximate discharge rate: 0.7 gpm

Smell of discharge: none.

Color: clear

pH: ________ Temp: cool. ~12°C

Conductivity: ________ Turbidity: ________

D.O.: ________ Salinity: ________

Test Kit Results:

TKN: ________ P: ________ Other: ________

Attachment 1
Pipe data sheet

Time, Date: 1143 9/21/05 4. Shute B

Pipe Location/GIS Number: NORTH SIDE OF BRIDGE

Pipe Dimensions: 18"

Pipe Material: concrete with shute.

above water by ~15'

Site Description:

Sediment below pipe (mound/delta, depth, etc):

NONE Shute has some moss.

Ambient Sediment (depth, character sediment not affected by outfall):

NONE

Evidence of floatables: NONE

Evidence of solids: NONE

Oil Sheen: NONE

Smell in area?: NONE

Stains, corrosion, concrete damage:

Shute shows some damage.

Plants (excess, absence): Moss in shute.

Other? ____

Ambient Water Characteristics

Temp: ____ pH: ____ D.O.: ____ Salinity: ____

Conductivity: ____ Turbidity: ____

Color: ____ Smell: ____

Outfall Discharging Currently? No (Yes) [circled]

If yes: Approximate discharge rate: ____

Smell of discharge: ____

Color: ____

pH: ____ Temp: ____

Conductivity: ____ Turbidity: ____

D.O.: ____ Salinity: ____

Test Kit Results:

TKN: ____ P: ____ Other: ____

Attachment 1
Pipe data sheet

Time, Date: 11:35 9/21/05 5.18 Sewell's Falls.
Pipe Location/GIS Number: NORTH SIDE OF BRIDGE
Pipe Dimensions: 18"
Pipe Material: STEEL at bank, north of shoto pipe

Site Description:

Sediment below pipe (mound/delta, depth, etc):
NONE, rocky

Ambient Sediment (depth, character sediment not affected by outfall):
some, rocky.

Evidence of floatables: NONE
Evidence of solids: none.
Oil Sheen: NONE
Smell in area?: NONE
Stains, corrosion, concrete damage: NONE

Plants (excess, absence): WEEDS BETWEEN STONES
Other?

Ambient Water Characteristics
Temp: ______ pH: ______ D.O.: ______ Salinity: ______
Conductivity: ______ Turbidity: ______
Color: ______ Smell: ______

Outfall Discharging Currently? (No) Yes
If yes: Approximate discharge rate: ______
Smell of discharge: ______
Color: ______
pH: ______ Temp: ______
Conductivity: ______ Turbidity: ______
D.O.: ______ Salinity: ______

Test Kit Results:
TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 11:30am, 21 Sept
Pipe Location/GIS Number: 6.12
Pipe Dimensions: 12"
Pipe Material: galvanized

Site Description: light bank
Sediment below pipe (mound/delta, depth, etc):
did not locate. Kevin Bartlett said it is here.
Ambient Sediment (depth, character sediment not affected by outfall):
Sand
Evidence of floatables: none
Evidence of solids: none
Oil Sheen: none
Smell in area?: mud
Stains, corrosion, concrete damage: —
Plants (excess, absence): —
Other? —

Ambient Water Characteristics
Temp: ________ pH: ________ D.O.: ________ Salinity: ________
Conductivity: ________ Turbidity: ________
Color: ________ Smell: ________

Outfall Discharging Currently? No Yes ? no sound did not locate.
If yes: Approximate discharge rate: ________
Smell of discharge: ________
Color: ________
pH: ________ Temp: ________
Conductivity: ________ Turbidity: ________
D.O.: ________ Salinity: ________

Test Kit Results:
TKN: ________ P: ________ Other: ________

Attachment 1
Pipe data sheet

Time, Date: 11:30 did not locate.

Pipe Location/GIS Number: 7.4 Kevin Ba[illegible]

Pipe Dimensions: 4" [illegible]

Pipe Material: PVC

from Sewall's Falls bridge.

Site Description: left side. downstream of bridge

Sediment below pipe (mound/delta, depth, etc): ______

Ambient Sediment (depth, character sediment not affected by outfall): ______

Evidence of floatables: ______

Evidence of solids: ______

Oil Sheen: ______

Smell in area?: ______

Stains, corrosion, concrete damage: ______

Plants (excess, absence): ______

Other? ______

Ambient Water Characteristics

Temp: ______ pH: ______ D.O.: ______ Salinity: ______

Conductivity: ______ Turbidity: ______

Color: ______ Smell: ______

Outfall Discharging Currently? No Yes

If yes: Approximate discharge rate: ______

Smell of discharge: ______

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

D.O.: ______ Salinity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

8.box

Time, Date: 1:40 21 Sept 05.
Pipe Location/GIS Number: downstream end of island
Pipe Dimensions: 6' wide, twin culverts
Pipe Material: concrete

Site Description:

Sediment below pipe (mound/delta, depth, etc): sand silt, one culvert blocked by dirt

Ambient Sediment (depth, character sediment not affected by outfall): Sand silt

Evidence of floatables: no

Evidence of solids: no

Oil Sheen: no

Smell in area?: no

Stains, corrosion, concrete damage: no one culvert blocked

Plants (excess, absence): no

Other? this is just a branch of the river coming back into river

Ambient Water Characteristics as for 9.[illegible]

Temp: ______ pH: ______ D.O.: ______ Salinity: ______

Conductivity: ______ Turbidity: ______

Color: ______ Smell: ______

Outfall Discharging Currently? No (Yes)

If yes: Approximate discharge rate: ______

Smell of discharge: Same as river

Color: ______

pH: ______ Temp: ______

Conductivity: ______ Turbidity: ______

D.O.: ______ Salinity: ______

Test Kit Results:

TKN: ______ P: ______ Other: ______

Attachment 1
Pipe data sheet

Time, Date: 1:48 N 43°14.591'
Pipe Location/GIS Number: 9, flap W 071° 33.723'
Pipe Dimensions: 24"
Pipe Material: unknown. only sealed flap gate

Site Description:

Sediment below pipe (mound/delta, depth, etc): silt, sand

Ambient Sediment (depth, character sediment not affected by outfall): silt, sand

Evidence of floatables: no

Evidence of solids: no

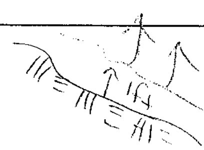
Oil Sheen: no

Smell in area?: mud smell

Stains, corrosion, concrete damage: flap gate rusted + sediment blocks the pipe

Plants (excess, absence):

Other? excessive erosion in bank



tree roots pointing bank
1' from ground

Ambient Water Characteristics

Temp: 20.6 pH: 7.5 D.O.: 8.25 mg/L Salinity: 0.04

Conductivity: 83 μS/cm Turbidity: 0.85

Color: slight turbid Smell: slight mud

Outfall Discharging Currently? (No) Yes

If yes: Approximate discharge rate:

Smell of discharge:

Color:

pH: Temp:

Conductivity: Turbidity:

D.O.: Salinity:

Test Kit Results:

TKN: P: Other: