STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
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CAROLANN WICKS, P.E.
SECRETARY

MEMORANDUM

TO: All Recipients of the May 2008 Storm Sewer CCTV Manual for Storm Sewer Assessment and Acceptance

FROM: George Spadafino, Acting Quality Engineer

DATE: May 22, 2008

SUBJECT: **2008 Storm Sewer CCTV Manual for Sewer Assessment and Acceptance**

Attached you will find the Delaware Department of Transportation's 2008 Storm Sewer CCTV Manual for Sewer Assessment and Acceptance which will become effective June 2, 2008. Any DelDOT contracts that are scheduled for advertisement after January 1, 2009 shall conform to this Manual. This manual is available on DelDOT's Internet site on the Publications page.

Any comments or questions regarding the 2008 Storm Sewer CCTV Manual for Sewer Assessment and Acceptance should be addressed to Joe Ellis at (302) 760-2184.

GS:los
Enclosure
cc: Bob Taylor, Chief Engineer
Dennis O'Shea, Asst. Director, Design
Kevin Canning, Quality Engineer
Linda Osiecki, Program Manager, Quality
Joe Ellis, CONTech, Quality

DelDOT

Delaware Department of Transportation

Storm Sewer CCTV Manual for Storm Sewer Assessment and Acceptance

Prepared By: **The Quality Section**

Coordinators: **Joe Ellis**
Linda Osiecki

Adopted as policy for all DelDOT Projects.

Authorized for advertisement after January 1, 2009.

Special Thanks To:
URS Corporation
Tri-State Grouting
Cobra Technologies

George Spadafino — May 22, 2008 — Date
Acting Quality Engineer

Dennis O'Shea — 5/28/08 — Date
Assistant Director, Design

Bob Taylor — 5/30/08 — Date
Chief Engineer

Carolann Wicks — 6/2/08 — Date
Secretary

DelDOT

State of Delaware
Department of Transportation

STORM SEWER CCTV MANUAL FOR STORM SEWER ASSESSMENT AND ACCEPTANCE

Developed by
Delaware Department of Transportation's Quality Section
and
URS Corporation

MAY 2008

SELECTIVE TABLE OF CONTENTS

SECTION 1 - INTRODUCTION

1.1 DelDOT CCTV PROGRAM OVERVIEW

This manual is the Delaware Department of Transportation (DelDOT) Closed Circuit Television (CCTV) Policy Manual specifically developed for storm sewer inspection. It has three purposes. First is to be used as a training tool for CCTV inspection. Second, it is as a reference guide for uniform CCTV inspection procedures and criteria so that this work in Delaware is performed in a consistent manner. Those who perform this work include the following:

1. DelDOT employees and consultant representatives.
2. CCTV Contractors retained directly by DelDOT working on State financed projects. Costs for this work is typically addressed in the contract between the CCTV Contractor and DelDOT.
3. CCTV Contractors retained by third parties, typically Developers, seeking acceptance of privately constructed roadways into the State system. Costs for such contractor work is solely the responsibility of the Developer/Contractor.

Third, where this work is performed in newly constructed public roadways, to assure that the storm sewer drainage systems are constructed in accordance with State Standards and Specifications. CCTV inspections of this system are required prior to acceptance into the State maintenance system. All CCTV inspections shall be conducted in accordance with this manual.

This Manual is divided into seven sections as follows:

SECTION 1 - INTRODUCTION – Program overview and dedication procedures.

SECTION 2 - CCTV INSPECTION PREPARATION – Preparation considerations including traffic control, storm sewer line cleaning, and system flow control.

SECTION 3 - CCTV INSPECTION PROCEDURES – Detailed specifications including expectations, CCTV components, evaluation of defect severity, camera operational guidelines, documentation of CCTV video imaging, response to defects found, third party re-evaluation, and CCTV finding report delivery.

SECTION 4 – DEFECTS AND DEFECT TERMS – In-depth descriptions with pictures.

SECTION 5 – PIPE JOINT ACCEPTANCE CRITERIA – A listing of acceptable pipe joint gaps for commonly manufactured storm sewer materials and sizes.

SECTION 6 – REPAIR TECHNIQUES – An overview of traditional storm sewer repair techniques as well as more advanced trenchless technologies.

SECTION 7 – STORM SEWER DEFECT MEASUREMENT – A CCTV camera calibration procedure that can be used to determine defect size.

1.2 DEDICATION PROCEDURES

With all newly installed storm sewer pipe in the State of Delaware on either DelDOT projects or new subdivisions, the Developer/Contractor shall conduct the CCTV inspection on all storm sewer drainage pipes except those cross road pipes with open ends on each side where the Engineer can clearly see the full length of the inside of the pipe and which clearly show no defects as determined by the Engineer. The Engineer, as defined by DelDOT Rules and Regulations for Subdivision Streets and Standard Specifications, shall have authority over all decisions.

The following processes will be followed:

1. The CCTV inspection must be completed per this manual and by an impartial, qualified and reputable Inspection Agency in the presence of a DelDOT inspector. The Department reserves the right to reject an Inspection Agency.
2. The Owner / Developer shall provide 48 hours notice to the Department prior to televising any pipe to allow an inspector to be on site.
3. A written inspection report accompanied by visual recording shall be provided to the Department's Inspector at the end of each day of CCTV inspection. Visual recording shall be digital mpeg4 format. The written report shall be in both list form and plan view.

   NOTE: VHS video tapes will not be accepted.
4. The acceptance of pipe joints will be based upon Section 4 of this Manual. It will be the Developer/Contractor's responsibility to demonstrate acceptable joint spacing.
5. Deflection visible on the CCTV monitor will be assumed to be greater than 5%. The Developer/Contractor has the right to challenge this decision by direct measurement or by the use of a GO-NO-GO Mandrel. The pipe will be rechecked for damage after use of the Mandrel.
6. The Developer/Contractor must repair all defects found during inspection. A follow-up CCTV inspection shall also be performed by the Develop/Contractor to assure the repairs have been completed satisfactorily.
7. These inspections shall be completed within 30 days prior to the placement of the final course of asphalt or the placement of Portland Cement Concrete (PCC) Paving, but no sooner than 60 days after installation of the pipe.
8. The cost of the CCTV Inspection will be paid by contracted unit cost on DelDOT projects and by the Developer/Contractor in new subdivisions.
9. These inspections will record the pipe condition at the time of the inspection, but does not relieve the Developer/Contractor of his responsibility under Delaware Law.

SECTION 2 - CCTV INSPECTION PREPARATION

2.0 INTRODUCTION

CCTV Inspection of storm sewer systems requires significant planning and preparation. This section presents some of the many considerations needed for a well-executed CCTV Inspection program.

The intent of the CCTV manual is that it be used as a tool to help provide the engineer and developer with a reliable inspection of the entire installed storm sewer system with uniform descriptions between vendors and engineers. This section deals with the following:

- Numbering storm sewer manhole or access structures
- Location of structures by GPS
- Traffic control
- Cleaning for inspections
- Flow control

2.1 NUMBERING SYSTEM STRUCTURES

Before starting CCTV inspection, the CCTV contractor shall assure that the plans have numbered structures and numbered pipe runs. Said numbering shall also be coordinated with the statewide MAXIMO storm sewer inventory program. If these numbers are not available from the local district office, inventory numbers shall be obtained by contacting DelDOT's NPDES Department.

2.2 LOCATION OF STRUCTURES BY GPS

The location of each structure within the storm sewer system, including drainage inlets, manholes and all inlet ends of pipes, shall be provided by the Developer/Contractor. Those locations are to be determined utilizing GPS coordinate technology. GPS coordinates, Northing and Easting, shall be reported in Delaware State Plane Coordinate System, U.S. Surveying feet N.A.D. 83 D.A.T.A.M. (NAD83 Delaware State Planes, US Foot) and provided to DelDOT on a separate written report listed both by plan numbering system and street address along with DelDOT's Drainage Inventory Numbering, when available, in an Excel spreadsheet.

2.3 TRAFFIC CONTROL

All contractors working on projects within the State right-of-way will be responsible for providing traffic control for all CCTV inspection services. Costs for traffic control will be borne solely by the contractor. All traffic control will adhere to **the current edition of the Delaware Traffic Control Manual** and the *Manual of Uniform Traffic Control Devices* (*MUTCD*).

Modified or additional traffic control measures not specified in the Delaware Traffic Control Manual may periodically be necessary as required by the Engineer. Any modified or additional traffic controls and plans will need to be coordinated with DelDOT prior to beginning any inspection or maintenance services.

The project specific Traffic Control Plan may require approval from the Engineer.

2.4 STORM SEWER CLEANING

A CCTV inspection cannot be adequately performed in a pipe that contains excessive amounts of silt or debris. Storm sewers must be cleaned as specified below prior to any CCTV work.

2.4.1 Intent

The intent of storm sewer line cleaning is to remove ALL foreign materials from the lines prior to televising the pipe in order to provide a clear, unobstructed view of the entire pipe. The success of the other phases of work will depend a great deal on the cleanliness of the lines. The importance of this phase of the operation cannot be over emphasized. It is recognized that there are some conditions such as major blockages that prevent typical cleaning from being accomplished. The Developer/Contractor will be required to remove ALL blockages. If in the course of normal cleaning operations, damage results to the pipe or structure of new installations, the Developer/Contractor will be required to repair the damage or replace the pipe or structure.

2.4.2 Cleaning Equipment

High-Velocity Jet (Hydrocleaning) Equipment: All high-velocity sewer cleaning equipment shall be constructed for ease and safety of operation. The equipment shall have a selection of high-velocity nozzles. The nozzles shall be capable of producing a scouring action from 15 to 45 degrees, in all size lines designated to be cleaned. Equipment shall also include a high-velocity gun for washing and scouring structure walls and floor. The gun shall be capable of producing flows from a fine spray to a solid stream. The equipment shall carry its own water tank, auxiliary engines, pumps, and hydraulically driven hose reel.

2.4.3 Cleaning Precautions

Developers and CCTV contractors shall take every precaution to avoid damage during pipe cleaning operations. CCTV Contractors working on DelDOT projects (Case 2 from Introduction) shall obtain approval from the Department before certain higher risk cleaning operations are begun. Satisfactory precautions shall be taken in the use of cleaning equipment. When hydraulically propelled cleaning tools (which depend upon water pressure to provide their cleaning force) or tools which retard the flow in the pipe line are used, precautions shall be taken to ensure that the water head pressure does not damage or cause flooding of public or private property being served by the storm sewer. Various cutter tips may need to be used depending upon site specific conditions. No fire hydrant shall be used without permission from the Utility Owner. If permission is given, the hydrant shall not be obstructed in case of a fire in the area served by the hydrant. Gate valves, backflow preventors, or an air gap shall be incorporated in the direct connection to a potable water source as required by the utility owner.

2.4.4 Safety

DelDOT employees will adhere to the Department's Confined Space Entry Policy. All others will adhere to OSHA Confined Space Entry Regulations.

2.4.5 Storm Sewer Cleaning

The designated storm sewer sections shall be cleaned using high-velocity jet, or mechanically powered equipment. Selection of the equipment used shall be based on the conditions of lines at the time the work commences. The equipment shall be capable of removing dirt, grease, rocks, sand, branches, leaves and other materials and obstructions from the storm sewer lines and structures. If cleaning an entire section cannot be successfully performed from one structure, the equipment shall be set up on the next structure and cleaning again attempted. If, again, successful cleaning cannot be performed or the equipment fails to traverse the entire section, it will be assumed that a major blockage exists and it is the Developer/Contractor's responsibility to remove this blockage. The Developer/Contractor shall use caution during cleaning operations so as not to cause damage to the pipe section being cleaned. If subsequent televising of the pipe reveals damage caused by the cleaning operation, the damage shall be repaired to the Department's satisfaction at no additional cost to the Department.

2.4.6 Material Removal

Debris such as dirt, sand, rocks, grease, and other solid or semisolid material resulting from the cleaning operation shall be removed at the downstream structure of the section being cleaned. Passing material from storm sewer section to section, which could cause line stoppages, accumulations of sand, etc. shall not be permitted.

2.4.7 Disposal of Materials

The Developer/Contractor shall properly dispose of all materials removed from the storm sewer in accordance with all applicable laws and regulations.

2.4.8 Final Acceptance

Final Acceptance. Acceptance of storm sewer line cleaning shall be made upon the successful completion of the television inspection and shall be to the satisfaction of the Department. If TV inspection shows the cleaning to be unsatisfactory, the Developer/Contractor shall be required to re-clean and re-inspect the storm sewer line until the cleaning is shown to be satisfactory.

2.5 FLOW CONTROL

2.5.1 Intent

It is the intent of these specifications that the storm sewer segment being televised be dry (no running water flow) during the CCTV work.

2.5.2 Plugging and Blocking

It may be required to insert a plug into the line upstream of the section being worked. The plug shall be so designed that all or any portion of the water can be released. During TV inspection, flow shall be stopped. After the work has been completed, flow shall be restored to normal.

2.5.3 Pumping and Bypassing

When pumping and bypassing is required, the Developer/Contractor shall supply the pumps, conduits, and other equipment to divert the flow of water around the section in which work is to be performed. The bypass system shall be of sufficient capacity to handle existing flow plus additional flow that may occur during a rainstorm. The Developer/Contractor will be responsible for furnishing the necessary labor and supervision to set up and operate the pumping and bypassing system. A bypass pumping plan shall be submitted to DelDOT for review.

If pumping is required on a 24-hour basis, equipment should include back-up pumps, controls, and alarms attached to an automatic alert call out device, where possible. Also, engines shall be equipped in a manner to keep noise to a minimum when 24-hour pumping is required.

2.5.4 Flow Control Precautions

When flow in a storm sewer line is plugged, blocked, or bypassed, sufficient precautions must be taken to protect the storm sewer lines from damage that might result from surcharging. Further, precautions must be taken to insure that storm sewer flow control operations do not cause flooding or damage to public or private property.

SECTION 3 - CCTV INSPECTION PROCEDURES

3.0 INTRODUCTION

The intent of the CCTV Inspection procedure described herein is to provide the Engineer with a quality inspection of the entire installed storm sewer system. This section presents some of the many considerations to be made for a well-executed CCTV Inspection program and the documentation that is required.

3.1 CLOSED CIRCUIT TELEVISION INSPECTION

3.1.1 Purpose

The purpose of the CCTV inspection is to observe the condition of the pipe prior to dedication of the pipe to the State of Delaware. The criteria for acceptance will be based on the number and severity of the defects observed.

3.1.2 Expectations

After cleaning, the pipe sections shall be visually inspected by means of color closed-circuit television. The inspection will be done one pipe section at a time and the flow in the section being inspected will be stopped as specified (See Section 2.3).

3.1.3 CCTV System Components

The color television camera used for the inspection shall be one specifically designed and constructed for such inspection. Lighting for the camera shall be suitable to allow a clear picture of the entire periphery of the pipe. The camera shall be operative in 100% humidity conditions. The camera, television monitor, and other components of the video system shall be capable of producing picture quality to the satisfaction of the Department's Representative and if unsatisfactory, equipment shall be removed and the pipe section re-televised.
The televising of the pipe shall be recorded at the "Standard Play" speed.

3.1.4 Defect Severity Assessment

Storm sewer acceptance may be based on the severity or size of defects observed, such as how far a pipe joint is separated as compared to standards of acceptance discussed in Section 5. It is therefore important to be able to determine the size of a defect as observed in-pipe by CCTV inspection. In order to be prepared to evaluate the size of a defect, the CCTV Contractor will be required to calibrate their camera just prior to the actual inspection, for each size of pipe.

The detailed CCTV Calibration guideline procedure in Section 7 is based on the following:

> The calibration procedure involves having an object of known size (i.e., a ruler, yard stick) placed in the pipe being inspected at the 12:00, 3:00, 6:00 and 9:00 positions. The pipe for this calibration may be unused sections of the same size of the installed pipe, or in-place pipe sections. The camera shall be inserted in the pipe, "homed up" to assure that 12:00 is straight up, and the head rotated to observe the measurement at each clock position. The image of the object of known size is measured on the monitor in the CCTV van and the size measured from the monitor noted for each position of the test pipe noted in a table for future reference in defect comparisons. This table will then accompany subsequent video recording and the

written report for each location. This will assist the CCTV Contractor and DelDOT reviewer in determining the size of a defect.

3.1.5 Camera Operational Considerations

3.1.5.a Camera Positioning in the Pipe

Accurate pipe distance measurements are necessary for surface location of pipe defects. Measurement for location of defects shall be by means of a metering device visible on the recording and on the CCTV operator's viewing screen. Push cameras for underdrain video shall be equipped with a distance meter on the cable reel. Marking on the cable, or the like, which would require interpolation for depth into pipe, will not be allowed. The distance from this metering device shall be manually entered onto the recording at each observation. Accuracy of the distance shall be checked by use of a walking meter, roll-a-tape, or other suitable device. The accuracy shall be satisfactory to the Department and shall be no less than one percent (1%) of the pipe length measured.

The camera must be centered as near as possible in the pipe by changing the size of the tires, adding fixed risers to raise the camera from the tractor, or by an adjustable gantry. The camera shall be moved through the line in either direction at a moderate rate (no greater than 30 feet per minute) stopping at each joint or when necessary to permit proper documentation of the pipe's condition and to observe and measure the size of the defects. If, during the CCTV inspection operation, the television camera will not pass through the entire pipe section, the CCTV operator shall set up his equipment so that the inspection can be performed from the opposite structure. If, again, the camera fails to pass through the entire pipe section, the inspection shall be considered incomplete and the line re-cleaned to remove obstructions. If traction is a problem, the operator may quickly proceed the camera to the end of the pipe run, stopping at each joint or defect in reverse order.

3.1.5.b An Unobstructed View

The Developer/Contractor shall assure that the Department has an unobstructed view of the entire pipe being televised including pipe sections that are depressed and may be holding water. It may be necessary to remove standing water in depressions to assure an unobstructed view of the entire pipe.

3.1.5.c Defect Observation Location and Documentation

The CCTV camera operator shall stop at each defect and pipe joint and televise the entire joint with the pan and tilt feature on the head of the camera, initially, in a complete counterclockwise direction followed by a complete clockwise direction. If a defect is found, the CCTV operator will "home up" the camera prior to defining the defect and determining its size and location. The CCTV operator will also stop and record <u>any</u> questionable item such as a stain, crack, paint mark, shadow found or character change in a pipe being inspected. In other words, the CCTV operator must stop, record and note anything questionable no mater how minor. The Engineer, as defined by DelDOT Standard Specifications, not the CCTV operator, will decide if a questionable item is a "problem event" when that Engineer reviews the video inspection.

3.1.5.d Inspection of Consecutive Pipe Sections

When consecutive pipe sections are inspected in a continuous manner, each structure and pipe run shall be properly identified. Resetting the distance meter will not be necessary. When the camera is passing through a structure, a thorough inspection of the structure shall be recorded.

3.1.5.e Light Control

The camera shall be equipped with an adjustable light for viewing in low light conditions in various size pipes. Due to the camera lens's sensitivity to light, the grates of all structures open to sunlight and open ends of pipes must be covered to prevent excessive glare during CCTV inspection and to allow adequate inspection of the interior of the structures and the end of the pipe run.

3.1.5.f CCTV Operator Comments on the Video

The CCTV camera operator shall provide continuous narrative on the video during the CCTV process. Written descriptions of defects and questionable objects will also be provided.

3.1.6. Documentation of CCTV Video Imaging

3.1.6.a Defect Terminology

Defect Terminology shall be in accordance with the terms in Section 4 of this manual.
NOTE: Use of an abbreviated defect code system will not be permitted.

3.1.6.b Television Inspection Logs/Printed Report:

Printed location records shall be kept by the Developer/Contractor and will clearly show the pipe run number as shown of the Plans, the location in the pipe in relation to an adjacent structure, and the size of each defect observed during inspection. In addition, other points of significance such as locations of unusual conditions, storm sewer connections, broken pipe, presence of scale and corrosion, roots, and other discernible features will be recorded and a copy of such findings supplied to the intended owner (DelDOT). The report shall be in both list form and a graphic presentation in plan or cross-sectional view. Examples of acceptable formats are at the end of this section.

3.1.6.c Header Information

All special header information shall be shown on the report and video. Information shall include but not be limited to:

a. Owner (DelDOT)
b. Developer/Contractor
c. Project # or Subdivision Name & Agreement #
d. Department inspector on site
e. CCTV Camera Operator
f. Beginning Structure Number
g. Ending Structure Number
h. Pipe Run Number
i. Pipe Material

j. Pipe size w/maximum joint width
k. Direction of flow (fall)
l. Direction of CCTV inspection

3.1.6.f CCTV Video Inspection Recordings

The CCTV contractor shall provide the information observed during the CCTV inspection to the Department on a DVD, which will contain the video recorded in mpeg4 digital format with verbal descriptions and separate files containing the written report and calibration charts. Each disc shall be labeled with the Project or Subdivision name, number and pipe run numbers it contains. Each disc shall be delivered in a plastic case.

NOTE: VHS video tapes will not be accepted.

3.2 THIRD PARTY INSPECTIONS

Where third party oversight of CCTV inspection is required by the Department, the third party inspector is to be onsite to observe the actual CCTV inspections, take personal notes during those observation, and compare those personal notes separately against the CCTV observation report to confirm accuracy and completeness of the final report.

3.3 WRITTEN REPORT

A written report ~~to~~ shall accompany any CCTV video inspection recordings provided to DelDOT per this manual. The written report shall consist of:

- Numbering System used for Structures from Section 2.1
- GPS structure location report from Section 2.2
- CCTV observations text list
- CCTV observations graphical report sheet(s) in plan or cross-sectional view as provided by the CCTV contractor

3.4 RESPONSE FROM DELDOT

The Department will respond to the receipt of the inspection video and report by returning a copy of the written report to the Developer/Contractor noting which defects need to be repaired. The Developer/Contractor will then submit their recommended repairs for correcting these defects.

SECTION 4 - DEFECTS AND DEFECT TERMS*

4.0 INTRODUCTION

The storm sewer observation terms below provide a consistent set of descriptors for use during storm sewer system CCTV inspection. These terms describe the variances found in a storm sewer system that are different from the structural quality expectations of a newly installed system. For most terms, an example picture has been included to provide a closely similar visual condition as a reference.

The terms used in this manual maintain a close consistency with the terms used by the National Association of Sewer Services Companies (NASSCO) Pipeline Assessment and Certification Program (PAPC). The descriptive terms herein specifically describe storm sewer conditions and as such are intended for general application without user certification.

The storm sewer Defects and Defect Terms are divided into three subsections as follows:

4.1 STRUCTURAL DEFECT TERMS
4.2 OPERATIONS AND MAINTENANCE TERMS
4.3 CONSTRUCTION FEATURE TERMS

The CCTV operator should use these terms, both verbally and keyed in, to describe similar defect observations during inspection on in-ground storm sewer systems

DISCLAIMER: The pictures presented in this section to represent defect terms were chosen in an effort to demonstrate the condition as closely as possible from the pictures available at the time of publication of this manual. Some pictures may demonstrate multiple points of inspection concern. Please focus on the application of the defect term as indicated by an arrow to the picture component.

PICTURE CREDITS: Pictures used as storm sewer examples were graciously provided directly from Cobra Technologies (CT), DelDOT, or from URS asset management projects for DelDOT.

4.1 STRUCTURAL DEFECT TERMS

Structural defect terms describe the variances in a storm sewer system that are different from the structural quality expectations of a newly installed system. Defects of the structural integrity of a storm sewer may shorten service life or interfere with the system's flow and operation.

The categories in Structural Defect Terms include:

4.1.1 Crack
4.1.2 Fracture
4.1.3 Broken
4.1.4 Hole
4.1.5 Deformed
4.1.6 Collapse
4.1.7 Joint
4.1.8 Surface Damage
4.1.9 Weld Failure
4.1.10 Pipe Repair
4.1.11 Masonry
4.1.12 Lining Failure

The CCTV operator should use these terms to describe similar defect observations during inspections of in-ground storm sewer systems.

4.1.1 Crack

General Description

A visible crack line along pipe/structure wall in which the pipe/structure material is still intact and the crack line is not visibly open in the storm sewer pipe.

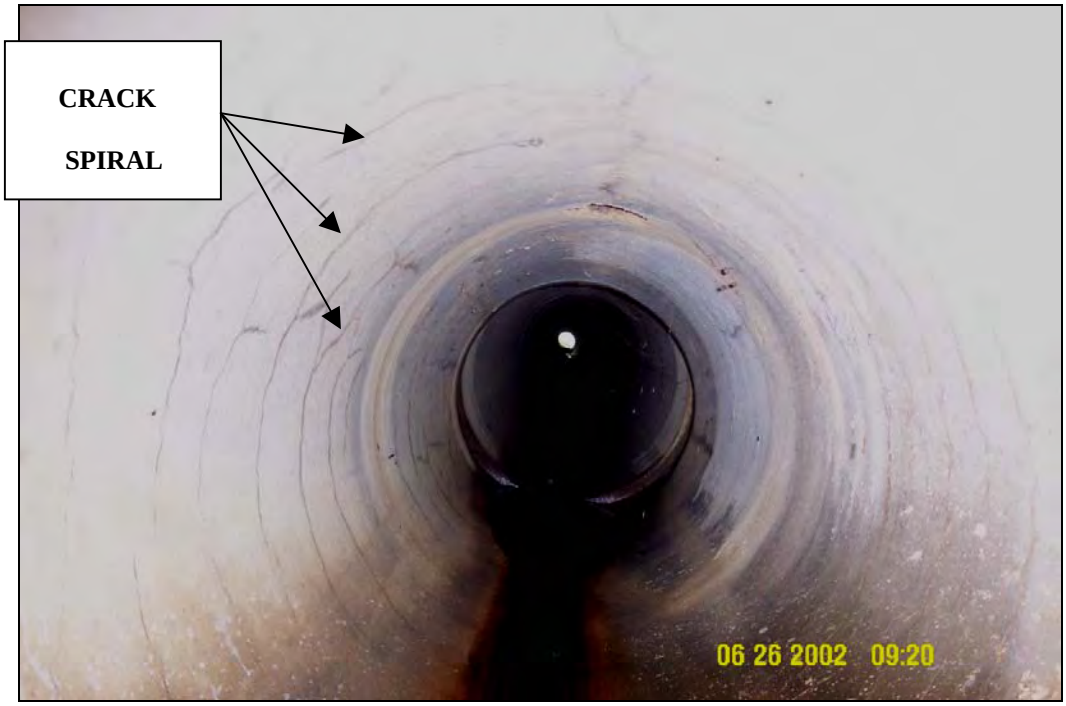
Details

1) Circumferential – runs at right angles to the axis (parallel with the joints).
2) Longitudinal – runs along the axis of the pipe (parallel with the centerline).
3) Spiral – crack changes position as it progresses along pipe.
4) Multiple –combination of circular, longitudinal, and/or spiral.

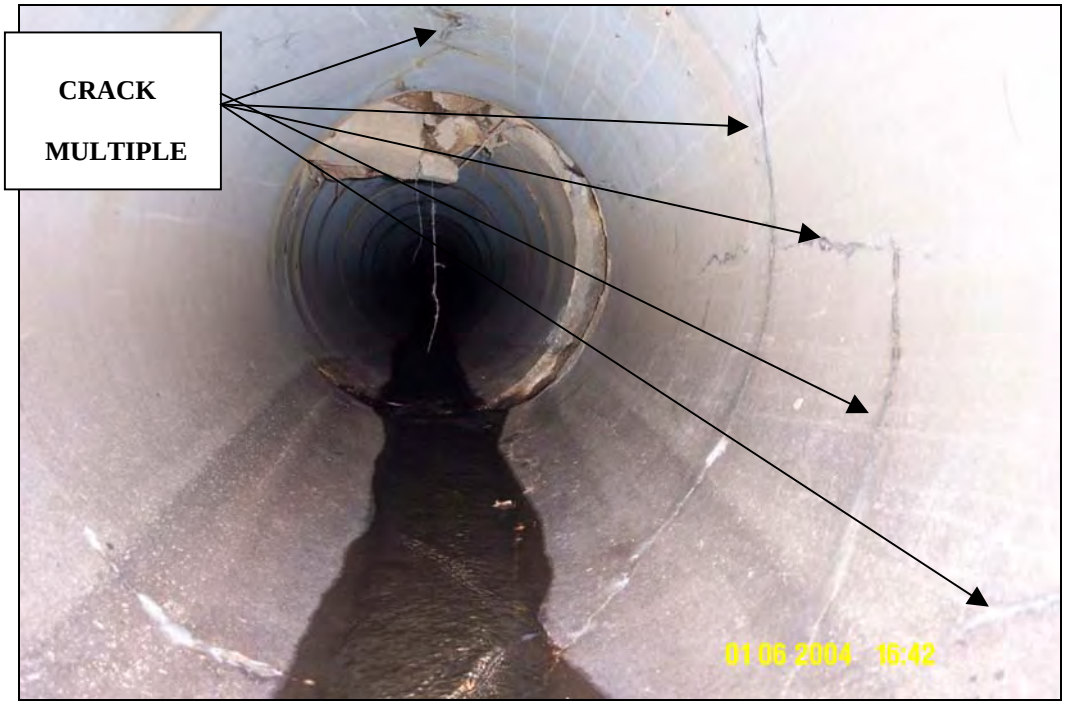
4.1.1 Crack - Picture Examples

Crack runs at right angles to the axis (parallel to the joints)

Crack runs along the axis of the pipe (parallel to the centerline)



Crack changes position as it progresses along pipe



Combination of circular, longitudinal, and/or spiral cracks

4.1.2 Fracture

General Description

A visible crack line along pipe/structure wall in which the pipe/structure material is still intact with a crack line that is visibly open in the storm sewer pipe.

Details

1) Circumferential – runs at right angles to the axis (parallel with the joints).

2) Longitudinal – runs along the axis of the pipe (parallel with the centerline).

3) Spiral – fracture changes position as progress along pipe.

4) Multiple –combination of circular, longitudinal, and/or spiral.

4.1.2 Fracture - Picture Examples

Fracture runs at right angles to the axis (parallel to the joints).

Fracture runs along the axis of the pipe (parallel to the centerline).

4.1.3 Broken

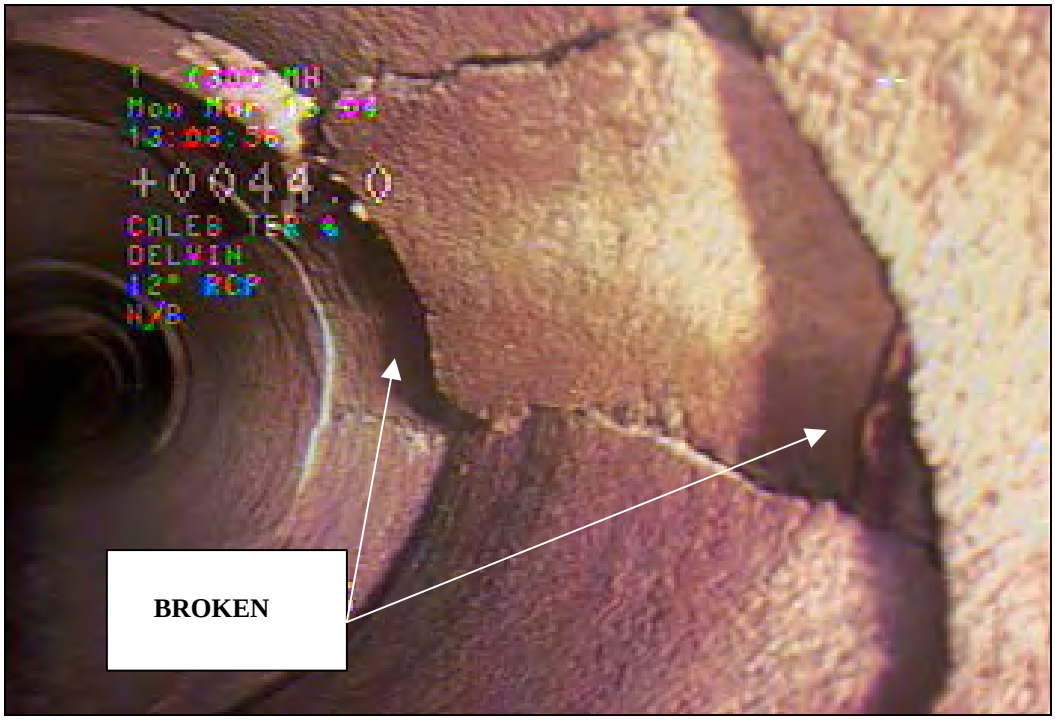
General Description

A visible displacement of pipe/structure material from its original position.

Details

None

4.1.3 Broken - Picture Examples



Visible displacement of pipe/structure material from its original position

Visible displacement of pipe/structure material from its original position

4.1.4 Hole

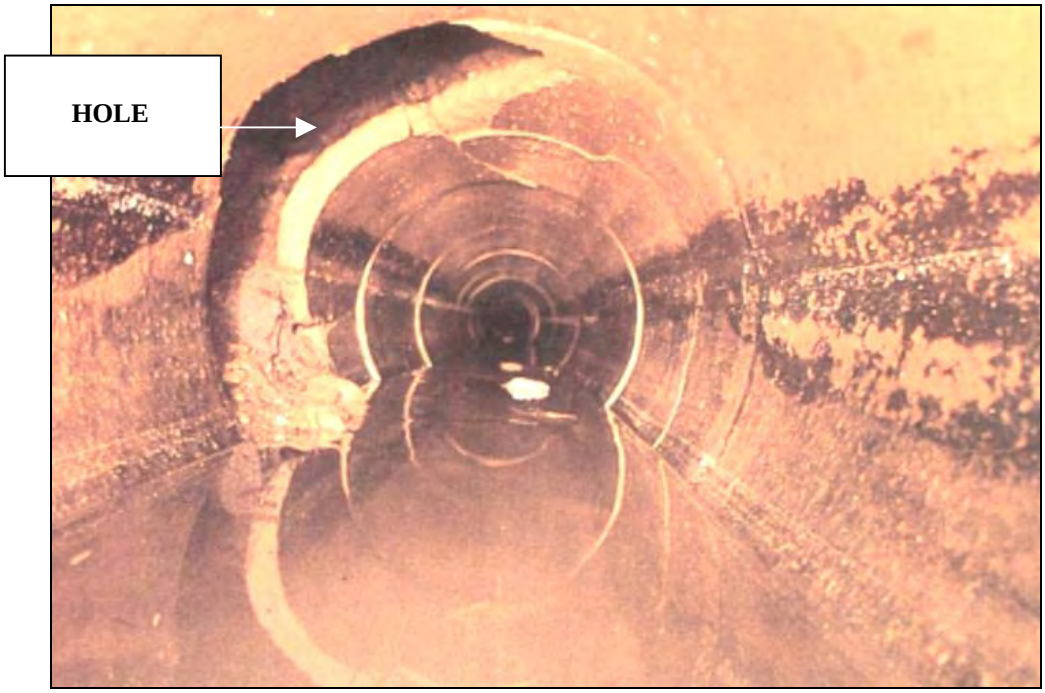
General Description

A visible hole in the pipe/structure wall where pipe material has dislodged from the wall or metal pipe which is corroded away.

Details

None

4.1.4 Hole - Picture Examples



CT

A visible hole in the pipe/structure wall where section dislodged.

A visible hole in the pipe/structure wall from corrosion.

4.1.5 Deformed (Dent/Depression/Deflection)

General Description

Visible evidence that original cross section in storm sewer pipe has been altered.

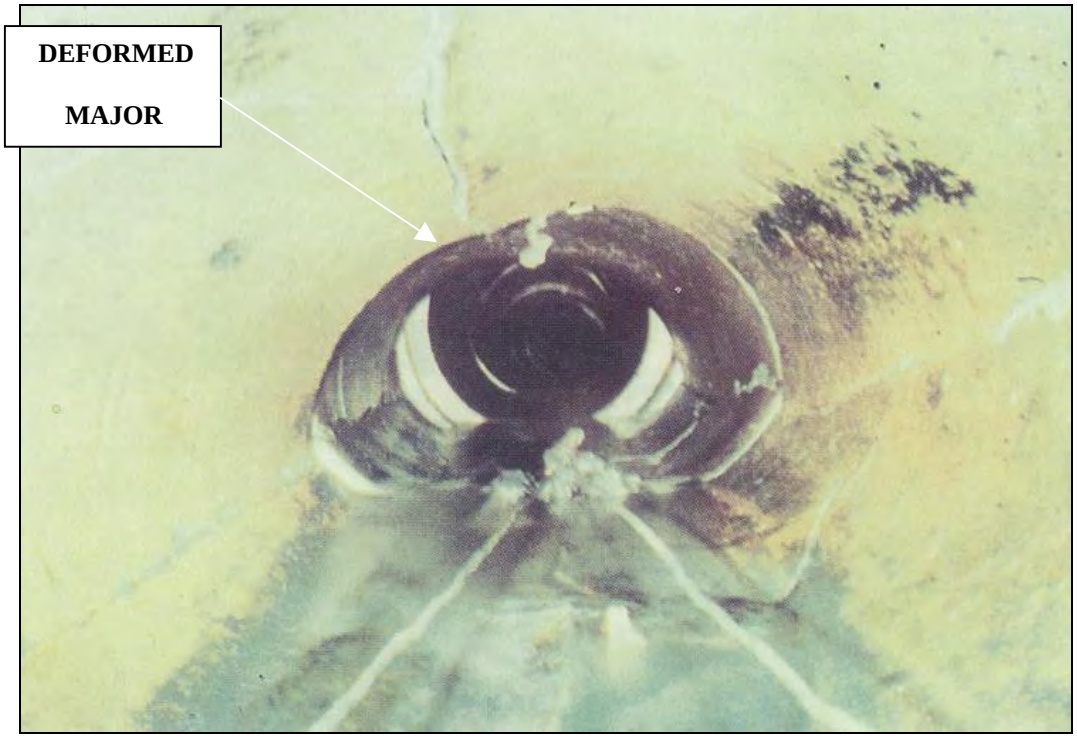
Details

1) Minor – slight alteration to original cross section, 0-20% change.

2) Severe – major alterations to original cross section, 20-40% change.

4.1.5 Deformed - Picture Examples

Slight alteration to original cross section.



CT

Major alterations to original cross section.

4.1.6 Collapse

General Description

A loss of structural integrity with greater than 40% cross sectional area lost. Pipe can not be reformed.

Details

1) Pipe

2) Manhole, Drainage Inlet or Junction Box Wall.

4.1.6 Collapse - Picture Examples

Collapse - of RCP

Collapse - of CMP

4.1.7 Joint

General Description

These defects describe visible displacement at joints in storm sewer pipes.

Details

1) Open - Pipes do not abut completely (or at all) on same level.
   Pipe joints are not pushed home and are separated.
   Opening may also be caused by misalignment or slope change of pipe.
   (See Section 4.3.3)

2) Offset - Pipes do not abut and are on different approach.
   The spigot is not concentric with the socket of the adjacent pipe.

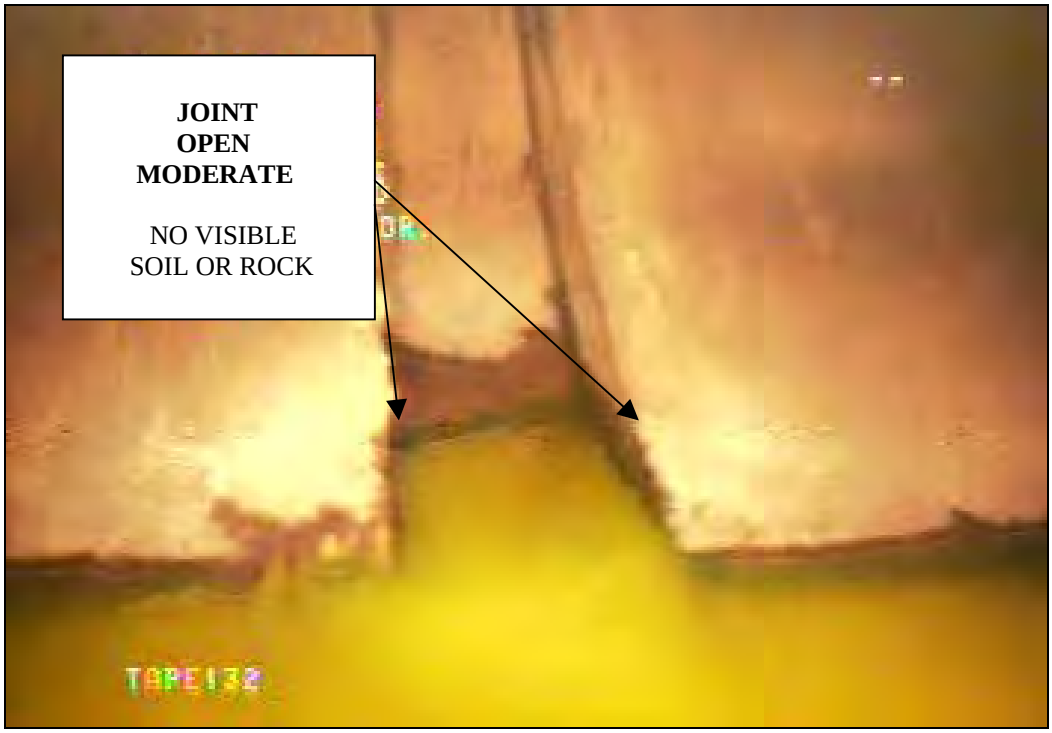
Severity

Moderate - No soil or rock visible.

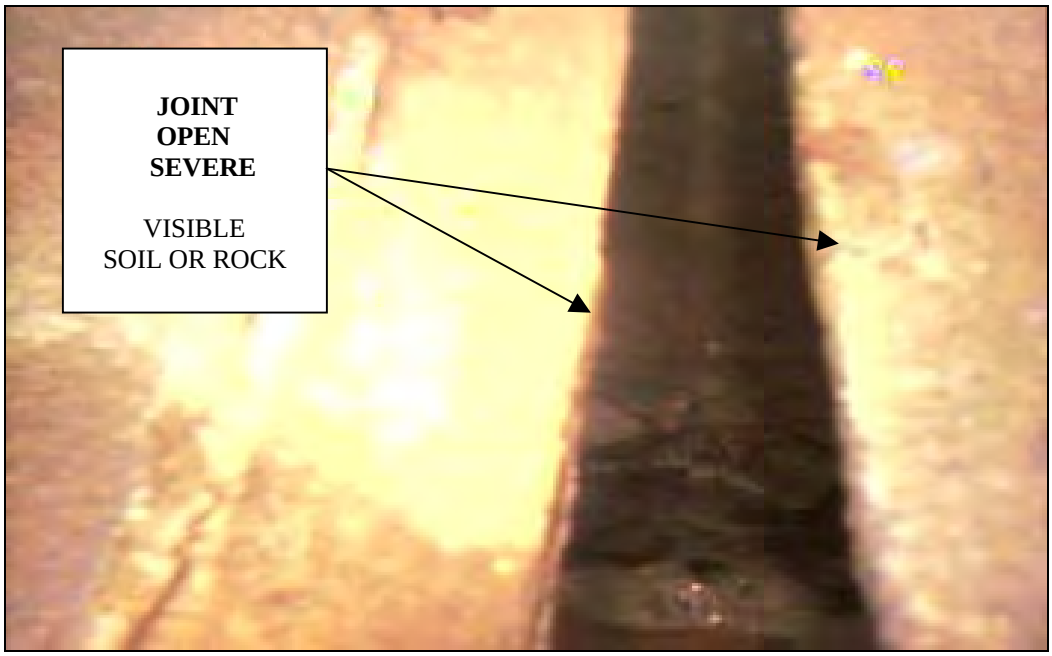
Severe - Soil or rock visible.

NOTE: CCTV Operator with calibrated camera should take measurements of gap as directed. See Section 7 for CCTV Camera equipment calibration procedure and forms.

4.1.7 Joint – OPEN - Picture Examples



Pipes end not tight or sealed on same level.



Pipes do not abut completely (or at all) on same level.

3.1.7 Joint - Picture Examples

Joint level-shifts – no joint match.

Joint side-shifts – no joint match.

4.1.8 Surface Damage

General Description

Storm sewer original or expected surface appearance has degraded.

General Causes

Loss of surface material due to spalling, chipping, or corrosion across surface resulting from Mechanical, Chemical (gas or liquid), or Unknown activity.

Details - Reinforced Concrete Pipe (RCP)

1) Roughness Increased - Slight loss of fine material on pipe surface.

2) Aggregate Visible - Fine material eaten away showing aggregate surface.

3) Aggregate Projecting - Aggregate protrudes out surface of remaining concrete.

4) Aggregate Missing - Aggregate dislodged from pipe wall.

5) Reinforcement Visible - Wall material loss exposing Reinforcement surface.

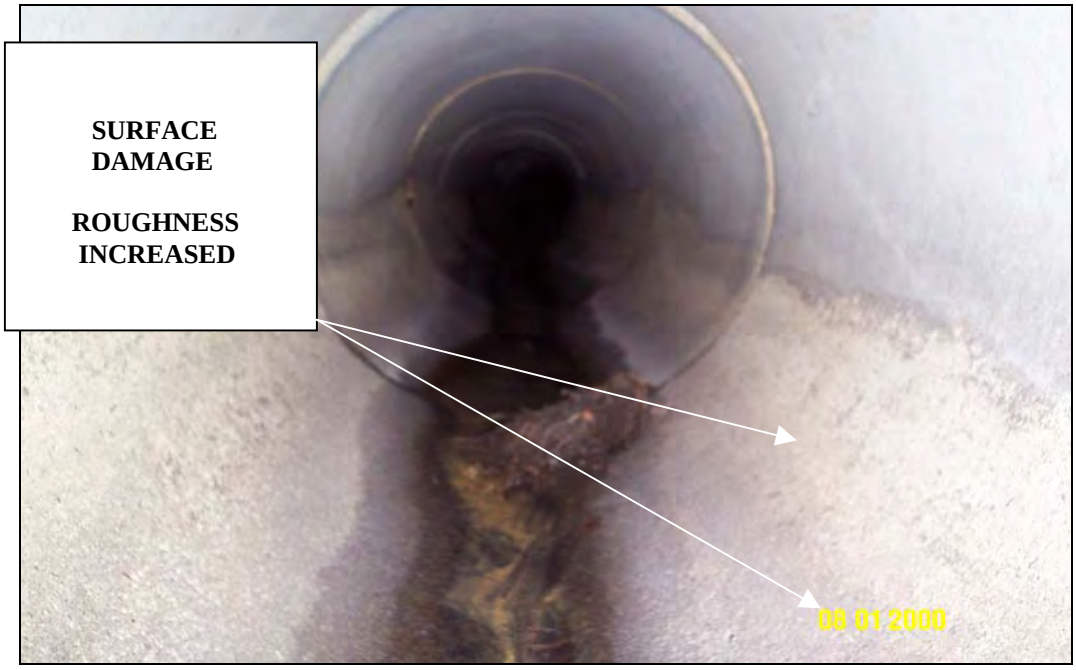
6) Reinforcement Projecting - Wall material loss exposing entire Reinforcement.

7) Reinforcement Corrosion - Visible rust from reinforcement corroding.

Details - Metal or Plastic Pipe

8) Corrosion - Visible loss of pipe material by corrosive attack.

4.1.8 Surface Damage - Picture Examples



Slight loss of fine material on pipe surface.

Fine material eaten away showing aggregate surface.

4.1.8 Surface Damage - Picture Examples

Fine material eaten away showing complete aggregate.

Wall material loss exposing reinforcement surface.

4.1.8 Surface Damage - Picture Examples

Wall material loss exposing entire reinforcement.

A visible loss of pipe material by corrosive attack.

4.1.9 Weld Failure

General Description

Failure in weld of plastic or metal pipe either at joint or manufactured seam.

Details

1) Plastic Pipe - Failure along weld of plastic pipe or butt fused pipe ends.
2) Metal Pipe - Failure along weld of metal pipe.

Secondary details include:

Circumferential – runs at right angles to the axis (parallel with the joints).
Longitudinal – runs along the axis of the pipe (parallel with the centerline).
Spiral – fracture changes position as progress along pipe.
Multiple –combination of circular, longitudinal, and/or spiral.

Picture

No picture available

4.1.10 Pipe Repair

General Description

Storm sewer pipe appears to have been replaced or repaired (patched or locally lined).

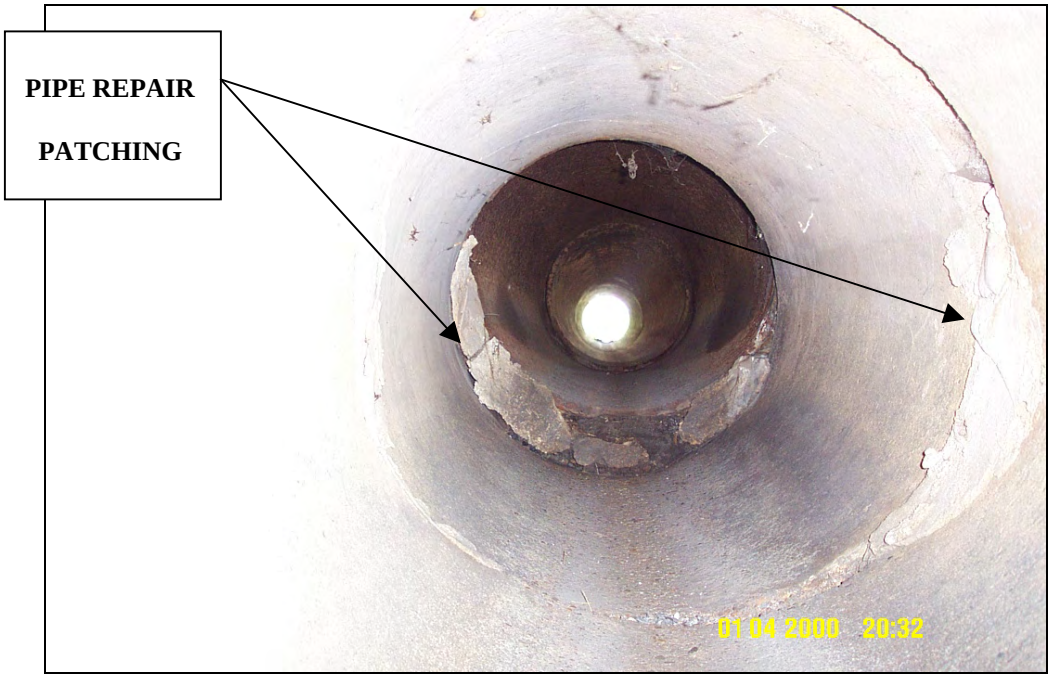
Details

1) Patched - Original pipe section(s) repaired by patching.

2) Localized Liner - Original pipe section(s) repaired using localized liner.

3) Replaced - Original pipe section(s) replaced with new pipe.

4.1.10 Pipe Repair - Picture Example



Original pipe section(s) repaired by patching.

CT

Original pipe section(s) repaired using localized liner.

4.1.11 Masonry (Brickwork)

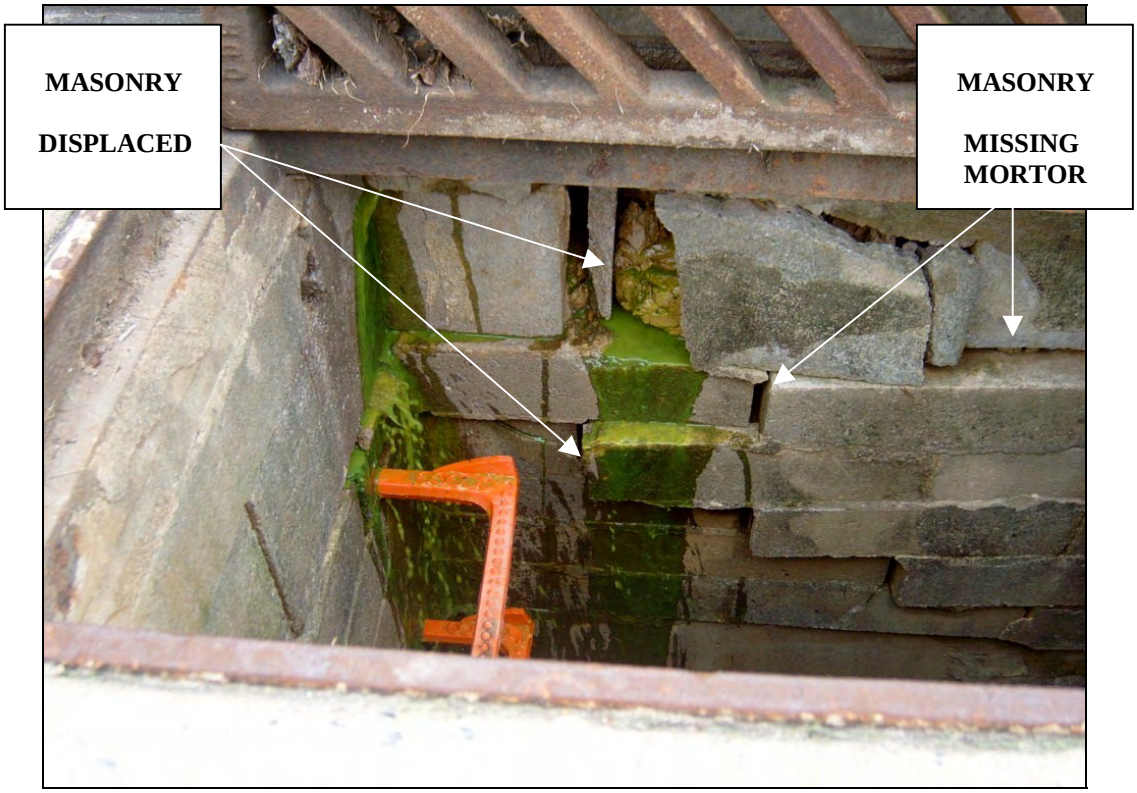
General Description

Damage to masonry storm sewer structures.

Details

1) Displaced - Bricks/mortar loosened and moving but still in place.
2) Missing - Brick(s) missing from structural surfaces.
3) Missing Mortar - Mortar missing from structural surfaces.
4) Missing Grout - Non-Shrink grout missing or needed around pipe connection.

4.1.11 Masonry (Brickwork) - Picture Example



Masonry storm sewer structure with defects.

4.1.12 Lining Failure (in rehabilitated pipe)

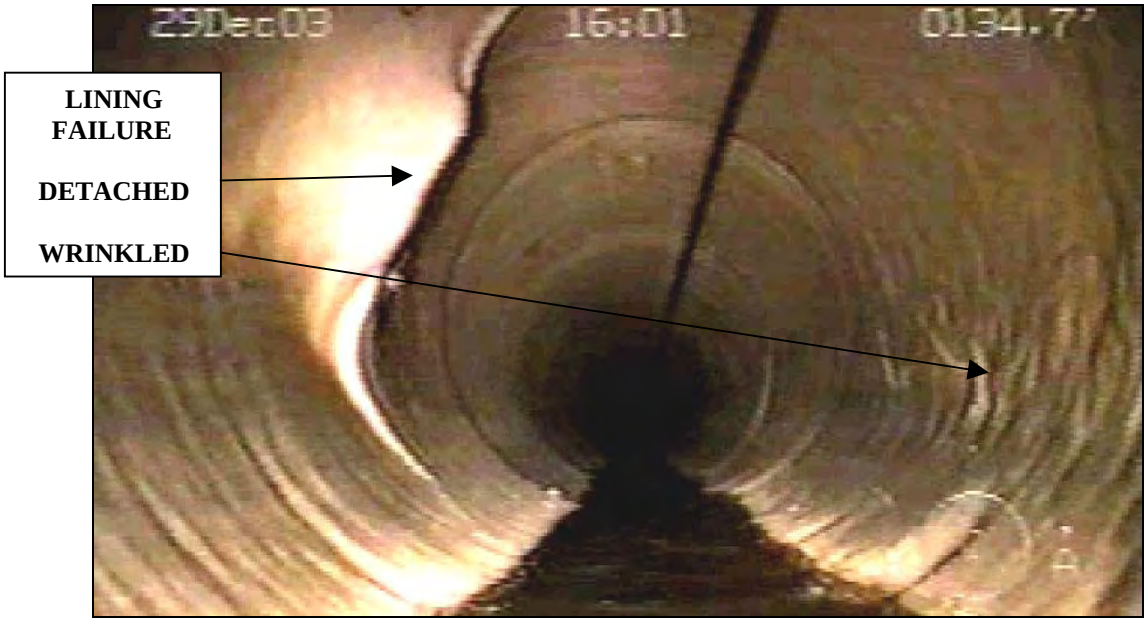
General Description

Lining in renewed pipe restricts flow or does not cover original pipe (Host Pipe).

Details

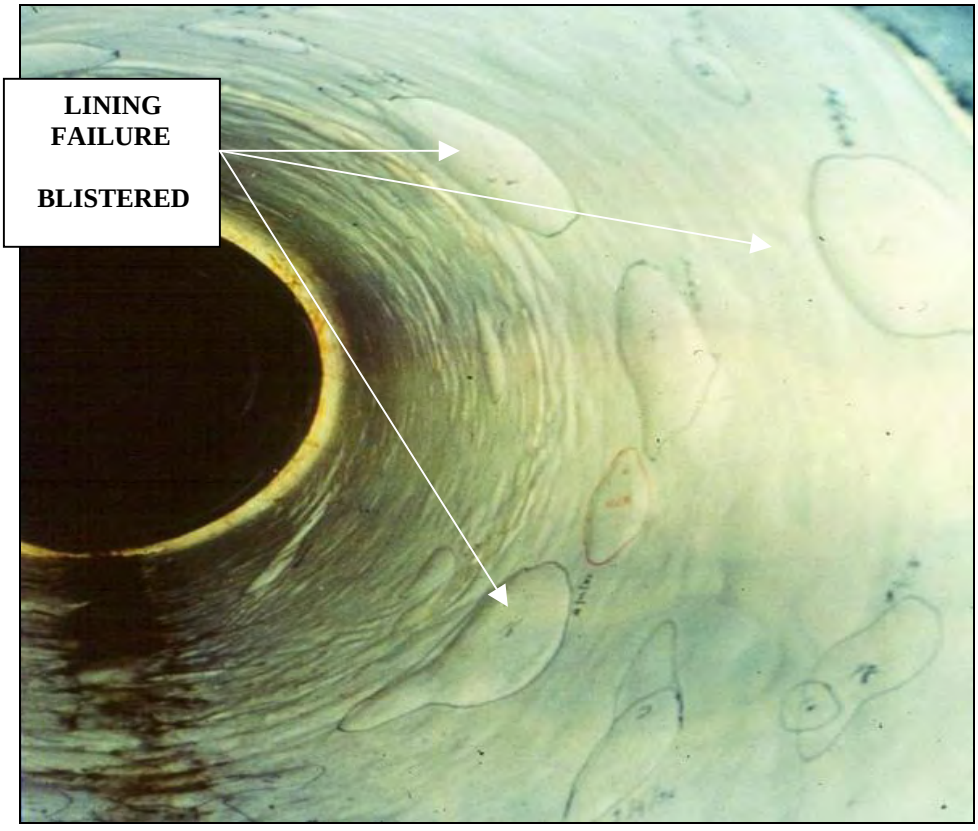
1) Detached - Lining no longer attached to the host pipe
2) Hole - Hole in liner due to rip or material defect.
3) Blistered - Lining surface is not smooth, exhibiting a Blistered effect.
4) Wrinkled - Lining surface is not smooth, exhibiting a Wrinkled effect.

4.1.12 Lining Failure (in rehabilitated pipe) – Picture Examples



CT

Lining no longer formed to original cross surface
- Wrinkled (not smooth) Defective Surface



CT

Lining surface has been damaged (not smooth).

4.2 OPERATIONS AND MAINTENANCE TERMS

Operations and Maintenance Terms describe the presence of foreign objects found in storm sewers that may shorten service life or interfere with the flow and operation of the system.

The categories in Operations and Maintenance Terms include:

3.2.1 Deposits (Attached, Settled, Ingress)

3.2.2 Roots

3.2.3 Infiltration

3.2.4 Obstacles and Obstruction

3.2.5 Vermin

The CCTV operator should use these terms to describe similar defect observations during inspections of in-ground storm sewer systems.

4.2.1 Deposits (Attached, Ingress, Settled)

General Description

Materials that have accumulated within a pipe or have accumulated over time at specific points. Deposits may or may not block hydraulic capacity.

Details

Attached - The formation of materials attached to the pipe walls by accumulative mechanisms, often found at points of inleakage (mineral deposits) or carried by flowing water surfaces along a pipe (grease deposits).

Settled -finer debris usually distributed evenly across and throughout the pipe length at flatter grades.

Ingress - The accumulation of chunky debris washed into the sewer from the surrounding ground, usually concentrated at faulty joints or broken pipes.

Secondary Details include:

1) Light - Accumulated materials block less than 20% of pipe diameter.

2) Moderate - Accumulated materials block 20% to 40% of pipe diameter.

3) Major - Accumulated materials block more than 40% of pipe diameter.

4.2.1 Deposits (Mineral) – Picture Examples

CT

Accumulated materials block less than 40% of pipe diameter.

Accumulated materials blocking 20-40% of pipe diameter.

4.2.2 Roots

General Description

Invasive plant access to storm sewer

Details

1) Light - Root growth obvious, but not blocking free flow through pipe.
2) Medium - Root growth less than 50% of pipe.
3) Heavy - Root growth more than 50% of pipe.
4) Severe - Root growth completely blocks free flow through pipe.

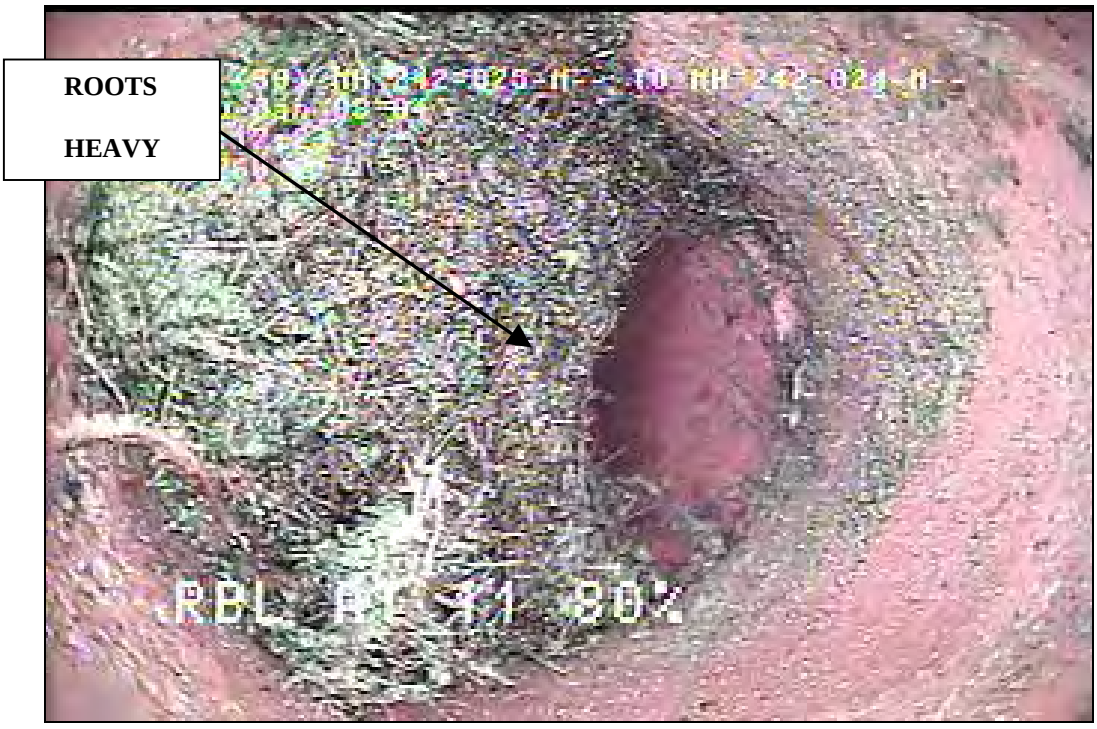
4.2.2 Roots - Picture Examples

Light root encroachment into pipe.

4.2.2 Roots - Picture Examples

CT

Root growth less than 50% of pipe.



Root growth more than 50% of pipe

4.2.3 Infiltration

General Description

The leakage of groundwater through a pipe defect. This term typically is used with other terms, such as crack or fracture, where leakage is apparent. Indication of leakage may be inactive or active, depending on the groundwater table.

Details

INACTIVE

Wall Stain -Past leak evidenced by stain on wall.

Mineral Deposit -Past leak evidenced by solids deposit on wall.

ACTIVE

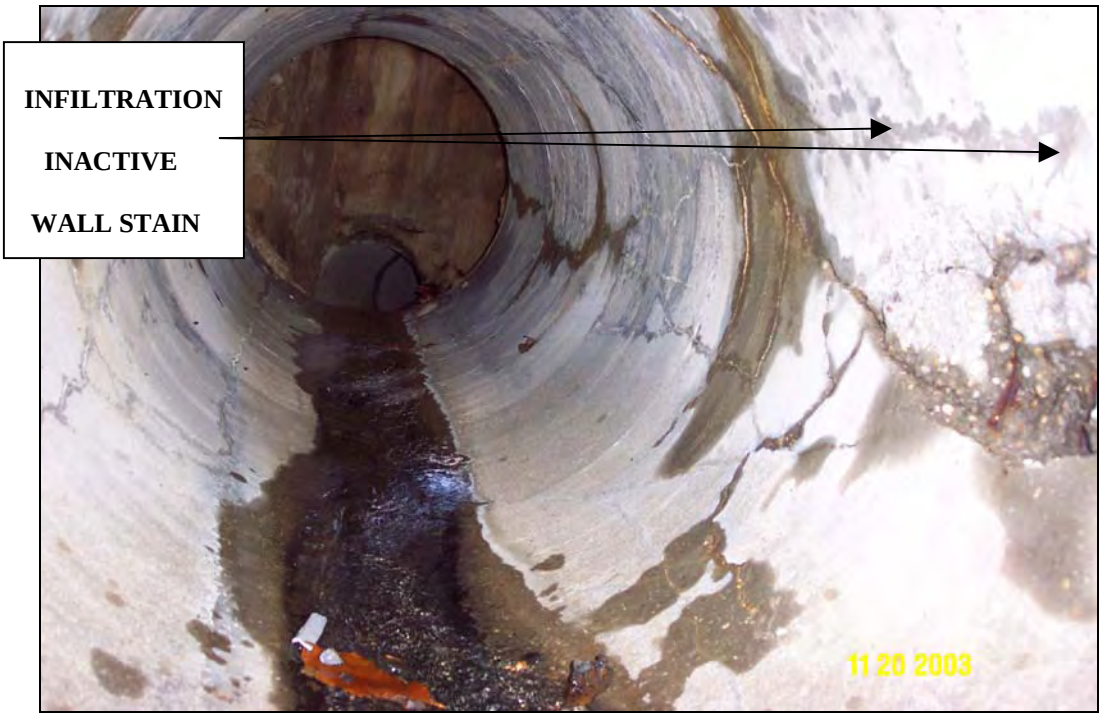
Weeper - Pipe wall damp or wet from slow leakage.

Drip - Free falling water droplets observed.

Runner - Continuous but low volume water stream observed entering pipe through a defect.

Gusher - Significant water flow entering a pipe through a defect. A severe active leak.

4.2.3 Infiltration – Inactive - Picture Examples

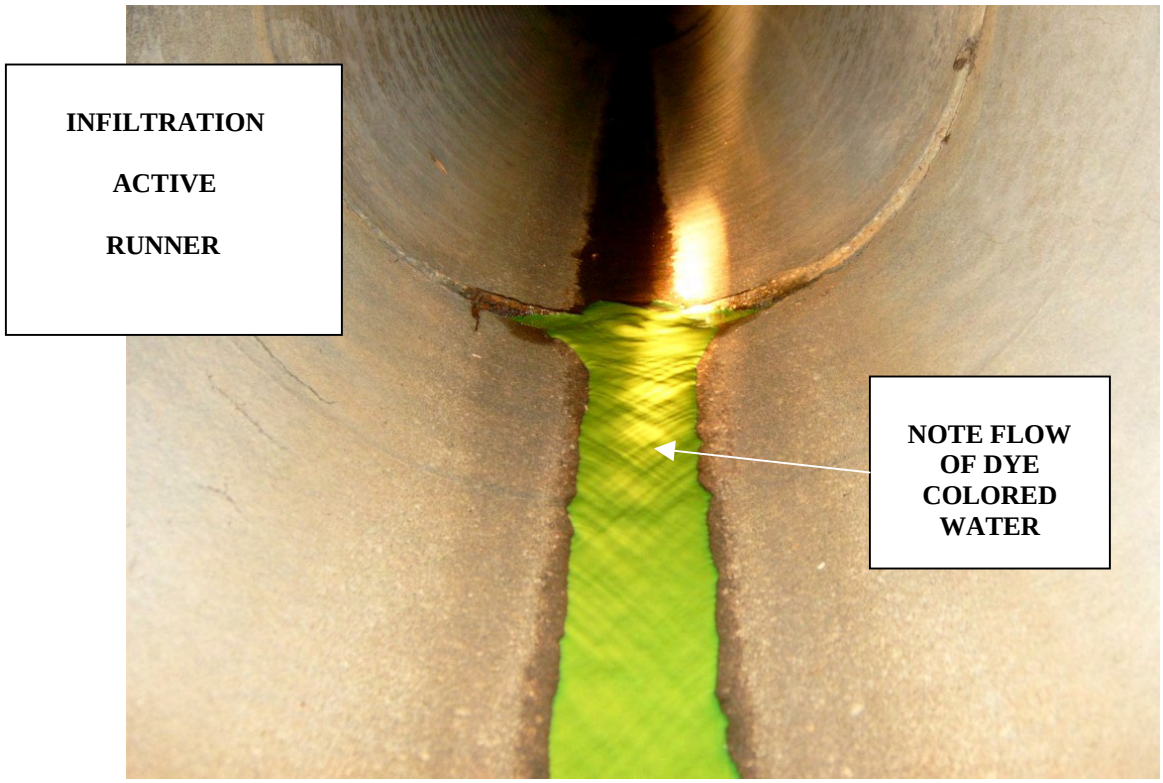


Past leak evidenced by stain on wall.

4.2.3 Infiltration – Active - Picture Examples

Weeping water infiltration into pipe.

4.2.3 Infiltration – Active - Picture Examples



Running water infiltration

Gushing water infiltration.

4.2.4 Obstacles and Obstructions

General Description

Obstacles and obstructions block hydraulic capacity. They may be constructed features or large debris that has accumulated at a single location or over a short length of pipe. Examples may include bricks, large stones, posts, logs, other utility pipes or cable lines inserted into and/or running side-to-side across pipe or longitudinally within the pipe.

Details

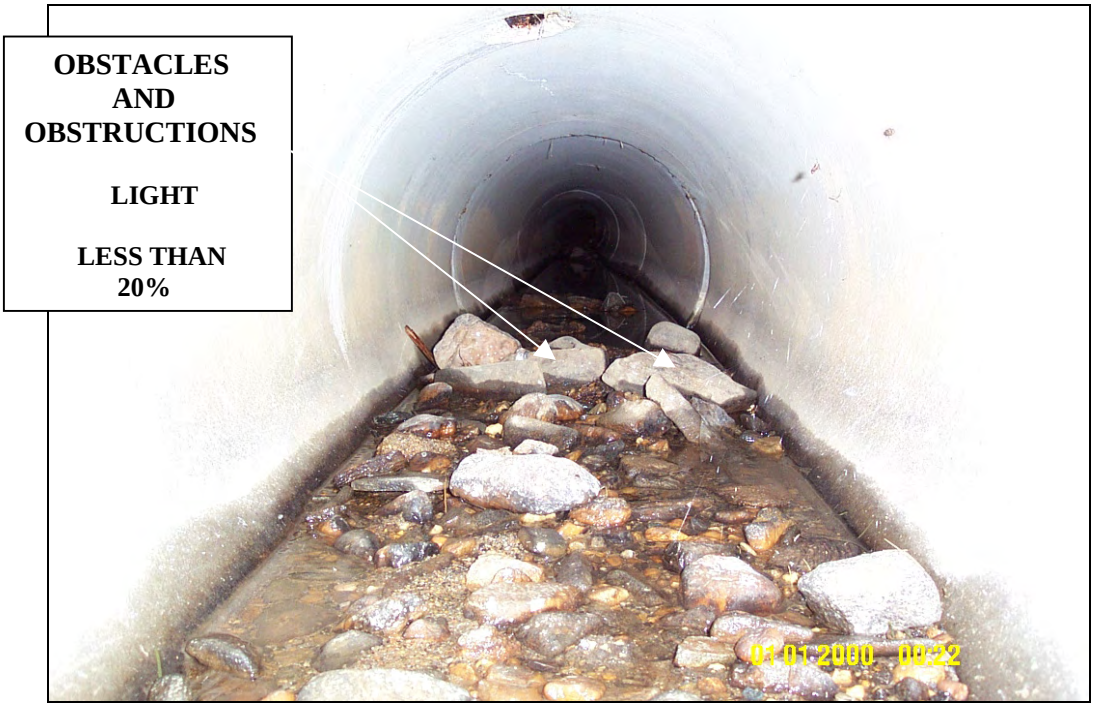
Light - Less than 20% obstructed

Moderate - 20% to 40% obstructed

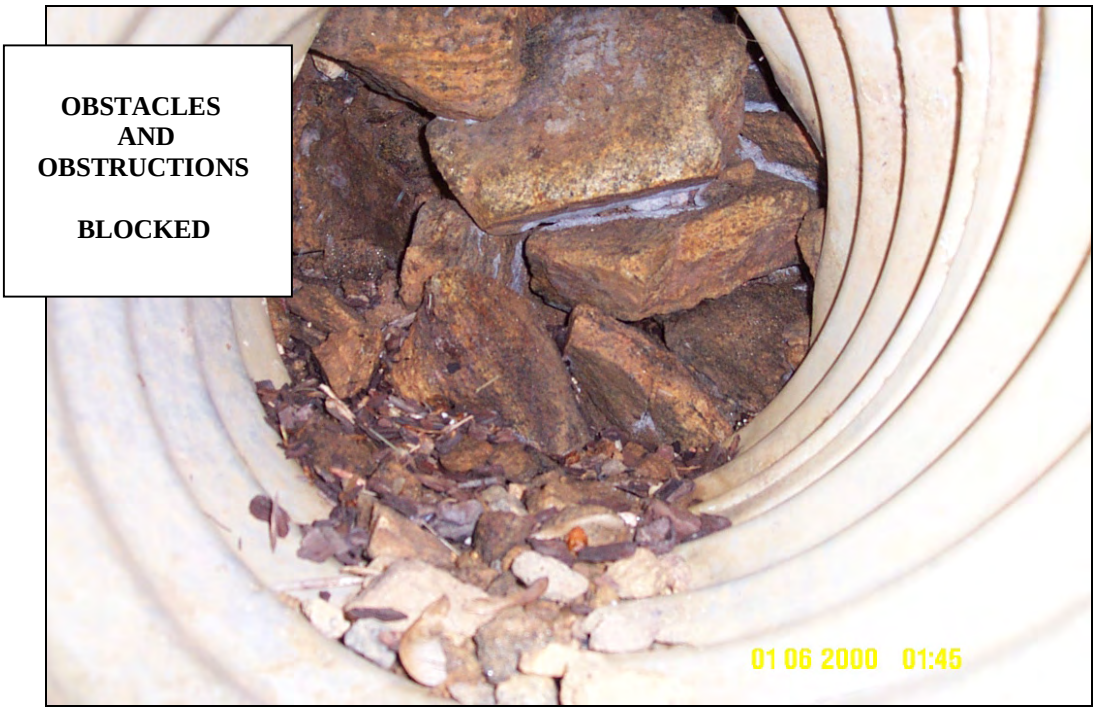
Heavy - Greater than 40% obstructed

Blockage - Completely obstructed

4.2.4 Obstacles and Obstructions – Picture Examples

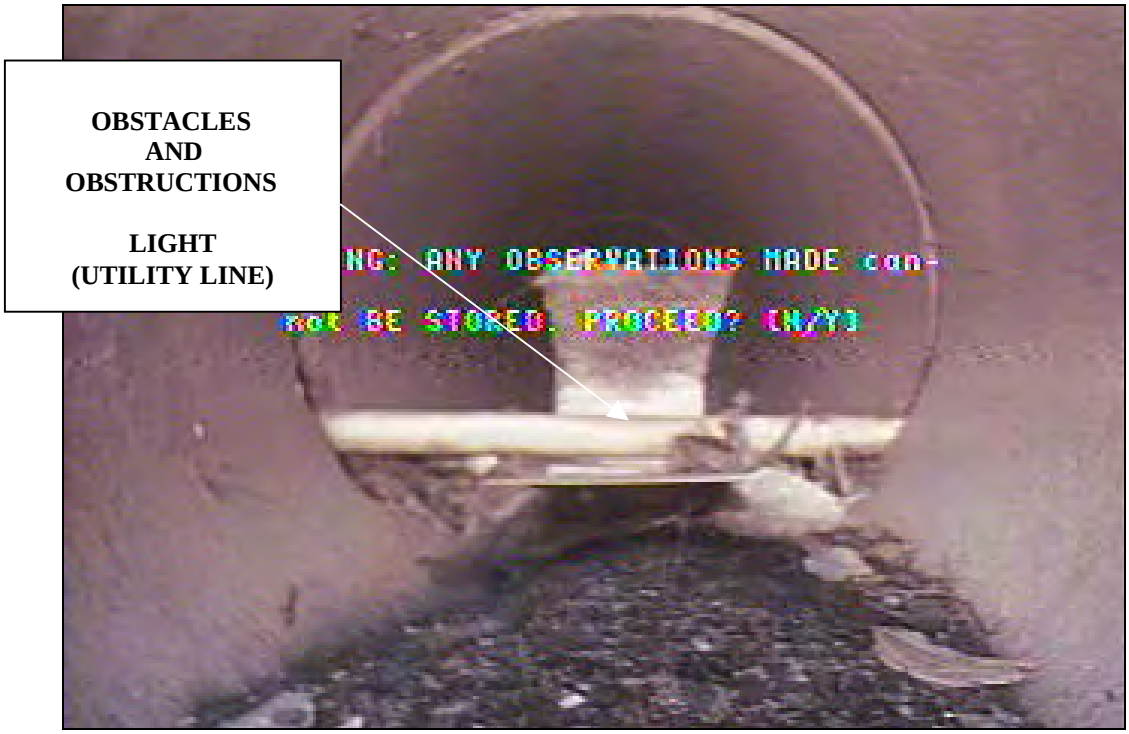


Debris –Obstacles lightly blocking hydraulic capacity.

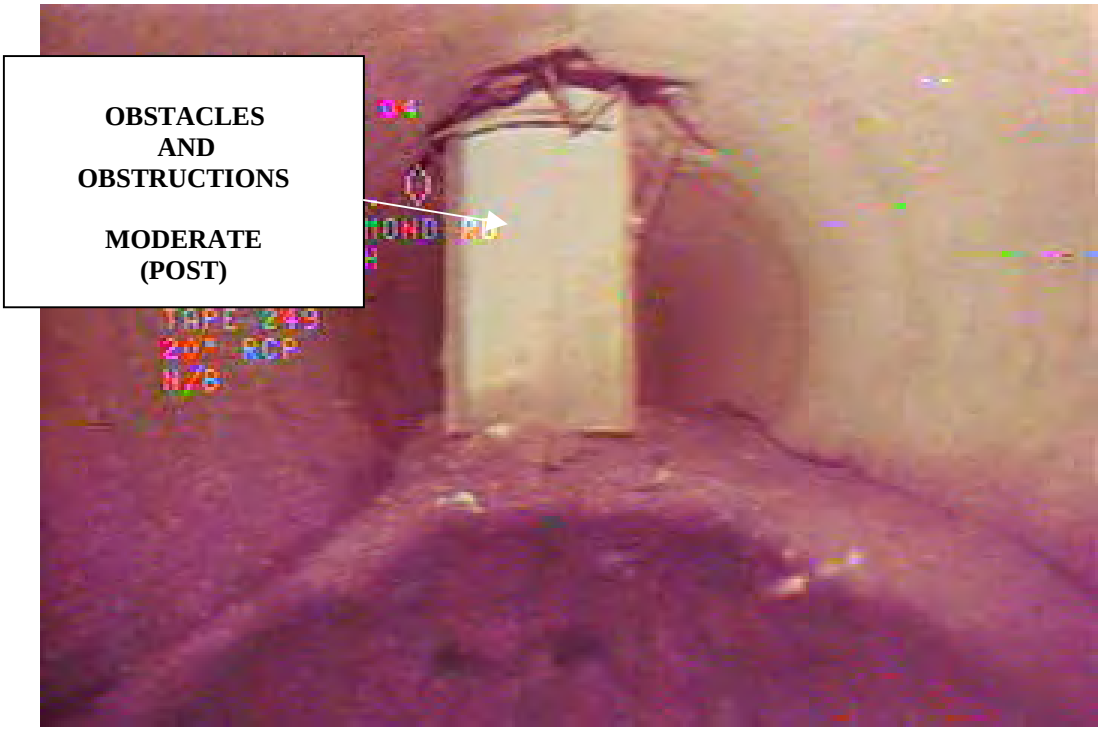


Completely blocked CPP

4.2.4 Obstacles and Obstructions – Picture Examples



Obstruction blocking hydraulic capacity – Utility Pipe



Obstruction blocking hydraulic capacity – Guardrail Post

4.2.5 Vermin

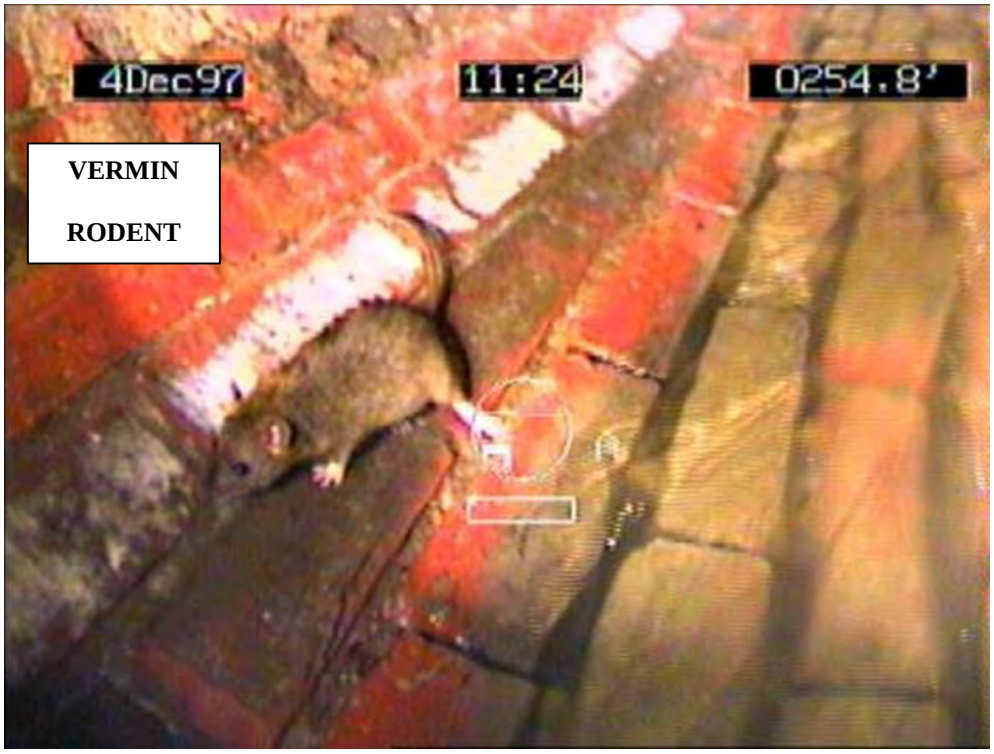
General Description

Animal access and/or use of pipe

Details

None

3.2.5 Vermin – Picture Examples



CT

Vermin (Rodent) in pipe

Vermin (Raccoon) in pipe

4.3 CONSTRUCTION FEATURE TERMS

Construction feature terms describe the presence of conditions generally created during storm sewer construction. Some conditions are not significant concerns and are simply the nature of the system resulting from construction requirements. However some conditions may shorten service life or interfere with the flow and operation of the system. Any condition found in a storm sewer system that is different from the quality expectations of a newly installed system should be reported.

The categories in Construction Feature Terms include:

- 4.3.1 Taps
- 4.3.2 Intruding Seal Material
- 4.3.3 Misalignment
- 4.3.4 Slope Change
- 4.3.5 Material Change
- 4.3.6 Point of Access

The CCTV operator should use these terms to describe similar conditions observed during inspections of in-ground storm sewer systems.

4.3.1 Taps

General Description

Secondary pipe connection between storm sewer pipe structures that is made during construction or as a retrofit.

Details

"Special Fitting" - A manufactured pipe connection, not at a structure, that is installed during construction or as a retrofit.

"Hammer" - Pipe connection made after initial construction by breaking into existing pipe and inserting pipe with no special fitting.

4.3.1 Taps – Picture Example

Tap - Break-in/"Hammer Tap"

4.3.2 Intruding Seal Material

General Description

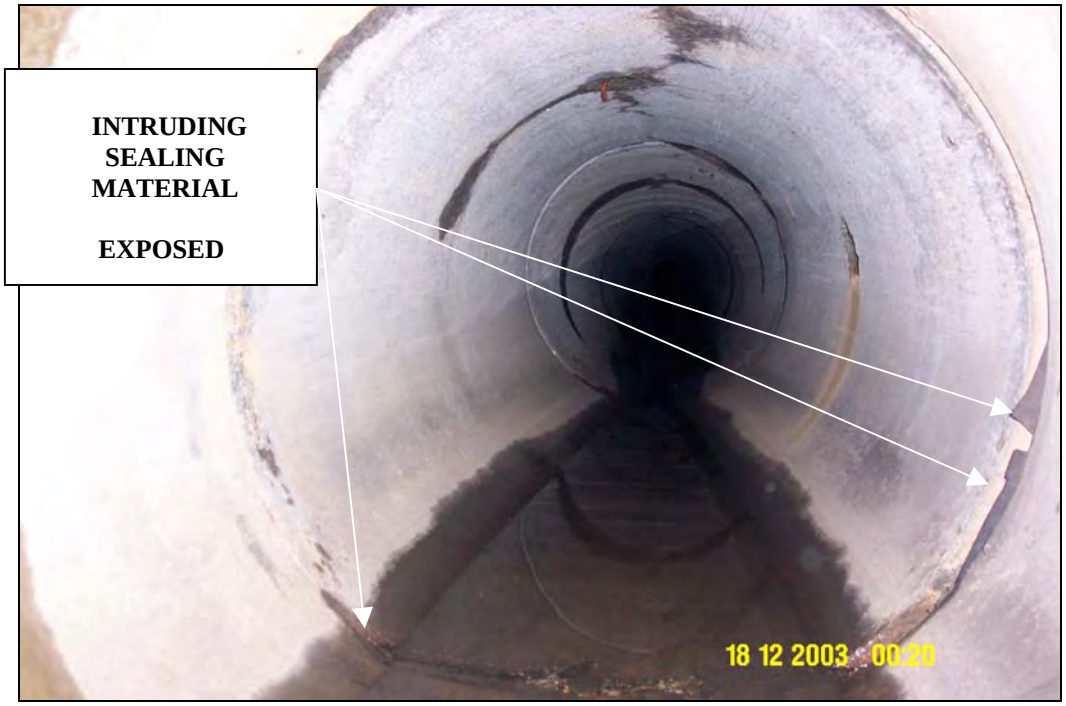
Construction seal material from pipe joints protrudes into pipe.

Details

Exposed - Seal material protrudes into pipe slightly.

Hanging - Seal material is free hanging in pipe.

4.3.2 Intruding Seal Material – Picture Examples



Pipe joint seal protruding

Joint seal material hanging inside pipe

4.3.3. Misalignment

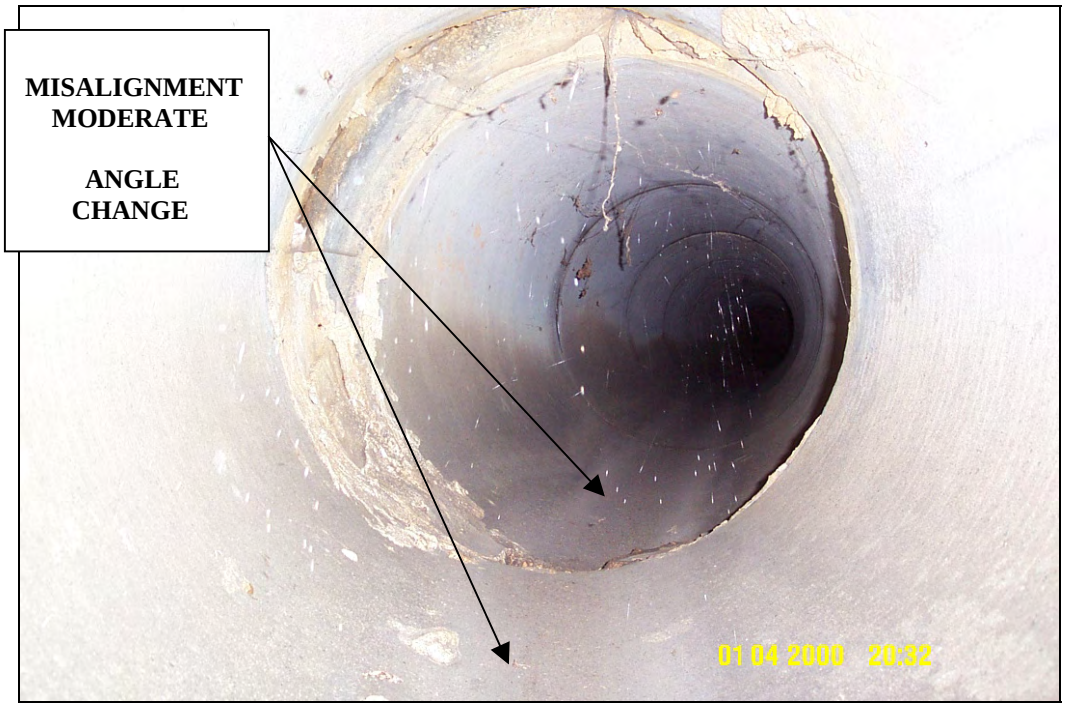
General Description

Pipes constructed together at different angles potentially causing a gap on one side.

Details

None - Describe as necessary.

4.3.3 Misalignment - Picture Examples



Pipes come together at different angles causing gap on one side.

Pipe changes direction at a joint causing gap on side(s).

4.3.4. Slope Change

General Description

Connected pipe sections shows vertical change in elevation up or down.

Details

None - Describe as necessary.

4.3.4 Slope Change – Picture Examples

Connected pipe sections change elevation up or down.

4.3.5 Material Change

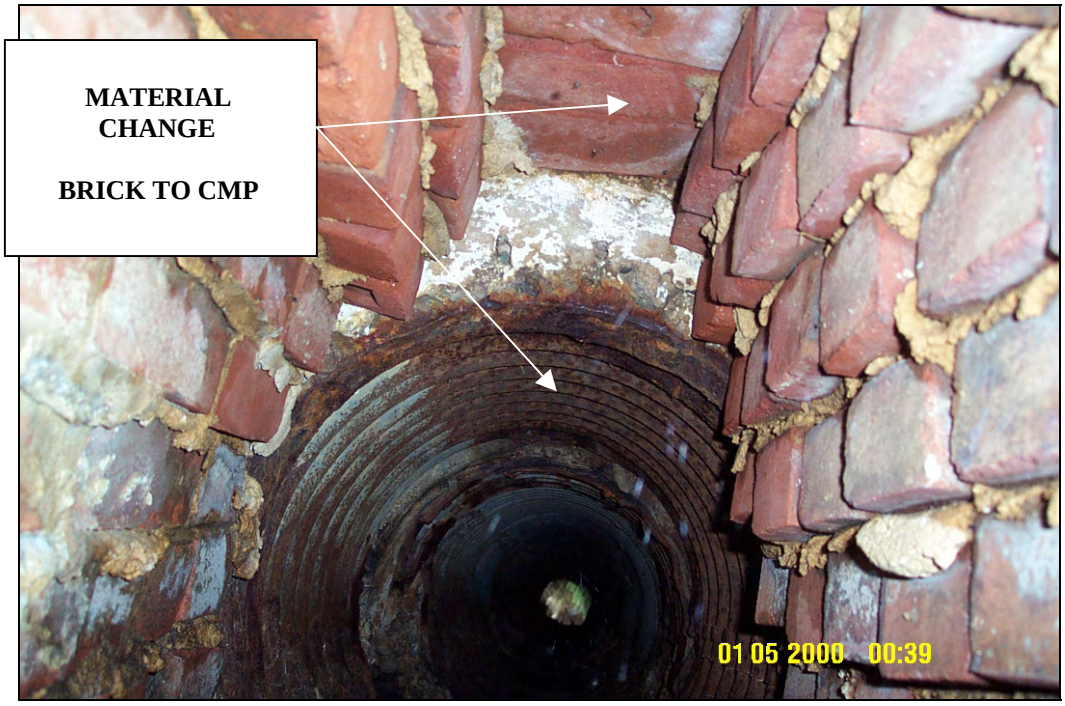
General Description

Materials of construction changes from one material to another material.

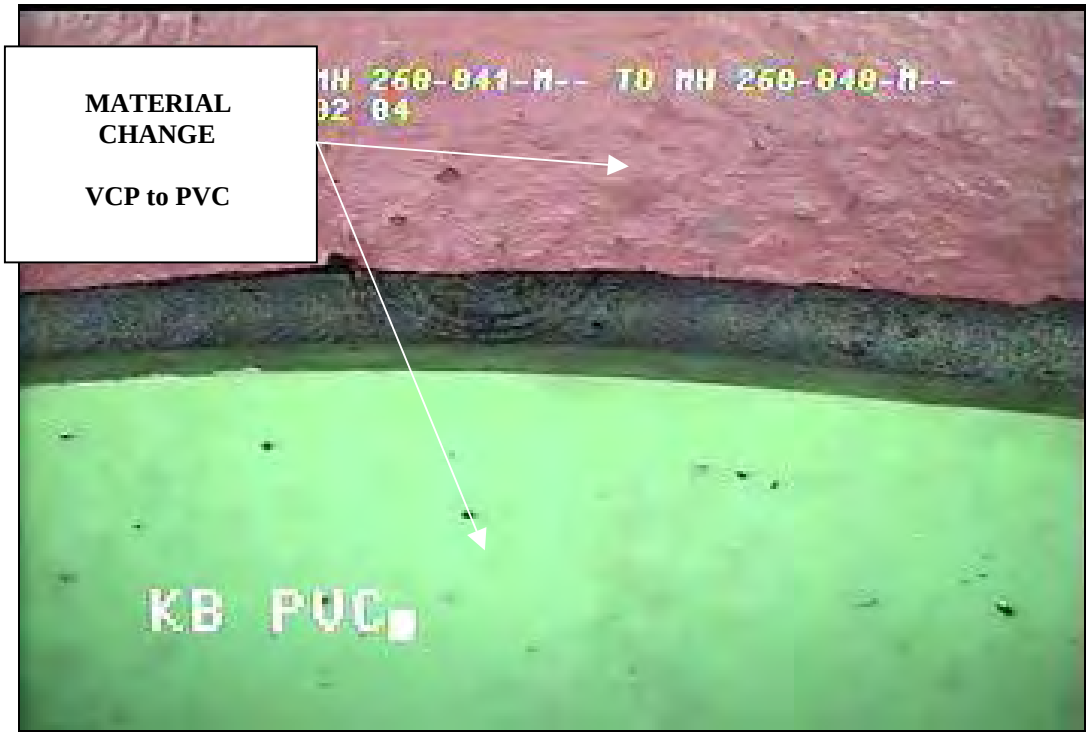
Details

None - Describe as necessary.

4.3.5 Material Change – Picture Examples



Material Change from Brick to CMP



Material Change from Clay to PVC Pipe

4.3.6 Point of Access

General Description

Constructed (manhole, surface grate, or other) means of access to storm sewer system.

Details

Manhole

Drainage Inlet (Catch Basin)

Types:

- Single grate
- Double grate
- Lawn
- Curb Opening
- Parkway
- Safety End Structure

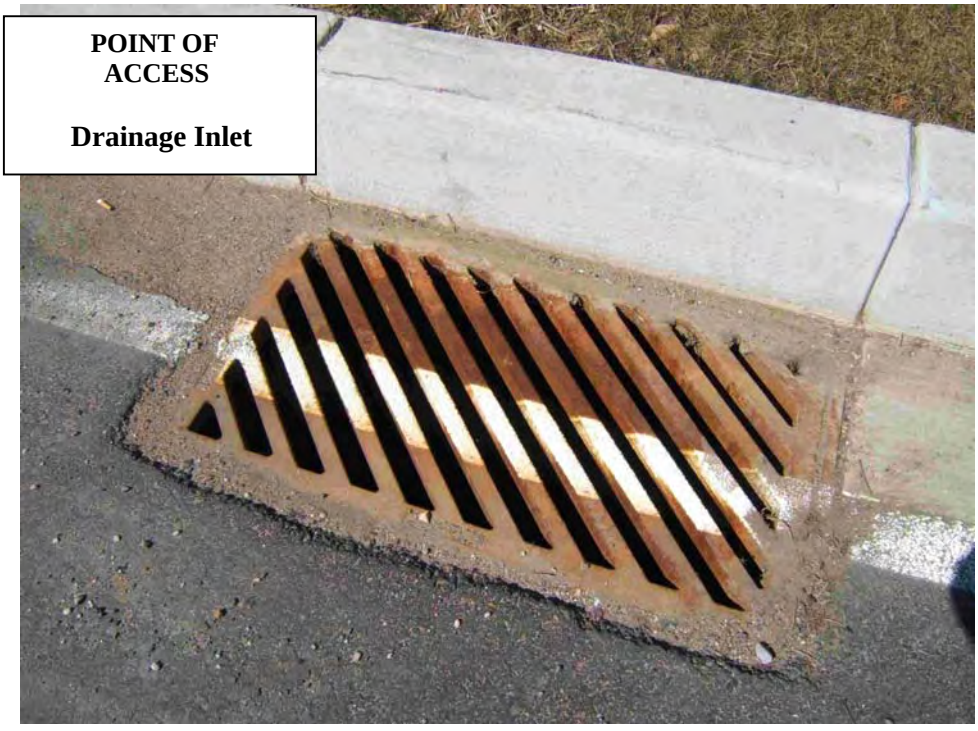
Open Ends

Types:

- Inlet
- Outlet

4.3.6 Point of Access - Picture Examples

Manhole access to storm sewer system.



Single Grate Drainage Inlet.

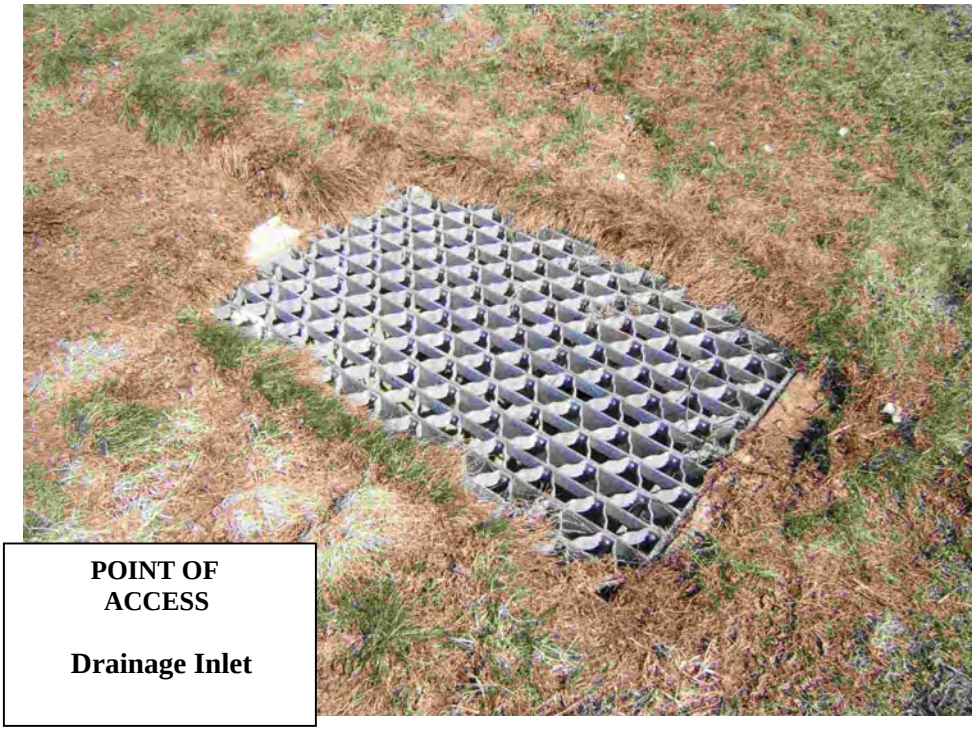
4.3.6 Point of Access – Picture Examples (Continued)

Double Grate Drainage Inlet.

Lawn Drainage Inlet.

4.3.6 Point of Access – Picture Examples (Continued)

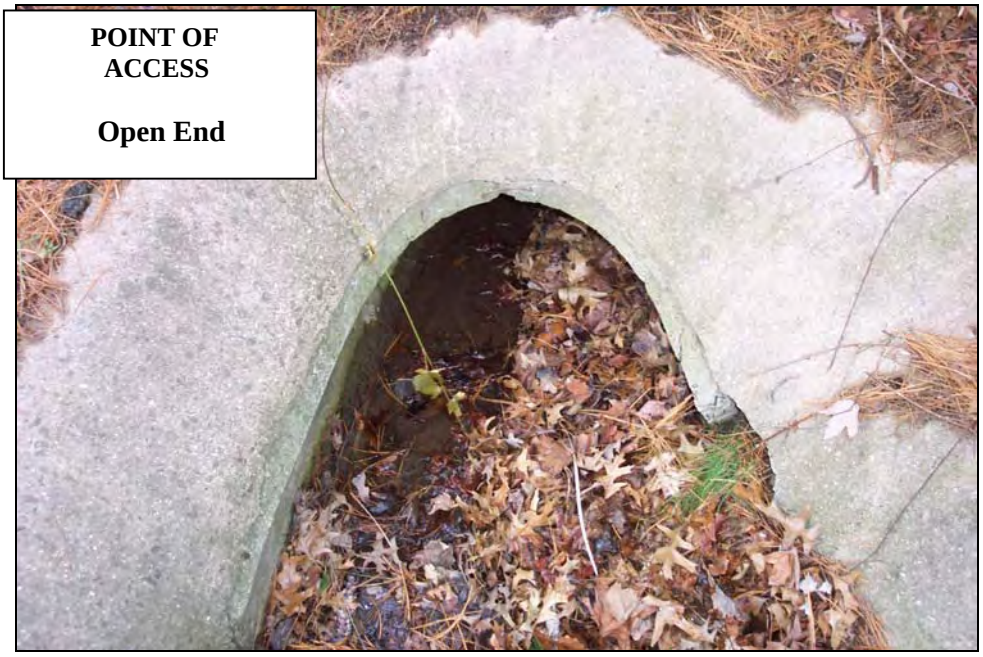
Curb Opening Drainage Inlet.



Parkway Drainage Inlet.

4.3.6 Point of Access – Picture Examples (Continued)

Safety End Drainage Structure.



Open End Pipes - Inlet /Outlet

4.4 SUMMARY LIST - DEFECT TERMS AND DETAILS*

4.1 STRUCTURAL DEFECT TERMS

Section	Term	Detail
4.1.1	Cracks	Circumferential, Longitudinal, Spiral, Multiple
4.1.2	Fractures	Circumferential, Longitudinal, Spiral, Multiple
4.1.3	Broken	None
4.1.4	Hole	None
4.1.5	Deformed	Minor: 0-20% change, Severe: 20-40% change.
4.1.6	Collapsed	Pipe, or Manhole, Drainage Inlet, Junction Box Wall.
4.1.7	Joint	Open or Offset w/ Severity of Moderate or Severe
4.1.8	Surface Damage	Roughness Increased, Aggregate Visible Aggregate Projecting, Aggregate Missing, Reinforcement Visible, Reinforcement Projecting, Reinforcement Corrosion, Corrosion
4.1.9	Weld Failure	Plastic Pipe, Metal Pipe Circumferential, Longitudinal, Spiral, Multiple
4.1.10	Point Repair	Patched, Localized Liner, Replaced
4.1.11	Masonry (Brick)	Displaced, Missing, Missing Mortar, Missing Grout
4.1.12	Lining Failure	Detached, Hole, Blistered, Wrinkled

4.2. OPERATIONS AND MAINTENANCE TERMS

4.2.1	Deposits	Attached, Settled, Ingress, w/ 2nd Pipe Blockage Details of: Light <20%, Moderate 20% to 40%, Major>40%
4.2.2	Roots	w/ 2nd Pipe Blockage Details of: Light, Medium (<50%), Heavy (>50%), Severe (Complete)
4.2.3	Infiltration	INACTIVE - w/Wall Stain, Mineral Deposit ACTIVE - w/Weeper, Drip, Runner, Gusher
4.2.4	Obstacles and Obstructions	Light (<20%), Moderate (20% to 40%), Heavy (>40%), Blocked (80 to 100%).
4.2.5	Vermin	None – Describe as necessary

4.3 CONSTRUCTION FEATURES

4.3.1	Taps	"Special Fitting" or "Hammer"
4.3.2	Intruding Seals	Exposed, Hanging
4.3.3	Misalignment	None – Describe as necessary
4.3.4	Slope Change	None – Describe as necessary
4.3.5	Material Change	None – Describe as necessary
4.3.6	Points of Access	Manhole, Open Ends w/ Inlet or Outlet, Drainage Inlet (Catch Basin) w/ Types=Single grate, Double grate, Lawn, Curb Opening, Parkway, Safety End Structure, Open

* The above terms are modified for storm sewer application from NASSCO Pipe Assessment and Certification Program (PACP).

SECTION 5 - PIPE JOINT ACCEPTANCE CRITERIA

5.0 Introduction

When conducting a CCTV inspection of newly constructed storm sewer pipes, it is necessary to determine if pipe joints are less than or greater than manufacturer's tolerances specified to maintain a watertight joint. DelDOT expects that all pipe installed in the field will be installed per manufacturer requirements and will be "pushed home" to minimize open joints.

The following acceptable pipe gap tables were developed based upon research and coordination with technical experts from pipe manufacturers, consultants, and DelDOT representatives. The allowable gap distances listed below are the maximum joint separations acceptable to maintain a water tight joint.

The information presented in these tables is based upon various joint designs as of the date of publication of this Manual. Subsequent changes in joint design by manufacturers may necessitate revisions to these charts.

5.1 HIGH DENSITY POLYETHYLENE PIPE (HDPE)

1. **ADS - N-12 Watertight Pipe**

Pipe Diameter (in.)	Allowable Gap for N-12 Watertight Pipe (in.)
12	2
15	2
18	2
24	1 1/4
30	3
36	1 5/8
42	1 1/2
48	2
60	2 1/8

2. Lane Enterprises – Watertight Pipe

Pipe Diameter (in.)	Allowable Gap for Watertight Pipe (in.)
6	1/2
8	5/8
10	7/8
12	1/4
15	1/2
18	3/4
24	1/2
30	1
36	1
42	1 3/4
48	1 5/8

3. **Hancor – Blue Seal Watertight Pipe**

Pipe Diameter (in.)	Allowable Gap for Blue Seal Watertight Pipe (in.)
10	3/4
12	3/4
15	1 1/4
18	1 1/2
24	1 1/2
39	1 3/4
36	1 3/4
42	2 1/4
48	2 1/4
54	2 1/4
60	2 3/4

5.2 CIRCULAR RIENFORCED CONCRETE PIPE (RCP)

1. Rinker – Hydro Conduit

Pipe Diameter (in.)	Allowable Gap for RCP with Tylox Super Seal 200 at Joints (in.)
12-36	3/4
42	1 1/4
48	1 1/4
54	1 7/8
60	1 3/4
72	1 5/8

5.3 ELIPTICAL RIENFORCED CONCRETE PIPE (RCP)

1. Rinker – Hydro Conduit

Pipe Diameter (in.)	Allowable Gap for RCP with Tylox Super Seal 200 at Joints (in.)
14x23	3/4
19x30	3/4

5.4 CORRUGATED METAL PIPE (CMP)

NOTE: Corrugated Metal Pipe (CMP) manufacturers contacted were not able to provide an allowable gap due to the variations of pipe configuration in field applications. Allowable gap shown below for CMP is DelDOT's allowable gap.

Pipe Diameter (in.)	Allowable Gap for CMP with Rubber Gasket under Collar (Band)
6" to 24"	1 1/2 "
30" and larger	3"

5.5 RIGID POLYVINYL CHLORIDE (PVC)

SDR 35 only

1. DelDOT Allowable Gap

Pipe Diameter (in.)	Allowable Gap for PVC with
Any	1/2 "

SECTION 6 - STORM SEWER REPAIR TECHNIQUES

6.0 INTRODUCTION

This section deals with repairs to the defects observed with Closed Circuit Television inspection.

Once defects have been identified, the Developer/Contractor shall submit a repair method to the Engineer for review and approval. Work to repair defects shall not begin until the Developer/Contractor receives approval from the Engineer. The Developer/Contractor shall be responsible to make repairs satisfactory to the Engineer and will be responsible to have the repaired storm sewer reinspected by Closed Circuit Television to verify the repairs have been completed per the approved submittal.

The repair to defects in new storm sewer pipe will generally involve open cut excavation to replace/repair the damaged sections of pipe. On a case by case basis, the Engineer will consider trenchless technologies to repair defects.

6.1 REPLACE/REPAIR

Using location footage determined from CCTV inspection, access to the defect is gained by surface cut. Defect is either replaced or repaired. Pipe bedding, surrounding soils, and surface are restored to appropriate standards as specified.

6.2 TRENCHLESS TECHNIQUES

The following is a list of trenchless repair techniques the Engineer may consider once defects have been identified. Please note that this section is meant as a general guide only and is not all-inclusive. Anybody wishing to undertake trenchless repairs of defects shall consult appropriate technical personnel to determine the best method and procedures to be followed. The choice of technique will depend on the nature of the defect. It is possible that different repair techniques may be required in the same pipe segment.

6.2.1 Chemical Grouting

A cylindrical packer with inflatable rubber end elements is inserted into the pipeline and positioned across a joint via CCTV. The rubber end elements are inflated to isolate the joint. Chemical grout is forced through open joints, lift holes and cracks or fractures and into the surrounding soil where it solidifies with the soil to form a waterproof mass, which cannot be pushed back into the storm sewer system. This water-tight collar adheres to the outer surface of the pipe or structure where it will stay indefinitely unless removed by excavation or exposed to sunlight for long periods of time. If groundwater pressures increase, the collar will be pressed more tightly against the structure, increasing its ability to stop leaks. Although an effective cure, there is a risk of pollution since the chemicals are not inert. There are many types of chemical grout available including urethane, acrylamide, epoxy, cementitious grouts, etc.

Chemical Grouting cannot be used to repair structural defects in the storm sewer piping.

6.2.2 Cured-in-Place Lining

Cured-in-place pipe (CIPP) is the generic term used to describe the class of pipe lining techniques whereby a pipe lining is directly cast against the wall of an existing host pipe. A thermosetting resin

is impregnated at ambient temperature into a flexible (commonly polyester felt) tube with a cross sectional perimeter equal to the inner circumference of the host pipe. The tube is then pressure inverted against the wall of the host pipe from a suitable access point, and heated in-situ (using water, steam or air) to cure the resin, thus forming a structurally competent lining. Entire pipe runs can be rehabilitated or short segments of pipe can be repaired. This process results in a seamless, jointless "pipe-within-a-pipe" with a smooth, continuous inner surface which usually increases flow capacity.

6.2.3 Fold-N-Form Pipe

This process makes use of thermoplastic pipe that is folded or deformed to decrease its cross sectional area. The deformed pipe is transported to the project and pulled through the host pipe. The liner is then expanded and rounded to conform to the existing shape and size of the host pipe with pressure and heat. This process also results in a seamless, jointless "pipe-within-a-pipe" with a smooth, continuous inner surface. The process results in a minor loss of capacity and can only be used in pipe up to 18” in diameter.

6.2.4 Slip Lining

A trenchless method of installing new pipe and service inside existing pipe. The process involves pulling a new liner pipe into the existing pipe with a winch cable inserted through the existing pipe line and then attached to the front of the new liner. The new liner pipe is then pulled into the existing pipe, and the new liner pipe reconnected to the system. If necessary, the void between the new and old pipes can be filled by grouting.

The liner is structurally sound and solves problems related to leakage and structural deterioration. However, this technique results in a reduction of the inside diameter of the rehabilitated pipe.

6.2.5 Pipe Bursting

In the pipe bursting process, a new polyethylene pipe is pulled through an old pipeline of equal or smaller size. The old pipeline is shattered as the new pipe is pulled through, with the pieces displaced into the surrounding soil. The process is an effective technique to maintain or upsize the existing pipe. The process can fail if there are obstructions surrounding the pipe. Care must also be taken to avoid damage to surrounding structures. This cannot be used for some pipe materials.

6.2.6 Spiral Winding

A technique in which a ribbed plastic strip is spirally wound by a winding machine to form a liner which is inserted into a defective pipeline. The annular space may be grouted or the spiral liner expanded to reduce the annulus and form a Close-Fit liner. In larger diameters, the strips are sometimes formed into panels and installed by hand. Grouting the annular space after installation is recommended.

6.2.7 Man Entry Techniques

There are numerous man entry repair procedures that can be utilized in large pipe such as pointing with repair mortars, the application of special coatings and the installation of hard pipe repair segments.

TABLE 6.1

GENERAL GUIDELINES FOR TRENCHLESS PIPE REHABILITATION

Defect	Rehabilitation Method	Description
Roots	Cleaning plus chemical root treatment	Techniques to remove roots depend on pipe size and amount of roots and include pressure cleaning, cutting and rodding
Debris	Cleaning	Techniques depend on pipe size and amount of debris in pipe and include pressure cleaning, bucketing and man entry
Open joints	Sealing	Techniques used include chemical grout, pipe liners and man entry in large pipe
Offset joint	Sealing	Various pipe liners or man entry in larger pipes
Intruding seal material	Seal the joint, cut and remove the seal	Techniques used include chemical grout, pipe liners and man entry in large pipe
Circumferential cracks and fractures	Sealing	Techniques used include chemical grout, pipe liners and man entry in large pipe
Longitudinal cracks and fractures	Sealing	Techniques include pipe lining by various methods, man entry for large pipes
Multiple cracks and fractures	Sealing	Techniques include pipe lining by various methods, man entry for large pipes
Broken Pipe Moderate	Point repair	Techniques include pipe lining by various methods, man entry for large pipes
Broken Pipe Severe	Point repair	Techniques include pipe lining by various methods, pipe bursting and man entry for large pipes
Collapsed Pipe	Point repair	Excavation, pipe bursting
Corrosion / Surface Damage	Sealing / Repair	Techniques include pipe lining by various methods, spray lining and man entry for large pipes.
Misalignment	Lining	Techniques include pipe lining by various methods, and man entry for large pipes
Lining failure	Replace the pipe, liner	Techniques include excavation, pipe bursting and man entry for larger pipes
Weld failure	Point repair	Techniques used include chemical grout, pipe liners and man entry in large pipe
Deformed minor	Lining	Techniques include pipe lining by various methods, and man entry for large pipes
Deformed severe	Replacement	Cut and cover, pipe bursting
Vermin	Cleaning	

SECTION 7 - CCTV EQUIPMENT CALIBRATION PROCEDURE FOR STORM SEWER DEFECT MEASUREMENT

7.0 PURPOSE

The purpose of this CCTV equipment calibration procedure is to provide a standardized method for determining the size in inches of pipe defects observed during CCTV inspection of storm sewer pipe systems.

7.1 PROCEDURE OVERVIEW

In order to calibrate CCTV equipment to determine in-pipe defect size measurements, a CCTV camera is inserted into a sample pipe and focused at four standard one inch markings on a measuring device (the target, yardstick or measuring tape) held flat around the sample pipe inside circumference. The in-pipe target is to be viewed with the camera at a perpendicular angle to the target and the camera at zero zoom. The resulting scale dimension will be recorded. Critical equipment physical characterizations are also recorded by the operator to be repeated on field application of the same equipment.

The scale measurements on the monitor screen of the standard one inch being viewed in the pipe by the camera will be used to determine the size of defects, pipe joints or cracks, found in the pipe during CCTV inspection of installed pipe. This dimension can be compared to the allowable gap for pipe joints as noted in Section 5 of this manual.

7.2 CALIBRATION EQUIPMENT/CONDITIONS

Standard CCTV equipment will be used for in-pipe inspections.

For cameras with zoom lens capability, calibration and in-pipe measurement are to be taken at zero zoom.

7.3 PROCEDURE

Place the CCTV camera in the SAMPLE PIPE until it is resting in normal inspection position.

Measure SAMPLE PIPE diameter and record.

Hold an IN-PIPE MEASUREMENT DEVICE, yardstick or measuring tape at the 3:00, 6:00, 9:00 and 12:00 clockwise positions, aligning the camera focus to be perpendicular to the target.

> NOTE: If excessive outside light enters the sample pipe and washes out the camera viewing capacity, cover the open pipe end with a tarp as necessary. Adjust camera lighting as necessary for best resolution.

Camera lens must be perpendicular to pipe. Tire size or camera height adjustment shall position camera as close as possible to the center of the pipe. Tire size or camera height, if adjustable, should be recorded on screen. It is imperative that the reviewer knows what size tires are used for each size pipe being videoed.

The contractor has the option of performing this calibration at each inspection for each size pipe being inspected or performs this calibration in advance on sample pipes of various size and

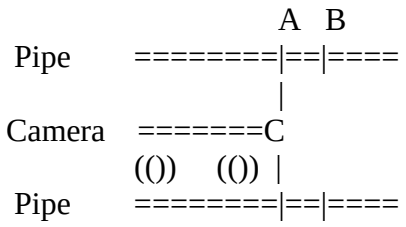
material. If sample pipes are used then this recording can be included with the inspection video or supplied as a separate video.

The reviewer will then use a scale to record the dimension of the 1" rule at 3:00, 6:00, 9:00 and 12:00 clockwise positions on his computer or TV screen to accurately measure the joints gaps or cracks within the pipe.

There are sample charts for the operator or reviewer to record these scaled measurements at the end of this section.

TARGET DISTORTION

CAMERA VIEW ANGLE TO IN-PIPE TARGETS - The camera location along the pipe should be adjusted as necessary to provide a direct view of the target. Consistency of the in-pipe camera observation position to target is very important. Referring to the drawing below, the camera should make all observations to a target at position "A." Position "A" is the straight-on or perpendicular view of the camera at zero zoom. If the measurement is taken at "B," or any unreproducible camera angle, a distortion may result leading to inaccurate measurement of the target or defects in the pipe.



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SIZE CALIBRATION MEASUREMENT LOG

CCTV Monitor Screen Size of Standard 1inch (1 in.) inside a Pipe

This calibration chart records CCTV Monitor screen image size of a standard one inch (1 in.) target as viewed on a flat ruler or yard stick held inside the pipe at 12:00, 3:00, and 6:00 positions within the pipe with the camera lens at zero zoom to view the object for consistent internal measurment in various pipe sizes.

PROJECT/NUMBER: _____ **DATE OF CALIBRATION:** _____

PROJECT NAME: _____ **CONTRACTOR:** _____

CCTV EQUIPMENT INFORMATION

CCTV COMPANY/VEHICLE INFORMATION

COMPANY NAME: _____ **PHONE:** _____

OPERATOR NAME: _____ _____

CCTV VEHICLE #: _____ Vehicle Manufacturer: _____

Camera Manufacturer: _____ Camera Manufactuer Model #: _____

MONITOR INFORMATION

Diagonal Screen Size: _____ Full Screen Image: _____

If not full screen image, explain: _____

I assure that the following measurments are as accurate as possible using the camera and vehicle described above.

_____ _____

SIGNED (CCTV Operator) DATE OF CALIBRATION:

CALIBRATION RECORD

Tracking Indicator	PIPE Size/Type	PIPE Position	**MONITOR SIZE** (to 1/32 inch) of Standard 1" In Pipe	+/- Value	**EQUIPMENT COMMENTS:** Wheel Size/Type	Gantry/Riser Height
		12:00				
		3:00				
		6:00				
		9:00				
		12:00				
		3:00				
		6:00				
		9:00				
		12:00				
		3:00				
		6:00				
		9:00				
		12:00				
		3:00				
		6:00				
		9:00				

SIZE CALIBRATION MEASUREMENT LOG (EXAMPLE)

CCTV Monitor Screen Size of Standard 1inch (1 in.) inside a Pipe

This calibration chart records CCTV Monitor screen image size of a standard one inch (1 in.) target as viewed on a flat ruler or yard stick held inside the pipe at 12:00, 3:00, and 6:00 positions within the pipe with the camera lens at zero zoom to view the object for consistent internal measurment in various pipe sizes.

PROJECT/NUMBER: 222222 **DATE OF CALIBRATION:** April 19, 2006

PROJECT NAME: Near Done Estates **CONTRACTOR:** Built4U

CCTV EQUIPMENT INFORMATION

CCTV COMPANY/VEHICLE INFORMATION

COMPANY NAME: Video Contract Vendor **PHONE:**

OPERATOR NAME: John Smith

CCTV VEHICLE #: #10 Vehicle Manufacturer: YourWayCCTV

Camera Manufacturer: YourWayCCTV Camera Manufactuer Model #: YourWayCCTV-07734

MONITOR INFORMATION

Diagonal Screen Size: 18 inch Full Screen Image: (Yes) / No (Circle)

If not full screen image, explain:

I assure that the following measurments are as accurate as possible using the camera and vehicle described above.

SIGNED (CCTV Operator) April 19, 2006 DATE OF CALIBRATION:

CALIBRATION RECORD

Tracking Indicator	PIPE Size/Type	PIPE Position	**MONITOR SIZE** (to 1/32 inch) of Standard 1" In Pipe	+/- Value	**EQUIPMENT COMMENTS:** Wheel Size/Type	Gantry/Riser Height
12:10	12" RCP	12:00	2 1/2"	Approximately		
12:14	12" RCP	3:00	2 1/2"	Approximately		
12:15	12" RCP	6:00	**2 3/4"**	Approximately		
12:17	12" RCP	9:00	2 1/2"	Approximately		
12:44	15" RCP	12:00	1 1/4"			
12:46	15" RCP	3:00	1 3/4"			
12:49	15" RCP	6:00	**2 3/4"**			
12:17	15" RCP	9:00		Approximately		
11:57	18" RCP	12:00	5/8"			
12:00	18" RCP	3:00	1 1/4	+/- 1/32		
12:02	18" RCP	6:00	**3 3/16"**			
12:03	18" RCP	9:00	1 1/4"	Approximately		
		12:00				
		3:00				
		6:00				
		9:00				

IN-PIPE DEFECT MEASUREMENT RECORD

PAGE __1__ of ____

CCTV Monitor Screen Size of Installed Pipe Defects

This table records the CCTV Monitor screen size (to 1/32 inch) of pipe defects as viewed by the same CCTV camera/configuration as used to develop the calibration information used for comparison.

PROJECT/NUMBER: _____ **DATE OF INSPECTION:** _____

PROJECT NAME: _____ **CONTRACTOR:** _____

CCTV EQUIPMENT INFORMATION

CCTV COMPANY/VEHICLE INFORMATION

COMPANY NAME: _____ **PHONE:** _____

OPERATOR NAME: _____ _____

CCTV VEHICLE #: _____ Vehicle Manufacturer: _____

Camera Manufacturer: _____ Camera Manufactuer Model #: _____

MONITOR INFORMATION

Diagonal Screen Size: _____ Full Screen Image: Yes / No (Circle)

If not full screen image, explain: _____

I assure that the following measurments are as accurate as possible using the camera and vehicle described above.

_____ _____

SIGNED (CCTV Operator) DATE OF CALIBRATION:

CALIBRATION INFORMATION USED FOR COMPARISON

DATE OF CALIBRATION: **ATTACH CALIBRATION CHART TO THIS RECORD**

INSPECTION OBSERVATION RECORD

Tracking Indicator	PIPE **Size/Type**	PIPE **Position**	**MONITOR SIZE** (1/32 in.) of In-pipe Defect Image	+/- Value	**DEFECT COMMENTS**

IN-PIPE DEFECT MEASUREMENT RECORD

PAGE ___ of ____

CCTV Monitor Screen Size of Installed Pipe Defects

This table records the CCTV Monitor screen size (to 1/32 inch) of pipe defects as viewed by the same CCTV camera/configuration as used to develop the calibration information used for comparison.

PROJECT/SITE: ______________________ **DATE OF INSPECTION:** ______________________

SITE CONTACT: ______________________ **PHONE:** ______________________

CALIBRATION INFORMATION USED FOR COMPARISON

DATE OF CALIBRATION: **ATTACH CALIBRATION CHART TO THIS RECORD**

INSPECTION OBSERVATION RECORD

Tracking Indicator	PIPE **Size/Type**	PIPE **Position**	**MONITOR SIZE** (1/32 in.) of In-pipe Defect Image	+/- Value	**DEFECT COMMENTS**