

# PIPE INSPECTION AND REPAIR



**2022 CONSTRUCTION ACADEMY**  
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# PIPE INSPECTION

- Over the last 5 years, the Department has spent over 200 million dollars on drainage pipe and over 20 million dollars on pipe repair.
- With costs like these, it is extremely important to ensure that pipe is installed correctly, inspected thoroughly, and replaced or repaired correctly.

# PIPE INSPECTION AND REPAIR

This presentation will cover:

- The Standard Specifications for pipe installation and inspection requirements.
- Information on the components of a pipe inspection.
- CPAM Chapter 8.13 guidance on some of the common issues associated with pipe installation.
- CPAM Chapter 8.13 guidance and the Pipe Repair Matrix for acceptable repair methods.

# DRAINAGE INSTALLATION

- All work on FDOT projects is governed by the Standard Specifications found in the contract documents.
- Drainage installation is covered in at least two separate sections – Section 5 and Section 430 of the Standard Specifications.

# DRAINAGE INSTALLATION

- **Section 5 – Control of Work** – describes some of the general guidelines associated with project construction.
- **Section 5-3 – Conformity of Work with Contract Documents** – states the Contractor will “perform all work and furnish all materials in reasonably close conformity with the lines, grades, cross sections, dimensions, and material requirements, including tolerances, as specified in the Contract Documents.”

# DRAINAGE INSTALLATION

- Section 430 – Pipe Culverts: Lists all the tolerances and construction requirements for furnishing and installing drainage pipe and end sections at locations called for in the plans.
  - Acceptable pipe materials
  - Instructions for laying pipe
  - Inspection requirements
  - Specific requirements for each pipe type

# PIPE INSPECTION

- FDOT is an optional pipe materials state.
  - Allow both flexible and rigid pipe.
  - Performance criteria for each pipe material.
  - Material information in Section 948.
- The Department strives for problem-free installation.
- Specifications for installing pipe and the Pipe Inspection Videos and Reports are tools used to achieve this goal.

# PIPE INSPECTION

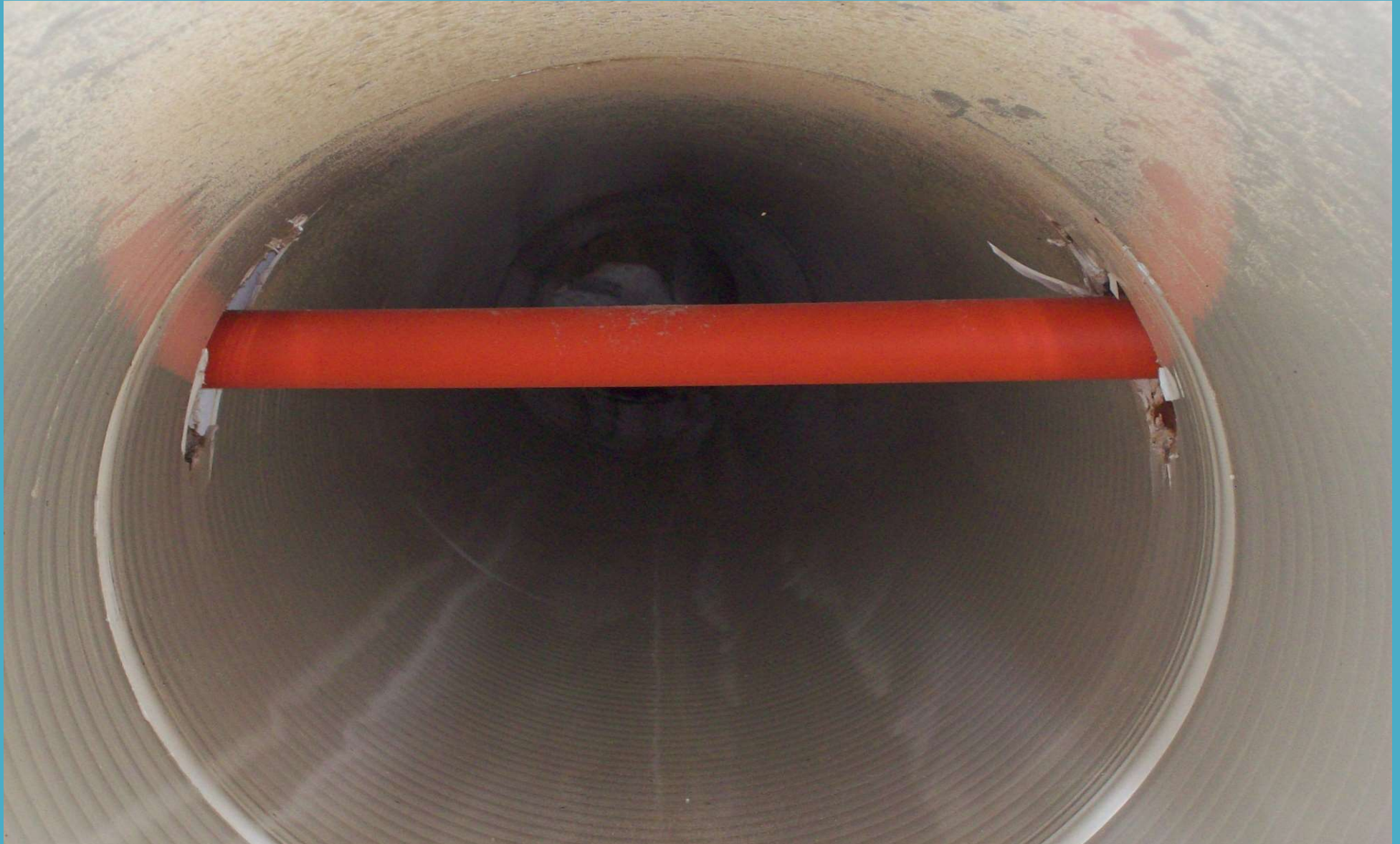




# PIPE INSPECTION

- Allows the Contractor and the Department to obtain a firsthand account of the condition of culvert pipe post-installation.
- Provides the Department with some assurance that the drainage system was installed correctly and is functioning properly.

# PIPE INSPECTION



# PIPE INSPECTION



# PIPE INSPECTION



# PIPE INSPECTION



# WHEN TO INSPECT

- Section 430-4.8 For pipes installed under the roadway, inspection is to be conducted when the backfill reaches 3 feet above the pipe crown or upon completion of the stabilized sub-grade. For pipe installed within fills, including embankments confined by walls, inspection is to be conducted when compacted embankment reaches 3 feet above the pipe crown or the finished earthwork grade as specified in the Plans.

# WHAT TO DO PRIOR TO INSPECTION

- Prior to inspection, dewater the pipe and remove all silt, debris, and obstructions.



# WHAT TO USE

- Section 430-4.8 states that for pipe 48 inches or less in diameter, submit to the Engineer the video files and report using low barrel distortion video equipment with laser profile technology, non-contact video micrometer and associated software.



# WHAT TO USE



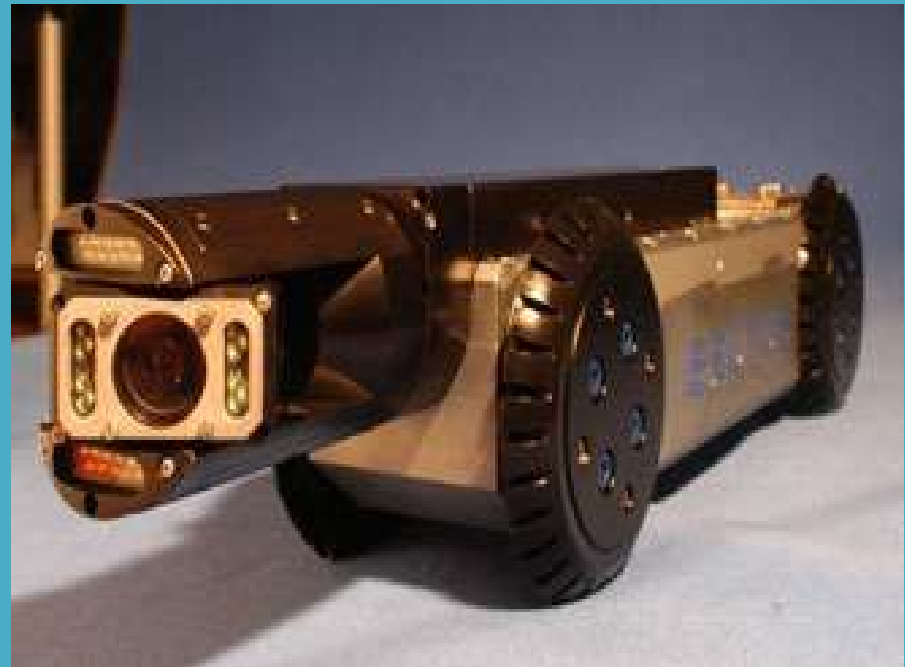
# INSPECTION EQUIPMENT

Laser Profiling and Video Inspection Equipment consists of 4 main components:

1. **Crawler** – moves the equipment through the pipeline.
2. **Closed Circuit TV camera** – records images and sends data back to a computer.
3. **Laser Profiler** – provides numerous measurements of a pipe's internal surface.
4. **Software** – interprets data and generates an inspection report.

# CRAWLER

- These machines come with several different wheel sets or tracks that must be changed out to accommodate the size and type of pipe being inspected.



# CCTV

- The Closed Circuit Television (CCTV) camera records all the images for the pipe inspections. This is the equipment that pans and tilts around the inside of a pipe for observations and measurements.



# LASER PROFILER

- There are currently two different types of technology used for profiling pipe in the Florida.
  - Rotating head laser profiler
  - Continuous ring laser profiler

# ROTATING PROFILER

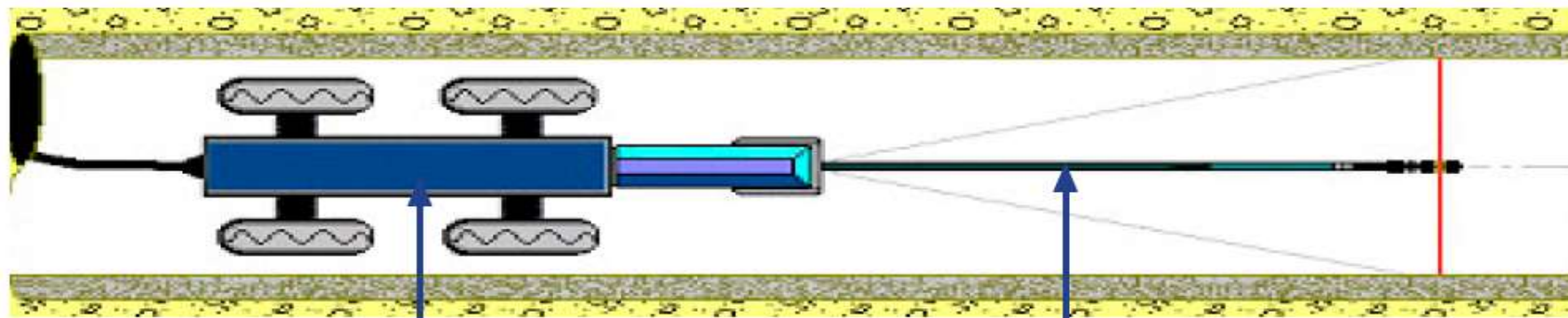
- The rotating head profiler has two laser diodes built into the CCTV camera head. The diodes take continual measurements while the camera head rotates 360° at a set speed while the crawler is pulled back through the pipe.



**DIODES**

# CONTINUOUS RING PROFILER

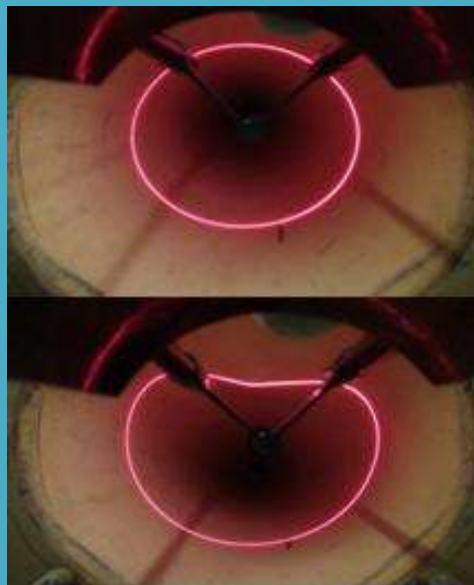
- The continuous ring profiler projects a visible laser beam onto the internal surface of the pipe. The beam is centered in the field of view of the CCTV camera and the camera records the image of the beam as it is pulled back through the pipe.



CCTV INSPECTION CAMERA

LASER PROFILER

# CONTINUOUS RING PROFILER





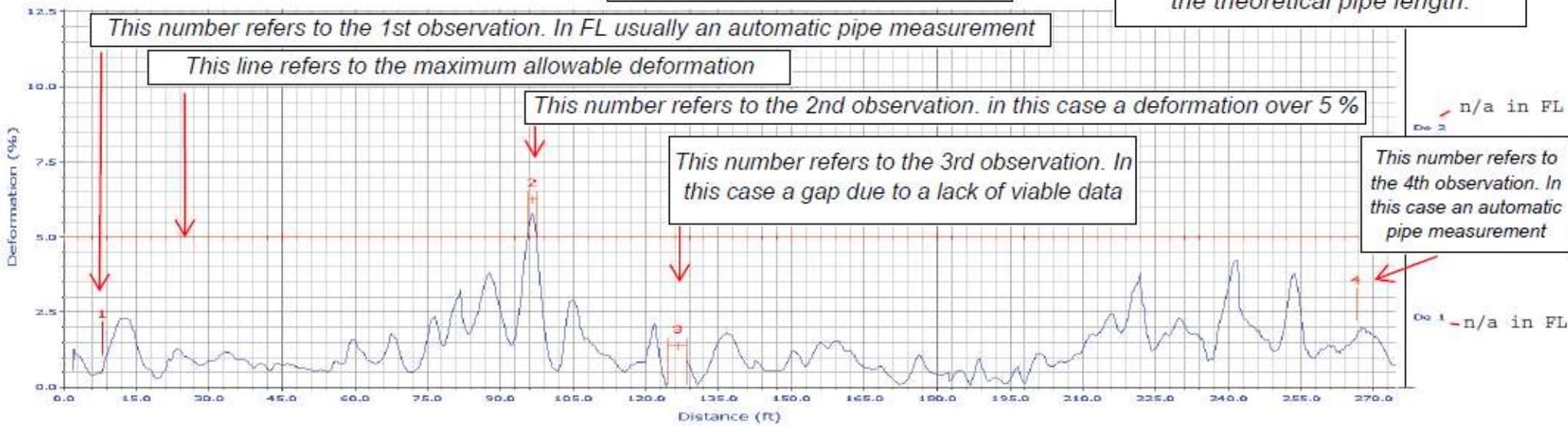
# SOFTWARE / REPORTS

Pipe section information				
Inspection Date	Street name	Upstream Manhole	Inspection Direction	Downstream Manhole
July 31, 2008	123	S71	<<<	S-66
Network Type	Material	Nominal Diameter(in)	Inspected/Theoretical Length(ft)	
Surface water	PVC	18	272.3 / 273.4	

## Deformation analysis

Dimensions of pipeline

1st number refers to the length processes. 2nd number refers to the theoretical pipe length.



S-66

This graph is always displayed from the start of the inspection to the end of the inspection



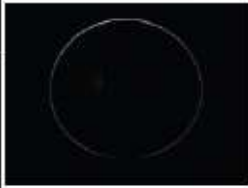





S71

**Note, observations are numbered on this graph and an explanation of what the observations are is given on the following table.**

# SOFTWARE / REPORTS

Pipe section information				
Inspection Date	Street name	Upstream Manhole	Inspection Direction	Downstream Manhole
July 31, 2008	123	S71	<<<	S-66

## Observation(s)

ID	Observation position			Maximum value		Laser image	Video image	
	Start(ft)	End(ft)	Length(ft)	Position(ft)	Max. Value (%)			
1	8	8	0	8				
	<b>Comment :</b> Pipe diameter automatic measurement at 8.0 ft : 17.6 in.							
<p><i>These Observation IDs refer to the observation numbers on the previous graph and provide an explanation as to what the observation is and its location in the pipeline.</i></p>						5.8		
2	<b>Comment :</b> Deformation > 5.0% (Class 2)							
3	124.5	128.3	3.8	126.7				
	<b>Comment :</b> No data available							
4	266.4	266.4	0	266.4				
	<b>Comment :</b> Pipe diameter automatic measurement at 266.4 ft : 17.6 in.							

# WHAT NEEDS TO BE INSPECTED ?

- All pipe!
- For pipe 48 inches or less in diameter, submit to the Engineer the video files and report using low barrel distortion video equipment with laser profile technology, non-contact video micrometer and associated software that provides:
  1. Actual recorded length and width measurements of all cracks
  2. Actual recorded separation measurement of rigid pipe joints
  3. Pipe ovality report (Flexible Pipe): Includes 5% deflection limit
  4. Representative diameter of the pipe (Flexible Pipe)
  5. Leaks, debris, or other damage or defects

# EVALUATING THE REPORTS

- The purpose of generating and collecting pipe inspection information is to compare reports generated by the software with the video observations to determine the presence and extent of defects after installation.
- You should not rely on one or the other by itself!

# VIDEO INSPECTION

- Overall, the quality of the video inspection documentation has improved greatly. However, there are still several areas of concern:
  - Camera Speed during the video inspection
  - Partial inspection or completely missing joints
  - Not evaluating the entire pipe
  - Pipe not fully dewatered or free of debris

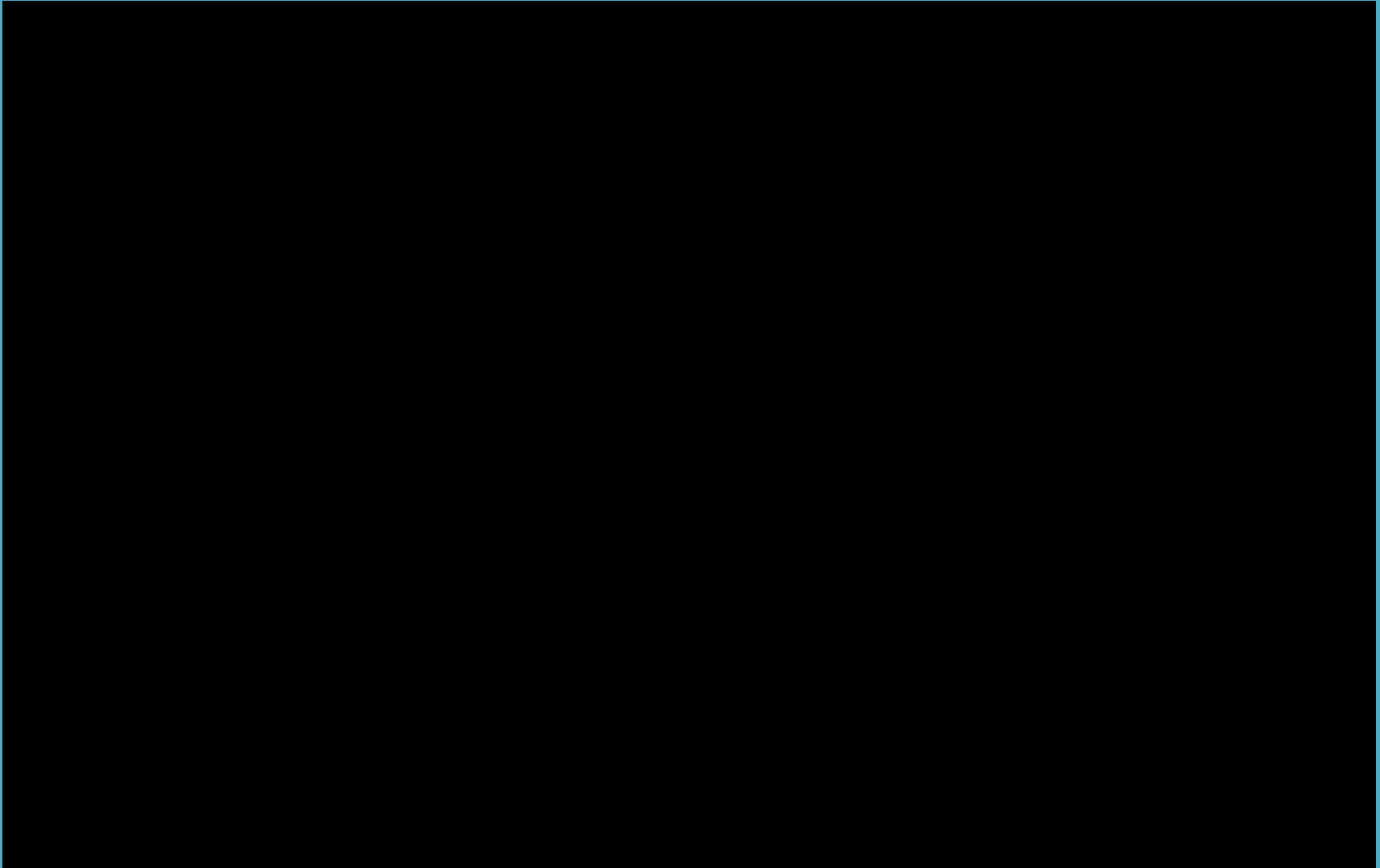
# CAMERA SPEED

- Move the camera through the pipe at a speed no greater than 30 feet per minute.



# JOINT INSPECTION

- Film the Entire circumference at each joint.



# DOCUMENT DEFECTS

- Stop the camera and pan when necessary to document defects.



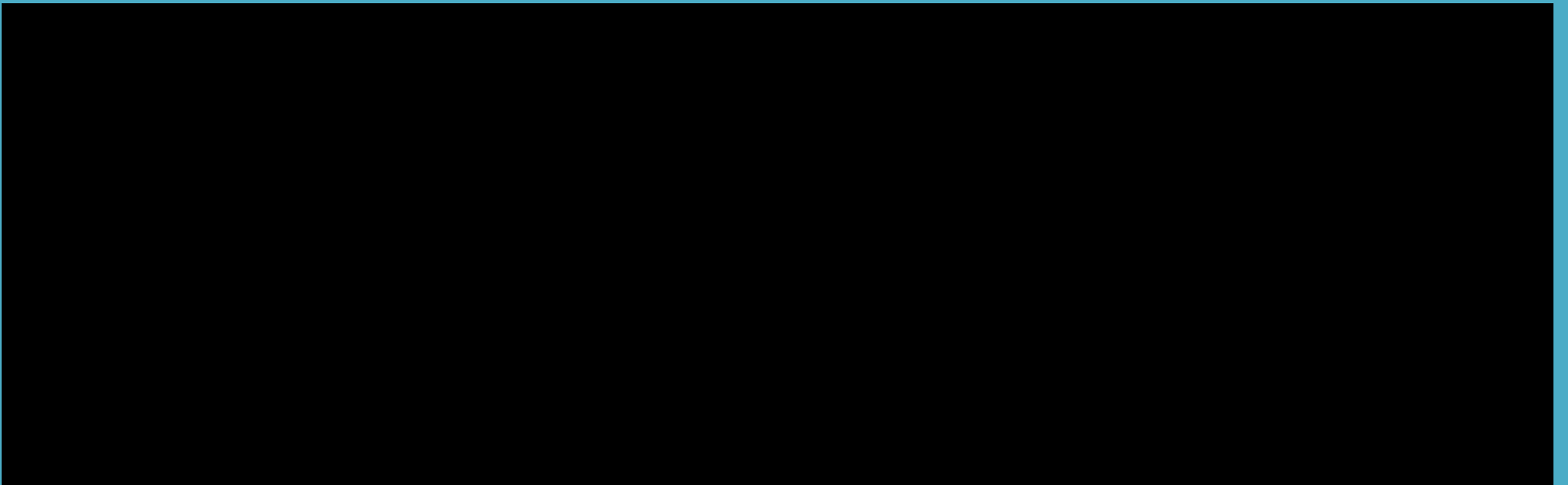


# PIPE OBSERVATIONS

- Observation Reports typically include crack and joint gap measurements, joint misalignment, ovality issues and any other type of damage sustained by the pipe.
- The defects noted in the report should be compared with the video to verify the location of defects in the pipe run and to ensure no defects were missed during the inspection.

# PIPE OBSERVATIONS

19.4	<p><b>Fracture Longitudinal</b> <b>Position: 3</b> <b>Severity: None</b> <b>Size: 0.03</b> <b>Remarks: with infill weeper</b> <b>Struct Weight: 3</b></p>	05:00	 <p>05:00:00 05:00:00 MH-3-0000 05:00:00 Fracture Longitudinal 0.03 3° 0.2% 19.4FT 0 FPM</p> <p>The image is a video frame from a pipe inspection. It shows a dark, circular pipe interior with a bright light source at the top. A small, reddish-brown fracture is visible in the center. Overlaid text includes '05:00:00' in the top corners, 'MH-3-0000' on the left, 'Fracture Longitudinal' and '0.03' in the center, and '3° 0.2% 19.4FT 0 FPM' at the bottom.</p>
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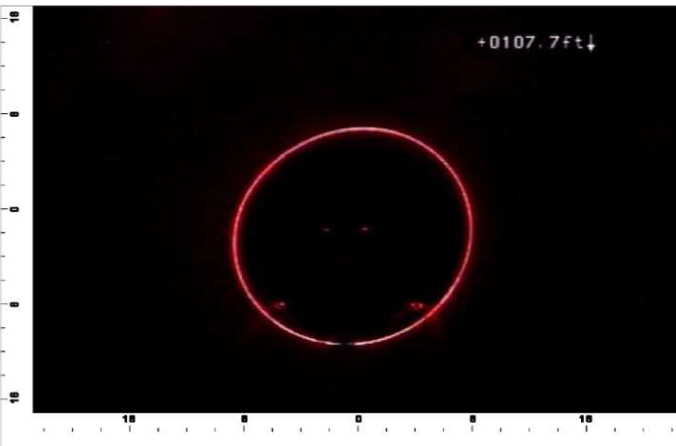
# OVALITY REPORT

## Ovality Observations Report

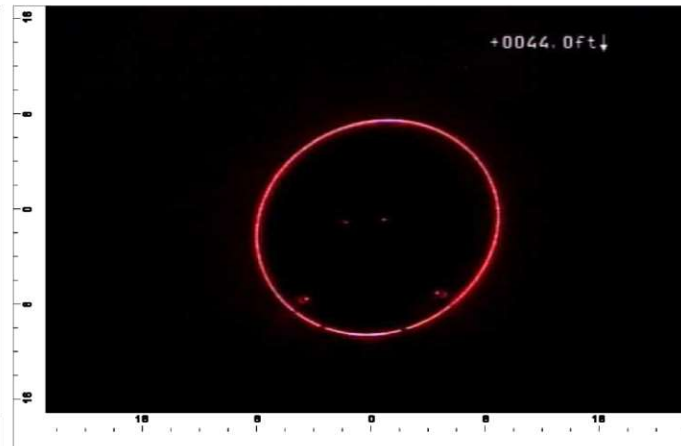
Owner FDOT  
Project ID SR 93/I-75 408459-4-52-01  
Start No S-104  
Location

Contractor BETTER ROADS  
Finish No S-100  
Location

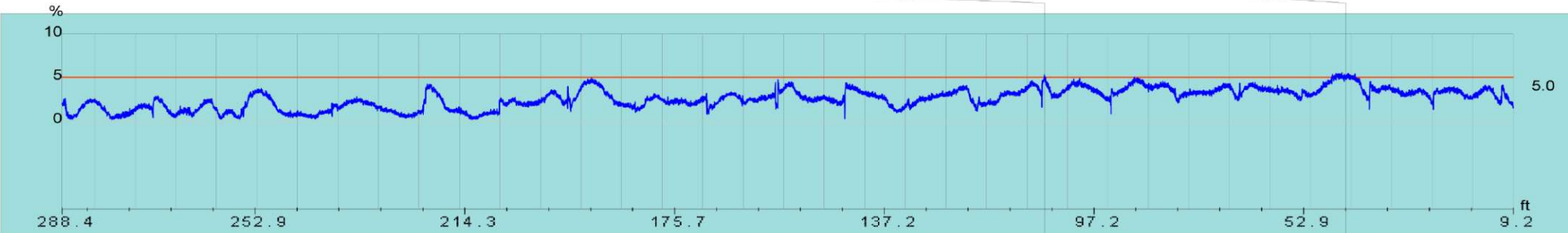
Date 1/5/2014  
Material PVC  
Pipeline Length 298.2 ft  
Internal Diameter (Expected) 17.6 in



OVALITY = 5.4%



OVALITY = 5.1%



90% - Fractile: 4.0%

Ovality 'q' (as per ASTM F 1216 Standard Practice) as a percentage of original pipe versus distance

# BAD OVALITY REPORT

## Ovality Summary Report

Site ID  
City  
Start No  
Location

Asset No.  
Finish No  
Location

Date 8/28/2013  
Material  
Pipeline Length 164 ft  
Internal Diameter 36 in

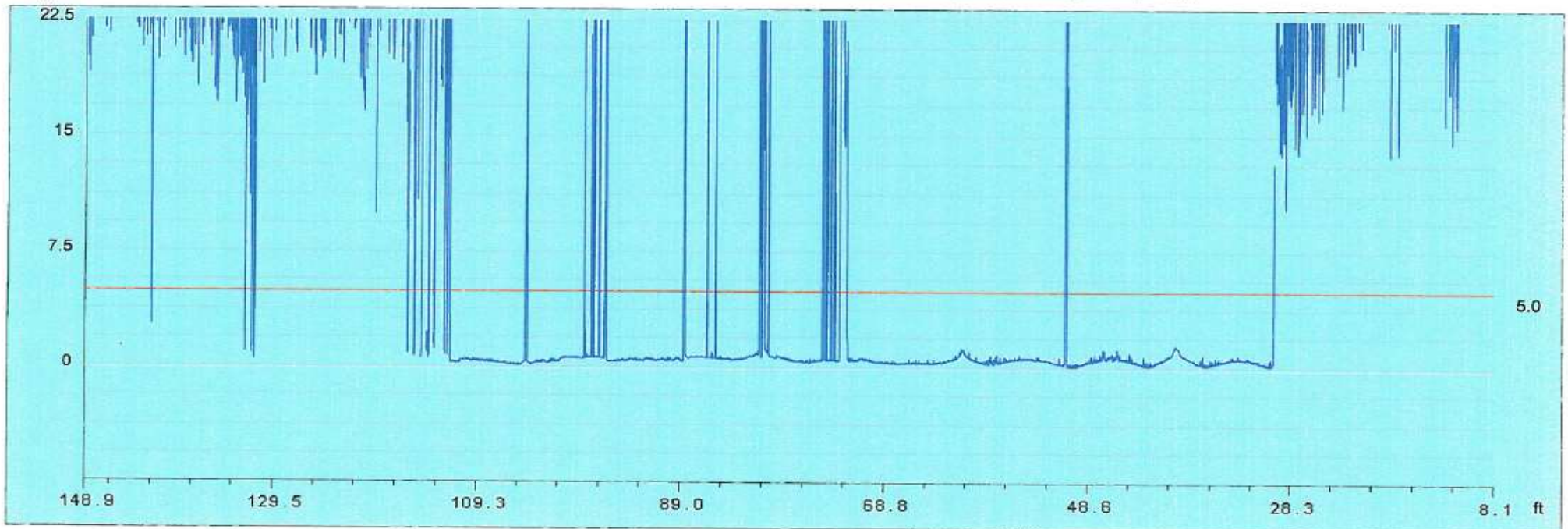
Comments

Limit Lines

Upper limit = 5  
Lower Limit = 5

% 90% - Fractile: 38.3%, Exceeded limits: 43.7%

Ovality 'q' (as per ASTM F 1216 Standard Practice) as a percentage of original pipe versus distance

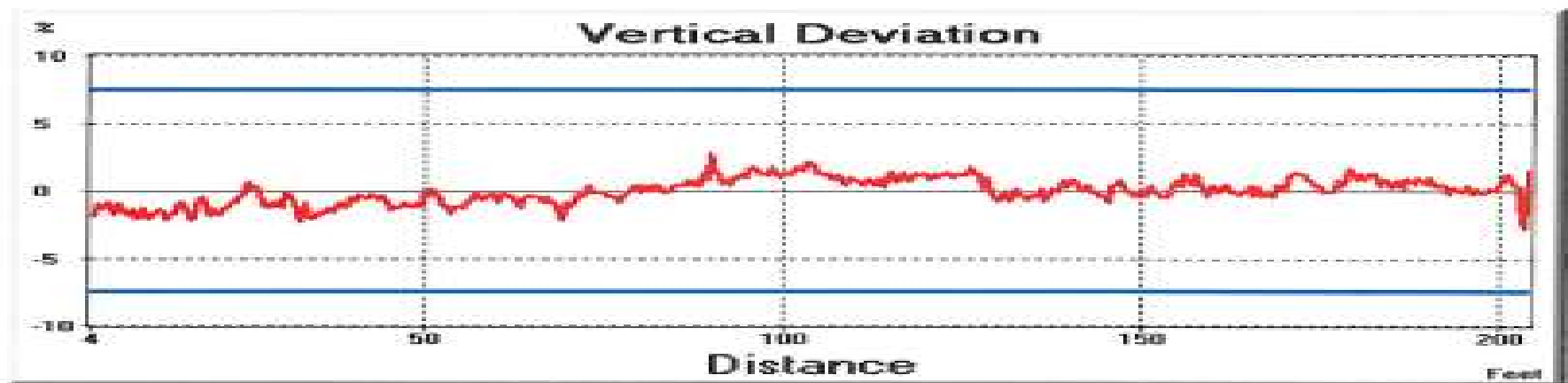
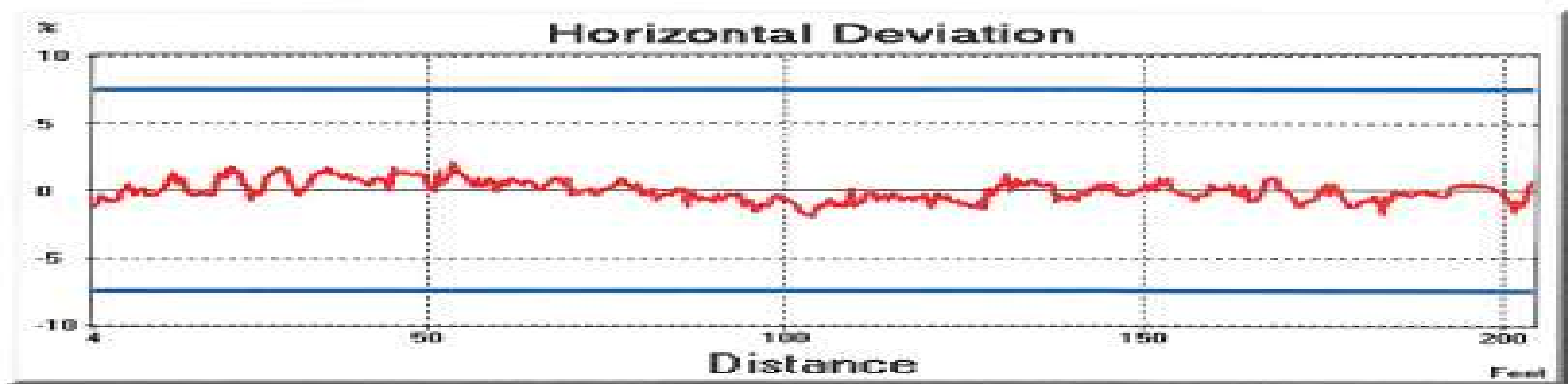


# OVALITY REPORT

## Project Name: I10

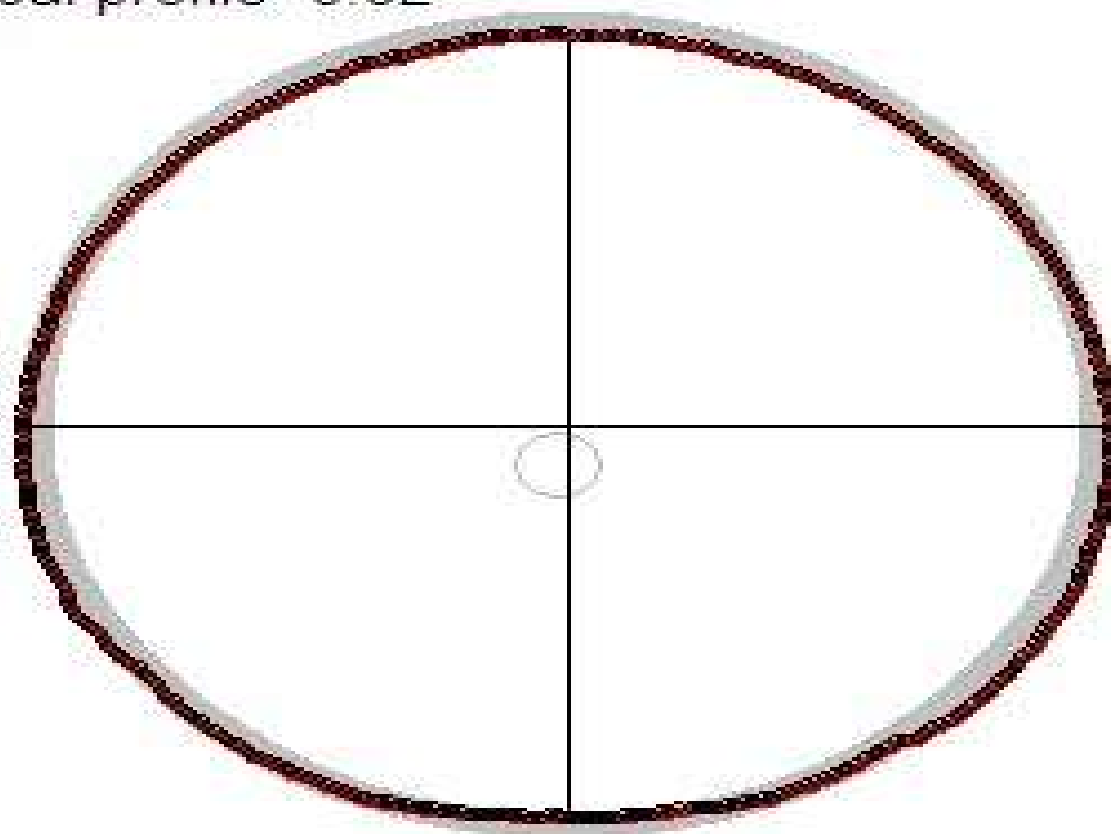
Date: 4/22/2009 9:23:00 AM  
Location: Leon County  
Length Surveyed: 205.5  
Run Number:  
Pipe Size: 18"

Asset ID:  
Upstream MH Number: S330Demo  
Downstream MH Number: S331Demo  
Direction Of Survey: Upstream  
Pipe Material: Polyvinyl Chloride



# REPRESENTATIVE DIAMETER OF THE PIPE

Horizontal profile 0.01"  
Vertical profile -0.02"



nom. dia 18

meas. dia 18.00

# PIPE INSPECTION

- It is important to remember that the video report is in fact part of the Specifications and can be rejected if they are not performed according to Section 430.
- Make sure your pipe inspector is familiar with the language in Section 430-4.8 or they may be performing this service more than once!

# RE-INSPECTION

- **Section 430- 4.8.2** “At any time after reviewing the submitted pipe inspection reports, the Engineer may direct additional inspections. If no defects are observed during the reinspection, the Department will pay for the cost of the reinspections in accordance with 4-3. If defects are observed, the reinspection and all work performed to correct the defects will be done at no cost to the Department. Acceptance of all replacements or repairs will be based on video documentation of the completed work prior to Final Acceptance.”



# COMMON PIPE ISSUES SEEN DURING INSPECTION

Overall, the majority of pipe issues reviewed and/or repaired have been:

- Leaking Joints
- Joint Gaps (Rigid)
- Deflection (Flexible Pipe)
- Cracking
- Stains

# LEAKING JOINTS



# LEAKING JOINTS

- **Section 430-4.1** Describes the general guideline for laying pipe on FDOT roadway construction projects.
- All joints must meet the following minimum standards:

Pipe Application	Minimum Standard
Storm and Cross Drains	Water-tight
Gutter Drain	Water-tight
Side Drains	Soil-tight

# LEAKING JOINTS

- Soil tight joints must be water-tight to 2 psi.
- Water-tight joints must be water-tight to 5 psi unless a higher pressure rating is required in the plans.
- Leaking joints occur in both flexible and rigid pipe types.

# LEAKING JOINTS

- If joints are leaking, it needs to be determined if the hydrostatic groundwater head exceeds the performance criteria and could cause the joint to leak.
- A quick determination can be made using the hydraulic equation:

$$p = wh$$

# LEAKING JOINTS

$p$  = pressure

$w$  = the specific weight of water, 62.4 lbs/ft<sup>3</sup>

$h$  = is the head, or the depth below the water surface

So, solving for  $h$  gives you  $h = p/w$

# LEAKING JOINTS

$$h = (2 \text{ psi} \times 144 \text{ in}^2/\text{ft}^2) / 62.4 \text{ lbs}/\text{ft}^3 \\ = 4.61 \text{ ft}$$

$$h = (5 \text{ psi} \times 144 \text{ in}^2/\text{ft}^2) / 62.4 \text{ lbs}/\text{ft}^3 \\ = 11.54 \text{ ft}$$

# LEAKING JOINTS

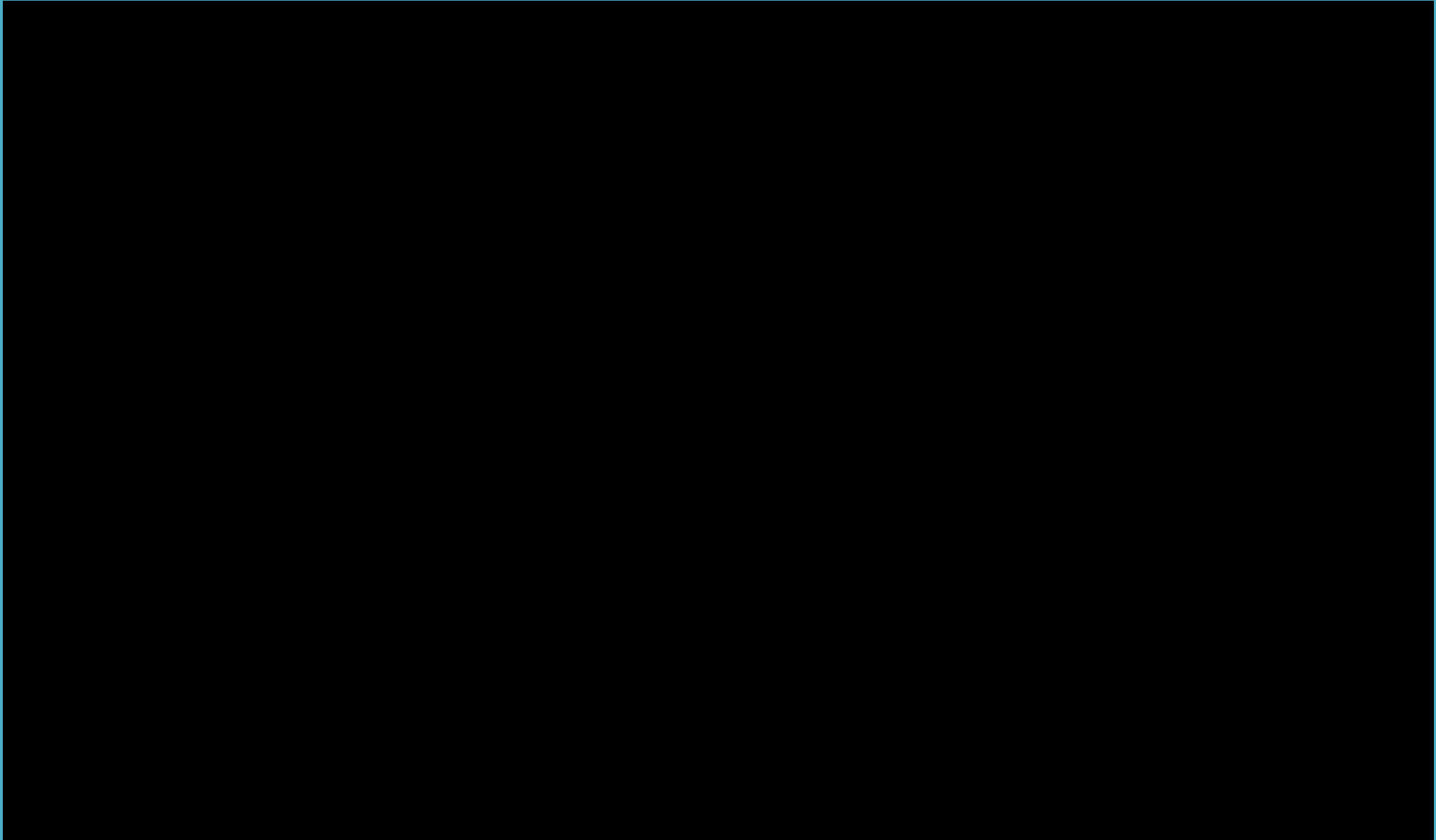
- 2 psi soil tight joints should not leak if they are less than 4.61 feet below the water table.
- 5 psi water tight joints should not leak if they are less than 11.54 feet below the water table.
- If your joints are leaking and the culvert does not exceed the above conditions, the joints are defective and in need of replacement/repair.



# LEAKING JOINTS

- So, if your joints are leaking you have two options:
  1. Repair the leaking joint using a repair method that is acceptable to the Department.
  2. Using water table data, be able to show that the hydrostatic head pressure on the pipe run exceeds the performance measurement for a soil tight or watertight joint.

# JOINT GAPS



# JOINT GAPS

- Section 430-7.2 addresses gap tolerances for concrete pipe with rubber gaskets:

5/8" for 12 to 18 inch diameter pipe

7/8" for 24 to 66 inch diameter pipe

1" for pipe diameters 72 inches or greater

# JOINT GAPS

- **Section 430-7.2** – Where minor imperfections in the manufacture of the pipe create an apparent gap in excess of the tabulated gap, the Engineer will accept the joint provided that the imperfection does not exceed  $\frac{1}{3}$  the circumference of the pipe, and the rubber gasket is  $\frac{1}{4}$  inch or more past the pipe joint entrance taper.

# JOINT GAPS

- What happens if the joints that are installed are outside of the tolerances?

Section 430-7.2 states: “Where concrete pipes are outside of these tolerances, replace them at no expense to the Department. Do not apply mortar, joint compound, or other filler to the gap which would restrict the flexibility of the joint.”

# JOINT GAPS

- If you have joint gaps in your pipe runs, you have two options:
  1. Repair the joint gap using a material or method accepted by the Department.
  2. Provide the Department with assurances that the joint(s) in question will perform according to the Specifications. Documented Engineering and Scientific judgment must be provided.

# DEFLECTION



# DEFLECTION

- All flexible pipe types must meet the Department's deflection criteria in Section 430.
- Pipe deflected 5% or more of the certified actual mean diameter of the pipe at final inspection shall be replaced at no cost to the Department.



# DEFLECTION

- The Department is aware of the AASHTO standard for deflection and the critical limits of deflections for flexible pipe types.
- However, the language in the current Specifications states that 5% deflection is the cutoff for acceptance for flexible pipe types.

# DEFLECTION

- So, if you have pipe runs with deflections greater than 5% of the certified mean diameter, you currently only have one option:
  1. Remove and replace those deflected sections at no cost to the Department.

# CRACKING



# CRACKING

- Cracking can occur in all pipe types.
- If the pipe is cracked during installation, it is usually due to the pipe being overloaded or not backfilled properly.
- Cracking can affect the structural integrity of the pipe.

# CRACKING

- Reinforced Concrete Pipe is the only pipe material with specific crack criteria at this time.
- The design of RCP is such that some amount of cracking is expected and allowable.
- However, the limits of acceptable cracking are defined in several documents.

# CRACKING

- Reinforced concrete pipe crack criteria is covered under Section 449, which references ASTM C 76.
- FDOT also refers to Section 27 of the AASHTO LRFD Bridge Construction Specifications concerning cracking in concrete pipe, as it provides good guidance on handling pipe crack issues.

# CRACKING

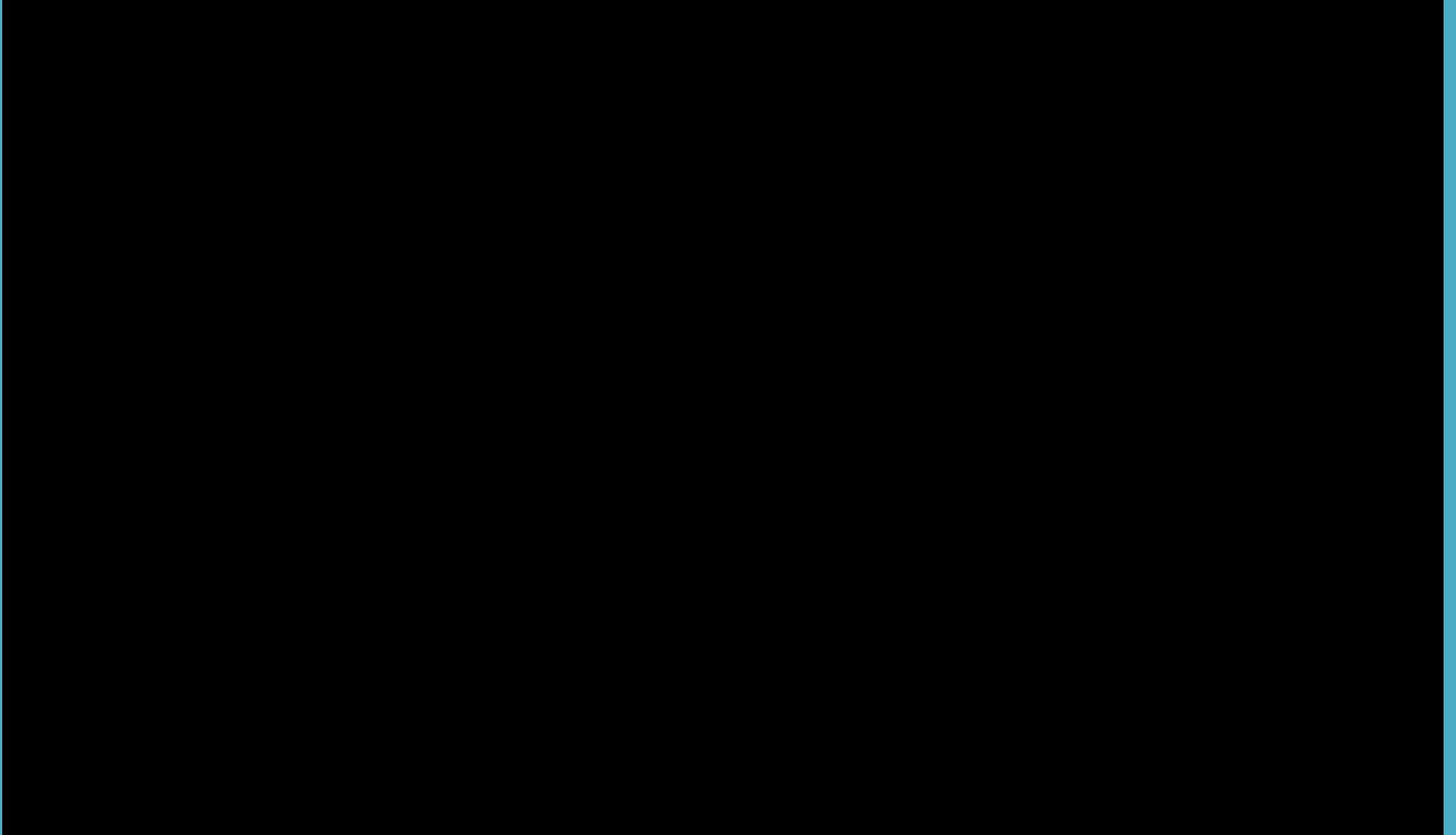
- AASHTO Section 27.4.1 states that “Cracks in an installed precast concrete culvert that exceed 0.01 in. (.25 mm) width shall be appraised by the Engineer considering the structural integrity, environmental conditions and the design service life of the pipe.
- Cracks having greater widths or otherwise determined to be detrimental shall be sealed by a method approved by the Engineer.

# CRACKING

- So, if you have cracks in Reinforced Concrete Pipe that meet or exceed the 0.01 in crack criteria, you have two options:
  1. Correct the defect using a repair method that is accepted by the Department.
  2. Provide the Department with assurances that the cracked pipes will perform according to the Specifications and will meet their expected service life. Documented Engineering and Scientific judgment must be provided.



# STAINS



# STAINS

- Stains in concrete pipe are not considered a defect in need of repair unless the stain is associated with a crack in excess of the tolerances referenced in ASTM C 76 and AASHTO LRFD Chp. 27, or active infiltration regardless of its location, size of the crack, or any other defect and shall be repaired.
- Stains in aluminized steel pipe shall be evaluated to determine the presence of damage to aluminized coating.
- Stains in thermoplastic pipe shall be evaluated to determine the presence of damage.

# STAINS



# So, how do we fix it ?

- CPAM Chapter 8.13.6.3
- First option is to remove and replace at no cost to the Department.
- When replacement is not practical, consider repair methods.

# So, how do we fix it ?

- Currently, the Department relies on Section 431 Pipe Liner and Section 948 Optional Drainage Products and Liner Repair Systems to address pipe repair issues.
- These specifications are updated periodically with the most current pipe repair materials and methods available to the Contractor.

# PIPE REPAIR

- The Department developed a Pipe Repair Matrix to assist the Districts in their repair decision making.
- This Matrix is a GUIDELINE and does not replace proper pipe installation or sound engineering judgment.

# MATRIX BACKGROUND

- The Repair Matrix is a compilation of Department Specifications, Design Standards and repair procedures submitted by members of FDOT's Pipe Advisory Group (PAG).
- The PAG consists of members from the pipe manufacturing industry, laser profiling and inspections industry and technical experts in the field of drainage pipe.

# MATRIX BACKGROUND

- The Department compiled the information into an interactive spreadsheet for use by the Districts and the Contracting Industry when reviewing damaged pipe and possible repair methods.
- The Matrix is a living document that will change as repair technology is updated and current methods are reviewed for their durability and performance.



**SO, LET'S ENTER THE MATRIX !**



# PIPE REPAIR MATRIX

- The Department encourages you to review the Pipe Repair Matrix.
- The Matrix can be found on the FDOT Construction Homepage under Construction Support.
- Or, it can be found here:

[FDOT-Construction-Pipe Repair Matrix](#)

# FINAL WORD ON THE PIPE REPAIR MATRIX

- Remember, the Matrix is a GUIDANCE document and does not replace the Specifications, proper installation, or sound engineering judgment. It is not a contract document.
- The Matrix is an evolving document that will continue to change with new advancements and additional research in pipe repair methods.

# ADDITIONAL REPAIR GUIDANCE

- CPAM 8.13.6.3
- Coordinate repairs with Drainage Office to ensure that hydraulic capacity of the pipe run is maintained.
- **Use of Grout for repair:** The Department does not accept the hand application of grout for pipe repair. All proposed grout repairs must utilize pressurized injection to ensure the grout completely fills the defect and any voids associated with it.

# ADDITIONAL REPAIR GUIDANCE

- **Use of Cured in Place point repairs:** The Department does not accept cured in place point repairs at this time due to quality assurance and maintenance concerns. All point repairs proposed by the Contractor must consist of steel, aluminum, and rubber per Section 948 of the Standard Specifications.
- If a Contractor proposes a repair method that is not found on the Pipe Repair Matrix, it must be evaluated and accepted by the State Construction Office prior to use.

# AND FINALLY...

12' Alligator found in the storm sewer during pipe desilting operations in Okeechobee on SR 70





# QUESTIONS ?

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05/12/2006