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GRAHAM MUNICIPAL AIRPORT
TxDOT Solicitation No.: RFQ2603GRAHM00095

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Texas Department of Transportation
Aviation Division
Request for Qualifications (RFQ) for
Professional Engineering Services

The City of Graham, through its agent, the Texas Department of Transportation (TxDOT), intends to engage a professional engineering firm for services pursuant to Chapter 2254, Subchapter A, of the Government Code. TxDOT Aviation Division will solicit and receive qualification statements for the current aviation project as described below.

Current Project: City of Graham; TxDOT CSJ/Project No.: 2603GRAHM. The TxDOT Project Manager is Earl Spurlock.

Scope: Provide engineering and design services, and at the agent's discretion, construction administration for:

1. Runway 03-21 Partial Reconstruction and
2. Drainage Improvements.

The Agent, in accordance with the provisions of Title VI of the Civil Rights Act of 1964 (78 Stat. 252, 42 U.S.C. §§ 2000d to 2000d-4) and the Regulations, hereby notifies all respondents that it will affirmatively ensure that for any contract entered into pursuant to this advertisement, disadvantaged business enterprises will be afforded full and fair opportunity to submit in response to this solicitation and will not be discriminated against on the grounds of race, color, or national origin in consideration for an award.

The proposed contract is subject to 49 CFR Part 26 concerning the participation of Disadvantaged Business Enterprises (DBE).

The DBE goal for the design phase of the current project is **0%**. The goal will be re-set for the construction phase.

To assist in your qualification statement preparation, the criteria, project diagram, and most recent Airport Layout Drawing is available online *http://www.dot.state.tx.us/avn/avninfo/notice/consult/index.html* by selecting "Graham Municipal Airport." The qualification statement should address a technical approach for the current scope only.

Response Procedure:

The successful firm will be selected on the basis of a Response. A prime provider may only submit one Response. If a prime provider submits more than one Response, that prime provider will be deemed non-responsive. The Response must contain the required information, and should address the recommended information, as listed below. Response submissions will be scored accordingly. If the Response is non-compliant with any of the following requirements, the Response may be deemed non-responsive.

1. Qualifications Statement (QS) - The QS shall contain no more than nine 8.5x11-inch single-sided pages.
   - **a.** **QS** Format:
     - i. Readability - The submitter has latitude in formatting the QS for visual effectiveness. Graphics, tables, photos, and other visual aids are permitted within the nine allotted pages, except that Quick Response (QR) codes or other external link(s) are not permitted. There is no specific font, font size, color, or other formatting requirements, although a font size smaller than 10 is not recommended. Selection committee members may consider legibility and readability when scoring. Unreadable text will not be considered and may cause the QS to be deemed non-responsive. **It is the submitter's res.eonsibili,ty to .erovide a legible" readable document.**
   - **b.** QS Content - It is recommended the QS include:
     - i. The RFQ number, airport name, name of firm, firm address, email address, telephone number and contact information for key personnel. The response shall also identify each proposed project team member, each proposed member's time commitment to this project as a percentage of their total work week, and whether the proposed member is an employee of the responding firm or a sub-contractor to that firm.
   - **c.** QS Content - For scoring purposes, the QS **must** include:
     - **i.** Information showing the firm's project understanding and technical approach, including similar project-related experience of the project manager and each task leader responsible for a major work category. For each project referenced, identify either the project manager's or the task leader's specific role(s) and work contributed. The project manager is required to be a Professional Engineer registered or licensed in Texas, by the submission deadline. If applicable to project, an Architect, is required to be registered or licensed in

Texas, by the submission deadline. License number(s) must be included in the response submission.

ii. In addition to individual project-related experience of the project manager and task leaders required under (ii), list no more than ten relevant projects performed by the responding firm within the last 10 years. This shall include project start date, airport name, location, phone number, and airport contact person's name, title, and phone number. It shall also include the original project completion time estimate vs. the actual completion time for the cited design project, as well as a brief narrative description of the project and whether or not your firm served as the prime or the sub on each project cited.

iii. Project Design Schedule: Indicate the number of weeks (not months) necessary to design the project in accordance with "Project Design Schedule Information" below.

Respondent must include on the first page of its Response a written certification that the responding Company, or any of its holding companies or subsidiaries, is not:

(a) Listed in Section 889 of the 2019 National Defense Authorization Act;
(b) Listed in Section 1260H of the 2021 National Defense Authorization Act; or
(c) Owned by the government of a country on the U.S. Department of Commerce's foreign adversaries list under 15 C.F.R Section 791.4; or
(d) Controlled by any governing or regulatory body located in a country on the U.S. Department of Commerce's foreign adversaries list under 15 C.F.R Section 791.4.

The Response must be submitted in eGrants following the Submission Procedures at the end of this notice.

Proiect Design Schedule Information

Based on the published project scope and your technical approach, indicate the number of **weeks** (not months) necessary for each phase and total design time to design the project. Some of the basic responsibilities within each design phase are included for reference. Do not include TxDOT review time. Assume, however, that your work will require some revision after TxDOT review, and that the time required to address these comments should be included within your schedule. If time is required for specialized studies, indicate the additional time.

NOTE: This proposed schedule may set the basis for the contract deadlines in the professional services agreement if your firm is selected. A draft contract will be sent out to the selected firm to begin the fee proposal/negotiations phase.

Preliminary Regort Phase
Attend pre-design conference
Obtain and analyze necessary survey data
Obtain and analyze necessary geotechnical data
Prepare comprehensive report

Preliminary Design Phase
Attend project meeting(s)
Prepare project drawings (70%)
Provide all technical specifications
Provide project cost estimate

Final Design Phase
Attend project meeting(s)
Finalize drawings and contract documents (100%)
Provide a revised opinion of probable total project costs
Prepare a Construction Management Plan
Update, if necessary, the Preliminary Report
Prepare and submit airspace study to FAA

Evaluation Criteria for Architectural/Engineering Qualifications

1. Recent experience of the project team with comparable airport projects within the past ten years. (25 points)

Do the qualifications indicate that the project team has recent direct experience on other general aviation airports designing similar improvements to those proposed at this location?

2. Proposed technical approach (30 points)

Does the architect/engineer provide evidence of understanding of the project; and any unique architectural/engineering aspects associated with the proposed project and how to address them?

3. Project design schedule and ability to meet schedules and deadlines (25 points)

Does the proposed design team have sufficient time to work on this project? Has the firm demonstrated an ability to meet design schedules in the past? Reasonableness of proposed schedule.

4. Construction Management Experience (20 points)

The architect/engineer will oversee the airport construction. Therefore, it is critical that the architect/engineer be involved in the day-to-day construction activities through a full-time resident project representative and periodic site visits. What evidence do the qualifications provide as to the architect/engineer's commitment to proactive and consistent representation during construction?

Submission Procedure:

The completed Response must be received in the TxDOT Aviation eGrants system no later than August 26, 2026, 2:00 PM. (CST).

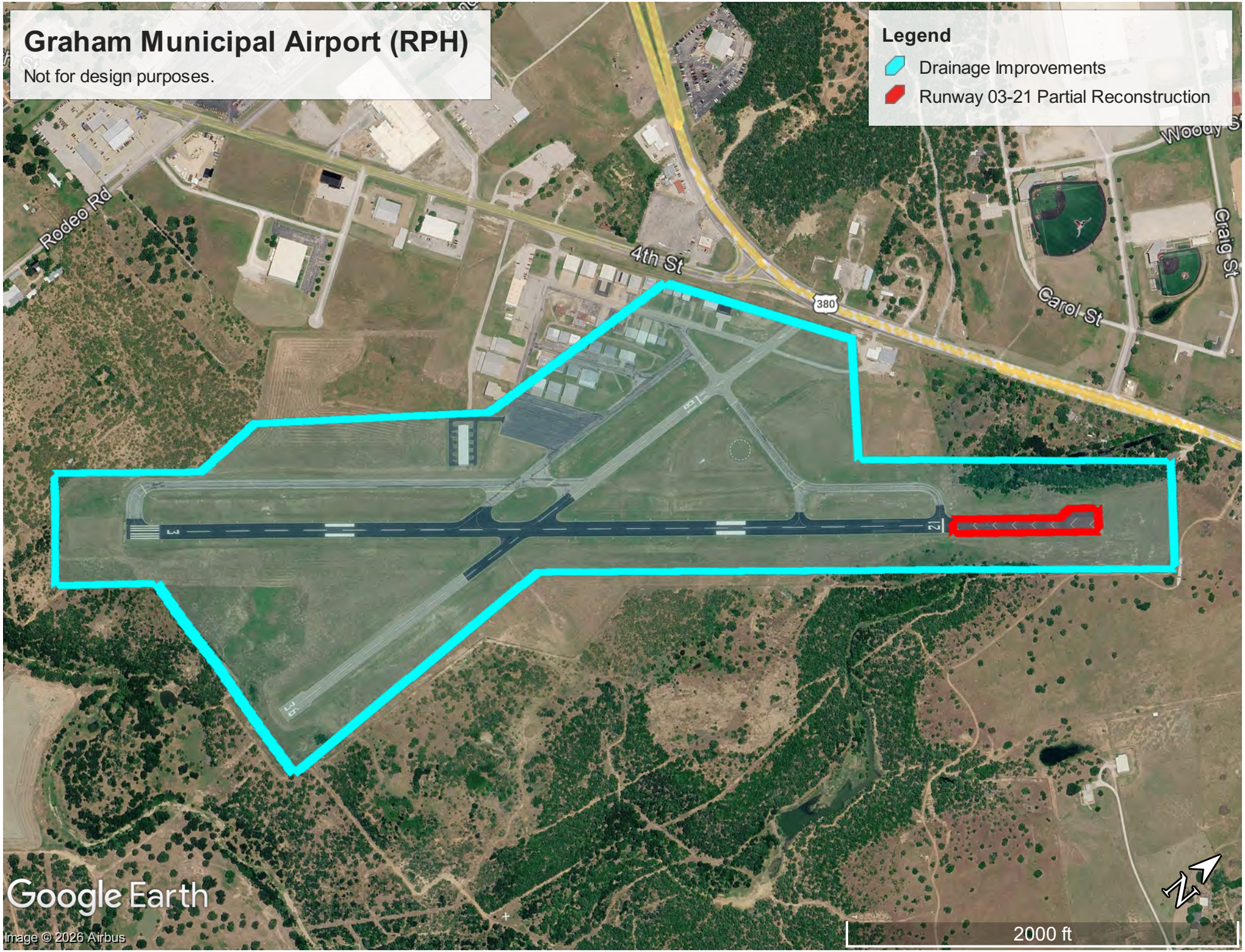
Firms that wish to submit a Response to this solicitation must be a user in the TxDOT Aviation eGrants system no later than one business day before the solicitation due date. To request access to eGrants, please complete the Contact Us web form located at *http://txdot.gov/govemmentlfundinglegrants-2016/aviation.html*

The consultant selection committee will be composed of TxDOT Aviation Division staff. The final selection by the committee will generally be made following the completion of review of Responses. The committee will review all Responses and rate and rank each. All firms will be notified, and the top-rated firm will be contacted to begin fee negotiations for the design and bidding phases. The selection committee does, however, reserve the right to conduct interviews for the top-rated firms if the committee deems it necessary. If interviews are conducted, selection will be made following interviews.

Please contact TxDOT Aviation for any technical or procedural questions at (800)-68-PILOT(74568). For procedural questions, please contact Debra Woodruff, Contract Specialist. For technical questions, please contact Earl Spurlock, Project Manager.

For questions regarding responding to this solicitation in eGrants, please contact the TxDOT Aviation help desk at 1-800-687-4568 or *avn-egrantshe/p@txdot.gov*.

Respondents are responsible for checking the TxDOT Aviation website regularly for any changes to the RFQ documents, such as Addenda. Here is a link to the TxDOT Aviation website for your convenience. http://www.txdot.gov/inside-txdot/division/aviation/proiects.html.


Graham Municipal Airport (RPH)
Not for design purposes.
Legend
Drainage Improvements
Runway 03-21 Partial Reconstruction
Rodeo Rd
4th St
380
Carol St
Craig St
Google Earth
Image © 2026 Airbus
2000 ft
N

Parkhill

GRAHAM
Where Texas Comes Home
City of Graham

DRAINAGE ANALYSIS REPORT

GRAHAM MUNICIPAL AIRPORT (RPH)

Graham, Texas

May | 2026
Parkhill Project #40701.24

Parkhill

GRAHAM
Where Texas Comes Home
City of Graham

DRAINAGE ANALYSIS REPORT

GRAHAM MUNICIPAL AIRPORT (RPH)

Graham, Texas



05/21/2026

May | 2026
Parkhill Project #40701.24

EXECUTIVE SUMMARY

This report presents the results of a comprehensive hydrologic and hydraulic evaluation of the existing stormwater system at Graham Municipal Airport.

A 1-dimensional hydraulic model was developed using StormWise software to simulate existing and proposed conditions. The model incorporated detailed watershed delineation, soil classifications, land use characteristics, surveyed culvert data, and LiDAR-based terrain. The airport was divided into eighteen contributing watersheds totaling approximately 1,051 acres. Hydrologic parameters, including curve numbers and time of concentration, were calculated in accordance with the TXDOT Hydraulic Design Manual. Rainfall inputs were based on NOAA Atlas 14 precipitation data, including the 24-hour 5-year and 24-hour 100-year storm events.

Model results indicate that several existing culverts are undersized or structurally deficient, contributing to reduced system performance and increasing the potential for ponding near critical airfield infrastructure. The hydraulic modeling evaluated system performance under both regulatory (5-year) and extreme (100-year) storm events to determine pipe sizing requirements necessary to prevent encroachment onto runways, taxiways, and roadways, consistent with FAA Advisory Circular 150/5320-5D.

Proposed pipe replacements were sized to fully convey the 24-hour 5-year storm without overtopping pavement surfaces, with additional evaluation under 100-year storm conditions to assess long-term system resilience. Results demonstrate that upsizing and replacing select culverts will significantly improve hydraulic capacity and system reliability.

In addition to hydraulic modeling, a ProPipe CCTV inspection was conducted to assess the structural condition of existing culverts. Of the sixteen pipes inspected, seven were identified as requiring replacement, including three that warrant immediate attention. Based on inspection findings and hydraulic performance, a prioritized replacement sequence has been developed to guide phased improvements.

Implementation of the recommended culvert replacements will enhance stormwater conveyance, reduce risk of runway inundation, and improve overall system performance while aligning with FAA and applicable regulatory guidance. These improvements provide a strategic and data-driven path forward for maintaining safe and effective drainage infrastructure at Graham Municipal Airport.

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1.0 INTRODUCTION

The City of Graham, as Owners of the Graham Municipal Airport (RPH), authorized Parkhill, along with TxDOT Aviation, to complete an Airport Layout Plan (ALP), with Narrative. In conjunction with the ALP Update, the City of Graham requested a comprehensive evaluation of the airports drainage system be added to address possible improvements to the system to be included in the ALP Update.

The original scope of the Drainage Report is as follows:

- Hydrologic and Hydraulic Evaluation of RPH's Airfield Drainage System to assess its effectiveness
- Provide Recommendations for System Improvements

In addition, an Engineer's Opinion of Probable Costs (EOPC) and recommendations for proposed improvements are presented herein. The proposed improvements are based upon limited topographic surveying and watershed evaluation models. Recommendations and proposed costs are based upon current grading contours that should be evaluated during a design project to optimize watershed conveyance and possible resizing of pipelines and quantities.



Figure 1: EXISTING SITE MAP

2.0 GENERAL AIRPORT DRAINAGE SYSTEM DESCRIPTION

Graham Municipal Airport is located approximately two miles east of the city center and is owned by the City of Graham. The airfield currently encompasses approximately 166 acres, including two paved runways, Runway 3-21 (5,001 feet x 75 feet) and Runway 18-36 (3,317 ft x 60 ft), an asphalt paved taxiway system and hangar complex serving general aviation aircraft.

3.0 EXISTING AIRPORT DRAINAGE SYSTEM

The existing drainage system consists of 16 existing drainage culverts, creating 18 watersheds as shown in Figure 2 and Figure 3.

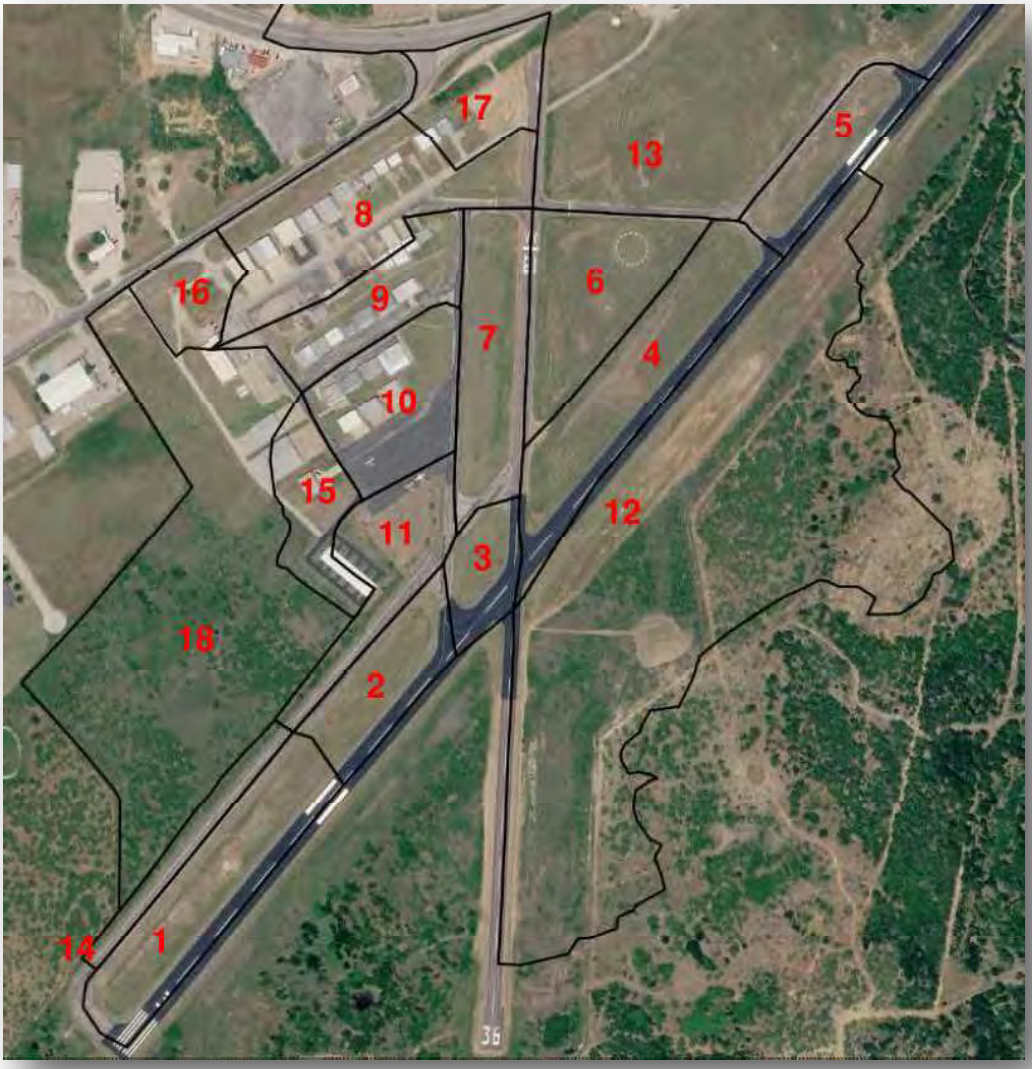


Figure 2: WATERSHED MAP



Figure 3: WATERSHED 13 MAP

3.1 TERRAIN

The terrain data was obtained from the Texas Geographic Information Office (TxGIO) and was used to represent both existing and proposed conditions. The TxGIO terrain is based on the 2016 Brazos River Basin LiDAR (Light Detection and Ranging) dataset. This aerial LiDAR acquisition was conducted by Dewberry on behalf of the U.S. Geological Survey (USGS) between November 17, 2016, and May 28, 2018. The terrain model was supplemented with survey data collected by Parkhill in May 2025. This survey data was limited to the upstream and downstream invert elevations of 15 of 16 stormwater culverts. The 16th culvert, the 8.5-foot culvert beneath Runway 3-21, was only partially surveyed due to conditions of the pipe and surrounding areas. The upstream invert was surveyed, however the downstream invert was calculated based on the headwall elevation.

Figure 4 shows the stormwater culverts evaluated in the StormWise 1D model. These culvert locations remain the same for the existing and recommended scenarios.

Generally, stormwater flows southwest from Watersheds 1, 14, 16, and 18. Stormwater also flows generally northeast from Watersheds 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15 and 17 until it reaches Watershed 13. Flow from the airport generally goes northeast in Watershed 13, however flow from the rest of Watershed 13 generally flows south-southwest.



Figure 4: AIRPORT DRAINAGE PIPE MAP

3.2 SOILS

The hydrologic soil groups used in the analysis were provided by the Web Soil Survey, WSS. The watersheds were inputted into the website, and the soil types were exported and used in AutoCAD Civil 3D to delineate the areas of interest. See APPENDIX B for the WSS reports.

3.3 LAND USE

The specific land use for each watershed was delineated by hand using visual information and descriptions. The descriptive information was taken from the Texas Department of Transportation (TxDOT) Hydraulic Design manual to obtain Curve Numbers (CN) used in our analysis. Table 1 shows the CNs used based upon cover type and hydrologic soil group. The composite CN for each watershed was calculated and is additionally summarized in Table 2. A breakdown for how each CN was calculated can be found in APPENDIX C.

Table 1: TXDOT CURVE NUMBERS

COVER TYPE	HYDROLOGIC CONDITION	HYDROLOGIC SOIL GROUP	
		C	D
IMPERVIOUS	-	98	98
INDUSTRIAL	-	91	93
1 ACRE	-	79	84
OPEN SPACE	POOR	86	-
	GOOD	-	80
HERBACEOUS	POOR	87	93
	FAIR	81	89
	GOOD	74	85
OAK-ASPEN	POOR	74	79
	FAIR	57	63
	GOOD	41	48

Table 2: CURVE NUMBER BREAKDOWN

WATERSHED	AREA (AC)	COMPOSITE CN
1	6.424	91
2	3.518	86
3	2.149	87
4	7.179	88
5	3.302	92
6	5.826	87
7	5.157	88
8	8.225	92
9	4.052	92
10	4.924	94
11	4.140	82
12	35.829	88
13	953.400	81
14	1.783	86
15	2.945	87
16	2.136	89
17	3.571	82
18	21.730	92

3.4 TIME OF CONCENTRATION

The time of concentration (Tc) for each watershed was determined using methods outlined in the TXDOT Hydraulic Design Manual. Different approved methods were applied based on the characteristics of each drainage area. Where calculated values were below TXDOT's minimum allowable threshold, a minimum Tc of 10 minutes was used in accordance with the manual.

A summary of the final Tc values for all watersheds is provided in Table 3, with detailed calculations included in APPENDIX D. These Tc values represent how quickly runoff from each watershed reaches the drainage system and directly influence the estimated peak flow rates used in the design. Watersheds with shorter response times can contribute to higher peak flows, which is an important consideration in evaluating the overall performance of the proposed drainage improvements.

Table 3: TIME OF CONCENTRATION

WATERSHED	TIME OF CONCENTRATION (Tc) (MIN)
1	21.98
2	13.30
3	10.00
4	22.74
5	10.00
6	11.06
7	11.82
8	16.89
9	11.71
10	12.00
11	32.30
12	35.10
13	224.67
14	10.14
15	10.00
16	10.00
17	10.00
18	20.00

4.0 DRAINAGE SYSTEM ANALYSIS MODEL - STORMWISE 1D

The modeling software StormWise was used to model the stormwater culvert system. The following are several of the main input types utilized to show how flow was conveyed throughout the model. Refer to APPENDIX E for more detailed information regarding modeling.

4.1 NODES

STAGE AREA NODES

Due to the storm system being modeled in 1D, the inlets and outlets of culverts were modeled using Stage/Area nodes. The tables within these nodes represent the storage area directly around the node, since the 1D model does not read the terrain and the information needs to be manually input.

TIME/STAGE NODES

Time Stage nodes are used to represent the outlet flow from a culvert that immediately exits the model. The node representing the outflow of the failing pipe also includes a Warning/Alert Stage to notify if the water exceeds the elevation that is input. This modification is in place to ensure that there is no water pooling on the pavement since it is a runway, this is to follow along with Federal Aviation Administration, FAA, standards. For the failing pipe, in both the existing and proposed scenarios the Warning and Alert stages were not an issue as the pipe is adequately sized. In the existing scenario other pipes did set off these alerts as they are undersized.

4.2 LINKS

The following shows the use of the link types in the model. Reference APPENDIX E for more information regarding StormWise 1D model inputs.

CHANNEL LINKS

Channel Links are used to model the channelized flow from one area to another.

WEIR LINKS

Weir Links are used to model overland flow that is not channelized.

PIPE LINKS

Pipe Links are used to model the culverts that are on the site.

5.0 PROPIPE PIPE INSPECTION

Parkhill utilized ProPipe to complete an internal pipe inspection on 13 of 16 existing drainage pipelines. Model Pipe 13 (Rwy 3-21 Pipeline) was not inspected due to the terrain around the pipeline and inaccessibility of ProPipe Equipment. Additionally, Model Pipes 15 and 16 were identified after the initial inspection scope was established and were therefore not included in the inspection effort. The inspection included the cleaning of the existing pipelines and videoing of the inside of the pipeline via a remote-controlled vehicle equipped with a 360-degree camera. Images of the inside of each pipe can be found in APPENDIX G. The images were unfolded to allow the viewing of the pipe invert. Upon Request, Parkhill can provide images split at the invert to allow complete viewing of the top of the pipe.

ProPipe's report uses a different nomenclature than the model developed by Parkhill. A figure of the nomenclature used by ProPipe can be found in APPENDIX G. Parkhill's evaluation of ProPipes inspection concluded that 7 of the 13 pipes inspected are in need of replacement. Three of which, Parkhill Model Pipe 12, 9, and 10, are in need of immediate replacement. The remaining pipes, Model Pipe No. 2, 4, 8, and 7, should be monitored and replaced as needed. The condition of Model Pipe 8 was unable to be determined because there are powerlines going through the existing pipe.

Below in Table 4 is Parkhill's recommended order of replacement. Pipes underneath runways were given precedence over pipes under taxiways in instances where similar pipe conditions were found.

Table 4: RECOMMENDED PIPE REPLACING ORDER DUE TO CONDITION

PRIORITY NUMBER	MODEL PIPE #	PROPIPE PIPE #	REPLACEMENT JUSTIFICATION
1	13	NOT SURVEYED	FAILING
2	12	8	PIPE CONDITION - HOLE (SOIL VISIBLE) AND DEFORMED EDGE
3	9	2	PIPE CONDITION - LINING DETACHED AND SEALING RING HANGING
4	10	1	PIPE CONDITION - ROOTS FINE JOINT, LINING DETACHED, AND SEALING RING HANGING
5	2	UNKNOWN 2	PIPE CONDITION - LONGITUDINAL CRACK X 2 AND ROOTS FINE JOINT
6	4	7	PIPE CONDITION - DEBRIS AND SETTLED DIRT
7	8	4	PIPE CONDITION UNKNOWN - POWERLINES IN PIPE
8	7	3	-
9	6	5	-
10	5	9	-
11	1	10	-
12	11	UNKNOWN	-
13	3	6	-
14	14	11	-
15	15	NOT SURVEYED	-
16	16	NOT SURVEYED	-

Additionally see APPENDIX H, APPENDIX I, and APPENDIX J for additional reports provided by ProPipe.

5.1 PIPE REPAIR RECOMMENDATIONS

In the event a project for the replacement of Model Pipe #12, 9 or 10 cannot be programmed within the next two to three years, below are possible repair methods that may be used to extend the pipeline's service life. Each of these recommendations are eligible for partial reimbursement through TxDOT Aviation's Routine Airport Maintenance Program (RAMP).

Model Pipe 12

Condition: Hole (Soil Visible) and Deformed Edge

Defect Location: 5-FT and 39-FT

Recommended Repair Options:

- Patch Repair
- Pipe Coatings
- Cured In-Place Pipe

Model Pipe 9

Condition: Sealing Ring Hanging and Lining Detached

Defect Location: 2-FT and 4-FT

Recommended Repair Options:

- Patch Repair
- Pipe Coatings
- Cured In-Place Pipe

Model Pipe 10

Condition: Roots Fine Joint, Lining Detached, and Sealing Ring Hanging

Defect Location: 4.5-FT, 22-FT, and 61-FT

Recommended Repair Options:

- Patch Repair
- Pipe Coatings
- Cured In-Place Pipe

Model Pipe 2

Condition: Roots Fine Joint and Longitudinal Crack x 2

Defect Location: 43-FT and 192-FT, Both cracks in same approximate location on opposite sides of pipe

Recommended Repair Options:

- Pipe Coatings
- Cured In-Place Pipe

Model Pipe 8

Condition: Pipe Condition Unknown – Powerlines in Pipe

The powerlines obstructing the pipe prevent a complete inspection at this time. Removal or relocation of the lines will be required to allow further investigation and evaluation of the pipe. Following this assessment, the feasibility of potential repair options can be determined based on the observed condition.

The estimated life expectancy of repair options can vary depending on the selected method and existing pipe conditions. Patch repairs are typically considered a short-term, lower-cost solution intended to address localized defects until a more extensive repair or full replacement can be completed. Pipe Coating repairs generally have an estimated life expectancy of 30 to 70 years, while Cured-In-Place Pipe (CIPP) repairs typically have an estimated life expectancy of 50 to 80 years. While these methods can significantly extend

the service life of existing pipelines, they are not typically considered permanent solutions and are often used to extend system functionality while a long-term solution is evaluated or funding becomes available.

6.0 RESULTS

6.1 EXISTING PIPE SIZING

Graham Municipal Airport's existing drainage system is summarized in Table 5. The existing system is of varying pipe sizes and materials.

Table 5: EXISTING PIPE SIZING

EXISTING PIPE SIZING				
MODEL PIPE #	PROPIPE PIPE #	BARRELS	MATERIAL	PIPE SIZE
1	10	1	CPP	24 IN
2	UNKNOWN 2	1	CPP	24 IN
3	6	1	CPP	24 IN
4	7	2	CPP	24 IN
5	9	1	CMP	18 IN
6	5	2	CMP	24 IN
7	3	1	CMP	24 IN
8	4	1	CMP	12 IN
9	2	1	CPP	12 IN
10	1	1	CPP	12 IN
11	UNKNOWN	1	CPP	18 IN
12	8	2	CMP	24 IN
13	-	1	CMP	102 IN
14	11	1	CPP	18 IN
15	-	1	CPP	12 IN
16	-	1	CPP	12 IN
ALL PIPES ARE CIRCULAR				
CMP = COURRGATED METAL PIPE				
CPP = COURRGATED PLASTIC PIPE				
RCP = REINFORCED CONCRETE PIPE				

6.2 5-YEAR STORM RESULTS

As required by FAA Advisory Circular 150/5320-5D, Section 2-2.4.2, the FAA recommends that the 5-year 24-hour storm event be used to size stormwater pipelines, while allowing no encroachment of runoff on taxiway and runway pavement. Each watershed was evaluated using existing pavement and soil conditions. Table 6 provides recommendations for the pipe size required to convey the design storm event while complying with FAA requirements. Existing pipe sizes, and any recommended increase in the number of pipes were used in lieu of increasing pipe diameter size. Additionally, the pipeline's existing inlet and outlet elevations were used to establish the recommended pipe sizing slope. Full topographic survey of ground cover above pipe was not obtained and it was assumed that minimum pipe sizes were used to establish proper cover between top of pipe and top of pavement section in order to establish existing pipe sizes.

During the design of these pipeline replacements, a licensed professional engineer should evaluate and recommend improvements to the watershed and pipeline slope to optimize the size or number of pipes required while still maintaining the requirements of all pertinent FAA Advisory Circulars.

It is understood that there are possible improvements to be made to Watershed 10 and Watershed 18. Based upon the planned improvements, changes to the watershed were considered and the following pipe sizes are recommended to be increased prior to the completion of these improvements.

Table 6: 5-YEAR 24-HOUR RECOMMENDED PIPE SIZING

PROPOSED 5-YEAR 24-HOUR PIPE SIZING					
MODEL PIPE #	PROPIPE PIPE #	BARRELS	MATERIAL	PIPE SIZE	CHANGE FROM EXISTING TO 5-YR 24-HR
1	10	1	CPP	24 IN	NO CHANGE
2	UNKNOWN 2	1	CPP	24 IN	NO CHANGE
3	6	1	CPP	24 IN	NO CHANGE
4	7	2	CPP	24 IN	NO CHANGE
5	9	1	RCP	18 IN	CMP TO RCP
6	5	4	RCP	24 IN	CMP TO RCP, 2 TO 4 - 24" PIPES
7	3	7	RCP	24 IN	CMP TO RCP, 1 TO 7 - 24" PIPES
8	4	7	RCP	12 IN	CMP TO RCP, 1 TO 7 - 12" PIPES
9	2	3	RCP	12 IN	CPP TO RCP, 1 TO 3 - 12" PIPES
10	1	2	RCP	12 IN	CPP TO RCP, 1 TO 2 - 12" PIPES
11	UNKNOWN	1	CPP	18 IN	NO CHANGE
12	8	3	RCP	24 IN	CMP TO RCP, 2 TO 3 - 24" PIPES
13	-	1	RCP	102 IN	CMP TO RCP
14	11	1	CPP	18 IN	NO CHANGE
15	-	1	CPP	12 IN	NO CHANGE
16	-	1	CPP	12 IN	NO CHANGE
ALL PIPES ARE CIRCULAR					
CMP = COURRGATED METAL PIPE					
CPP = COURRGATED PLASTIC PIPE					
RCP = REINFORCED CONCRETE PIPE					

6.3 100-YEAR STORM RESULTS

FAA Advisory Circular 150/5320-5D, Section 2-2.4.2, indicates that storm events greater than the 5-year event may not be warranted as the increased cost does not warrant the need. In an effort to provide a full evaluation of the existing system, below are the required pipe sizes and number of pipes in order to convey a 100-year 24-hour storm event to prevent the encroachment of runoff onto the airfield runways and taxiways.

Table 7: 100-YEAR 24-HOUR PROPOSED PIPE SIZING

PROPOSED 100-YEAR 24-HOUR PIPE SIZING					
MODEL PIPE #	PROPIPE PIPE #	BARRELS	MATERIAL	PIPE SIZE	CHANGE FROM 5-YR 24-HR TO 100-YR 24-HR
1	10	1	CPP	24 IN	NO CHANGE
2	UNKNOWN 2	1	CPP	24 IN	NO CHANGE
3	6	1	CPP	24 IN	NO CHANGE
4	7	2	CPP	24 IN	NO CHANGE
5	9	2	RCP	18 IN	1 TO 2 - 18" PIPES
6	5	7	RCP	30 IN	4 - 24" PIPES TO 7 - 30" PIPES
7	3	11	RCP	30 IN	7 - 24" PIPES TO 11 - 30" PIPES
8	4	17	RCP	12 IN	7 TO 17 - 12" PIPES
9	2	12	RCP	12 IN	3 TO 12 - 12" PIPES
10	1	2	RCP	12 IN	NO CHANGE
11	UNKNOWN	1	CPP	18 IN	NO CHANGE
12	8	4	RCP	30 IN	3 - 24" PIPES TO 4 - 30" PIPES
13	-	1	RCP	102 IN	NO CHANGE
14	11	1	CPP	18 IN	NO CHANGE
15	-	1	CPP	12 IN	NO CHANGE
16	-	1	CPP	12 IN	NO CHANGE
ALL PIPES ARE CIRCULAR					
CMP = COURRGATED METAL PIPE					
CPP = COURRGATED PLASTIC PIPE					
RCP = REINFORCED CONCRETE PIPE					

7.0 SUMMARY AND CONCLUSION

This drainage study utilized a 1D StormWise hydraulic model to evaluate existing conditions and proposed improvements to the stormwater conveyance system at RPH. The model incorporated watershed delineation, soil and land use data, time of concentration calculations, surveyed culvert elevations, and NOAA Atlas 14 rainfall data to simulate the 5-year 24-hour and 100-year 24-hour storm events.

Results indicate that several existing culverts are undersized or structurally deficient under current conditions. Proposed pipe replacements demonstrate improved hydraulic performance, conveying design storm runoff without overtopping adjacent pavements, runways, or taxiways in accordance with FAA Advisory Circular AC 150/5320-5D.

Table 8, below, provides a prioritized list of pipeline replacement and reasoning. The most urgent is Pipeline 13, due to its failing condition. Pipelines from Priority 2 through 9 should be replaced as soon as a Capital Improvement Plan (CIP) project can be programmed for their replacement or within a CIP project that involves the rehabilitation or reconstruction of the pavement above the pipeline. The remaining pipelines may be replaced in a similar fashion to those with higher priority or may be a stand-alone project as the need for their replacement arises.

Table 8: EOPC OVERVIEW

Priority Number	Model Pipe #	ProPipe #	Main Reason for Pipe Replacement	Cost Estimate
1	13	-	Condition - Failing	$4,903,840
2	12	8	Condition & Insufficient Pipe Sizing	$339,595
3	9	2	Condition & Insufficient Pipe Sizing	$288,670
4	10	1	Condition & Insufficient Pipe Sizing	$220,450
5	2	UNKNOWN 2	Condition	$244,480
6	4	7	Condition	$261,260
7	8	4	Condition Unknown & Insufficient Pipe Sizing	$305,925
8	7	3	Insufficient Pipe Sizing	$979,770
9	6	5	Insufficient Pipe Sizing	$232,070
10	5	9	Change Material	$196,450
11	1	10	Age of pipe*	$230,970
12	11	UNKNOWN	Age of pipe*	$206,150
13	3	6	Age of pipe*	$243,370
14	14	11	Age of pipe*	$202,180
15	15	-	Age of pipe*	$191,290
16	16	-	Age of pipe*	$175,860
Total Cost for All Pipe Replacements				$9,222,330
* Pipe replacement is not currently urgent, replace when updates to taxiway/runway are made				

Special consideration of Pipeline 7 and Pipeline 8 was provided. Pipeline 7 crosses Runway 18-36, diagonally and is undersized. Additionally, Pipeline 8, which moves stormwater from Watershed 8 into Watershed 7, before draining into Watershed 13, is also undersized. The triangular basin created between the runway and taxiways may be modified to allow Pipeline 8 to be reoriented to underneath Runway 18-36. This could reduce the stormwater flow entering Watershed 7 therefore possibly reducing the required seven, 24-inch pipes to two, 24-in pipes. Additionally Pipe 8 would possibly be reduced from seven, 12-inch pipes to three, 18-inch pipes.

Improvements are anticipated within Watershed 10 and Watershed 18. Potential improvements may include modifications that affect surface conditions, such as paving or construction of new hangar facilities, which could alter runoff characteristics and soil permeability. For any project within these watersheds, a Licensed Professional Engineer should evaluate existing watershed flow conditions and assess the potential impacts of proposed improvements on both the subject watershed and downstream watersheds.

Within Watershed 18, stormwater runoff generally flows in two primary directions. The northern portion west of the terminal building generally drains to the west, while the northwestern portion adjacent to Taxiway E generally drains to the north. In both cases, stormwater appears to exit airport property and discharge onto properties adjacent to Corporate Drive.

If development occurs within Watershed 18, the engineer responsible for facility design should evaluate post-development flow patterns. Improvements should, where feasible, redirect stormwater into watersheds that do not directly impact adjacent landowners. If runoff is redirected south into Watersheds 11 or 14, an evaluation should be conducted to confirm that the existing drainage infrastructure can accommodate the additional runoff and still comply with Advisory Circular 150/5320-5, latest edition.

Pipeline 14 currently appears to function as an equalization pipe between Watershed 1 and Watershed 14, as its invert elevation is not located at a low point within either watershed. Proposed improvements should consider resizing Pipe 14 and/or Pipe 1, or increasing the capacity of the drainage channel north of Taxiway E, as necessary to accommodate revised flow conditions.

The potential resizing of the drainage channel south of the Pierce Hangar was not addressed in this report. This channel is directly influenced by the current capacities of Pipe 6 and Pipe 7. Any project that modifies Pipe 6 and/or Pipe 7 should include an evaluation of the downstream drainage channel capacity and the outfall area to ensure that the Pierce Hangar remains protected if runoff to this area increases.

An Engineers Opinion of Probable Cost (EOPC) is provided for each pipe replacement in APPENDIX K. A brief overview of the EOPCs are also provided in Table 8. Each EOPC contains a cost for pavement repair, assuming each pipeline would need to be replaced outside of a CIP project. Upon inclusion of a CIP project, the cost of the pavement repair may be removed, if applicable

APPENDIX A FEMA INFORMATION

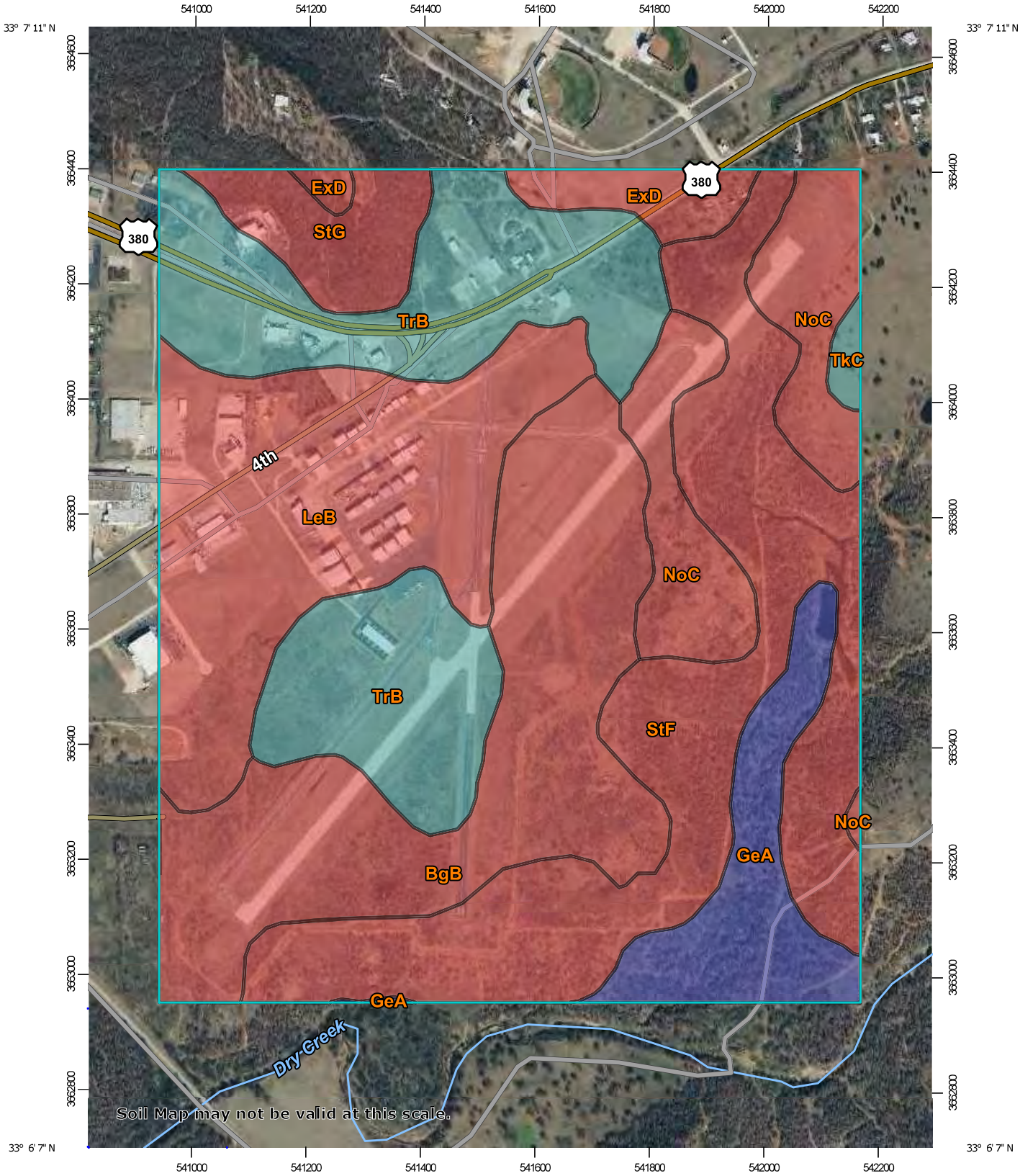
The section of Runway 3-21 where the currently failing culvert is, is the only section of the study area in Flood Zone A according to FEMA's National Flood Hazard Layer, NFHL, Viewer. However, according to the Viewer the center area of the stream on the downstream end of the main culvert also includes Flood Zone AE. This information is also in FEMA FIRM Map 48503C0460E effective 7/18/2011.



NFHL MAP FROM FEMA

APPENDIX B WEB SOIL SURVEY RESULTS

Hydrologic Soil Group—Young County, Texas
(Airport_Subcatchment_Soils)



Map Scale: 1:9,500 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 100 200 400 600

Feet: 0 450 900 1800 2700

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Young County, Texas
Survey Area Data: Version 21, Aug 30, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 26, 2021—Jan 29, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
BgB	Bluegrove fine sandy loam, 1 to 3 percent slopes	D	86.9	19.7%
ExD	Exray-Loving complex, 1 to 8 percent slopes, extremely stony	D	10.5	2.4%
GeA	Gowen loam, 0 to 1 percent slopes, occasionally flooded	B	27.9	6.3%
LeB	Leeray clay, 1 to 3 percent slopes	D	79.8	18.1%
NoC	Newcastle-Jolly complex, 1 to 5 percent slopes	D	35.8	8.1%
StF	Shatruce gravelly fine sandy loam, 8 to 30 percent slopes, rubbly	D	97.2	22.1%
StG	Shatruce gravelly sandy loam, 12 to 50 percent slopes, very rubbly	D	16.1	3.7%
TkC	Throck silty clay loam, 1 to 5 percent slopes	C	2.1	0.5%
TrB	Truce fine sandy loam, 1 to 3 percent slopes	C	83.8	19.0%
Totals for Area of Interest			**440.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

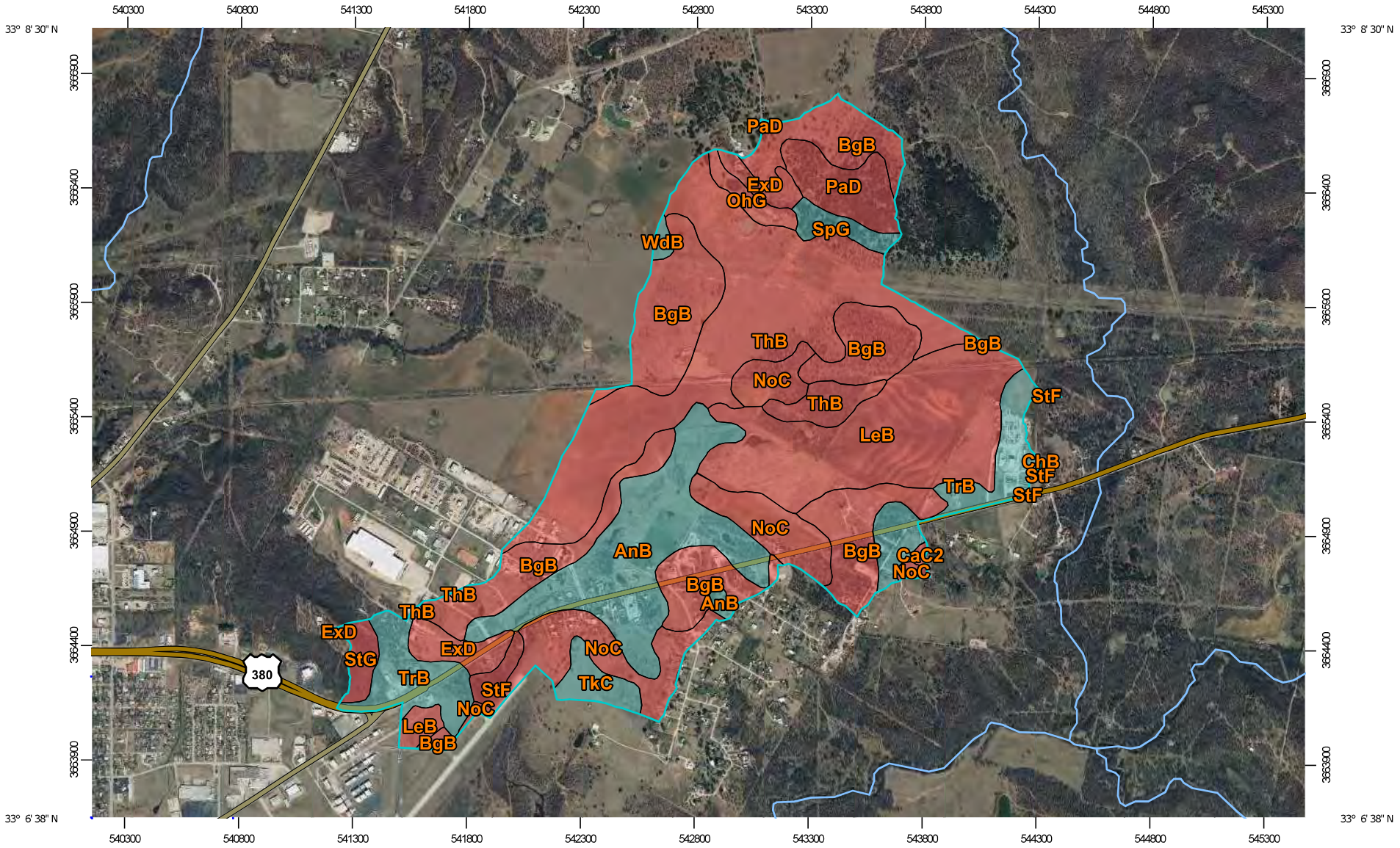
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Young County, Texas
(Large_Watershed)



Map Scale: 1:24,300 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 350 700 1400 2100

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Soil Rating Lines

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Soil Rating Points

A
A/D
B
B/D
C
C/D
D
Not rated or not available

Water Features

Streams and Canals

Transportation

Rails
Interstate Highways
US Routes
Major Roads
Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Young County, Texas
Survey Area Data: Version 21, Aug 30, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 26, 2021—Jan 29, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AnB	Anocon fine sandy loam, 1 to 3 percent slopes	C	113.9	11.9%
BgB	Bluegrove fine sandy loam, 1 to 3 percent slopes	D	218.3	22.9%
CaC2	Callahan loam, 2 to 5 percent slopes, moderately eroded	D	1.2	0.1%
ChB	Chaney loamy fine sand, 0 to 3 percent slopes	C	0.1	0.0%
ExD	Exray-Loving complex, 1 to 8 percent slopes, extremely stony	D	24.0	2.5%
LeB	Leeray clay, 1 to 3 percent slopes	D	146.0	15.3%
NoC	Newcastle-Jolly complex, 1 to 5 percent slopes	D	88.5	9.3%
OhG	Owens-Harpersville complex, 8 to 45 percent slopes, extremely bouldery	D	9.4	1.0%
PaD	Palopinto very stony clay loam, 1 to 8 percent slopes, rubbly	D	30.0	3.1%
SpG	Set-Palopinto complex, 8 to 40 percent slopes, extremely stony	C	11.1	1.2%
StF	Shatruce gravelly fine sandy loam, 8 to 30 percent slopes, rubbly	D	8.9	0.9%
StG	Shatruce gravelly sandy loam, 12 to 50 percent slopes, very rubbly	D	10.2	1.1%
ThB	Thurber clay loam, 1 to 3 percent slopes	D	201.2	21.1%
TkC	Throck silty clay loam, 1 to 5 percent slopes	C	14.5	1.5%
TrB	Truce fine sandy loam, 1 to 3 percent slopes	C	73.2	7.7%
WdB	Markley fine sandy loam, 1 to 3 percent slopes	C	2.9	0.3%
Totals for Area of Interest			**953.6**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

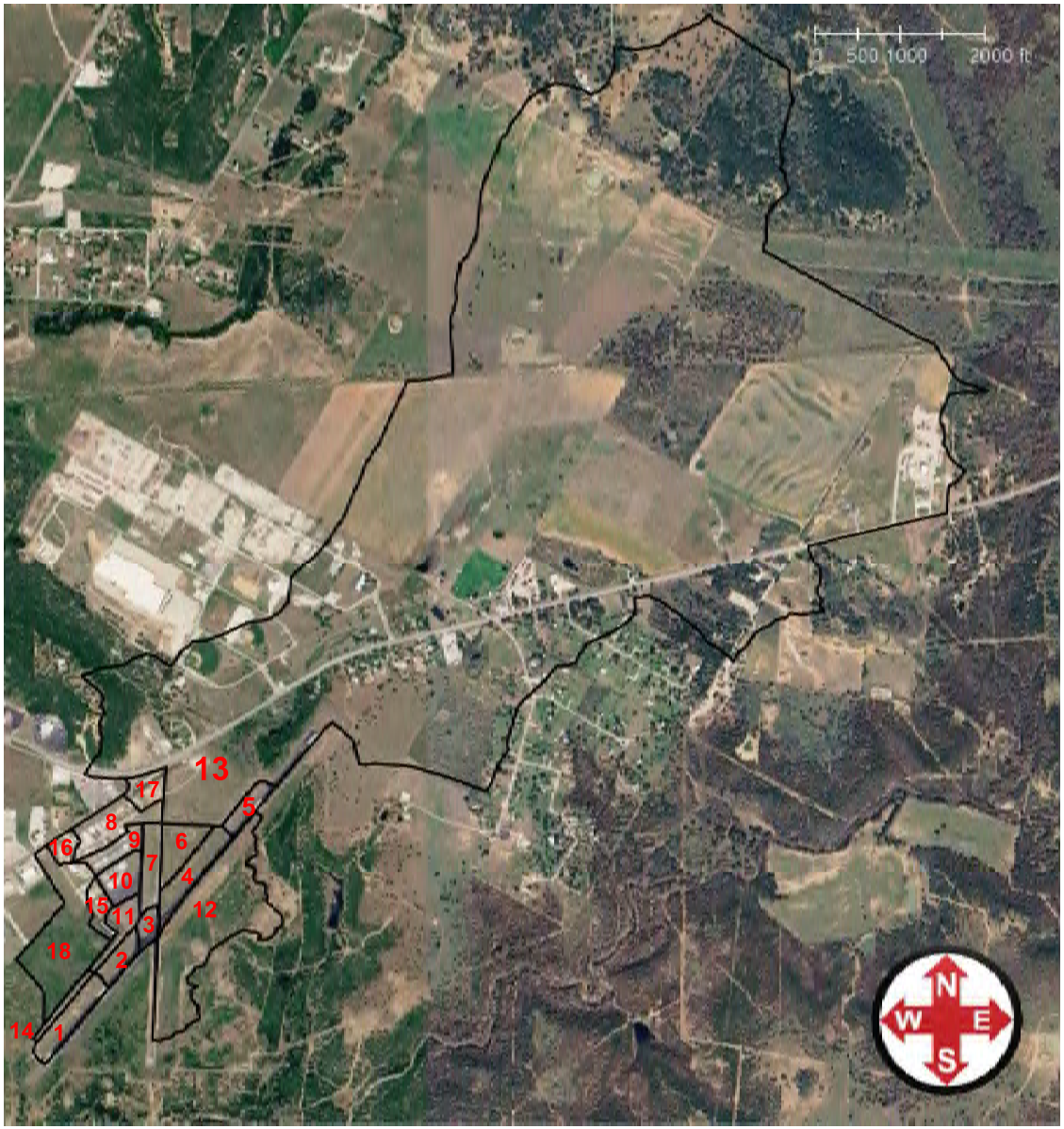
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX C CURVE NUMBER CALCULATIONS

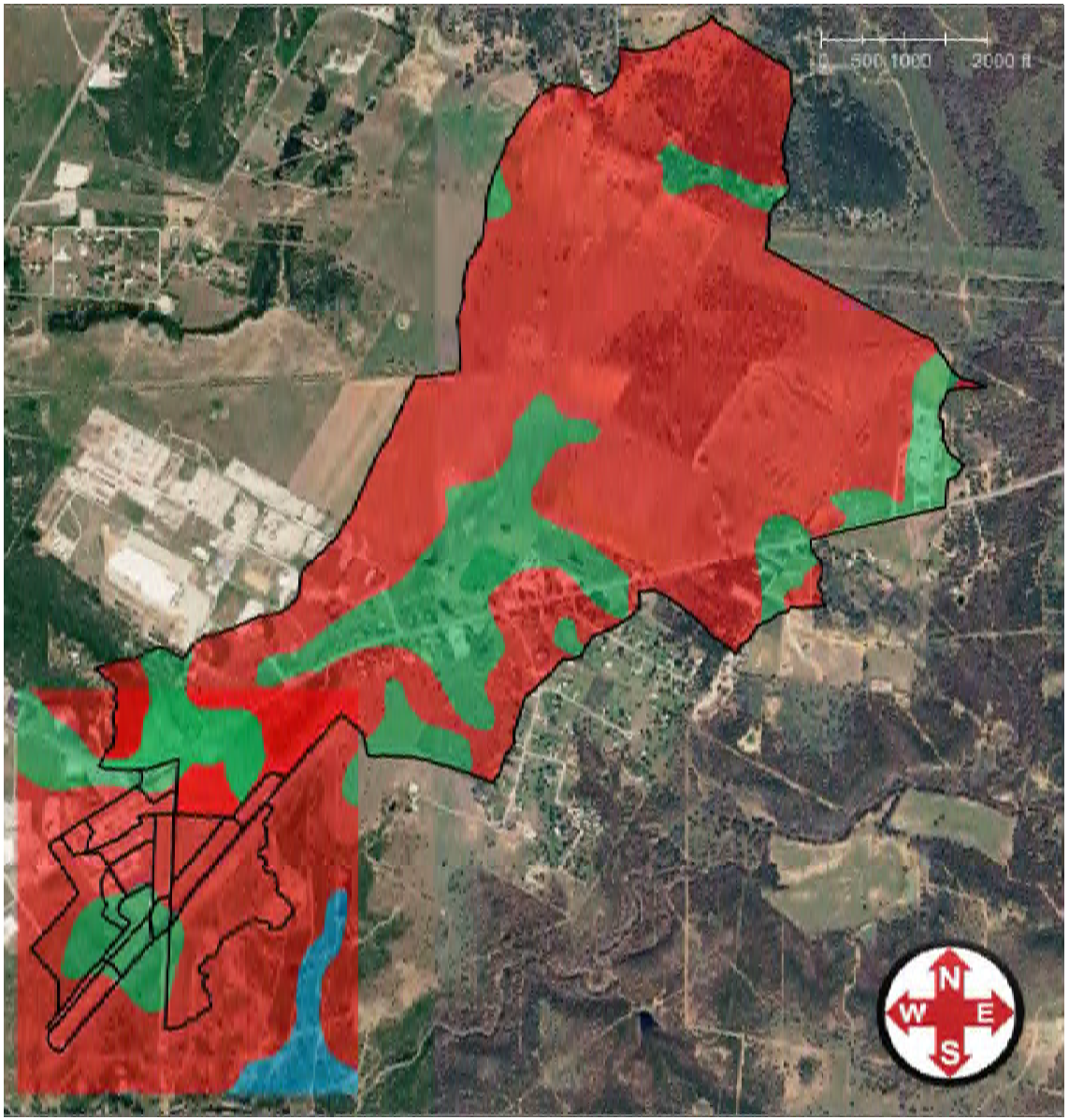


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

WATERSHED MAP

Parkhill

407201-24
C



HYDROLOGIC SOIL GROUP LEGEND	
COLOR	HSG
	B
	C
	D

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

HYDROLOGIC SOIL GROUP MAP

Parkhill

40701-24
C

Watershed 1				
Impervious C Area	Herb - FAIR - C	Impervious D Area	Herb - FAIR - D	
68641.86	23046.87	3877.08 2906.51	181365.12	
68641.86	23046.87	6783.60	181365.12	279837.45
1.58	0.53	0.16	4.16	6.42
98	81	98	89	
154.43	42.86	15.26	370.56	583.10
			CN =	91

Watershed 2				
Impervious C Area	Herb - FAIR - C	Impervious D Area	Soil D Area	
43826.68	109432.91	0	0	
43826.68	109432.91	-	-	153259.59
1.01	2.51	-	-	3.52
98	81	-	-	
98.60	203.49	-	-	302.09
			CN =	86

Watershed 3				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
40279.98	38926.53	7696.04	6710.84	
40279.98	38926.53	7696.04	6710.84	93613.38
0.92	0.89	0.18	0.15	2.15
98	74	98	85	
90.62	66.13	17.31	13.10	187.16
			CN =	87

Watershed 4				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
8388.66	1422.34	73400.08	229494.95	
8388.66	1422.34	73400.08	229494.95	312706.04
0.19	0.03	1.69	5.27	7.18
98	74	98	85	
18.87	2.42	165.13	447.82	634.24
			CN =	88

Watershed 5				
Impervious C Area	Soil C Area	Impervious D Area	Herb - FAIR - D	
0.00	0.00	51723.60	92120.05	
-	-	51723.60	92120.05	143843.65
-	-	1.19	2.11	3.30
-	-	98	89	
-	-	116.37	188.22	304.58
			CN =	92

Watershed 6				
Impervious C Area	Soil C Area	Impervious D Area	Herb - GOOD - D	
0.00	0.00	30639.80	223124.43	
-	-	30639.80	223124.43	253764.23
-	-	0.70	5.12	5.83
-	-	98	85	
-	-	68.93	435.39	504.32
			CN =	87

Watershed 7				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
7447.36	2603.06	54380.92	160219.01	
7447.36	2603.06	54380.92	160219.01	224650.36
0.17	0.06	1.25	3.68	5.16
98	74	98	85	
16.75	4.42	122.34	312.64	456.16
			CN =	88

Watershed 8				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
1717.90	1732.01	16834.32	87636.09	
		25219.97	28764.92	
		56788.91	1049.12	
		44321.21	41697.51	
		881.06	694.50	
		1505.06	486.95	
		1699.04	665.94	
		1408.06	907.89	
		1444.94	3269.37	
		29734.35	1092.85	
			6678.50	
			1503.32	
			527.94	
1717.90	1732.01	179836.92	174974.90	358261.73
0.04	0.04	4.13	4.02	8.22
98	74	98	85	
3.86	2.94	404.59	341.43	752.83
			CN =	92

Watershed 9				
Impervious C Area	Soil C Area	Impervious D Area	Herb - GOOD - D	
0.00	0.00	64983.16	594.30	
		18689.84	7843.80	
		1368.31	2076.07	
		7729.42	36904.59	
		2524.55	32152.20	
		1619.68		
-	-	96914.96	79570.96	176485.92
-	-	2.22	1.83	4.05
-	-	98	85	
-	-	218.04	155.27	373.31
			CN =	92

Watershed 10				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
15678.42	0	94177.88	61090.69	
		39948.53	3615.01	
15678.42	0.00	134126.41	64705.70	214510.53
0.36	0.00	3.08	1.49	4.92
98	74	98	85	
35.27	0.00	301.75	126.26	463.29
			CN =	94

Watershed 11				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
56436.87	115076.97	473.97	0	
6049.95	519.06			
	441.37			
	481.65			
	467.35			
	401.82			
62486.82	117388.22	473.97	0.00	180349.01
1.43	2.69	0.01	0.00	4.14
98	74	98	85	
140.58	199.42	1.07	0.00	341.07
			CN =	82

Watershed 12						
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - POOR D	Herb - FAIR - D	Herb - GOOD - D	
20299.83	95004.65	5558.43	139363.48	301924.93	393188.05	
		54939.45		550442.93		
20299.83	95004.65	60497.88	139363.48	852367.86	393188.05	1560721.75
0.47	2.18	1.39	3.20	19.57	9.03	35.83
98	74	98	93	89	85	
45.67	161.39	136.11	297.54	1741.52	767.24	3149.47
					CN =	88

	Watershed 13																			
	Open Space - C	Open Space - D	Impervious - C	Imperviou s - D	1 Acre - C	1 Acre - D	Industrial - C	Industrial - D	Herb - POOR - C	Herb - FAIR - C	Herb - GOOD - C	Herb - POOR - D	Herb - FAIR - D	Herb - GOOD - D	Oak - POOR C	Oak - FAIR - C	Oak - GOOD - C	Oak - POOR D	Oak - FAIR - D	Oak - GOOD - D
	8884.7	664490.5	254.8	90644.7	112570.2	43185.2	100389.5	708887.3	46552.6	35263.8	24996.2	74492.5	644448.7	7488.4	162845.0	161724.8	22657.6	454092.4	94982.0	110436.2
	37927.2	9647.5	2029.8	3480.1	105326.4	58665.1	13585.9	66362.6	16934.5	8900.2	60551.4	143868.2	239495.9	312371.7	239112.2	38541.7		223364.8	73091.9	27723.3
	397.1		28815.2	6679.6	51233.9	636383.7	55.8	133579.8	33886.5	266066.9	234171.3	718302.0	312837.8	35720.7	212996.2	88204.8		437324.6	13965.0	19079.6
			143776.0	46384.1	137505.0	529364.0	544165.0	79.5	224540.7	484814.3	48243.8	770226.1	17327.0	7589.0	349211.4	96064.5		17587.1	318537.8	415381.1
			7592.4	11788.2	20107.6	64478.6	106837.1	330687.1	556727.7	139057.5	392505.1	168272.6	1894.8	2820.3	138405.5	94148.9		309488.9	1441371.1	28287.5
			96852.1	28.6	95759.7	19029.7	39781.9	144.7	90740.7	25342.1	67846.8	140960.4	6562.8	154533.9		17127.2			3374639.1	
			29935.8	3029.0	368.1	15298.8			93482.3	12687.4	58345.5	87284.9	5589.8	775.9		483930.3			635163.3	
			10503.0	22172.7	122356.8	43970.7				191539.5	38992.4	76440.1	74492.3	1041.8					384689.6	
			2304.2	50270.2	106798.3	45294.3				66582.6	14551.5		25339.9	14226.8					1963.2	
			24697.4	70850.9	323094.3	40230.6				6919.8	8396.0		36334.8	17939.4						
			72044.8	2116.2	5804.7	304932.2				140058.2	3340.1		63261.6	580272.4						
			7166.3	721.2	98675.8	293923.3				34904.8	196913.1		3309783.6	105575.7						
			2309.6	8383.9	55899.3					171642.9	245304.1		175756.0	2832134.1						
			1793.7	7330.7	360.8					56723.8	22793.8		299459.1	450.5						
			24063.3	2158.8	2776.3					143019.0			2132236.9	656931.0						
				14218.7	570.2					135257.5			384212.3	1408887.4						
										309574.0			1676681.6	1160889.4						
										35884.4			58917.3	7962.8						
													171519.3							
													282019.3							
TOTALS	47209.1	674138.0	454138.5	340257.5	1239207.4	2094756.1	804815.2	1239741.0	1062864.9	2264238.6	1416951.1	2179846.7	9918170.8	7307611.1	1102570.3	979742.1	22657.6	1441857.7	6338403.0	600907.7
CN	86	80	98	98	79	84	91	93	87	81	74	93	89	85	74	57	41	79	63	48

WATERSHED 13 COMPOSITE CURVE NUMBER =	81

Watershed 14				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
3005.91	14417.64	17056.94	43187.22	
3005.91	14417.64	17056.94	43187.22	77667.71
0.07	0.33	0.39	0.99	1.78
98	74	98	85	
6.76	24.49	38.37	84.27	153.90
			CN =	86

Watershed 15				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
1171.74	18126.67	38080.04	2297.26	
15622.70	27565.32		11969.40	
5967.31	2432.77		2751.28	
	275.84			
	546.24			
	568.74			
	614.23			
	302.16			
22761.75	50431.97	38080.04	17017.94	128291.70
0.52	1.16	0.87	0.39	2.95
98	74	98	85	
51.21	85.67	85.67	33.21	255.76
			CN =	87

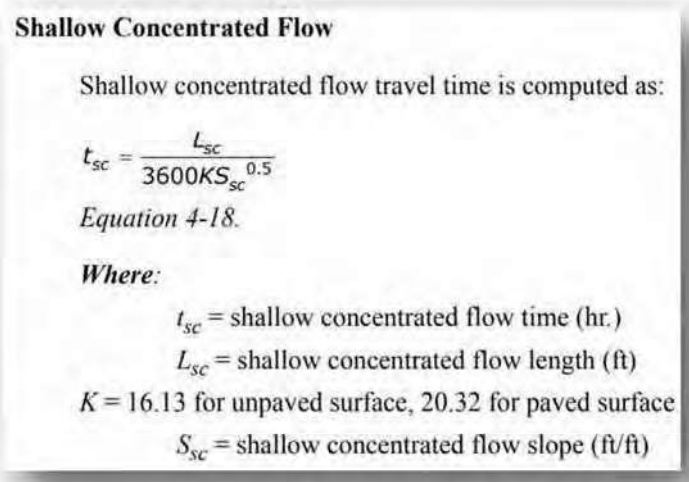
Watershed 16				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
0	0	19622.36	10174.48	
		2404.48	19472.84	
		9619.14	3291.55	
			28440.42	
0.00	0.00	31645.98	61379.29	93025.27
0.00	0.00	0.73	1.41	2.14
98	74	98	85	
0.00	0.00	71.20	119.77	190.97
			CN =	89

Watershed 17				
Impervious C Area	Herb - GOOD - C	Impervious D Area	Herb - GOOD - D	
26452.62	90456.46	11197.68	4701.00	
143.94	3377.98	1167.48	74.60	
1223.96			12772.94	
3998.03				
31818.55	93834.44	12365.16	17548.54	155566.69
0.73	2.15	0.28	0.40	3.57
98	74	98	85	
71.58	159.41	27.82	34.24	293.05
			CN =	82

APPENDIX D TIME OF CONCENTRATION INFORMATION

TIME OF CONCENTRATION

Time of concentration (Tc) was calculated by hand using the NRCS (Natural Resources Conservation Service) method for watersheds 1 through 12 and 14 through 16. Equations for the NRCS Method can be found in the TXDOT manual previously mentioned in Chapter 4, Section 11. The following 4 images show the equations used in the manual. If the calculated Tc was less than 10 minutes, the Tc was changed to 10 minutes to meet the minimum Tc stated in the TXDOT manual mentioned as per Section 12 under Assumptions and Limitations. Watershed 13 was calculated using the Kerby-Kirpich methodology. Equations from the TXDOT manual for Kerby-Kirpich can also be found in Chapter 4, Section 11. The total Tc for each watershed can be found in Table 3 within the report. A breakdown of how the Tc for each watershed was found can be found below the equations.



Shallow Concentrated Flow

Shallow concentrated flow travel time is computed as:

$$t_{sc} = \frac{L_{sc}}{3600KS_{sc}^{0.5}}$$

Equation 4-18.

Where:

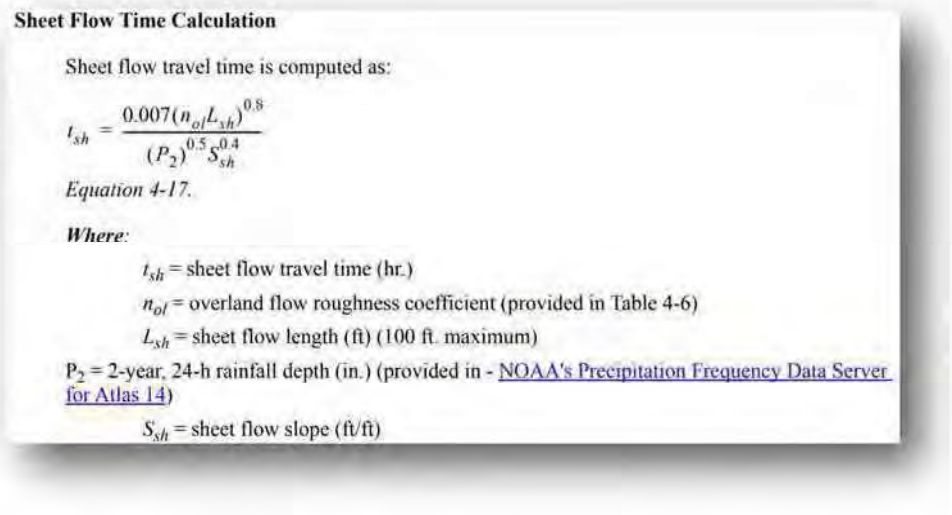
t_{sc} = shallow concentrated flow time (hr.)

L_{sc} = shallow concentrated flow length (ft)

K = 16.13 for unpaved surface, 20.32 for paved surface

S_{sc} = shallow concentrated flow slope (ft/ft)

SHALLOW CONCENTRATED FLOW EQUATION



Sheet Flow Time Calculation

Sheet flow travel time is computed as:

$$t_{sh} = \frac{0.007(n_{ol}L_{sh})^{0.8}}{(P_2)^{0.5}S_{sh}^{0.4}}$$

Equation 4-17.

Where:

t_{sh} = sheet flow travel time (hr.)

n_{ol} = overland flow roughness coefficient (provided in Table 4-6)

L_{sh} = sheet flow length (ft) (100 ft. maximum)

P_2 = 2-year, 24-h rainfall depth (in.) (provided in - NOAA's Precipitation Frequency Data Server for Atlas 14)

S_{sh} = sheet flow slope (ft/ft)

SHEET FLOW EQUATION

The Kerby Method

For small watersheds where overland flow is an important component of overall travel time, the Kerby method can be used. The Kerby equation is

$$t_{ov} = K(L \times N)^{0.467} S^{-0.235}$$

Equation 4-14.

Where:

t_{ov} = overland flow time of concentration, in minutes

K = a units conversion coefficient, in which K = 0.828 for traditional units and K = 1.44 for SI units

L = the overland-flow length, in feet or meters as dictated by K

N = a dimensionless retardance coefficient

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S = the dimensionless slope of terrain conveying the overland flow

THE KERBY METHOD EQUATION

The Kirpich Method

For channel-flow component of runoff, the Kirpich equation is:

$$t_{ch} = KL^{0.770} S^{-0.385}$$

Equation 4-15.

Where:

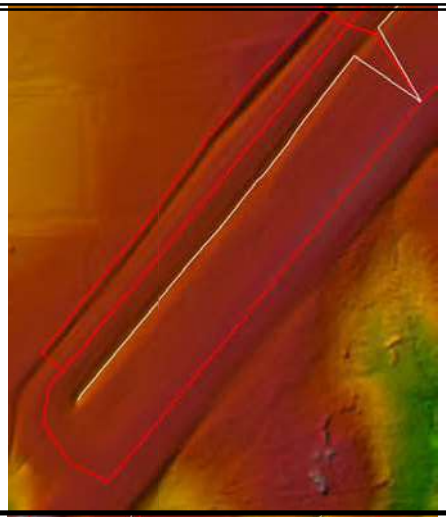
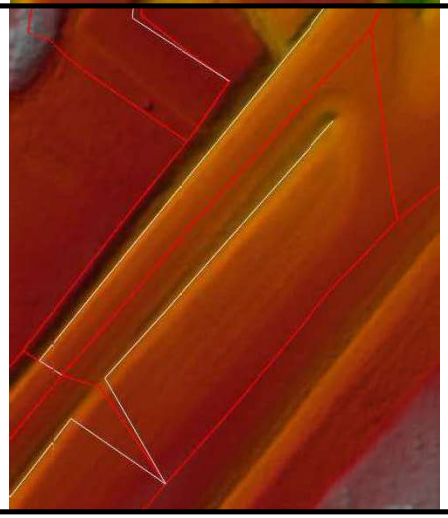
t_{ch} = the time of concentration, in minutes

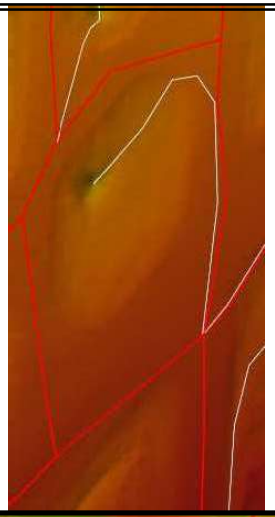
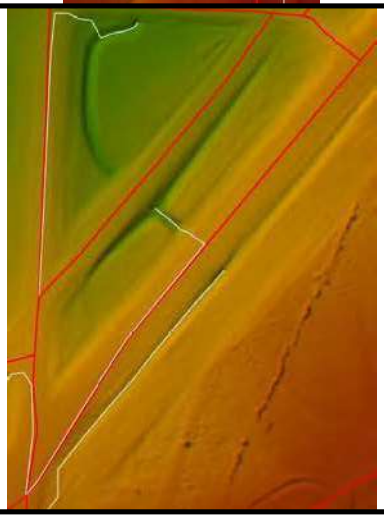
K = a units conversion coefficient, in which K = 0.0078 for traditional units and K = 0.0195 for SI units

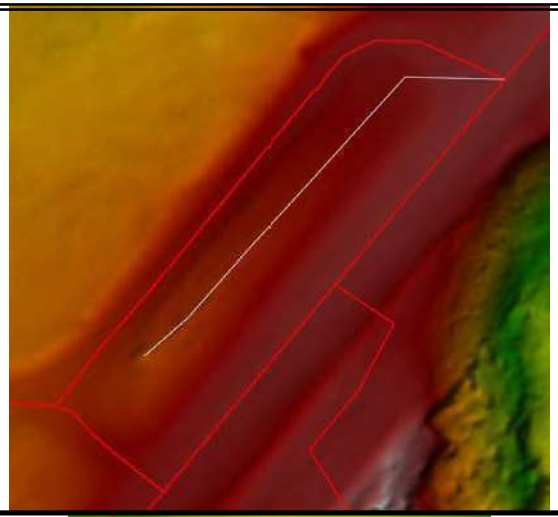
L = the channel flow length, in feet or meters as dictated by K

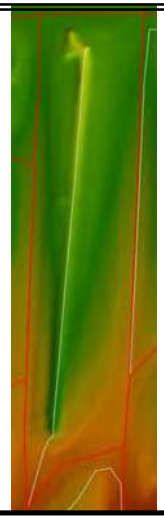
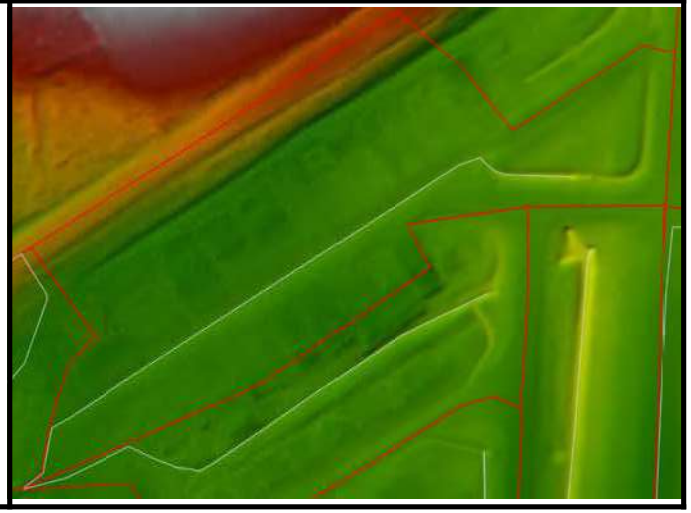
S = the dimensionless main-channel slope

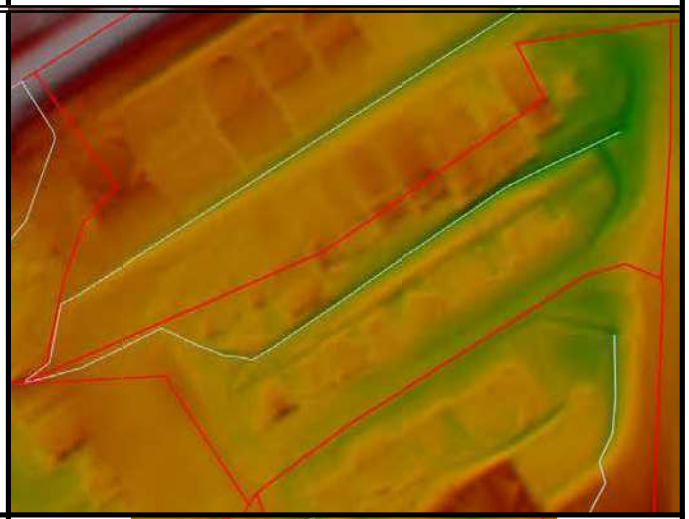
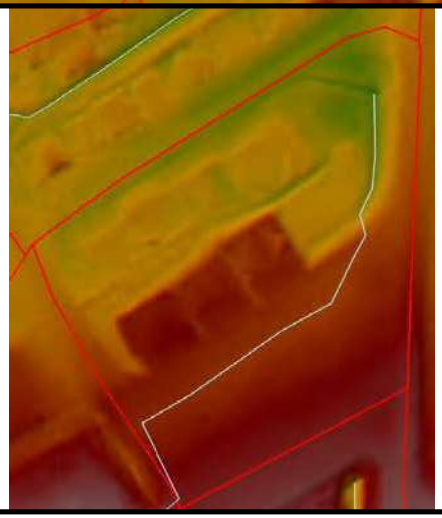
THE KIRPICH METHOD EQUATION

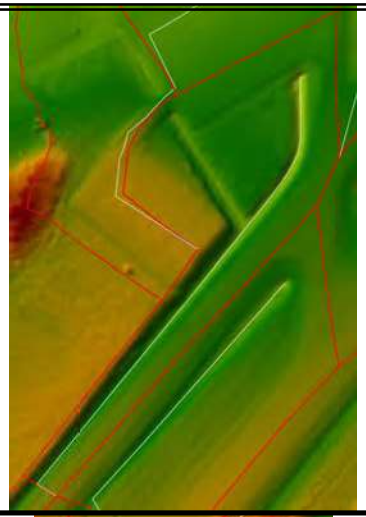
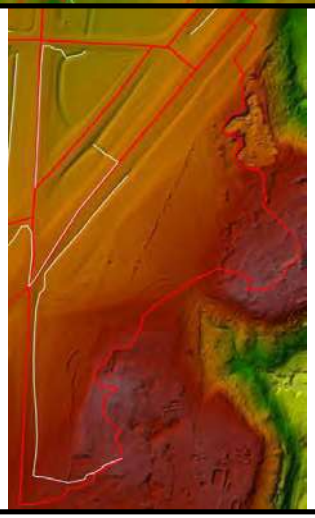
TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
1	
2	

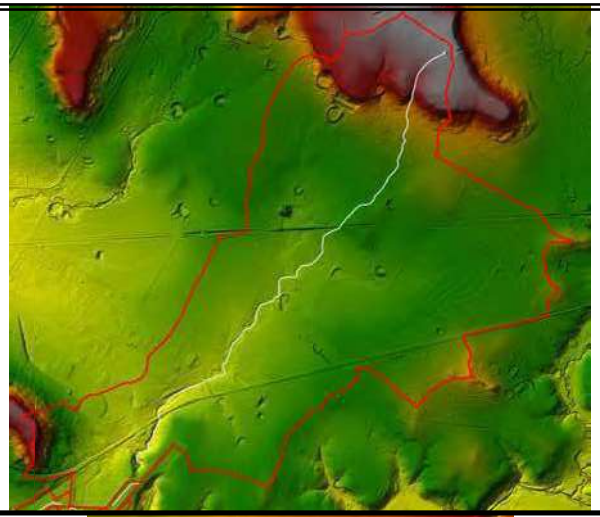
TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
3	
4	

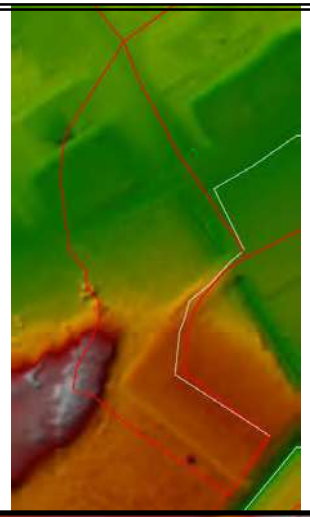
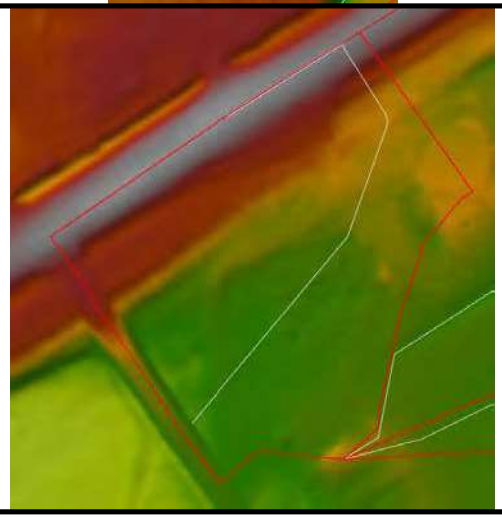
TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
5	
6	

TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
7	
8	

TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
9	
10	

TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
11	
12	

TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
13	
14	

TC PATHS	
RED - WATERSHED	
PALE BLUE - TC PATH	
WATERSHED	PATH LOCATION
15	
16	

Watershed 1

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	40.15	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.017	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.010	hours	
T_t=	0.61	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient
L=	59.85	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.021	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.103	hours	
T_t=	6.20	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	1101.05	ft	Shallow Concentrated flow length
S=	0.006	ft/ft	slope of hydraulic grade line, ground slope
v=	1.210	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.253	hours	
T_t=	15.17	minutes	

Time of Concentration =	**21.98**	**minutes**

Watershed 2

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	42.89	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.017	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.011	hours	
T_t=	0.64	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient
L=	57.11	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.023	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.097	hours	
T_t=	5.81	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	652.04	ft	Shallow Concentrated flow length
S=	0.010	ft/ft	slope of hydraulic grade line, ground slope
v=	1.586	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.114	hours	
T_t=	6.85	minutes	

Time of Concentration =	**13.30**	**minutes**

Watershed 3

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	100	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.006	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.032	hours	
T_t=	1.91	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	243.21	ft	Shallow Concentrated flow length
S=	0.008	ft/ft	slope of hydraulic grade line, ground slope
v=	1.866	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.036	hours	
T_t=	2.17	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	194.89	ft	Shallow Concentrated flow length
S=	0.022	ft/ft	slope of hydraulic grade line, ground slope
v=	2.405	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.023	hours	
T_t=	1.35	minutes	

Time of Concentration =	**5.43**	**minutes**	*Time of Concentration was changed to 10 minutes to meet the minimum Tc per the TXDOT Drainage Manual
Time of Concentration Used =	**10.00**	**minutes**	

Watershed 4

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	36.58	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.002	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.021	hours	
T_t=	1.28	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient
L=	63.42	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.011	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.139	hours	
T_t=	8.32	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	138.98	ft	Shallow Concentrated flow length
S=	0.001	ft/ft	slope of hydraulic grade line, ground slope
v=	0.493	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.078	hours	
T_t=	4.69	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	630.29	ft	Shallow Concentrated flow length
S=	0.004	ft/ft	slope of hydraulic grade line, ground slope
v=	1.330	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.132	hours	
T_t=	7.90	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	127.34	ft	Shallow Concentrated flow length
S=	0.057	ft/ft	slope of hydraulic grade line, ground slope
v=	3.837	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.009	hours	
T_t=	0.55	minutes	

Time of Concentration =	**22.74**	**minutes**

Watershed 5

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	102.63	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.011	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.026	hours	
T_t=	1.54	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	581.18	ft	Shallow Concentrated flow length
S=	0.011	ft/ft	slope of hydraulic grade line, ground slope
v=	1.693	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.095	hours	
T_t=	5.72	minutes	

Time of Concentration =	**7.26**	**minutes**	*Time of Concentration was changed to 10 minutes to meet the minimum Tc per the TXDOT Drainage Manual
Time of Concentration Used =	**10.00**	**minutes**	

Watershed 6

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	100	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.008	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.029	hours	
T_t=	1.74	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	690.93	ft	Shallow Concentrated flow length
S=	0.005	ft/ft	slope of hydraulic grade line, ground slope
v=	1.488	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.129	hours	
T_t=	7.74	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	242.15	ft	Shallow Concentrated flow length
S=	0.025	ft/ft	slope of hydraulic grade line, ground slope
v=	2.546	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.026	hours	
T_t=	1.59	minutes	

Time of Concentration =	**11.06**	**minutes**

Watershed 7

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	100	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.006	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.031	hours	
T_t=	1.86	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	32.74	ft	Shallow Concentrated flow length
S=	0.013	ft/ft	slope of hydraulic grade line, ground slope
v=	2.357	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.004	hours	
T_t=	0.23	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	899.89	ft	Shallow Concentrated flow length
S=	0.009	ft/ft	slope of hydraulic grade line, ground slope
v=	1.542	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.162	hours	
T_t=	9.73	minutes	

Time of Concentration =	**11.82**	**minutes**

Watershed 8

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	99.15	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.010	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.025	hours	
T_t=	1.53	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	856.21	ft	Shallow Concentrated flow length
S=	0.003	ft/ft	slope of hydraulic grade line, ground slope
v=	1.040	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.229	hours	
T_t=	13.72	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	133.78	ft	Shallow Concentrated flow length
S=	0.008	ft/ft	slope of hydraulic grade line, ground slope
v=	1.443	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.026	hours	
T_t=	1.55	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	20.2	ft	Shallow Concentrated flow length
S=	0.051	ft/ft	slope of hydraulic grade line, ground slope
v=	3.661	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.002	hours	
T_t=	0.09	minutes	

Time of Concentration =	**16.89**	**minutes**

Watershed 9

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient as shown in Table 3-2
L=	100	ft	sheet flow length (max 100' developed; 300' undeveloped)
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.0093	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.027	hours	
T_t=	1.60	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	75.62	ft	Shallow Concentrated flow length
S=	0.0029093	ft/ft	slope of hydraulic grade line, ground slope
v=	1.096	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.019	hours	
T_t=	1.15	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	13.04	ft	Shallow Concentrated flow length
S=	0.023773	ft/ft	slope of hydraulic grade line, ground slope
v=	2.488	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.001	hours	
T_t=	0.09	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	690.1	ft	Shallow Concentrated flow length
S=	0.0040719	ft/ft	slope of hydraulic grade line, ground slope
v=	1.297	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.148	hours	
T_t=	8.87	minutes	

Time of Concentration =	**11.71**	**minutes**

Watershed 10

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	100.08	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.010	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.026	hours	
T_t=	1.56	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	427.73	ft	Shallow Concentrated flow length
S=	0.002	ft/ft	slope of hydraulic grade line, ground slope
v=	0.846	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.141	hours	
T_t=	8.43	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	25.03	ft	Shallow Concentrated flow length
S=	0.062	ft/ft	slope of hydraulic grade line, ground slope
v=	4.028	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.002	hours	
T_t=	0.10	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	167.92	ft	Shallow Concentrated flow length
S=	0.008	ft/ft	slope of hydraulic grade line, ground slope
v=	1.468	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.032	hours	
T_t=	1.91	minutes	

Time of Concentration =	**12.00**	**minutes**

Watershed 11

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	15.11	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.021	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.004	hours	
T_t=	0.26	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	7.13	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.065	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.001	hours	
T_t=	0.09	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient
L=	1.85	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.059	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.004	hours	
T_t=	0.25	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient
L=	19.07	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.098	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.022	hours	
T_t=	1.35	minutes	

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient
L=	57.28	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.001	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.295	hours	
T_t=	17.73	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	899.3	ft	Shallow Concentrated flow length
S=	0.005	ft/ft	slope of hydraulic grade line, ground slope
v=	1.187	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.210	hours	
T_t=	12.62	minutes	

Time of Concentration =	**32.30**	**minutes**

Watershed 12

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Short Prairie Grass		
n=	0.150	dimensionless	Manning's roughness coefficient as shown in Table 3-2
L=	100	ft	sheet flow length (max 100' developed; 300' undeveloped)
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.020	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.160	hours	
T_t=	9.59	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	2233.25	ft	Shallow Concentrated flow length
S=	0.010	ft/ft	slope of hydraulic grade line, ground slope
v=	1.589	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.390	hours	
T_t=	23.42	minutes	

Time of Concentration =	**33.01**	**minutes**

Watershed 13

Kerby

Tov=[K(L*N)^0.467*S^(-0.235)]

Surface =	Dense Grass, etc.	
K=	0.828	dimensionless
L=	937.52	ft
N=	0.8	dimensionless
S=	0.035	dimensionless
T_{ov}=	40.141	minutes

Kerby

Tov=[K(L*N)^0.467*S^(-0.235)]

Surface =	Dense Grass, etc.	
K=	0.828	dimensionless
L=	343.08	ft
N=	0.8	dimensionless
S=	0.095	dimensionless
T_{ov}=	19.820	minutes

Kerby

Tov=[K(L*N)^0.467*S^(-0.235)]

Surface =	AVERAGE GRASS TO DECIDUOUS FOREST	
K=	0.828	dimensionless
L=	1375.4	ft
N=	0.5	dimensionless
S=	0.030	dimensionless
T_{ov}=	39.871	minutes

Kerby

Tov=[K(L*N)^0.467*S^(-0.235)]

Surface =	AVERAGE GRASS	
K=	0.828	dimensionless
L=	1526.23	ft
N=	0.4	dimensionless
S=	0.008	dimensionless
T_{ov}=	51.400	minutes

Kerby

Tov=[K(L*N)^0.467*S^(-0.235)]

Surface =	POOR GRASS	
K=	0.828	dimensionless
L=	1134.85	ft
N=	0.2	dimensionless
S=	0.017	dimensionless
T_{ov}=	27.025	minutes

Kirpich

Tch=[K*L^0.770*S^(-0.385)]

K=	0.0078	dimensionless	
L=	5797.45	ft	
S=	0.005	dimensionless	*ADJUSTED SLOPE
T_{ch}=	46.413	minutes	

Time of Concentration =	**224.67**	**minutes**

Watershed 14

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	100.91	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.002	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.050	hours	
T_t=	3.00	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	14.74	ft	Shallow Concentrated flow length
S=	0.035	ft/ft	slope of hydraulic grade line, ground slope
v=	3.781	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.001	hours	
T_t=	0.06	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	24.8	ft	Shallow Concentrated flow length
S=	0.029	ft/ft	slope of hydraulic grade line, ground slope
v=	2.749	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.003	hours	
T_t=	0.15	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	404.18	ft	Shallow Concentrated flow length
S=	0.004	ft/ft	slope of hydraulic grade line, ground slope
v=	0.973	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.115	hours	
T_t=	6.92	minutes	

Time of Concentration =	**10.14**	**minutes**

Watershed 15

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface =	Smooth surfaces (concrete, asphalt, gravel, or bare soil)		
n=	0.011	dimensionless	Manning's roughness coefficient
L=	96.2	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.001	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.077	hours	
T_t=	4.64	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	126	ft	Shallow Concentrated flow length
S=	0.003	ft/ft	slope of hydraulic grade line, ground slope
v=	1.040	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.034	hours	
T_t=	2.02	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	unimproved (unpaved)		
L=	40.61	ft	Shallow Concentrated flow length
S=	0.002	ft/ft	slope of hydraulic grade line, ground slope
v=	0.716	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.016	hours	
T_t=	0.95	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	58.97	ft	Shallow Concentrated flow length
S=	0.026	ft/ft	slope of hydraulic grade line, ground slope
v=	3.296	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.005	hours	
T_t=	0.30	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one =	improved (paved)		
L=	114.04	ft	Shallow Concentrated flow length
S=	0.031	ft/ft	slope of hydraulic grade line, ground slope
v=	3.587	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.009	hours	
T_t=	0.53	minutes	

Time of Concentration =	**8.43**	**minutes**	*Time of Concentration was changed to 10 minutes to meet the minimum Tc per the TXDOT Drainage Manual
Time of Concentration Used =	**10.00**	**minutes**	

Watershed 16

Sheet Flow

$T_t=[0.007(nL)^{0.8}]/[(P2)^{0.5}*S^{0.4}]$

Surface = Smooth surfaces (concrete, asphalt, gravel, or bare soil)

n=	0.011	dimensionless	Manning's roughness coefficient
L=	99.77	ft	sheet flow length
P_2=	3.37	in	2-year, 24 hour rainfall
S=	0.002	ft/ft	slope of hydraulic grade line, ground slope
T_t=	0.048	hours	
T_t=	2.90	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one = improved (paved)

L=	46.3	ft	Shallow Concentrated flow length
S=	0.011	ft/ft	slope of hydraulic grade line, ground slope
v=	2.091	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.006	hours	
T_t=	0.37	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one = unimproved (unpaved)

L=	54.34	ft	Shallow Concentrated flow length
S=	0.048	ft/ft	slope of hydraulic grade line, ground slope
v=	3.543	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.004	hours	
T_t=	0.26	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one = improved (paved)

L=	111.33	ft	Shallow Concentrated flow length
S=	0.006	ft/ft	slope of hydraulic grade line, ground slope
v=	1.565	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.020	hours	
T_t=	1.19	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one = unimproved (unpaved)

L=	159.9	ft	Shallow Concentrated flow length
S=	0.007	ft/ft	slope of hydraulic grade line, ground slope
v=	1.356	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.033	hours	
T_t=	1.96	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one = improved (paved)

L=	48.92	ft	Shallow Concentrated flow length
S=	0.003	ft/ft	slope of hydraulic grade line, ground slope
v=	1.048	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.013	hours	
T_t=	0.78	minutes	

Shallow Concentrated Flows

$T_t=L/(3600v)$

Select one = unimproved (unpaved)

L=	34.78	ft	Shallow Concentrated flow length
S=	0.004	ft/ft	slope of hydraulic grade line, ground slope
v=	0.986	ft/s	velocity (unimproved = 16.1345*S^0.5; improved = 20.3283*S^0.5)
T_t=	0.010	hours	
T_t=	0.59	minutes	

Time of Concentration =	**8.04**	**minutes**	*Time of Concentration was changed to 10 minutes to meet the minimum Tc per the TXDOT Drainage Manual
Time of Concentration Used =	**10.00**	**minutes**	

APPENDIX E STORMWISE SUPPORTING INFORMATION

STORMWISE 1D MODEL PARTS

NODES

STAGE AREA NODES

Due to the storm system being modeled in 1D, the inlets and outlets of culverts were modeled using Stage/Area nodes. There are also 2 other Stage/Area nodes used to connect the outflow of several culverts. This type of node only needs an Initial Stage, which is the invert elevation of what they are representing. In the model 2 different nodes that are modeled as the inlets of 2 different culverts also included a Stage/Area Table, these were for watersheds 4 and 13. These tables represent the storage area directly around the node, since the 1D model does not read the terrain and the information needs to be manually input. These 2 tables were formed using a function in StormWise called a Pond Control Volume, where software is given the boundary of a closed contour and it reads the terrain and creates the table of how much area is at each elevation. Once these tables were created, they were copied to the respective nodes.

TIME/STAGE NODES

Time Stage nodes are used to represent the outlet flow from a culvert that immediately exits the model. Essentially these nodes act as the outflow for the model as a whole. This type of node only needs an Initial Stage, which is the invert elevation of what they are representing. However, the node representing the outflow of the failing pipe also includes a Warning/Alert Stage to notify if the water exceeds the elevation that is input. The input elevation for this use is the lowest elevation of the surrounding pavement. This modification is in place to ensure that there is no water pooling on the pavement since it is a runway, this is to follow along with Federal Aviation Administration, FAA, standards. There is also a Stage/Storage table on the node representing the outlet of pipe 13, the failing pipe. This models a tailwater to allow the model to be more realistic.

LINKS

CHANNEL LINKS

Channel Links are a way of modeling the channelized flow from one area to another. The inputs for these links are as follows:

- From Node and To Node:
  - The From and To Nodes are to facilitate where the channel sections begin and end. Typically, the From Node is the upstream node and the To Node is the downstream node. These nodes direct water into and out of the channel.
- Link Count:
  - The Link Count is used to model how many channels are being modeled of the same length and shape with the same beginning and end points. For this model, the link count for channels is always 1.
- Length:
  - The length is used to model the length of the channel with the same shape. This also shows how far the water travels from the From Node to the To Node.
- Upstream and Downstream Invert:
  - Upstream and Downstream Inverts are the elevation of the lowest point on the Upstream and Downstream cross sections respectively.

- Geometry Type and Main Cross Section:
    - The Geometry Type is to determine the shape of the geometry. Since the channels in the model are not exact shapes the "Irregular" geometry type was used. Due to the geometry type, cross sections are necessary for the software to have a shape to base its calculations on.

WEIR LINKS

Weir Links are a way of modeling overland flow that is not channelized. The inputs for these links are as follows:

- From Node and To Node:
    - The From and To Nodes are to facilitate where the overland flow sections begin and end. Typically, the From Node is the upstream node and the To Node is the downstream node. These nodes direct water around the model to and from culverts or channels.
- Link Count:
    - The Link Count is used to model how many areas of overland flow are being modeled of the same length and shape with the same beginning and end points. For this model, the link count for weirs is always 1.

- Geometry:
    - The geometry is used to determine the shape of the overland flow area being modeled. Since the overland flow areas in the model are not exact shapes the Irregular geometry type was used. Due to the geometry type, a cross section is necessary for the software to have a shape to base its calculations on.
- Invert and Control Elevation:
    - The Invert and Control elevations are the same elevation. The number is chosen from the lowest elevation of the singular weir cross section.
- Cross Section:
    - Due to the geometry type, a cross section is necessary for the software to have a shape to base its calculations on.

PIPE LINKS

Pipe Links are a way of modeling the culverts that are on the site. The inputs for these links are as follows:

- From Node and To Node:
    - The From and To Nodes are to facilitate the upstream inlet and downstream outlet of each pipe. The From Node is the upstream inlet and the To Node is the downstream outlet. These nodes direct water through the pipe.
- Link Count:
    - The Link Count is used to model how many culverts flow are being modeled of the same length and shape with the same beginning and end points.
- Length:
    - The length is used to model the length of the culvert between the inlet and outlet.
- Entrance Loss Coefficient:
    - Entrance Loss Coefficient is based on the type of entrance utilized at the upstream inlet. See the end of this appendix for the entrance loss coefficient types, values, and an example from the site.

- Upstream and Downstream Invert:
    - Upstream and Downstream Inverts are the elevation of the lowest point of the culvert shape on the upstream or downstream side of the pipe. Since a survey of the site was done, the inverts used were from the survey, not directly from the terrain.
- Upstream and Downstream Manning's N:
    - Manning's N values represent the roughness of a culvert. The roughness is determined by the material used. In the model we had 2 different materials used. See the end of this Appendix for the material, the manning's N value and an example from the site.
- Geometry Type and Max Depth:
    - The Geometry of the Pipe Link is the shape of the culvert, in this model there is only circular pipes, therefore the "Type" is only "Circular". The Max Depth is the radius of the pipe in feet. Because a survey of the site was done, the Max Depth was input based on the survey data.

CROSS SECTIONS

CHANNEL XS'S

Because a 1D model does not read terrain, the Channel Cross Sections are used to show the 1D model how the terrain looks in areas that have channelized flow. Channel cross sections need an upstream and a downstream cross section, therefore the cross sections were taken closer to each end of the section that is considered a channel. Since channels can be different materials the software requires a Manning's N, roughness value, for the bottom of the channel. Since all of the channels were grass-like a Manning's N value of 0.035 was used for each cross section.

WEIR XS'S

Weir cross sections perform the same function as Channel cross sections, but for Weir links. Weir links also only need 1 cross section, so the cross section is typically taken towards the middle of the Weir link. Weir cross sections also do not need a Manning's N value input.

RUNTIME & OTHER SIMULATION INPUTS

This model was run for 72 hours to allow all the rainfall to dissipate and to allow the peak of the hydrographs to pass through the system. This allows for a 24-hour storm and 48 hours after the storm ends to see how system responds. The calculation time steps used were recommended by Streamline in the help manual for StormWise to help minimize instability. They are as follows:

HYDROLOGY

- Minimum Calculation Time: 30 seconds

SURFACE HYDRAULICS

- Minimum Calculation Time: 0.05 seconds
- Maximum Calculation Time: 10 seconds

The minimum calculation time for Hydrology is a constant time step while the minimum and maximum calculations for Surface Hydraulics are variable. Using these calculation times allows the model to run efficiently. In this case that means the model is running within a reasonable time frame, not allowing an unnecessary number of small calculations, and still providing accurate results

RAINFALL

Rainfall Name

- Rainfall Name is the storm distribution type. For this model "~SCSII-24" was used. This stands for a SCS Type 2, 24-hour storm. SCS Type 2 is a standard storm distribution and that is why it was used.

Storm Duration

- The Storm Duration is the length of time the model will stimulate rainfall. For this model a 24-hour storm was used because it is a standard rainfall.

Rainfall Amount

- The rainfall amount is the total amount of rainfall expected for a determined storm event. The storm event used in this model was a 100-yr, 24-hr event. The rainfall amount was found using NOAA Atlas 14, see APPENDIX F for the output. The table from NOAA states that the 100 year, 24-hour storm event has a rainfall of 8.46 inches.

ENTRANCE LOSS COEFFIECINET		
TYPE	COEFFICENT	EXAMPLE FROM SITE
HEADWALL OR HEADWALL AND WINGWALLS SQUARE-EDGE	0.5	
MITERED TO CONFORM TO FILL SLOPE, PAVED OR UNPAVED	0.7	

MANNING'S N VALUES		
MATERIAL	MANNING'S N	EXAMPLE FROM SITE
COURRUGATED METAL PIPE (CMP)	0.024	
COURRUGATED PLASTIC PIPE (CPP)	0.011	

APPENDIX F NOAA ATLAS 14 RESULTS

NOAA Atlas 14, Volume 11, Version 2
Location name: Graham, Texas, USA*
Latitude: 33.1123°, Longitude: -98.5573°
Elevation: 1107 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.378 (0.286-0.499)	0.447 (0.342-0.587)	0.561 (0.428-0.738)	0.655 (0.491-0.871)	0.781 (0.566-1.06)	0.875 (0.618-1.22)	0.972 (0.670-1.39)	1.08 (0.724-1.58)	1.22 (0.796-1.84)	1.34 (0.850-2.06)
10-min	0.609 (0.461-0.805)	0.721 (0.553-0.947)	0.906 (0.691-1.19)	1.06 (0.794-1.41)	1.26 (0.917-1.72)	1.42 (1.00-1.98)	1.57 (1.08-2.25)	1.74 (1.17-2.54)	1.96 (1.27-2.95)	2.13 (1.35-3.27)
15-min	0.748 (0.566-0.988)	0.884 (0.678-1.16)	1.11 (0.846-1.46)	1.29 (0.970-1.72)	1.54 (1.12-2.10)	1.72 (1.22-2.40)	1.91 (1.32-2.73)	2.12 (1.43-3.10)	2.41 (1.57-3.63)	2.64 (1.67-4.06)
30-min	1.02 (0.771-1.34)	1.20 (0.921-1.58)	1.50 (1.15-1.98)	1.75 (1.32-2.33)	2.08 (1.51-2.83)	2.33 (1.64-3.24)	2.58 (1.78-3.68)	2.86 (1.92-4.18)	3.26 (2.12-4.91)	3.58 (2.27-5.51)
60-min	1.30 (0.987-1.72)	1.54 (1.18-2.02)	1.94 (1.48-2.55)	2.26 (1.70-3.01)	2.70 (1.95-3.66)	3.02 (2.13-4.20)	3.35 (2.31-4.79)	3.73 (2.51-5.45)	4.26 (2.77-6.42)	4.69 (2.97-7.21)
2-hr	1.58 (1.21-2.06)	1.89 (1.46-2.44)	2.39 (1.84-3.10)	2.81 (2.13-3.69)	3.40 (2.49-4.58)	3.86 (2.75-5.32)	4.33 (3.01-6.11)	4.84 (3.27-6.98)	5.54 (3.62-8.23)	6.10 (3.87-9.24)
3-hr	1.74 (1.34-2.26)	2.10 (1.62-2.68)	2.67 (2.06-3.43)	3.16 (2.41-4.12)	3.85 (2.85-5.16)	4.41 (3.17-6.04)	4.99 (3.48-6.98)	5.59 (3.79-7.99)	6.41 (4.19-9.43)	7.05 (4.49-10.6)
6-hr	2.04 (1.59-2.61)	2.49 (1.93-3.11)	3.17 (2.47-4.02)	3.77 (2.91-4.86)	4.65 (3.48-6.16)	5.38 (3.90-7.28)	6.14 (4.31-8.47)	6.92 (4.72-9.75)	7.98 (5.24-11.6)	8.80 (5.62-13.0)
12-hr	2.38 (1.87-3.00)	2.90 (2.27-3.57)	3.70 (2.92-4.63)	4.42 (3.44-5.62)	5.47 (4.12-7.15)	6.35 (4.63-8.47)	7.28 (5.15-9.91)	8.29 (5.68-11.5)	9.70 (6.40-13.9)	10.8 (6.94-15.8)
24-hr	2.75 (2.19-3.43)	3.37 (2.66-4.08)	4.30 (3.42-5.30)	5.13 (4.03-6.43)	6.35 (4.82-8.16)	7.35 (5.40-9.67)	8.46 (6.02-11.3)	9.68 (6.68-13.3)	11.5 (7.59-16.2)	12.9 (8.31-18.6)
2-day	3.21 (2.58-3.94)	3.90 (3.13-4.69)	4.96 (4.00-6.05)	5.90 (4.69-7.30)	7.27 (5.55-9.20)	8.37 (6.19-10.8)	9.59 (6.87-12.7)	11.0 (7.62-14.8)	13.0 (8.67-18.1)	14.7 (9.52-20.9)
3-day	3.52 (2.84-4.29)	4.26 (3.45-5.09)	5.41 (4.40-6.54)	6.42 (5.13-7.88)	7.88 (6.04-9.88)	9.05 (6.71-11.6)	10.3 (7.43-13.5)	11.8 (8.22-15.8)	14.0 (9.34-19.3)	15.8 (10.2-22.2)
4-day	3.75 (3.04-4.54)	4.53 (3.69-5.38)	5.75 (4.69-6.92)	6.82 (5.47-8.31)	8.35 (6.43-10.4)	9.57 (7.13-12.2)	10.9 (7.87-14.2)	12.5 (8.69-16.6)	14.7 (9.86-20.2)	16.6 (10.8-23.2)
7-day	4.24 (3.48-5.08)	5.12 (4.21-6.02)	6.48 (5.34-7.72)	7.68 (6.21-9.26)	9.38 (7.28-11.6)	10.7 (8.05-13.5)	12.2 (8.85-15.7)	13.9 (9.73-18.2)	16.3 (10.9-22.0)	18.3 (11.9-25.2)
10-day	4.66 (3.84-5.54)	5.60 (4.64-6.55)	7.09 (5.87-8.37)	8.37 (6.82-10.0)	10.2 (7.96-12.5)	11.7 (8.79-14.6)	13.2 (9.64-16.9)	15.0 (10.6-19.6)	17.5 (11.8-23.5)	19.6 (12.8-26.8)
20-day	5.93 (4.94-6.95)	7.06 (5.92-8.16)	8.84 (7.42-10.3)	10.4 (8.54-12.3)	12.5 (9.88-15.1)	14.3 (10.8-17.6)	16.1 (11.8-20.3)	18.1 (12.8-23.3)	21.0 (14.2-27.7)	23.3 (15.3-31.4)
30-day	6.99 (5.86-8.13)	8.27 (6.99-9.49)	10.3 (8.70-11.9)	12.0 (9.96-14.1)	14.5 (11.5-17.3)	16.4 (12.5-20.0)	18.4 (13.6-23.0)	20.6 (14.7-26.3)	23.8 (16.1-31.1)	26.3 (17.2-35.1)
45-day	8.54 (7.21-9.85)	10.0 (8.55-11.4)	12.4 (10.6-14.3)	14.4 (12.0-16.8)	17.3 (13.8-20.5)	19.5 (15.0-23.6)	21.8 (16.1-27.0)	24.3 (17.3-30.7)	27.8 (18.9-36.0)	30.6 (20.1-40.4)
60-day	9.93 (8.43-11.4)	11.6 (9.96-13.2)	14.3 (12.3-16.4)	16.6 (13.9-19.2)	19.8 (15.8-23.4)	22.3 (17.2-26.9)	24.9 (18.4-30.6)	27.6 (19.7-34.6)	31.4 (21.4-40.4)	34.4 (22.6-45.1)

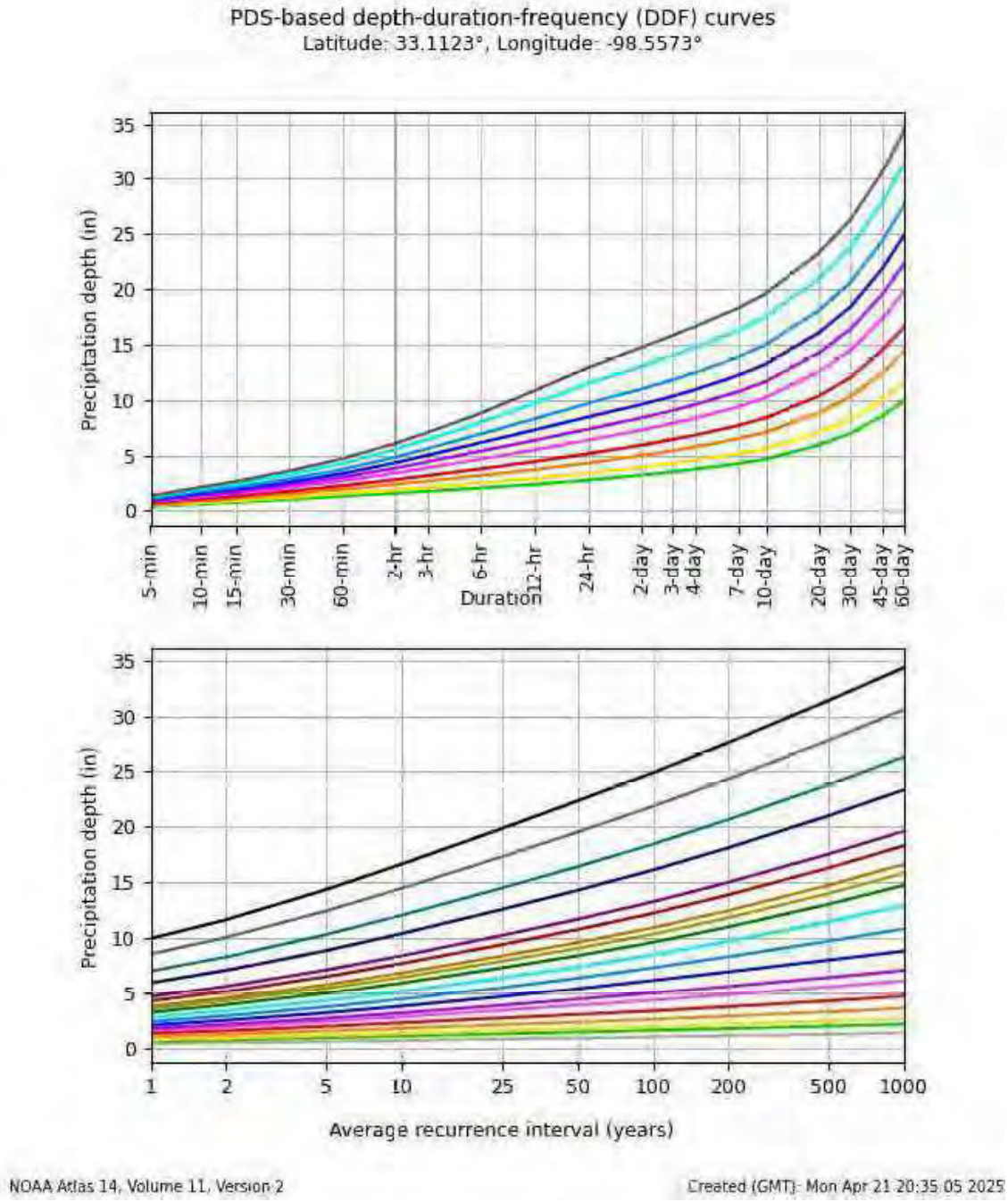
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical



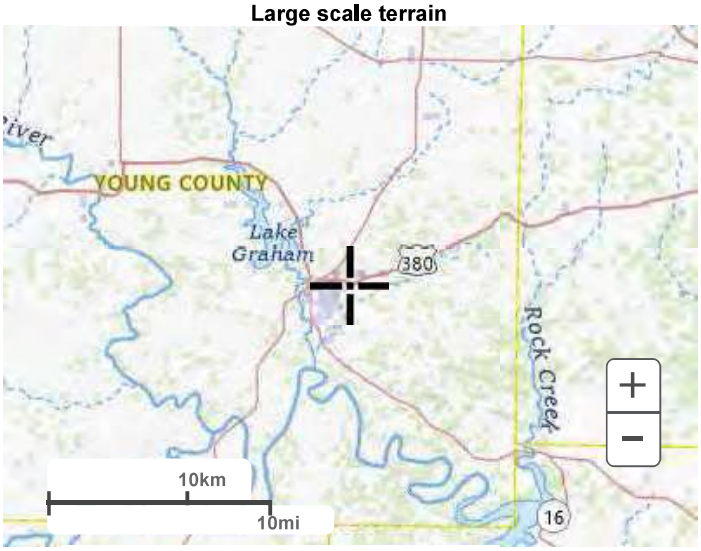
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Maps & aerials

Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

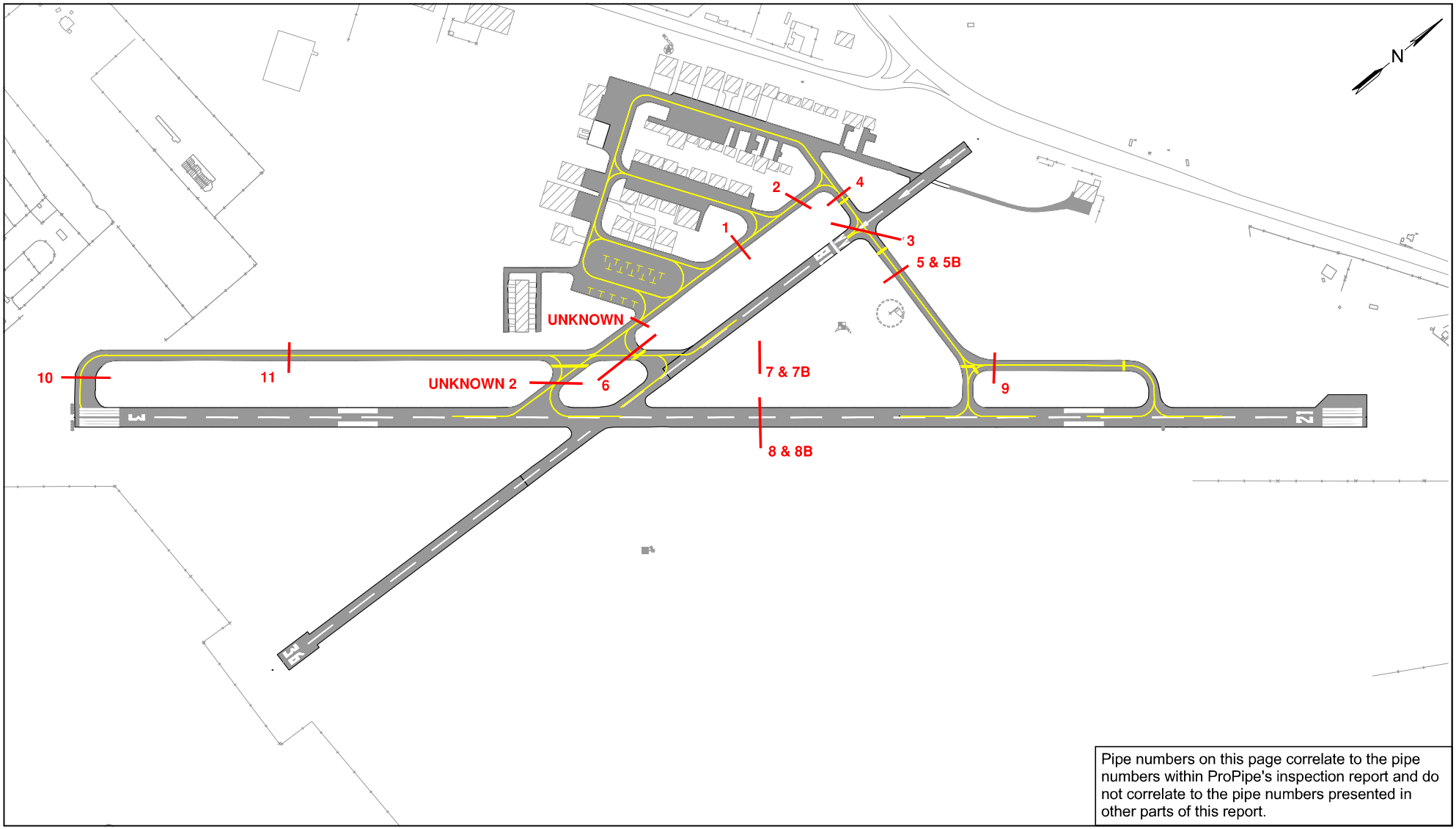


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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX G UNFOLDED PIPE REPORT



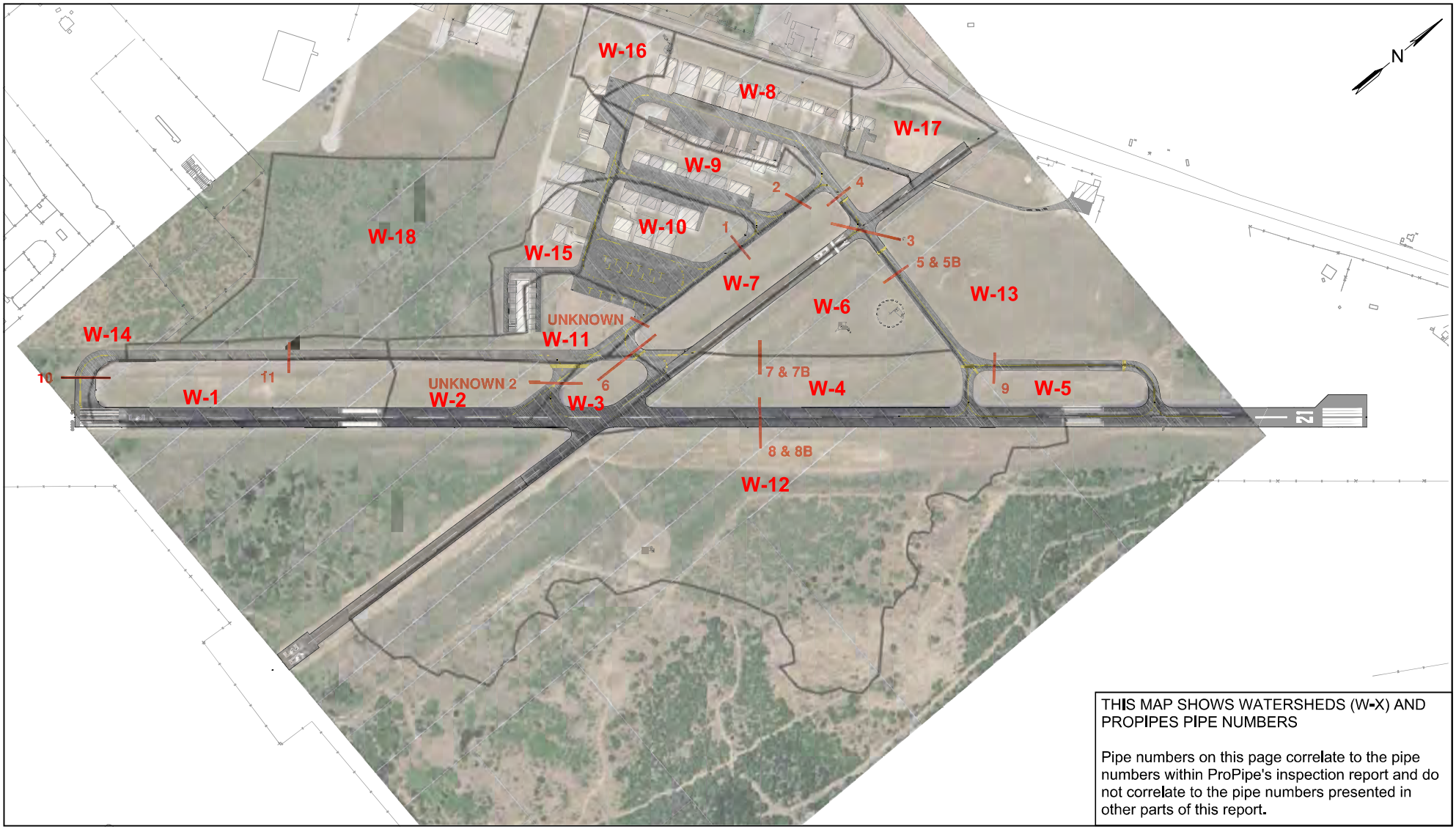
Pipe numbers on this page correlate to the pipe numbers within ProPipe's inspection report and do not correlate to the pipe numbers presented in other parts of this report.

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

OVERALL SITE MAP

Parkhill

407011-24



THIS MAP SHOWS WATERSHEDS (W-X) AND PROPIPES PIPE NUMBERS

Pipe numbers on this page correlate to the pipe numbers within ProPipe's inspection report and do not correlate to the pipe numbers presented in other parts of this report.

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

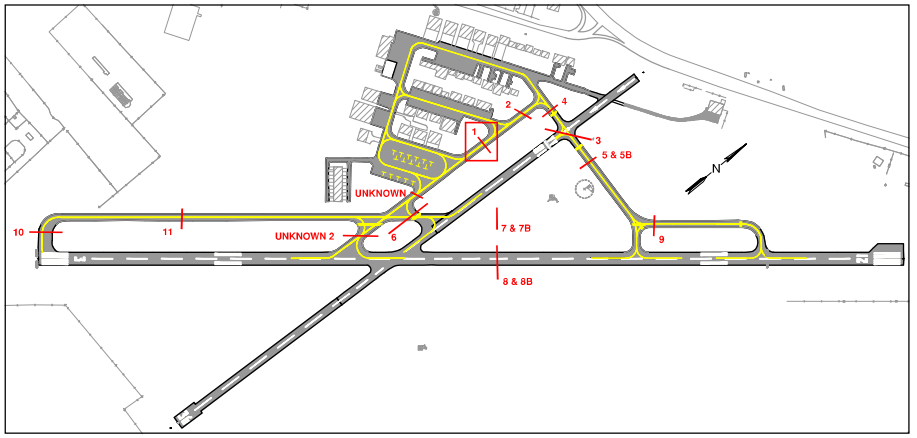
OVERALL SITE MAP

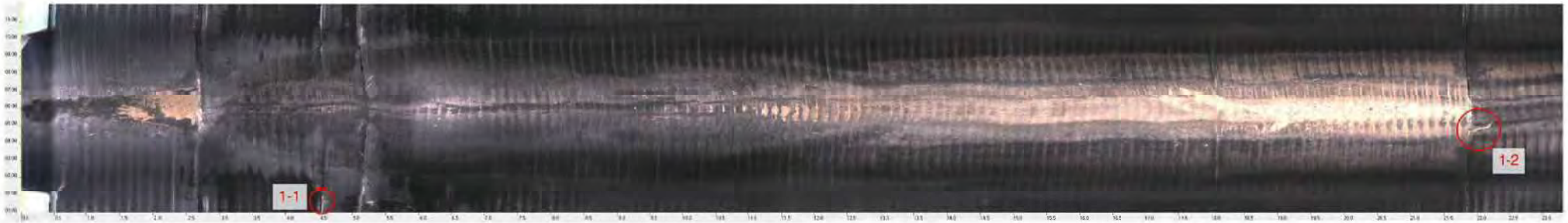
Parkhill

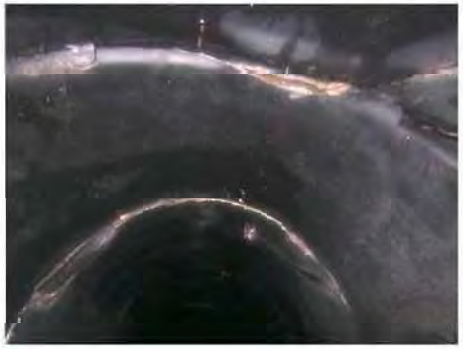
40701-24
G

FIELD NOTES FROM PROPIPE:

1 - 106 FT
2 - BROKEN PIPE 98 FT
3 - 303 FT
4 - COULD NOT MAKE IT THROUGH POWER LINES IN PIPE
5 - 77.5 FT
5B - 77.8 FT
UNKNOWN - 126.2 FT
6 - 210.8 FT
7 - 129.3 FT
7B - 133.6 FT
8 - 150 FT
8B - 148.8 FT
9 - 79.0 FT
10 - 168.6 FT
11 - 115.4 FT
UNKNOWN # 2 - 215 FT







1-1
STA: 4.5 FT
NOTE: LINING FEATURE DETATCHED

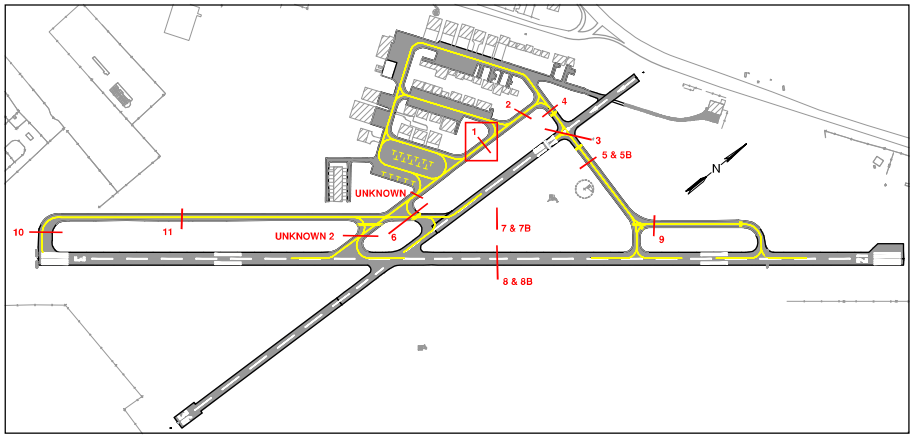


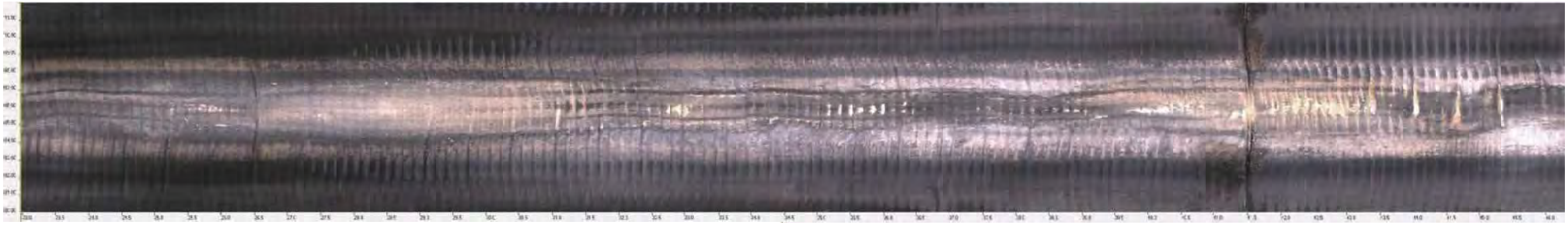
1-2
STA: 22 FT
NOTE: ROOTS FINE JOINT

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #1
STA 0 FT TO 23 FT

Parkhill



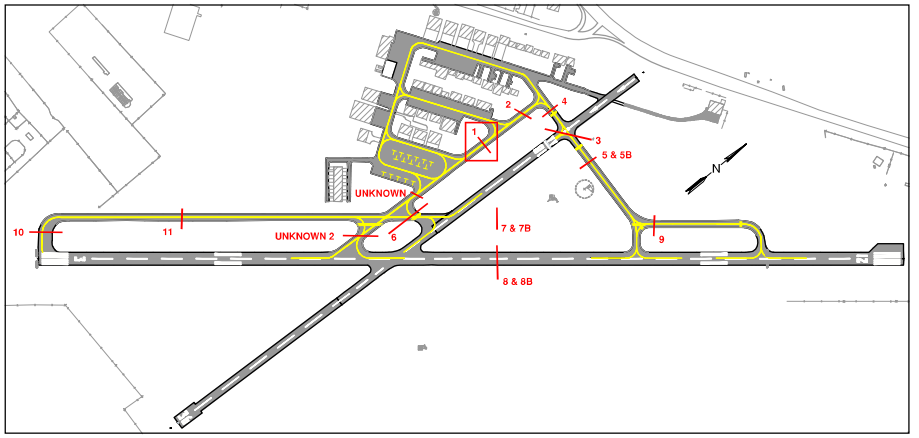


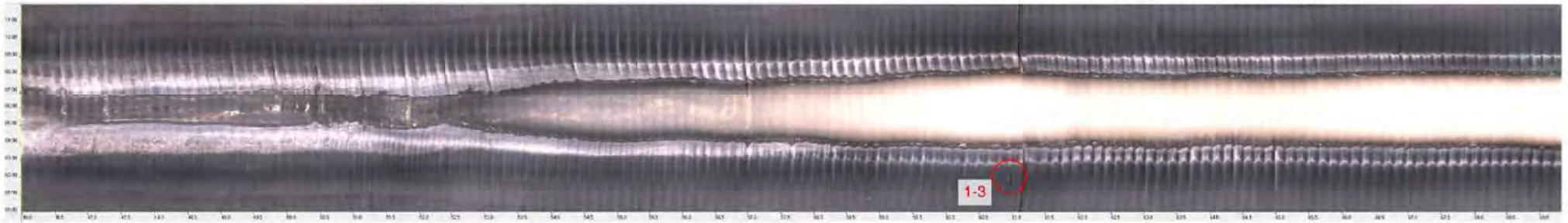
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #1
STA 23 FT TO 46 FT

Parkhill

407011-24
G





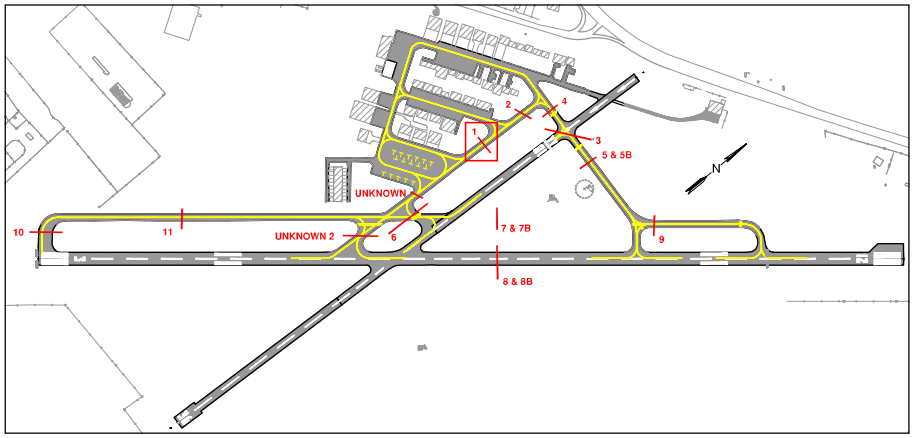


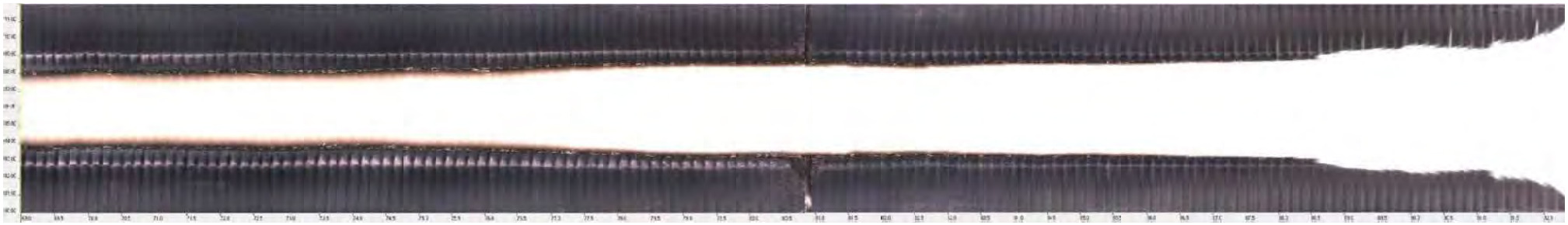
1-3
LOCATION IN PIPE: 61 FT
NOTE: INTRUDING SEALING MATERIAL
SEALING RING HANGING

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #1
STA 46 FT TO 69 FT

Parkhill



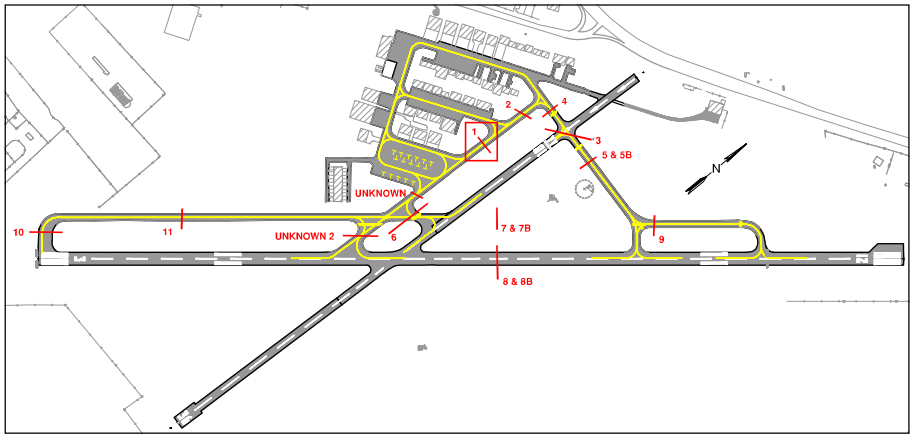


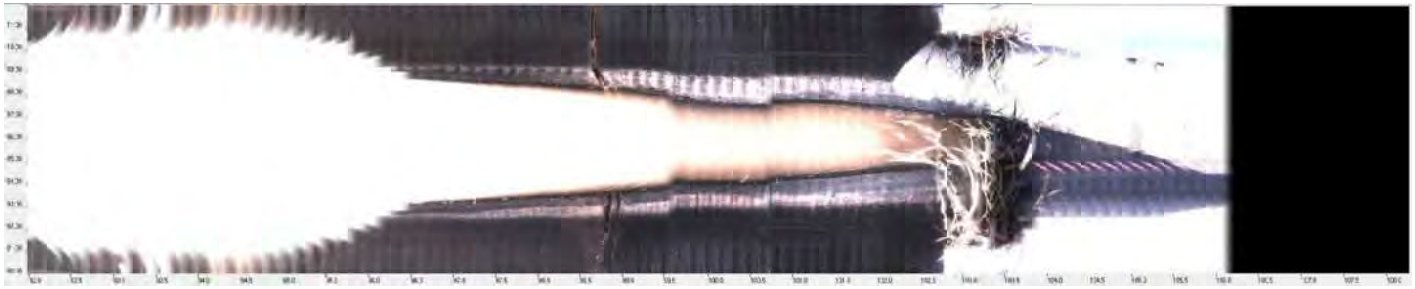
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #1
STA 69 FT TO 92 FT

Parkhill

407001-24
G



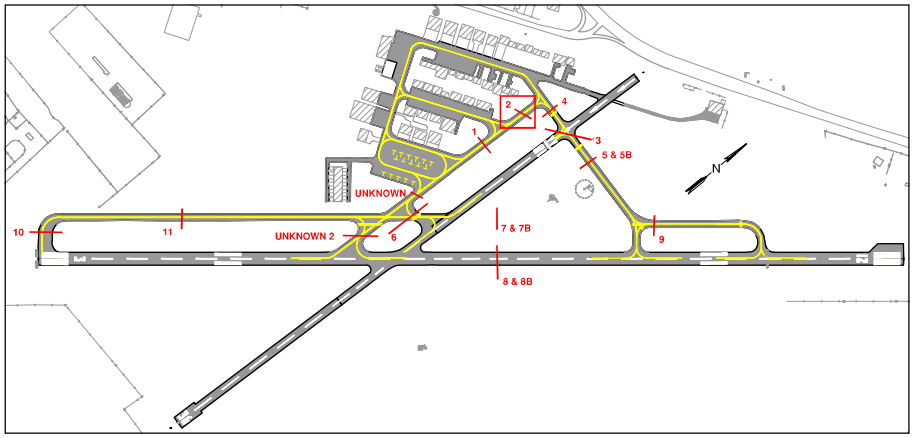


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #1
STA 92 FT TO 106 FT

Parkhill

40701-24







2-1
LOCATION IN PIPE: 2 FT
NOTE: INTRUDING SEALING MATERIAL
SEALING RING HANGING



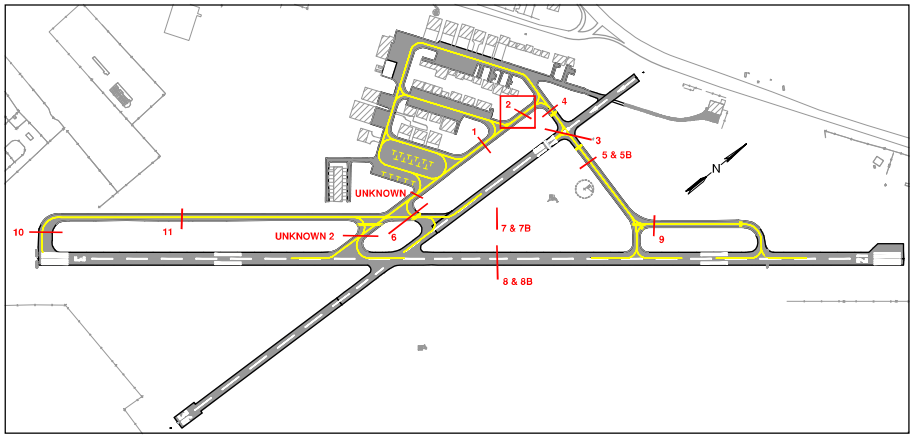
2-2
LOCATION IN PIPE: 4 FT
NOTE: LINING FEATURE DETACHED

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #2
STA 0 FT TO 23 FT

Parkhill

407001-24



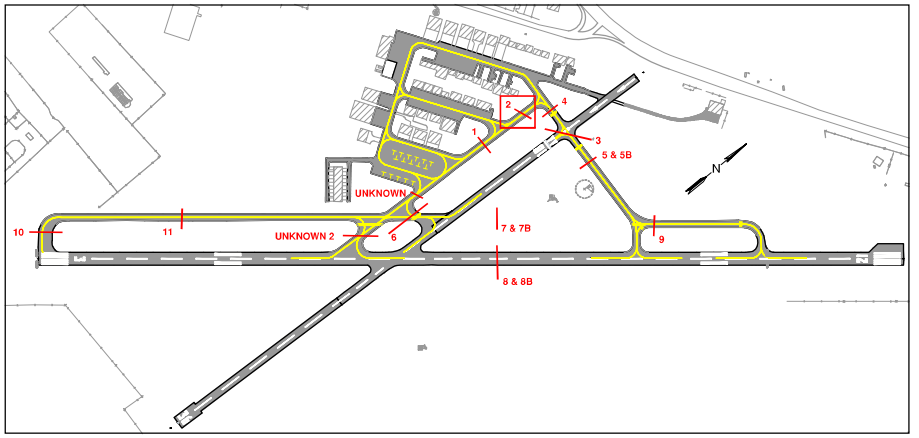


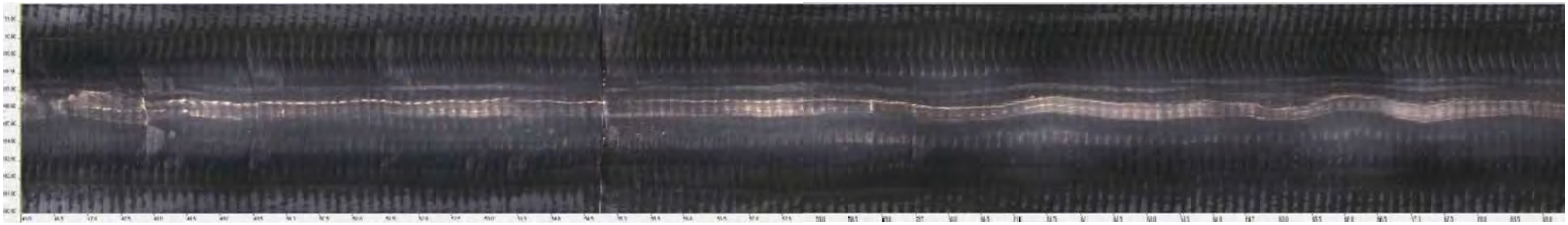
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #2
STA 23 FT TO 46 FT

Parkhill

407001-24
G



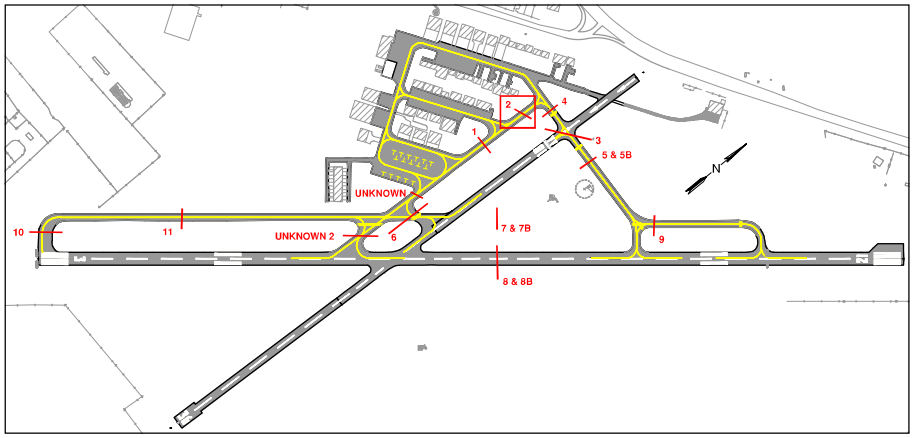


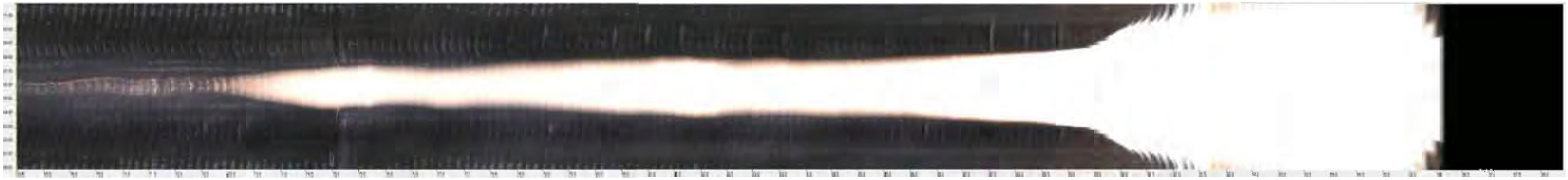
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #2
STA 46 FT TO 69 FT

Parkhill

407041-24



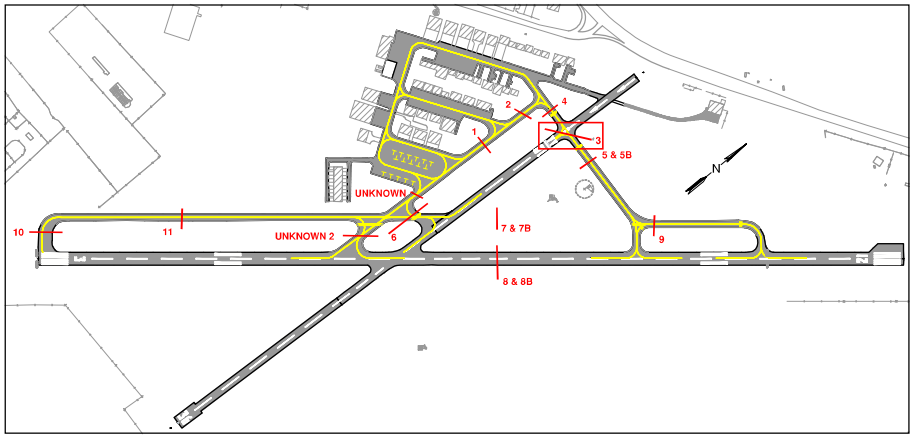


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #2
STA 69 FT TO 96 FT

Parkhill

407011-24



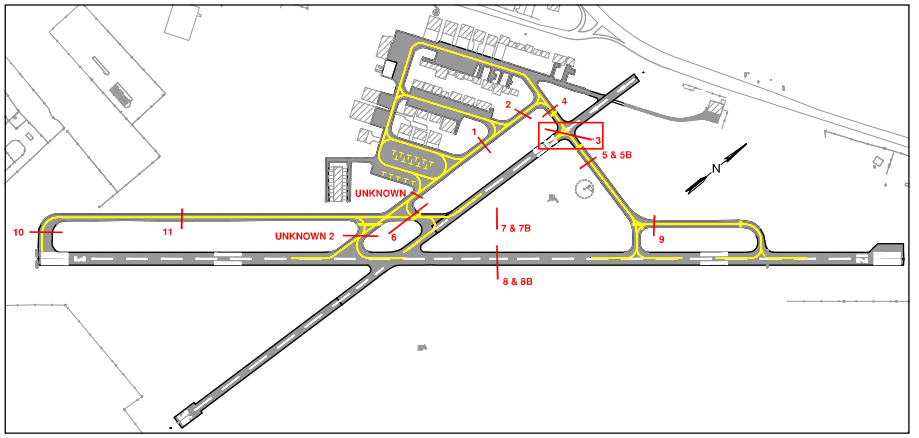


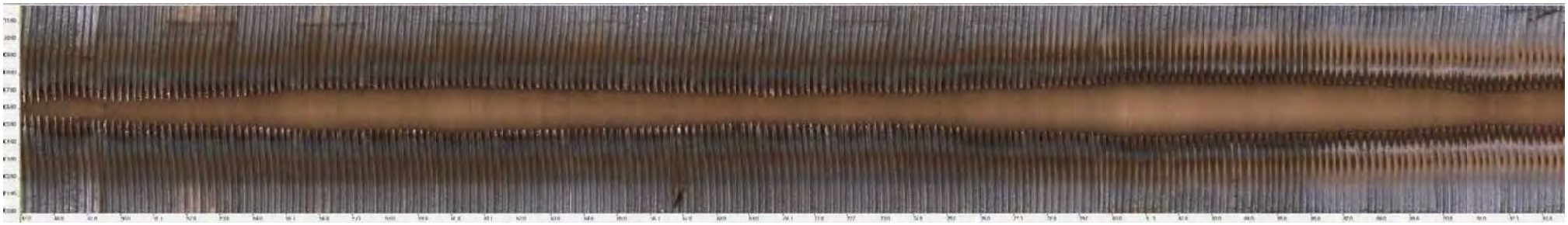
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 0 FT TO 47 FT

Parkhill

407041-24



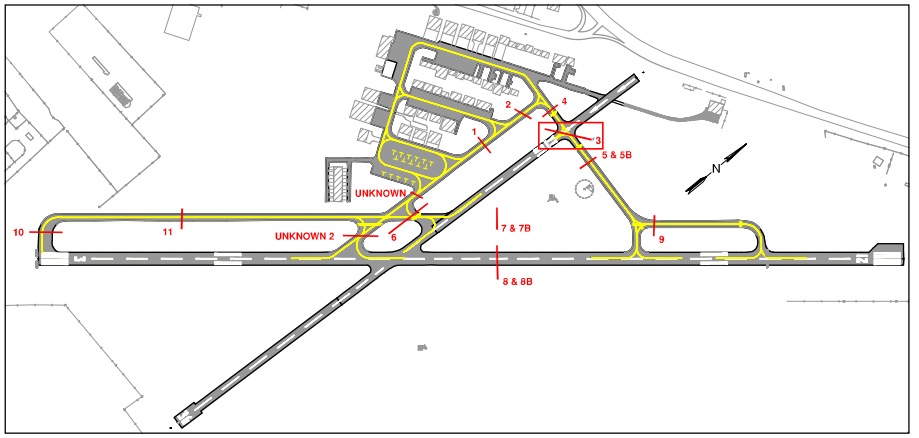


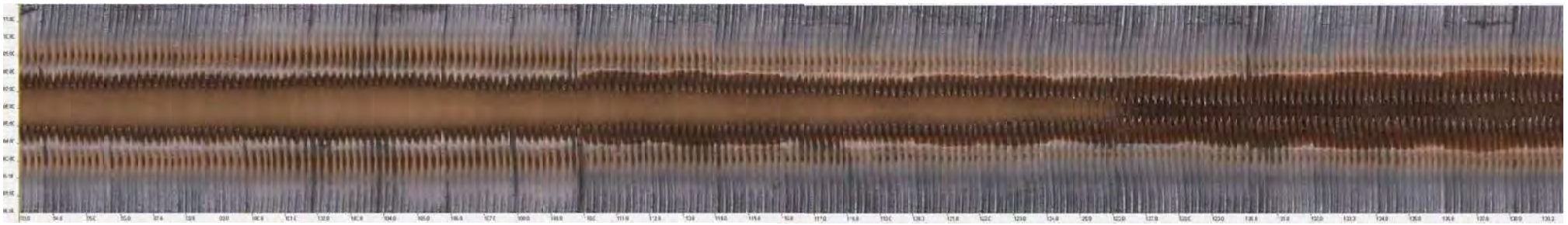
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 47 FT TO 93 FT

Parkhill

40701-24



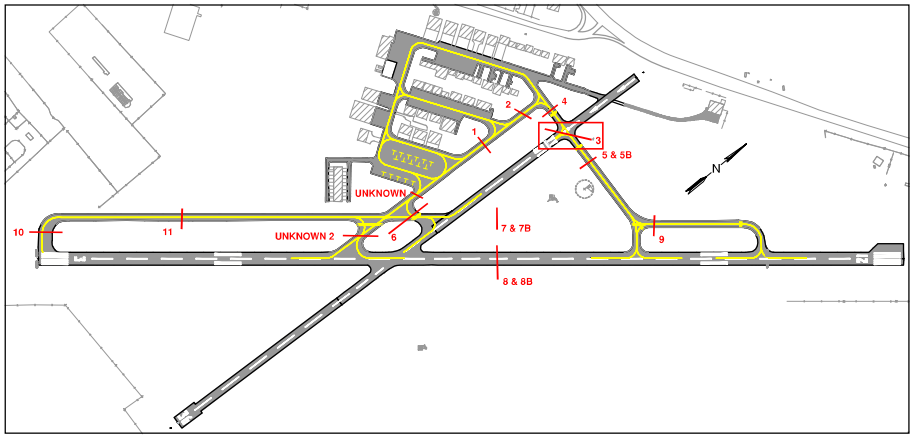


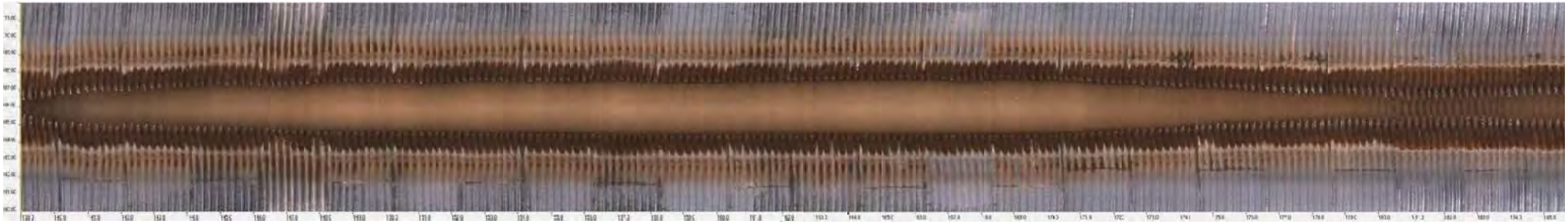
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 93 FT TO 139 FT

Parkhill

407001-24
G



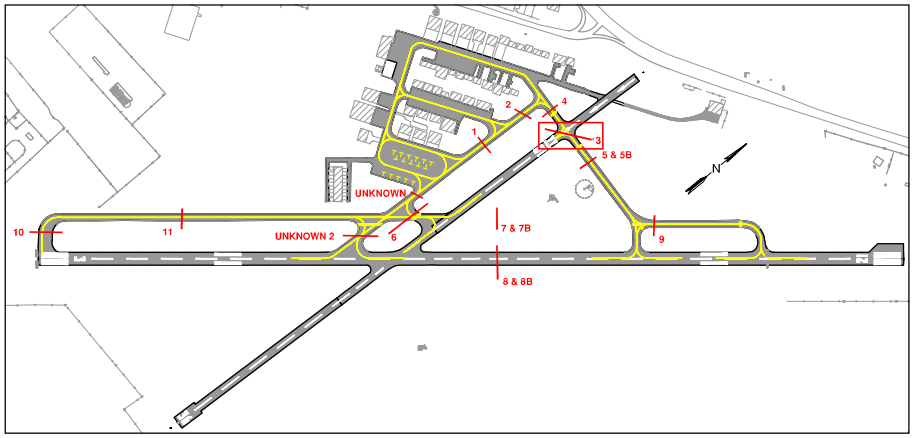


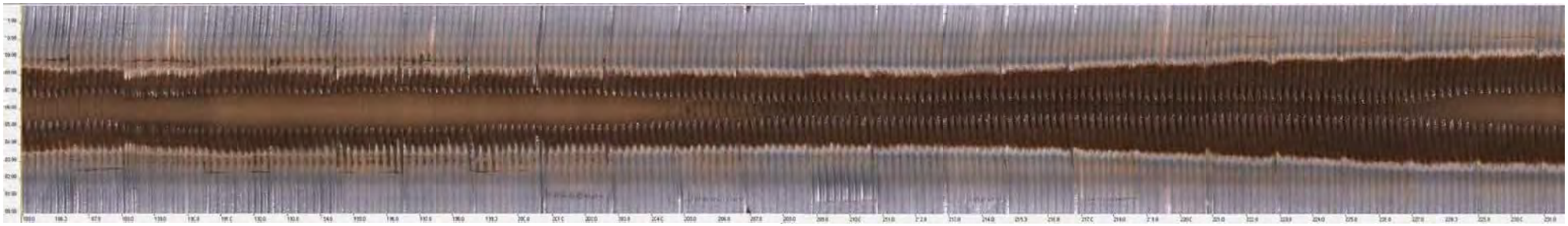
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 139 FT TO 185 FT

Parkhill

407001-24
G



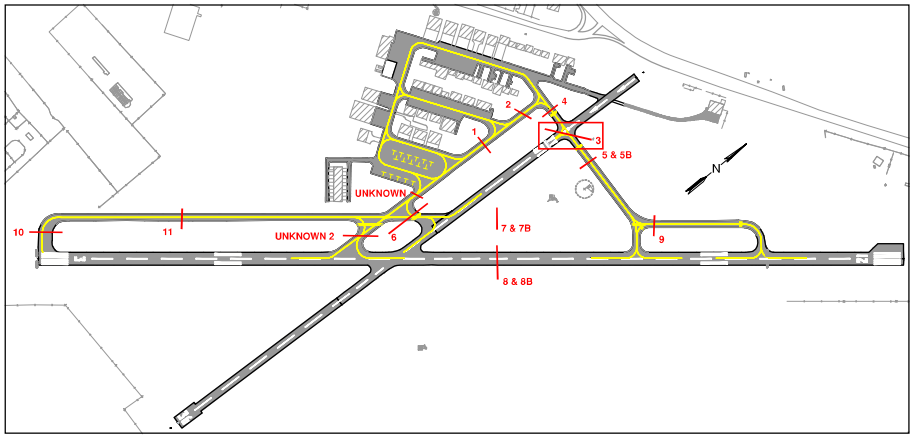


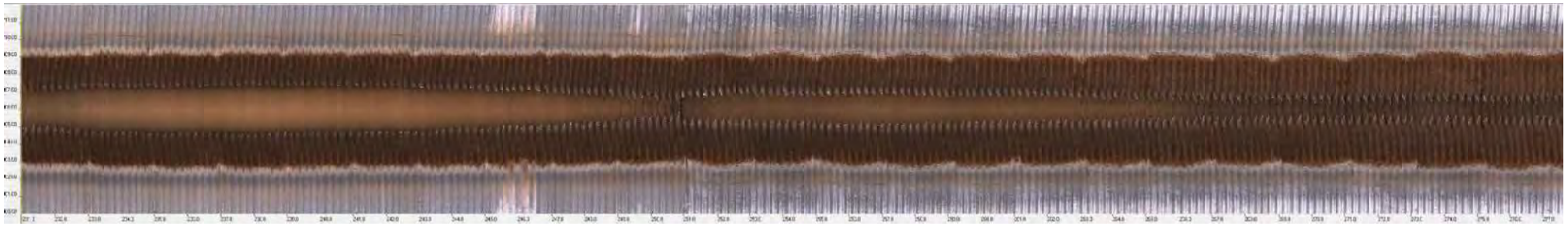
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 185 FT TO 231 FT

Parkhill

407041-24
G



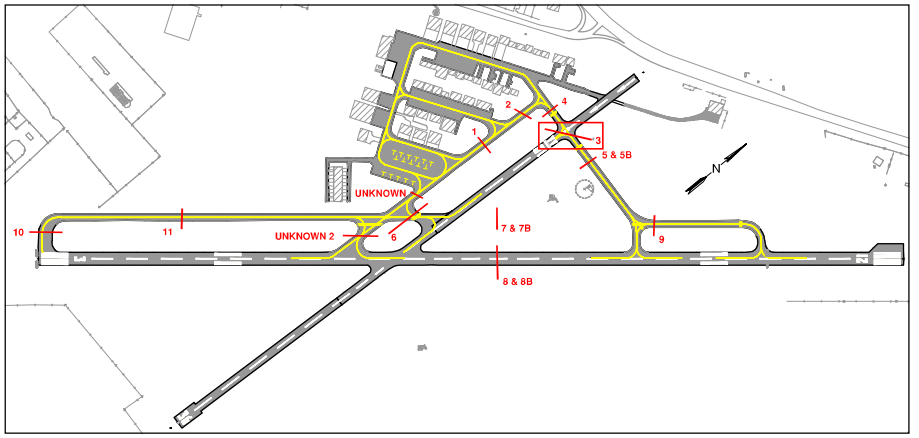


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 231 FT TO 277 FT

Parkhill

407041-24
G



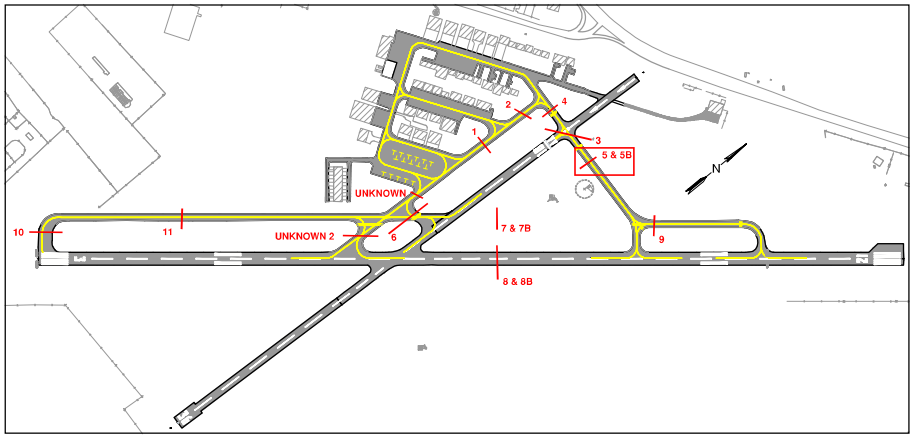


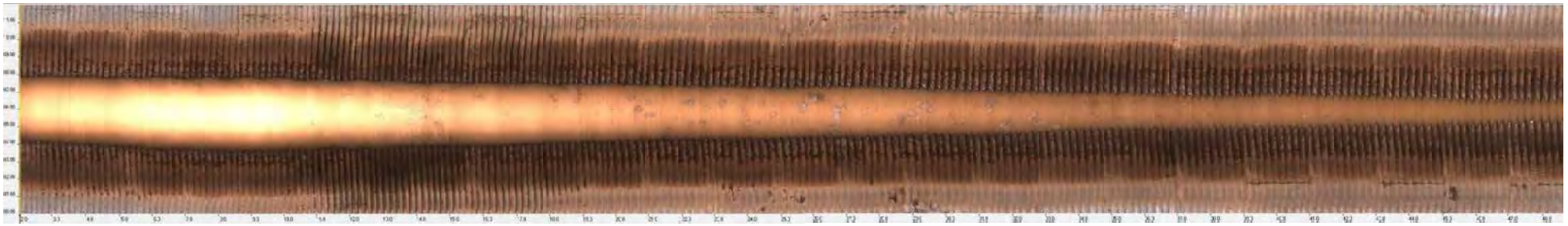
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #3
STA 277 FT TO 303 FT

Parkhill

407001-24



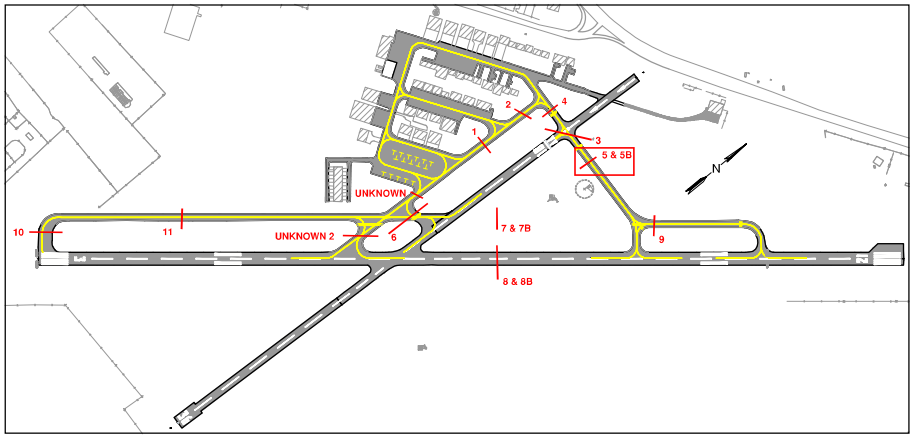


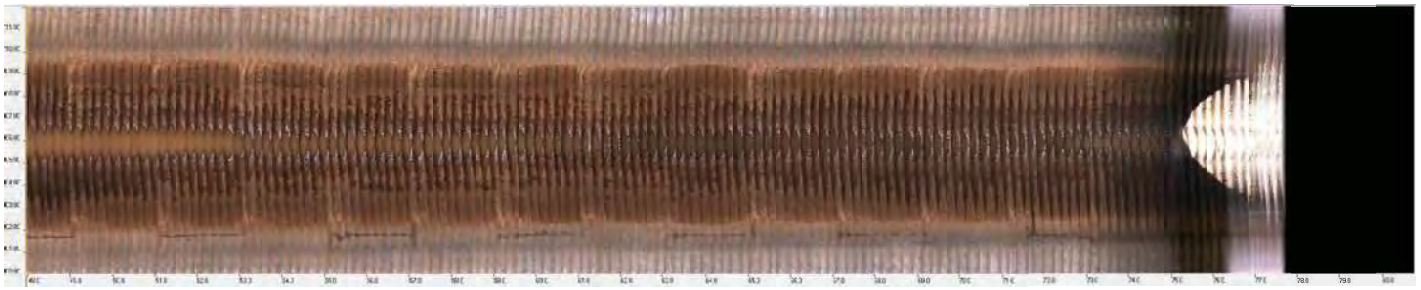
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #5
STA 2 FT TO 48 FT

Parkhill

40701-24



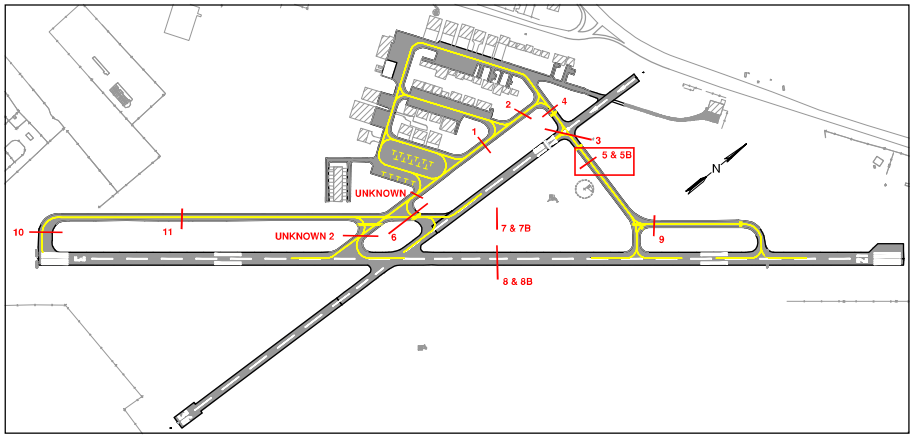


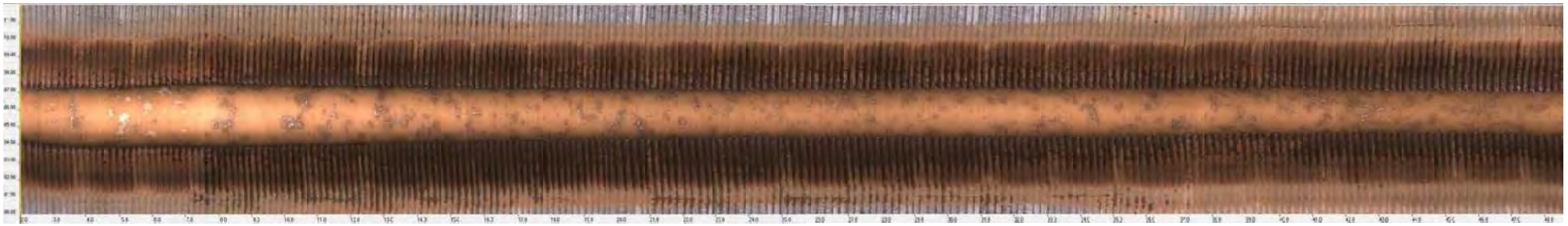
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #5
STA 48 FT TO 77.5 FT

Parkhill

40701-24



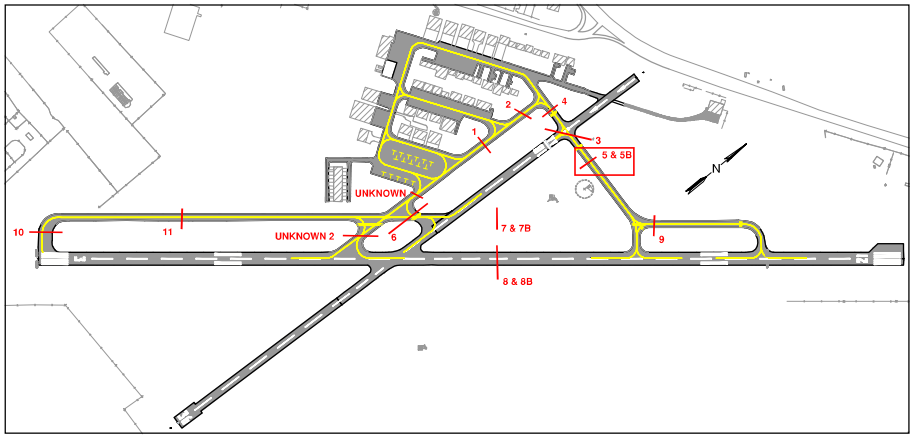


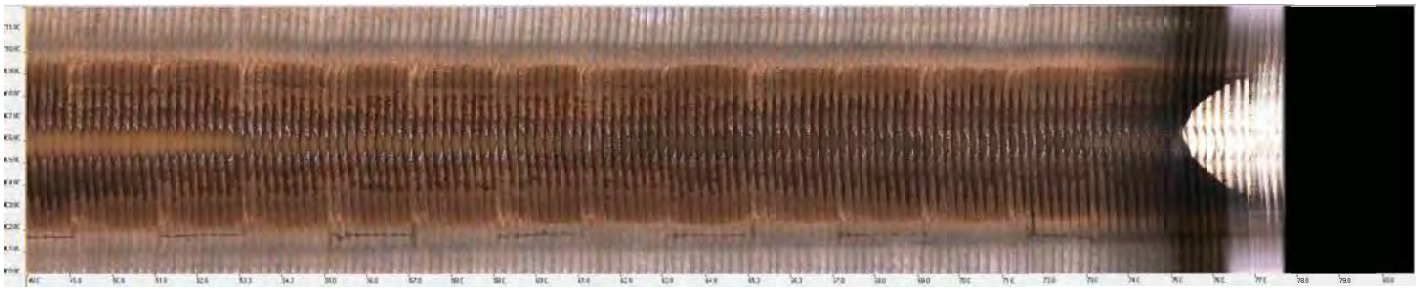
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #5B
STA 2 FT TO 48 FT

Parkhill

407001-24
G



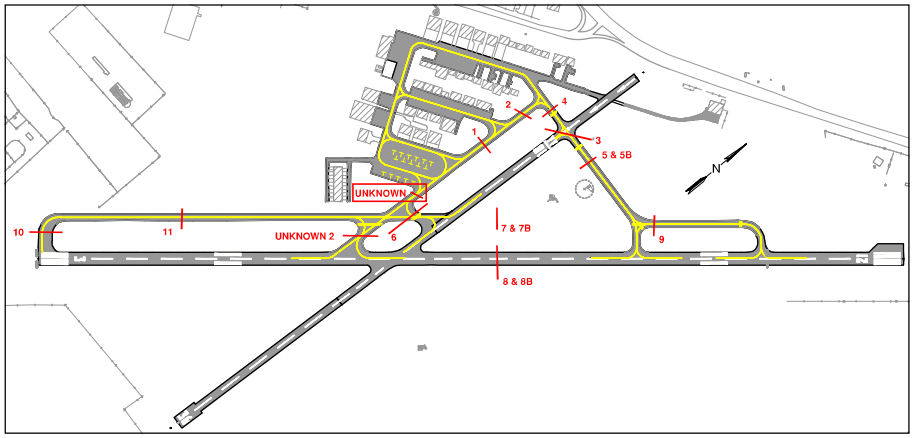


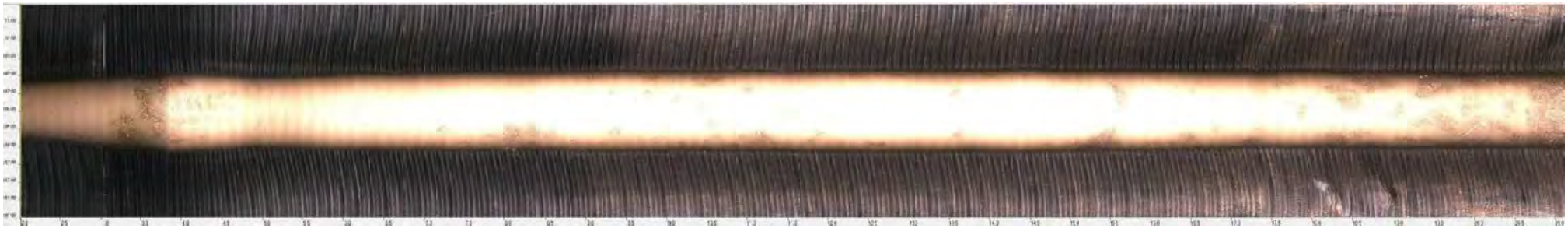
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #5B
STA 48 FT TO 77.8 FT

Parkhill

40701-24



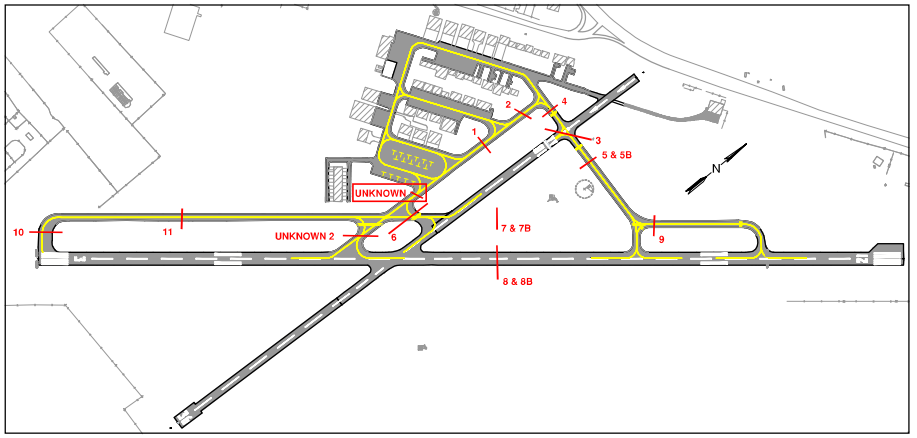


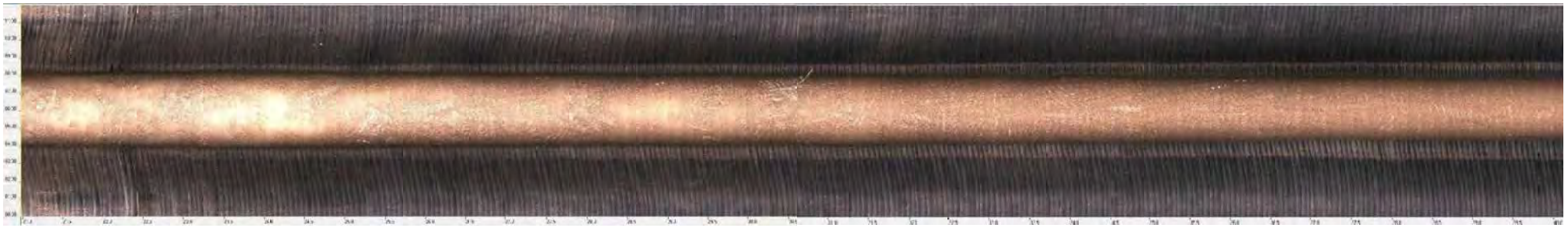
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 2 FT TO 21 FT

Parkhill

40701-24
G



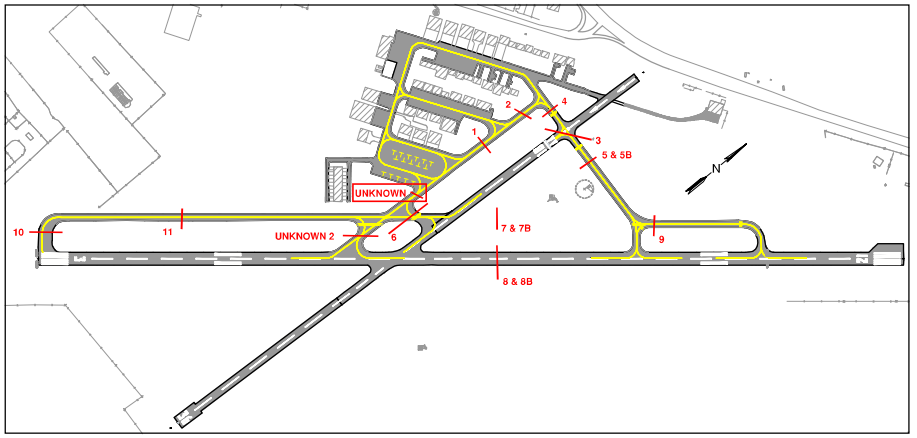


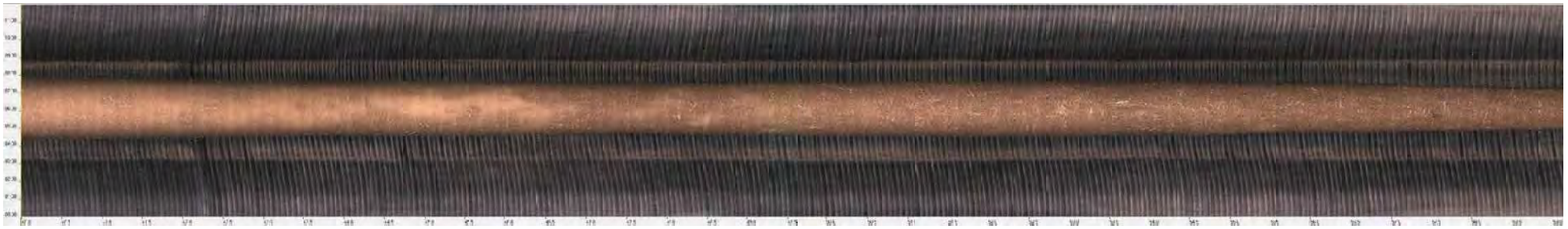
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 21 FT TO 40 FT

Parkhill

407011-24
G



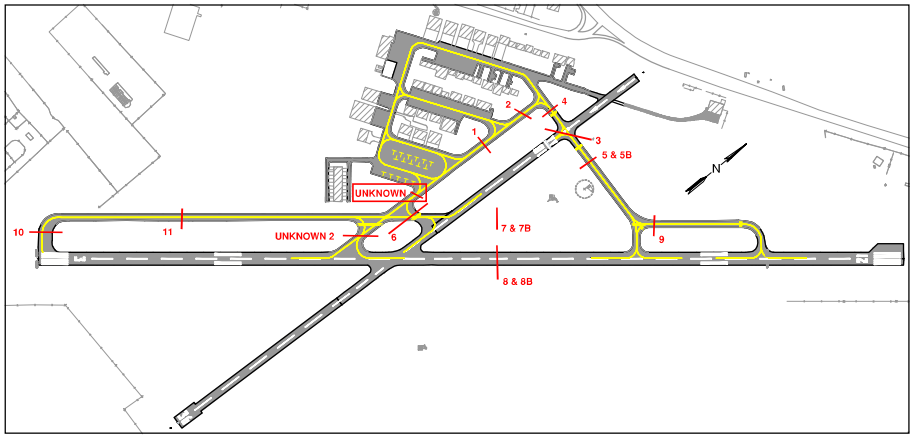


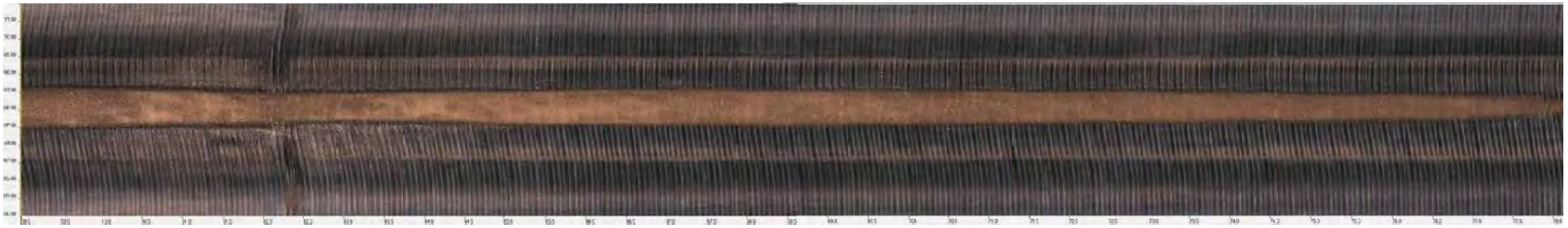
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 40 FT TO 59 FT

Parkhill

40701-24
G



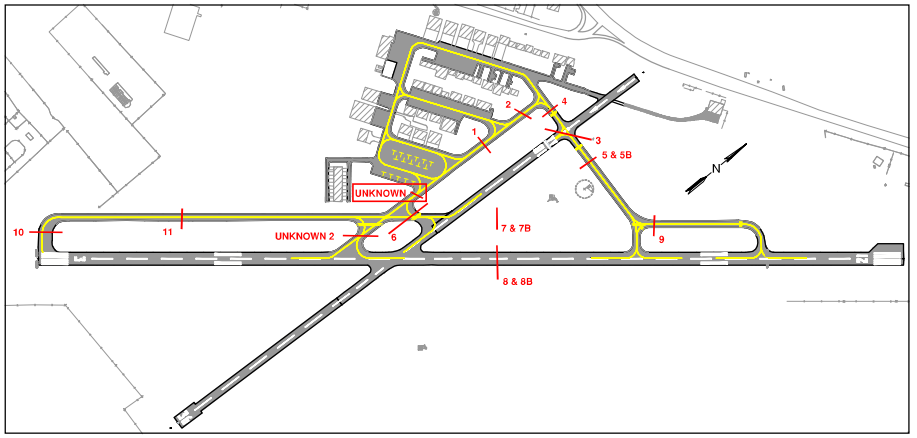


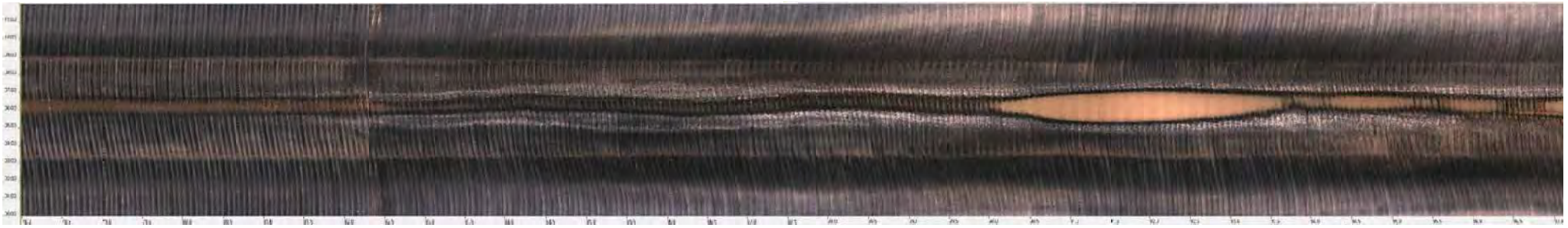
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 59 FT TO 78 FT

Parkhill

407001-24



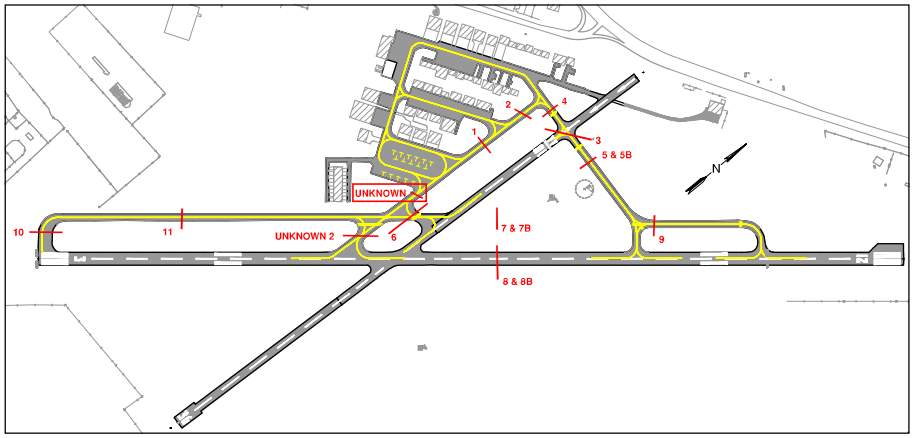


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 78 FT TO 97 FT

Parkhill

407041-24



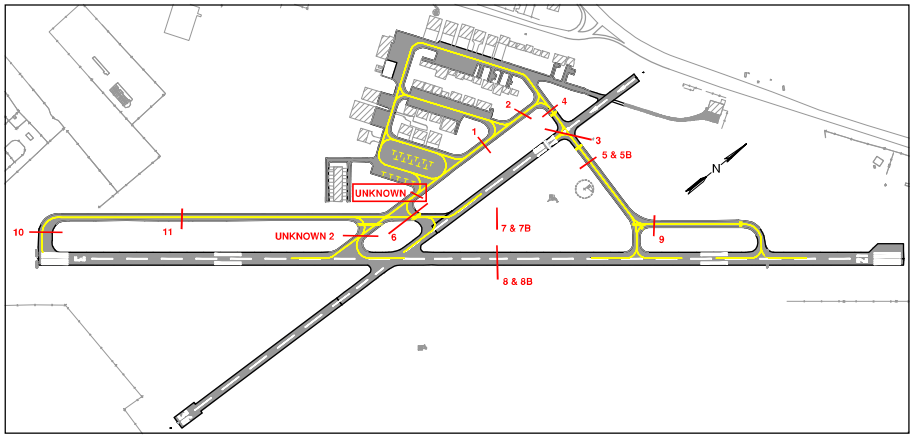


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 97 FT TO 116 FT

Parkhill

40701-24
G



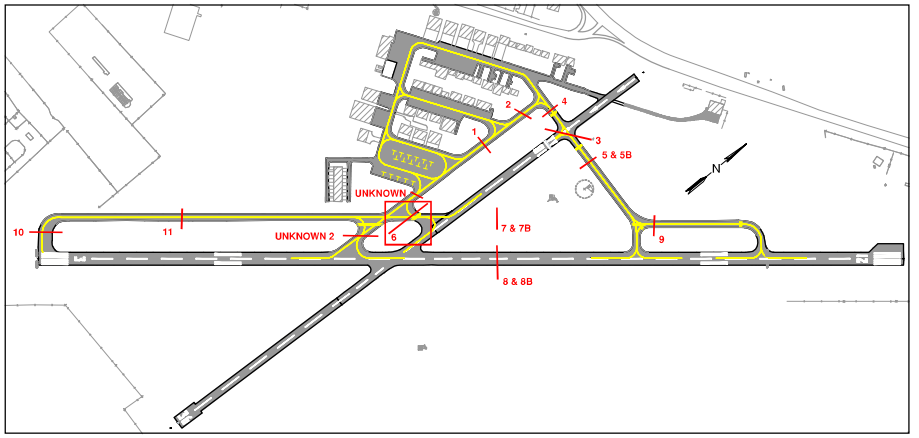


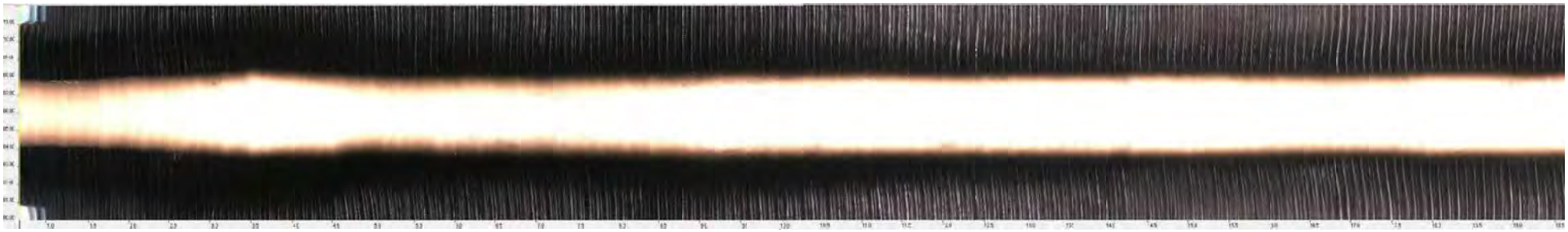
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN
STA 116 FT TO 126.2 FT

Parkhill

407011-24
G



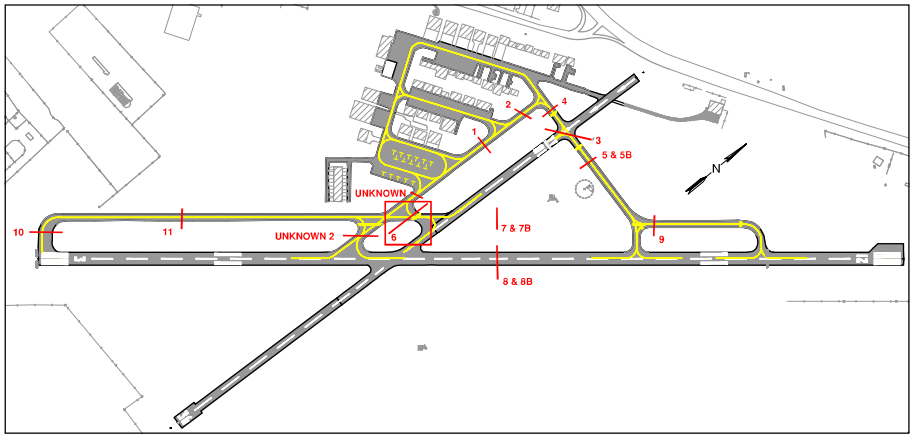


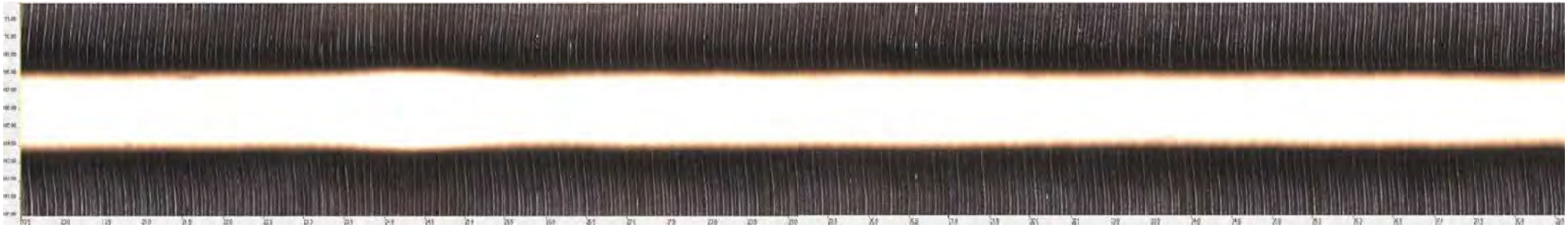
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 0.66 FT TO 19.5 FT

Parkhill

407011-24



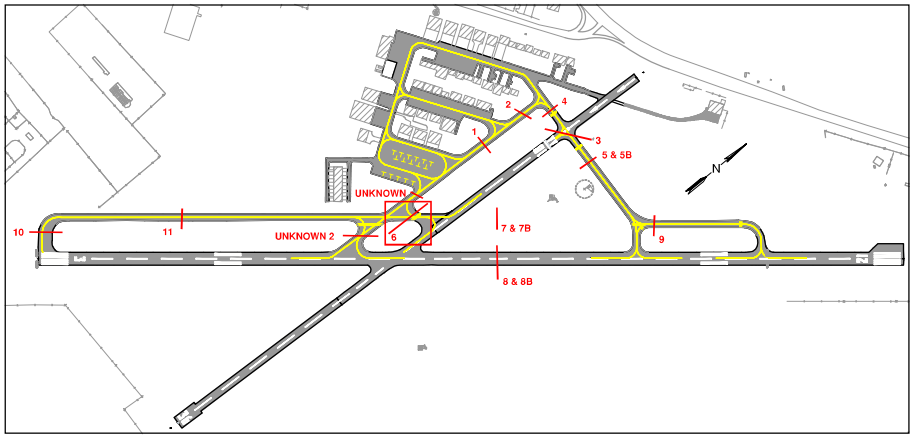


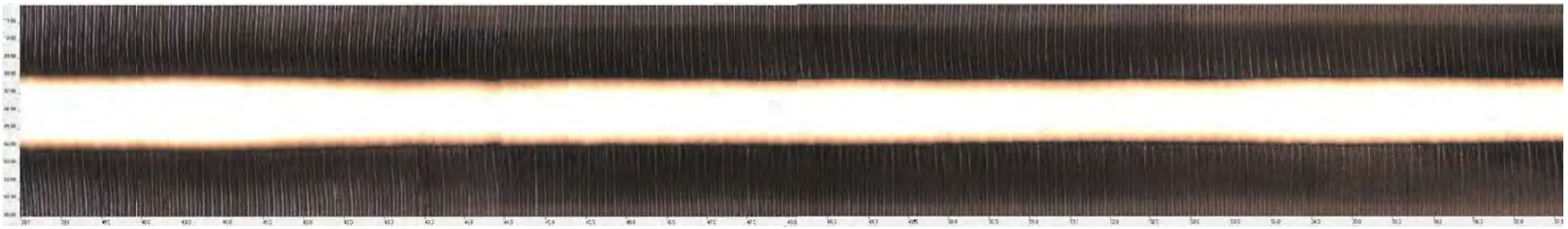
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 19.5 FT TO 38.5 FT

Parkhill

407011-24
G



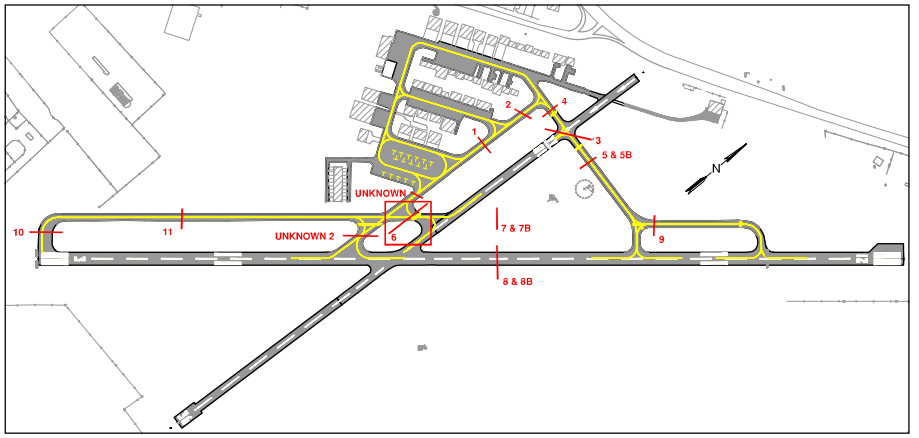


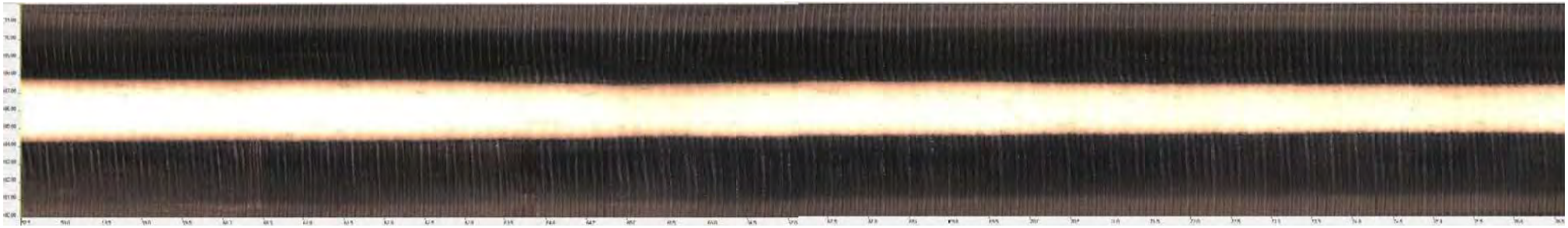
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 38.5 FT TO 57.5 FT

Parkhill

407011-24
G



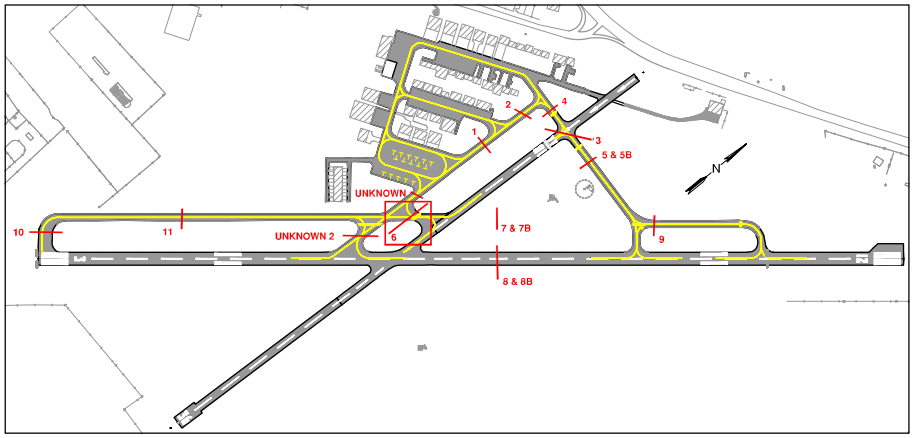


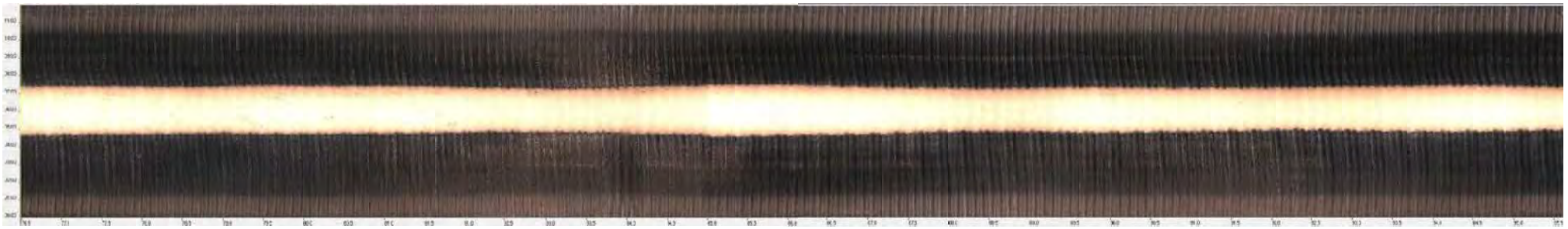
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 57.5 FT TO 76.5 FT

Parkhill

40701-24
G



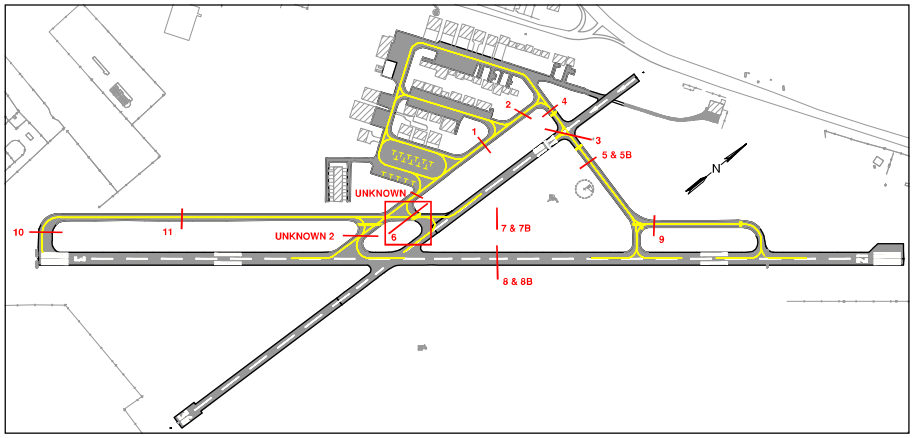


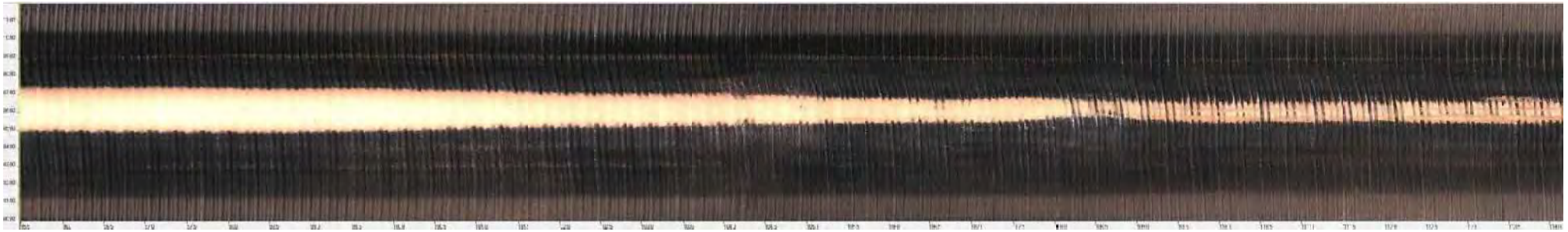
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 76.5 FT TO 95.5 FT

Parkhill

407011-24
G



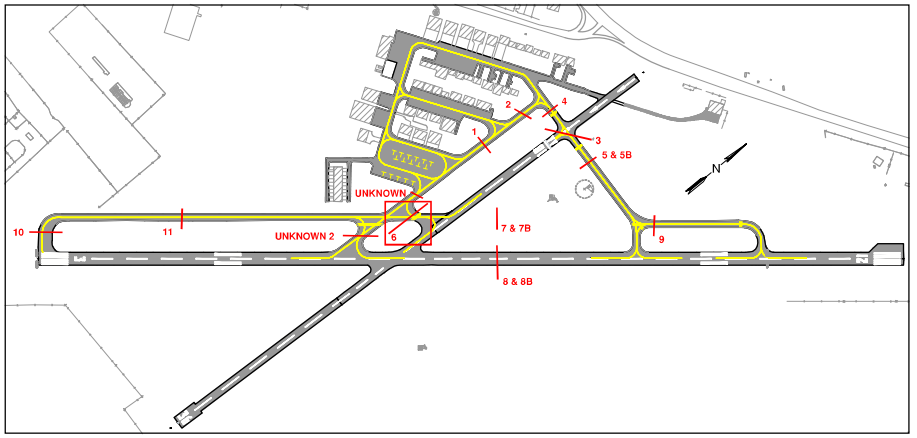


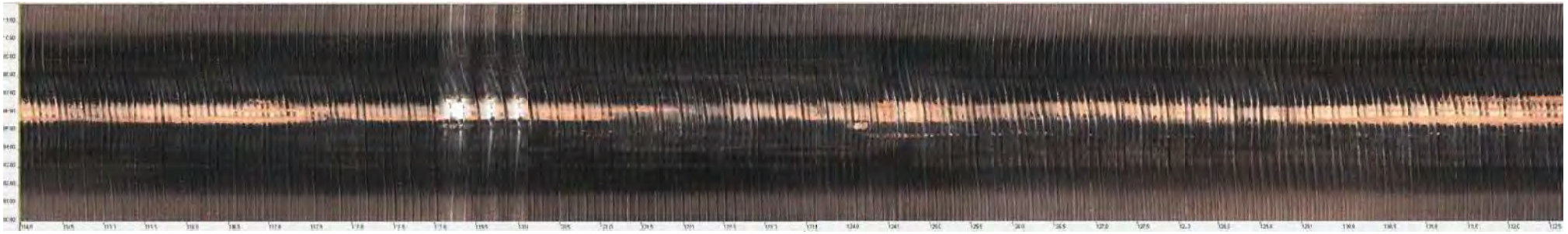
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 95.5 FT TO 114 FT

Parkhill

407041-24
G



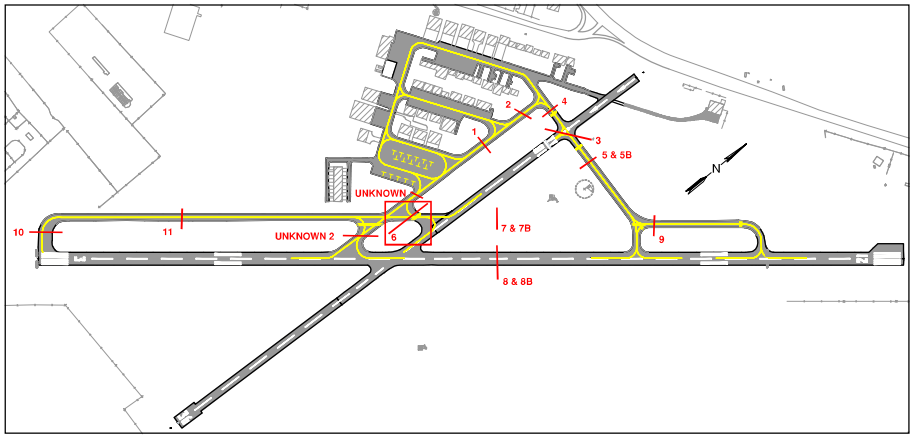


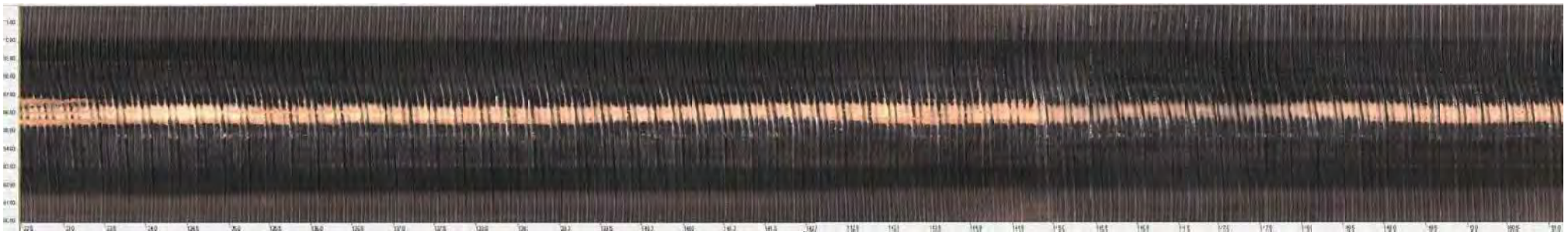
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 114 FT TO 132.5 FT

Parkhill

407011-24
G



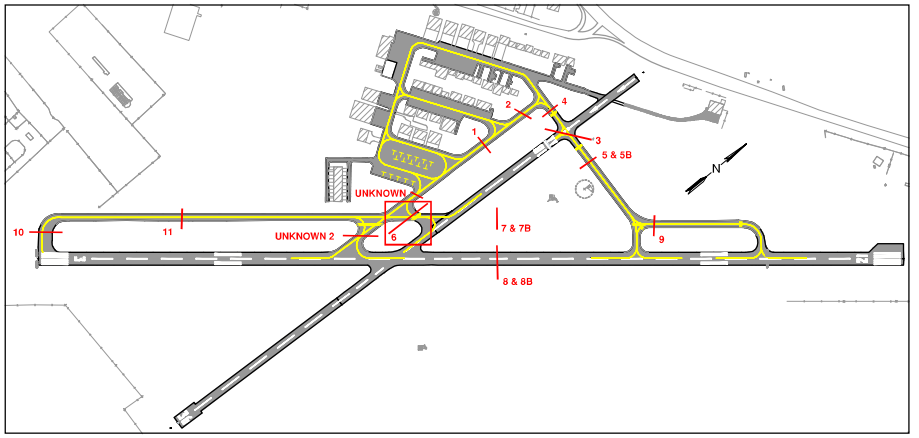


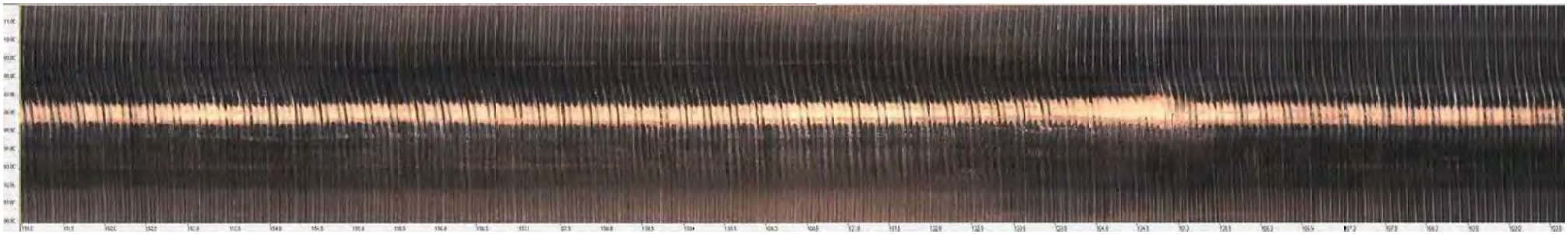
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 132.5 FT TO 151 FT

Parkhill

407011-24
G



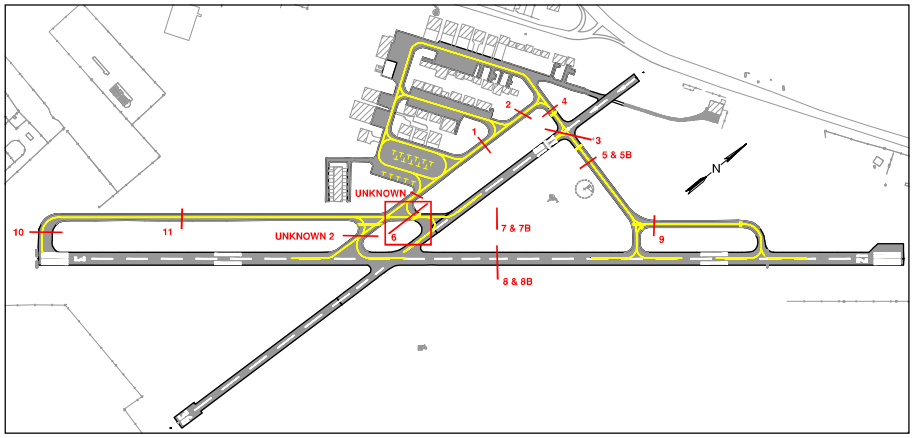


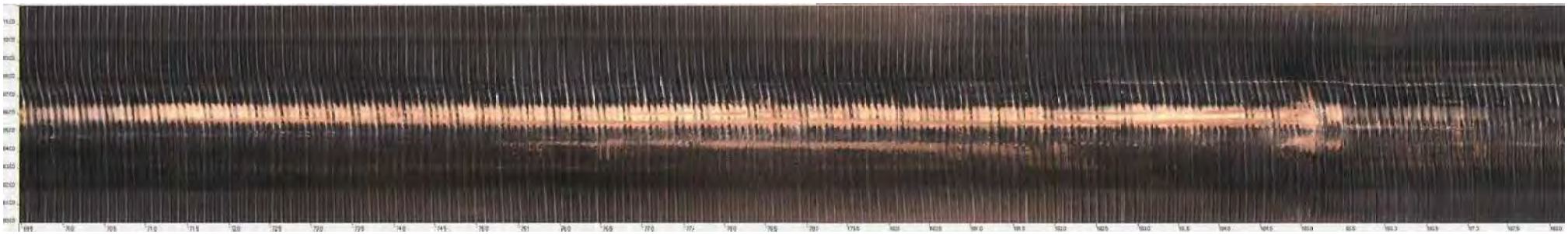
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 151 FT TO 169.5 FT

Parkhill

40701-24
G



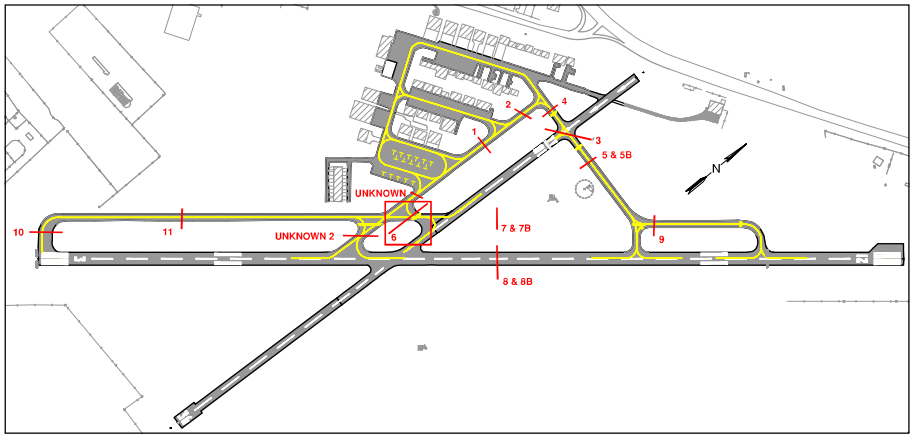


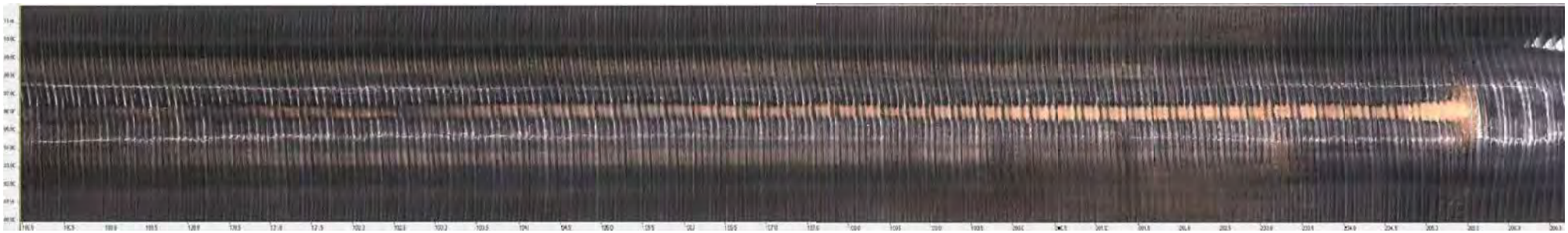
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 169.5 FT TO 188 FT

Parkhill

407001-24
G



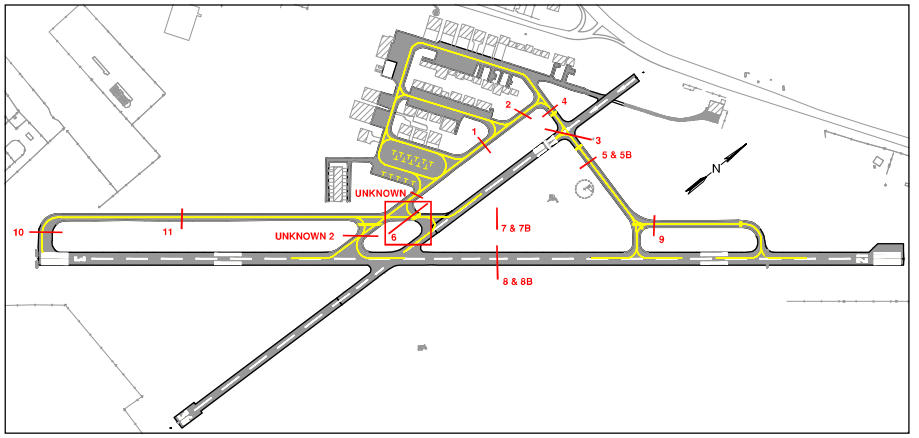


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 188 FT TO 206.5 FT

Parkhill

40701-24
G



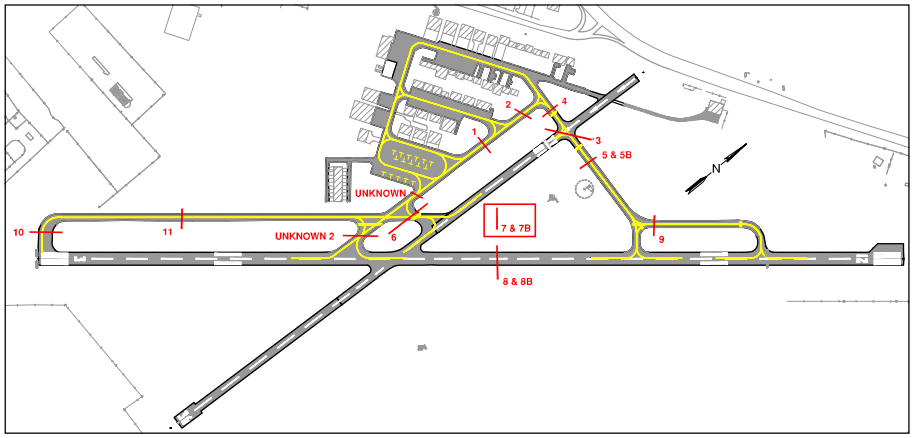


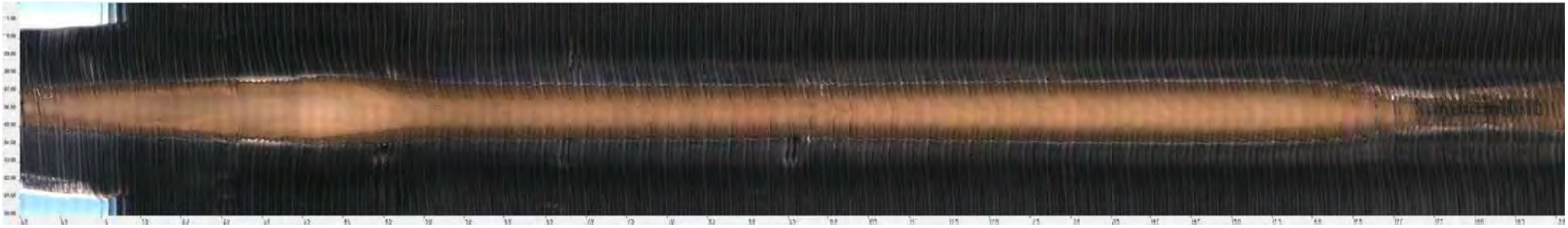
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #6
STA 206.5 FT TO 210.8 FT

Parkhill

407001-24



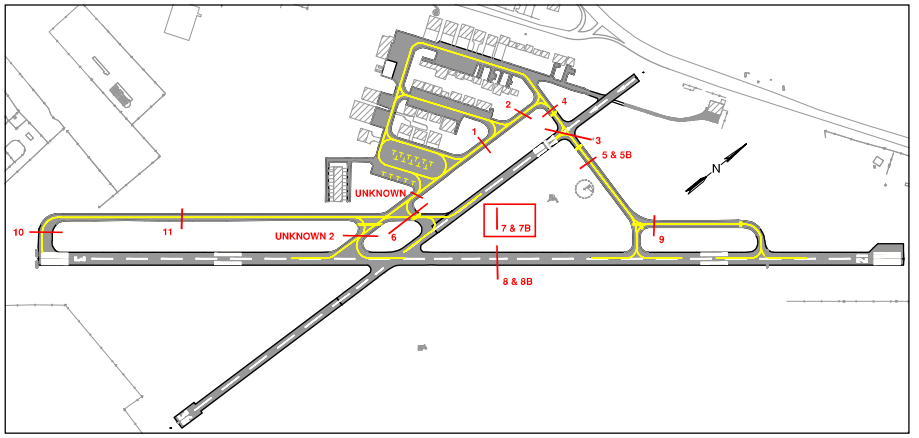


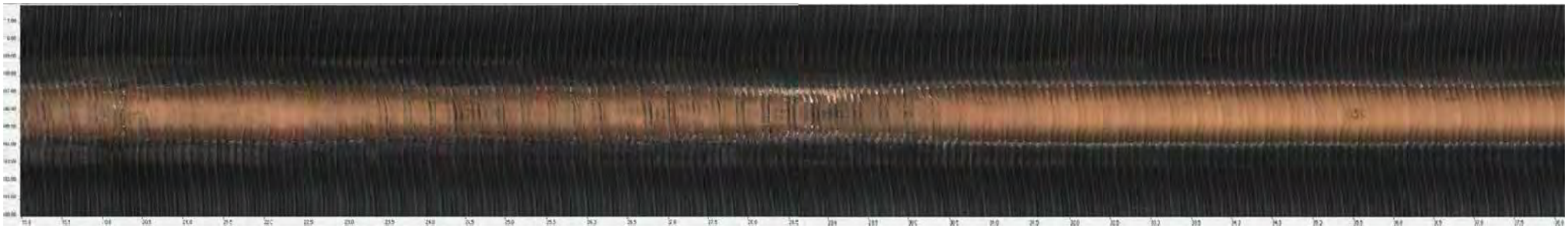
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7
STA 0 FT TO 19 FT

Parkhill

407041-24



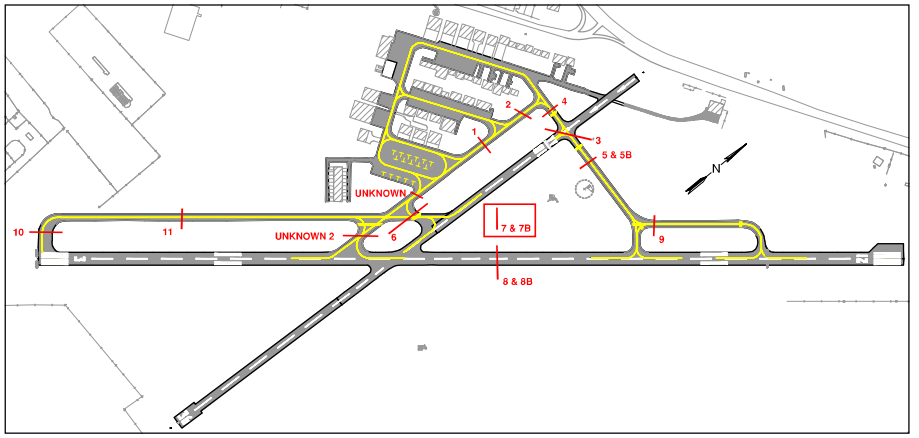


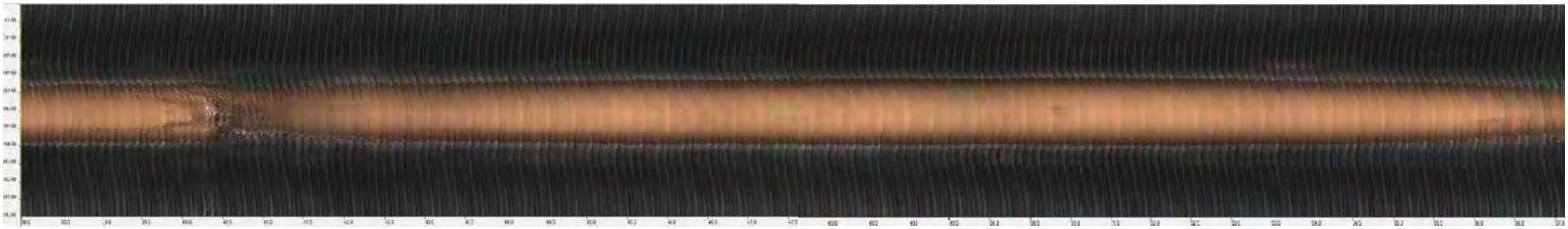
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7
STA 19 FT TO 38 FT

Parkhill

407041-24
G



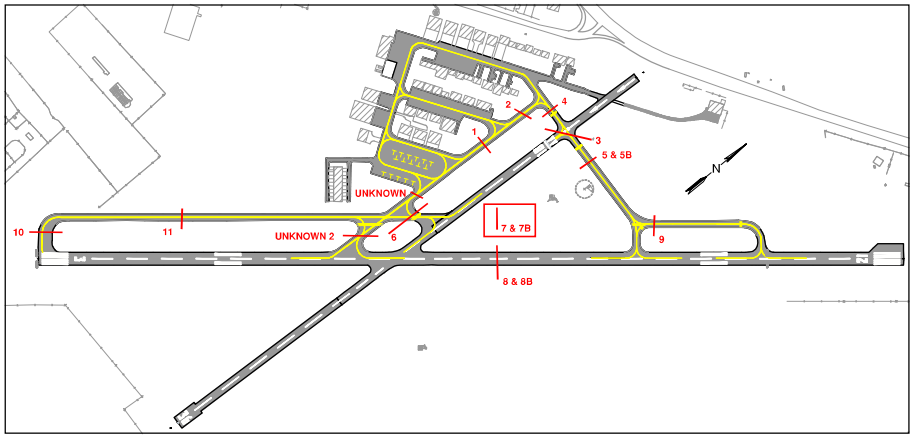


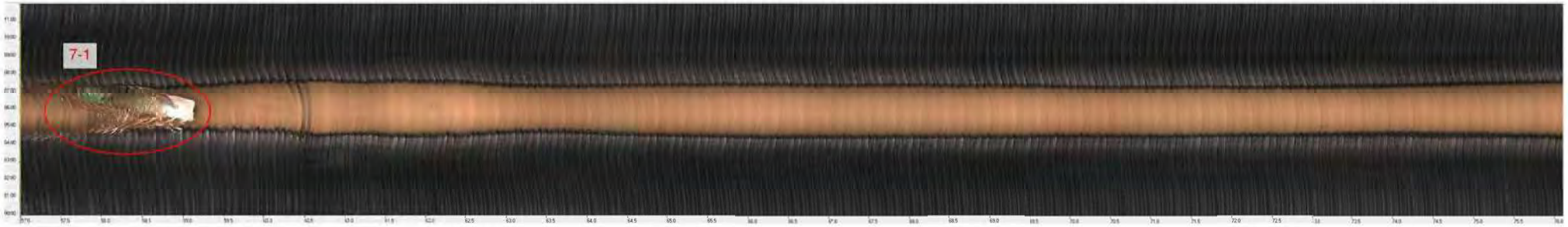
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7
STA 38 FT TO 57 FT

Parkhill

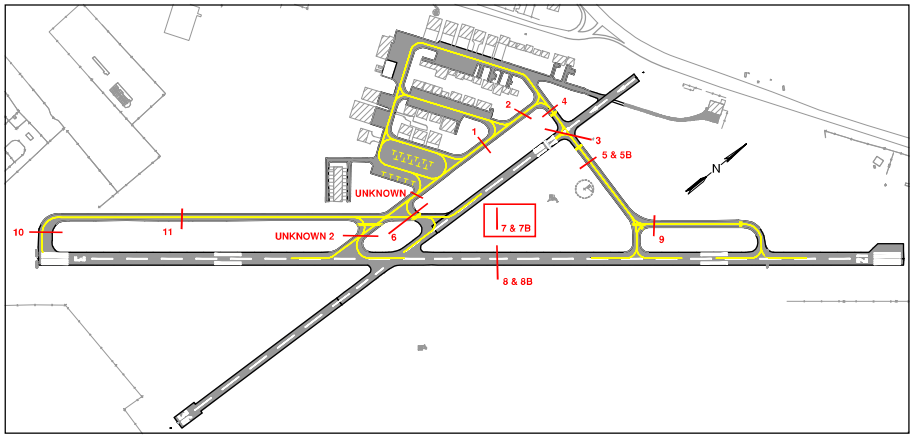
407041-24
G

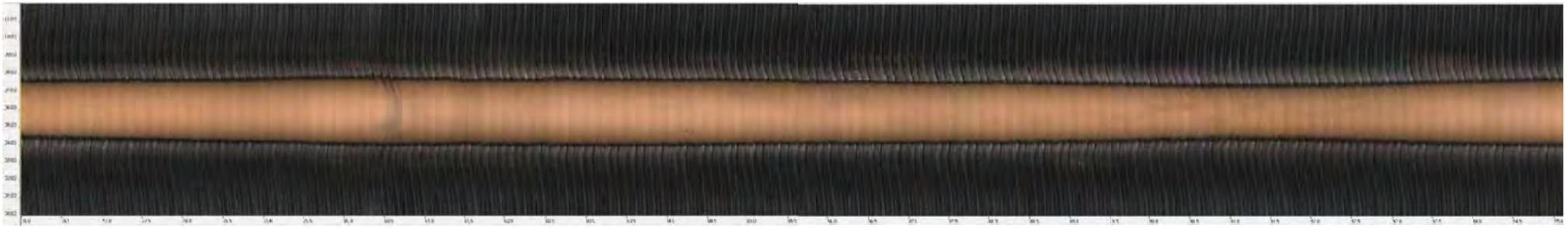






7-1
LOCATION IN PIPE: 58 FT
NOTE: DEPOSITS ATTACHED OTHER



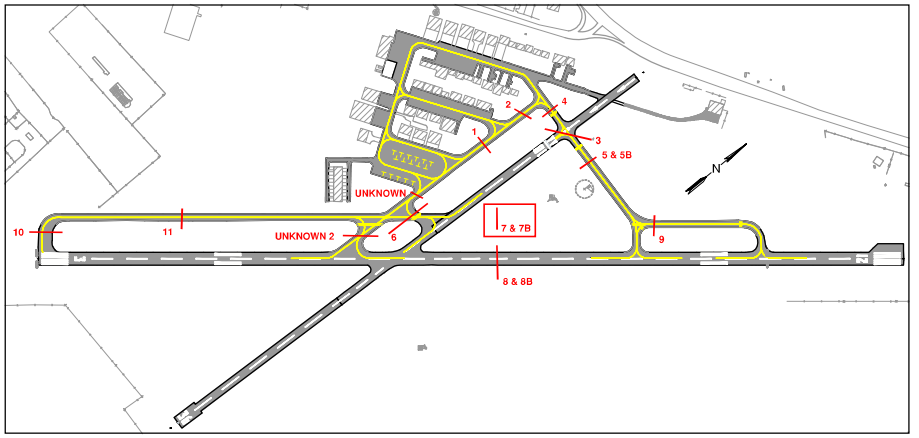


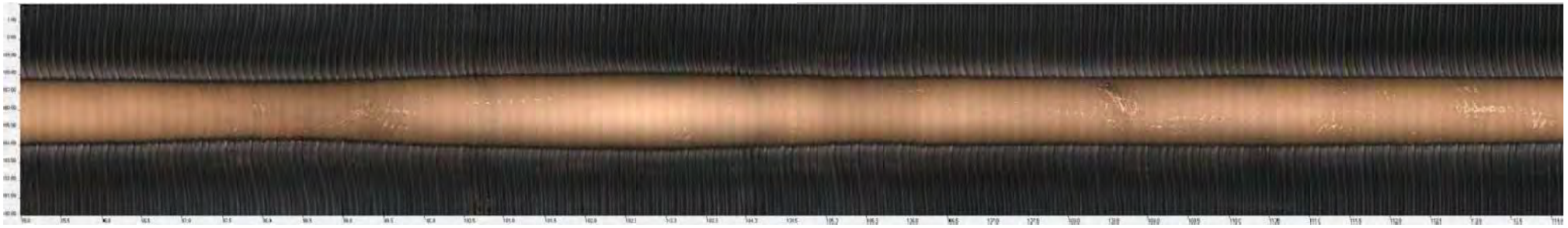
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7
STA 76 FT TO 95 FT

Parkhill

407041-24



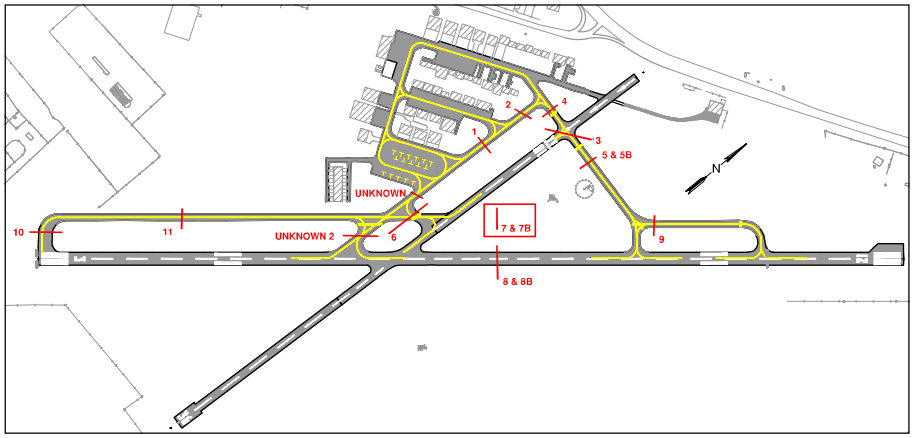


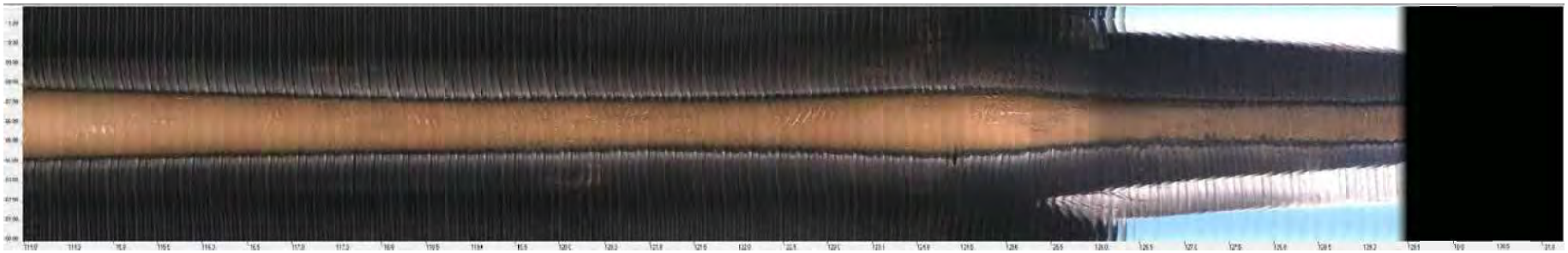
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7
STA 95 FT TO 114 FT

Parkhill

407041-24
G



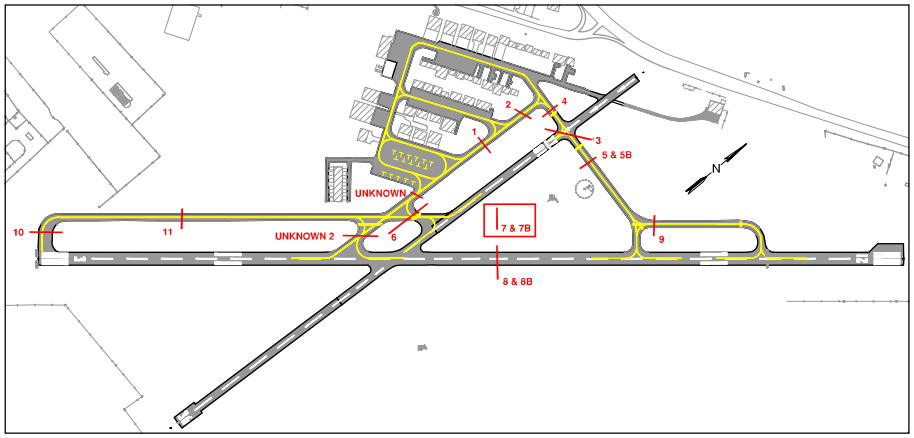


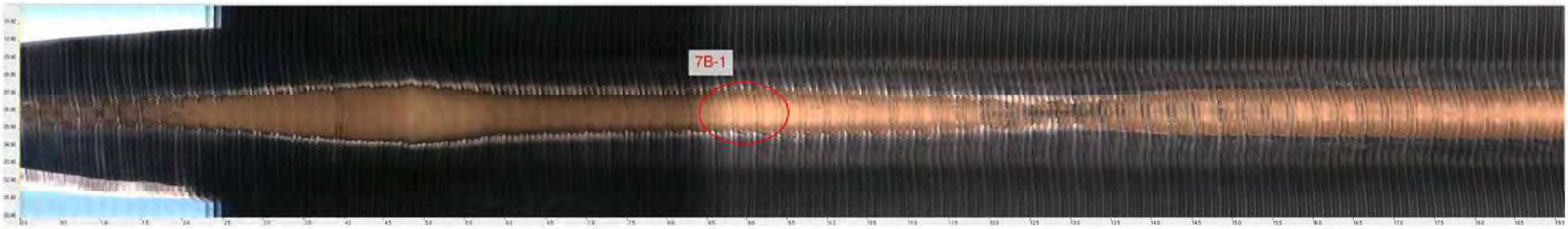
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

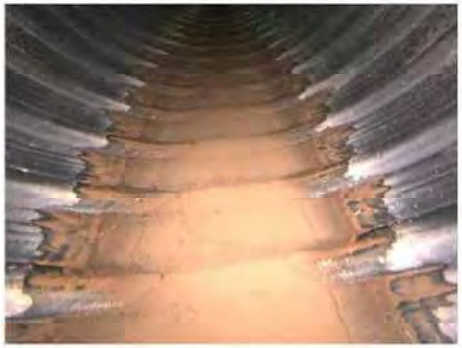
UNFOLDED PIPE #7
STA 114 FT TO 129.3 FT

Parkhill

40701-24
G







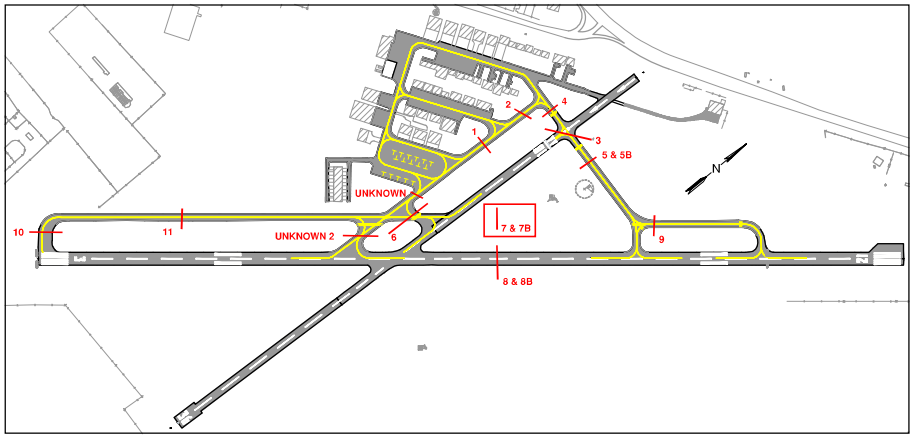
7B-1
LOCATION IN PIPE: 9 FT
NOTE: DEPOSITS SETTLED FINE

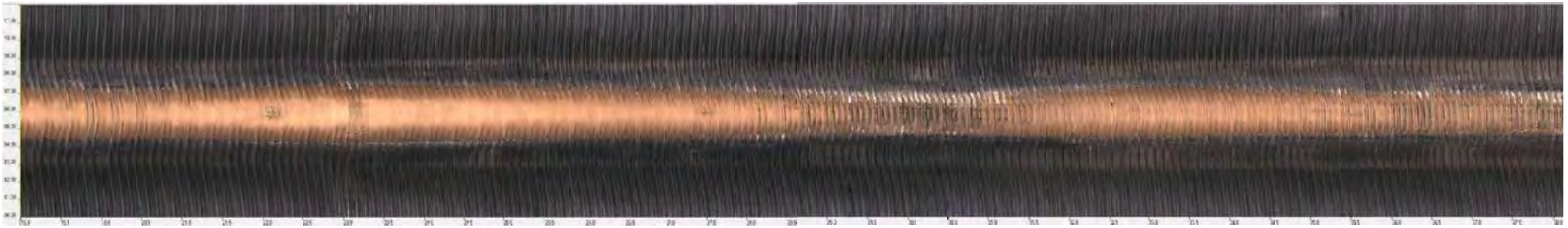
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 0 FT TO 19 FT

Parkhill

40701-24



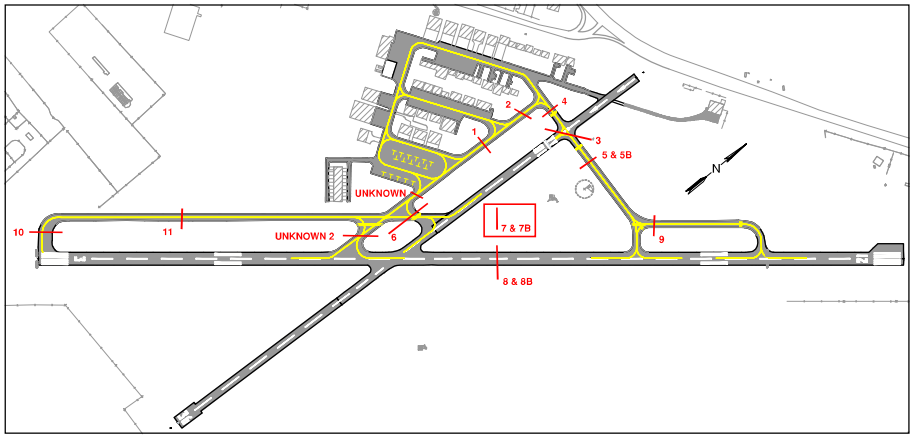


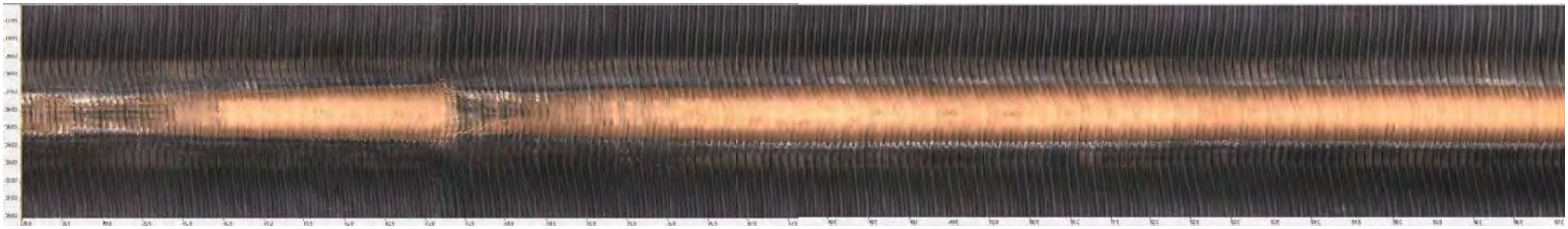
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 19 FT TO 38 FT

Parkhill

40701-24



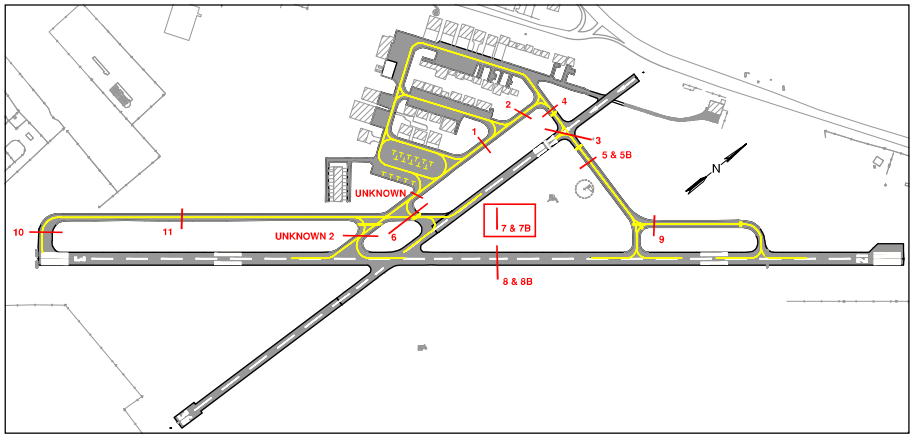


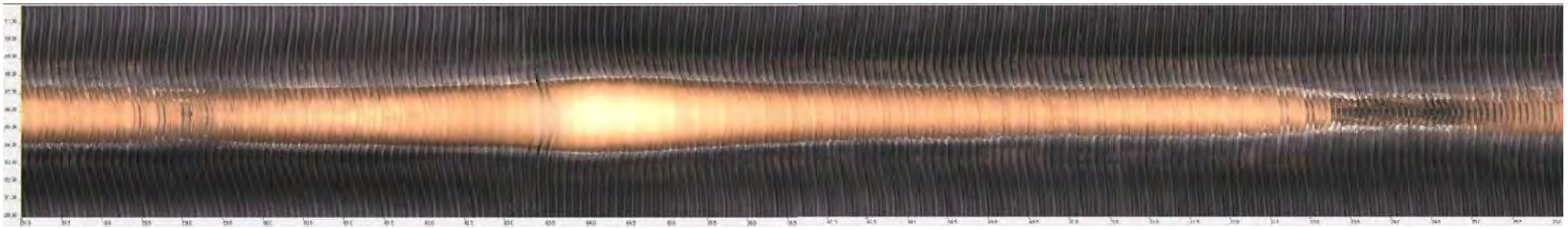
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 38 FT TO 57 FT

Parkhill

40701-24
G



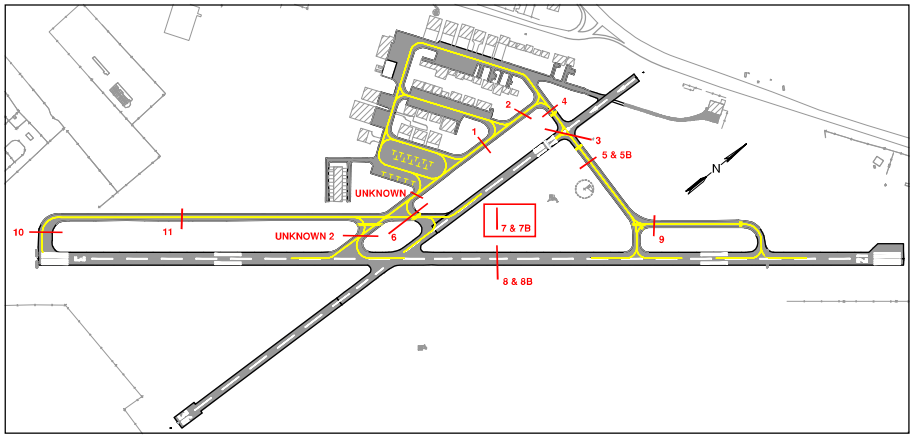


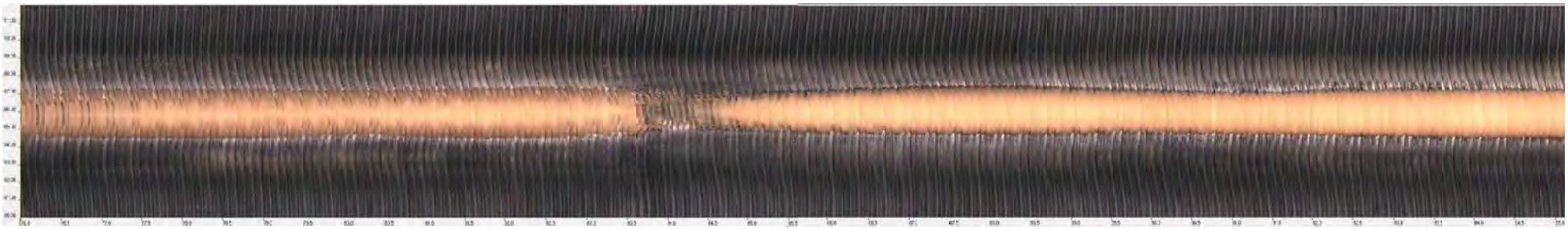
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 57 FT TO 76 FT

Parkhill

407041-24
G



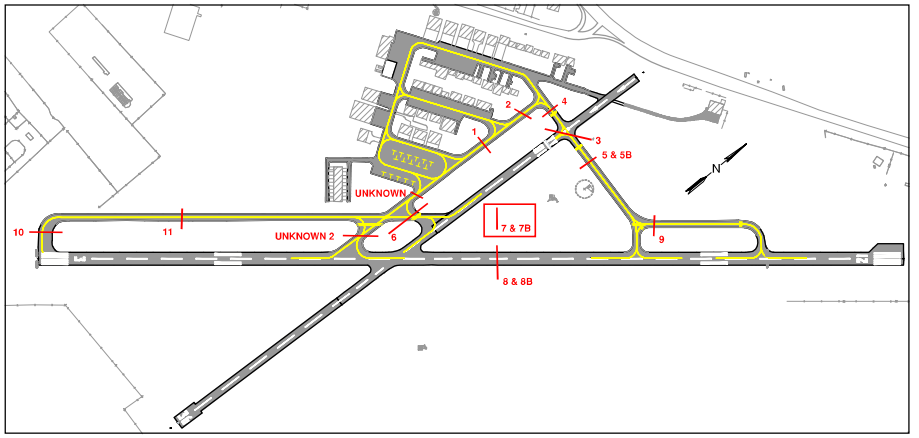


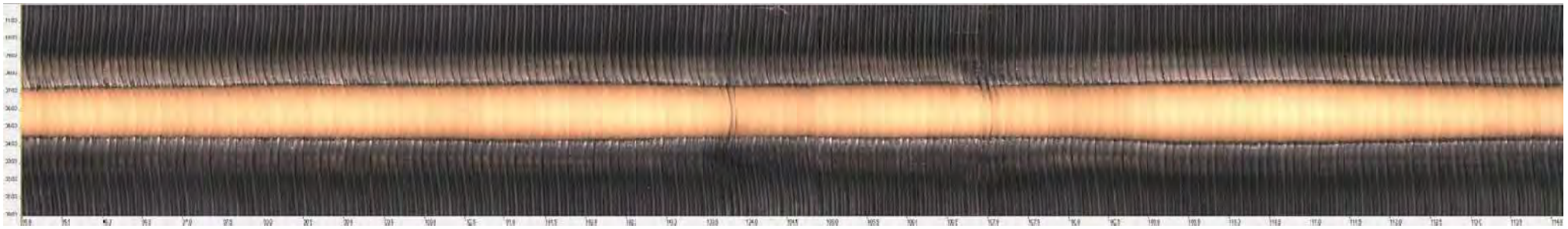
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 76 FT TO 95 FT

Parkhill

407011-24
G



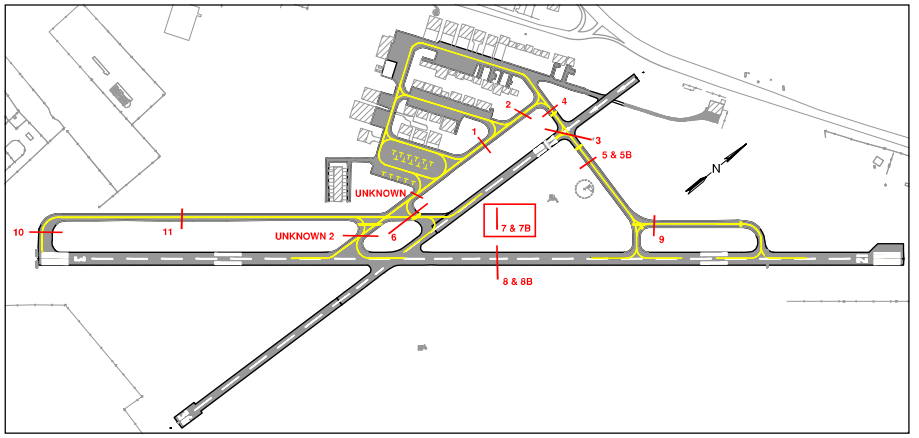


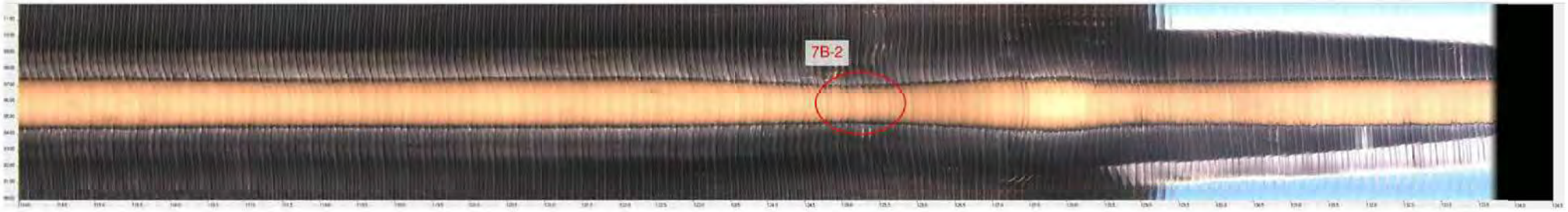
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 95 FT TO 114 FT

Parkhill

407011-24





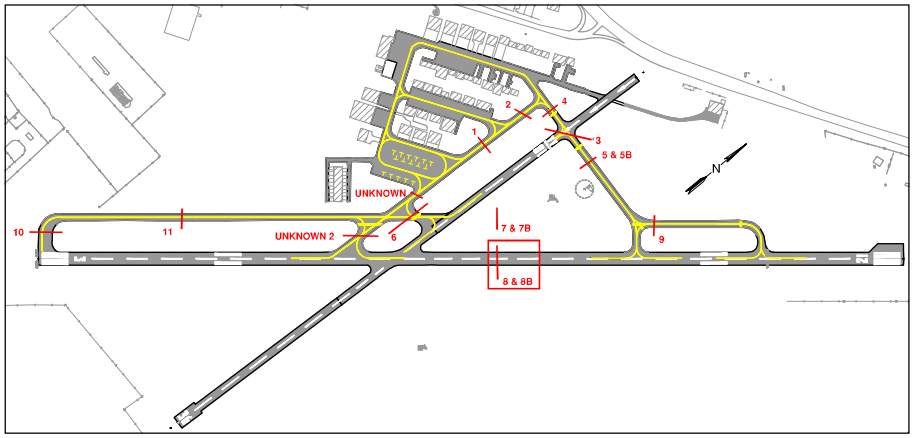


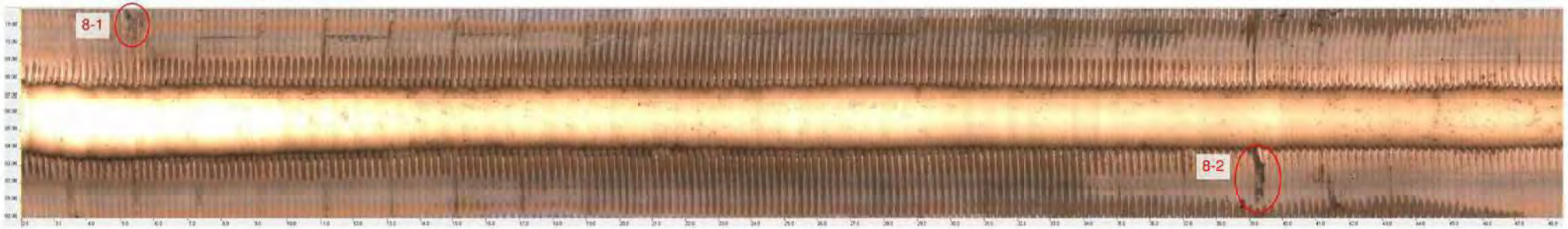
7B-2
LOCATION IN PIPE: 125.5 FT
NOTE: DEPOSITS SETTLED FINE

GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #7B
STA 114 FT TO 133.5 FT

Parkhill







8-1
LOCATION IN PIPE: 5 FT
NOTE: HOLE SOIL VISIBLE



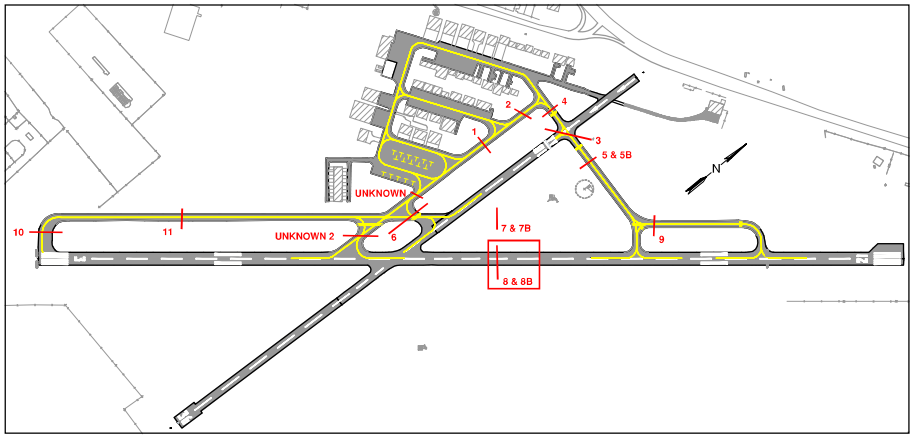
8-2
LOCATION IN PIPE: 39 FT
NOTE: DEFORMED RIDGE

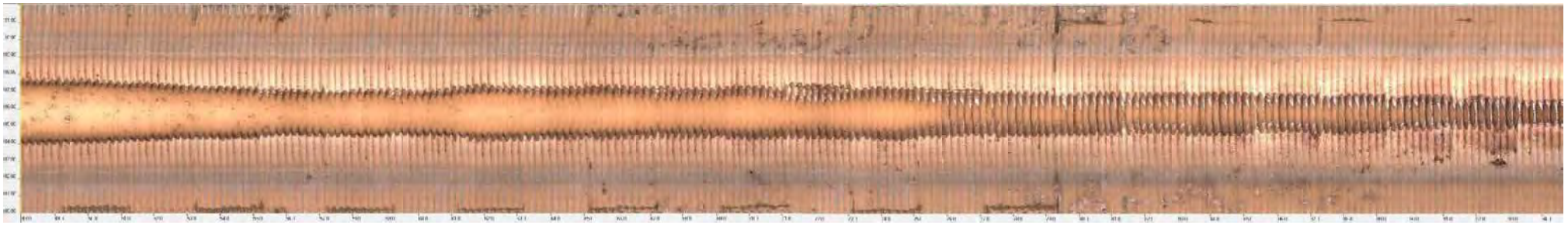
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8
STA 2 FT TO 48 FT

Parkhill

01-24



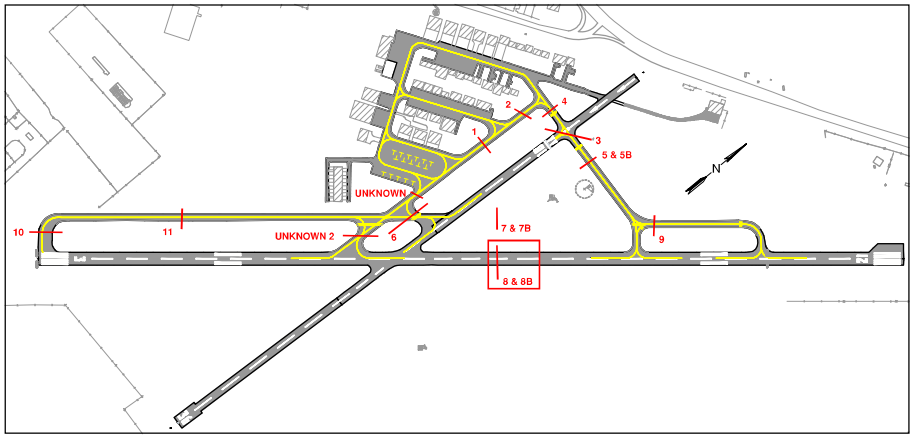


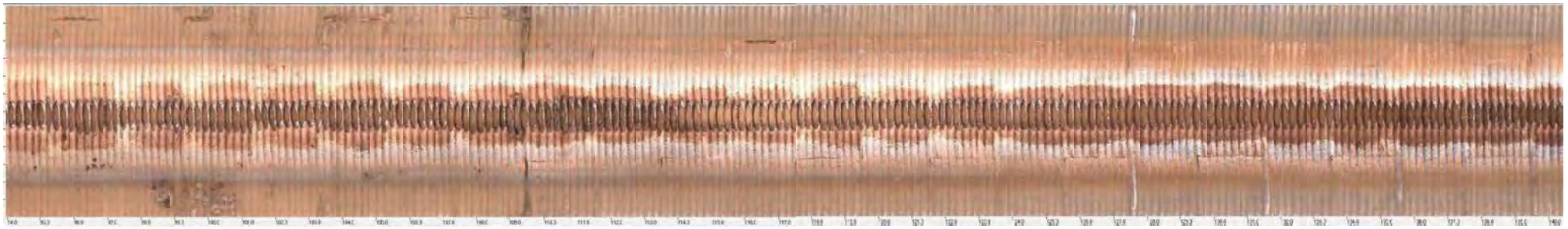
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8
STA 48 FT TO 94 FT

Parkhill

40701-24



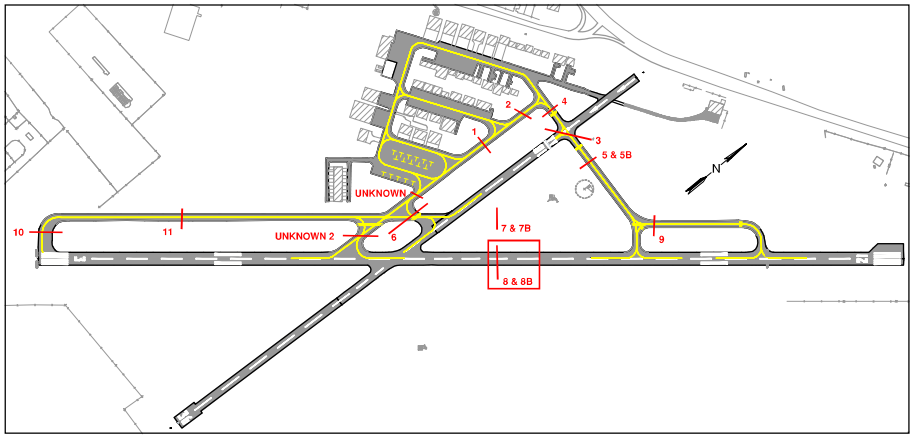


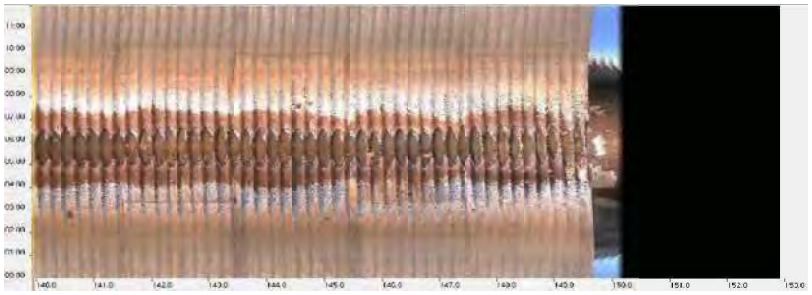
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8
STA 94 FT TO 140 FT

Parkhill

407041-24
G



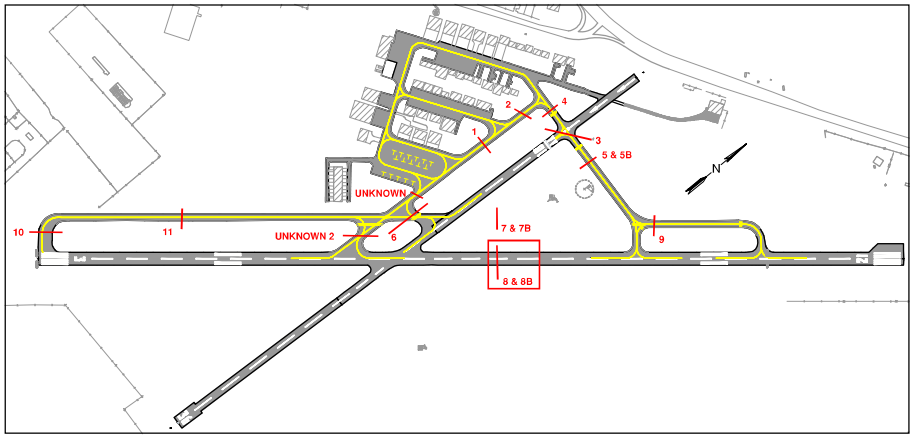


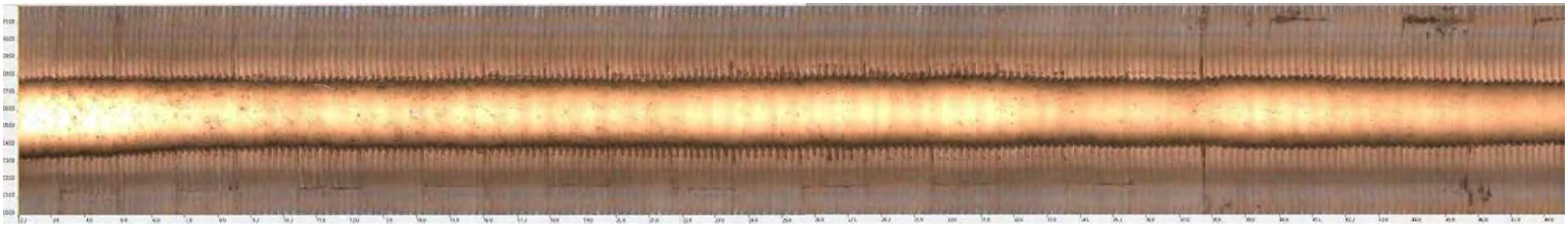
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8
STA 140 FT TO 150 FT

Parkhill

407001-24
G



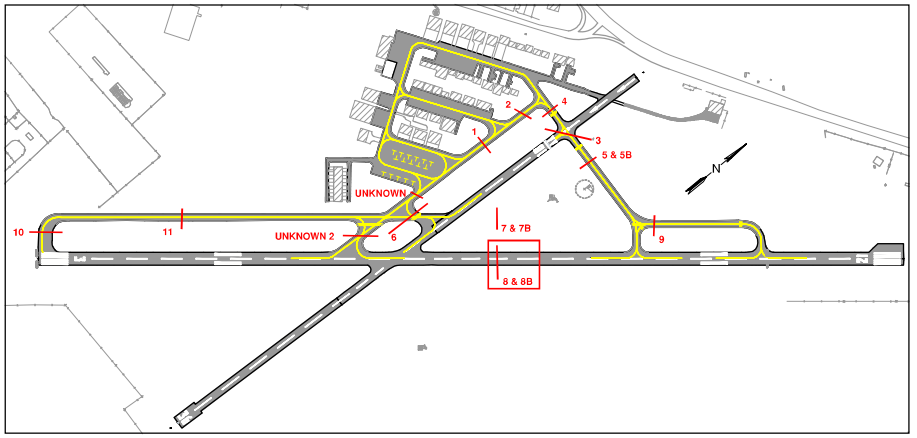


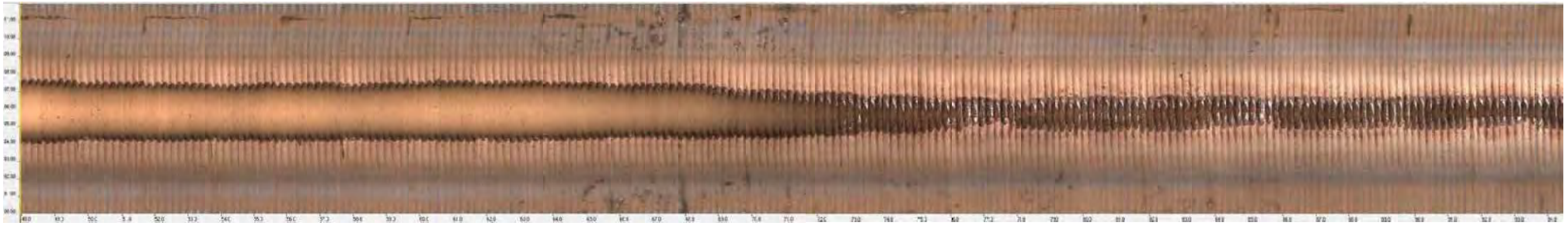
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8B
STA 2 FT TO 48 FT

Parkhill

40701-24



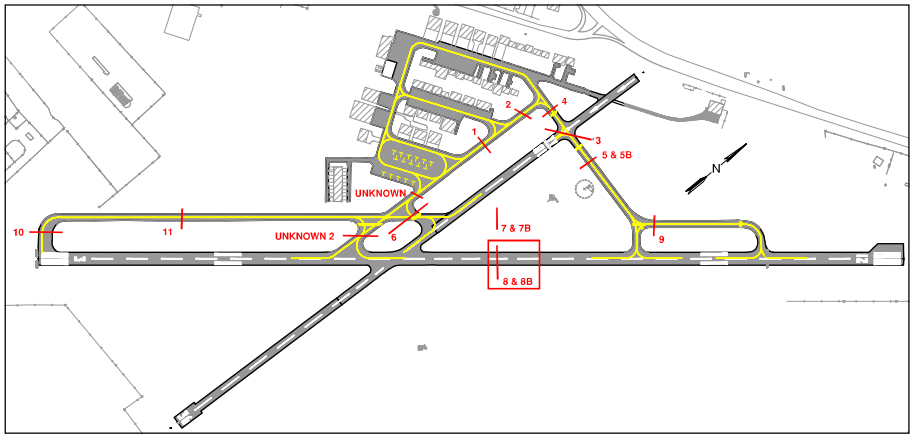


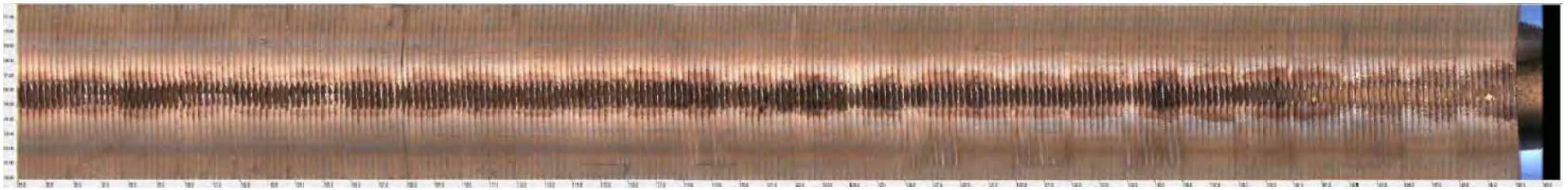
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8B
STA 48 FT TO 94 FT

Parkhill

407001-24
G



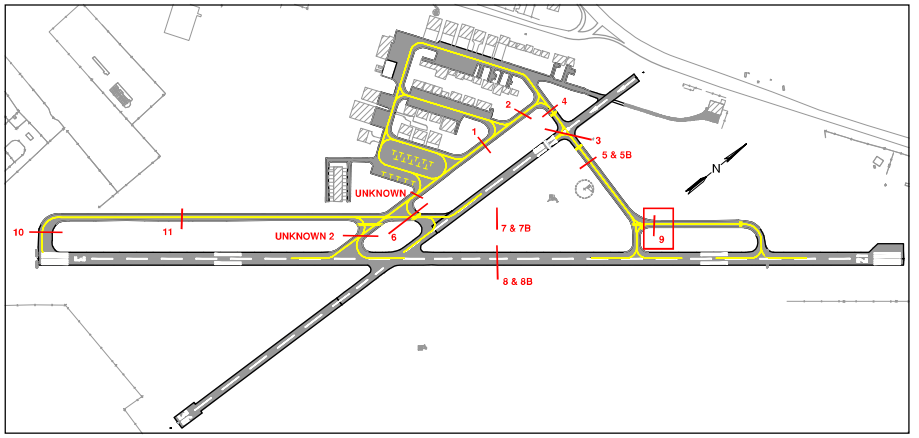


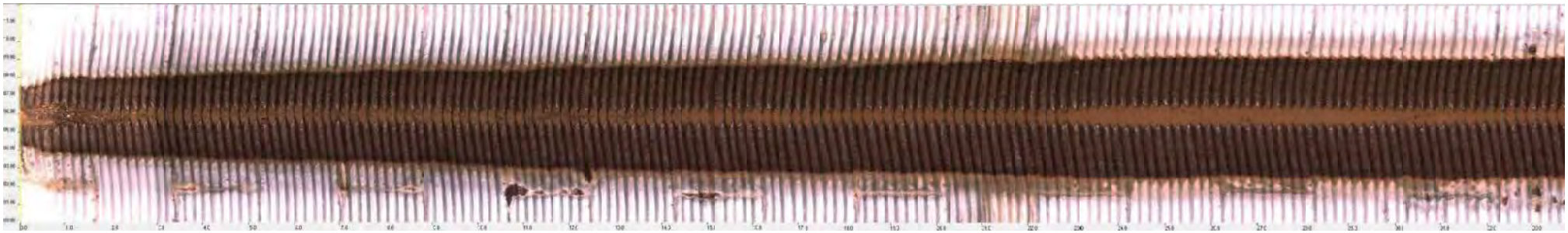
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #8B
STA 94 FT TO 148.8 FT

Parkhill

407011-24



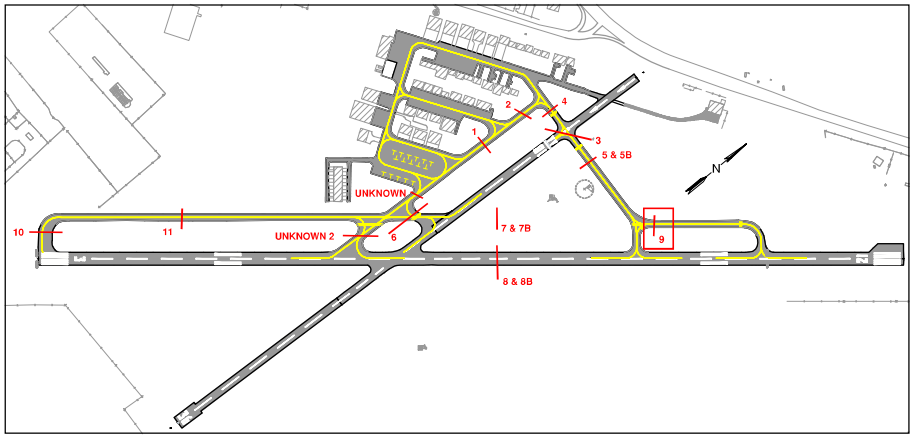


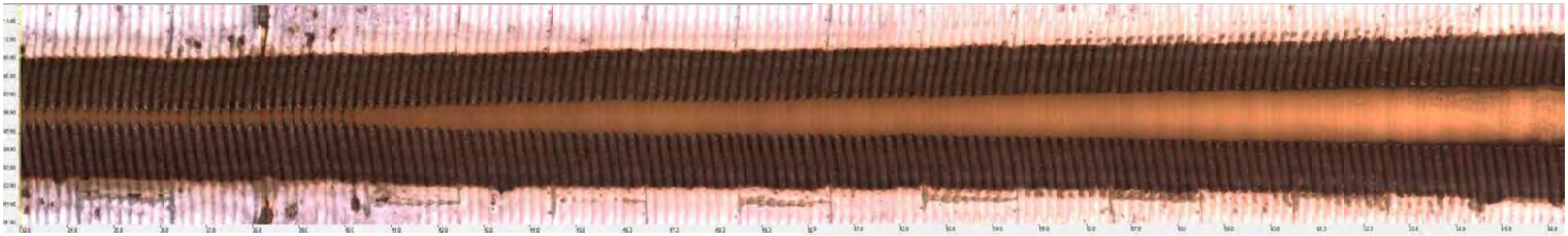
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #9
STA 0 FT TO 33 FT

Parkhill

407011-24



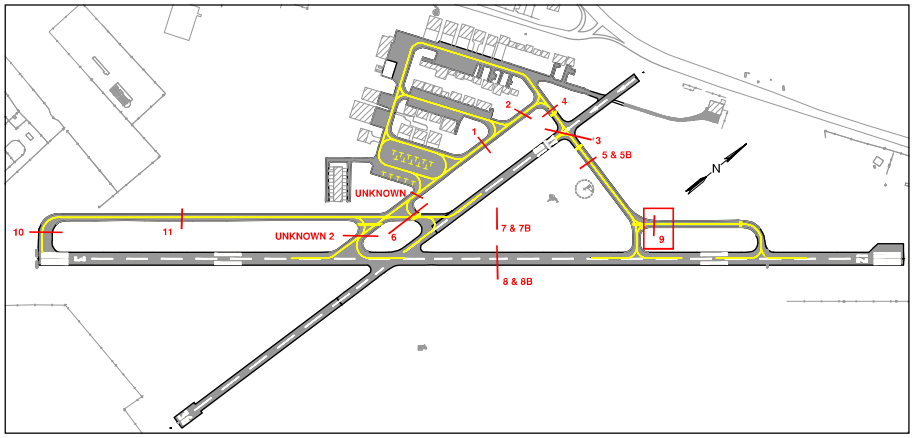


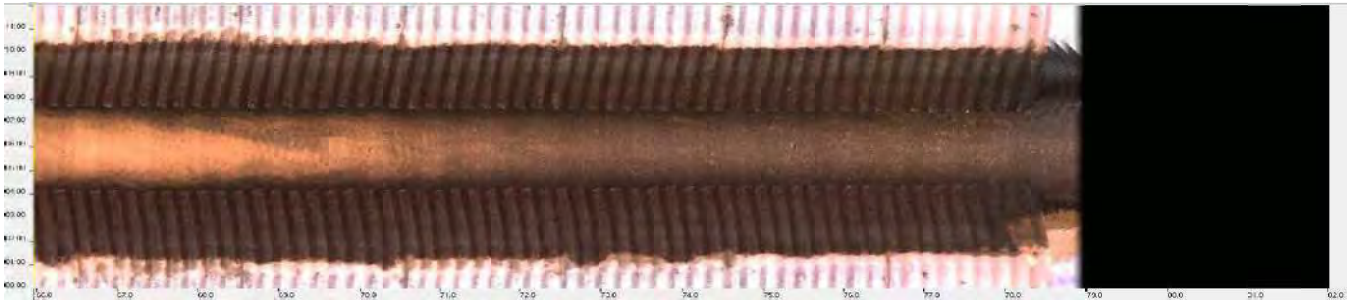
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #9
STA 33 FT TO 66 FT

Parkhill

407041-24
G



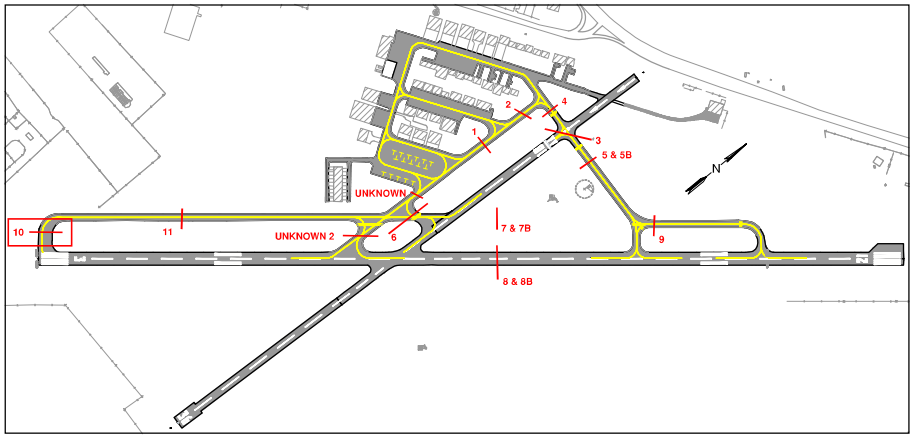


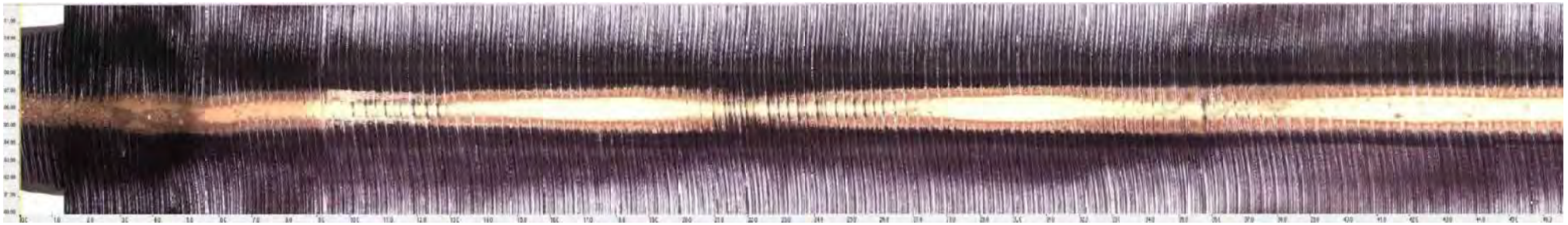
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #9
STA 66 FT TO 79 FT

Parkhill

407001-24



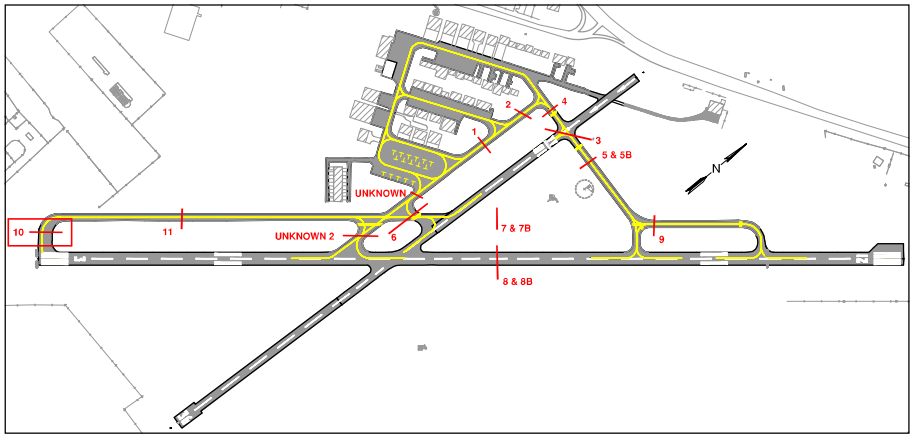


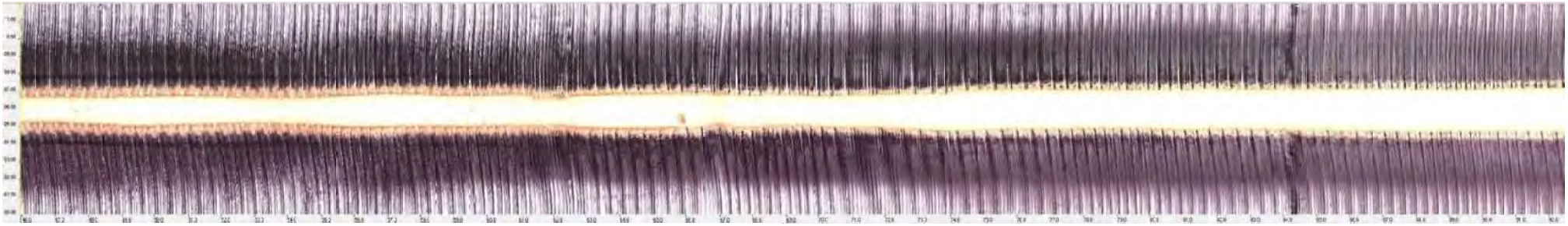
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #10
STA 0 FT TO 46 FT

Parkhill

40701-24



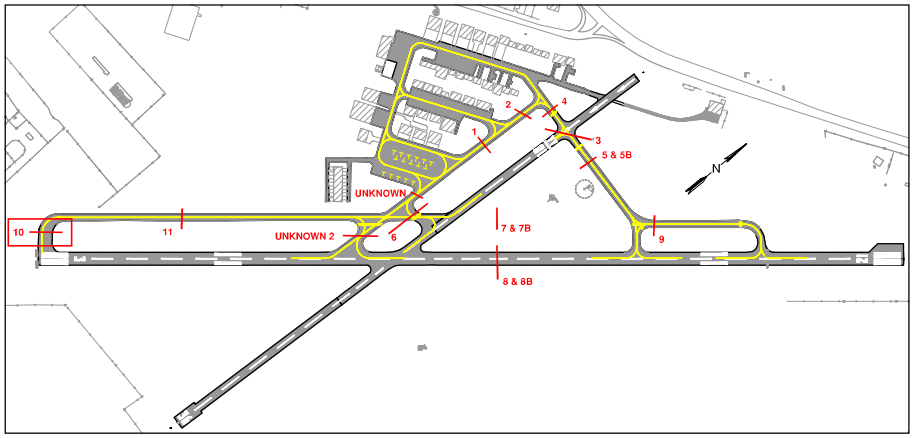


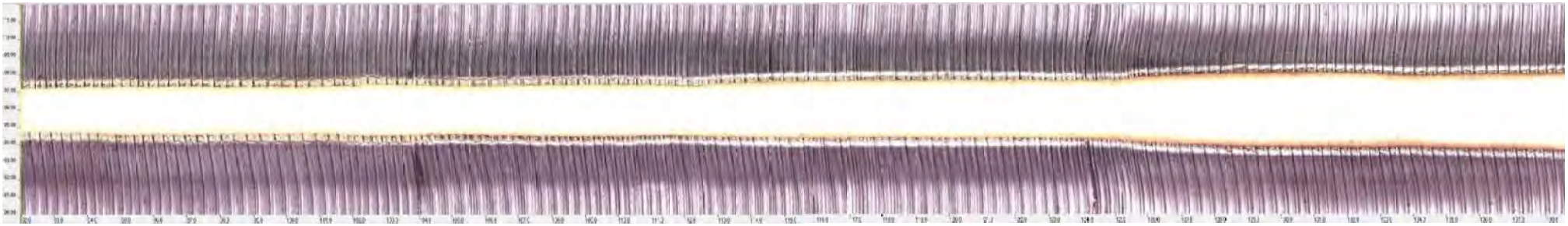
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #10
STA 46 FT TO 92 FT

Parkhill

407041-24
G



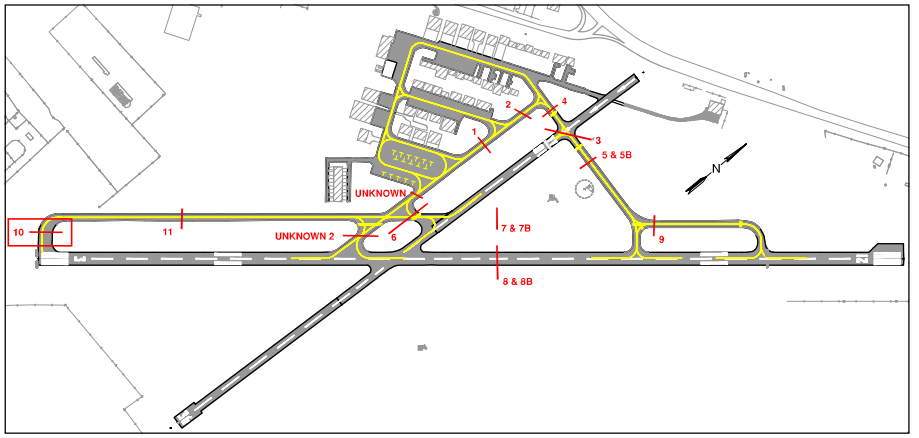


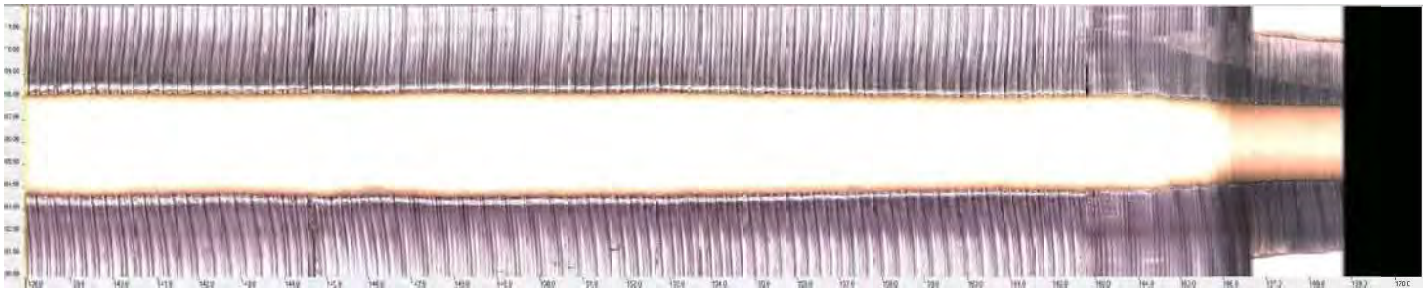
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #10
STA 92 FT TO 138 FT

Parkhill

407011-24



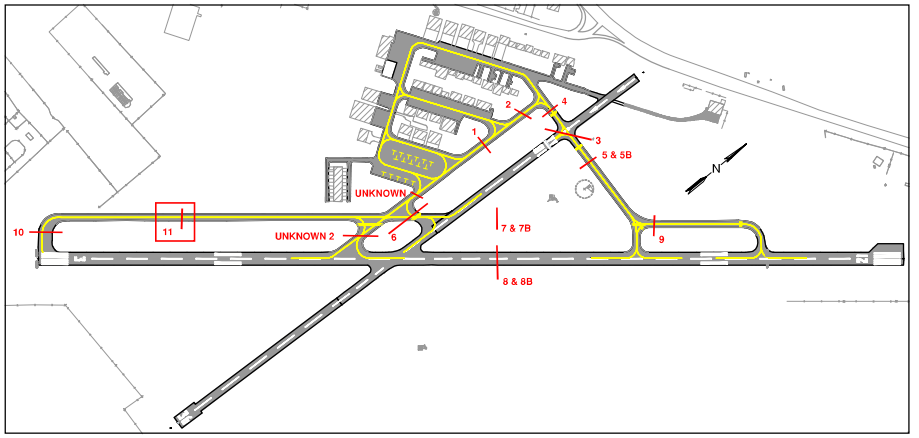


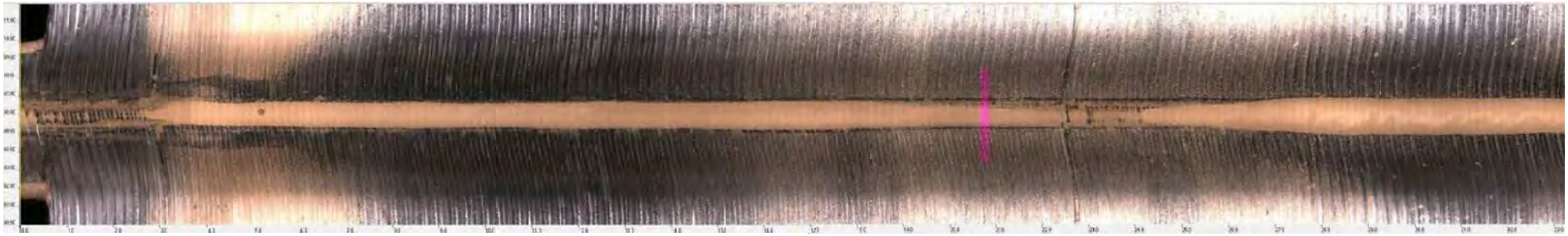
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #10
STA 138 FT TO 168.8 FT

Parkhill

407011-24



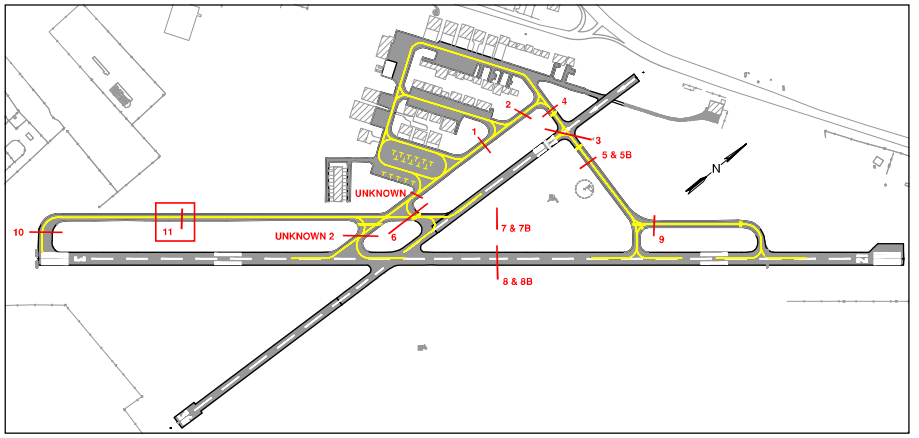


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #11
STA 0 FT TO 33 FT

Parkhill

40701-24
G



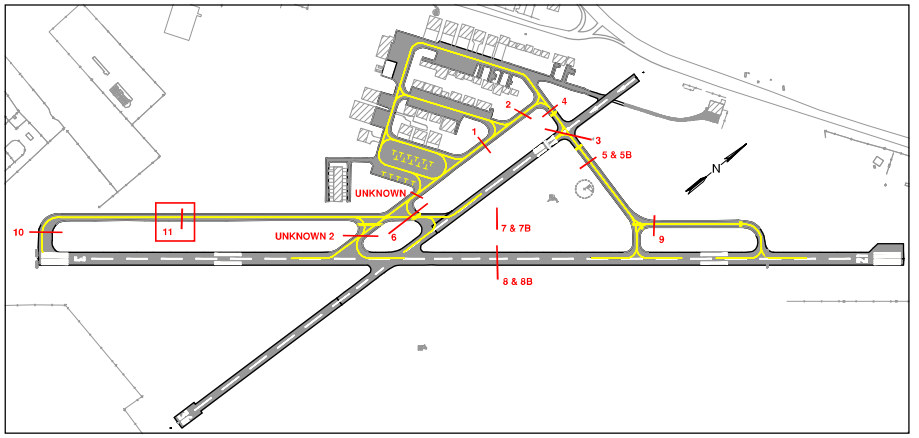


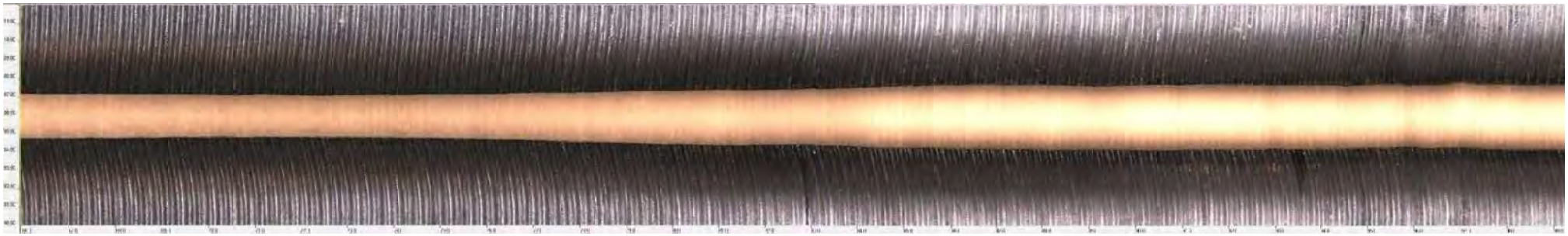
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #11
STA 33 FT TO 66 FT

Parkhill

40701-24



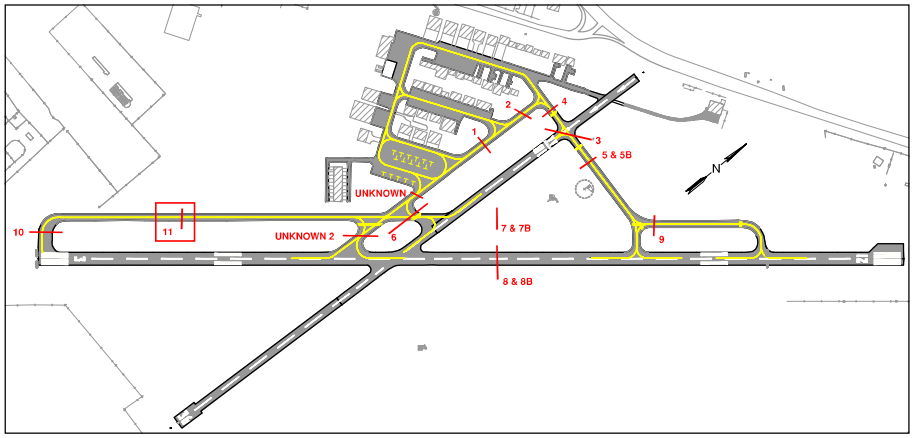


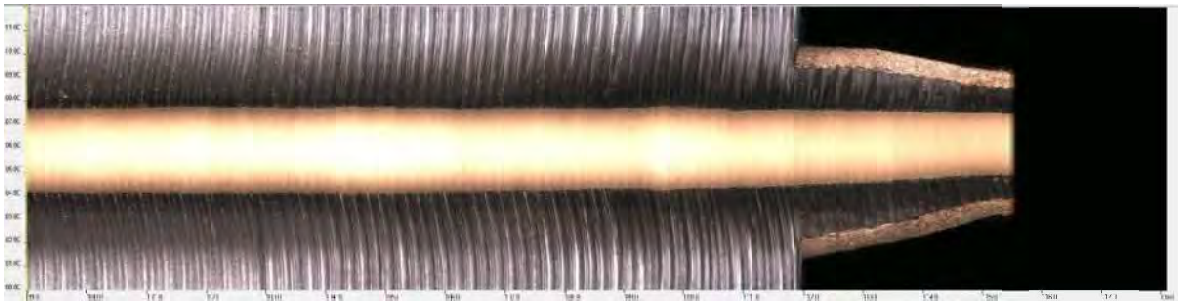
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #11
STA 66 FT TO 99 FT

Parkhill

407001-24



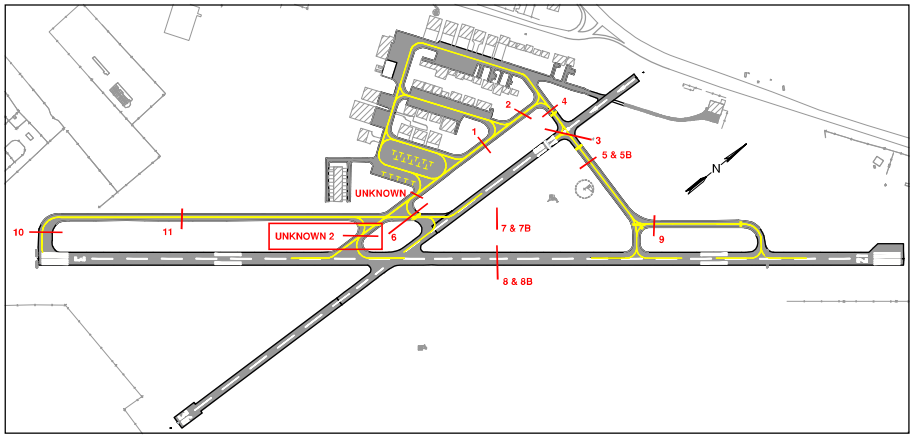


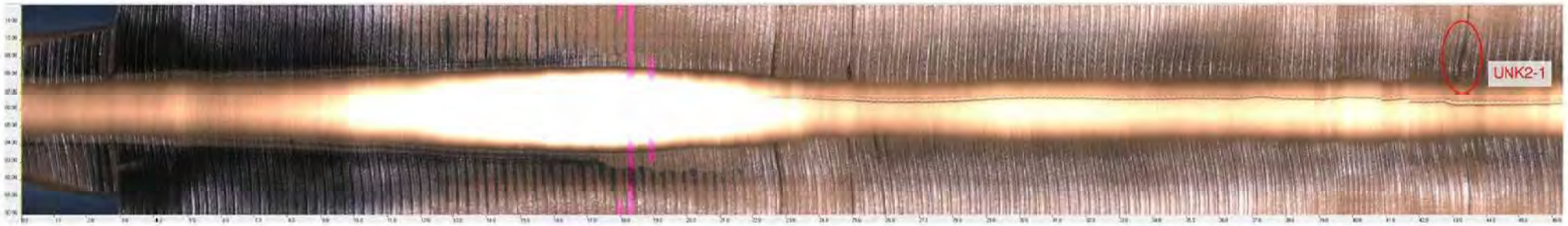
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE #11
STA 99 FT TO 115.4 FT

Parkhill

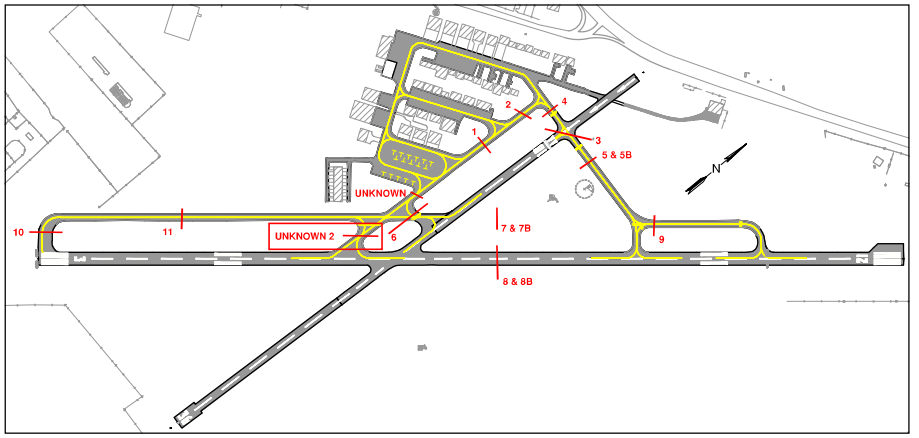
407001-24
G

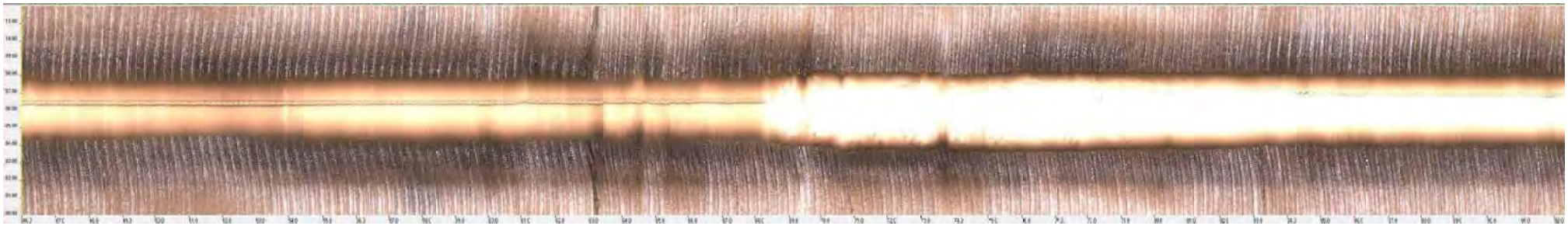






UNK2-1
LOCATION IN PIPE: 43 FT
NOTE: ROOTS FINE JOINT



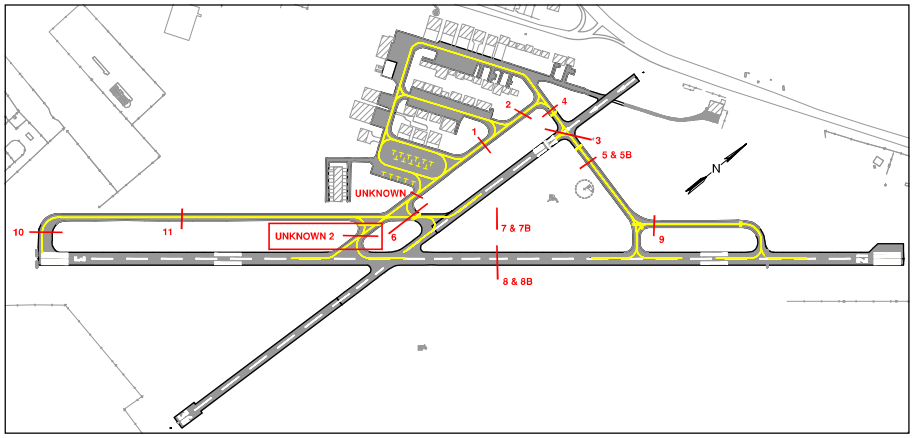


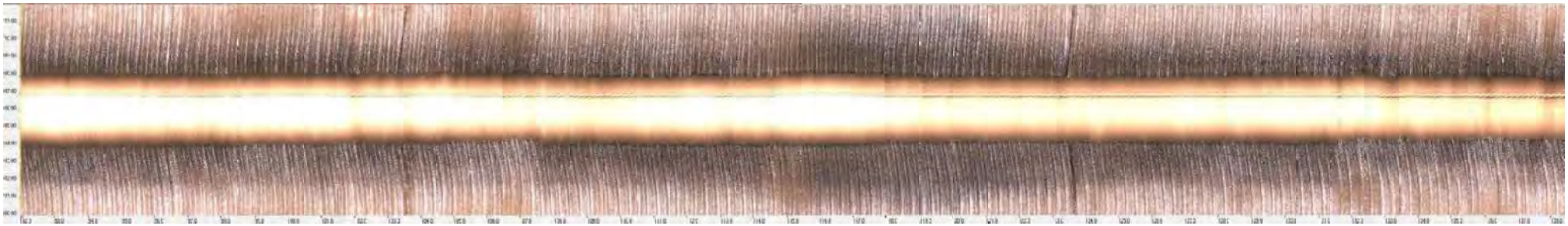
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN 2
STA 46 FT TO 92 FT

Parkhill

407011-24
G



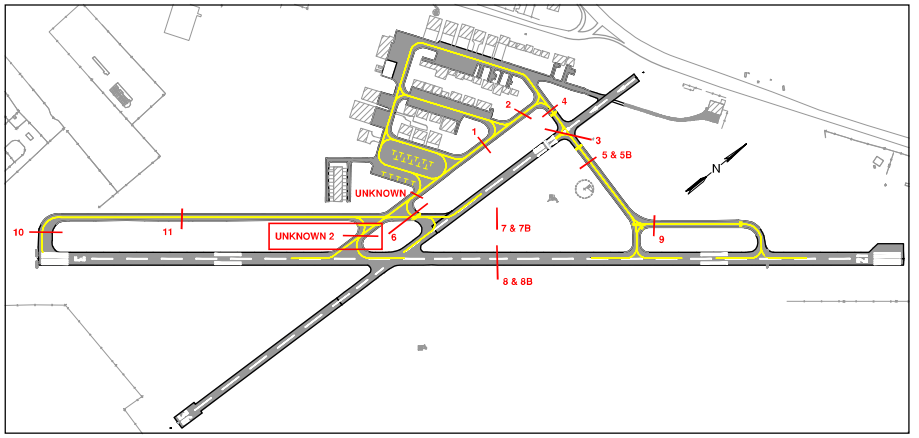


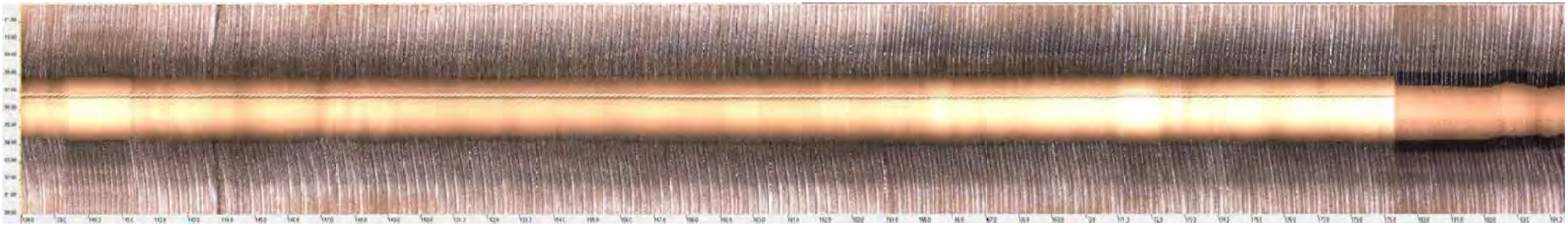
GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN 2
STA 92 FT TO 138 FT

Parkhill

407011-24



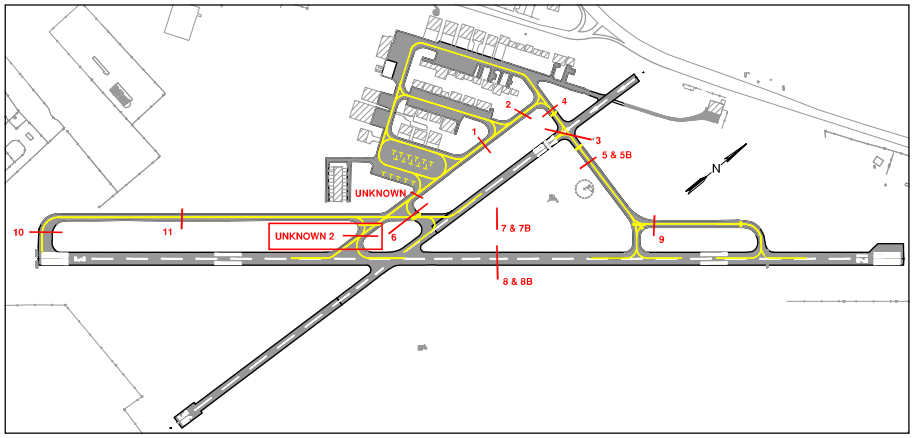


GRAHAM MUNICIPAL AIRPORT
1810 4TH ST.

UNFOLDED PIPE UNKNOWN 2
STA 138 FT TO 184 FT

Parkhill

407011-24
G







UNK2-2
LOCATION IN PIPE: 192 FT
NOTE: CRACK LONGITUDINAL



UNK2-3
LOCATION IN PIPE: 192 FT
NOTE: CRACK LONGITUDINAL

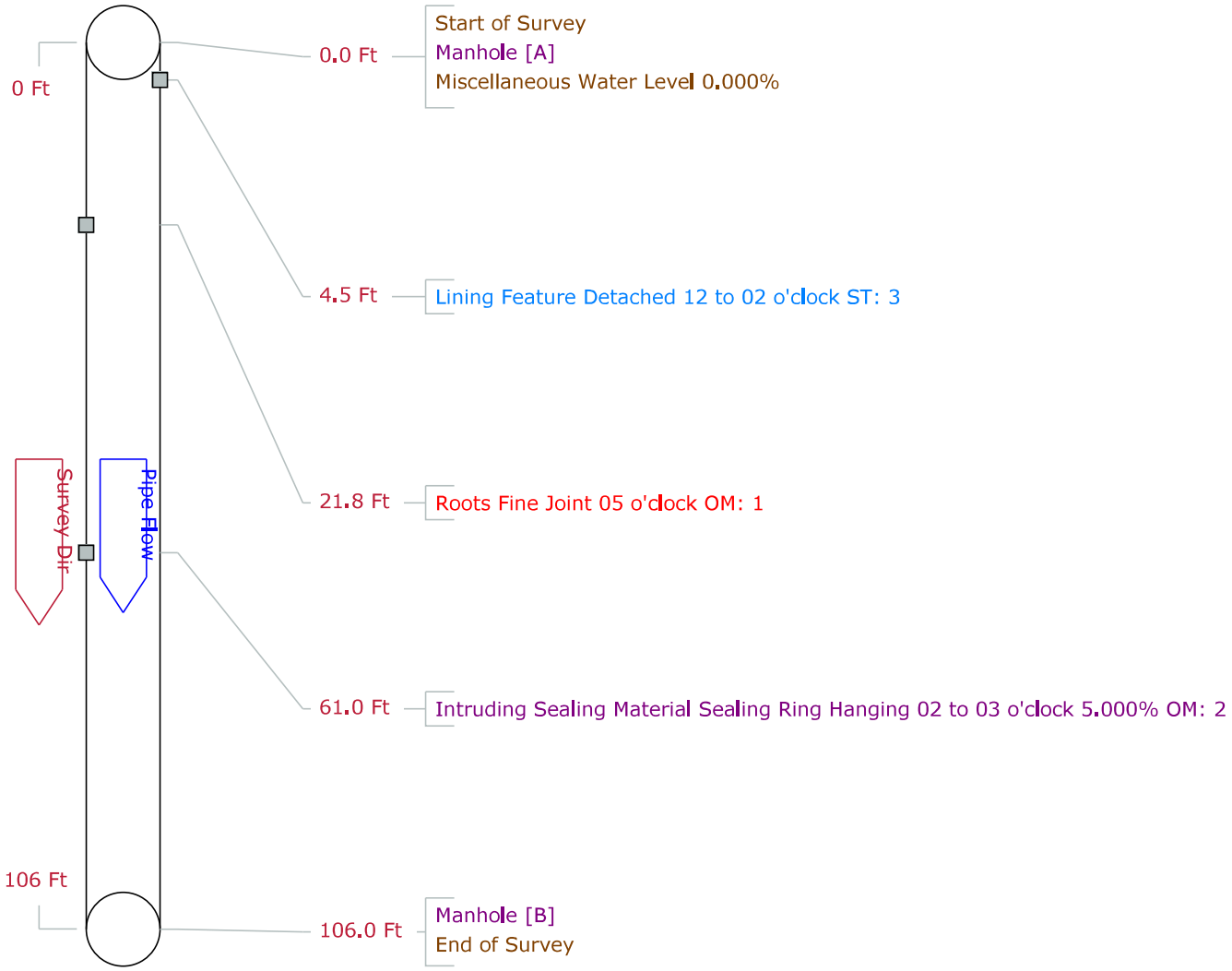
APPENDIX H PROPIPE PIPE GRAPHIC REPORTS

Pipe Graphic Report of PLR #1 for CITY OF GRAHAM

Setup	1	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	9:15	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code		Pipe Use	Stormwater Pipe		
Location details		Height	12	Width	ins
Shape	Circular	Material	Polyvinyl Chloride	Lining	
Coating		Pipe Joint length	Ft	Total length	106.0 Ft
Length Surveyed	106.00 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

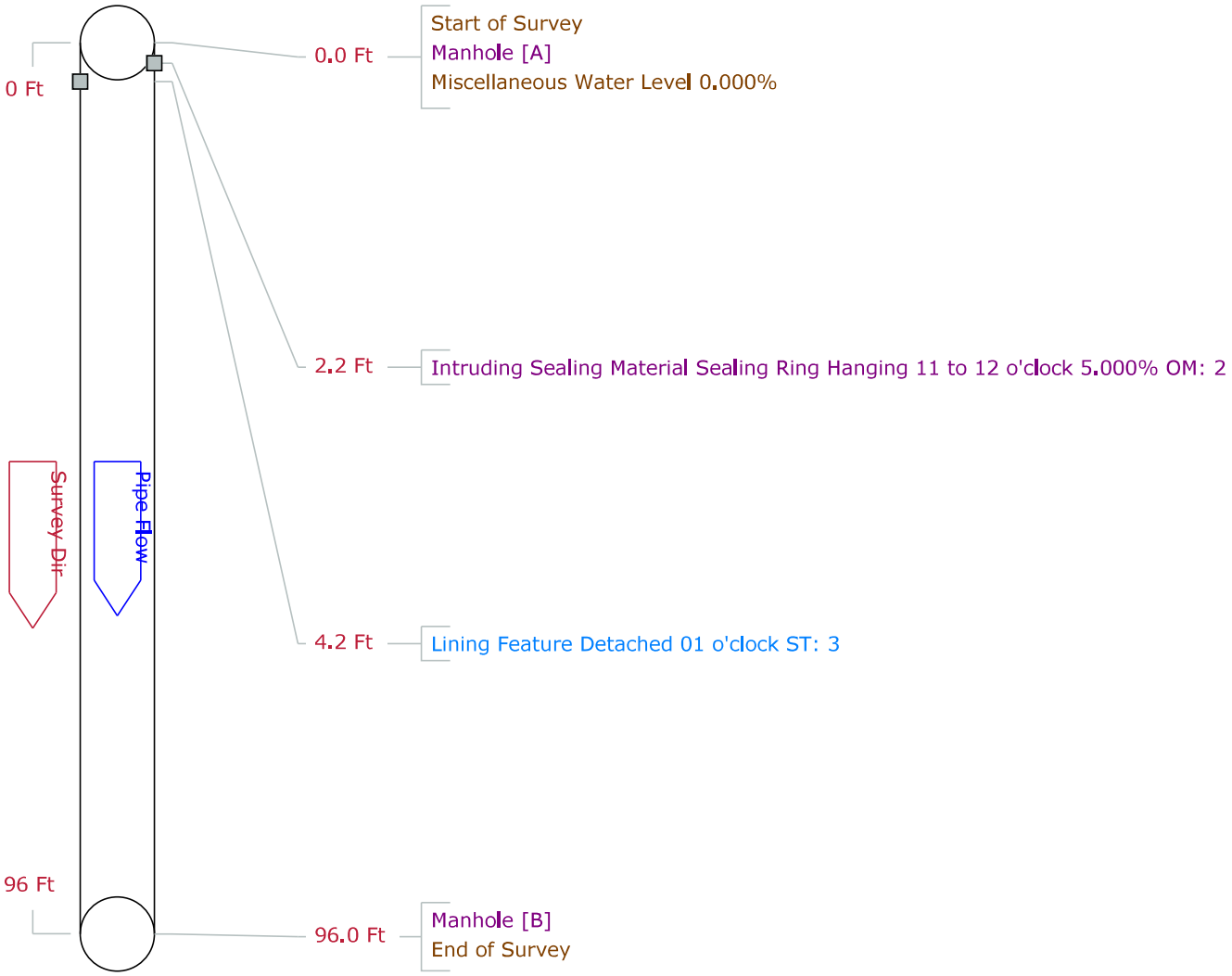


Pipe Graphic Report of PLR #2 for CITY OF GRAHAM

Setup	2	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	9:46	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	12
Width	ins				
Shape	Circular	Material	Polyvinyl Chloride	Lining	
Coating		Pipe Joint length	Ft	Total length	96.0 Ft
Length Surveyed	96.00 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

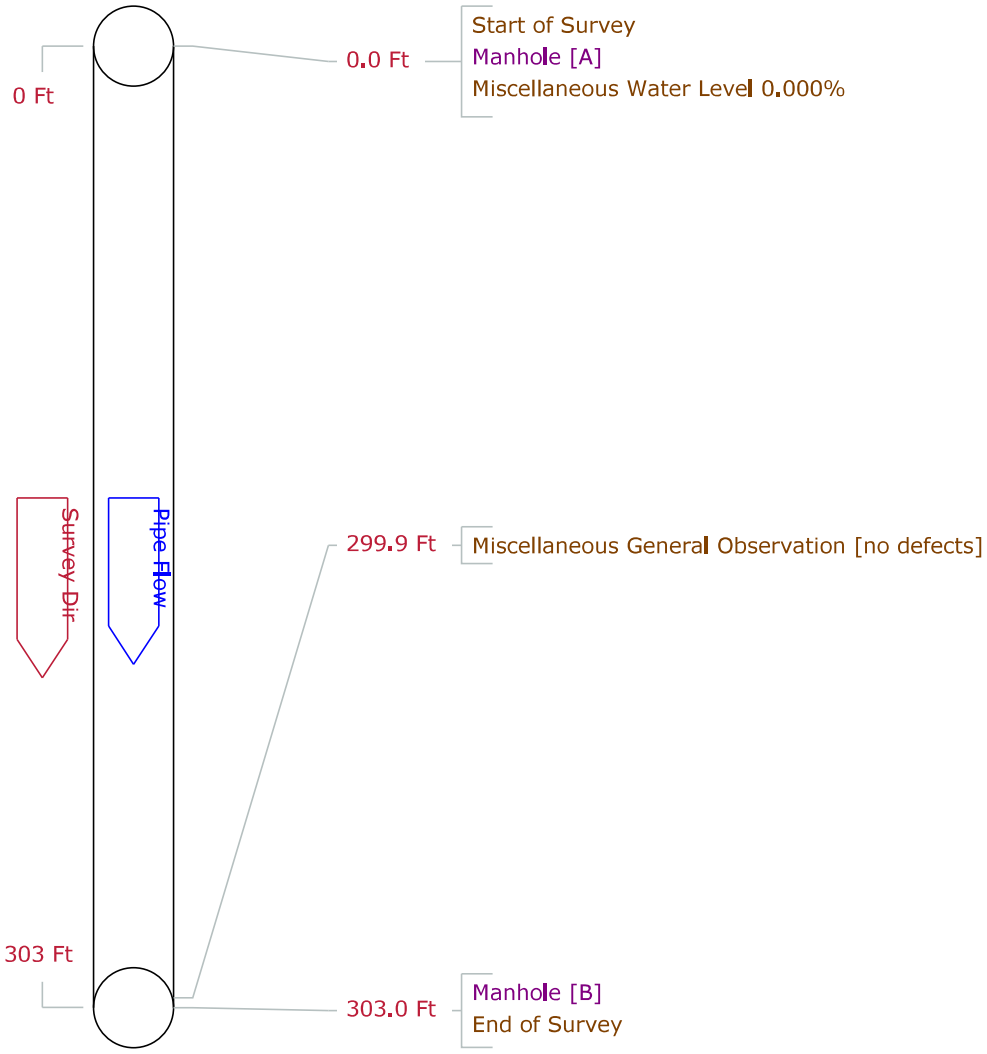


Pipe Graphic Report of PLR #3 for CITY OF GRAHAM

Setup	3	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	11:04	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Polyvinyl Chloride	Lining	
Coating		Pipe Joint length	Ft	Total length	303.0 Ft
Length Surveyed	303.00 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

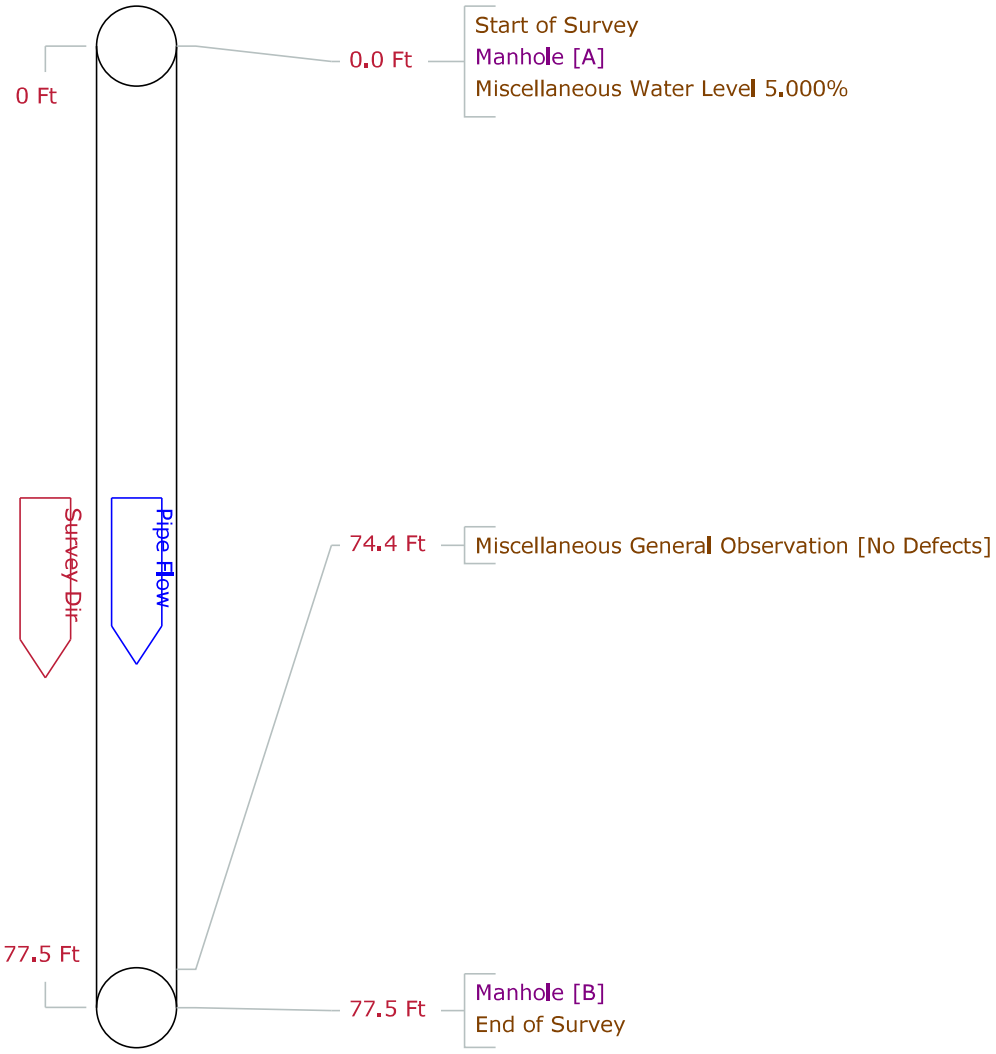


Pipe Graphic Report of PLR #5 for CITY OF GRAHAM

Setup	5	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	12:04	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Cast Iron	Lining	
Coating		Pipe Joint length	Ft	Total length	77.5 Ft
Length Surveyed	77.50 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

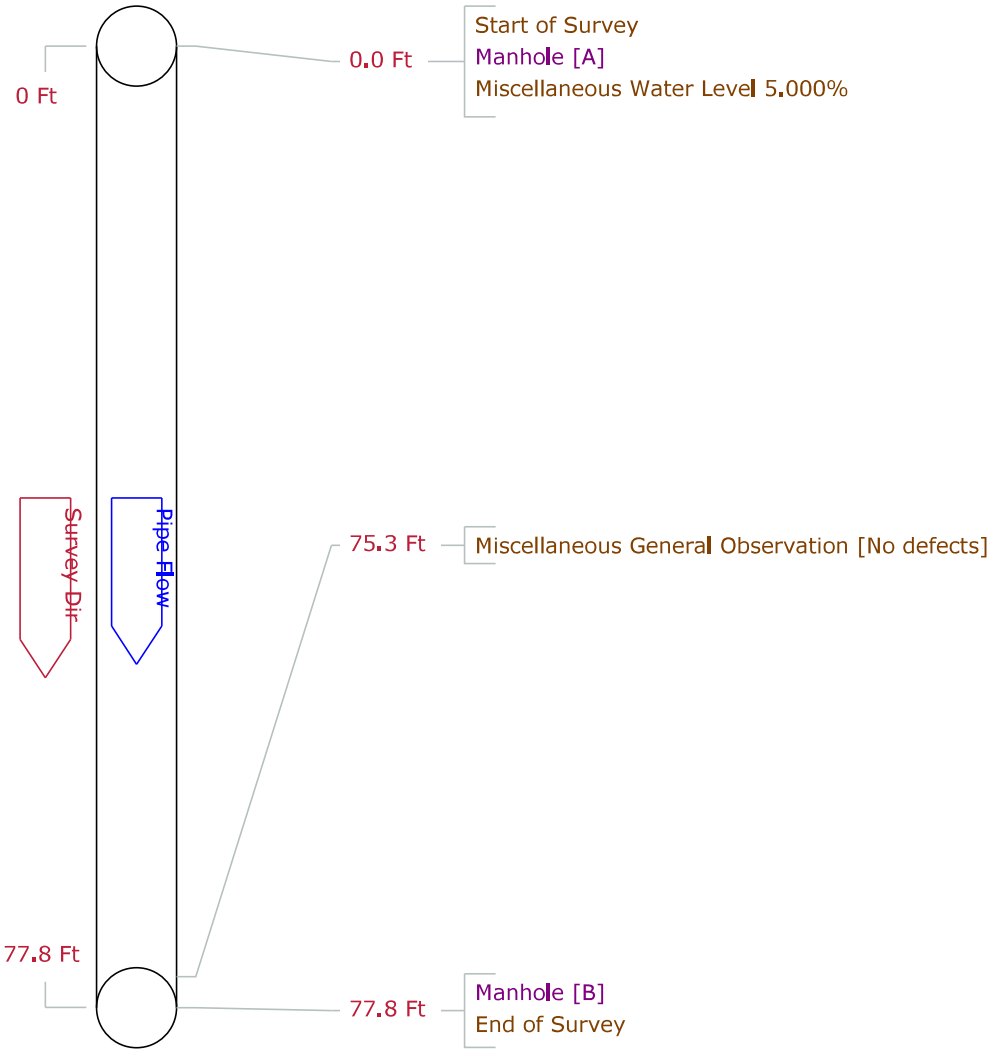


Pipe Graphic Report of PLR #5B for CITY OF GRAHAM

Setup	6	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	12:17	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Cast Iron	Lining	
Coating		Pipe Joint length	Ft	Total length	77.8 Ft
Length Surveyed	77.80 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

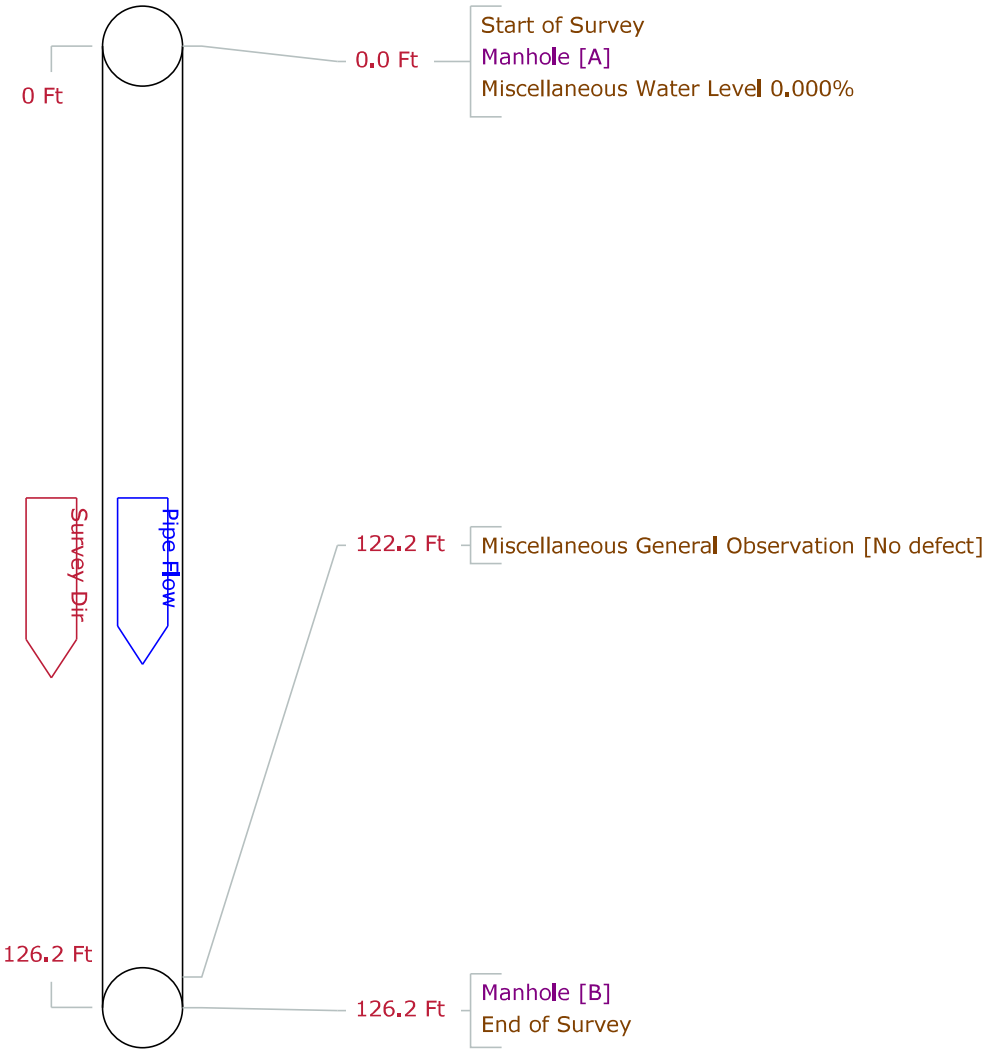


Pipe Graphic Report of PLR UNKNOW NOT ON MAP for CITY OF GRAHAM

Setup	7	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	12:55	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	10
Width	ins				
Shape	Circular	Material	Cast Iron	Lining	
Coating		Pipe Joint length	Ft	Total length	126.2 Ft
Length Surveyed	126.20 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

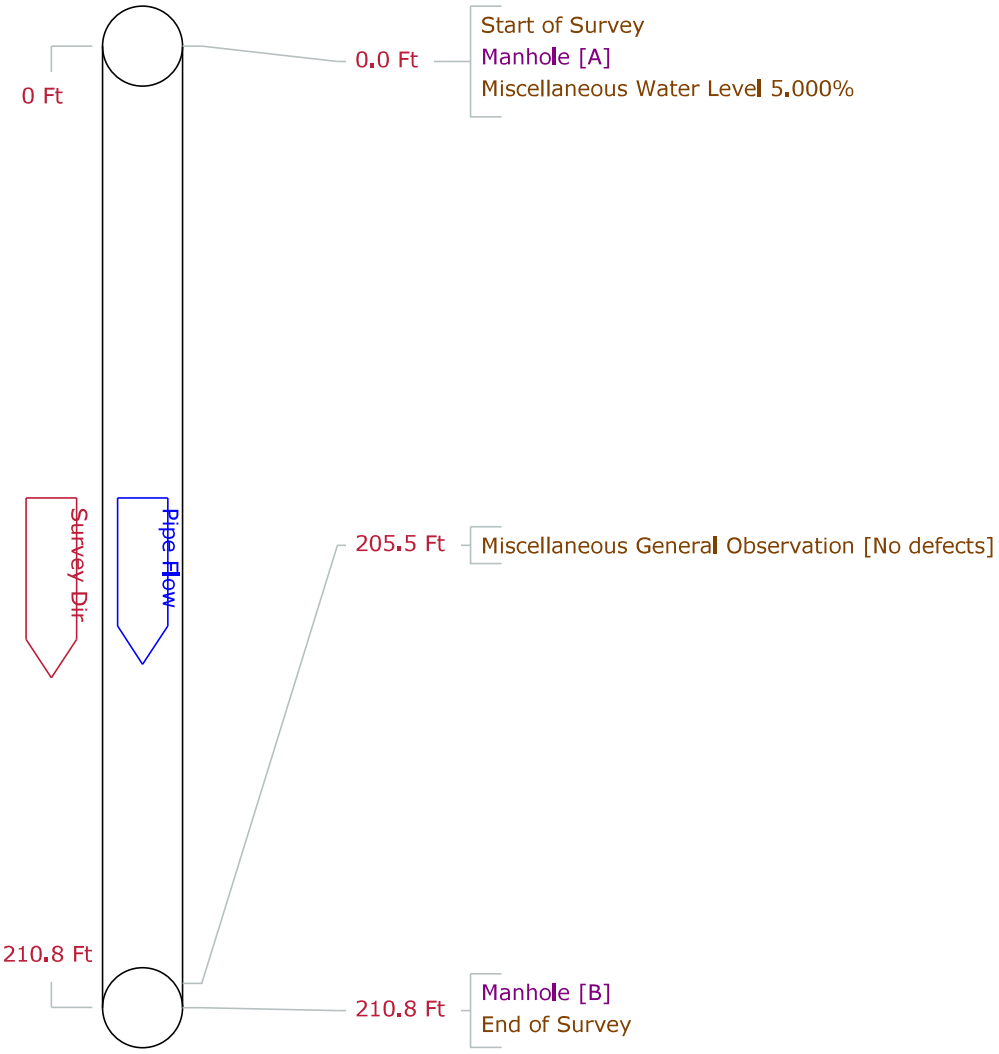


Pipe Graphic Report of PLR #6 for CITY OF GRAHAM

Setup	8	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	13:12	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	10
Width	ins				
Shape	Circular	Material	Cast Iron	Lining	
Coating		Pipe Joint length	Ft	Total length	210.8 Ft
Length Surveyed	210.80 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

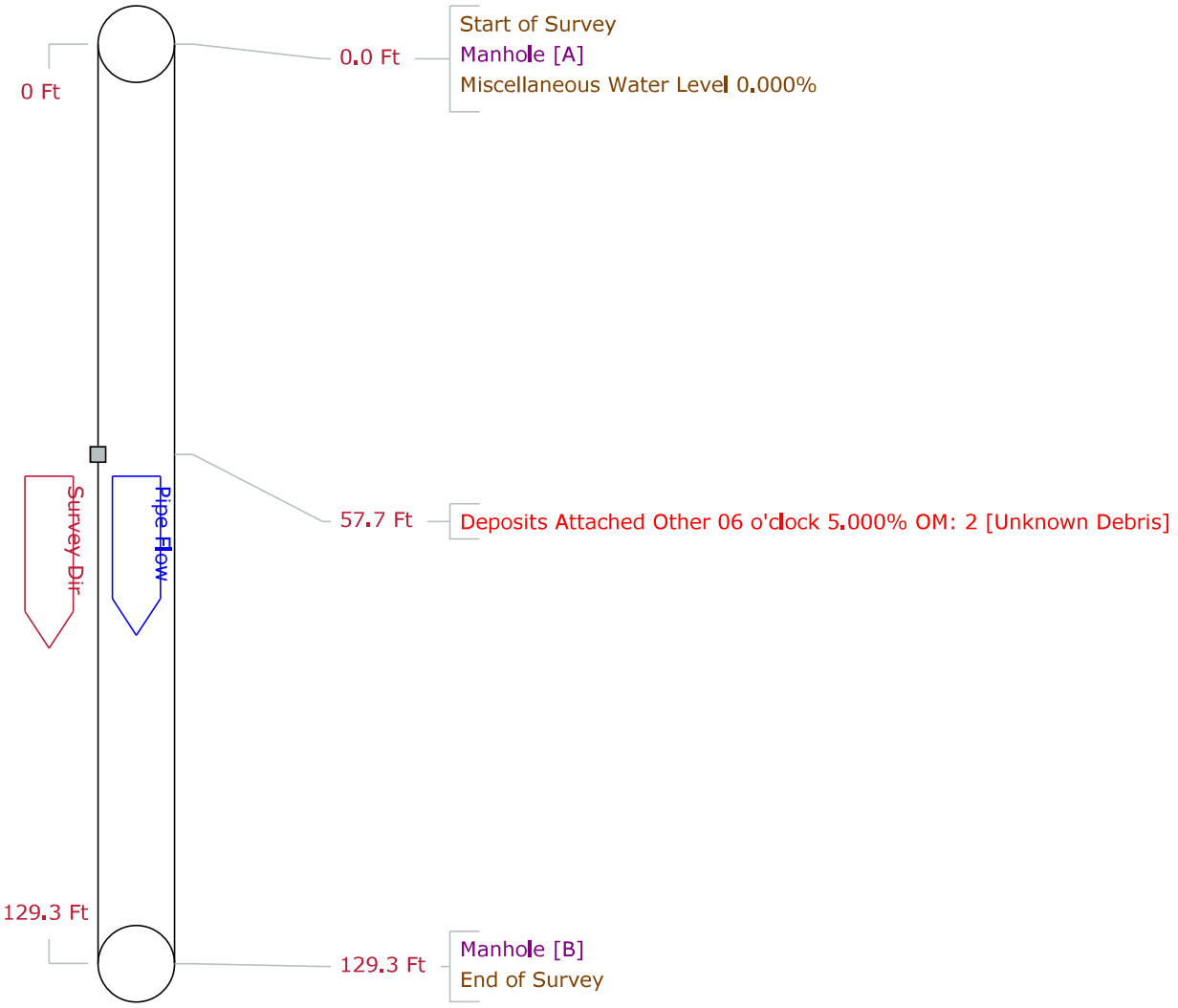


Pipe Graphic Report of PLR #7 for CITY OF GRAHAM

Setup	9	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	14:54	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	10
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	129.3 Ft
Length Surveyed	129.30 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

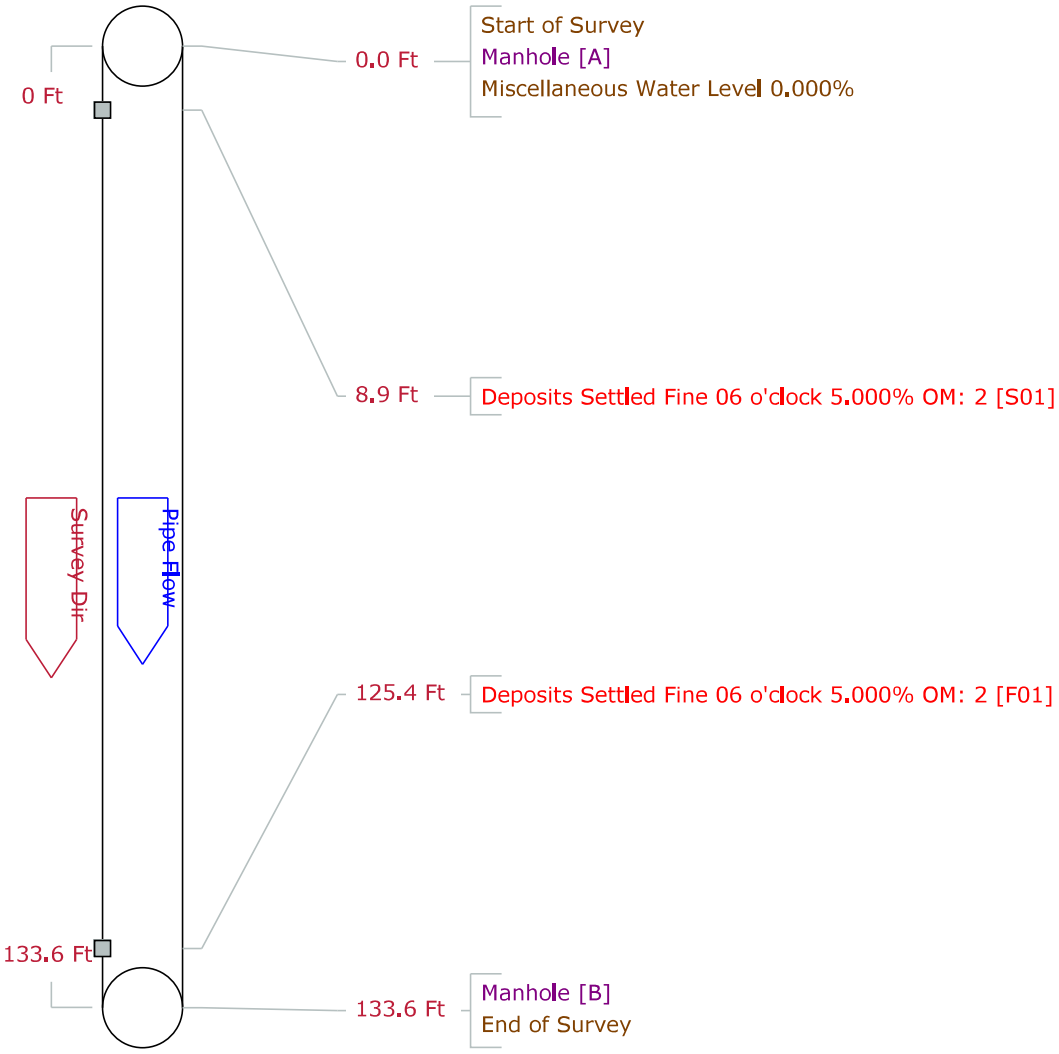


Pipe Graphic Report of PLR #7B for CITY OF GRAHAM

Setup	10	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	15:13	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	10
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	133.6 Ft
Length Surveyed	133.60 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

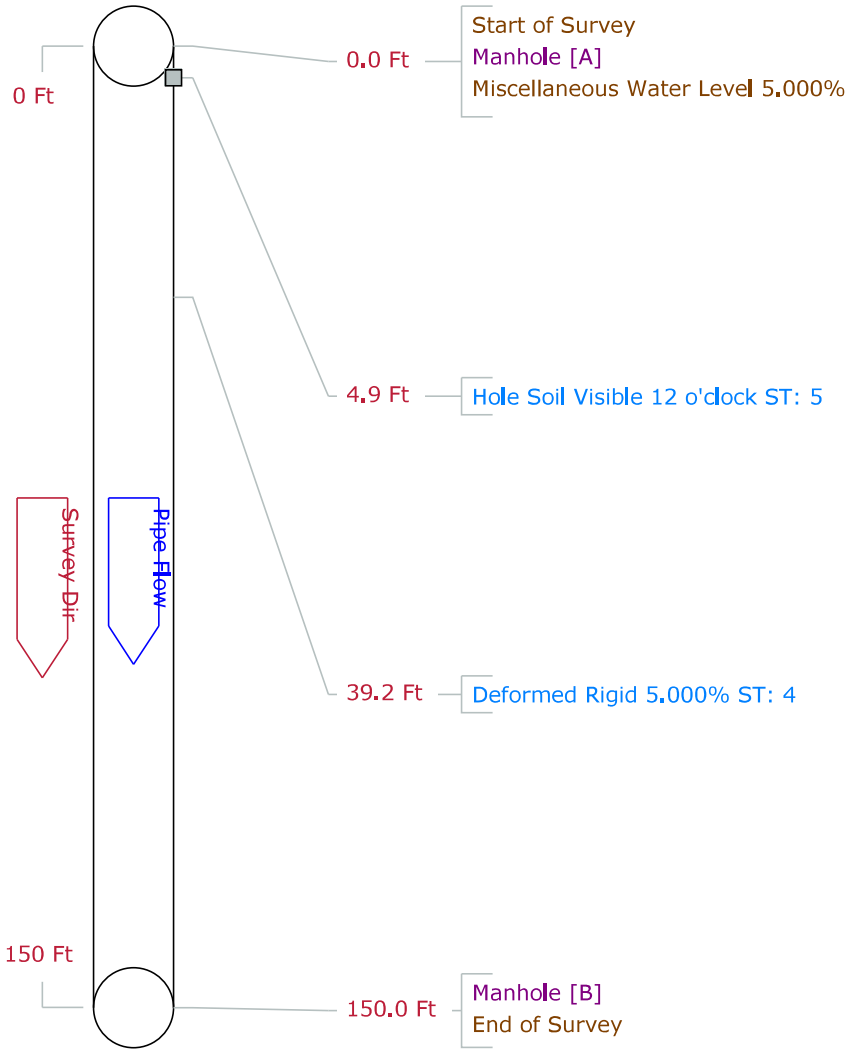


Pipe Graphic Report of PLR #8 for CITY OF GRAHAM

Setup	11	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	15:40	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	150.0 Ft
Length Surveyed	150.00 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

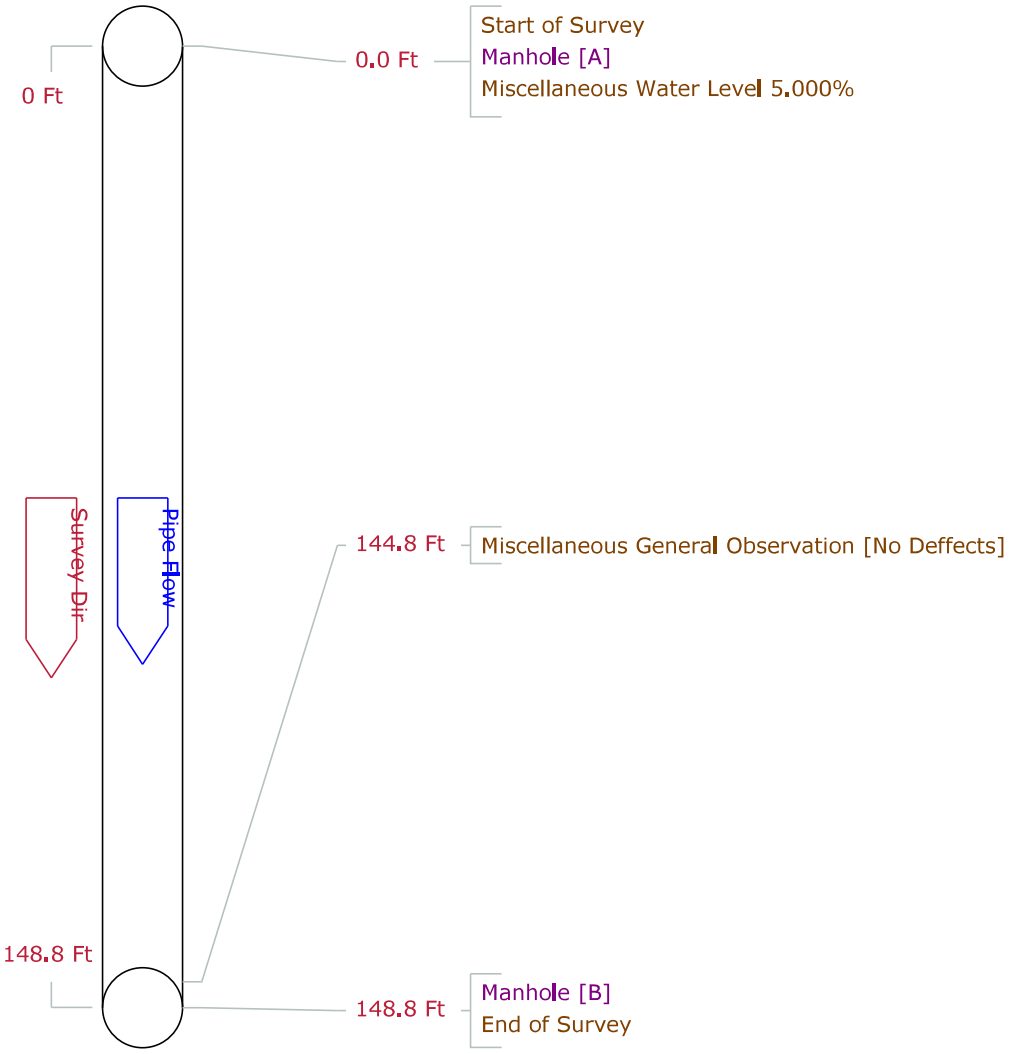


Pipe Graphic Report of PLR #8B for CITY OF GRAHAM

Setup	12	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	15:58	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	148.8 Ft
Length Surveyed	148.80 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

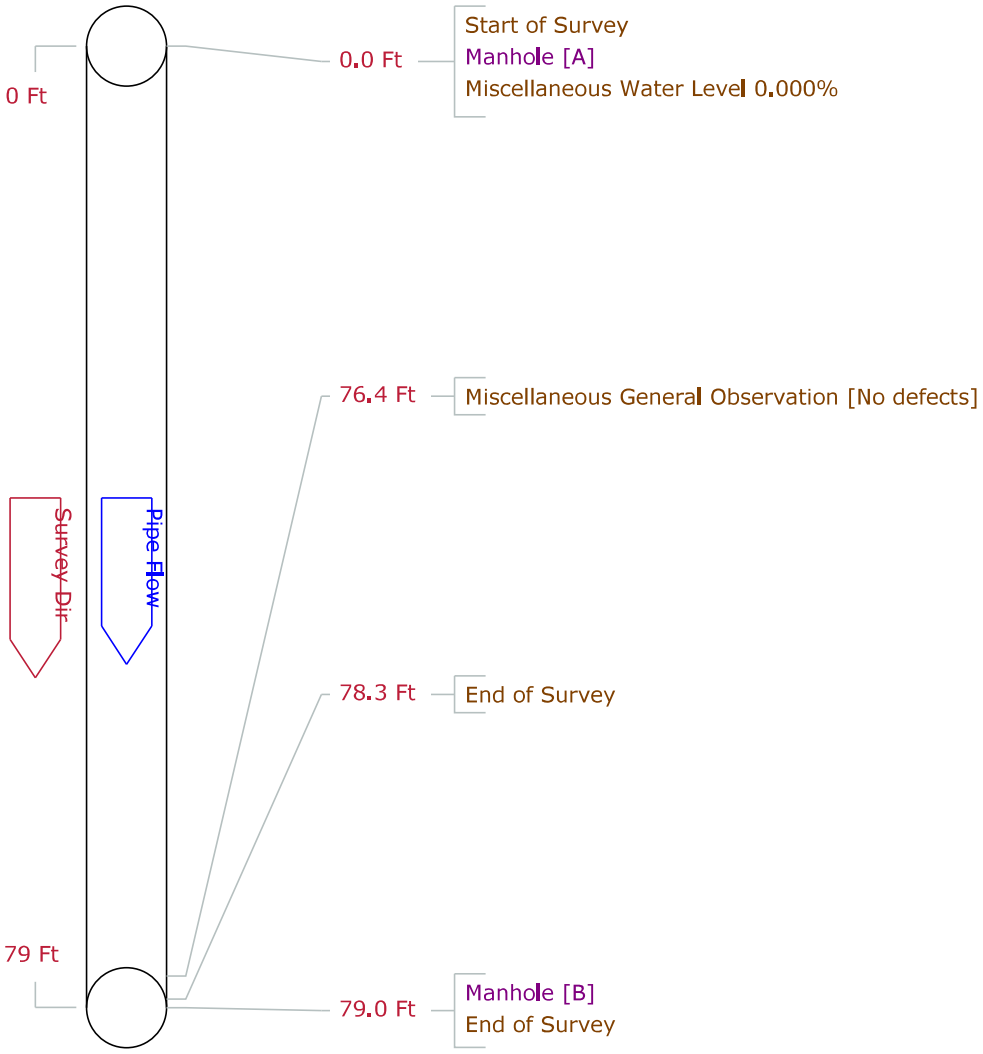


Pipe Graphic Report of PLR #9 for CITY OF GRAHAM

Setup	13	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/15	Time	16:23	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	18
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	78.3 Ft
Length Surveyed	79.00 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

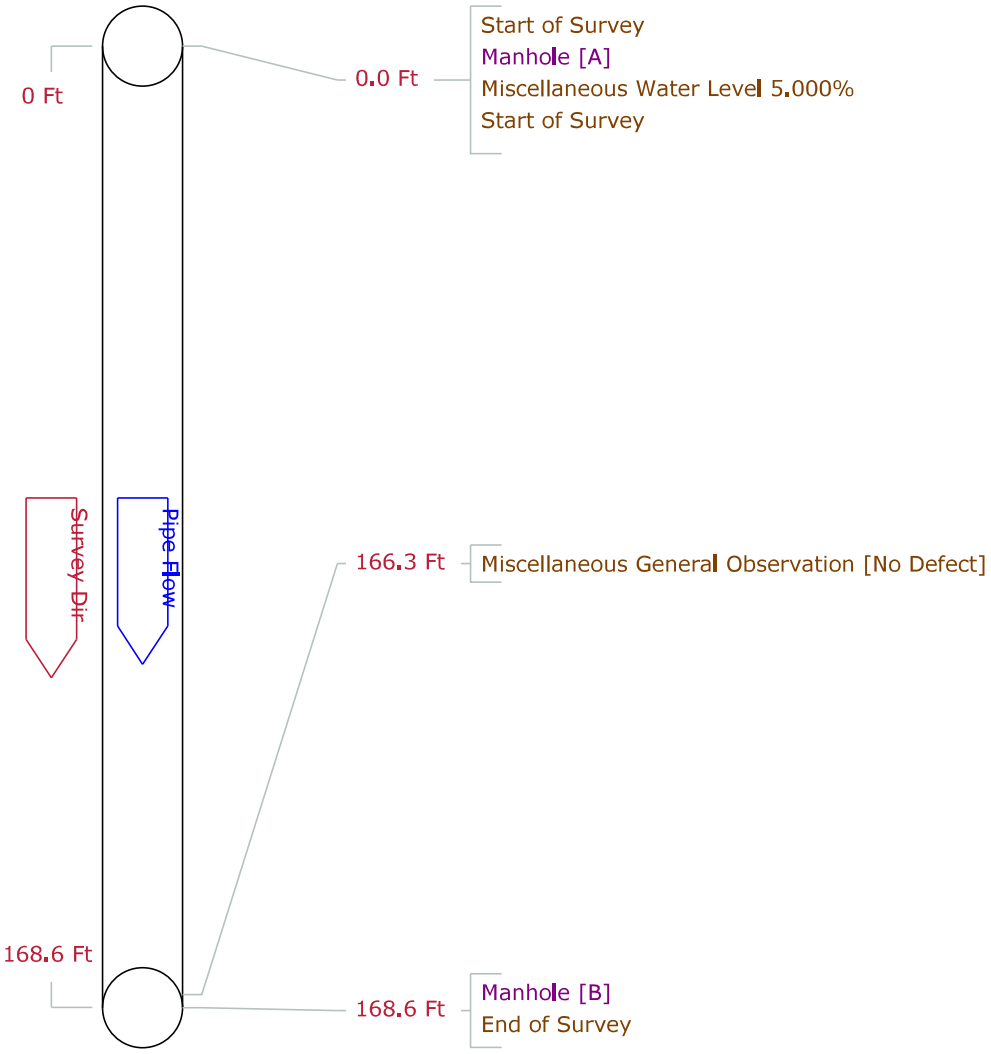


Pipe Graphic Report of PLR #10 for CITY OF GRAHAM

Setup	15	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/16	Time	15:47	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	168.6 Ft
Length Surveyed	168.60 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

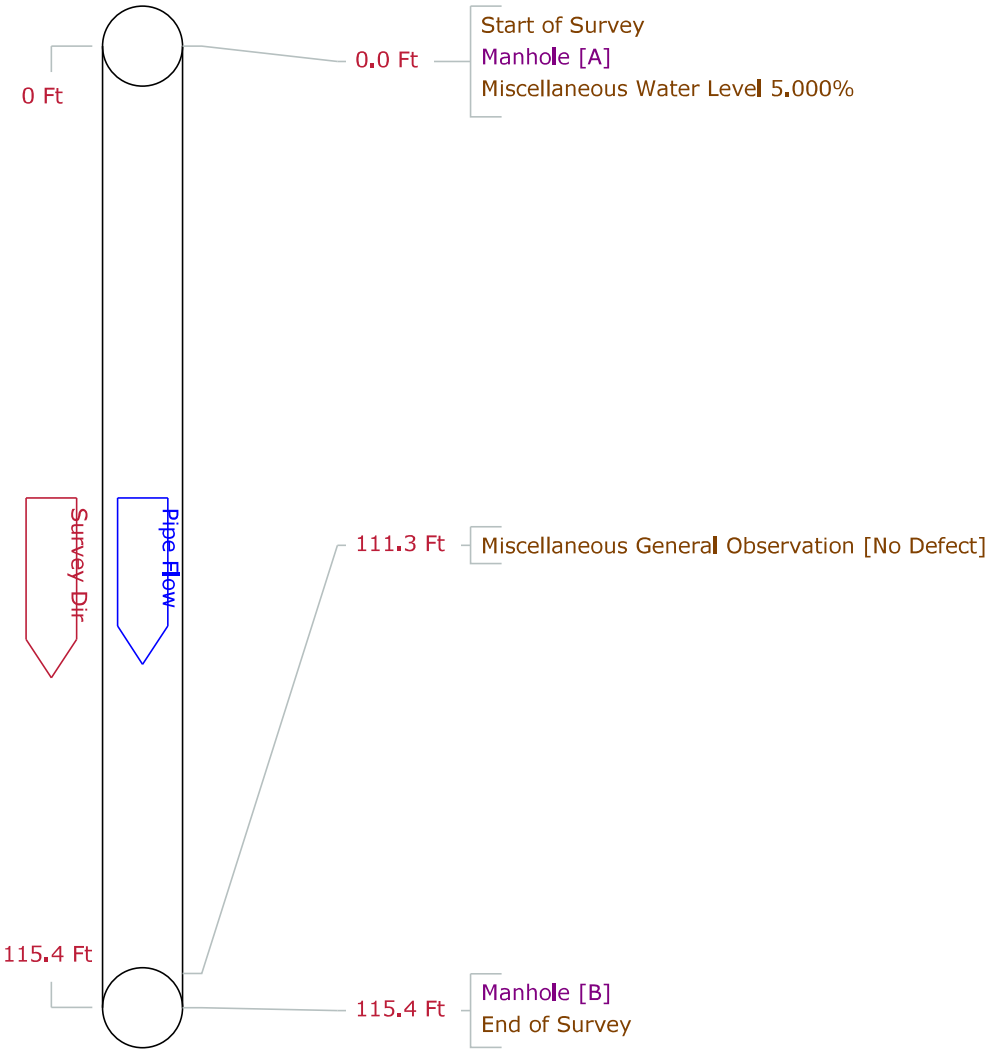


Pipe Graphic Report of PLR #11 for CITY OF GRAHAM

Setup	14	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/16	Time	14:06	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	18
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	115.4 Ft
Length Surveyed	115.40 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft

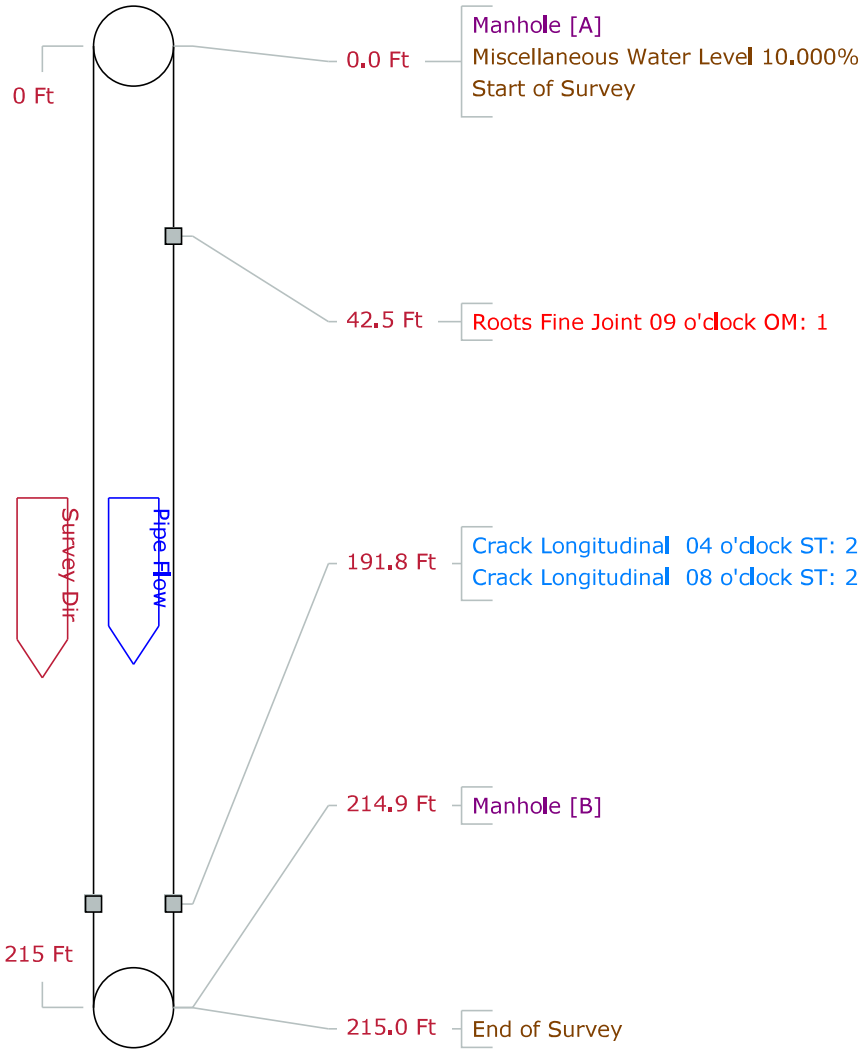


Pipe Graphic Report of PLR UNKNOWN #2 for CITY OF GRAHAM

Setup	16	Surveyed By	JRAM	Certificate #	P0051465-122024
Owner					
Reviewed By		Reviewer #		Work Order	
Customer				P/O #	
Media Label		Project	GRAHAM AIRPORT		
Date	2025/10/16	Time	16:49	Weather	
Pre-Cleaning	L	Date Cleaned			
Flow control		Survey Purpose		Direction	Downstream
Street	AIRPORT	City	GRAHAM	Drainage area	
Location Code				Pipe Use	Stormwater Pipe
Location details				Height	24
Width	ins				
Shape	Circular	Material	Plastic/Steel Composite	Lining	
Coating		Pipe Joint length	Ft	Total length	215.0 Ft
Length Surveyed	215.00 Ft	Year Constructed		Year Renewed	
Additional info					

Structural	O & M				
Miscellaneous	Constructional				

Up	A	Rim to invert	Grade to invert	Rim to grade	Ft
Down	B	Rim to invert	Grade to invert	Rim to grade	Ft



APPENDIX I PROPIPE CCTV PICTURE LIST REPORTS

CCTV Picture List of #1 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 1
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 4.5 Ft
Code Lining Feature Detached
Remarks
File Name #1_3_1.jpg



Video Index Count 21.8 Ft
Code Roots Fine Joint
Remarks
File Name #1_4_2.jpg



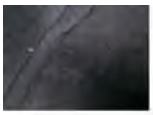
Video Index Count 61.0 Ft
Code Intruding Sealing Material Sealing Ring Hanging
Remarks
File Name #1_5_3.jpg

CCTV Picture List of #1 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 1
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #2 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 2
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 2.2 Ft
Code Intruding Sealing Material Sealing Ring Hanging
Remarks
File Name #2_3_1.jpg



Video Index Count 4.2 Ft
Code Lining Feature Detached
Remarks
File Name #2_4_2.jpg

CCTV Picture List of #2 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 2
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #3 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 3
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 299.9 Ft
Code Miscellaneous General Observation
Remarks no defects

File Name #3_3_1.jpg

CCTV Picture List of #3 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 3
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #5 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 5
Path to picture files	\Snaps		
Path to video files	\IPF		
Path to media files			



Video Index Count 74.4 Ft
Code Miscellaneous General Observation
Remarks No Defects

File Name #5_3_1.jpg

CCTV Picture List of #5 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 5
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #5B for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 6
Path to picture files	\Snaps	
Path to video files	\MPF	
Path to media files		



Video Index Count 75.3 Ft
Code Miscellaneous General Observation
Remarks No defects
File Name #5B_3_1.jpg

CCTV Picture List of #5B for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 6
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of UNKNOW NOT ON MAP for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 7
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 122.2 Ft
Code Miscellaneous General Observation
Remarks No defect
File Name UNKNOW NOT ON MAP_3_1.jpg

CCTV Picture List of UNKNOW NOT ON MAP for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 7
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #6 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 8
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 205.5 Ft
Code Miscellaneous General Observation
Remarks No defects

File Name #6_3_1.jpg

CCTV Picture List of #6 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 8
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #7 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 9
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 57.7 Ft
Code Deposits Attached Other
Remarks Unknown Debris
File Name #7_3_1.jpg

CCTV Picture List of #7 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 9
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #7B for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 10
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 8.9 Ft
Code Deposits Settled Fine
Remarks
File Name #7B_3_1.jpg



Video Index Count 125.4 Ft
Code Deposits Settled Fine
Remarks
File Name #7B_4_2.jpg

CCTV Picture List of #7B for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 10
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #8 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 11
Path to picture files	\Snaps		
Path to video files	\IPF		
Path to media files			



Video Index Count 4.9 Ft
Code Hole Soil Visible
Remarks
File Name #8_3_1.jpg



Video Index Count 39.2 Ft
Code Deformed Rigid
Remarks
File Name #8_4_2.jpg

CCTV Picture List of #8 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 11
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #8B for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15 Setup 12
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 144.8 Ft
Code Miscellaneous General Observation
Remarks No Deffects

File Name #8B_3_1.jpg

CCTV Picture List of #8B for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 12
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #9 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 13
Path to picture files	\Snaps		
Path to video files	\IPF		
Path to media files			



Video Index Count 76.4 Ft
Code Miscellaneous General Observation
Remarks No defects

File Name #9_3_1.jpg

CCTV Picture List of #9 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/15	Setup 13
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #10 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/16 Setup 15
Path to picture files	\Snaps	
Path to video files	\IPF	
Path to media files		



Video Index Count 166.3 Ft
Code Miscellaneous General Observation
Remarks No Defect

File Name #10_4_1.jpg

CCTV Picture List of #10 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/16	Setup 15
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of #11 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/16	Setup 14
Path to picture files	\Snaps		
Path to video files	\IPF		
Path to media files			



Video Index Count 111.3 Ft
Code Miscellaneous General Observation
Remarks No Defect

File Name #11_3_1.jpg

CCTV Picture List of #11 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/16	Setup 14
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

CCTV Picture List of UNKNOWN #2 for CITY OF GRAHAM

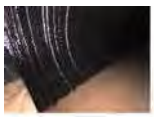
Work Order Video	Survey Date	2025/10/16	Setup 16
Path to picture files	\Snaps		
Path to video files	\IPF		
Path to media files			



Video Index Count 42.5 Ft
Code Roots Fine Joint
Remarks
File Name UNKNOWN #2_3_1.jpg



Video Index Count 191.8 Ft
Code Crack Longitudinal
Remarks
File Name UNKNOWN #2_4_2.jpg



Video Index Count 191.8 Ft
Code Crack Longitudinal
Remarks
File Name UNKNOWN #2_5_3.jpg

CCTV Picture List of UNKNOWN #2 for CITY OF GRAHAM

Work Order Video	Survey Date	2025/10/16	Setup 16
Path to picture files	\Snaps		
Path to video files	\MPF		
Path to media files			

APPENDIX J PROPIPE PIPE TABULAR REPORTS

Tabular Report of PSR #1 for CITY OF GRAHAM

Setup 1 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 9:15 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 12 Width ins

Shape Circular Material Polyvinyl Chloride Lining

Coating Pipe Joint length Ft Total length 106.0 Ft

Length Surveyed 106.0 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video	CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0			ST	Start of Survey								
0.0			AMH	Manhole								A
0.0			MWL	Miscellaneous Water Level			0.000					
4.5			LFD	Lining Feature Detached					12	02		
21.8			RFJ	Roots Fine Joint				J	05			
61.0			ISSRH	Intruding Sealing Material Sealing R			5.000		02	03		
106.0			AMH	Manhole								B
106.0			FH	End of Survey								

106.0 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 3	Pipe Ratings Index 3	Quick Rating 3100
O&M:	Pipe Rating 3	Pipe Ratings Index 1.5	Quick Rating 2111
Overall	Pipe Rating 6	Pipe Ratings Index 2.0	Quick Rating 3121

Tabular Report of PSR #2 for CITY OF GRAHAM

Setup 2 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/15 Time 9:46 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 12 Width ins
Shape Circular Material Polyvinyl Chloride Lining
Coating Pipe Joint length Ft Total length 96.0 Ft
Length Surveyed 96.0 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			0.000					
2.2				ISSRH	Intruding Sealing Material Sealing R			5.000		11	12		
4.2				LFD	Lining Feature Detached					01			
96.0				AMH	Manhole								B
96.0				FH	End of Survey								

96.0 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 3	Pipe Ratings Index 3	Quick Rating 3100
O&M:	Pipe Rating 2	Pipe Ratings Index 2	Quick Rating 2100
Overall	Pipe Rating 5	Pipe Ratings Index 2.5	Quick Rating 3121

Tabular Report of PSR #3 for CITY OF GRAHAM

Setup 3 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/15 Time 11:04 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 24 Width ins
Shape Circular Material Polyvinyl Chloride Lining
Coating Pipe Joint length Ft Total length 303.0 Ft
Length Surveyed 303.0 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			0.000					
299.9				MGO	Miscellaneous General Observation								no defects
303.0				AMH	Manhole								B
303.0				FH	End of Survey								

303.0 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #5 for CITY OF GRAHAM

Setup 5 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 12:04 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 24 Width ins

Shape Circular Material Cast Iron Lining

Coating Pipe Joint length Ft Total length 77.5 Ft

Length Surveyed 77.5 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
74.4				MGO	Miscellaneous General Observation								No Defects
77.5				AMH	Manhole								B
77.5				FH	End of Survey								

77.5 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #5B for CITY OF GRAHAM

Setup 6 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 12:17 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 24 Width ins

Shape Circular Material Cast Iron Lining

Coating Pipe Joint length Ft Total length 77.8 Ft

Length Surveyed 77.8 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
75.3				MGO	Miscellaneous General Observation								No defects
77.8				AMH	Manhole								B
77.8				FH	End of Survey								

77.8 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR UNKNOW NOT ON MAP for CITY OF GRAHAM

Setup 7 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/15 Time 12:55 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 10 Width ins
Shape Circular Material Cast Iron Lining
Coating Pipe Joint length Ft Total length 126.2 Ft
Length Surveyed 126.2 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			0.000					
122.2				MGO	Miscellaneous General Observation								No defect
126.2				AMH	Manhole								B
126.2				FH	End of Survey								

126.2 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #6 for CITY OF GRAHAM

Setup 8 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 13:12 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 10 Width ins

Shape Circular Material Cast Iron Lining

Coating Pipe Joint length Ft Total length 210.8 Ft

Length Surveyed 210.8 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
205.5				MGO	Miscellaneous General Observation								No defects
210.8				AMH	Manhole								B
210.8				FH	End of Survey								

210.8 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #7 for CITY OF GRAHAM

Setup 9 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 14:54 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 10 Width ins

Shape Circular Material Plastic/Steel Composite Lining

Coating Pipe Joint length Ft Total length 129.3 Ft

Length Surveyed 129.3 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			0.000					
57.7				DAZ	Deposits Attached Other			5.000		06			Unknown Debris
129.3				AMH	Manhole								B
129.3				FH	End of Survey								

129.3 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
O&M:	Pipe Rating 2	Pipe Ratings Index 2	Quick Rating 2100
Overall	Pipe Rating 2	Pipe Ratings Index 2.0	Quick Rating 2100

Tabular Report of PSR #7B for CITY OF GRAHAM

Setup 10 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/15 Time 15:13 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 10 Width ins
Shape Circular Material Plastic/Steel Composite Lining
Coating Pipe Joint length Ft Total length 133.6 Ft
Length Surveyed 133.6 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video	CD	Code		Val1	Val2	%	Jnt	Fr	To	Im	Ref	Remarks
0.0			ST	Start of Survey									
0.0			AMH	Manhole									A
0.0			MWL	Miscellaneous Water Level			0.000						
8.9		S01	DSF	Deposits Settled Fine			5.000		06				
125.4		F01	DSF	Deposits Settled Fine			5.000		06				
133.6			AMH	Manhole									B
133.6			FH	End of Survey									

133.6 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 46	Pipe Ratings Index 2	Quick Rating 2C00
	Overall	Pipe Rating 46	Pipe Ratings Index 2.0	Quick Rating 2C00

Tabular Report of PSR #8 for CITY OF GRAHAM

Setup 11 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 15:40 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☐ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 24 Width ins

Shape Circular Material Plastic/Steel Composite Lining

Coating Pipe Joint length Ft Total length 150.0 Ft

Length Surveyed 150.0 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
4.9				HSV	Hole Soil Visible					12			
39.2				DR	Deformed Rigid			5.000					
150.0				AMH	Manhole								B
150.0				FH	End of Survey								

150.0 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 9	Pipe Ratings Index 4.5	Quick Rating 5141
O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
Overall	Pipe Rating 9	Pipe Ratings Index 4.5	Quick Rating 5141

Tabular Report of PSR #8B for CITY OF GRAHAM

Setup 12 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/15 Time 15:58 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☑ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 24 Width ins

Shape Circular Material Plastic/Steel Composite Lining

Coating Pipe Joint length Ft Total length 148.8 Ft

Length Surveyed 148.8 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
144.8				MGO	Miscellaneous General Observation								No Deffects
148.8				AMH	Manhole								B
148.8				FH	End of Survey								

148.8 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #9 for CITY OF GRAHAM

Setup 13 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/15 Time 16:23 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☑ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 18 Width ins
Shape Circular Material Plastic/Steel Composite Lining
Coating Pipe Joint length Ft Total length 78.3 Ft
Length Surveyed 79.0 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video	CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0			ST	Start of Survey								
0.0			AMH	Manhole								A
0.0			MWL	Miscellaneous Water Level			0.000					
76.4			MGO	Miscellaneous General Observation								No defects
78.3			FH	End of Survey								
79.0			AMH	Manhole								B
79.0			FH	End of Survey								

79.0 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #10 for CITY OF GRAHAM

Setup 15 Surveyed By JRAM Certificate # P0051465-122024 Owner

Reviewed By Reviewer # Work Order

Customer P/O #

Media Label Project GRAHAM AIRPORT

Date 2025/10/16 Time 15:47 Weather Pre-Cleaning L Date Cleaned

Flow control Survey Purpose Direction Down

Inspection Status Complete Inspection Consequence Of Failure Pressure

Inspection Technology Used ☑ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area

Location Code Pipe Use Stormwater Pipe

Location details Height 24 Width ins

Shape Circular Material Plastic/Steel Composite Lining

Coating Pipe Joint length Ft Total length 168.6 Ft

Length Surveyed 168.6 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft

Northing Easting Elevation

Coordinate System Vertical Datum

GPS Accuracy

Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
0.0				ST	Start of Survey								
166.3				MGO	Miscellaneous General Observation								No Defect
168.6				AMH	Manhole								B
168.6				FH	End of Survey								

168.6 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR #11 for CITY OF GRAHAM

Setup 14 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/16 Time 14:06 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☑ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 18 Width ins
Shape Circular Material Plastic/Steel Composite Lining
Coating Pipe Joint length Ft Total length 115.4 Ft
Length Surveyed 115.4 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video		CD	Code		Val1	Val2	%	Jnt	Fr	To	ImRef	Remarks
0.0				ST	Start of Survey								
0.0				AMH	Manhole								A
0.0				MWL	Miscellaneous Water Level			5.000					
111.3				MGO	Miscellaneous General Observation								No Defect
115.4				AMH	Manhole								B
115.4				FH	End of Survey								

115.4 Ft Total Length Surveyed

Scores				
	Structural:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	O&M:	Pipe Rating 0	Pipe Ratings Index 0	Quick Rating 0000
	Overall	Pipe Rating 0	Pipe Ratings Index	Quick Rating 0000

Tabular Report of PSR UNKNOWN #2 for CITY OF GRAHAM

Setup 16 Surveyed By JRAM Certificate # P0051465-122024 Owner
Reviewed By Reviewer # Work Order
Customer P/O #
Media Label Project GRAHAM AIRPORT
Date 2025/10/16 Time 16:49 Weather Pre-Cleaning L Date Cleaned
Flow control Survey Purpose Direction Down
Inspection Status Complete Inspection Consequence Of Failure Pressure
Inspection Technology Used ☑ CCTV ☐ Laser ☐ Sonar ☐ Sidewall ☐ Zoom ☐ Other

Street AIRPORT City GRAHAM Drainage area
Location Code Pipe Use Stormwater Pipe
Location details Height 24 Width ins
Shape Circular Material Plastic/Steel Composite Lining
Coating Pipe Joint length Ft Total length 215.0 Ft
Length Surveyed 215.0 Ft Year Constructed Year Renewed

Up A Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Down B Rim to invert Grade to invert Rim to grade Ft
Northing Easting Elevation

Coordinate System Vertical Datum
GPS Accuracy
Additional info

Structural O & M
Miscellaneous Constructional

Count	Video	CD	Code		Val1	Val2	%	Jnt	Fr	To	Im	Ref	Remarks
0.0			AMH	Manhole									A
0.0			MWL	Miscellaneous Water Level			10.000						
0.0			ST	Start of Survey									
42.5			RFJ	Roots Fine Joint				J	09				
191.8			CL	Crack Longitudinal					04				
191.8			CL	Crack Longitudinal					08				
214.9			AMH	Manhole									B
215.0			FH	End of Survey									

215.0 Ft Total Length Surveyed

Scores

Structural:	Pipe Rating 4	Pipe Ratings Index 2	Quick Rating 2200
O&M:	Pipe Rating 1	Pipe Ratings Index 1	Quick Rating 1100
Overall	Pipe Rating 5	Pipe Ratings Index 1.7	Quick Rating 2211

APPENDIX K COST ESTIMATES

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 1 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$7,910	$7,910.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" HDPE with bedding material	LF	173	$250	$43,250.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$166,160.00**
				Contingency:	**$33,230.00**
				Engineering:	**$16,620.00**
				Permitting:	**$6,650.00**
				Inspection and Review:	**$8,310.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$230,970.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 2 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$8,380	$8,380.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" HDPE with bedding material	LF	210	$250	$52,500.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$175,880.00**
				Contingency:	**$35,180.00**
				Engineering:	**$17,590.00**
				Permitting:	**$7,040.00**
				Inspection and Review:	**$8,790.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$244,480.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 3 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$8,340	$8,340.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" HDPE with bedding material	LF	207	$250	$51,750.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$175,090.00**
				Contingency:	**$35,020.00**
				Engineering:	**$17,510.00**
				Permitting:	**$7,000.00**
				Inspection and Review:	**$8,750.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$243,370.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 4 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$8,950	$8,950.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" HDPE with bedding material	LF	256	$250	$64,000.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$187,950.00**
				Contingency:	**$37,590.00**
				Engineering:	**$18,800.00**
				Permitting:	**$7,520.00**
				Inspection and Review:	**$9,400.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$261,260.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 5 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$6,730	$6,730.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	18" Class V RCP with bedding material	LF	80	$245	$19,600.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$141,330.00**
				Contingency:	**$28,270.00**
				Engineering:	**$14,130.00**
				Permitting:	**$5,650.00**
				Inspection and Review:	**$7,070.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$196,450.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 6 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$7,950	$7,950.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" Class V RCP with bedding material	LF	160	$275	$44,000.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$166,950.00**
				Contingency:	**$33,390.00**
				Engineering:	**$16,700.00**
				Permitting:	**$6,680.00**
				Inspection and Review:	**$8,350.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$232,070.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 7 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$34,820	$34,820.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" Class V RCP with bedding material	LF	2,114	$275	$581,350.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$731,170.00**
				Contingency:	**$146,230.00**
				Engineering:	**$36,560.00**
				Permitting:	**$29,250.00**
				Inspection and Review:	**$36,560.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$979,770.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 8 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$10,710	$10,710.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	12" Class V RCP with bedding material	LF	567	$175	$99,225.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$224,935.00**
				Contingency:	**$44,990.00**
				Engineering:	**$15,750.00**
				Permitting:	**$9,000.00**
				Inspection and Review:	**$11,250.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$305,925.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 9 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$10,110	$10,110.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	12" Class V RCP with bedding material	LF	498	$175	$87,150.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$212,260.00**
				Contingency:	**$42,450.00**
				Engineering:	**$14,860.00**
				Permitting:	**$8,490.00**
				Inspection and Review:	**$10,610.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$288,670.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 10 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$7,550	$7,550.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	12" Class V RCP with bedding material	LF	206	$175	$36,050.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$158,600.00**
				Contingency:	**$31,720.00**
				Engineering:	**$15,860.00**
				Permitting:	**$6,340.00**
				Inspection and Review:	**$7,930.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$220,450.00**

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Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 11 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$7,060	$7,060.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	18" HDPE with bedding material	LF	125	$210	$26,250.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$148,310.00**
				Contingency:	**$29,660.00**
				Engineering:	**$14,830.00**
				Permitting:	**$5,930.00**
				Inspection and Review:	**$7,420.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$206,150.00**

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Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 12 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$11,980	$11,980.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	24" Class V RCP with bedding material	LF	453	$275	$124,575.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$251,555.00**
				Contingency:	**$50,310.00**
				Engineering:	**$15,090.00**
				Permitting:	**$10,060.00**
				Inspection and Review:	**$12,580.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$339,595.00**

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Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 13 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$174,270	$174,270.00
2	Erosion Control, Install, and Maintain	MO	3	$5,000	$15,000.00
3	Dewater, Bypass Pumping	LS	1	$100,000	$100,000.00
4	96" Class V RCP with bedding material	LF	450	$2,100	$945,000.00
5	Trench Safety	LF	450	$3	$1,350.00
6	Excavate and Stockpile	CY	21,440	$30	$643,200.00
7	Haul soil in for erosion loss and compaction loss (20%)	CY	4,288	$20	$85,760.00
8	Compaction in 6-inch lifts	SY	131,000	$10	$1,310,000.00
9	Inlet and Outfall Structures	EA	2	$30,000	$60,000.00
10	Runway Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$300,000	$300,000.00
11	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$3,659,580.00**
				Contingency:	**$731,920.00**
				Engineering:	**$182,980.00**
				Permitting:	**$146,380.00**
				Inspection and Review:	**$182,980.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$4,903,840.00**

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Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 14 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$6,930	$6,930.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	18" HDPE with bedding material	LF	112	$210	$23,520.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$145,450.00**
				Contingency:	**$29,090.00**
				Engineering:	**$14,550.00**
				Permitting:	**$5,820.00**
				Inspection and Review:	**$7,270.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$202,180.00**

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Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 15 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$6,510	$6,510.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	12" HDPE with bedding material	LF	112	$135	$15,120.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$136,630.00**
				Contingency:	**$27,330.00**
				Engineering:	**$15,030.00**
				Permitting:	**$5,470.00**
				Inspection and Review:	**$6,830.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$191,290.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

Graham Airport SD EOPC

ITEM NO.	DESCRIPTION	UNITS	ESTIMATED QUANTITY	UNIT PRICE	AMOUNT
	PIPE 16 - OPEN CUT TRENCH EOPC				
1	Mobilization/Demobilization	LS	1	$5,940	$5,940.00
2	Erosion Control, Install, and Maintain	MO	2	$5,000	$10,000.00
3	12" HDPE with bedding material	LF	28	$135	$3,780.00
4	Inlet and Outfall Structures	EA	2	$15,000	$30,000.00
5	Pavement Repair (Base, HMAC, Slurry Seal, Markings)	LS	1	$50,000	$50,000.00
6	Revegetation	LS	1	$25,000	$25,000.00
				Subtotal:	**$124,720.00**
				Contingency:	**$24,940.00**
				Engineering:	**$14,970.00**
				Permitting:	**$4,990.00**
				Inspection and Review:	**$6,240.00**
	***ROW Identification, Negotiation & Acquisition NOT Included**				
				GRAND TOTAL:	**$175,860.00**

This Opinion of Probable Cost was prepared by Mark B. Luehrs P.E. #141460, Firm No. 560, and shall not be used for construction, permitting or other construction purposes

Parkhill

RUNWAY 3-21 102” DRAINAGE PIPE REPAIR OPTIONS

CITY OF GRAHAM

GRAHAM MUNICIPAL AIRPORT

1810 4th St.

Graham, Texas

March | 2025

Parkhill

RUNWAY 3-21 102” DRAINAGE PIPE REPAIR OPTIONS

CITY OF GRAHAM

GRAHAM MUNICIPAL AIRPORT

1810 4th St.

Graham, Texas



Parkhill

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1.0 EXECUTIVE SUMMARY

The existing 102-inch corrugated metal drainage pipe beneath Runway 3-21 at Graham Municipal Airport has deteriorated significantly, resulting in runway settling and structural instability. This report evaluates multiple repair and replacement methods, considering cost, feasibility, and impact on airport operations.

Several trenchless and traditional repair options were examined, including patch repair, epoxy coatings, cured-in-place pipe (CIPP), pipe bursting, open trench excavation, jack and bore, horizontal directional drilling (HDD), microtunneling, and liner plate installation. Each method was assessed based on structural integrity, environmental impact, regulatory compliance, and cost-effectiveness.

After careful evaluation, the recommended solution is a hybrid approach combining microtunneling and open trench excavation. This method balances construction efficiency, cost, and minimal disruption to airport operations. The estimated project cost ranges from $3.54M to $5.36M, with a projected construction timeline of 13 to 25 weeks.

This approach ensures long-term infrastructure resilience while minimizing downtime for Runway 3-21. Future planning should include detailed site surveys and soil reports to refine design parameters and optimize implementation.

2.0 INTRODUCTION

Parkhill has been contracted to provide preliminary repair methods for the 102-inch stormwater drainage pipe underneath Runway 3-21 for Graham Airport, determine a preliminary Engineer's Estimate of Probable Cost and anticipated construction schedule for each repair method. Figure 1 shows the project site.



FIGURE 1: PROJECT SITE

3.0 HISTORY

The Record Drawings drawings, dated November 1974, show that prior to the runway extension, the Dry Creek had two culverts of unknown size and material. A sheet revised May, 1975, as part of the project shown on the partial record drawings that Parkhill obtained, the culvert is shown as a single barrel, 102-inch pipe of 450 LF. Record drawings do not indicate pipe material but the site investigation found the pipe to be Corrugated Metal Pipe (CMP). The upstream (south) end of the pipe is shown with a flow line elevation of 1076.13 and the downstream (north) end of the pipe is shown with a flowline elevation of 1073.00. The pipe sits with approximately ±31-feet of cover over the top of pipe to the runway surface. Although not shown on the received Record Drawings, it is assumed that the elevations are on the NGVD 29 vertical datum. The

Record Drawings are attached to this report as Appendix A. The conversion from NNGVD to NAVD at Graham Municipal Airport is +0.298 usft.

4.0 PROBLEM

The existing 450 LF 102-inch CMP pipe that drains from southwest to northeast under the eastern end of RWY 3-21 is in failing condition. As a result, Runway 3-21 has begun to settle and repair of the runway will be required to fix the damage for the sinking runway. There are multiple issues that are readily identifiable as to the deficiencies in the existing pipe.

- The invert of the existing CMP has rusted out,
- the crown is collapsing effectively reducing the carrying capacity of the culvert,
- joint separation allowing for soil intrusion into the pipe which creates voids behind the pipe and causes potential collapses of infrastructure above the pipe,
- the headwall has separated from the pipe which will increase the opportunity for piping on the outside of the pipe and increased erosion potential.

The following Images show the failures of the existing pipe.



FIGURE 2: HEADWALL SEPARATION & JOINT SEPARATION



FIGURE 3: CULVERT INVERT DETERIORATION



FIGURE 4: RUNWAY 3-21 SETTLING

5.0 REPAIR METHODS

There are several options for storm drain pipe repair and replacement. These options look at the severity of the damage and the specific needs of the area. The options range from as small as patching portions of the pipe, lining the pipe, replacing the pipe with trenchless technologies, replacing the pipe with open cut trench, and replacing combinations of the above methods. This section will look at various options to repair and replace the 102-in CMP culvert and provide advantages and disadvantages of each method. There are key considerations when deciding on the repair and replacement method.

- Material Choice: Common Materials for storm drain pipes include concrete, HDPE, CMP, steel, Fiberglass Reinforced Polymer Mortar (FRPM) and polymer concrete. Each has its benefits and is selected based on the environmental conditions and load requirements.
- Location and Accessibility: Choosing the right repair method can depend on how accessible the culvert is. Trenchless options can be more suitable for difficult-to-access areas.
- Cost and Time: Trenchless methods (like Cured-in-Place Pipe, CIPP, and pipe bursting) tend to be faster and less disruptive, while traditional excavation may take longer and be more expensive.
- Regulations: Ensure that any storm drain replacement complies with local regulations and environmental standards.

5.1 PATCH REPAIR – LOCALIZED PIPE REHABILITATION

Patch repair is a trenchless method used to fix localized damage in pipelines, such as cracks, leaks, or small structural defects, without replacing the entire pipe. It involves installing a reinforced patch liner inside the damaged section of the pipe, restoring its strength and preventing leaks.

Patch Repair Methods:

- Fiberglass or Resin-Impregnated Patch (Point Repair)
  - A flexible liner (fiberglass or felt) is saturated with epoxy, polyester, or silicate resin.
  - The patch is positioned inside the pipe using a packer (inflatable bladder).
  - The packer is inflated, pressing the patch against the pipe wall until it cures.
  - The packer is deflated and removed, leaving a hardened, watertight repair.
- Mechanical Repair Clamps
  - Stainless steel repair clamps with rubber seals are placed around external pipe defects.
  - Common for pressurized pipes (water mains, gas pipes, industrial pipelines).
  - Provides an immediate, cost-effective repair without pipe replacement.
- Internal Sleeve Repair
  - A stainless steel or polymer sleeve is expanded inside the pipe.
  - Used for high-pressure pipes and gravity flow systems.
  - Can be installed via remote robotic equipment for hard-to-reach areas.
- Advantages of Patch Repair
  - Minimally Invasive – No need to dig up entire pipes.
  - Cost-Effective – Cheaper than full pipe relining or replacement.
  - Quick Installation – Repairs take hours instead of days.
  - Works for Various Pipe Materials – Used on PVC, concrete, clay, steel, and cast iron.
  - Extends Pipe Lifespan – Provides 10-50 years of additional service life.

Limitations:

Not Suitable for Severe Damage – Works best for cracks, small holes, and joint failures, not full pipe collapses.
Limited Coverage Area – Typically only repairs 1-3 feet of pipeline at a time.
May Require Multiple Repairs – If damage is widespread, full CIPP lining or replacement may be a better option.

Common Applications:

Sewer & Storm Drain Repairs
Water & Gas Line Leak Repairs
Industrial & Chemical Pipeline Fixes
Localized Structural Defects in Large Pipelines

Typical Pipe Sizes: 4” to 60”

Repair Lengths: 1 to 3 feet per patch

5.2 CEMENTITIOUS & EPOXY COATINGS – PIPE REHABILITATION & PROTECTION

Cementitious and epoxy coatings are trenchless rehabilitation methods used to protect, restore, or extend the life of existing pipelines. These coatings are applied internally to pipes to prevent corrosion, seal leaks, and improve structural integrity without full replacement.

Cementitious Coatings

- Overview

  Cementitious coatings use high-strength cement-based materials to reline and reinforce pipes. These coatings provide a corrosion-resistant, watertight barrier inside the pipe.

- Application Process

  Surface Preparation – The pipe is cleaned via high-pressure water jetting or mechanical brushing.

  Cement Mortar Application – A spray or spin-cast method applies the coating evenly inside the pipe.

  Curing & Inspection – The coating is allowed to harden, forming a strong, corrosion-resistant liner.

Advantages of Cementitious Coatings:

Restores Structural Integrity – Reinforces aging pipes.
Corrosion & Chemical Resistance – Protects against acidic wastewater or aggressive soils.
Effective for Large-Diameter Pipes – Used for culverts, storm drains, and sewer mains.
Cost-Effective – Lower cost than full pipe replacement.

Limitations of Cementitious Coatings:

Not Suitable for High-Pressure Pipes – Used mainly for gravity-flow systems.
Limited Flexibility – Can crack in pipes subject to movement or vibration.
Thickness Requirements – May reduce internal pipe diameter if applied too thickly.

Common Applications of Cementitious Coatings:

Sewer & stormwater pipes
Concrete, clay, and brick culverts

Typical Pipe Sizes: Large-diameter pipelines (24”–120”)

Epoxy Coatings

- Overview

  Epoxy coatings use liquid polymer resins that cure into a durable, corrosion-resistant barrier inside pipes. These coatings provide seamless protection against leaks, corrosion, and chemical attacks.

- Application Process

  Pipe Cleaning & Preparation – High-pressure jetting removes debris, rust, and scale.

  Epoxy Coating Application – Sprayed or spin-coated inside the pipe.

  Curing & Final Inspection – The coating hardens into a smooth, protective liner.

Advantages of Epoxy Coatings:

Corrosion & Chemical Resistance – Ideal for water, gas, and industrial pipelines.
Seamless & Leak-Proof – Prevents water infiltration and exfiltration.

Suitable for Pressurized Systems – Works for water mains, oil & gas pipes.
Minimal Diameter Loss – Thin application retains maximum flow capacity.

Limitations of Epoxy Coatings:

Surface Prep is Critical – Any remaining debris affects adhesion.
Limited Structural Support – Unlike CIPP or cementitious coatings, epoxy does not restore pipe strength.
Temperature Sensitivity – Requires controlled conditions for proper curing.

Common Applications of Epoxy Coatings:

Water & wastewater pipes
Oil & gas pipelines
Industrial chemical pipelines

Typical Pipe Sizes: Small & large-diameter pipes (2"–72")

Cementitious vs. Epoxy Coatings – When to Use Each

Factor	Cementitious Coating	Epoxy Coating
Structural Repair	Yes (Reinforces pipe)	No (Protective only)
Corrosion Protection	Yes	Yes
Chemical Resistance	Limited	High
Pipe Sizes	Large pipes (24"-120")	Small & large pipes (2"-72")
Suitable for Pressurized Pipes	No	Yes
Flexibility	Rigid	Flexible
Application Time	Longer cure time	Fast cure time

5.3 CURED-IN-PLACE PIPE (CIPP) – TRENCHLESS PIPE REHABILITATION

Cured-in-Place Pipe (CIPP) is a trenchless pipe rehabilitation method used to repair damaged, deteriorated, or leaking pipelines without excavation. It involves inserting a flexible resin-saturated liner into an existing pipe and curing it to form a seamless, structural pipe within a pipe.

Installation Process:

- Pre-Installation Preparation
  - Pipeline Inspection – A CCTV camera is used to assess pipe conditions.
  - Cleaning & Debris Removal – The host pipe is cleaned using high-pressure jetting or mechanical methods.
- Liner Insertion
  - A felt or fiberglass liner is impregnated with a thermosetting resin (epoxy, polyester, or vinyl ester).
  - The liner is inserted into the existing pipe via inversion (air/water pressure) or winching.
- Curing the Liner
  - The liner is expanded and pressed against the host pipe.
  - Curing methods:
    - Hot Water / Steam Curing – Accelerates resin hardening.
    - UV Light Curing – Used for fast, high-strength applications.

- Final Inspection & Reinstatement
  - Once cured, a CCTV inspection verifies the integrity of the new pipe.
  - Service connections (if applicable) are reopened using robotic cutters.

Advantages:

Minimal Excavation – No need to dig trenches.
Corrosion Resistant – Extends pipe lifespan (50+ years).
Hydraulic Improvement – Smooth surface enhances flow.
Structural Strength – Restores pipe integrity without full replacement.
Versatile Application – Works for sewer, stormwater, potable water, and industrial pipes.

Limitations:

Host Pipe Must Be Structurally Sound – Severe collapse may require full replacement.
Limited Diameter Expansion – Does not significantly increase pipe size.
Chemical Resistance Varies – Requires specialized resins for aggressive environments.
Curing Time & Conditions – Affected by temperature and liner thickness.

Typical Pipe Range: 6" to 120"

5.4 PIPE BURSTING – TRENCHLESS PIPE REPLACEMENT

Pipe bursting is a trenchless method used to replace old or damaged pipelines by breaking apart the existing pipe and pulling in a new one without excavation. It is ideal for upgrading undersized pipes, replacing failing infrastructure, and minimizing surface disruption.

Installation Process:

- Site Preparation
  - Pre-Inspection – CCTV cameras assess pipe condition and locate obstacles.
  - Excavation of Access Pits – Small entry and exit pits are dug at both ends of the pipeline.
- Insertion of Bursting Equipment
  - A bursting head (expander) is attached to the pulling cable or rod.
  - The new pipe (HDPE, PVC, or ductile iron) is connected to the back of the expander.
- Breaking & Replacement
  - The bursting head is pulled through the existing pipe, fracturing or splitting it.
  - Fragments of the old pipe are pushed outward into the surrounding soil.
  - The new pipe is simultaneously pulled into place as the old pipe is destroyed.
- Connection & Restoration
  - The new pipe is inspected, pressure tested (if applicable) and connected to the existing system.
  - Service connections are reestablished, and the access pits are backfilled.

Types:

Static Pipe Bursting – Uses hydraulic or mechanical rods to pull the bursting head forward.
Pneumatic Pipe Bursting – Uses a compressed air-driven hammer to break the pipe as it moves.
Lateral Pipe Bursting – Used for small-diameter pipes (e.g., residential sewer lines).

Advantages:

Trenchless Replacement – No need for open trench excavation.

Upgrades Pipe Size – Can install a larger pipe than the original.
Works with Various Materials – Replaces clay, concrete, cast iron, PVC, and steel pipes.
Cost-Effective – Reduces labor and restoration costs compared to open-cut methods.
Minimal Disruption – Ideal for urban areas, roads, and environmentally sensitive locations.

Limitations:

Requires Suitable Soil Conditions – Works best in compressible soils (not dense rock).
Access Pits Needed – Some excavation is still required.
Potential Utility Conflicts – Nearby underground utilities must be carefully located.
Pipe Material Restrictions – May not work well for pipes with strong structural reinforcement.

Typical Pipe Size Range: 4" to 36"

Larger Pipe Size Applications: Up to 48" with specialized equipment

5.5 OPEN TRENCH EXCAVATION – TRADITIONAL PIPE INSTALLATION & REPLACEMENT

Open trench excavation is the most common and traditional method for installing, replacing, or repairing underground pipes. It involves digging a trench, placing the pipe, and backfilling the trench after installation. This method is typically used when trenchless options are not feasible due to cost, pipe size, depth, or soil conditions.

Excavation Process:

- Site Preparation & Safety Measures
  - Survey & Utility Marking – Underground utilities are located and marked.
  - Traffic Control & Permitting – If working near roads or public spaces.
  - Erosion Control & Dewatering – Pumps or barriers manage groundwater and surface runoff.
- Excavation of the Trench
  - Trench Width & Depth – Designed based on pipe diameter and soil stability.
  - Shoring & Shielding – Used in deep excavations to prevent trench collapse.
  - Soil Storage & Disposal – Excavated material is stored for backfill or hauled away.
- Pipe Installation
  - Bedding Material Placement – A stable base (sand, gravel) is laid for pipe support.
  - Pipe Laying & Joint Connection – Pipes are placed, aligned, and connected.
  - Leak Testing – Pressure or air tests verify the integrity of the installation.
- Backfilling & Restoration
  - Layered Backfilling – Compacted in stages to prevent settlement.
  - Surface Restoration – Roadways, sidewalks, or landscaping are restored.

Advantages:

No Diameter Restrictions – Works for all pipe sizes, including large culverts.
Straightforward & Proven – Simple installation with minimal specialized equipment.
Effective in All Soil Types – Suitable for unstable or rocky ground.
No Specialized Pipe Required – Works with all materials (RCP, HDPE, PVC, steel, etc.).

Limitations:

High Disruption – Significant impact on roads, traffic, businesses, and the environment.

High Restoration Costs – Requires repaving roads, landscaping, or utility relocations.
Slow & Labor-Intensive – Longer construction timelines than trenchless methods.
Dewatering May Be Needed – High groundwater levels can complicate excavation.

Common Applications:

Large-diameter culverts & storm drains
New water & sewer main installations
Pipeline repairs in accessible areas
Rocky or unstable soil conditions

Typical Pipe Sizes: Any size (from small to extra-large pipes over 120")

Depth Limitations: Can exceed 20 feet but requires extensive shoring

5.6 JACK AND BORE – TRENCHLESS PIPE INSTALLATION

Jack and Bore (also called Auger Boring) is a trenchless method used to install pipes under obstacles such as roads, railways, and rivers. It involves jacking a casing pipe forward while simultaneously removing soil with an auger drill inside the pipe.

Installation Process:

- Site Preparation & Setup
  - Excavation of Pits – A launch (drive) pit and a receiving pit are dug.
  - Boring Machine Setup – The auger boring machine (ABM) is placed in the drive pit and aligned.
- Casing Pipe Jacking & Auger Drilling
  - The casing pipe (steel, RCP, or polymer) is pushed forward using hydraulic jacks.
  - An auger drill inside the pipe removes soil as the pipe advances.
  - The process continues by adding new pipe segments until the exit pit is reached.
- Pipe Installation & Finishing
  - If a final carrier pipe is required (e.g., water or sewer main), it is installed inside the casing.
  - Grouting is applied around the carrier pipe if necessary.
  - The launch and receiving pits are backfilled and restored.

Advantages:

No Surface Disruption – Ideal for highways, railroads, and developed areas.
Predictable & Controlled – Less risk of ground collapse compared to Horizontal Directional Drilling (HDD).
Works in Most Soil Types – Effective in sand, clay, gravel, and some rock.
Handles Large Diameters – Suitable for culverts, storm drains, and sewer mains.

Limitations:

Requires Large Pits – Needs entry and exit pits, which may limit use in tight spaces.
Limited Length – Typically under 500 feet (150m) per bore.
Difficult in Unstable Soils – Not ideal for loose sand, saturated ground, or cobbles.
Steering Control is Limited – Not as precise as HDD for curved alignments.

Common Applications:

Road & Railway Crossings
Large-Diameter Gravity Sewers & Culverts
Pipeline Installations in Urban Areas
Oil, Gas, and Water Transmission Pipelines

Typical Pipe Diameters: 12" to 84"

Typical Lengths: 50 to 500 feet

5.7 HORIZONTAL DIRECTIONAL DRILLING (HDD) – TRENCHLESS PIPELINE INSTALLATION

Horizontal Directional Drilling (HDD) is a trenchless method used to install pipelines, conduits, and cables under obstacles such as roads, rivers, railways, and environmentally sensitive areas. It involves drilling a pilot hole along a predetermined path and pulling the new pipe into place.

Installation Process:

- Site Preparation & Setup
  - Survey & Planning – Engineers design the bore path based on soil conditions, pipe size, and utility locations.
  - Drilling Rig Setup – A horizontal drill rig is positioned at the entry pit.
- Pilot Hole Drilling
  - A small-diameter drill bit is guided along the designed path using tracking technology.
  - The drill bit is steered using fluid pressure and hydraulic controls.
- Borehole Enlargement (Reaming)
  - The pilot hole is gradually widened using reamers to match the pipe diameter.
  - Drilling fluid (bentonite slurry) stabilizes the hole and removes debris.
- Pipe Pullback
  - The new pipe (HDPE, steel, or PVC) is welded and attached to the reamer via a swivel.
  - The pipe is pulled back through the borehole to complete installation.

Advantages:

Minimal Surface Disruption – No need for open trenches.
Long Installations Possible – Can drill thousands of feet without excavation.
Crosses Obstacles Easily – Ideal for rivers, highways, and urban areas.
Versatile Pipe Materials – Works with HDPE, PVC, steel, and ductile iron.
Strong & Leak-Free Joints – Uses butt-fused HDPE or welded steel for long-lasting installations.

Limitations:

Not Ideal for All Soil Conditions – Works best in soft to medium soils, but hard rock drilling is costly.
Requires Specialized Equipment – Large drill rigs and skilled operators are needed.
Risk of Fluid Loss (Frac-Out) – Drilling fluid can leak into the environment if not managed properly.
Higher Upfront Cost – More expensive than open trench for short-distance installations.

Common Applications:

Water, sewer, and gas pipelines
Power and fiber optic conduits
Crossing rivers, highways, and environmentally sensitive areas
Long-distance pipeline projects

Typical Pipe Diameters: 4" to 48"

Maximum Lengths: Up to 5,000 feet depending on soil and pipe size.

5.8 MICROTUNNELING – TRENCHLESS PIPELINE INSTALLATION

Microtunneling is a trenchless pipe installation method used for precise, remote-controlled pipe jacking. It is ideal for installing gravity flow pipes, storm drains, and sewer lines under roads, railways, and urban areas with minimal surface disruption.

Installation Process:

- Site Preparation & Setup
  - Excavation of Pits – A launch (drive) pit and a receiving pit are dug.
  - Microtunnel Boring Machine (MTBM) Setup – The MTBM is placed in the drive pit and aligned to the designed path.
- Pipe Jacking & Tunnel Excavation
  - The MTBM is hydraulically pushed forward, excavating soil while maintaining precise alignment.
  - A slurry system or auger conveyor removes excavated soil.
  - New pipe segments (reinforced concrete, steel, or polymer) are continuously jacked into place as excavation progresses.
- Completion & Final Connection
  - The MTBM reaches the receiving pit and is removed.
  - The installed pipeline is inspected and tested for alignment, leaks, and structural integrity.
  - The launch and receiving pits are backfilled and restored.

Advantages:

Minimal Surface Disruption – Ideal for urban areas, railroads, and waterways.
High Precision & Remote Control – Can follow exact alignments & grades for gravity pipes.
Handles Various Soil Conditions – Works in clay, sand, rock, and saturated soils.
Can Install Large Pipes – Suitable for diameters from 30" to 12 feet.
No Ground Settlement Issues – Pressurized slurry balance prevents ground collapse.

Limitations:

High Cost & Specialized Equipment – More expensive than jack and bore or HDD.
Requires Large Launch & Receiving Pits – Space constraints may limit feasibility.
Limited to Straight Alignments – Cannot make sharp horizontal or vertical turns like HDD.
Soil & Water Pressure Considerations – High groundwater may require dewatering.

Common Applications:

Gravity Sewer & Storm Drain Installations
Railroad & Highway Crossings

Deep Pipeline Installations (30+ feet below surface)
Water Transmission & Utility Tunnels

Typical Pipe Diameters: 30" to 144"

Maximum Lengths: Up to 5,000 feet per bore

5.9 LINER PLATE – TRENCHLESS PIPELINE INSTALLATION

Liner plates can be used to rehabilitate or replace large-diameter pipes and culverts without full excavation. This method is commonly used in trenchless pipe rehabilitation when existing structures are deteriorated but still capable of supporting a liner.

Installation Process:

- Site Preparation & Inspection
  - Assess existing pipe condition (corrosion, cracks, deformation).
  - Remove debris, obstructions, and sediment buildup inside the pipe.
  - If needed, perform dewatering to control groundwater inflow.
- Assembling Liner Plates Inside the Pipe
  - Liner plates are delivered in curved steel sections, sized for the pipe's diameter.
  - Plates are manually lowered and assembled inside the existing pipe.
  - Plates are bolted together in a circular pattern, forming the new pipe structure.
  - Work progresses incrementally down the pipe.
- Typical Plate Specs for Large Pipe Rehabilitation:
  - Material: Galvanized or epoxy-coated steel
  - Plate Thickness: 12 gauge – 3/8"
  - Segment Width: 16 – 24 inches
  - Bolted Joints for Secure Fit
- Grouting the Annular Space (Between Old Pipe & Liner)
  - After the liner is fully assembled, the gap between the new liner and the old pipe is filled with cementitious grout.
  - Grouting process:
    - Grout ports are installed at intervals along the liner.
    - Low-pressure grout is pumped into the annular space.
    - Flow is monitored to prevent voids or excessive pressure.
  - Grout provides structural stability, prevents liner collapse, and seals leaks.
- Pipe Joint Sealing & Final Adjustments
  - If the liner connects to manholes, junctions, or outlets, custom seals are installed.
  - End seals or concrete collars may be used to secure the liner at both pipe ends.
- Restoration & Final Inspection
  - Perform a CCTV inspection or manual walkthrough (if diameter allows).
  - Confirm grout distribution and check for leaks.
  - Restore any excavation areas at pipe entry/exit points.

Advantages:

No Full Excavation – Ideal for culvert & storm drain rehab under roads & railways.
Can Handle Large Diameters – Works for 8 ft – 30 ft+ pipes.

Extends Service Life – Adds 50 – 100 years of durability.
Strong & Corrosion-Resistant – Especially with galvanized or epoxy coatings.
Minimal Traffic Disruption – Work is done inside the pipe, avoiding surface closures.

Limitations:

Limited Structural Strength for High Loads.
Not Suitable for Rock Tunneling.
Requires Proper Groundwater Control.
Assembly is Labor-Intensive.
Corrosion Risk Without Proper Coating.

Common Applications:

Large-diameter culvert and storm drain repairs
Trenchless pipe rehabilitation without full replacement
Projects requiring minimal surface disturbance
Pipes with minor structural damage but failing integrity

Typical Pipe Diameters: 8 ft – 30 ft

6.0 ENGINEER'S OPINION OF PROBABLE COST (EOPC)

This comprehensive cost summary includes total costs, labor, material, equipment, fuel, maintenance, and other associated costs for each construction method. All values reflect current industry standards. The EOPC's found in this section are not all inclusive of the repair methods found in the previous section due to the fact that Parkhill has determined that not all repair methods presented are applicable for this project.

6.1 HORIZONTAL DIRECTIONAL DRILLING (HDD)

Total Estimated Cost: $2.5M – $4.2M

Duration: 8-14 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Pipe Material (HDPE/Steel)	$900K – $1.3M	35%
Labor (Crew of 10–16)	$550K – $850K	23%
Equipment Rental & Operation	$550K – $900K	20%
Fuel & Maintenance	$250K – $450K	12%
Drilling Mud & Disposal	$250K – $400K	10%

Key Points:

Most significant costs: Pipe material, fuel, and maintenance
HDD is ideal for deeper, longer crossings but requires careful fluid management and extensive equipment
Fuel consumption and mud disposal are significant operational costs

6.2 JACK & BORE (AUGER BORING)

Total Estimated Cost: $2.2M – $3.5M

Duration: 10-18 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Pipe Material (Steel Casing + Carrier Pipe)	$850K – $1.2M	40%
Labor (Crew of 8–12)	$500K – $750K	22%
Equipment Rental & Operation	$400K – $650K	20%
Fuel & Maintenance	$150K – $250K	10%
Excavation & Pits	$300K – $500K	8%

Key Points:

Lower operational costs compared to HDD, especially fuel and maintenance
Steel casing adds substantial costs, but the method is ideal for short, relatively shallow crossings
Excavation of entry/exit pits and equipment handling can increase labor costs

6.3 MICROTUNNELING

Total Estimated Cost: $4.0M – $5.8M

Duration: 12-20 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Pipe Material (Reinforced Concrete/Steel)	$1.3M – $1.8M	35%
Labor (Crew of 12–18)	$700K – $1.0M	18%
Equipment Rental & Operation	$800K – $1.4M	25%
Fuel & Maintenance	$400K – $700K	12%
Slurry & Dewatering Costs	$400K – $600K	10%

Key Points:

Most expensive method due to MTBM equipment and extended operation
High maintenance and fuel costs
Slurry management and dewatering add significant operational costs

6.4 CURED-IN-PLACE PIPE (CIPP)

Total Estimated Cost: $900K – $1.6M

Duration: 4-8 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Liner Material & Resin	$450K – $750K	45%
Labor (Crew of 6–10)	$250K – $400K	25%
Equipment Rental & Operation	$170K – $270K	15%
Fuel & Maintenance	$35K – $70K	5%
Bypass Pumping	$90K – $150K	10%

Key Points:

Cost-effective for rehabilitation of existing pipes
Lower operational costs due to reduced labor and equipment needs
Liner material costs (epoxy or cementitious) are the largest driver of costs

6.5 CEMENTITIOUS OR EPOXY COATING

Total Estimated Cost: $700K – $1.3M

Duration: 4-8 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Coating Material (Epoxy or Cementitious Spray)	$350K – $550K	45%
Labor (Crew of 6–10)	$225K – $375K	30%
Equipment Rental & Operation	$120K – $230K	15%
Fuel & Maintenance	$40K – $90K	5%
Surface Prep & Ventilation	$65K – $130K	5%

Key Points:

Most cost-effective method but limited to pipes in good structural condition
Lower costs overall but requires proper surface preparation and ventilation

6.6 OPEN TRENCH EXCAVATION

Total Estimated Cost: $4.5M – $7.2M

Duration: 10-20 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Pipe Material (Reinforced Concrete/Steel)	$1.7M – $2.4M	35%
Labor (Crew of 12–20)	$1.0M – $1.6M	22%
Equipment Rental & Operation	$1.2M – $1.9M	25%
Fuel & Maintenance	$600K – $950K	15%
Excavation & Backfill	$600K – $900K	12%

Key Points:

Most expensive method due to deep excavation, dewatering, and backfilling
Labor and equipment costs drive up total expenses significantly

6.7 LINER PLATE

Total Estimated Cost: $1,837,490.08

Duration: 8-12 weeks

Cost Breakdown:

Category	Estimated Cost	% of Total
Mobilization	$91,874.46	5%
Equipment Procurement	$315,000.00	17%
102" Tunnel Installation	$1,421,617.50	77%
Tunnel Protective Coating (optional)	$0.00	0%
Site Restoration	$8,998.12	1%

Key Points:

Only method based on actual cost estimate.
Cost estimate may have other expenses not included in estimate

6.8 FINAL COMBINED SUMMARY: ALL METHODS

Method	Total Estimated Cost	Duration	Life Expectancy
HDD	$2.5M – $4.2M	8-14 weeks	50-100 years
Jack & Bore	$2.2M – $3.5M	10-18 weeks	75-100 years
Microtunneling	$4.0M – $5.8M	12-20 weeks	75-125 years
CIPP	$900K – $1.6M	4-8 weeks	50-80 years
Coatings	$700K – $1.3M	4-8 weeks	30-70 years
Open Trench	$4.5M – $7.2M	10-20 weeks	75-125 years
Liner Plate	$1,837,490.08	8-12 weeks	50-100 years

Key Takeaways:

- Microtunneling and Open Trench Excavation are the most expensive methods, due to equipment needs, fuel, and deep excavation.
- CIPP and Coating methods are more cost-effective, making them ideal for rehabilitation projects where the pipe is structurally sound.
- Liner Plate Offers a Trenchless, Mid-Range Cost Alternative – Best for large-diameter culverts and deep installations (30–40 ft) without full excavation. Requires modular steel liner assembly and grouting, making it more labor-intensive than CIPP but cheaper than microtunneling.
- Jack & Bore offers a mid-range cost, suitable for shorter, shallower installations.
- HDD offers a balance of cost and efficiency for long, deep crossings, but drilling fluid and mud disposal add to its complexity.

6.9 RUNWAY 3-21 PAVEMENT REPAIRS

In the preceding sections, anticipated costs were provided for the repair of the drainage pipe. To repair the portion of the runway that has sagged due to the failing pipe, the existing pavement section within the depressed area would have to be removed and the subgrade area filled to bring the base material and asphalt material back to their original lines and grades. To save on costs, it is recommended that the existing base material may be utilized as a subbase course and to act as select fill material.

Upon completion of the subgrade and subbase layers, Parkhill would recommend six inches of P-209 Aggregate Base Material be installed underneath four inches of P-403 Asphalt Mix Pavement. This section will match the existing section for Runway 3-21. It is estimated that this repair would add between $100,000 to $150,000 to the overall project cost, regardless of the pipe repair method chosen.

7.0 ANTICIPATED CONSTRUCTION SCHEDULE

7.1 HORIZONTAL DIRECTIONAL DRILLING (HDD)

- Estimated Timeline: 8 to 14 weeks
- Breakdown:
  - Site Preparation & Rig Setup: 7–10 days
  - Pilot Hole Drilling: 14–21 days
  - Reaming (Hole Enlargement): 20–35 days (multiple passes needed for 102")
  - Pipe Pullback & Finalization: 7–14 days

Challenges: Requires specialized large-diameter HDD rigs, longer reaming process, high fluid volume for drilling

7.2 JACK & BORE (AUGER BORING)

- Estimated Timeline: 10 to 18 weeks
- Breakdown:
  - Excavation of Launch & Receiving Pits: 2–3 weeks
  - Machine Setup & Alignment: 7–10 days
  - Boring & Pipe Jacking: 6–10 weeks (~8–20 ft/day)
  - Final Pipe Placement & Grouting: 7–10 days

Challenges: Larger bore diameter slows progress, higher jacking forces, pit size requirements (~40'+ launch pit)

7.3 MICROTUNNELING

- Estimated Timeline: 12 to 20 weeks
- Breakdown:
  - Excavation of Launch & Receiving Pits: 3–4 weeks
  - Microtunneling & Pipe Jacking: 8–14 weeks (~6–15 ft/day)
  - Final Inspection & Backfill: 7–10 days

Challenges: Requires a larger microtunnel boring machine (MTBM), slurry system for soil stabilization, high jacking loads

7.4 CURED-IN-PLACE PIPE (CIPP) LINING

- Estimated Timeline: 4 to 8 weeks
- Breakdown:
  - Pipeline Cleaning & Inspection: 7–10 days
  - Liner Insertion & Curing: 3–6 weeks (~25–75 ft/day)
  - Final Inspection & Testing: 5–7 days

Challenges: Handling and curing large-diameter liners, high resin volume, precise inflation

7.5 CEMENTITIOUS OR EPOXY COATING

- Estimated Timeline: 4 to 8 weeks
- Breakdown:
  - Surface Preparation & Cleaning: 7–10 days
  - Coating Application: 3–6 weeks (~25–50 ft/day)
  - Curing & Final Inspection: 5–7 days

Challenges: Thick coatings required for structural integrity, drying times increase with larger diameters

7.6 OPEN TRENCH EXCAVATION

- Estimated Timeline: 10 to 20 weeks
- Breakdown:
  - Excavation & Shoring: 5–10 weeks (~5–15 ft/day, slow due to deep trenching)
  - Pipe Installation: 4–8 weeks (~10–30 ft/day)
  - Backfill & Surface Restoration: 7–14 days

Challenges: Large trench widths (~30-40 ft wide), major dewatering, heavy shoring requirements

7.7 LINER PLATE

- Estimated Timeline: 8 to 12 weeks
- Breakdown:
  - Site Preparation: 1-2 weeks ()
  - Liner Plate Installation: 4-6 weeks (10-15 ft/day)
  - Grouting Process: 2-3 weeks (requires 24-48 hours to set before moving forward)
  - Final Adjustments & Inspections: 1-2 weeks

Challenges: Confined space work restrictions and slow liner plate installation rate due to misalignment.

7.8 COMPARISON OF ESTIMATED SCHEDULES FOR A 450-FT, 102" PIPE AT 31-FT COVER

Method	Estimated Duration	Installation Rate
HDD	8 to 14 weeks	10-30 ft/day
Jack & Bore	10 to 18 weeks	8-20 ft/day
Microtunneling	12 to 20 weeks	6-15 ft/day
CIPP Lining	4 to 8 weeks	25-75 ft/day
Coatings (Cement/Epoxy)	4 to 8 weeks	25-50 ft/day
Open Trench Excavation	10 to 20 weeks	5-30 ft/day
Liner Plate	8 to 12 weeks	10-15 ft/day

8.0 MATERIALS

8.1 JACKING PIPES

Jacking pipes are specially designed to withstand high axial forces during microtunneling, pipe jacking, and other trenchless methods. The selection depends on soil conditions, load requirements, and project specifications.

- Reinforced Concrete Jacking Pipe (RCP)
  - Advantages: Best for: Gravity-flow culverts, storm drains, sewers
    Strength: Handles high compressive loads
    Durability: Long lifespan, resists corrosion
    Watertight Joints: Rubber gaskets or welded steel collars
  - Disadvantages: Heavy Weight: Requires large jacking forces
    Limited Bending: Works best in straight or gently curved alignments
  - Common Size Range: 24" to 144"

- Steel Jacking Pipe
  - Advantages: Best for: High-pressure culverts, rail & road crossings
    High Strength: Handles extreme jacking forces
    Versatile: Suitable for all soil conditions, including rock
    Customizable Joints: Can be welded for pressure pipes
  - Disadvantages: Corrosion Risk: May require coatings or cathodic protection
    Higher Cost: More expensive than concrete
  - Common Size Range: 24" to 120"

- Fiberglass Reinforced Polymer Mortar (FRPM) Jacking Pipe – Also known as HOBAS
  - Advantages: Best for: Corrosive environments (wastewater, chemical plants)
    Corrosion Resistant: Ideal for aggressive soils and chemicals
    Lightweight: Easier handling, lower jacking force
    Smooth Interior: Enhances flow efficiency
  - Disadvantages: Lower Axial Strength: Requires careful handling
    Higher Cost: More expensive than RCP

Common Size Range: 18" to 96"

- Polymer Concrete Jacking Pipe
  - Advantages: Best for: Aggressive soils, chemical exposure
    Highly Corrosion Resistant: No need for coatings
    High Compressive Strength: Stronger than standard concrete
    Smooth Bore: Reduces hydraulic friction
  - Disadvantages: Fragile During Handling: Brittle under improper force
    Expensive: Higher cost than RCP
  - Common Size Range: 24" to 96"

- Clay Jacking Pipe (Vitrified Clay Pipe - VCP)
  - Advantages: Best for: Gravity sewer systems
    Highly Corrosion Resistant: Does not degrade in acidic environments
    Smooth Interior: Reduces buildup, increases flow
    Long Lifespan: Over 100 years in stable conditions
  - Disadvantages: Brittle Material: Requires precision jacking
    Limited Size Range: Not suitable for very large culverts
  - Common Size Range: 8" to 48"

8.2 CHOOSING THE RIGHT JACKING PIPE

Factor	Best Pipe Type
High Strength (Axial Loads)	Steel, RCP
Corrosion Resistance	FRPM, Polymer Concrete, VCP
Long Lifespan & Durability	RCP, VCP, Polymer Concrete
Hydraulic Efficiency (Smooth Flow)	FRPM, Polymer Concrete
Tight Space & Lightweight Handling	FRPM, Steel
Budget-Friendly	RCP, VCP

9.0 REGULATORY

9.1 NATIONAL WETLANDS INVENTORY

A 3.00-acre riverine habitat that is classified as R4SBC runs both upstream, through the culvert and downstream of the project site. The wetlands and deepwater habitats in this area were photo interpreted using 1:58,000 scale, color infrared imagery from 1983. See Figure 5 for an image of the wetlands going through the site.

Classification code: R4SBC

- System Riverine (R): The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater. A channel is an open conduit either naturally or artificially created which

periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

- Subsystem Intermittent (4): This Subsystem includes channels that contain flowing water only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be absent.
- Class Streambed (SB): Includes all wetlands contained within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or of the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.
- Water Regime Seasonally Flooded (C): Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.



FIGURE 5: NATIONAL WETLANDS INVENTORY

10.0 AIRSPACE EVALUATION

Prior to constructing a project of this scope, consideration of the project and its impact on the protected airspace for Runway 3-21 needs to occur. Depending upon the scope of the project, Parkhill anticipates three possible impact scenarios to the runway's protected airspace. All the preceding temporary threshold displacements are based upon additional displacements from the already relocated threshold used to keep aircraft out of the depressed area atop the damaged pipe.

10.1 SCENARIO 1

No Runway Closure with 700-to-800-foot Temporary Threshold Displacement – Projects that require large equipment to be used for the duration of the project will have the largest impact to Runway 3-21's airspace. Of the projects suggested, Open Trench Excavation, fits this scenario. The anticipated construction methods would require large equipment to remove the overburden atop the pipe and reach the depths of the pipe from the runway surface. It is anticipated that multiple excavators, with an estimated 30-to-40 foot boom, could be used to complete the project. Due to the large excavation required for this construction method, the threshold for Runway 21 would have to be displaced approximately 713 feet to ensure that approaching aircraft could avoid construction equipment in the nearest portion of the construction area. Additionally, aircraft using Runway 3 for departure will have a significant reduction in the Takeoff Run Area (TORA) and Takeoff Distance Area (TODA) in order for departing aircraft to clear the construction equipment.

10.2 SCENARIO 2

Minor Runway Closure with 200-to-300-foot Temporary Threshold Displacement – A few construction methods suggested would require the use of large excavation machinery, like anticipated for Open Trench Excavation, but only temporarily, until smaller equipment could be used for pipe placement. As anticipated by the Microtunneling method, large excavation equipment would be needed to construct the launch and receiving pits but once pipe tunneling had begun, smaller equipment could be used to deliver pipe into the shafts for placement under the runway. During the large excavation, it would be recommended to close the runway for approximately 2-3 weeks, but after their completion, smaller equipment would allow for the runway to be reopened. Upon reopening, Runway 21 would need to be displaced an additional 225 feet so aircraft could clear equipment the restricted construction area. Additionally, aircraft using Runway 3 for departure would have a reduction in the runway's TORA and TODA so departing aircraft could clear the construction equipment.

10.3 SCENARIO 3

Little to No Disruption to the Currently Displaced Threshold – A few of the suggested construction methods that would require little to no excavation on top of the pipeline would require little to no additional displacement of the threshold. These methods, like liner plate installation, pipe coatings, cured-in-place pipe, etc., would be performed within the pipe. Assuming the contractor would not need to stage on the runway, or any closer to the currently displaced threshold, there appears to be no additional impact to the airspace of Runway 3-21.

Below is a table of possible Landing Distance Available (LDA), Takeoff Run Available (TORA), Takeoff Distance Available (TODA), Accelerate-Stop Distance Available (ASDA) for both approaches to Runway 3-

21. These declared distances would have to be fully evaluated during the design process of the selected project and may change slightly as construction equipment is fully evaluated.

Anticipated Declared Distances (Runway 21)			
Declared Distance	Scenario 1	Scenario 2	Scenario 3 (Current)
TORA	3919'	4030'	4200'
TODA	3919'	4030'	4200'
ASDA	3919'	4030'	4200'
LDA	3487'	3975'	4200'

Anticipated Declared Distances (Runway 3)			
Declared Distance	Scenario 1	Scenario 2	Scenario 3 (Current)
TORA	2687'	3475'	4200'
TODA	2687'	3475'	4200'
ASDA	3919'	4030'	4200'
LDA	3919'	4030'	4200'

11.0 RECOMMENDATION

Based on the condition of the existing pipe, and the potential repair/replacement options available, Parkhill recommends that the best replacement option be a combination of two options. In the opinion of Parkhill, the existing 102" corrugated metal pipe that traverses Runway 3-21 pipe is in a critical location for future runway function. It is our opinion that attempting to repair the pipe is not in the best interest of the airport and a replacement is necessary. The method we recommend is a combination of microtunneling and open trench constructions. Due to the depth of cut necessary on the site, full open trench becomes unfeasible. But as the runway slopes off down the embankments, the depth becomes much more reasonable to open cut the trenches on either side of the runway an commence with a microtunneling operation under Runway 3-21. This will help facilitate the amount of time that the runway is both limited in use and also give a complete new constructed pipe in place of the CMP that in our opinion is in disrepair.

While there are aspects of the recommended repair option that can and would likely be expected to change during the design phase of the project with more detailed site survey and soils report information, we believe a launching pit could best be serviced off the southern side of runway and receiving pit on the northern side of the runway. The microtunneling would commence between the two pits for an estimated distance of 181± LF with open trench extending on either end to the termination of the existing pipe where the headwalls would be replaced. The total estimated open trench cuts would be 142± LF on the southern end and 127± LF on the northern end for a total of 269± LF open trench pipe. Refer to Appendix B: Recommended Repair Method Schematic for a drawing of this option.

11.1 CONSTRUCTION SCHEDULE: COMBINED MICROTUNNELING AND OPEN TRENCH

Microtunneling:

- Estimated Timeline: 7 to 11 weeks
- Breakdown:
  - Excavation of Launch & Receiving Pits: 3–4 weeks
  - Microtunneling & Pipe Jacking: 3–6 weeks (~6–15 ft/day)
  - Final Inspection & Backfill: 7–10 days

Open Trench Excavation:

- Estimated Timeline: 6 to 13weeks
- Breakdown:
  - Excavation & Shoring: 3–7 weeks (~5–15 ft/day, slow due to deep trenching)
  - Pipe Installation: 2–4 weeks (~10–30 ft/day)
  - Backfill & Surface Restoration: 7–14 days

Combined Total: 13 to 25 weeks

11.2 EOPC: COMBINED MICROTUNNELING AND OPEN TRENCH

Total Estimated Cost: $3.54M – $5.36M

Cost Breakdown:

Category	Estimated Cost	% of Total
Pipe Material (Reinforced Concrete/Steel)	$1.21M – $1.69M	35%
Labor (Crew of 12–20)	$690K – $1.05M	22%
Equipment Rental & Operation	$810K – $1.33M	25%
Fuel & Maintenance	$410K – $670K	15%
Excavation & Backfill	$170K – $250K	12%
Excavation & Backfill	$250K – $370K	12%

12.0 CONCLUSION

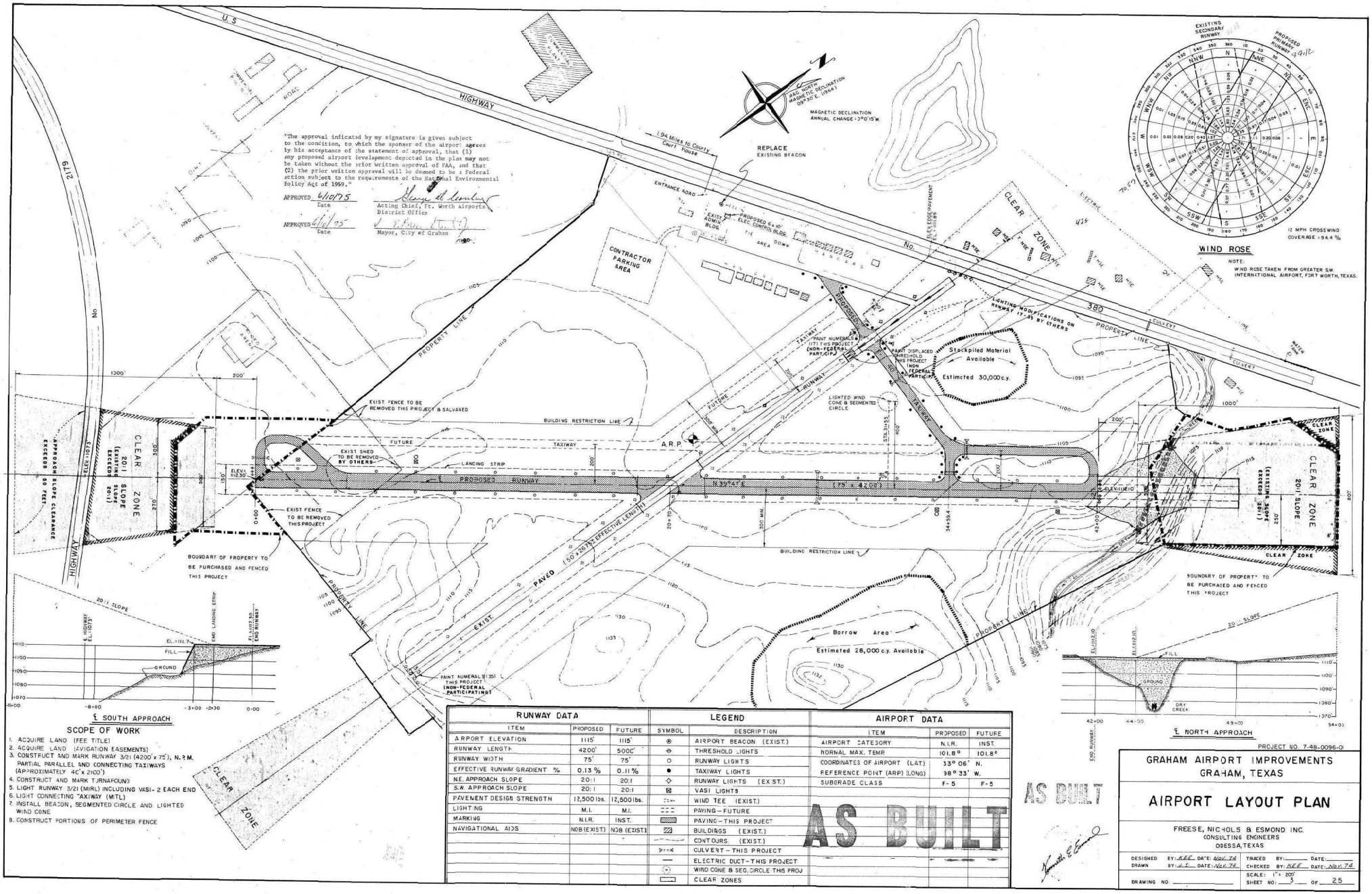
The deteriorating condition of the existing drainage pipe poses a critical risk to Runway 3-21 at Graham Municipal Airport. A comprehensive assessment of repair and replacement methods was conducted, leading to the recommendation of a combined microtunneling and open trench excavation approach.

This method offers a durable, cost-effective solution that minimizes runway disruptions while ensuring structural integrity. Though construction will temporarily impact operations, the long-term benefits include enhanced drainage performance and runway stability.

As the project progresses, additional site-specific investigations and engineering refinements will be necessary to finalize the design and ensure seamless execution. The proposed solution aligns with both operational and budgetary constraints, securing the long-term functionality of the airport's drainage infrastructure.

It is Parkhill's opinion that the construction cost of the combined microtunnel and open trench trends toward the lower end of this cost estimate. This is primarily due to the tunnel being substantially in place, allowing for expedited tunneling, reducing the cost associated with the microtunneling operation. Additionally, the overburden material atop the tunnel was likely constructed with select fill material, lowering costs that could be incurred if tunneling encountered rock or other unsuitable soil materials. As with any tunneling operation, there is a risk of collapse that may result in cost increases. For this specific project, there are unknowns soil condition surrounding the pipe that caused the initial settling of the runway. If significant time passes and additional sagging occurs, increased costs would need to be added to ensure collapse doesn't occur during the microtunneling process. It is suggested that these conditions be explored more in depth in the initial stages of the design of this project.

APPENDIX A: GRAHAM AIRPORT 1974/1975 AS-BUILTS



RUNWAY DATA		
ITEM	PROPOSED	FUTURE
AIRPORT ELEVATION	1115'	1115'
RUNWAY LENGTH	4200'	5000'
RUNWAY WIDTH	75'	75'
EFFECTIVE RUNWAY GRADIENT %	0.13 %	0.11 %
N.E. APPROACH SLOPE	20:1	20:1
S.W. APPROACH SLOPE	20:1	20:1
PAVEMENT DESIGN STRENGTH	12,500 lbs.	12,500 lbs.
LIGHTING	M.I.	M.I.
MARKING	N.I.R.	INST.
NAVIGATIONAL AIDS	NDB (EXIST.)	NDB (EXIST.)

LEGEND	
SYMBOL	DESCRIPTION
⊛	AIRPORT BEACON (EXIST.)
⊖	THRESHOLD LIGHTS
○	RUNWAY LIGHTS
●	TAXIWAY LIGHTS
◇	RUNWAY LIGHTS (EXIST.)
⊠	VASI LIGHTS
	WIND TEE (EXIST.)
	PAVING - FUTURE
	PAVING - THIS PROJECT
	BUILDINGS (EXIST.)
	CONTOURS (EXIST.)
	CULVERT - THIS PROJECT
	ELECTRIC DUCT - THIS PROJECT
	WIND CONE & SEG. CIRCLE THIS PROJ
	CLEAR ZONES

AIRPORT DATA		
ITEM	PROPOSED	FUTURE
AIRPORT CATEGORY	N.I.R.	INST.
NORMAL MAX. TEMP.	101.8°	101.8°
COORDINATES OF AIRPORT (LAT)	33° 06' N.	
REFERENCE POINT (ARP) (LONG)	98° 33' W.	
SUBGRADE CLASS	F-5	F-5

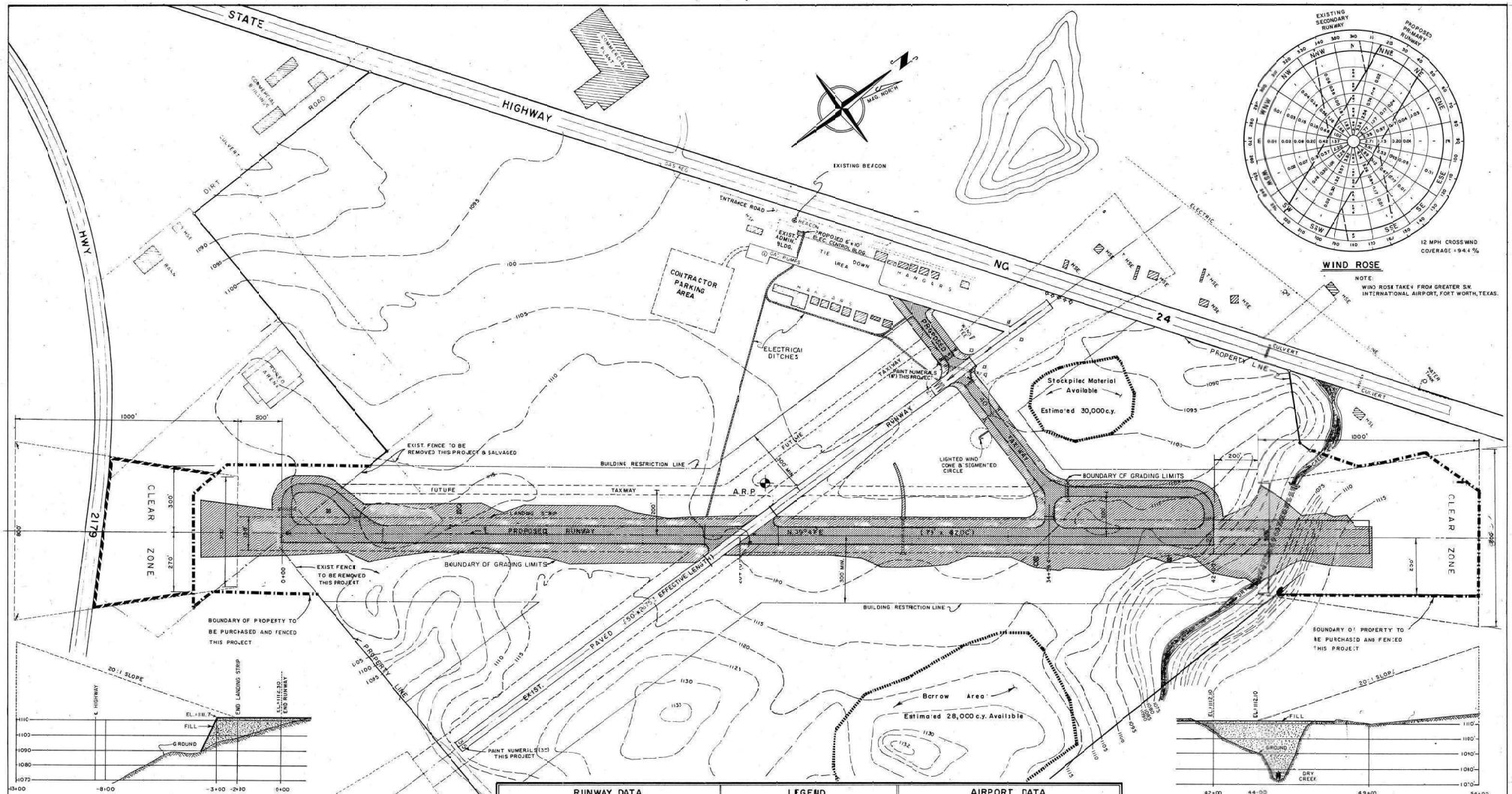
PROJECT NO. 7-48-0096-01

GRAHAM AIRPORT IMPROVEMENTS
GRAHAM, TEXAS

AIRPORT LAYOUT PLAN

FREESE, NICHOLS & ESMOND INC.
CONSULTING ENGINEERS
ODESSA, TEXAS

DESIGNED BY: KEE DATE: Nov. 74
DRAWN BY: J.E. DATE: Nov. 74
TRACED BY: DATE:
CHECKED BY: KEE DATE: Nov. 74
DRAWING NO.
SCALE: 1" = 200'
SHEET NO: 3 OF 25



SCOPE OF WORK

1. ACQUIRE LAND (FEE TITLE)
2. ACQUIRE LAND (AVIGATION EASEMENTS)
3. CONSTRUCT AND MARK RUNWAY 3/21 (4200' x 75'), PARTIAL PARALLEL AND CONNECTING TAXIWAYS (APPROXIMATELY 40' x 2100')
4. CONSTRUCT AND MARK TURNAROUND
5. LIGHT RUNWAY 3/21 (MIRL) INCLUDING VASI-2 EACH END
6. LIGHT CONNECTING TAXIWAY (MITL)
7. INSTALL BEACON, SEGMENTED CIRCLE AND LIGHTED WIND CONE
8. CONSTRUCT PORTIONS OF PERIMETER FENCE

RUNWAY DATA		
ITEM	PROPOSED	FUTURE
AIRPORT ELEVATION	1115'	1115'
RUNWAY LENGTH	4200'	5000'
RUNWAY WIDTH	75'	75'
EFFECTIVE RUNWAY GRADIENT %	0.13 %	0.11%
N.E. APPROACH SLOPE	20:1	20:1
S.W. APPROACH SLOPE	20:1	20:1
PAVEMENT DESIGN STRENGTH	12,500 lbs.	12,500 lbs.
LIGHTING	M.I.	M.I.
MARKING	N.I.R.	INST.
NAVIGATIONAL AIDS	NDB (EXIST)	NDB (EXIST)

LEGEND	
SYMBOL	DESCRIPTION
⊛	AIRPORT BEACON (EXIST.)
⊖	THRESHOLD LIGHTS
○	RUNWAY LIGHTS
●	TAXIWAY LIGHTS
◇	RUNWAY LIGHTS (EXIST.)
⊠	VASI LIGHTS
⊂⊃	WIND TEE (EXIST.)
▭	PAVING - FUTURE
▨	PAVING - THIS PROJECT
▨	BUILDINGS (EXIST.)
~~	CONTOURS (EXIST.)
▷▷◁◁	CULVERT - THIS PROJECT
—	ELECTRIC DUCT - THIS PROJECT
⊕	WIND CONE & SEG. CIRCLE - THIS PROJ.

AIRPORT DATA		
ITEM	PROPOSED	FUTURE
AIRPORT CATEGORY	N.I.R.	INST.
NORMAL MAX. TEMP	101.8°	01.8°
COORDINATES OF AIRPORT (LAT.)	33° 06' N.	
REFERENCE POINT (ARP) (LONG.)	98° 33' W.	
SUBGRADE CLASS	F-5	F-5

AS BUILT

PROJECT NO. 7-48-0096-01

GRAHAM AIRPORT IMPROVEMENTS
GRAHAM, TEXAS

GRADING LIMITS
TOPSOIL AND SEEDING AREAS

FREESE, NICHOLS & ESMOND INC.
CONSULTING ENGINEERS
ODESSA, TEXAS

DESIGNED BY: KKE DATE: NOV 74 | TRACED BY: | DATE:
DRAWN BY: W.E. DATE: NOV 74 | CHECKED BY: KEE | DATE: NOV 74
SCALE: 1" = 200'
DRAWING NO: | SHEET NO: 3-A OF 25

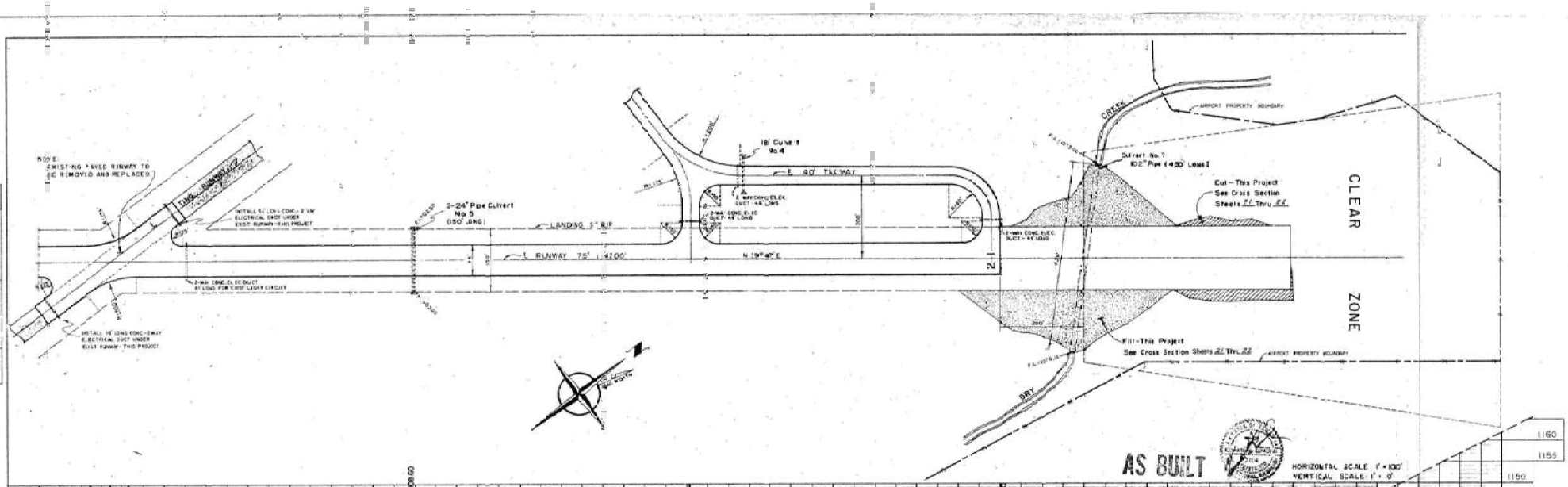


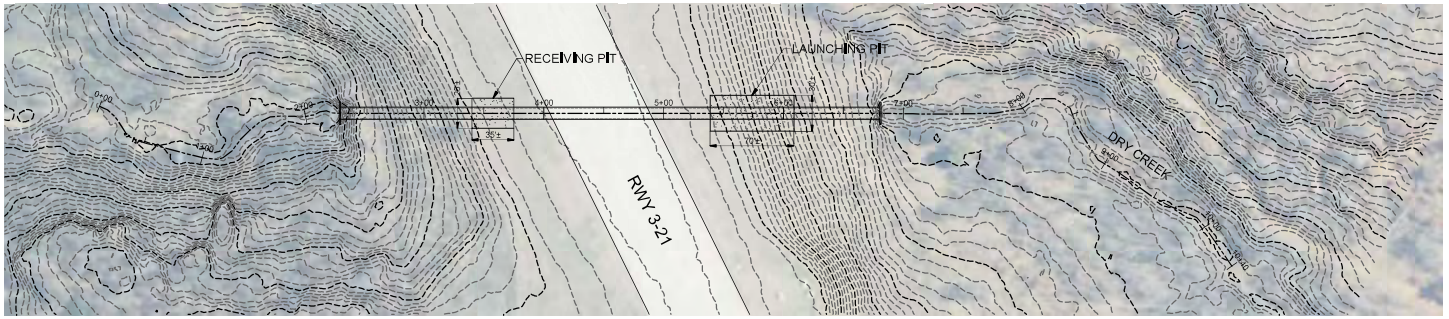
PLATE I PLAN-PROFILE

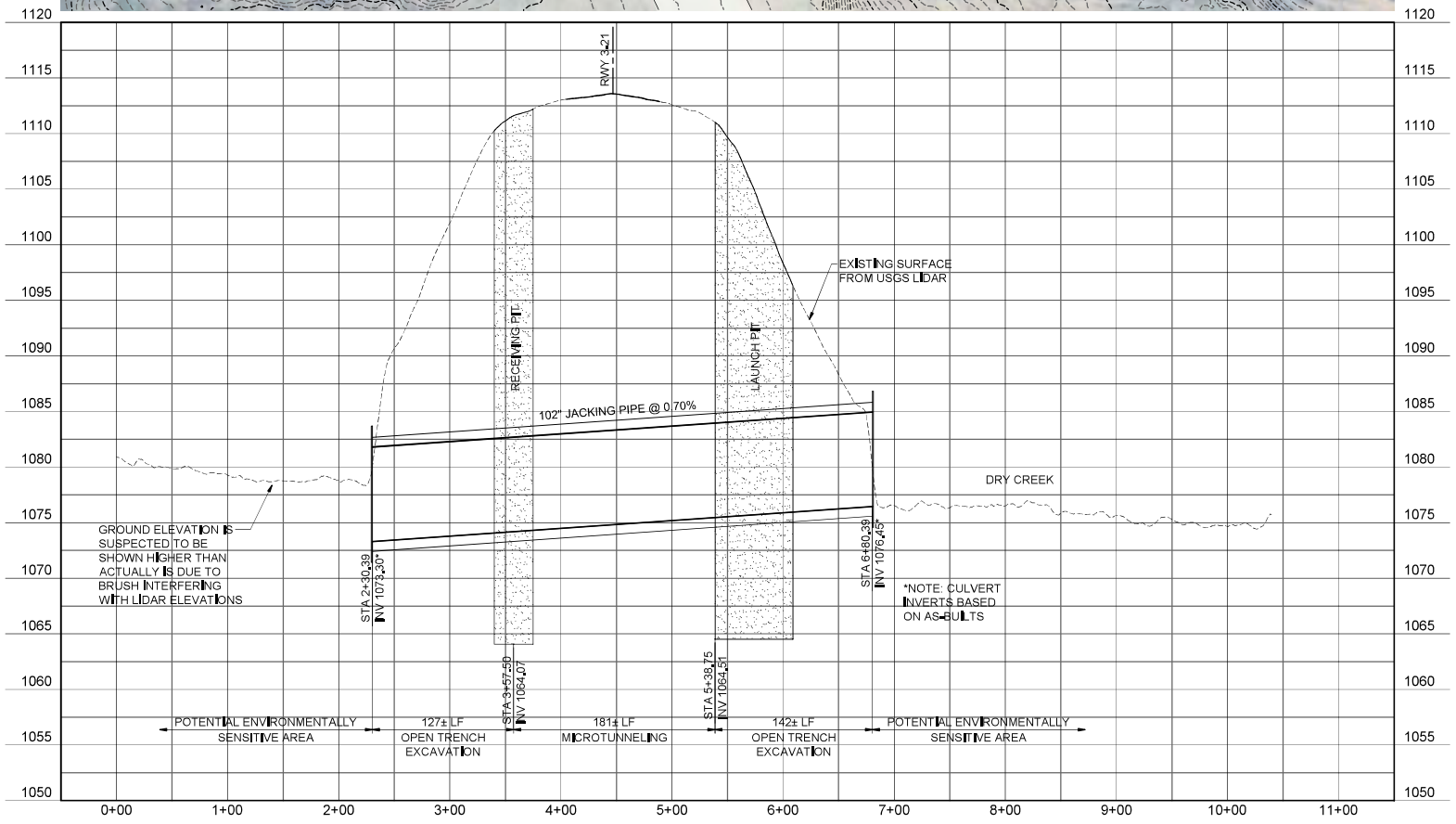
RUNWAY STATIONS 19+00 THRU 42+00
GRAHAM AIRPORT IMPROVEMENTS

REVISED: MAY 7, 1975

SHEET 7 OF 25

APPENDIX B: RECOMMENDED REPAIR METHOD SCHEMATIC PLAN





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HORIZONTAL SCALE 0 50 100 Feet

VERTICAL SCALE 0 5 10 Feet

GRAHAM MUNICIPAL AIRPORT DRAINAGE CULVERT | RECOMMENDED REPAIR OPTION

1810 4TH ST., GRAHAM, TEXAS | FEBRUARY 2025

Parkhill

44682.24

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APPENDIX C: LINER PLATE ESTIMATE

To:	Graham Airport	**Contact:**	
Address:	Graham, TX	**Phone:**	
		Fax:	
Project Name:	Graham, TX 102" Culvert Replacement	**Bid Number:**	
Project Location:	Graham Airport, Graham, TX	**Bid Date:**	1/6/2025

Item #	Item Description	Estimated Quantity	Unit	Unit Price	Total Price
1	Mobilization	1.00	LS	$91,874.46	$91,874.46
2	Equipment Procurement	1.00	LS	$315,000.00	$315,000.00
3	102" Tunnel Installation	450.00	LF	$3,159.15	$1,421,617.50
4	Tunnel Protective Coating (optional)	450.00	LF	$0.00	$0.00
5	Site Restoration	1.00	LS	$8,998.12	$8,998.12

Total Bid Price: $1,837,490.08

Notes:

- Bonds are not included in quote, if bonds are required please notify for additional bond costs.
- Owner is responsible for all permit costs required for the proejct.
- We assume all excess dirt to be left on site and spread near the ends of the tunnel.
- Existing headwalls to stay in place. Tunnel will be excavated, launched, and recieved from back side of existing headwalls, liner plate will be terminated at the existing openings in the headwalls.
- 102" Liner plate quoted to replace the existing culvert in place.
- to be held harmless for any settlement of the ground or runway, tunnel liner will be grouted for all over excavating during tunnelling, but we can not guarantee all existing voids from the existing damaged culvert will be filled by our operation.
- Optional protective coatings is based on a Obic Products polyurea lining system to protect the metal liner plate for a longer life span.
- 50% of equipment procurement item to be paid at date of equipment order placement, 25% at 50% completion of equipment manufacturing, and 25% at time of equipment pickup from the manufacturer.

ACCEPTED:

The above prices, specifications and conditions are satisfactory and are hereby accepted.

Buyer: _____

Signature: _____

Date of Acceptance: _____

CONFIRMED:

Authorized Signature:

Estimator:

_____

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Aviation Division

eGrants Workflow:	**RFQ Response**
eGrants Role:	Subgrantee Administrator (SA) Subgrantee Staff (SS)
eGrants link eGrants help:	https://apps2.dot.state.tx.us/apps/egrants2/logout2.aspx eGrants help desk Monday – Friday 8AM – 4PM CD/ST (excluding state/federal holidays) avn-egrantshelp@txdot.gov or 1-800-687-4568

STEP	ROLE	ACTIONS	NOTES
01	SA	Go to View Opportunities. a. Select Apply Now to the opportunity b. The RFQ Response Menu is opened	Very important to click on the name of the document and not the organization name. Make a note of the opportunity due date to ensure you respond in time
02	SA/SS	Click on View, Edit and Complete Forms a. Select RFQ Applicant Form b. Confirm Project information and address c. Upload RFQ response PLEASE MAKE SURE YOU SELECT THE CORRECT PDF FILE BEFORE CHANGING STATUS.* d. Hit Save	You should print the proposal document to a PDF so that it becomes un-editable.
03	SA	When you are ready to submit your response, click on "Save and submit to CS review". YOU	You will get an email saying the response was successfully submitted; the status must be changed to RFQ Response in

		ARE DONE	CS Review by the due date and time posted in the solicitation.
04	SA/SS	WAIT UNTIL A SELECTION NOTIFICATION IS SENT TO YOU	
05	SS/SA	AFTER SELECTION NOTIFICATION IS RECEIVED Log in to view status of response. Once the scores are verified, TxDOT will move the response to an interview, selected or not selected status of which you can log in to see the status of your response.	The selection notification will refer users to eGrants to view the status of their response. User may also view the TxDOT website for selection information.

*If the responder posts the incorrect file.

- If status has been changed and the due date for the response has not expired, contact the help desk to ask for the status to be administratively changed back to Response in Process.
- If the incorrect submission was posted, the incorrect file may be deleted and the correct one posted as long as the status has not been changed to Response in CS Review. Respondent will need to check the “delete” box and hit save. The page refreshes. Then post the correct submission, save, and change the status.

If you are not set up in eGrants and wish to respond to a posted solicitation, you may contact the aviation help desk for assistance by using the webform available at

eGrants Help Desk Form

Some organizations will have many user members. Each organization should determine which user member will submit the completed submission in eGrants. After the opportunity is selected for the

organization, it will no longer appear on any other user's home page unless the initiating user cancels the response.