



Forest Drive Stream Erosion Assessment and Conceptual Alternatives Development

September 2022

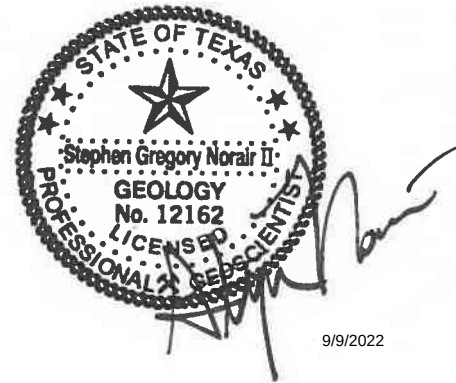
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City of Bedford, Texas

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FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

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Introduction

Freese and Nichols, Inc. (FNI) conducted a stream erosion assessment on approximately 0.5 miles of stream channel on an unnamed tributary of Little Bear Creek in Bedford, Texas between Forest Drive and Cummings Drive (**Exhibit A**). This assessment evaluated existing and potential future erosion that may impact homes and infrastructure adjacent to the creek. The results of the assessment then guided the development of conceptual solutions/alternatives that may protect private property and infrastructure from stream erosion.

The stream erosion assessment included the following components:

- Review of historic watershed development, soils, and underlying geology.
- Establishment of stream stationing to communicate the location of features within the study area, beginning at the upstream extent of the reach at Forest Drive (Station 0+00) and ending at Cummings Drive (Station 25+00).
- Documentation of existing geomorphic conditions (e.g., channel morphology, locations of scour, mass failures, sediment deposition patterns, etc.).
- Measurement of three cross-sections at representative locations.
- GPS-tagged photo-documentation of the project site.
- Evaluation of streambank erosion potential using the Bank Erosion Hazard Index (BEHI; Rosgen, 2006).
- Mapping of an Erosion Hazard Zone (EHZ), a delineated boundary that estimates the maximum probable extent of future erosion.

The results of the stream erosion assessment identified the locations of areas of concern. Four conceptual level solutions/alternatives were then developed at priority locations to protect private property and public infrastructure from stream erosion. General permitting considerations for each alternative were also provided.

This report provides a description of the stream erosion assessment, followed by a description of each of the developed alternatives.

1.0 Stream Erosion Assessment

1.1 Watershed Description

Physiography - The Unnamed Tributary of Little Bear Creek is a headwater stream located within Bedford, Texas. The watershed is within the Eastern Cross Timbers ecoregion and Grand Prairie physiographic province. This is a transitional area between the staircase low hills and grasslands to the west and the plains to the east. This region is characterized by surface material that is easily eroded by streams. Major streams in this region flow to the southeast.

Watershed Development History - Land use change within the watershed began in earnest in the 1970s and 1980s with the construction of Highway 121. In the late 1980s and early 1990s the interstate highway was expanded, and homes east of Forest Drive (known as four phases of the Rustic Woods Addition) were constructed. Around 2005 an additional subdivision was built upstream of Forest Drive. These two periods of abrupt development each led to sudden changes in watershed hydrology. Each of these periods of construction likely initiated channel adjustments via downcutting and widening (erosion).

Soil and Geology - Soils within the study area are disturbed urban soils that generally follow the landscape features/topography. Two soils are present immediately along the stream corridor (NRCS, 2022):

- Rader fine sandy loam, a moderately well drained, high runoff soil associated with stream terraces in hydrologic soil group C. This soil is present in the upstream half of the study area at the surface.
- Crosstell fine sandy loam, a moderately well drained very high runoff soil in hydrologic soil group D. This soil is present in the downstream half of the study area.

The underlying geology within the study area consists of the Woodbine formation, which is predominately of fine-grained sandstone interbedded with clay, marl, and friable shale. This unit is highly erodible in some locations and prone to slaking, the erosional process by which cycles of wetting and drying cause exposed surface layers to slough off easily.

1.2 Existing Conditions

Fluvial Geomorphologists from FNI performed a site visit on April 25th, 2022 to document the conditions of the Unnamed Tributary of Little Bear Creek. In general, the Unnamed Tributary of Little Bear Creek between Forest Drive and Cummings Drive is in the process of channel adjustment as a response to changes in hydrology following development within the watershed.

Channel adjustment, and associated erosion, does not occur all at once, but progresses systematically in stages. This process is explained by the Channel Evolution Model (CEM). The CEM is a conceptual model that describes how streams change over time, following a disturbance within a watershed (**Figure 1**). In the first stage of this process a stream will begin to downcut (vertical erosion). After the stream banks become over steepened, stream bank erosion occurs (lateral erosion). Next aggradation by sediment sourced from the erosion and lateral adjustments continue until a new stable channel is formed. This process occurs from downstream to upstream, as instabilities known as headcuts migrate through the watershed. This process can take decades and explains that different segments along a stream can experience erosion at different periods in time.

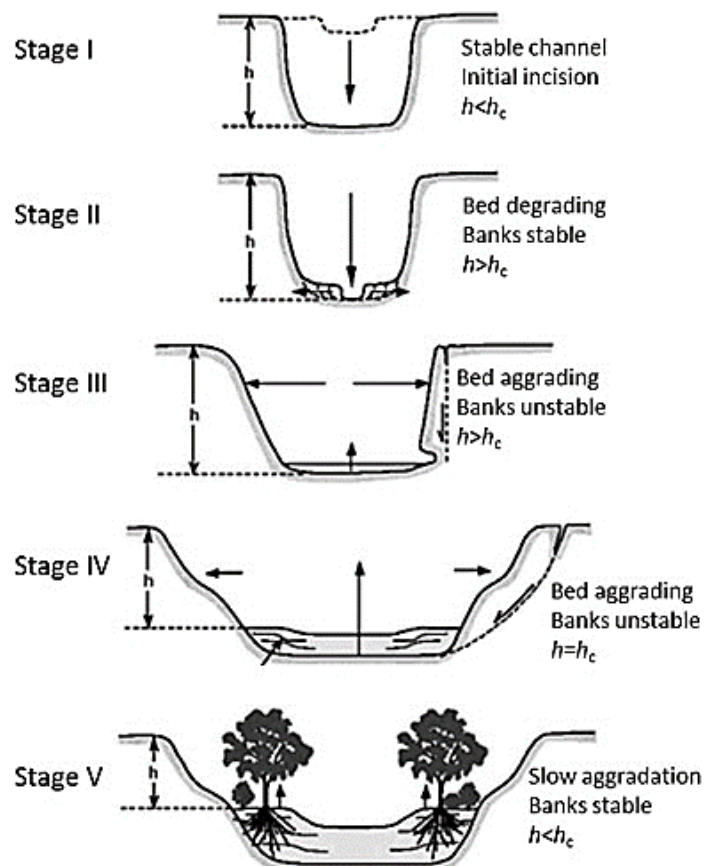


Figure 1. Diagram showing the stages of the Channel Evolution Model. Different segments of the Unnamed Tributary of Little Bear Creek are in various stages of this process.

Stream segments with similar characteristics are described below. A photo walkthrough of the channel showing representative channel conditions, City owned infrastructure, and identified areas of concern is provided in **Appendix A**. The location of each photo is shown on **Exhibit A**. **Appendix B** provides a table of the geomorphic stream metrics. **Appendix C** provides a plot of the longitudinal profile of the stream showing the locations of key features and estimated total downcutting (vertical channel adjustments).

Station 0+00 - Station 5+00 – The first 500 feet of channel is in the beginning stages of downcutting. The stream is not yet deeply incised (vertical degradation) but numerous headcuts and grade breaks were observed. The channel bottom has cut down into the underlying bedrock, which is composed of slakable/erodible Marl. Channel widening and lateral erosion were observed insolated locations through this reach. If left unaddressed, an estimated 4-feet of downcutting could occur. Infrastructure in this reach includes:

- A culvert crossing at Forest Drive (Station 0+00). Future vertical downcutting could impact the culvert because placed rip rap is likely insufficient to protect against erosion.
- A sewer line crossing is exposed on the stream bottom at Station 4+50. Bank scour and downcutting are not an immediate threat, but the sewer line crossing appears to be holding the grade of the stream. Future downcutting could threaten this structure and upstream reaches. Placed rip rap protection has been removed by flow. No protection measures are currently present.

Station 5+00 - Station 10+50 – This section of channel is further along in the channel adjustment process. Downcutting has occurred and is ongoing. Stream banks through this reach are taller (typically around 6-feet high) and nearly vertical in many locations. Major headcuts were observed at Stations 6+75, 9+00, and 10+50. If left unaddressed, between 3-feet and 8-feet of downcutting could occur through this reach. Bank erosion is also extensive and migrating into the backyards of several properties through this section. Infrastructure in this reach includes:

- A stormwater outfall at Station 5+75. The foundation of the outfall is on the bedrock channel bottom. At present, the outfall appears to be in functioning condition. But future downcutting may undercut below outfall.
- A stormwater outfall at Station 7+75. Downcutting has occurred leading to undermining of this structure by scour.
- An exposed sewer line at Station 8+50. Rip rap protection has been eroded. Downcutting and bank scour appears to be ongoing. Without grade control measures, downcutting could further threaten the sewer line and allow instabilities to migrate upstream.

Station 10+50 - Station 14+50 – The form of the channel changes at station 10+50, below a headcut. The stream no longer has steep vertical banks (1- to 3- foot bank heights), and the stream valley opens up, providing a geomorphic floodplain that dissipates the energy of higher flows. Erosion is minimal through this section but is still present in isolated locations. However, at the end of this reach there appears to be a 2.5-foot headcut that could migrate upstream. Headcut migration would allow instabilities to progress upstream. Infrastructure within this reach includes:

- A stormwater outfall at Station 13+00. This structure is in poor condition. Bag walls have been built around the outfall, but local scour appears to be occurring.

Station 14+50 – 17+50 – This reach begins below a headcut and the confluence of a tributary with drainage from N Industrial Blvd. The channel is larger through this section and the stream banks are taller (6- to 12- foot bank heights). Downcutting has already occurred, and the slope of the stream flattens from 0.015 to 0.009. However, bank scour and historic slumping was observed. Erosion could affect the backyards of homes. Infrastructure through this reach includes:

- At Station 14+50 to 15+50, grouted rip rap bank protection is present at the terminus of Creekside Ct. This bank stabilization measure is in poor condition due to scour undercutting the toe. Continued erosion may impact Creekside Ct.

Station 17+50 – 25+00 – The most downstream reach is in good condition. The concrete channel below Cummings drive acts as a hard point, preventing downcutting from progressing upstream. Minor vertical adjustments may still occur. Bank protection, likely installed by homeowners, also armors the banks in several locations. This area had minor evidence of erosion. Infrastructure through this reach includes:

- Stormwater outfalls observed at Stations 19+00 and 22+00. Both outfalls were in good condition.
- A sewer line runs below the channel bottom between Station 20+25 and 22+25. This sewer line is not exposed and there is no evidence stream processes are currently affecting this structure.

While the channel adjustments described above are on-going, further development in the watershed will likely cause the existing instabilities to migrate upstream more rapidly. The existing instabilities are a byproduct of land use changes within the watershed. Adding more development exacerbates the existing ongoing channel adjustments (erosion). Essentially, development causes water to reach the stream more quickly and with greater discharge because the path of runoff changes from overland flow through grass fields to a more direct and efficient route following the construction of pipes, stormwater infrastructure, and smooth impervious surfaces.

1.3 Bank Erosion Hazard Index (BEHI)

The Bank Erosion Hazard Index (BEHI) is a rapid technique to used evaluate a stream banks potential to erode laterally based on its characteristics. These characteristics include bank height, bankfull height, vegetation root depth, vegetation root density, bank slope steepness, and surface protection. Each of these characteristics were evaluated and then used to calculate a BEHI rating: Extreme, Very High, High, Moderate, Low, or Very Low potential to erode. Streambanks were mapped and rated using this system to indicate where erosion potential was the highest (**Exhibit B**).

The distribution of BEHI ratings found on the stream banks of the unnamed tributary are presented in **Figure 2**. In general, BEHI scores were clustered within specific areas associated with the reaches described in the previous section.

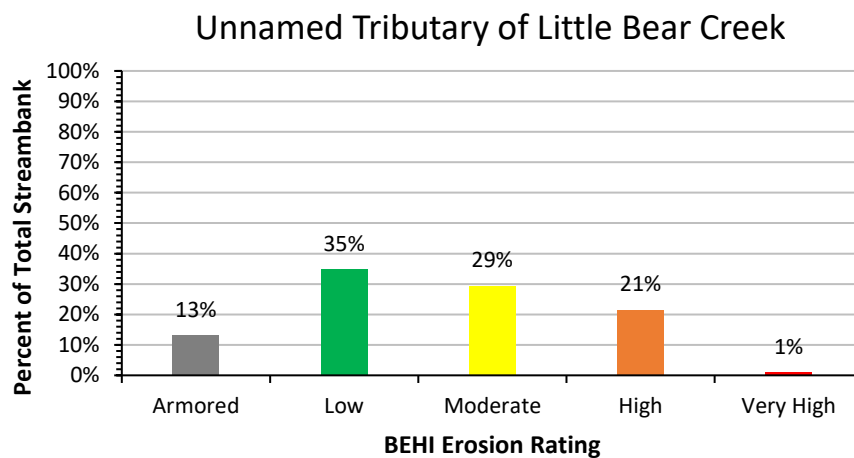


Figure 2. BEHI distribution within study area.

Station 0+00 - Station 5+00 - BEHI scores were generally low to moderate because vertical channel adjustments (downcutting/headcut migration) occur prior to significant channel widening. Lateral adjustments (bank erosion) will occur once the stream has downcut to a point where bank heights are too tall to support themselves.

Station 5+00 - Station 10+50 - BEHI scores are generally rated as High. The stream banks through this area are near vertical and downcutting is occurring. Banks are also undercut through much of this area. However, heavy vegetation is providing some resistance against widening and channel slumping.

Station 10+50 - Station 14+50 – The stream channel has low BEHI scores. This is because there is a wide geomorphic floodplain available to dissipate the energy during higher flows.

Station 14+50 – 17+50 – Through this area the BEHI scores are between Moderate and Very High. Even areas that have been armored by bank protection projects have evidence of scour.

Station 17+50 – 25+00 – BEHI scores through the most downstream section of stream range between Low and Moderate. Through this section downcutting and widening have reached their maximum extent due to the channel slope being maintained by the downstream section of artificial channel. Bank stabilization installed by homeowners also protect the stream against erosion.

1.4 Erosion Hazard Zone (EHZ)

An erosion hazard zone is a 3-dimensional area delineating the maximum probable extent of potential erosion around a stream. Numerous methodologies to delineate this distance are available with varying degrees of conservativeness. Erosion is a complicated process, as such, an EHZ does not predict the location or timeframe of when erosion may occur, but merely estimates the expected areas that could be affected by erosion.

For this analysis, cross-sections along the Unnamed Tributary of Little Bear Creek were cut from LiDAR data (supplemented with field observations and measurements) every 150- to 300-feet, ensuring that changes in channel geometry were captured. Next, a 3:1 slope from the toe of the stream bank beginning at the elevation of expected downcutting was projected outward to the ground surface. A 3:1 side slope was assumed to be the stable angle of repose for stream banks given their material composition. A minimum buffer of 50-feet from the toe of slope is also indicated by many methodologies, **Figure 3** diagrams how the EHZ is delineated.

The 3:1 bank projection was within the 50-foot minimum in many locations. Almost all homes adjacent to the stream were within the EHZ. As such, the EHZ was also calculated without a 50-foot minimum. However, this may underestimate the potential extent of erosion. Maps showing the erosion hazard are provided in **Exhibit C**.

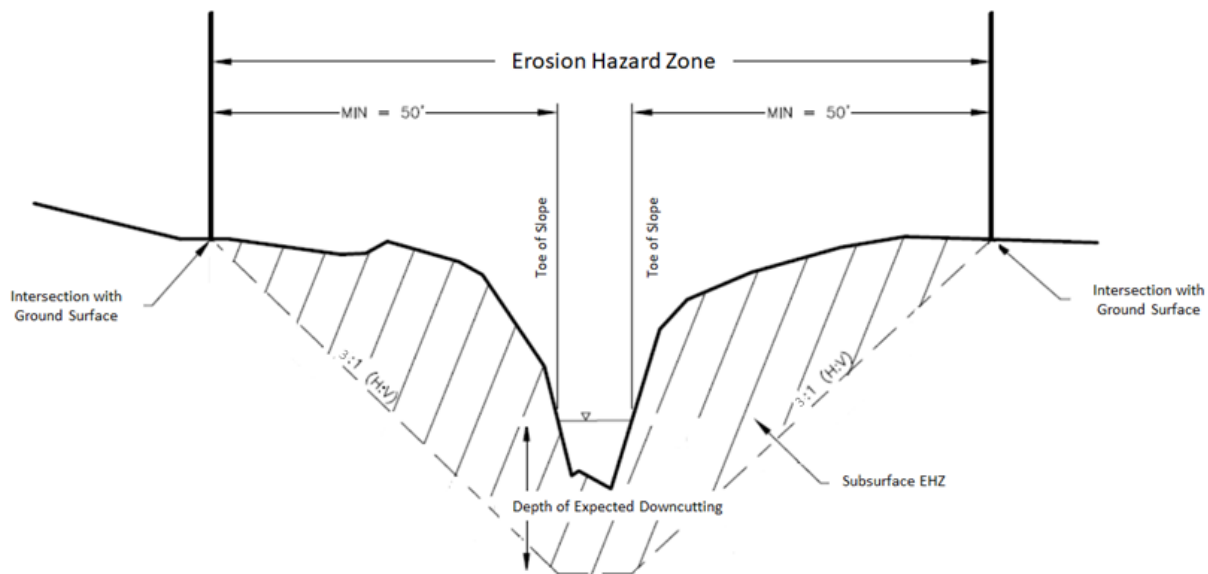


Figure 3. Diagram showing the delineation of a 3D erosion hazard zone at a stream cross-section.

2.0 Areas of Concern

Erosion has the potential to have negative impacts to infrastructure or homes in many locations due to ongoing channel adjustments. The locations of the areas concerns are shown on **Exhibit A** and **Table 1** provides a full list of identified areas of concern. The estimated priority of each of these concerns is also denoted. Photos of each of these concerns are also called out in the Photo Walkthrough provided in **Appendix A**.

In general, these concerns are due to system wide channel adjustments and are not isolated incidents. This means that any potential future erosion protection measures targeting strategic locations may have beneficial effects that extend beyond the immediate area where a concern was observed. By locking in the slope of the stream, channel adjustments (downcutting and widening) may be truncated prematurely. To be most effective, future projects at specific locations should incorporate expected system wide channel adjustments into their designs.

Table 1. Identified Areas of Concern

Location	Impacted Features	Description	Priority
#1 Station 0+00	Forest Drive	Migrating headcuts could impact the culvert below Forest Drive. The rip rap channel protection may not be sufficient to prevent downcutting from occurring.	High
#2 Station 1+00 – 4+00	Home Backyards	Bank scour is occurring in isolated locations along the stream banks, this is partially a result of downcutting and will likely become more pronounced into the future.	Moderate
#3 Station 4+50	Sewer Line Crossing	A sewer line crossing is exposed on the stream bottom. While bank scour and downcutting are not an immediate threat, the sewer line crossing appears to be holding the grade of the stream. Future downcutting could threaten this structure and upstream reaches. Placed rip rap protection has been removed by flow. No protection measures are currently present.	High
#4 Station 5+75	Stormwater Outfall	A stormwater outfall is present, future downcutting and scour may undermine the stability of this structure.	Low
#5 Station 6+00 – 10+00	Home Backyards	The stream is incised through this section. Bank scour as a result of channel downcutting could impact the backyards of homes.	Moderate
#6 Station 7+75	Stormwater Outfall	A stormwater outfall has been undermined by downcutting on the stream bed. Local scour was observed below the foundation of this structure.	Moderate
#7 Station 8+50	Sewer Line Crossing	A sewer line is exposed at this location. Rip rap protection has also been eroded. The stream appears to be downcutting and bank scour is present upstream and downstream of the crossing. Without grade control measures, downcutting could further threaten the sewer line and allow instabilities to migrate upstream.	High
#8 Station 10+75 – 11+25	Homes, Upstream Impacts	There is an approximately 3-foot headcut that is migrating upstream at this location. It appears that rip rap has been placed over this change in slope. However, this stone is being eroded. Immediately downstream subsequent bank erosion has occurred and is less than 20-feet from the foundation of a home along the stream.	High
#9 Station 13+00	Stormwater Outfall	The stormwater outfall present at this location is being impacted by local scour. A bag wall is present to protect this structure but is in poor condition.	Moderate
#10 Station 14+50 – 15+00	Creekside Ct, Upstream Impacts	Bank stabilization measures, in the form of grouted rock rip rap, to protect Creekside Court has been undercut by toe scour and is failing. This is due to channel downcutting below the depth of the protection measures. The headcut that initiated this issue is still present and at the upstream extent of the bank protection. Any measures to address this issue should also incorporate grade control to protect upstream reaches from migrating instabilities.	High
#11 Station 15+50 – 17+50	Home Backyards	Bank erosion was observed through this section and could impact home backyards. This includes a failing bag wall and railroad tie wall bank protection at Station 17+50.	Moderate

3.0 Conceptual Alternatives Development

This section proposes four conceptual level alternatives/solutions, discusses the potential permitting considerations, and suggests monitoring of the stream condition. These alternatives are intended to protect infrastructure and help mitigate system wide channel adjustments and erosion by locking the slope in place; thereby reducing upstream downcutting and widening. Alternative #1 addresses stream bank erosion adjacent to Creekside Court between Station 14+50 and 15+50. Alternative #2 addresses an exposed sewer line located at Station 8+50. Alternative #3 addresses an exposed sewer line at Station 4+50. Alternative #4 is protects the headwall on the downstream side of Forest Drive at Station 0+00.

3.1 Alternative #1 – Retaining Wall from Station 14+50 to 15+50

The purpose of Alternative #1 is to protect an existing eroded slope along the right bank between stations 14+50 and 15+50. The failing bank is within 15 feet from the existing sidewalk along the western edge of the cul-de-sac of Creekside Court. The design will consist of removing the existing rock riprap bank protection which is currently being undermined. The bank will be reconstructed with a hard armored toe protection and mechanically stabilized earth (MSE) on top. Soil anchors are assumed because of the likeliness of traffic loading at the top of the bank. The toe protection will be a minimum of 6 feet in height with the bottom fully buried. Proposed riprap to be placed along the toe of wall and along the channel bottom to mitigate against a knickpoint migrating upstream. An exhibit was created to visually display design elements for Alternative #1 and is attached to this report in **Exhibit D**.

A conceptual opinion of probable construction cost (OPCC) for Alternative 1 is \$515,000. A detailed OPCC is attached.

3.2 Alternative #2 – Sewer Crossing at Station 8+50

The purpose of Alternative #2 is to protect an existing exposed 8" sanitary sewer line located at station 8+50. The design will consist of concrete encasement to be placed in line with the existing utility having dimensions of 3 feet wide, 25 feet long and 3.5 feet in depth. Concrete encasement shall be sloped to have a low point in the center of the channel to direct flow away from the banks. Rock riprap bank protection will be placed along the banks over the crossing to protect from lateral migration of the stream. Rock riprap bed material will be placed downstream of the encasement to further protect the utility crossing from existing stream instabilities. An exhibit was created to visually display design elements for Alternative #2 and is attached to this report in **Exhibit E**

A conceptual opinion of probable construction cost (OPCC) for Alternative #2 is \$165,000. A detailed OPCC is attached.

3.3 Alternative #3 – Sewer Crossing at Station 4+50

The purpose of Alternative #3 is to protect an existing exposed 8" sanitary sewer line located at station 4+50. The design will consist of concrete encasement to be placed in line with the existing utility having dimensions of 3 feet wide, 25 feet long and 3.5 feet in depth. Concrete encasement shall be sloped to have a low point in the center of the channel to direct flow away from the banks. Rock riprap bank protection will be placed along the banks over the crossing to protect from lateral migration of the stream. Rock riprap bed material will be placed downstream of the encasement to further protect the utility crossing from existing stream instabilities. An exhibit was created to visually display design elements for Alternative #3 and is attached to this report in **Exhibit F**

A conceptual opinion of probable construction cost (OPCC) for Alternative #3 is \$153,000. A detailed OPCC is attached.

3.4 Alternative #4 – Forest Drive Headwall Protection at Station 0+00

The purpose of Alternative #4 is to protect an existing headwall at Forest Drive from instabilities migrating upstream. Land use upstream of Forest Drive is expecting to change which could expedite the migration of these instabilities. Rock riprap channel protection should be placed within the stream bottom on the downstream end of the headwall at a depth that would intercept the potential downcutting depth (estimated at 4-feet). Rock riprap should contain a variety of well-mixed stone sizes, thereby creating a matrix with minimal void space. Conceptual dimensions for the protection include 260 SY of riprap channel protection. An exhibit was created to visually display design elements for Alternative #4 and is attached to this report in **Exhibit D**

A conceptual opinion of probable construction cost (OPCC) for Alternative #4 is \$240,000. A detailed OPCC is attached.

3.5 Permitting Requirements

The United States Army Corps of Engineers (USACE) regulates the discharge of dredged and fill material into waters of the U.S. (WOTUS), including wetlands, under Section 404 of the Clean Water Act (Section 404). It is our understanding that the unnamed tributary of Little Bear Creek, an intermittent stream within the project area, is considered a WOTUS by the USACE. Any activity which would result in the discharge of dredged or fill material into this stream or other WOTUS would require USACE authorization under Section 404. Three alternatives were evaluated for impacts to WOTUS and Section 404 permitting based on the approaches described above.

Nationwide Permit 58 (NWP 58; *Utility Line Activities for Water and Other Substances*), authorizes activities required for the construction, maintenance, repair, and removal of utility lines for water and other substances, excluding oil, natural gas, products derived from oil or natural gas, and electricity. This

NWP is typically used to authorize construction activities related to water utility line improvements. If contours of the project area within WOTUS are restored to pre-construction conditions and permanent project impacts to WOTUS are less than 0.1 acre, there are no impacts to federally listed threatened and endangered species, there are no impacts to historic properties (including archeological sites), and regional pre-construction notification (PCN) triggers are avoided, Alternatives 1 and 2 for the proposed project could be authorized by NWP 58 without the requirement to submit a PCN to the USACE.

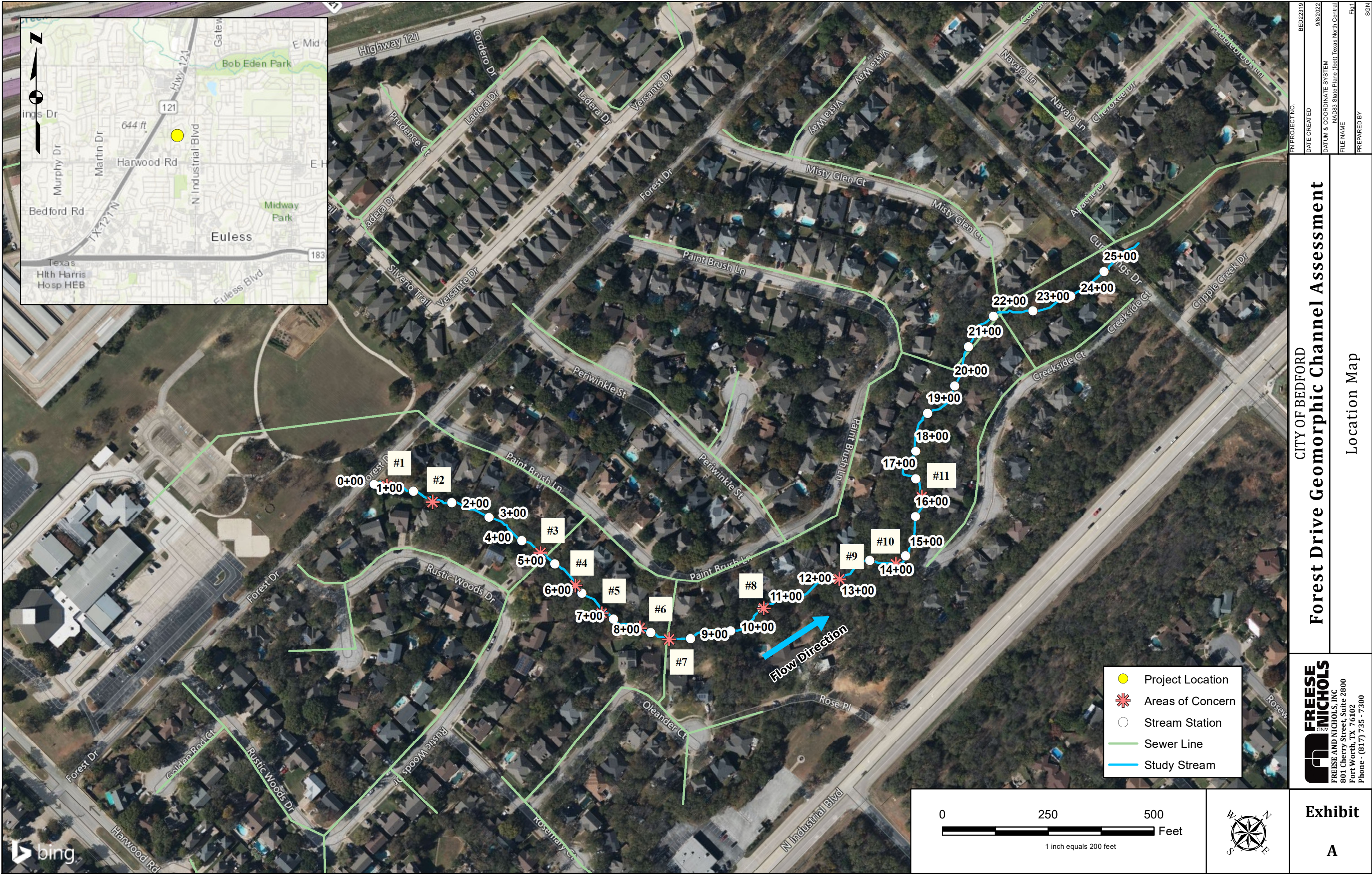
Nationwide Permit 14 (NWP 14 (*Linear Transportation Projects*)) authorizes activities required for crossings of WOTUS associated with the construction, expansion, modification, or improvement of linear transportation projects (e.g., roads). This NWP is typically used to authorize construction activities related to roadway improvements and associated bank stabilization. If permanent project impacts to WOTUS are less than 0.1 acre, there are not impacts to special aquatic sites (such as wetlands), there are no impacts to federally listed threatened and endangered species, there are no impacts to historic properties (including archeological sites), and regional PCN triggers are avoided, Alternative 3 for the proposed project could be authorized by NWP 14 without the requirement to submit a PCN to the USACE. If it is later determined that bank protection is desired outside the immediate vicinity of the roadway improvements and cannot be authorized by NWP 14, then NWP 13, *Bank Stabilization*, should be considered as a potential permit to authorize bank stabilization activities.

3.6 Stream Monitoring

Continued stream monitoring is recommended to evaluate erosion and stream conditions through time. Monitoring would provide the City a method of evaluating when erosion impacts may occur. This could be done in numerous ways with varying levels of detail:

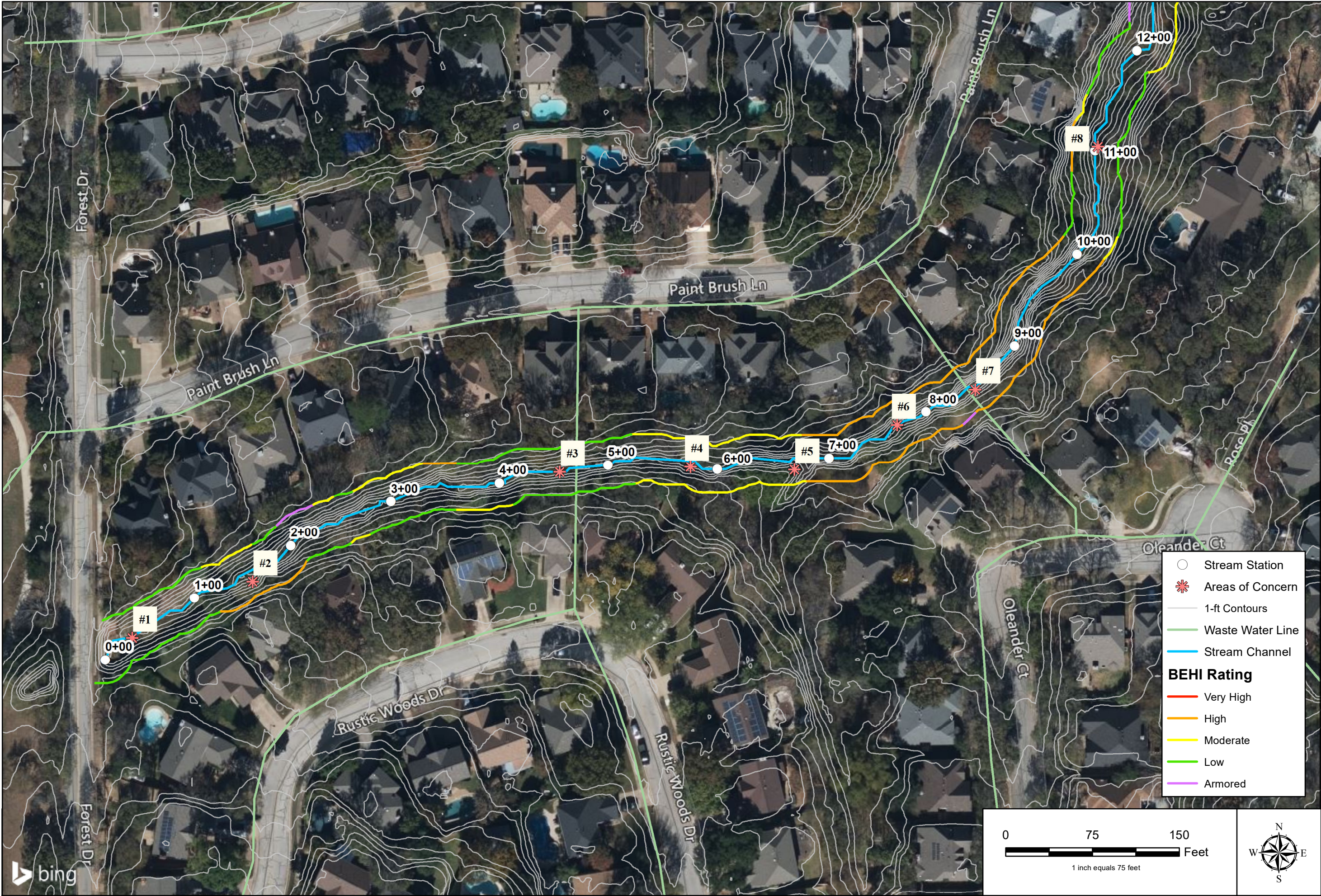
- High level monitoring could be done by photo documenting stream conditions at specific locations at a recurring time interval (e.g., annually). This would provide a qualitative method of documenting on-going channel adjustments.
- Alternatively, general predictions of future stream conditions could be made quantitatively if the location of migrating headcuts were tracked through time. By tracking the migration rate of headcuts, estimating when specific locations will experience downcutting and widening possible.
- A high detail method of stream monitoring could include surveying the stream slope and cross-sections repetitively through time. This would provide a thorough account changes in the stream dimensions and profile. Re-surveying the slope would provide an account of when and how much downcutting and widening occurred at specific locations. Re-surveying cross-sections could also be extrapolated to provide erosion rates at specific locations.

Exhibits

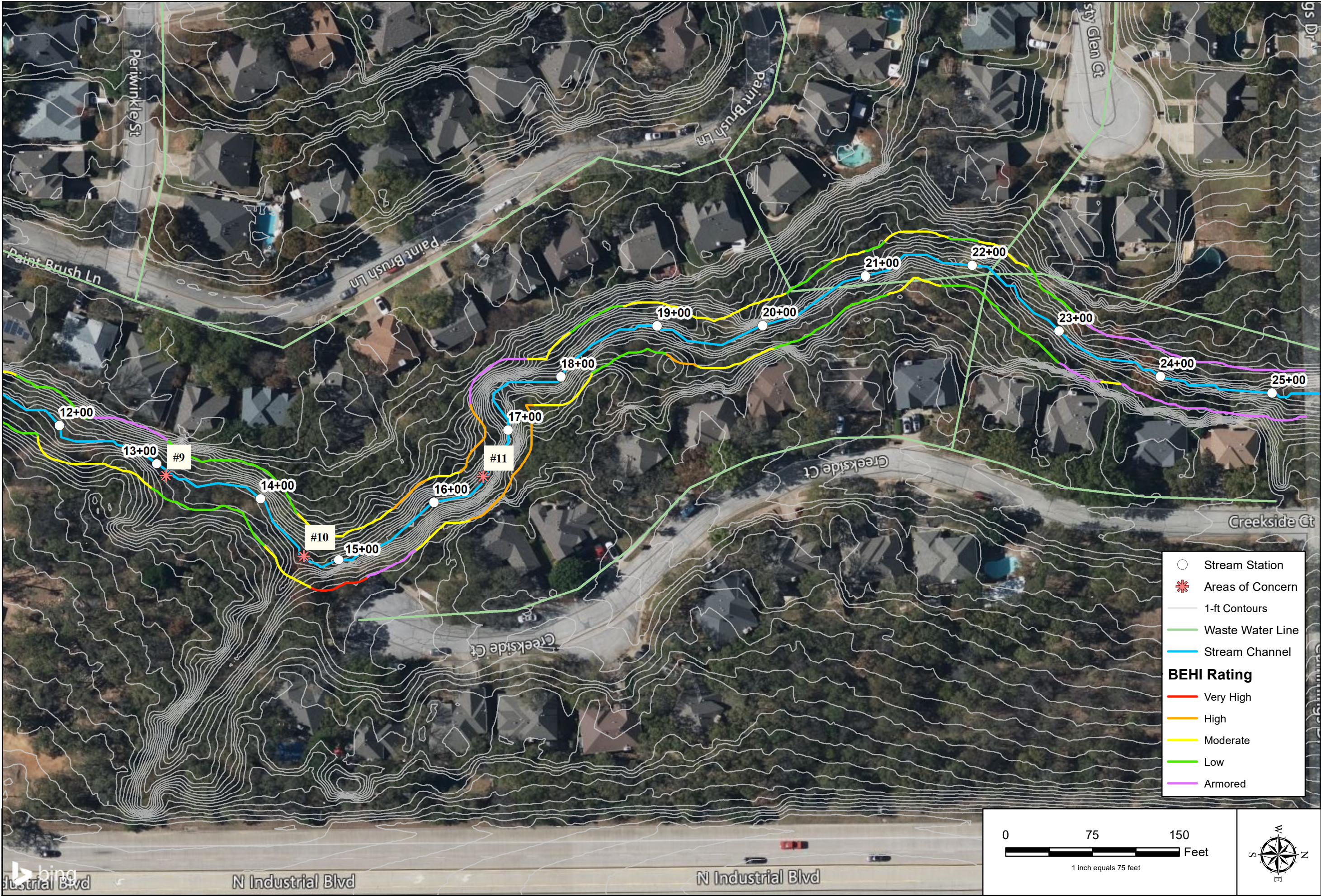


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CITY OF BEDFORD	
Forest Drive Geomorphic Channel Assessment	
Location Map	
FREESE AND NICHOLS, INC. 801 Cherry Street, Suite 2800 Fort Worth, TX 76102 Phone - (817) 735 - 7300	
Exhibit A	
PROJECT NO. BED22319	DATE CREATED 9/9/2022
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet), Texas North Central	
FILE NAME	PREPARED BY
Eq1	SGN



CITY OF BEDFORD		Forest Drive Geomorphic Channel Assessment		BED22319	
Bank Erosion Hazard Index (BEHI) Map		Station 0 - 1200		BOE14.195	
FREESE AND NICHOLS, INC. 801 Cherry Street, Suite 2800 Fort Worth, TX 76102 Phone - (817) 735-7300		DATE CREATED 9/9/2022		DATE CREATED 9/9/2022	
FILE NAME NAD83 State Plane (feet), Texas North Central		DATUM & COORDINATE SYSTEM		DATUM & COORDINATE SYSTEM	
PREPARED BY Eq3		FILE NAME		FILE NAME	
SGN		PREPARED BY		PREPARED BY	



CITY OF BEDFORD	
Forest Drive Geomorphic Channel Assessment	
Bank Erosion Hazard Index (BEHI) Map	
Station 1200 - 2500	
FREESE AND NICHOLS, INC. 801 Cherry Street, Suite 2800 Fort Worth, TX 76102 Phone - (817) 735-7300	
Exhibit B Page 2 of 2	
PROJECT NO. BED22319	DATE CREATED 9/8/2022
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet), Texas North Central	
FILE NAME Fig4	
PREPARED BY SGN	



CITY OF BEDFORD	
Forest Drive Geomorphic Channel Assessment	
Erosion Hazard Zone (EHZ) Map	
Station 0 - 1200	
FREESE AND NICHOLS, INC. 801 Cherry Street, Suite 2800 Fort Worth, TX 76102 Phone - (817) 735-7300	
Exhibit C	
Page 1 of 2	
PROJECT NO. BED22319	DATE CREATED 9/8/2022
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet), Texas North Central	
FILE NAME Fig7	
PREPARED BY SGN	



Stream Station

Areas of Concern

1-ft Contours

Waste Water Line

Stream Channel

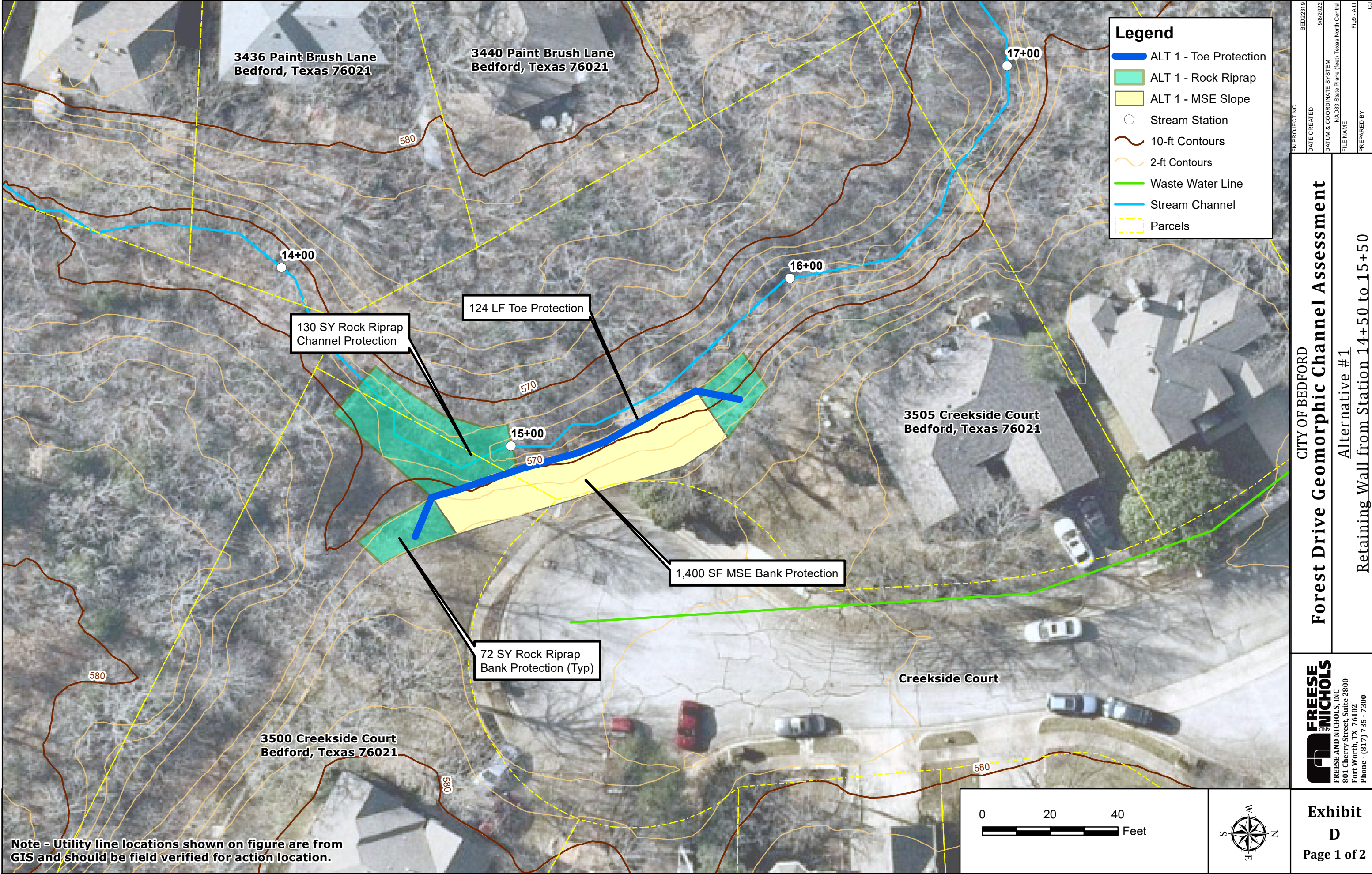
Structure Outlines

EHZ w/ 50ft Minimum Buffer

EHZ w/o Minimum Buffer



CITY OF BEDFORD	
Forest Drive Geomorphic Channel Assessment	
Erosion Hazard Zone (EHZ) Map	
Station 1200 - 2500	
FRESEE AND NICHOLS, INC. 801 Cherry Street, Suite 2800 Fort Worth, TX 76102 Phone - (817) 735-7300	
Exhibit C	
Page 2 of 2	
PROJECT NO. BED22310	DATE CREATED 9/8/2022
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet), Texas North Central	
FILE NAME	PREPARED BY
Eq8	SGN



Legend

ALT 1 - Toe Protection

ALT 1 - Rock Riprap

ALT 1 - MSE Slope

Stream Station

10-ft Contours

2-ft Contours

Waste Water Line

Stream Channel

Parcels

CITY OF BEDFORD	PROJECT NO.	BED22319
	DATE CREATED	9/8/2022
	DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
Forest Drive Geomorphic Channel Assessment	FILE NAME	Fig9 - Alt1
	PREPARED BY	CJ
Alternative #1	Retaining Wall from Station 14+50 to 15+50	
FRESEE & NICHOLS FRESEE AND NICHOLS, INC. 801 Cherry Street, Suite 2800 Fort Worth, TX 76102 Phone - (817) 735-7300	Exhibit D Page 1 of 2	

Exhibit D (Page 2 of 2)
Alternative #1 - Retaining Wall from Station 14+50 to
15+50 - Conceptual Design

Opinion of Probable Construction Cost
City of Bedford



ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE	
BED22319	CJ	KWB	September 8, 2022	
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
CONSTRUCTION				
1 Mobilization (10%)	1	LS	\$ 33,415	\$ 33,415
2 Site Preparation	1	LS	\$ 20,000	\$ 20,000
3 Construction Access	1	LS	\$ 5,000	\$ 5,000
4 Unclassified Channel Excavation	100	CY	\$ 40	\$ 4,000
5 Toe Protection	720	SF	\$ 95	\$ 68,400
6 MSE Wall System	1400	SF	\$ 85	\$ 119,000
7 Soil Anchors	28	EA	\$ 1,500	\$ 42,000
8 Rock Riprap Bank Protection	75	CY	\$ 250	\$ 18,750
9 Rock Riprap Channel Protection	130	CY	\$ 300	\$ 39,000
10 Sidewalk Repair	250	SF	\$ 10	\$ 2,500
11 Stormdrain Reconstruction	1	LS	\$ 10,000	\$ 10,000
12 Pavement Repair	55	SY	\$ 100	\$ 5,500
SUBTOTAL:				\$ 367,565
CONTINGENCY PERCENTAGE:				40% \$ 147,026
PROJECT TOTAL:				\$ 515,000
Notes:				
1. Site Preparation includes haul-road to site location.				
2. Assumes 2 rows of anchors at 10-ft spacing.				
3. MSE includes topsoil, sod, and irrigation.				
4. Stormdrain Reonstruction sssumes replacement of existing curb inlet and headwall into channel.				
5. FNI OPCC classified as an AACE Class 4 Estimate with accuracy range or -30 to + 50.				
6. FNI OPCC does not include costs associated with engineering fees, permits, surveying, etc.				
Disclaimer				
The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs				



Legend

- ALT 2 - Concrete Encasement
- ALT - 2 Rock Riprap
- Stream Station
- 10-ft Contours
- 2-ft Contours
- Waste Water Line
- Stream Channel
- Parcels

CITY OF BEDFORD
Forest Drive Geomorphic Channel Assessment

Alternative #2

Sewer Crossing at Station 8+50

FRESEE & NICHOLS
FRESEE AND NICHOLS, INC.
801 Cherry Street, Suite 2800
Fort Worth, TX 76102
Phone - (817) 735-7300

Exhibit E
Page 1 of 2

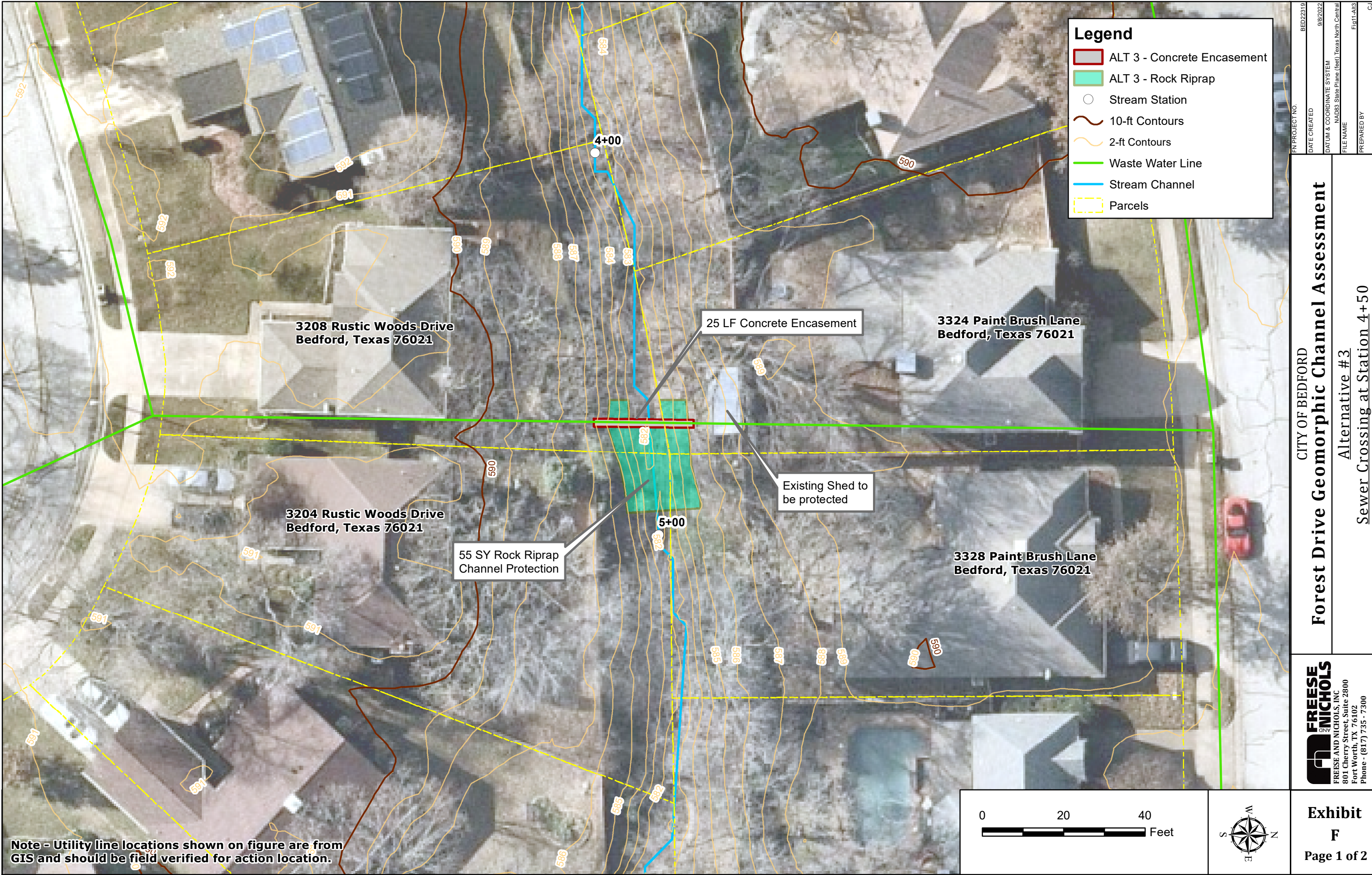
PROJECT NO.	BED22310
DATE CREATED	9/8/2022
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas North Central
FILE NAME	Fig10-AI2
PREPARED BY	CJ

Exhibit E (Page 2 of 2)
Alternative #2 - Sewer Crossing at Station 8+50
Conceptual Design

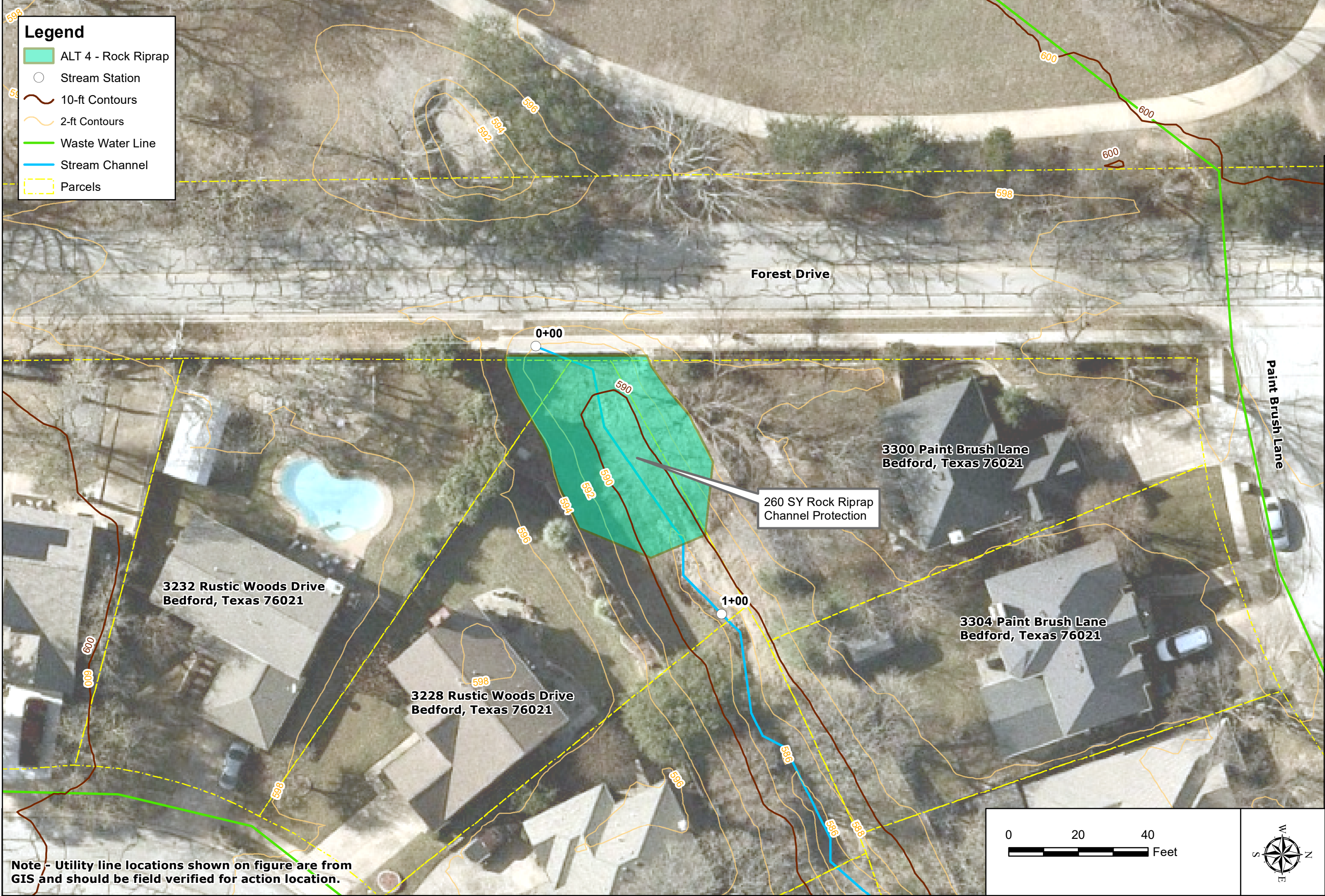
Opinion of Probable Construction Cost
City of Bedford



ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE		
BED22319	CJ	KWB	September 8, 2022		
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL	
CONSTRUCTION					
1 Mobilization (10%)	1	LS	\$ 10,700	\$ 10,700	
2 Site Preparation	1	LS	\$ 10,000	\$ 10,000	
3 Construction Access	1	LS	\$ 20,000	\$ 20,000	
4 Backyard Restoration	2	EA	\$ 10,000	\$ 20,000	
5 Unclassified Channel Excavation	75	CY	\$ 40	\$ 3,000	
6 Rock Riprap Channel Protection	50	CY	\$ 300	\$ 15,000	
7 Concrete Encasement	12	CY	\$ 2,000	\$ 24,000	
8 Vegetation Establishment	1	LS	\$ 15,000	\$ 15,000	
			SUBTOTAL:	\$ 117,700	
CONTINGENCY PERCENTAGE:			40%	\$ 47,080	
			PROJECT TOTAL: \$ 165,000		
Notes:					
1. Site Preparation includes haul-road to site location.					
2. Vegetation Establishment includes channel grading, top soil, sod, vegetation establishment, and general channel clean-up to pre-project condition.					
3. Concrete encasement 25-ft long by 3-ft wide by 3.5-ft deep.					
4. Assumes no replacement of existing 8-in sanitary sewer line					
5. FNI OPCC classified as an AACE Class 4 Estimate with accuracy range or -30 to + 50.					
6. FNI OPCC does not include costs associated with engineering fees, permits, surveying, etc.					
Disclaimer					
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ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE		
BED22319	CJ	KWB	September 8, 2022		
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL	
CONSTRUCTION					
1 Mobilization (10%)	1	LS	\$ 9,920	\$ 9,920	
2 Site Preparation	1	LS	\$ 10,000	\$ 10,000	
3 Construction Access	1	LS	\$ 15,000	\$ 15,000	
4 Backyard Restoration	2	EA	\$ 10,000	\$ 20,000	
5 Unclassified Channel Excavation	80	CY	\$ 40	\$ 3,200	
6 Rock Riprap Channel Protection	50	CY	\$ 300	\$ 15,000	
7 Temporary Construction Access	1	LS	\$ 2,000	\$ 2,000	
8 Concrete Encasement	12	CY	\$ 2,000	\$ 24,000	
9 Vegetation Establishment	1	LS	\$ 10,000	\$ 10,000	
			SUBTOTAL:	\$ 109,120	
CONTINGENCY PERCENTAGE:			40%	\$ 43,648	
			PROJECT TOTAL:	\$ 153,000	
Notes:					
1. Site Preparation includes haul-road to site location.					
2. Vegetation Establishment includes channel grading, top soil, sod, vegetation establishment, and general channel clean-up to pre-project condition.					
3. Concrete encasement 25-ft long by 3-ft wide by 3.5-ft deep.					
4. Assumes no replacement of existing 8-in sanitary sewer line					
5. FNI OPCC classified as an AACE Class 4 Estimate with accuracy range of -30 to + 50.					
6. FNI OPCC does not include costs associated with engineering fees, permits, surveying, etc.					
Disclaimer					
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PROJECT NO. BED22319	CITY OF BEDFORD		
	Forest Drive Geomorphic Channel Assessment		
	Alternative #4		
	Channel Protection at Station 0+00		
DATE CREATED 9/8/2022	DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas North Central		
FILE NAME Fig12-Alt4	PREPARED BY CJ		

Exhibit G (Page 2 of 2)
Alternative #4 - Forest Drive Headwall at Station 0+00

Opinion of Probable Construction Cost
City of Bedford



ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE		
BED22319	CJ	KWB	September 8, 2022		
ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL	
CONSTRUCTION					
1 Mobilization (10%)	1	LS	\$ 15,540	\$ 15,540	
2 Site Preparation	1	LS	\$ 10,000	\$ 10,000	
3 Construction Access	1	LS	\$ 5,000	\$ 5,000	
4 Traffic Control	1	LS	\$ 15,000	\$ 15,000	
5 Backyard Restoration	1	EA	\$ 10,000	\$ 10,000	
6 Unclassified Channel Excavation	310	CY	\$ 40	\$ 12,400	
7 Rock Riprap Channel Protection	310	CY	\$ 300	\$ 93,000	
8 Vegetation Establishment	1	LS	\$ 10,000	\$ 10,000	
			SUBTOTAL:	\$ 170,940	
			CONTINGENCY PERCENTAGE:	40%	\$ 68,376
			PROJECT TOTAL:	\$ 240,000	
Notes:					
1. Site Preparation includes haul-road to site location.					
2. Vegetation Establishment includes channel grading, top soil, sod, vegetation establishment, and general channel clean-up to pre-project condition.					
3. Concrete encasement 25-ft long by 3-ft wide by 3.5-ft deep.					
4. Assumes no replacement of existing 8-in sanitary sewer line					
5. FNI OPCC classified as an AACE Class 4 Estimate with accuracy range or -30 to + 50.					
6. FNI OPCC does not include costs associated with engineering fees, permits, surveying, etc.					
Disclaimer					
The Engineer has no control over the cost of labor, materials, equipment, or over the Contractor's methods of determining prices or over competitive bidding or market conditions. Opinions of probable costs provided herein are based on the information known to Engineer at this time and represent only the Engineer's judgment as a design professional familiar with the construction industry. The Engineer cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from its opinions of probable costs					

Appendix A

Photo Walkthrough of Study Area

Appendix A – Study Area Photo Walkthrough



Upstream of Station 0+00 - Looking downstream at the Forest Drive culvert above the study area.



Station 0+00 -Looking downstream from Forest Drive.

Appendix A – Study Area Photo Walkthrough



Station 1+00 - Looking upstream the beginning stages of downcutting and headcut migration can be observed. This photo shows **Area of Concern #1**.



Station 3+25 - Looking at left bank, this photo shows representative conditions, including isolated bank erosion near home backyards. This photo illustrates the concern with **Area of Concern #2**.

Appendix A – Study Area Photo Walkthrough



Station 4+50 - Looking upstream, this photo shows the exposed sewer line at this location and illustrates the concern with **Area of Concern #3**.



Station 5+75 - Looking upstream at the right stream bank, this photo shows the condition of the stormwater outfall and the beginning stages of downcutting at scour (**Area of Concern #4**).

Appendix A – Study Area Photo Walkthrough



Station 6+00 - Looking upstream, this photo shows a representative example of a headcut propagating upstream.



Station 7+00 - Looking downstream, this photo shows representative conditions and bank erosion into home backyards
(Area of Concern #5)

Appendix A – Study Area Photo Walkthrough



Station 7+75 - Looking at the stormwater outfall on the right stream bank, this photo shows scour beneath this structure (**Area of Concern #6**). Bank scour of similar magnitude is occurring on opposite bank.



Station 8+50 - Looking upstream at the location of an exposed sewer line (**Area of Concern #7**). This photo shows how the sewer line is holding the grade of the stream.

Appendix A – Study Area Photo Walkthrough



Station 8+50 - Looking downstream from the exposed sewer line showing the scour and bank erosion adjacent to **Area of Concern #7**.



Station 9+00 - Looking downstream, this photo shows the representative conditions of the channel between station 6+00 and 10+00, also showing the concerns with **Area of Concern #5**

Appendix A – Study Area Photo Walkthrough



Station 10+75 - Looking upstream, this photo shows a headcut that is propagating upstream, and landowner attempts to prevent erosion impacts into back yards (**Area of Concern #8**).



Station 11+25 - Looking at the left stream bank, this photo shows the bank erosion below the headcut and impacts to a nearby property (**Area of Concern #8**).

Appendix A – Study Area Photo Walkthrough



Station 11+75 - Looking downstream, this photo shows representative conditions of the stream channel in this area.



Station 13+00 - Looking at the left stream bank, this photo shows the condition of a stormwater outfall
(Area of Concern #9).

Appendix A – Study Area Photo Walkthrough



Station 13+75 - Looking upstream, this photo shows the representative conditions of the stream in this area.



Station 14+50 - Looking upstream, this photo shows an approximately 3-foot head cut that may be migrating upstream into a stable section of channel (**Area of Concern #10**).

Appendix A – Study Area Photo Walkthrough



Station 14+90 - Looking at right bank, this photo shows the bank undercutting immediately upstream of the grouted rip rap protection of Creekside Ct (**Area of Concern #10**).



Station 15+15 - Looking downstream, this photo shows the undercutting below bank protection measures at this location (**Area of Concern #10**).

Appendix A – Study Area Photo Walkthrough



Station 16+25 - Looking downstream, this photo shows representative conditions of the channel in this area. Bank erosion may impact the backyards of homes (**Area of Concern #11**).



Station 17+50 - Looking upstream, this photo shows the failing bag wall and railroad tie wall behind a home (**Area of Concern #12**)

Appendix A – Study Area Photo Walkthrough



Station 18+75 - Looking downstream, this photo shows the representative stream conditions.

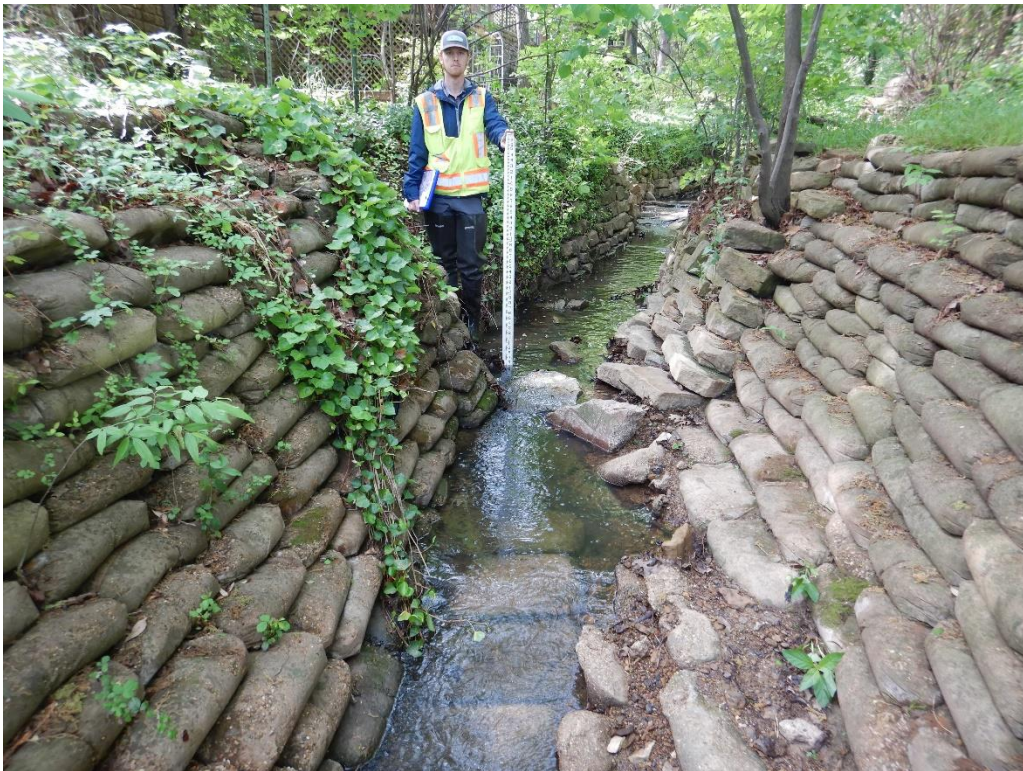


Station 20+75 - Looking upstream, this photo shows the representative stream conditions.

Appendix A – Study Area Photo Walkthrough



Station 22+00 - Looking upstream, this photo shows the representative stream conditions.



Station 24+00 - Looking upstream, this photo shows the homeowner constructed bank protection measures, at the end of the study area.

Appendix A – Study Area Photo Walkthrough



Downstream of Station 25+00 - Looking upstream at Cummings Drive from below the study area.



Downstream of Station 25+00 - Looking downstream from Cummings Drive at the concrete lined channel below the study area.

Appendix B

Geomorphic Stream Data

Appendix B. General Stream Metrics for the Unnamed Tributary of Little Bear Creek between Forest Drive (Station 0+00) and Cummings Drive (Station 25+00)

Drainage Area (sq mi)	0.25
Stream Order	1
Stream Classification	Intermittent
Sinuosity	1.13
Stream Slope (Station 0+00 – Station 14+50)	0.015
Stream Slope (Station 14+50 – Station 25+00)	0.009
Rosgen Stream Types	G6, C6, F6
Typical Bank Height (ft)	4- 12
Typical Bank Angle (degrees)	45 – 80
Typical Channel Top Width (ft)	8 – 16
Entrenchment Ratio Range	1.2 (Entrenched) – 1.9 (Moderately Entrenched)
Average Max Bankfull Depth (ft)	1.2
Average Mean Bankfull Depth (ft)	0.7
Average Bankfull Area (sq ft)	5.2
Width/Depth Ratio Range	9.5 (Low) - >12 (High)

Appendix C

Longitudinal Profile of the Stream

Longitudinal Profile

