Grantham & Associates, Inc.

1919 S. Shiloh Rd., Suite 310, LB 8, Garland, TX 75042

MEMO

Date: May 12, 2005 **G&A No:** 334

To: Mr. Eduardo Ugarte – DART

Cc: Mr. Steve Chutchian – Town of Addison
Mr. Mike Tucker – Explorer
Mr. Michael Floyd – Explorer

From: Bruce Grantham, P.E.

Re: Lindbergh Drive Drainage Channel
Comparison of Watershed Conditions between 1990 and 2004

At the March 1, 2005 meeting, which included representatives from DART, Explorer, and the Town of Addison, DART raised a concern that development at or adjacent to the Addison Airport, subsequent to DART's purchase of the adjacent railroad in 1990, may have increased storm water runoff rates in the railroad ditch.

In order to investigate the level of development at the airport between 1990 and today, we acquired aerial photographs of the site from February 1990 (see Exhibit 1) and 2004 (see Exhibit 2). A comparison between these aerials revealed only minor changes in the amount of impervious surface on the airport. For example, impervious surfaces were replaced with grass when the Keller Springs Tunnel was constructed.

The aerials also show that Lindbergh Drive was constructed in its current location prior to DART's railroad purchase. The existing culverts under Lindbergh are undersized relative to Town of Addison standards, consequently, they result in the detention of stormwater on the Airport.

We respectfully request your consideration of the following two matters:

1. Does the information presented in this memo provide sufficient evidence to alleviate your concern that the Addison Airport development has increased stormwater runoff rates in the railroad ditch subsequent to DART's purchase of the railroad in 1990?

2. Can the proposed channel improvements prepared by our firm for Addison be considered by DART on their own merits, separate from the matter of historical upstream development?

Please contact me if you have any questions.

Regards,

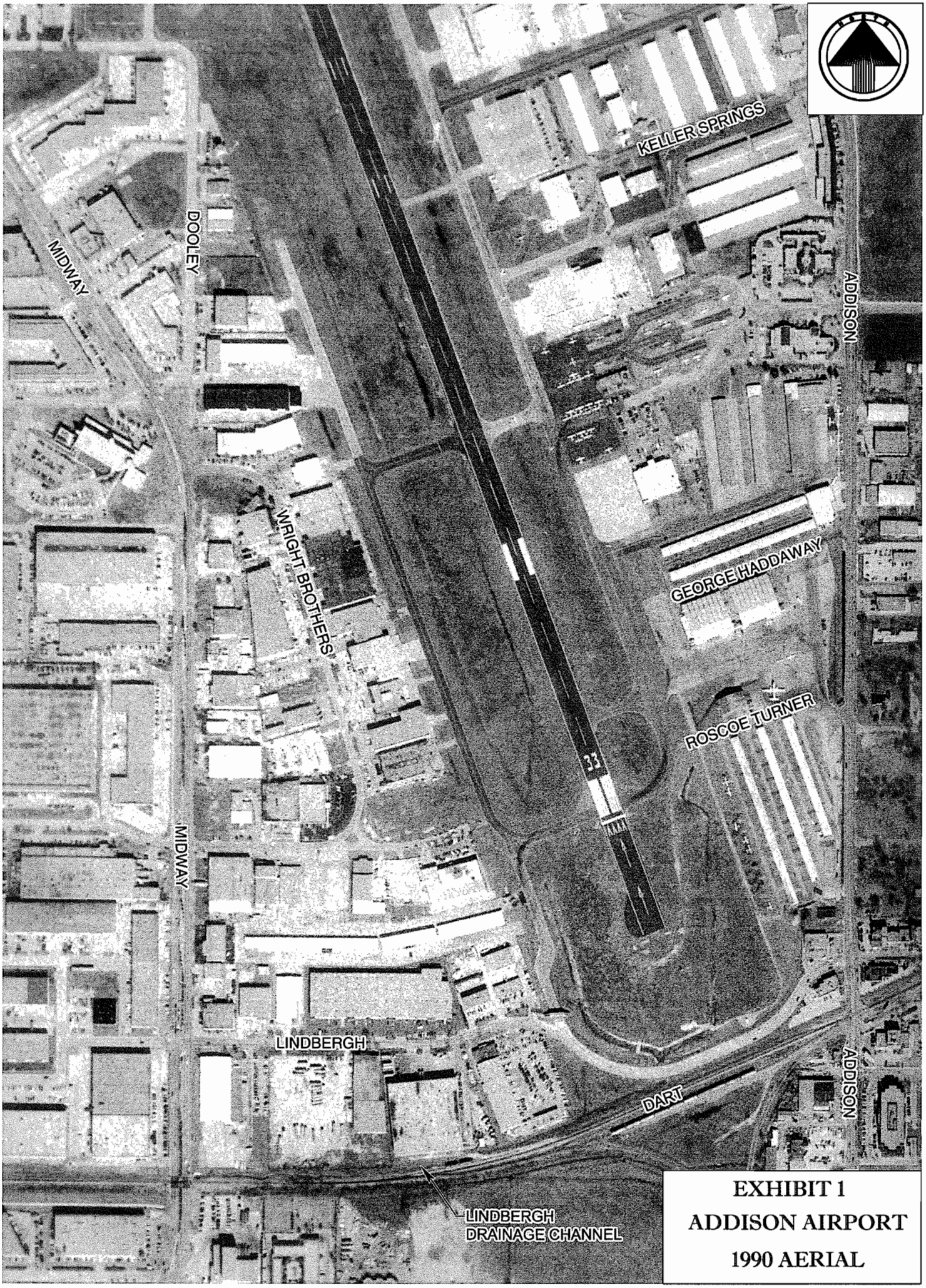

EXHIBIT 1
ADDISON AIRPORT
1990 AERIAL

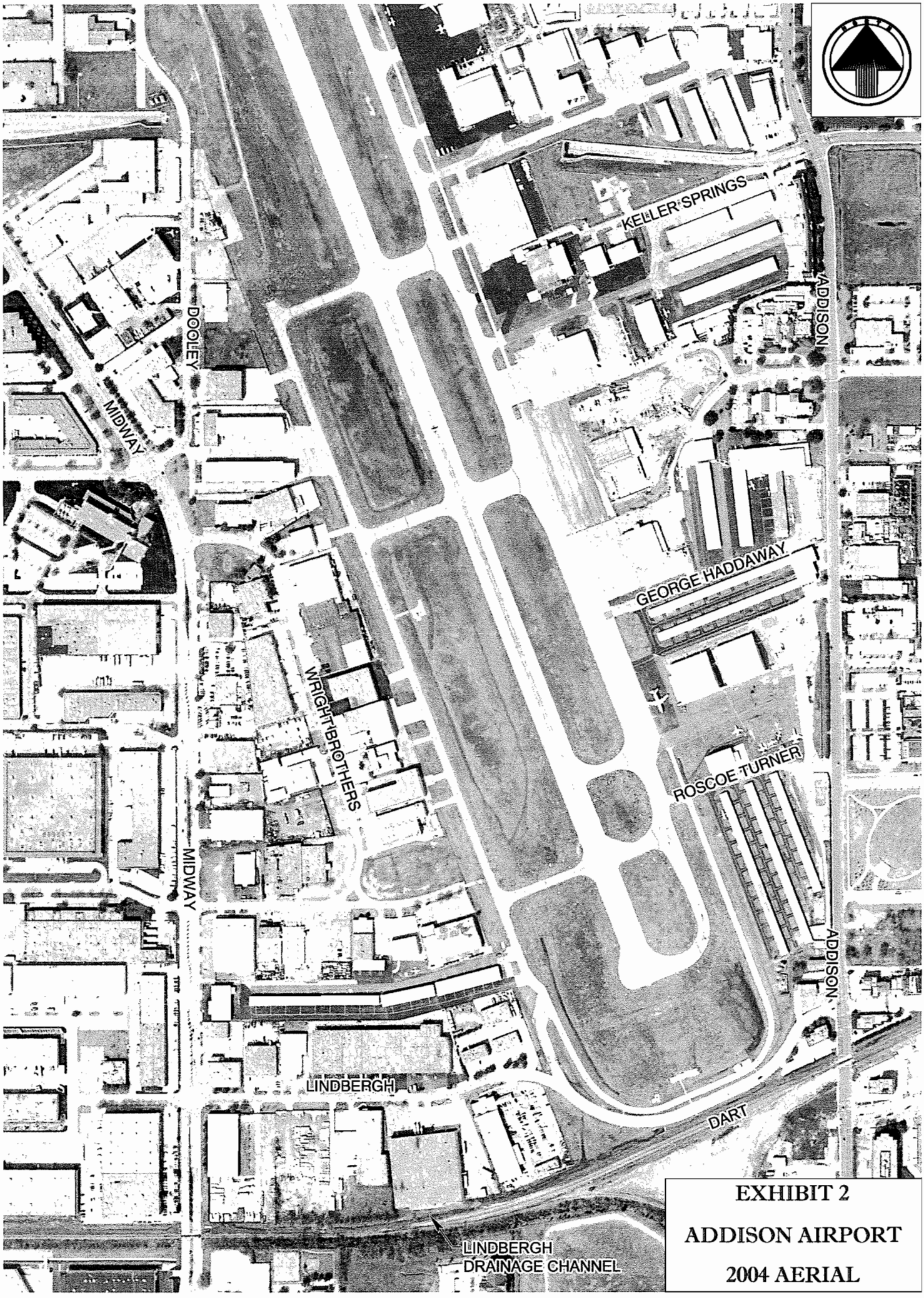

EXHIBIT 2

ADDISON AIRPORT

2004 AERIAL

DART Notes
Lindbergh Drainage Channel

DART Comments:

- Considers this project only beneficial for erosion control around their facilities
- Grantham & Associates drainage report is not complete and doesn't take the affect of Airport stormwater into account.
- This project, as designed, will prevent DART from building future parallel line and changes water levels in this area.
- Not very receptive to doing a "maintenance" project in lieu of a permanent fix for future rail construction.
- Wants stormwater detained with detention ponds on Airport property.
- Considers water entering channel area at a higher rate than is acceptable.
- DART parallel line is 15-20 years out.
- DART prefers the project to be expanded to provide long term channel improvements that will not be torn out later and that addresses Airport water issue.
- Considers previous Airport improvements to have directed excessive stormwater to DART right-of-way, despite their written protests over many years.
- DART doesn't want the Town to construct a "band-aid" repair project, when the issue of excessive water from the Airport still exists.

Grantham & Associates, Inc. Comments:

- Stated that water conditions existed prior to DART purchasing their right-of-way. DART representatives disagreed with this.
- In order to meet DART's needs to contain additional water volume and lower water elevations, and much larger project in scope and cost is required, and is far beyond the limits of this project's intention.

Summary:

- Explorer Pipeline said that if DART is building their new line to the north of the existing track, then Explorer may have to relocate their line in 15-20 years and do not want to spend their $90,000 participation at this time.
- Explorer will field check their line to see if it is out of compliance in terms of adequate cover.
- DART will create a proposed cross-section that includes the location of the future parallel line and will include the existing Explorer line.
- Grantham will re-study their drainage calculations.
- Town stated that we are willing at this time to participate with Explorer to protect their pipeline and two of the Town's existing property owners that are experiencing flooding.
- Town echoed the statement that the Airport stormwater issue is beyond the scope of this project and should be considered subsequently to the preparation of a future Airport Drainage Master Plan.
- All parties agreed to meet again to discuss the project in about two weeks.

PREPARED BY THE ACT21 TEAM FOR THE

DART **DALLAS AREA RAPID TRANSIT SYSTEM**

COTTON BELT

Town of Addison
Lindbergh Channel Drainage
28 March 2005

LETTER REPORT

Doc. No. _____

ACT21
General Engineering Consultants
A Joint Venture of
Carter & Burgess, Jacobs, STV Incorporated and KAI Alliance

Table of Contents

1.0 INTRODUCTION

The Lindbergh Channel is a natural drainage ditch on the north side of the Cotton Belt tracks between Addison and Midway Roads. This ditch is located on DART right-of way for its entire length in this area. Flooding of areas adjacent to the Lindbergh Channel were first reported by the Town of Addison in 1998.
The Town of Addison has proposed the installation of a lined channel which does not meet DART Design Requirements for storm drainage next to the tracks.

2.0 Existing Site Summary

The discharge of storm water runoff from the airport and developments next to this channel have increased the amount of storm water runoff into this natural ditch. Development along this area has effectively reduced the width of the natural drainage channel. The current channel dimensions will not convey a 100year flood event in accordance with DART Design Criteria for the railroad track-way. The Town of Addison has noted flooding of areas adjacent to the ditch.

3.0 Project Design Criteria and Evaluation

Under Vol. 1 Chapter 7, Section 7.6 – Channels of the current DART Design Criteria Status:

> "Freeboard for roadbed ditches shall be the maximum of either 1.0 feet from the shoulder of a road without curb and gutter, or 1.0 feet from top of curb, and 1.0 foot from the bottom of the track-way sub-ballast for the 100-year frequency storm."

This track-way will eventually be used for DART Commuter Rail or Light Rail Transit operation. If the quantity of storm water runoff is not reduced, the rail tracks will need to be elevated several feet to meet the design requirements for a 100 year flood event next to the tracks. This increase of track-way elevation will require an increase in the top of rail elevation, which will result in raising the Midway Road crossing and any other grade crossing on either side of this location for several hundred feet.

4.0 License Agreements

No license agreements were found which would allow the airport or any of the developed areas to discharge their increased storm water runoff directly onto the track-way. The Town of Addison has proposed in their letter dated February 16, 2000 (See Appendix) to

direct the flow from the airport area into their proposed storm drain system under the Arapaho Road extension, which will reduce the flow into the Lindbergh Channel significantly.

5.0 Conclusion

The major cause of impacts (erosion & flooding) to the existing ditch in DART Right-of - Way is the flow generated from Addison Airport area passing through the existing culverts (4- elliptical RCP) under Lindbergh Drive.

It appears the proposed channel improvements will not lower the water surface in the channel significantly within the project limits. (Between Lindbergh Avenue and Midway Road)

The top of rail elevation of any future Commuter Rail/ LRT tracks along this DART Right-of Way will have to be raised three to four feet to meet the current DART Design Criteria. (The Design Criteria requires that the 100 year flood elevation to be a minimum of four feet below the top of rail which will provide a minimum free board of one foot below the sub-ballast level)

Rerouting or detaining the runoff from the airport will allow for a Lindbergh Channel design in accordance with the DART design requirements, without elevating the tracks.

6.0 Recommendations

We recommend the runoff from the airport be routed to an alternate storm drainage facility or detained in a means, which will not exceed the ability of the Lindbergh Channel to convey this water in accordance with the 100 year flood event design criteria for the track-way.

The money earmarked for this channel ($250,000) would probably alleviate the flooding issues if it were spent in controlling the source of the flooding upstream of Lindbergh Avenue by means of a retention facility in the Airport boundaries.

Further, we recommend DART consider an indemnification agreement from the Town of Addison to protect DART from any present or future flooding liabilities if the storm drainage is not rerouted or detained, as all the improvements are within DART ROW and will be perceived by the general public as a DART Project. Also, we recommend DART require the Town of Addison to waive the requirements for any future DART drainage improvements to accommodate offsite drainage according to present or future Town of Addison drainage criteria.

APPENDIX

DALLAS AREA RAPID TRANSIT
RECEIVED

FEB 1 8 2000

COMMUTER RAIL &
RAILROAD MANAGEMENT

ADDISON

PUBLIC WORKS DEPARTMENT

Post Office Box 9010 Addison, Texas 75001-9010 (972) 450-2871

16801 Westgrove

February 16, 2000

Ms. Jan Seidner
Right-Of-Way Management Representative
Dallas Area Rapid Transit
P.O. Box 660163
1401 Pacific Avenue
Dallas, Texas 75266-7230

Copy to Rick Brown
Dennis Henning

Re: Lindbergh Drainage Improvements

Dear Jan:

Thank you for your continued support on this project. We appreciate the opportunity to meet with you last week to work through DART's concerns about the referenced drainage improvements.

Based on our meeting, the Town of Addison agrees to modify the existing plans for the referenced project and address future concerns. Our recent bond election approved the extension of Arapaho Road from Addison Road to Marsh Lane. The extension of Arapaho Road will include a storm sewer system that will intercept runoff from the airport and development south of the DART right-of-way. The Town of Addison will allow DART to review these plans, and address the impact to your right-of-way.

Per your request, the construction plans have been modified to address compaction of fill material placed on the project, this material will be compacted to 95% proctor density and tested by Terra-Mar, Inc. at the Town's expense. The Town of Addison also plans to independently contract a company to place 2 rock berms in the flowline of the drainage channel and have the disturbed areas in question hydro-mulched.

These modifications should address the concerns of DART staff. As we discussed, we have selected TRI-DAL to perform these improvements for $14,995. It is my understanding that TRI-DAL has worked on DART projects in the past and meets all of your insurance requirements. As soon as we receive acceptance from DART, the work will begin. Please call me at 972-450-2878 if you have any questions or need additional information.

Sincerely,

Michael E. Murphy, P.E.
Interim Director of Public Works

cc: Jeff Markiewicz
Chris Terry
Ron Whitehead

MM/JM/mdh

Dallas Area Rapid Transit
P.O. Box 660163
Dallas, Texas 75266-0163
DART
214 749-3278

January 8, 1999

Mr. John Baumgartner, P.E.
Director of Public Works
Town of Addison
P. O. Box 144
Addison, Texas 75001

Re: Neil Gayden's letter of October 2, 1998

Dear Mr. Baumgartner:

Upon inspection of the DART-owned railroad right of way between Midway Road and the "wye" property retained by Union Pacific Railroad, it is our opinion that we, too, are victims of increased flows and hydraulic inefficiency due to developments adjacent to the railroad right of way. Addressing both sides of the right of way, the ditches within the railroad corridor are capable of handling the natural sheet flow from the adjacent properties. The maps reflect that prior to development these properties drained toward the railroad corridor. However, the ditches are not designed to accommodate the increased and concentrated drainage discharged by the adjacent developments and the Town's street and airport improvement projects.

We have no record of agreements from the St. Louis Southwestern Railway or DART to the Town of Addison providing permission for these increased flows from the developments' parking lots and various types of outfalls, or for handling storm water drainage and upstream runoff from the airport. If you have evidence of such review and permission by the railroad, please provide this to us.

DART's contractor will remove the railroad ties and any other loose debris which impedes the flow of the stream on the south side of the tracks. It is our opinion the vegetation holds the embankment and prevents further erosion toward the track bed.

It is our opinion that the Town of Addison is responsible for bettering the drainage on the north and the south sides of the main line track to prevent further damage to the railroad right of way and the adjacent properties. I enclose two (2) reports from engineers, Frank Mennis and Dennis Henning. Please review this documentation. If a meeting or a site visit is in order, please contact Jan Scribner at [illegible].

Sincerely,

Lonnie E. Blaydes, Jr.
Vice President
Commuter Rail & Railroad Management

c: Rick Brown
Neil Gayden
Dennis Henning
Frank Mennis

ADDISON
ENVIRONMENTAL SERVICES
16801 Westgrove Drive
(972) 450-2881 Fax (972) 450-2837
Post Office Box 144 Addison, Texas 75001

October 2, 1998

Certified Mail No. 471-492-876

Mr. Lonnie Blaydes, Jr.
Vice President
Commuter Rail & Railroad Management
Dallas Area Rapid Transit
P.O. Box 660163
Dallas, Texas 75266-7210

DALLAS AREA RAPID TRANSIT
RECEIVED
OCT 07 1998
COMMUTER RAIL &
RAILROAD MANAGEMENT

Dear Mr. Blaydes:

During the rainstorm on October 2, 1998 we received a number of complaints regarding the conveyance of storm water along the Cotton Belt railroad right-of-way in Addison. These complaints included reports of private property damage due to storm water that must flow west along the right-of-way. Of particular concern is the area between the railroad yard just west of Addison Road and Midway Road. I had our Public Works Director John Baumgartner evaluate the complaints and his observations were as follows:

1. On the northside of the railroad there is evidence of high vegetation and some siltation in the drainage way that may have contributed to the high water complaints.
2. On the south side of the railroad the drainage way is choked with willows and cottonwoods in addition to a large number of railroad ties lodged between trees. These items coupled with the sedimentation appear to degrade the hydraulic efficiency of the waterway.

In accordance with the Town of Addison Ordinance No. 10-24 we respectfully request that DART take action to correct the maintenance issues associated with the railroad right-of-way between Addison Road and Midway Road.

Please contact me so I can let the affected property owners know your schedule and plans for corrective action. Thank you in advance for your prompt attention regarding this issue.

Sincerely,

Neil Gayden

Attachments: Ordinance No. 10-24

cc: John Baumgartner, Director of Public Works, Town of Addison
Roger Snoble, President/Executive Director, DART
Ron Whitehead, City Manager, Town of Addison

Dallas Area Rapid Transit
P.O. Box 660163
Dallas, Texas 75266-0163
214-749-3278

DART

February 19, 1999

ADDISON OFFICE
1 MAR 05 AM 8:50
RECEIVED

Mr. John Baumgartner, P.E.
Director of Public Works
Town of Addison
P. O. Box 144
Addison, Texas 75001

Re: Drainage between Midway Road and Addison Road in Addison

Dear John:

Pursuant to our meeting Friday, January 29, 1999, it remains our position that the silting and ponding of water on the railroad right of way is a direct result of the increased flows from adjacent properties channeled to the railroad corridor without provision for the downstream. The ditches within the railroad right of way were designed to accommodate the natural sheet flow drainage onto the right of way.

DART and the operating railroad(s) have made no changes in the right of way to cause the drainage problems that exist today, therefore, DART nor the railroad will assume any liability or responsibility to modify the right of way to accommodate the concentrated, increased flows from the adjacent developments. However, if the Town of Addison desires to design, engineer and contract for improvements to grade the right of way, we will offer suggestions and recommendations in our review of the plans.

As mentioned in our meeting, Dallas, Garland and Northeastern Railroad has taken over freight operations within the right of way and has contractually assumed maintenance responsibility. We will apprise their management and maintenance of way crews of the drainage issues in this area so that they can keep the right of way mowed and free of debris collecting in the ditches.

Frank Mercer and Dennis Fleming offer a suggestion that the Town of Addison and W. O. Bankston investigate a detention pond within the Town's right of way immediately adjacent to the WOB property and Lindberg with outfall into DART railroad right of way maintaining a maximum eight (8) cfs.

In order that we may properly manage and preserve this corridor for continued freight and potential transit use, we would appreciate opportunity to review development plans in the future as they impact the railroad right-of-way. Please contact me at (214) 749-2917 as problems arise.

Sincerely,

Jan Seidner
Manager, Railroad Facilities
Commuter Rail & Railroad Management

JMS:

c: Lonnie Blaydes
Richard Brown
David Eyermann, DGNO
Paul Jones
Frank Menair

Steve Chutchian

From: Bruce Grantham [bgrantham@gra-ce.net]
Sent: Monday, January 03, 2005 3:32 PM
To: Jim Pierce
Cc: Steve Chutchian; Mike Murphy; Katura Curry; Mike Tucker
Subject: RE: Lindbergh Drainage

Jim:
To bring you up to date, I spoke with Mike Tucker last week. Mike confirmed Explorer's position regarding this project; that is they will contribute around $70k to the channel improvements. This is the bid amount they received from a contractor to lower their line, which is the alternative they have to participating in channel improvements. Mike said he would e-mail me the exact $ amount which I have not received yet. However, he is not at liberty to increase their participation amount.

Katura is back today from her holiday time off and we will visit regarding a submittal of the drainage report to DART. I would anticipate it could be this week subject to your okay on the items below.

Given Explorer's position, your input on the following would be appreciated:
1. Do not still want me to schedule a joint meeting with Mike and, if so, what should I tell him is the purpose?
2. Do you have our latest Opinion of Probable Cost for the concrete-lined channel plans we have prepared?
3. Do you want to confirm that the Town can fund this project as designed, and with $70k from Explorer, prior to our submittal of the drainage report to DART? The hickup here could be getting DART approval on the report and a set of plans which would change if a less expensive channel project if needed.

I am available Wednesday morning, Thursday afternoon, and all day Friday to meet this week.

Regards, Bruce

> -----Original Message-----
> **From:** "Jim Pierce" <jpierce@ci.addison.tx.us>
> **Sent:** 1/3/2005 1:32 PM
> **To:** "bgrantham@gra-ce.net"
> **Cc:** "Mike Murphy" ; "Steve Chutchian"
> **Subject:** Re: Lindbergh Drainage
>
> Bruce: I would like to get in our "Technical" meeting with DART before you leave. Jim.
>
> Jim Pierce, P.E.
> Assistant Public Works Director
> P.O. Box 9010
> Addison, TX 75001-9010
> 972-450-2879
>
> > -----Original Message-----
> > **From:** Bruce Grantham [mailto:bgrantham@gra-ce.net]
> > **Sent:** Thursday, December 30, 2004 8:19 AM
> > **To:** Mike Murphy; Jim Pierce; Steve Chutchian; John Baumgartner; Chris Flanigan; Aaron Russell; Walter Shumac; John Baker; Robert Wunderlich; Donna Manhart; Michael Polocek; Tom Johnson; Mr. Daniel Tracy
> > **Cc:** Katura Curry; Molly Pierson; Matt Kirk; Barry Williams

Subject: G&A Staff News

Please note that I am going to be out of the office for two weeks beginning Monday, January, 10. I will return to the office on Monday, January 24.

During my absence, Katura Curry, P.E., and Molly Pierson, P.E., will be the primary contacts on engineering projects. Matt Kirk, R.P.L.S., will be the primary contact on survey projects.

I will be in the office all next week if you anticipate needing to visit with me directly during the first part of January. Upon my return, I hope to have the opportunity to introduce you to Barry Williams who has recently joined our firm as the Business Director. Barry is a key addition to our staff here at G&A.

Regards,
Bruce Grantham

Dallas Area Rapid Transit
P.O. Box 660163
1401 Pacific Avenue
Dallas, Texas 75266-7213

Doug Allen
Executive Vice President
Program Development

(214) 749-2750
(214) 749-3662 Fax
allen@dart.org

CONTACT: KATHY WATERS
214 749 3208

KEY GUY

Dallas Area Rapid Transit
P.O. Box 660163
1401 Pacific Avenue
Dallas, Texas 75266–7206

John E. Haenftling
Assistant Vice President
Technical Services

(214) 749–2810
(214) 749–3320 Fax
haenftli@dart.org

PHONE CALL

FOR S.C. DATE 11/17 TIME 2:40 A.M. P.M.

M GRANTHAM

OF Bruce

PHONE ☐ FAX ☐ MOBILE

AREA CODE NUMBER EXTENSION

MESSAGE 972-864 2388

☑ PHONED
☑ RETURNED YOUR CALL
☑ PLEASE CALL
☐ WILL CALL AGAIN
☐ CAME TO SEE YOU
☐ WANTS TO SEE YOU

SIGNED S

SECOND NATURE™ RECYCLED TOPS FORM 74620

From: Steve Chutchian
Sent: Wednesday, October 15, 2003 3:09 PM
To: Mike Murphy
Cc: Jim Pierce
Subject: Lindbergh Channel Improvements

LINDBERGH CHANNEL IMPROVEMENTS

- Our Engineer and Public Works staff have met on several occasions with the DART Engineering Department, in an attempt to obtain approval to perform the proposed improvements.
- Unfortunately, we have been unable to satisfy their engineering staff, due to existing physical restrictions in the field. Specifically, we are unable to meet the 100 year flood design and include their required 1 ft. of free board.
- Our only alternative consists of terminating this project, and leaving Explorer Pipeline and the Town's adjacent properties in a precarious situation.
- The Town recently submitted the design for a concrete lined channel to DART. This design provided for protection of the existing shallow Explorer pipeline system within the DART easement and elimination of flooding to adjacent commercial properties.
- The existing condition, as it is today, is an unimproved tributary, with extensive vegetation and other growth.
- Properties to the north of this easement are subject to frequent flooding during minor wet weather events.
- The design submitted is monumental improvement over existing conditions, and meets the Town's requirement of providing for the 100 year storm occurrence.
- However, the design does not allow for a DART mandated 1 ft. free board, which is an increased height of channel above the depth required to meet the 100 year storm event.
- In addition, this project will greatly benefit and protect the existing DART rail line.
- This is a request that DART grant a variance to allow this project to move forward and permit the Town to meet all storm drainage criteria, except the 1 ft. free board.
- The conditions that exist today, versus the proposed channel improvements will be extraordinary. All parties involved will experience a substantial benefit.

STEVE,
I'll MEET YOU @ TOWN HALL

Mike

FKT

MEMO

Grantham & Associates, Inc.
1919 S. Shiloh Rd., Suite 310, LB 8, Garland, TX 75042

Date: October 15, 2003 **G&A No. 334**

To: Steve Chutchian, P.E., Town of Addison
cc: Mike Tucker, Explorer Pipeline

From: Katura Curry, P.E.

Re: Lindbergh Drive Drainage Channel Project
History and Current Status

Pursuant to the request we received from you and Mike Tucker at our previous meeting on the Lindbergh Drive channel, which extends from Lindbergh Drive to Midway Road parallel to the existing DART railroad tracks, we have prepared this memo regarding the current project status. In addition, we have outlined the channel benefits, the next steps and a project history as we understand it.

Executive Summary

This project has been a moving target. When we entered into a design contract with the Town in 2002, Explorer had previously furnished a verbal estimate of approximately $130,000, which their contractor had provided, for the construction of a concrete block pilot channel. At this time, with Explorer offering to contribute $100,000 and the Town appropriating about $50,000, this appeared to be a financially viable project.

During the design of this project, several factors arose which, in combination, now call into question this project's financial viability. These factors are summarized below:

- When G&A was asked by the Town to extend the limits of the concrete blocks beyond a pilot channel to convey a 100-year storm event without freeboard, and to maintain a minimum longitudinal slope of 0.5%, we focused on the engineering viability of these parameters prior to evaluating their impact on the project cost.
- In finding a way to meet these additional design parameters we redesigned the project which increased the construction cost significantly.
- When DART's staff attended a project meeting at the Town earlier this year, they reiterated their desire to expand the limits of the concrete blocks even further to provide freeboard within the lined portion of the channel, although they did indicate a willingness to reconsider the freeboard requirement.
- As a result of the DART meeting, Mike Tucker decided to determine the cost of lowering Explorer's line, rather than improving the channel, in order to provide 4 feet of cover over their line.
- Explorer's cost to lower their line has since been estimated at $65,000 while their contractor is now verbally estimating the construction cost of G&A's current channel design to be over $600,000.
- Our latest Opinion of Probable Cost is closer to $300,000.
- Michael Floyd with Explorer has made a number of attempts to contact a decision maker at Bankston, without success, to find out if they are willing to help fund this project. (Bankston had apparently made such an offer to Explorer in the past).

- We submitted a preliminary drainage report to DART in order to help them evaluate the need for freeboard, but no final determination has been made to waive the freeboard requirement to our knowledge.

In our opinion, if the project were scaled back to a concrete block pilot channel, the order of magnitude of it's construction cost would be about $200,000.

Channel Benefits

Here are the benefits, as we see them, for finding a way to make the channel improvement project work:

- As the existing drainage ditch would be cleared in conjunction with the channel project, Explorer would have much better access to their line. In addition, if the currently designed concrete block channel were built, the Explorer pipeline would be protected from future erosion.
- The Town would assist Bankston in resolving a long standing flooding problem on their property.
- DART would have a drainage ditch with much greater conveyance than the current ditch, and the Town would take over maintenance of the new channel.

The question to be resolved by the Town, Explorer and DART is whether these benefits are sufficient for the Town and Explorer to increase their funding levels, and DART to allow a concrete block pilot channel to be constructed without freeboard.

The Next Steps

The following next steps were discussed in our recent meeting:

- The Town and Explorer will re-evaluate their funding limits for this project.
- If it is determined that a $200,000 concrete block pilot channel can be funded, G&A will apply value engineering principles to this project through a meeting with Explorer's contractor to reevaluate the project design and confirm that the funds available are sufficient to construct the job.
- If the project can be constructed for the funds available, G&A will submit a revised design memo to DART in order to obtain approval for the pilot channel project.

Project History

To the best of our knowledge, the following summarizes previous drainage studies that have been performed on the existing Lindbergh Drive drainage channel.

1985± :	Espey, Huston, & Associates, Inc. performed a study of the drainage ditch and the Bankston property flooding for the Town.
1994:	Bankston contracted with Foerster Engineers to study the drainage ditch. They designed a grass-lined drainage channel from Midway Road to Lindbergh Drive.
1999:	Shimek, Jacobs and Finklea, LLP (now Birkhoff, Hendricks, and Conway), under contract with the Town, designed a grass-lined grade-to-drain from Lindbergh Drive to downstream of Bankston near the abandoned railroad spur, in order to reduce the Bankston property flooding.
2000:	GBW Engineers, Inc. prepared an Opinion of Probable Cost for the Town based on three alternatives to improve the existing drainage channel:

1. Box Culvert: Opinion of Probable Construction Cost – $1.1 million
2. Fully Lined Concrete Channel: Opinion of Probable Construction Cost – $415,000
3. Concrete Pilot Channel: Opinion of Probable Construction Cost – $245,000

Additional details of these alternatives were summarized in memos provided to the Town.

2001: Explorer Pipeline approached the Town regarding a financial partnership to improve the subject ditch. Explorer is in the DART right-of-way and is required to maintain a minimum of 4 feet of cover. There are locations where erosion in the ditch has reduced the cover to less than 4 feet. Explorer obtained an estimated construction cost of $130,000 from their contractor to construct a concrete block pilot channel over the pipeline.

2002: The Town contracted with Grantham & Associates, Inc. (G&A) to design a concrete pilot channel over the Explorer Pipeline which will also reduce the Bankston flooding.

2003: The following events have occurred in recent months:

- At the request of the Town, the design scope was changed from a concrete block pilot channel to a channel with a minimum slope of 0.5% that would contain the 100-year storm without any freeboard.
- Upon DART's review of the project, they requested that freeboard be added pursuant to their new design standards.
- On August 27, 2003, Michael Floyd with Explorer indicated that their contractor had increased his estimate of the cost to construct the channel per G&A's plans from $130,000 to over $200,000.
- On September 5, 2003, per Michael Floyd, the Explorer contractor increased his project estimate to $375,000.
- Later in September, Mike Tucker indicated that their contractor's estimate had increased again to $600,000, based on a verbal quote. Their contractor had also indicated that the pipeline could be lowered to achieve the minimum cover criteria for $70,000 to $100,000.
- As of the end of September, Dan Warwick, the District Manager with Bankston, had not returned multiple phone calls from Michael Floyd with Explorer. Michael was trying to reach Mr. Warwick to discuss Bankston's willingness to help fund the project. Michael had previously spoken with Mr. Jim Smickless the General Manager who indicated that he did not have the authority to approve a financial contribution to the project; however, he did provide Mr. Warwick's name and phone number.
- G&A developed an Engineer's Opinion of Probable Cost for the project of approximately $340,000, including a 10% contingency.

Lindbergh Drive Channel Drainage Improvements
Town of Addison

Engineer's Opinion of Probable Cost

Item No.	Item Description	Units	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	$ 10,000.00	$ 10,000.00
2	Clearing, Grubbing, Tree Removal	LS	1	$ 5,000.00	$ 5,000.00
3	Remove / Dispose of Partial RCP	LS	1	$ 1,000.00	$ 1,000.00
8	Unclassified Channel Excavation	CY	3,000	$ 10.00	$ 30,000.00
4	Concrete Channel Block	SY	4,755	$ 45.00	$ 213,975.00
5	6" Concrete Channel Lining (2500 psi)	SY	810	$ 55.00	$ 44,550.00
6	24" Reinforced Concrete Pipe	LF	412	$ 65.00	$ 26,780.00
7	Remove / Replace 33" R.C.P.	LF	10	$ 80.00	$ 800.00
9	Hydro Mulch/Sod	SY	5,910	$ 2.00	$ 11,820.00
10	Trench Safety	LF	421	$ 2.00	$ 842.00
11	Stabilize Const. Entrance	EA	2	$ 2,500.00	$ 5,000.00
12	Erosion Control Devices	LS	1	$ 5,000.00	$ 5,000.00
				Sub-Total	$ 308,767.00
				10% Contingency	$ 30,876.70
				Total	$ 339,643.70

Steve Chutchian

From: Steve Chutchian
Sent: Wednesday, October 15, 2003 3:09 PM
To: Mike Murphy
Cc: Jim Pierce
Subject: Lindbergh Channel Improvements

LINDBERGH CHANNEL IMPROVEMENTS

- Our Engineer and Public Works staff have met on several occasions with the DART Engineering Department, in an attempt to obtain approval to perform the proposed improvements.
- Unfortunately, we have been unable to satisfy their engineering staff, due to existing physical restrictions in the field. Specifically, we are unable to meet the 100 year flood design and include their required 1 ft. of ** free board.
- Our only alternative consists of terminating this project, and leaving Explorer Pipeline and the Town's adjacent properties in a precarious situation.
- The Town recently submitted the design for a concrete lined channel to DART. This design provided for protection of the existing shallow Explorer pipeline system within the DART easement and elimination of flooding to adjacent commercial properties.
- The existing condition, as it is today, is an unimproved tributary, with extensive vegetation and other growth.
- Properties to the north of this easement are subject to frequent flooding during minor wet weather events.
- The design submitted is monumental improvement over existing conditions, and meets the Town's requirement of providing for the 100 year storm occurrence.
- However, the design does not allow for a DART mandated 1 ft. free board, which is an increased height of channel above the depth required to meet the 100 year storm event.
- In addition, this project will greatly benefit and protect the existing DART rail line.
- This is a request that DART grant a variance to allow this project to move forward and permit the Town to meet all storm drainage criteria, except the 1 ft. free board.
- The conditions that exist today, versus the proposed channel improvements will be extraordinary. All parties involved will experience a substantial benefit.

** free board: Clearance distance between maximum water level and height of overflow of structure.

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Steve Chutchian

From: K Curry [kcurry@gra-ce.net]
Sent: Wednesday, July 30, 2003 9:05 AM
To: Steve Chutchian
Cc: Bruce Grantham; Mike Tucker; Michael Floyd
Subject: Lindbergh Drainage Channel Update

Steve,
I wanted to provide you an update on the Lindbergh Drainage Channel report.

As you know, I sent out a draft version of the letter report to DART towards the end of last week. I have since received verbal comments from DART's engineer, Glenn Celerier. His comments were as follows:

1. Determine the elevation of the top of rail and the sub-ballast and provide freeboard information from the 100-year water surface elevation to the sub-ballast. If this difference is less than 2 feet in any location, we may be required to compute other frequency events to determine freeboard during those events, as well. Once I have obtained this information, I am to contact him to let him know the results.

2. Provide more detail on the values assumed during calculations, i.e. manning's roughness coefficients, etc.

3. Provide detail of the velocities in the channel.

We are currently working on getting the information for him that is detailed in item number 1. Items 2 and 3 are a matter of adding text to the letter report and submitting the appropriate summary tables that were already planned.

If you have any questions or comments concerning this project, please contact me.

Thanks,
Katura

****
Katura Curry, P.E.
Grantham & Associates, Inc.
Tel(972)864-2333
kcurry@gra-ce.net

Steve Chutchian

To: Mike Murphy
Cc: Jim Pierce
Subject: Lindbergh Channel Improvements

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- The conditions that exist today, versus the proposed channel improvements will be extraordinary. All parties involved will experience a substantial benefit.

Grantham & Associates, Inc.

MEMO

1919 S. Shiloh Rd., Suite 310, LB 8, Garland, TX 75042

Date: October 15, 2003 **G&A No. 334**

To: Steve Chutchian, P.E., Town of Addison
cc: Mike Tucker, Explorer Pipeline

From: Katura Curry, P.E.

Re: Lindbergh Drive Drainage Channel Project
History and Current Status

Pursuant to the request we received from you and Mike Tucker at our previous meeting on the Lindbergh Drive channel, which extends from Lindbergh Drive to Midway Road parallel to the existing DART railroad tracks, we have prepared this memo regarding the current project status. In addition, we have outlined the channel benefits, the next steps and a project history as we understand it.

Executive Summary

This project has been a moving target. When we entered into a design contract with the Town in 2002, Explorer had previously furnished a verbal estimate of approximately $130,000, which their contractor had provided, for the construction of a concrete block pilot channel. At this time, with Explorer offering to contribute $100,000 and the Town appropriating about $50,000, this appeared to be a financially viable project.

During the design of this project, several factors arose which, in combination, now call into question this project's financial viability. These factors are summarized below:

- When G&A was asked by the Town to extend the limits of the concrete blocks beyond a pilot channel to convey a 100-year storm event without freeboard, and to maintain a minimum longitudinal slope of 0.5%, we focused on the engineering viability of these parameters prior to evaluating their impact on the project cost.
- In finding a way to meet these additional design parameters we redesigned the project which increased the construction cost significantly.
- When DART's staff attended a project meeting at the Town earlier this year, they reiterated their desire to expand the limits of the concrete blocks even further to provide freeboard within the lined portion of the channel, although they did indicate a willingness to reconsider the freeboard requirement.
- As a result of the DART meeting, Mike Tucker decided to determine the cost of lowering Explorer's line, rather than improving the channel, in order to provide 4 feet of cover over their line.
- Explorer's cost to lower their line has since been estimated at $65,000 while their contractor is now verbally estimating the construction cost of G&A's current channel design to be over $600,000.
- Our latest Opinion of Probable Cost is closer to $300,000.
- Michael Floyd with Explorer has made a number of attempts to contact a decision maker at Bankston, without success, to find out if they are willing to help fund this project. (Bankston had apparently made such an offer to Explorer in the past).

- We submitted a preliminary drainage report to DART in order to help them evaluate the need for freeboard, but no final determination has been made to waive the freeboard requirement to our knowledge.

In our opinion, if the project were scaled back to a concrete block pilot channel, the order of magnitude of it's construction cost would be about $200,000.

Channel Benefits

Here are the benefits, as we see them, for finding a way to make the channel improvement project work:

- As the existing drainage ditch would be cleared in conjunction with the channel project, Explorer would have much better access to their line. In addition, if the currently designed concrete block channel were built, the Explorer pipeline would be protected from future erosion.
- The Town would assist Bankston in resolving a long standing flooding problem on their property.
- DART would have a drainage ditch with much greater conveyance than the current ditch, and the Town would take over maintenance of the new channel.

The question to be resolved by the Town, Explorer and DART is whether these benefits are sufficient for the Town and Explorer to increase their funding levels, and DART to allow a concrete block pilot channel to be constructed without freeboard.

The Next Steps

The following next steps were discussed in our recent meeting:

- The Town and Explorer will re-evaluate their funding limits for this project.
- If it is determined that a $200,000 concrete block pilot channel can be funded, G&A will apply value engineering principles to this project through a meeting with Explorer's contractor to reevaluate the project design and confirm that the funds available are sufficient to construct the job.
- If the project can be constructed for the funds available, G&A will submit a revised design memo to DART in order to obtain approval for the pilot channel project.

Project History

To the best of our knowledge, the following summarizes previous drainage studies that have been performed on the existing Lindbergh Drive drainage channel.

1985± :	Espey, Huston, & Associates, Inc. performed a study of the drainage ditch and the Bankston property flooding for the Town.
1994:	Bankston contracted with Foerster Engineers to study the drainage ditch. They designed a grass-lined drainage channel from Midway Road to Lindbergh Drive.
1999:	Shimek, Jacobs and Finklea, LLP (now Birkhoff, Hendricks, and Conway), under contract with the Town, designed a grass-lined grade-to-drain from Lindbergh Drive to downstream of Bankston near the abandoned railroad spur, in order to reduce the Bankston property flooding.
2000:	GBW Engineers, Inc. prepared an Opinion of Probable Cost for the Town based on three alternatives to improve the existing drainage channel:

1. Box Culvert: Opinion of Probable Construction Cost – $1.1 million
2. Fully Lined Concrete Channel: Opinion of Probable Construction Cost – $415,000
3. Concrete Pilot Channel: Opinion of Probable Construction Cost – $245,000

Additional details of these alternatives were summarized in memos provided to the Town.

2001: Explorer Pipeline approached the Town regarding a financial partnership to improve the subject ditch. Explorer is in the DART right-of-way and is required to maintain a minimum of 4 feet of cover. There are locations where erosion in the ditch has reduced the cover to less than 4 feet. Explorer obtained an estimated construction cost of $130,000 from their contractor to construct a concrete block pilot channel over the pipeline.

2002: The Town contracted with Grantham & Associates, Inc. (G&A) to design a concrete pilot channel over the Explorer Pipeline which will also reduce the Bankston flooding.

2003: The following events have occurred in recent months:

- At the request of the Town, the design scope was changed from a concrete block pilot channel to a channel with a minimum slope of 0.5% that would contain the 100-year storm without any freeboard.
- Upon DART's review of the project, they requested that freeboard be added pursuant to their new design standards.
- On August 27, 2003, Michael Floyd with Explorer indicated that their contractor had increased his estimate of the cost to construct the channel per G&A's plans from $130,000 to over $200,000.
- On September 5, 2003, per Michael Floyd, the Explorer contractor increased his project estimate to $375,000.
- Later in September, Mike Tucker indicated that their contractor's estimate had increased again to $600,000, based on a verbal quote. Their contractor had also indicated that the pipeline could be lowered to achieve the minimum cover criteria for $70,000 to $100,000.
- As of the end of September, Dan Warwick, the District Manager with Bankston, had not returned multiple phone calls from Michael Floyd with Explorer. Michael was trying to reach Mr. Warwick to discuss Bankston's willingness to help fund the project. Michael had previously spoken with Mr. Jim Smickless the General Manager who indicated that he did not have the authority to approve a financial contribution to the project; however, he did provide Mr. Warwick's name and phone number.
- G&A developed an Engineer's Opinion of Probable Cost for the project of approximately $340,000, including a 10% contingency.

Lindbergh Drive Channel Drainage Improvements
Town of Addison

Engineer's Opinion of Probable Cost

Item No.	Item Description	Units	Quantity	Unit Cost	Total Cost
1	Mobilization	LS	1	$ 10,000.00	$ 10,000.00
2	Clearing, Grubbing, Tree Removal	LS	1	$ 5,000.00	$ 5,000.00
3	Remove / Dispose of Partial RCP	LS	1	$ 1,000.00	$ 1,000.00
8	Unclassified Channel Excavation	CY	3,000	$ 10.00	$ 30,000.00
4	Concrete Channel Block	SY	4,755	$ 45.00	$ 213,975.00
5	6" Concrete Channel Lining (2500 psi)	SY	810	$ 55.00	$ 44,550.00
6	24" Reinforced Concrete Pipe	LF	412	$ 65.00	$ 26,780.00
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				Sub-Total	$ 308,767.00
				10% Contingency	$ 30,876.70
				Total	$ 339,643.70

LAN/STV

A Joint Venture of Lockwood, Andrews & Newnam, Inc. and STV Incorporated
General Engineering Consultants to DART

Dennis K. Henning, P.E.

Deputy Program Manager - Design Support

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(214) 749-2946 • FAX (214) 749-3301
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Glenn Celerier, P.E.
Senior Civil Engineer

Accelerated Cost-effective Transit For The 21st Century

Mike Tucker
Greenville Area Manager

Explorer PIPELINE

2856 Country Road 2168
Caddo Mills, TX 75135
Office 903-527-1262 • Fax 903-527-1270
Cell 214-533-7232
mtucker@expl.com

Dallas Area Rapid Transit
P.O. Box 660163
1401 Pacific Avenue
Dallas, Texas 75266-7210

Benjamin Claybour
Right-of-Way Representative

214.749.2636
214.749.3609 Fax
bclaybou@dart.org

EXPLORER PIPELINE

Michael Floyd
Project Engineer

P.O. Box 2650 • Tulsa, OK 74101-2650
(918) 493-5153 • Fax (918) 493-5177
mfloyd@expl.com

Facsimile Transmittal

Date: 7/24/03

Fax To: Ben Claybour

Of: DART

Fax# (214) 749-3609

Ref: LINDBERGH CHANNEL

# of Pages (including this sheet): 7

From: **Grantham & Associates, Inc.**
1919 S. Shiloh Rd.
Suite 310, L.B. 8
Garland, Texas 75042
Tel. (972) 864-2333
Fax (972) 864-2334
Email: Info@gra-ce.net

Fax From: KATURA CURRY

Comments:

CC:→GLENN CELERIER – ACT 21
FAX (214) 749-5353

✳ CC:→STEVE CHUTCHIAN – ADDISON
FAX (972) 450-2837

CC:→MIKE TUCKER – EXPLORER
FAX (903) 527-1270

Please review the following DRAFT REPORT for content. If any elements have been omitted, please let me know.

Katura Curry

DRAFT

July 21, 2003

Mr. Ben Claybour
Dallas Area Rapid Transit
P.O. Box 660163
Dallas, Texas 75266-0163

G&A No. 02-334

Re: Drainage Study for Lindbergh Drainage Channel
Addison, Texas

Dear Mr. Claybour:

Per our recent meeting at the Addison Service Center, we are submitting to you this letter summarizing the design of the Lindbergh Drainage Channel project. The information provided with this letter should satisfy DART's Drainage Report criteria. Specifically, it will provide you with information concerning the purpose of the project, the design constraints, the design assumptions and the hydrologic and hydraulic computations. It is our expectation that this will provide an all inclusive document for your reference purpose.

Project Location
The Lindbergh Drainage Channel is located within the DART right-of-way, north of the tracks, and extends from the east side of Midway Road to Lindbergh Drive, just south of the Addison Airport. The drainage channel drains a portion of the airport property, the light industrial area just north of the channel, and a portion of the DART right-of-way.

Project Purpose
This project was initiated by Explorer Pipeline (Explorer) for the exclusive purpose of providing erosion control above its petroleum pipeline which is located within the DART right-of-way. As part of Explorer's agreement with DART, Explorer must maintain a minimum of 4 feet of cover over its pipeline in order to protect both DART and Explorer. Based on the survey performed for this project, there are locations which currently do not meet this minimum cover criteria.

A secondary purpose of this project is to provide flood relief to the Bankston property, which is the last property on the north side of the DART right-of-way before Lindbergh Drive. This property is built low and experiences flooding during minor storms, as well as large storms. Eliminating this flooding at the Bankston property creates the need for this project to be looked at from the perspective of drainage as well as erosion control.

As a note, the need for this drainage project was noted back in the 1980's. Since then, numerous analyses of this drainage channel have been performed in order to design improvements which would alleviate the flooding that Bankston experiences; however, as will be expanded upon later, the design constraints on this project make the project extremely complex. Therefore, these previous projects were not

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constructed.

Project Design Constraints
The following design constraints were used in the design of this project:

- Provide Explorer with 4 feet minimum cover.
- Provide the Sprint fiber optics line with 18 inches of cover as measured from the bottom of the concrete blocks.
- The crossing of the Explorer pipeline and the Sprint fiber optics.
- Size the channel to convey a 100-year storm event, not considering freeboard.
- Keep the proposed drainage channel out of the railroad embankment.
- Consider constructability and future maintenance concerns.
- Minimize encroachment on adjacent properties.

Existing Conditions
The existing channel is fed by 4 sources:

- Direct overland runoff
- 24" RCP under Lindbergh, from the Airport property
- 4 - 29" x 45" elliptical concrete culverts under Lindbergh, from the Airport property
- 1 - 33" RCP at proposed channel station 5+70, from Lindbergh drive storm sewer system

The existing channel is a small, vegetated channel with a centerline that has been cut by the drainage through most reaches. In some reaches, the centerline and channel confines are difficult to locate. Evidence of erosion of the channel banks is present at the downstream end near Midway as well as near the 33" RCP at station 5+70. At some point, an attempt has been made to stop the erosion at 5+70 by dumping loose riprap. This erosion is located in the southern channel bank, which appears to be part of the railroad embankment.

At one time, a railroad spur crossed the existing channel to the back of one of the adjacent buildings. During this time, the channel drainage under the spur was maintained with three reinforced concrete pipes. Once the spur was removed, the tops of these pipes were removed. The remaining pipes are located at approximately station 12+00.

Proposed Improvements
This section will summarize previous alternatives, as well as the currently proposed design.

Previous Alternatives Analyzed
Prior to the current proposed improvements, analyses were performed to determine what alternatives were available for improving this drainage situation. These alternatives described are only those performed since 1994. Others have performed previous analyses to fit a channel through this reach; however, the specifics of these studies are not known at this time. All of these analyses consider drainage as the primary purpose. Cover over Explorer does not appear to have been considered.

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- June to August 2000 - Analyses performed in conjunction with the Arapaho Road project.
  - *Alternative 1*: Pilot Channel from Lindbergh to Midway
    - Grass-lined side slopes
    - Concrete pilot channel
    - Did not convey 100-year storm event
    - Estimated Cost: $250,000
  - *Alternative 2*: 3.5' Deep Concrete Trapezoidal Channel
    - Concrete lined channel up to 3.5 feet deep
    - Conveyed 100-year storm event
    - Estimated Cost: $420,000
  - *Alternative 3*: 1 - 11' x 4' Concrete Box Culvert
    - Conveyed 100-year storm event underground
    - Estimated Cost: $1.2 million
- Analyses by Others.
  - August 1999 - Performed for the Town of Addison by Shimek, Jacobs & Finklea, LLP (now Birkhoff, Hendricks, & Conway, LLP)
    - Improvements did not consider Explorer location
    - Purely a drainage project to alleviate flooding of Bankston.
    - Hydraulic computations not shown.
    - Grass-lined trapezoidal channel.
    - Project extended from Lindbergh to the downstream end of the Bankston Property.
  - November 1994 - Performed for W.O. Bankston Body Shop by R. Foerster Civil Engineers
    - Improvements showed location of Explorer but did not provide minimum coverage.
    - Not all cross-sections shown conveyed full 100-year storm event.
    - Grass-lined trapezoidal channel.

Proposed Design

The channel improvements currently being proposed accomplish the following:

- Maintain 4 feet minimum cover over Explorer.
- Maintain 18 inches of cover over Sprint.
- Contain a 100-year storm event within the lined portion of the channel.

The proposed channel section can be broken into three reaches, beginning downstream:

Reach 1: Station 1+00 to Station 8+88

- Trapezoid, concrete block channel
- 2:1 side slopes

- Varying bottom width

Reach 2: Station 8+88 to Station 13+00
- Same trapezoidal channel as Reach 1
- Includes a 24" RCP for low flow conveyance

Reach 3: Station 13+00 to Station 18+50
- Same trapezoidal channel as Reach 1 and 2
- Includes a 3' wide, varying depth concrete pilot channel

Concrete blocks are being used instead of a concrete lined channel in order to provide a permeable surface in the unlikely event of a leak in the petroleum line. The permeable surface makes it easier to detect this occurrence and fix the problem.

Project Design and Calculations
The following summarizes the calculations that have been performed to design the proposed channel.

Hydrology
The drainage areas contributing to this channel are fully developed, primarily light industrial. The rational method was used to calculate the discharges. Exhibit 1 shows the contributing drainage areas and Table 1 presents the drainage calculations for the project.

The drainage calculations take into account detention which appears to be occurring on the Addison Airport property just upstream of Lindbergh Drive. A detailed analysis of the detention has not been performed due to lack of detailed topographic information in the area. However, calculations for the culverts under Lindbergh have been performed. The following is a summary of the calculations and findings for the Lindbergh culverts.

- There appears to be significant potential for detention on the Airport property.
- There have been no reports of water overtopping Lindbergh Drive.
- Lindbergh culverts: 4-29"x45" elliptical concrete culverts; 1-24" RCP.
- Calculations show a drainage area upstream of the Lindbergh culverts of 113 acres generating a runoff of 435 cfs.
- Under Inlet Control, the two sets of culverts release approximately 310 cfs assuming a headwater at the Lindbergh Drive top of pavement. Open areas in the immediate vicinity of the culvert outfalls generate an additional 10 cfs of runoff into the Lindbergh Channel.

It is estimated that, based on the time of concentration, a peak runoff reaches the Lindbergh culverts from the airport property at approximately 33 minutes. We believe that, once the peak flow reaches these culverts, detention begins to occur in the junction box and grassed swale areas at the south end of the airport.

Using a worst case scenario, in which the headwater at the culvert entrance reaches the Lindbergh pavement elevation, 310 cfs will be released until the storm water level recedes. Consequently, a modified CA (runoff coefficient * area) was calculated based on the release rate of 310 cfs plus the additional 10 cfs of minor runoff.

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Horizontal & Vertical Alignment

The horizontal and vertical alignment of the channel are directly related to the location of the underground Explorer pipeline and the Sprint fiber optics line. The horizontal alignment of the channel was designed such that the Explorer pipeline remained, as much as possible, under the side slopes of the channel with a minimum of 4 feet of cover. To do this, we designed the horizontal alignment of the channel on a cross-section by cross-section basis, based on cross-sections every 50 feet.

The vertical alignment of the channel was set using the following criteria:

- Minimum longitudinal channel slope of 0.5%.
- Minimum cover over Explorer of 4 feet.
- Minimum cover over Sprint of 18 inches.
- Provide cross-section capacity for a 100-year storm event.

Channel Cross-Section

As was outlined previously, the channel can be divided into three reaches. Reach 1 is a simple trapezoidal, concrete block lined section with a bottom width set based on the location of Explorer and the capacity of the channel needed. Reach 2 and 3 have, respectively, a 24" RCP and a 3' wide pilot channel in addition to the trapezoid channel. In Reach 3, the pilot channel was added because the longitudinal slope of the trapezoid channel could not meet the minimum slope and the minimum cover requirements. Therefore, the addition of the pilot channel provided the longitudinal slope needed during low flows and the additional capacity needed. The 24" RCP in Reach 2, is considered functional during low flows for the purpose of draining the pilot channel. Debris bars will be in place at both the upstream and downstream ends of the pipe in order to keep the pipe from getting clogged. During high flows, the 24" RCP is considered inconsequential as the trapezoid channel will carry the majority of the flow.

Channel Hydraulics

The proposed channel will provide the additional conveyance necessary to alleviate the flooding which occurs frequently at the Bankston property. The capacity of the channel has been determined using Haestad Methods FlowMaster. Printouts from FlowMaster are attached to this letter for your reference. A comparison of the hydraulic properties of the existing and proposed channels are provided in Table 2.

Impediments to Providing Proposed Freeboard

The channel design shown on the enclosed preliminary plans does not include freeboard within the lined channel section. We have prepared the following regarding freeboard.

- The top of the DART rail embankment sits several feet above the 100-year water surface elevation, consequently, freeboard is not a concern on the DART side of the channel.
- On the developed property side of the channel, freeboard is provided on the existing grass channel overbank areas everywhere except _____.
- Adjacent to _____, freeboard cannot be provided to the existing adjacent Bankston storage facility and parking garage due to:
  -

Impact on Downstream Property Owners

The Town of Addison has previously completed channel lining improvements downstream of the subject

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project between Belt Line Road and Surveyor Boulevard, as well as from Surveyor Boulevard to Midway Road. At Belt Line Road, the existing box culverts are significantly undersized, which results in a reduction in the stormwater flow downstream of Belt Line. Upstream of Surveyor Boulevard to Midway Road, plans are currently being prepared for the Town to enclose the existing concrete channel in a double box culvert in conjunction with the Arapaho Road Phase 3 project; thereby, modifying, to some degree, the velocity in this reach. Consequently, the subject drainage channel, between Midway Road and Lindbergh Drive is just one of several drainage improvement projects which impact this drainage basin.

Conclusions
The following can be concluded concerning this project:

- This proposed channel design meets the criteria that has been set forth for this project.
- This channel significantly improves drainage for adjacent property owners.
- This channel will provide the protection that is required by DART for the Explorer pipeline and will alleviate the frequent flooding which the Bankston property experiences.
- This channel meets the basic Design Assumptions set forth in Section 7.1.1 of the DART drainage criteria, which are:
    - The proposed improvements will not increase the flood or inundation hazard to adjacent property
    - The proposed improvements will not raise the flood level of a drainage way
    - The proposed improvements will not reduce the flood storage capacity or impede the movement of floodwater within a drainage way.

Please contact me should you have any questions or need additional information.

Sincerely,

A. Katura Curry, P.E.
Project Engineer

attachments

cc: Ben Claybour - DART
Steve Chutchian - Town of Addison
Mike Tucker - Explorer Pipeline
Mike Floyd - Explorer Pipeline

kc / AKC

E:\WPDOCS\PROJECTS\ADDISON\a02-334\lindbergh drainage.ltr

Steve Chutchian

From: Jim Pierce
Sent: Thursday, July 24, 2003 2:37 PM
To: Bill Dyer (E-mail)
Cc: Luis Elguezabal (E-mail); Steve Chutchian; Mark Acevedo
Subject: FW: Ensearch Corporation Gas Line

Bill: See the attached. The info is sketchy, but to me, wherever that gas line is is where the easement is. Were you able to get the gas line marked? Perhaps we should consider asking the gas company to excavate and actually physically locate the line. Let me know what you think

Jim Pierce, P.E.
Assistant Public Works Director
P.O. Box 9010
Addison, TX 75001-9010
972-450-2879

-----Original Message-----
From: Sedi Toumani [mailto:sedi@Dal-tech.com]
Sent: Wednesday, July 23, 2003 5:00 PM
To: Jim Pierce
Subject: FW: Ensearch Corporation Gas Line

Hello Jim,
Sorry for being slow responding , we had to dig out the original gas esm'ts recorded instrument.
The following is Alan's finding in response to your inquiry. Please let me know if you need additional information.
Thanks
Sedi

-----Original Message-----
From: Alan Moore
Sent: Tuesday, July 22, 2003 4:49 PM
To: Sedi Toumani
Subject: Ensearch Corporation Gas Line

Sedi,

Based upon my investigation of the easement document and our electronic files, the centerline of the Ensearch easement was plotted in our electronic files according to the sketch contained within the actual instrument creating the easement (Volume 83007, Page 3479 of the Deed Records of Dallas County, Texas). The instrument does not contain a metes and bounds description, but only the said sketch. Furthermore, the centerline shown on this sketch is defined only by dimensions from physical features on site at that time such as building lines, pavement lines, and fence lines and is devoid of any angular relationships between the those lines. Unfortunately, many of these lines are gone or changed and make it difficult to plot the location of the centerline with any good measure of accuracy. Bottom line - we plotted the easement, to the best of our ability, according to an ambiguous sketch contained in the instrument of record. For all practical purposes, the actual location of the gas line as evidenced by gas manholes, other pertinent above-ground features, and SUE marks the true location of the easement, and that is perhaps the most important issue at hand.

Sincerely,
Alan

7/24/2003

February 28, 2005

Mr. Eduardo Ugarte
Dallas Area Rapid Transit
P.O. Box 660163
Dallas, Texas 75266-0163

G&A No. 02-334

Re: Drainage Study for Lindbergh Drainage Channel
Addison, Texas

Dear Mr. Ugarte:

The Lindbergh Drainage Channel Project is a maintenance project being prepared for the Town of Addison in order to alleviate the flooding of property and to protect existing utilities adjacent to the existing DART rail. This letter will provide you with information concerning the purpose of the project, the design constraints, the design assumptions and the hydrologic and hydraulic computations. It is our expectation that this will provide an all inclusive document for your reference purpose.

Project Location
The Lindbergh Drainage Channel is located within the DART right-of-way, north of the tracks, and extends from the east side of Midway Road to Lindbergh Drive, just south of the Addison Airport. The drainage channel drains a portion of the airport property, the light industrial area just north of the channel, and a portion of the DART right-of-way.

Project Purpose
This project was initiated by Explorer Pipeline (Explorer) for the exclusive purpose of providing erosion control above its petroleum pipeline which is located within the DART right-of-way. As part of Explorer's agreement with DART, Explorer must maintain a minimum of 4 feet of cover over its pipeline in order to protect both DART and Explorer. Based on the survey performed for this project, there are locations which currently do not meet this minimum cover criteria.

A secondary purpose of this project is to provide flood relief to the Bankston property, which is the last property on the north side of the DART right-of-way before Lindbergh Drive. This property is built low and experiences flooding during minor storms, as well as large storms. Eliminating this flooding at the Bankston property creates the need for this project to be looked at from the perspective of drainage as well as erosion control.

As a note, the need for this drainage project was noted back in the 1980's. Since then, numerous analyses of this drainage channel have been performed in order to design improvements which would alleviate the flooding that Bankston experiences; however, as will be expanded upon later, the design constraints on this project make the project extremely complex. Therefore, these previous projects were not constructed.

Project Design Constraints
The following design constraints were used in the design of this project:

- Provide Explorer with 4 feet minimum cover.

- Provide the Sprint fiber optics line with 18 inches of cover as measured from the bottom of the concrete blocks.
- The crossing of the Explorer pipeline and the Sprint fiber optics.
- Size the channel to convey a 100-year storm event, not considering freeboard.
- Keep the proposed drainage channel out of the railroad embankment.
- Consider constructability and future maintenance concerns.
- Minimize encroachment on adjacent properties.

Existing Conditions
The existing channel is fed by 4 sources:

- Direct overland runoff
- 24" RCP under Lindbergh, from the Airport property
- 4 - 29" x 45" elliptical concrete culverts under Lindbergh, from the Airport property
- 1 - 33" RCP at proposed channel station 5+70, from Lindbergh drive storm sewer system

The existing channel is a small, vegetated channel with a centerline that has been cut by the drainage through most reaches. However, in some reaches, the centerline and channel confines are difficult to locate. Evidence of erosion of the channel banks is present at the downstream end near Midway as well as near the 33" RCP at station 5+70. At some point, an attempt has been made to stop the erosion at 5+70 by dumping loose riprap. This erosion is located in the southern channel bank, which appears to be part of the railroad embankment.

At one time, a railroad spur crossed the existing channel to the back of one of the adjacent buildings. During this time, the channel drainage under the spur was maintained with three reinforced concrete pipes. Once the spur was removed, the tops of these pipes were removed. The remaining portion of the pipes are located at approximately station 12+00.

Proposed Improvements
This section will summarize previous alternatives, as well as the currently proposed design.

Previous Alternatives Analyzed
Prior to the current proposed improvements, analyses were performed to determine what alternatives were available for improving this drainage situation. These alternatives described are only those performed since 1994. Others have performed previous analyses to fit a channel through this reach; however, the specifics of these studies are not known at this time. All of these analyses consider drainage as the primary purpose. Cover over Explorer does not appear to have been considered.

- June to August 2000 - Analyses performed in conjunction with the Arapaho Road project.
  Alternative 1: Pilot Channel from Lindbergh to Midway
  - Grass-lined side slopes
  - Concrete pilot channel
  - Did not convey 100-year storm event
  - Estimated Cost: $250,000

Alternative 2: 3.5' Deep Concrete Trapezoidal Channel
- Concrete lined channel up to 3.5 feet deep
- Conveyed 100-year storm event
- Estimated Cost: $420,000

Alternative 3: 1 - 11' x 4' Concrete Box Culvert
- Conveyed 100-year storm event underground
- Estimated Cost: $1.2 million

- Analyses by Others.
  August 1999 - Performed for the Town of Addison by Shimek, Jacobs & Finklea, LLP (now Birkhoff, Hendricks, & Conway, LLP)
  - Improvements did not consider Explorer location
  - Purely a drainage project to alleviate flooding of Bankston
  - Hydraulic computations not shown
  - Grass-lined trapezoidal channel
  - Project extended from Lindbergh to the downstream end of the Bankston Property

  November 1994 - Performed for W.O. Bankston Body Shop by R. Foerster Civil Engineers
  - Improvements showed location of Explorer but did not provide minimum coverage
  - Not all cross-sections shown conveyed full 100-year storm event
  - Grass-lined trapezoidal channel

Proposed Design
The channel improvements currently being proposed accomplish the following:

- Maintain 4 feet minimum cover over Explorer
- Maintain 18 inches of cover over Sprint
- Contain a 100-year storm event within the lined portion of the channel

The proposed channel section can be broken into three reaches, beginning downstream:

Reach 1: Station 1+00 to Station 8+88
- Trapezoid, concrete block channel
- 2:1 side slopes
- Varying bottom width

Reach 2: Station 8+88 to Station 13+00
- Same trapezoidal channel as Reach 1
- Includes a 24" RCP for low flow conveyance

Reach 3: Station 13+00 to Station 18+50

- Same trapezoidal channel as Reach 1 and 2
- Includes a 3' wide, varying depth concrete pilot channel

Concrete blocks are being used instead of a concrete lined channel in order to provide a permeable surface in the unlikely event of a leak in the petroleum line. The permeable surface makes it easier to detect this occurrence and fix the problem.

Project Design and Calculations
The following summarizes the calculations that have been performed to design the proposed channel.

Hydrology
The drainage areas contributing to this channel are fully developed, primarily light industrial. The rational method was used to calculate the discharges. The attached drainage area map shows the contributing drainage areas and Table 1 presents the drainage calculations for the project.

The drainage calculations take into account detention which appears to be occurring on the Addison Airport property just upstream of Lindbergh Drive. A detailed analysis of the detention has not been performed due to lack of detailed topographic information in the area. However, calculations for the culverts under Lindbergh have been performed. The following is a summary of the calculations and findings for the Lindbergh culverts.

- There appears to be significant potential for detention on the Airport property.
- There have been no reports of water overtopping Lindbergh Drive.
- Lindbergh culverts: 4-29"x45" elliptical concrete culverts; 1-24" RCP.
- Calculations show a drainage area upstream of the Lindbergh culverts of 113 acres generating a runoff of 435 cfs.
- Under Inlet Control, the two sets of culverts release approximately 310 cfs assuming a headwater at the Lindbergh Drive top of pavement. Open areas in the immediate vicinity of the culvert outfalls generate an additional 10 cfs of runoff into the Lindbergh Channel.

It is estimated that, based on the time of concentration, a peak runoff reaches the Lindbergh culverts from the airport property at approximately 33 minutes. We believe that, once the peak flow reaches these culverts, detention begins to occur in the junction box and grassed swale areas at the south end of the airport.

Using a worse case scenario, in which the headwater at the culvert entrance reaches the Lindbergh pavement elevation, 310 cfs will be released until the storm water level recedes. Consequently, a modified CA (runoff coefficient * area) was calculated based on the release rate of 310 cfs.

Horizontal & Vertical Alignment
The horizontal and vertical alignment of the channel are directly related to the location of the underground Explorer pipeline and the Sprint fiber optics line. The horizontal alignment of the channel was designed

such that the Explorer pipeline remained, as much as possible, under the side slopes of the channel with a minimum of 4 feet of cover. To do this, we designed the horizontal alignment of the channel on a cross-section by cross-section basis, based on cross-sections every 50 feet.

The vertical alignment of the channel was set using the following criteria:

- Minimum longitudinal channel slope of 0.5%.
- Minimum cover over Explorer of 4 feet.
- Minimum cover over Sprint of 18 inches.
- Provide cross-section capacity for a 100-year storm event.

Channel Cross-Section
As was outlined previously, the channel can be divided into three reaches. Reach 1 is a simple trapezoidal, concrete block lined section with a bottom width set based on the location of Explorer and the capacity of the channel needed. Reach 2 and 3 have, respectively, a 24" RCP and a 3' wide pilot channel in addition to the trapezoid channel. In Reach 3, the pilot channel was added because the longitudinal slope of the trapezoid channel could not meet the minimum slope and the minimum cover requirements. Therefore, the addition of the pilot channel provided the longitudinal slope needed during low flows and the additional capacity needed. The 24" RCP in Reach 2, is considered functional during low flows for the purpose of draining the pilot channel. Debris bars will be in place at both the upstream and downstream ends of the pipe in order to keep the pipe from getting clogged. During high flows, the 24" RCP is considered inconsequential as the trapezoid channel will carry the majority of the flow.

Channel Hydraulics
The proposed channel will provide the additional conveyance necessary to alleviate the flooding which occurs frequently at the Bankston property. The capacity of the channel has been determined using Haestad Methods FlowMaster. Printouts from FlowMaster are attached to this letter for your reference. A comparison of the water surface elevations of the existing and proposed channels, along with hydraulic properties of the proposed channel are provided in Table 2.

Impediments to Providing Proposed Freeboard
The channel design shown on the enclosed preliminary plans does not include freeboard within the lined channel section. We have prepared the following regarding freeboard.

- The top of the DART rail embankment sits above the 100-year water surface elevation, consequently, freeboard is not a concern on the DART side of the channel, see Table 3.
- On the developed property side of the channel, freeboard is provided on the existing grass channel overbank areas everywhere except near station 12+50.
- At the Bankston property, additional freeboard is not available due to the existing low elevations of the property and the constraints on the channel.

Impact on Downstream Property Owners
As part of the Arapaho Road Phase 3 project being performed by the Town of Addison, the channel

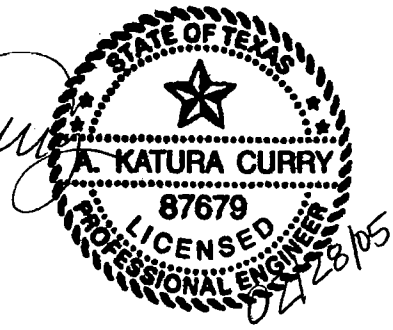
downstream of Midway Road to Surveyor Boulevard is currently being enclosed in a double box culvert. This reach, as well as from Surveyor to Belt Line Road, was previously a concrete lined channel. At Belt Line Road, the existing box culverts are significantly undersized, which results in a reduction in the stormwater flow downstream of Belt Line. Consequently, the subject drainage channel, between Midway Road and Lindbergh Drive is just one of several drainage improvement projects which impact this drainage basin.

Conclusions
The following can be concluded concerning this project:

- This proposed channel design meets the criterion that has been set forth for this project.
- This channel significantly improves drainage for adjacent property owners.
- This channel will provide the protection that is required by DART for the Explorer pipeline and will alleviate the frequent flooding which the Bankston property experiences.
- This channel meets the basic Design Assumptions set forth in Section 7.1.1 of the DART drainage criteria, which are:
    - The proposed improvements will not increase the flood or inundation hazard to adjacent property.
    - The proposed improvements will not raise the flood level of a drainage way.
    - The proposed improvements will not reduce the flood storage capacity or impede the movement of floodwater within a drainage way.

Please contact me should you have any questions or need additional information.

Sincerely,



A. Katura Curry, P.E.
Project Engineer

attachments

cc: Steve Chutchian - Town of Addison
Mike Tucker - Explorer Pipeline

kc / AKC

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TABLES

TABLE 1

LINDBERGH DRAINAGE CHANNEL
HYDROLOGIC CALCULATIONS

THIS SPREADSHEET ASSUMES DETENTION ON THE AIRPORT PROPERTY USING A MODIFIED CA VALUE

DRAINAGE AREA	AREA	C100	DA CA	Mod CA	ΣCA	DA Tc	Tc	I100	Q100
	acres					minutes	minutes	in/hr	cfs
A	113.00	0.70	79.10	56.36	56.36	33.0	33.0	5.50	310
B	2.6	0.30	0.78		57.14	10.0	33.0	5.50	314
C	21.6	0.80	17.28		74.42	15.0	39.5	5.05	376

TABLE 2

LINDBERGH DRAINAGE CHANNEL
SUMMARY OF CHANNEL PROPERTIES

STATION	100-YR FLOW	CHANNEL SLOPE	N-VALUE	VELOCITY	NORMAL DEPTH	CHANNEL DEPTH	100- YR WATER SURFACE ELEVATION		
							EXISTING	PROPOSED	DIFFERENCE
	cfs	%		ft/sec	feet	feet	feet	feet	feet
2+00	380	0.5	0.022	7.88	3.30	3.50	618.63	617.55	-1.08
5+00	380	0.5	0.022	7.76	3.04	3.25	620.92	618.79	-2.13
8+00	380	0.5	0.022	8.00	3.78	4.10	623.17	621.43	-1.74
10+00	380	0.5	0.022	7.43	2.55	2.75	625.06	622.80	-2.26
14+00	380	0.5	0.022	7.01	4.79	4.80	626.31	624.49	-1.82
16+00	320	0.5	0.022	6.77	3.98	4.00	626.28	624.68	-1.60

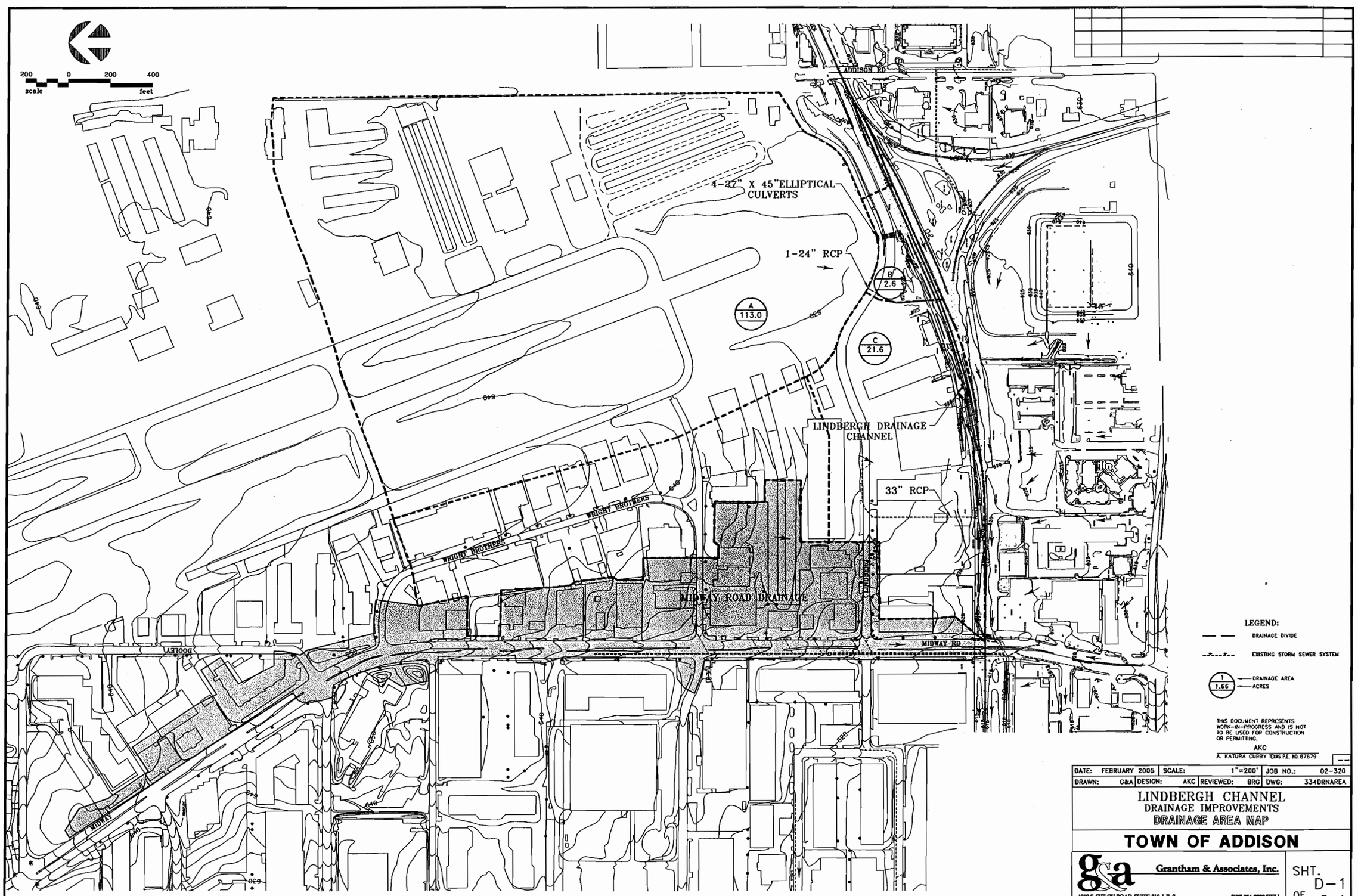
TABLE 3

LINDBERGH DRAINAGE CHANNEL
COMPARISON OF WATER SURFACE ELEVATION TO TOP OF RAIL

STATION	TOP OF RAIL	100-YR WATER SURFACE ELEVATION		FREEBOARD		
		EXISTING	PROPOSED	EXISTING	PROPOSED	INCREASE
	feet	feet	feet	feet	feet	feet
2+00	619.9	618.63	617.55	1.27	2.35	1.08
5+00	622.1	620.92	618.79	1.18	3.31	2.13
8+00	623.7	623.17	621.43	0.53	2.27	1.74
10+00	624.6	625.06	622.80	-0.46	1.80	2.26
14+00	626.7	626.31	624.49	0.39	2.21	1.82
16+00	627.9	626.28	624.68	1.62	3.22	1.60

Note: Top of Rail information based on information from the Arapaho Road field survey.

DRAINAGE AREA MAP



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PHOTOGRAPHS

Photo 1 - Looking Upstream at Midway Culvert

Photo 2 - Looking Downstream of Midway Culvert

Photo 3 - Upstream side of Midway Road

Photo 4 - Looking downstream from Midway Road

Photo 5 - Looking Upstream, near Midway

Photo 6 - Looking Downstream, Midway in background

Photo 7 - Existing broken RCP, to be removed. Looking Upstream

Photo 8 - Looking Upstream, near Bankston property

Photo 9 - Looking downstream from Lindbergh

Photo 10 - Lindbergh Culverts

FLOWMASTER CALCULATIONS
EXISTING

Worksheet for Section 2+00, existing

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	380.00	ft^3/s

Options		
Current Roughness Weighted Meth	ImprovedLotters	
Open Channel Weighted Roughnes	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.050	
Water Surface Elevation:	618.63	ft
Elevation Range:	613.75 to 618.50 ft	
Flow Area:	104.71	ft^2
Wetted Perimeter:	46.14	ft
Top Width:	43.00	ft
Normal Depth:	4.88	ft
Critical Depth:	3.39	ft
Critical Slope:	0.03352	ft/ft
Velocity:	3.63	ft/s
Velocity Head:	0.20	ft
Specific Energy:	5.08	ft
Froude Number:	0.41	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 618.25)	(0+43, 618.50)	0.050

Section Geometry

Station	Elevation
0+00	618.25
0+07	618.00

Worksheet for Section 2+00, existing

Station	Elevation
0+13	614.30
0+14	615.40
0+16	614.80
0+17	613.75
0+19	614.75
0+25	615.50
0+32	615.50
0+43	618.50

Worksheet for Section 5+00, existing

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	380.00	ft^3/s

Options		
Current Roughness Weighted Meth	ImprovedLotters	
Open Channel Weighted Roughnes	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.050	
Water Surface Elevation:	620.92	ft
Elevation Range:	615.00 to 620.00 ft	
Flow Area:	107.49	ft^2
Wetted Perimeter:	49.26	ft
Top Width:	45.00	ft
Normal Depth:	5.92	ft
Critical Depth:	4.81	ft
Critical Slope:	0.03531	ft/ft
Velocity:	3.54	ft/s
Velocity Head:	0.19	ft
Specific Energy:	6.11	ft
Froude Number:	0.40	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 619.75)	(0+45, 620.00)	0.050

Section Geometry

Station	Elevation
0+00	619.75
0+21	618.50

Worksheet for Section 5+00, existing

Station	Elevation
0+30	615.00
0+35	619.00
0+45	620.00

Worksheet for Section 8+00, existing

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	380.00	ft^3/s

Options	
Current Roughness Weighted Meth	ImprovedLotters
Open Channel Weighted Roughnes	ImprovedLotters
Closed Channel Weighted Roughne	Hortons

Results		
Roughness Coefficient:	0.060	
Water Surface Elevation:	623.17	ft
Elevation Range:	619.00 to 622.50 ft	
Flow Area:	149.26	ft^2
Wetted Perimeter:	85.17	ft
Top Width:	83.00	ft
Normal Depth:	4.17	ft
Critical Depth:	3.22	ft
Critical Slope:	0.05484	ft/ft
Velocity:	2.55	ft/s
Velocity Head:	0.10	ft
Specific Energy:	4.27	ft
Froude Number:	0.33	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 622.25)	(0+83, 622.50)	0.060

Section Geometry

Station	Elevation
0+00	622.25
0+40	621.50

Worksheet for Section 8+00, existing

Station	Elevation
0+54	620.00
0+58	619.00
0+62	620.50
0+83	622.50

Worksheet for Section 10+00, existing

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	380.00	ft^3/s

Options		
Current Roughness Weighted Meth	ImprovedLotters	
Open Channel Weighted Roughnes	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.050	
Water Surface Elevation:	625.06	ft
Elevation Range:	621.00 to 625.00 ft	
Flow Area:	111.20	ft^2
Wetted Perimeter:	53.63	ft
Top Width:	51.00	ft
Normal Depth:	4.06	ft
Critical Depth:	2.81	ft
Critical Slope:	0.03348	ft/ft
Velocity:	3.42	ft/s
Velocity Head:	0.18	ft
Specific Energy:	4.24	ft
Froude Number:	0.41	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 625.00)	(0+51, 623.00)	0.050

Section Geometry

Station	Elevation
0+00	625.00
0+45	621.00

Worksheet for Section 10+00, existing

Station	Elevation
0+51	623.00

Worksheet for Section 14+00, existing

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	380.00	ft^3/s

Options		
Current Roughness Weighted Meth	ImprovedLotters	
Open Channel Weighted Roughnes	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.050	
Water Surface Elevation:	626.31	ft
Elevation Range:	622.00 to 627.00 ft	
Flow Area:	125.80	ft^2
Wetted Perimeter:	73.00	ft
Top Width:	71.70	ft
Normal Depth:	4.31	ft
Critical Depth:	2.95	ft
Critical Slope:	0.03271	ft/ft
Velocity:	3.02	ft/s
Velocity Head:	0.14	ft
Specific Energy:	4.45	ft
Froude Number:	0.40	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 627.00)	(0+80, 626.00)	0.050

Section Geometry

Station	Elevation
0+00	627.00
0+12	626.00

Worksheet for Section 16+00, existing

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	320.00	ft^3/s

Options		
Current Roughness Weighted Meth	ImprovedLotters	
Open Channel Weighted Roughnes	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.050	
Water Surface Elevation:	626.28	ft
Elevation Range:	623.25 to 625.00 ft	
Flow Area:	97.38	ft^2
Wetted Perimeter:	49.79	ft
Top Width:	47.00	ft
Normal Depth:	3.03	ft
Critical Depth:	2.09	ft
Critical Slope:	0.03589	ft/ft
Velocity:	3.29	ft/s
Velocity Head:	0.17	ft
Specific Energy:	3.20	ft
Froude Number:	0.40	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 625.00)	(0+47, 625.00)	0.050

Section Geometry

Station	Elevation
0+00	625.00
0+14	623.75

Worksheet for Section 16+00, existing

Station	Elevation
0+15	623.25
0+41	624.75
0+47	625.00

FLOWMASTER CALCULATIONS
PROPOSED

Worksheet for Section 2+00

Project Description		
Flow Element:	Trapezoidal Channel	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Roughness Coefficient:	0.022	
Channel Slope:	0.00500	ft/ft
Left Side Slope:	2.00	ft/ft (H:V)
Right Side Slope:	2.00	ft/ft (H:V)
Bottom Width:	8.00	ft
Discharge:	380.00	ft^3/s

Results		
Normal Depth:	3.30	ft
Flow Area:	48.24	ft^2
Wetted Perimeter:	22.77	ft
Top Width:	21.21	ft
Critical Depth:	3.16	ft
Critical Slope:	0.00596	ft/ft
Velocity:	7.88	ft/s
Velocity Head:	0.96	ft
Specific Energy:	4.27	ft
Froude Number:	0.92	
Flow Type:	Subcritical	

GVF Input Data		
Downstream Depth:	0.00	ft
Length:	0.00	ft
Number Of Steps:	0	

GVF Output Data		
Upstream Depth:	0.00	ft
Profile Description:		
Headloss:	0.00	ft
Downstream Velocity:	Infinity	ft/s
Upstream Velocity:	Infinity	ft/s
Normal Depth:	3.30	ft
Critical Depth:	3.16	ft
Channel Slope:	0.00500	ft/ft

Worksheet for Section 2+00

Critical Slope:	0.00596	ft/ft

Worksheet for Section 5+00

Project Description		
Flow Element:	Trapezoidal Channel	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	
Input Data		
Roughness Coefficient:	0.022	
Channel Slope:	0.00500	ft/ft
Left Side Slope:	2.00	ft/ft (H:V)
Right Side Slope:	2.00	ft/ft (H:V)
Bottom Width:	10.00	ft
Discharge:	380.00	ft^3/s
Results		
Normal Depth:	3.04	ft
Flow Area:	48.94	ft^2
Wetted Perimeter:	23.61	ft
Top Width:	22.17	ft
Critical Depth:	2.91	ft
Critical Slope:	0.00595	ft/ft
Velocity:	7.76	ft/s
Velocity Head:	0.94	ft
Specific Energy:	3.98	ft
Froude Number:	0.92	
Flow Type:	Subcritical	
GVF Input Data		
Downstream Depth:	0.00	ft
Length:	0.00	ft
Number Of Steps:	0	
GVF Output Data		
Upstream Depth:	0.00	ft
Profile Description:		
Headloss:	0.00	ft
Downstream Velocity:	Infinity	ft/s
Upstream Velocity:	Infinity	ft/s
Normal Depth:	3.04	ft
Critical Depth:	2.91	ft
Channel Slope:	0.00500	ft/ft

Worksheet for Section 5+00

Critical Slope:	0.00595	ft/ft

Worksheet for Section 8+00

Project Description		
Flow Element:	Trapezoidal Channel	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	
Input Data		
Roughness Coefficient:	0.022	
Channel Slope:	0.00500	ft/ft
Left Side Slope:	2.00	ft/ft (H:V)
Right Side Slope:	2.00	ft/ft (H:V)
Bottom Width:	5.00	ft
Discharge:	380.00	ft^3/s
Results		
Normal Depth:	3.78	ft
Flow Area:	47.50	ft^2
Wetted Perimeter:	21.91	ft
Top Width:	20.12	ft
Critical Depth:	3.62	ft
Critical Slope:	0.00600	ft/ft
Velocity:	8.00	ft/s
Velocity Head:	0.99	ft
Specific Energy:	4.78	ft
Froude Number:	0.92	
Flow Type:	Subcritical	
GVF Input Data		
Downstream Depth:	0.00	ft
Length:	0.00	ft
Number Of Steps:	0	
GVF Output Data		
Upstream Depth:	0.00	ft
Profile Description:		
Headloss:	0.00	ft
Downstream Velocity:	Infinity	ft/s
Upstream Velocity:	Infinity	ft/s
Normal Depth:	3.78	ft
Critical Depth:	3.62	ft
Channel Slope:	0.00500	ft/ft

Worksheet for Section 8+00

Critical Slope:	0.00600	ft/ft

Worksheet for Section 10+00

Project Description		
Flow Element:	Trapezoidal Channel	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Roughness Coefficient:	0.022	
Channel Slope:	0.00500	ft/ft
Left Side Slope:	2.00	ft/ft (H:V)
Right Side Slope:	2.00	ft/ft (H:V)
Bottom Width:	15.00	ft
Discharge:	380.00	ft^3/s

Results		
Normal Depth:	2.55	ft
Flow Area:	51.16	ft^2
Wetted Perimeter:	26.39	ft
Top Width:	25.19	ft
Critical Depth:	2.42	ft
Critical Slope:	0.00600	ft/ft
Velocity:	7.43	ft/s
Velocity Head:	0.86	ft
Specific Energy:	3.40	ft
Froude Number:	0.92	
Flow Type:	Subcritical	

GVF Input Data		
Downstream Depth:	0.00	ft
Length:	0.00	ft
Number Of Steps:	0	

GVF Output Data		
Upstream Depth:	0.00	ft
Profile Description:		
Headloss:	0.00	ft
Downstream Velocity:	Infinity	ft/s
Upstream Velocity:	Infinity	ft/s
Normal Depth:	2.55	ft
Critical Depth:	2.42	ft
Channel Slope:	0.00500	ft/ft

Worksheet for Section 10+00

Critical Slope:	0.00600	ft/ft

Worksheet for Section 14+00

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	380.00	ft^3/s

Options		
Current Roughness Weighted Meth	ImprovedLotters	
Open Channel Weighted Roughnes	ImprovedLotters	
Closed Channel Weighted Roughne	Hortons	

Results		
Roughness Coefficient:	0.022	
Water Surface Elevation:	624.49	ft
Elevation Range:	619.70 to 624.50 ft	
Flow Area:	54.18	ft^2
Wetted Perimeter:	30.44	ft
Top Width:	24.56	ft
Normal Depth:	4.79	ft
Critical Depth:	4.50	ft
Critical Slope:	0.00748	ft/ft
Velocity:	7.01	ft/s
Velocity Head:	0.76	ft
Specific Energy:	5.55	ft
Froude Number:	0.83	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 624.50)	(0+25, 624.50)	0.022

Section Geometry

Station	Elevation
0+00	624.50
0+05	622.25

Worksheet for Section 14+00

Station	Elevation
0+07	622.21
0+07	619.70
0+10	619.70
0+10	622.00
0+20	622.20
0+25	624.50

Worksheet for Section 16+00

Project Description		
Flow Element:	Irregular Section	
Friction Method:	Manning Formula	
Solve For:	Normal Depth	

Input Data		
Channel Slope:	0.00500	ft/ft
Discharge:	320.00	ft^3/s

Options	
Current Roughness Weighted Meth	ImprovedLotters
Open Channel Weighted Roughnes	ImprovedLotters
Closed Channel Weighted Roughne	Hortons

Results		
Roughness Coefficient:	0.022	
Water Surface Elevation:	624.68	ft
Elevation Range:	620.70 to 624.75 ft	
Flow Area:	47.28	ft^2
Wetted Perimeter:	28.03	ft
Top Width:	23.57	ft
Normal Depth:	3.98	ft
Critical Depth:	3.73	ft
Critical Slope:	0.00728	ft/ft
Velocity:	6.77	ft/s
Velocity Head:	0.71	ft
Specific Energy:	4.69	ft
Froude Number:	0.84	
Flow Type:	Subcritical	

Segment Roughness

Start Station	End Station	Roughness Coefficient
(0+00, 624.75)	(0+24, 624.70)	0.022

Section Geometry

Station	Elevation
0+00	624.75
0+05	622.50

Worksheet for Section 16+00

Station	Elevation
0+07	622.46
0+07	620.70
0+10	620.70
0+10	622.40
0+20	622.60
0+24	624.70