3050 Post Oak Blvd., Suite 300
Houston, Texas 77056
tel: 713-423-7300
fax: 713-840-0173

January 30, 2014

Mr. John Lothrop
City of League City
305 East Main Street
League City, Texas 77573

Subject: City of League City, Texas
State Highway 3 Booster Pump Station Improvements Project
Request for Additional Services Funding and Authorization
CDM Smith P/N: 2070-83930

Dear Mr. Lothrop:

CDM Smith is requesting authorization of additional funding for both Basic Services and Additional Services in support of the State Highway Booster Pump Station and 36-inch Pipeline Improvements Project. There are several tasks in which additional compensation is being requested due to reasons outside of our control. The additional compensation is for work beyond our current scope of services and acknowledged by the City as necessary to complete the projects.

Several of these out of scope services have already been completed in good faith without delay for the benefit of City and the project in terms of controlling cost claims. A summary of costs already incurred and estimated at completion are presented in the Table below. Please note the costs shown below represent the entire Design Team's efforts.

No.	Task/Description	Spent to Date	Anticipated Additional Amount	Total Out of Scope Services Amount
1	***Landscape/Irrigation Design*** City of Webster classified the facility as commercial/retail with regard to landscape & irrigation requirements necessitating the preparation of landscaping and irrigation construction documents and specifications.	$9,200	$0	$9,200
2	***36-inch Pipeline Design Revisions*** Design proceeded to a 30% level when pipeline alignment changed due to route revisions necessitated by other parties (Genco and less expensive alternatives). **Revised alignment capital cost savings exceed $1.3M.**	$0.00	$68,100	$68,100

No.	Task/Description	Spent to Date	Anticipated Additional Amount	Total Out of Scope Services Amount
3	***City of Houston – Flow Metering Station Design Changes*** Significant design revisions required due to protracted review and input by the City of Houston reviewing authority. Resulted in a significant number of drawing changes to accommodate the COH demands.	$51,000	$0.00	$51,000
4	***Generator Set Removal From Drawings*** City elected to remove the standby generator scope from the SH3 Improvements project in an effort to capitalize on grant funding. Requires revision to construction drawings, additional modifications to record drawings and coordination with 3rd party City consultant team resulting in a $583,000 savings to the construction cost.	$16,300	$0.00	$16,300
5	***Transient Surge Analysis – 36-inch Piping Revised Alignment*** Due to new alignment change need to re-run the transient surge analysis with the new alignment. Revised alignment capital cost savings exceed $1.3M.	$0.00	$18,100	$18,100
6	***Additional Survey Based on Revised Pipeline Route*** Request for contract supplement to provide for survey additional services for revised pipeline route. Revised alignment capital cost savings exceed $1.3M.	$0.00	$155,600	$155,600
	Total	$76,500	$241,800	**$318,300**

As previously discussed, the Design Team plans on continued execution of these out of scope tasks with the mutual understanding we will be compensated accordingly. A detailed summary/ justification for each task is described below. A detailed breakdown of the level of effort is shown in **Attachment A**.

Architectural and Landscape/Irrigation Requirements

As you are aware, the SH 3 Booster Pump Station is physically located in the City of Webster. During the course of final design and permitting process, the City of Webster determined the facility would be classified as commercial/retail and would therefore be required to comply with the relevant ordinances which included commercial landscaping with irrigation systems to support the landscaping. To comply with this requirement, it was required to prepare an architectural package for the City of Webster to review that included proposed landscaping including plant types, hedge and shrub types, and irrigation systems and construction drawings for review. Per Section IV.1.15

of Exhibit A of the professional services agreement, landscape and irrigation design was not included in the original Scope of Services.

36-inch Pipeline Design Revisions

During the preliminary engineering of the 36-inch pipeline, several initial pipeline routes were identified and discussed with the City and the City's surveyor. As a result of these efforts, a pipeline alignment as indicated in **Attachment B** was selected. After a lengthy delay in field survey results, it was determined that a less costly (capital and O&M) route is available between stations 31+00 and 91+00. Additionally, conflicts (and associated high costs) with the CenterPoint/Genco canal alignment resulted in the need to significantly modify the proposed waterline alignment from station 91+00 to 172+50 and from 178+50 to 207+00. In total 16,400 linear feet of the originally planned 17,100 linear feet (or 95%) had to be relocated. As a result of this alignment change, nearly all generated sheets need to be discarded in favor of new sheets to reflect the revised alignment. **However, the estimated capital savings is over $1.3 million.**

City of Houston – Flow Metering Station Design Changes

Design improvements to this project required coordination with the City of Houston due to the fact that the City of League City is a Co-Participant (via GCWA) where wholesale water is obtained from the Southeast Water Purification Plant (SEWPP). A chain of custody flow metering station is required at each Co-Participant take point site thus requiring coordination with the City of Houston (COH) design review authority.

CDM Smith has extensive experience with the COH Flow Metering Station design review group starting from the design of the Katy Addicks Surface Water Pump Station Project (2000), SEWPP Co-Participant Flow Strategy Report (2007), and City of Pearland Alice Street Water Plant Improvements Project (2009) which is nearly identical to the SH 3 project in concept as the Alice Street Water Plant is one of two of Pearland's Co-Participant take points.

Based on our past successful projects and our excellent professional relationships with COH staff, CDM Smith anticipated a similar execution process to obtain COH approval. In general, that process, in order, would consist of jointly meeting with COH and League City staff at the very early stages of the project to communicate the project scope and needs, develop concept sketches and flow diagrams for initial review and approval prior to beginning detailed design, submitting 30% drawings for review and comment, submit the 90% drawings for final review, and then make any minor corrections necessary to submit the 100% drawing set for signature and approval. This process is designed to minimize redesign efforts, expedite the design schedule, and have a high level of confidence regarding cost implications as the project moves through the design stage in order to minimize any unexpected costs during the construction phase.

Despite our best intentions and a proven execution strategy, several difficulties were encountered with the COH. These difficulties were attributed to COH staff turnover which resulted in inconsistent design philosophy within the City of Houston. Additionally, during our initial coordination meeting with the COH on September 1, 2011, were made aware of the reluctance of City of Houston staff to share information during the design process and therefore required the 100% complete design, including League City approvals before the COH would begin their review process.

The CDM Smith design team proceeded with the preparation of construction drawings, utilizing the same COH chain of custody design philosophy approved in their most recent Co-Participant project for the City of Pearland. These 100% complete construction drawings for SH 3 Booster Pump Station Project were submitted to the City of Houston on September 20, 2012. The results of the first COH review required the revision of 65 drawings and the addition of additional flow meters and backflow prevention devices that added an additional $300,000 in construction cost and would also require League City to maintain these additional devices in perpetuity.

League City staff was promptly informed of the results of the COH review. Due to the overall completion schedule of the project, revisions immediately commenced followed by joint COH and League City coordination meetings. This process continued with two more resubmittals and subsequent joint coordination meetings with the number of subsequent revisions being dramatically reduced at each review submission milestone. Through the course of the coordination meetings, the CDM Smith design team, working with League City staff, was successful in coming up with a revised design that allowed the successful negotiation to remove the additional flow meters and backflow prevention devices and **therefore saving League City approximately $300,000 in additional construction costs.**

In **Attachment C** to this letter is included a Summary Memorandum dated August 9, 2013 summarizing all of the required changes for this project. Also attached is a listing of drawings submitted to the City of Houston along with number of required revisions in order to gain signature acceptance by the COH.

Our original scope contemplated and made provisions for additional efforts associated with gaining COH approval through a separate additional service budget of $10,000. This additional service was to cover the additional coordination meetings with the COH. If the project would have followed the normal and customary anticipated process, the CDM Smith design team would have been able to prepare the design drawings alongside and in conjunction with the COH coordination process with very little additional effort. As you are aware, the construction drawing process typically starts with the piping arrangements and once those are solidified, the other disciplines, such as electrical, structural, and instrumentation, design in support of and around the large piping and valve systems. However, because the COH deviated from past historical project protocols and required a

completed set before providing any review comments, any required changes to the piping system would also require coordinated changes to the electrical, structural, and instrumentation discipline drawings as well, and substantially increasing the level of effort for each design review submittal.

Obtaining approval for this project from the COH involved additional extensive coordination, communication, and multiple extra meetings to understand the scope of COH requirements. As a result, costs associated with the original COH coordination effort budget of $10,000 were approximately $20,000. The additional efforts necessary to revise the completed construction drawings was $68,000 for a total additional effort of $78,000. CDM Smith is requesting approximately $51,000 in additional funding as the balance of the remaining effort would be considered inclusive of the original scope. Therefore, CDM Smith is respectfully requesting reimbursement for the additional extra efforts necessary to revise the completed construction drawings to COH satisfaction in order to gain the necessary approvals. These revisions also included additional design elements that eliminated the need to provide the additional backflow prevention and flow metering devices originally requested by the COH **and therefore saving League City $300,000 construction costs.**

Generator Set Removal from Drawings

A recent scope change implemented by the City on this project was to remove the generator set from the current project scope in an effort to capture available CDBG grant funding for the installation of the proposed 1,750 kW diesel engine generator set and related appurtenances at the SH3-BPS **resulting in a net savings of approximately $580,000 to the City.** CDM Smith coordinated both with the City of League City and PBK (the City's generator set design consultant) to provide information and design insight on the elements to be placed in a separate bid package.

Transient Surge Analysis – New 36-inch Alignment

As part of the alignment change for the 36-inch pipeline from SH3-BPS to the SSH-BPS, a revised hydraulic transient analysis will need to be performed to confirm protective surge devices and control valve settings. CDM Smith had previously completed the surge analysis for the original pipeline route as indicated in **Attachment D**.

Funding Request

In summary the CDM Smith Team is requesting additional funding authorization(s) for out of scope work that has been completed and for work efforts that are still necessary to complete the project. The current total contract amount for Basic and Additional Services is $1,600,000 for both the booster pump and waterline projects or just over 6% of the construction cost. The proposed amendment amount of $318,300 represents approximately 1.2% of the construction cost (7.2% total).

The CDM Smith team is committed to continuing our high level of support in good faith for the benefit of City and the project on these out of scope tasks with the mutual understanding we will be compensated accordingly. Should you have any questions or need further information, please call me at 713-423-7300.

Sincerely,

Jeffrey S. Peters, P.E., BCEE
Principal Engineer
CDM Smith Inc.
TBPE Firm Registration No. F-3043

Attachments

cc: Brent Nicholas & Kim Chanslor, File – CDM Smith

City of League City, Texas
State Highway 3 Booster Pump Station Improvements
CDM Smith P/N 2070-83930
Engineering Fee Proposal for Additional Services

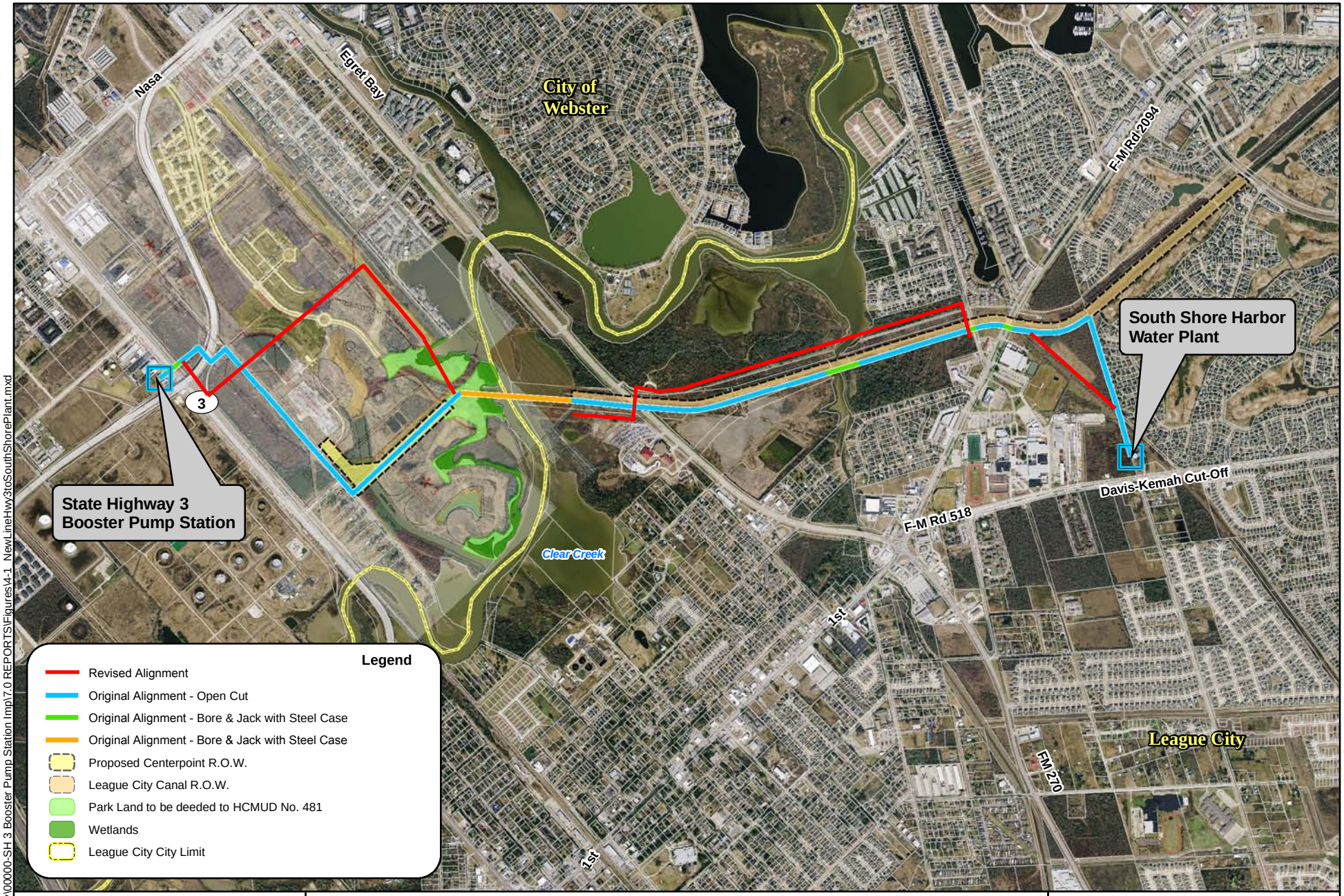
ATTACHMENT A

Item	Description / Task	Estimated Man-hours: Principal (hrs.)	Technical Director(s) (hrs.)	Project Manager (hrs.)	Engr. Grade 7/8 (hrs.)	Engr. Grade 5/6 (hrs.)	Engr. Grade 3/4 (hrs.)	Designer (hrs.)	Cost Estimator (hrs.)	Sr. Word Processor (hrs.)	Contract Admin 5/6 (hrs.)	Admin Assistant (hrs.)	Subtotal (hrs.)	Subtotal (cost $)	Subs (cost $)	Subs (cost+10%)	Other Direct Costs	Total Fee (hrs. + Sub Markup of 10% + ODC)
		$ 200.00	$ 175.00	$ 165.00	$ 175.00	$ 150.00	$ 135.00	$ 120.00	$ 150.00	$ 100.00	$ 100.00	$ 90.00						
ADDITIONAL SERVICES REQUIRED																		
TASK 1.4 (NEW)	LANDSCAPE & IRRIGATION DESIGN & SUPPORT AND ADDITIONAL ARCHITECTURAL SERVICES																	
1	Landscape & Irrigation design & support services														$ 7,900.00	$ 8,690.00		$ 8,690.00
2	Project Task Expenses (Shipping, Supplies, Repro, etc.)													$ -	$ -	$ -	$ 434.50	$ 434.50
	Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	$ -	$ 7,900.00	$ 8,690.00	$ 434.50	$ 9,200.00
TASK 2.2	36-INCH PIPELINE DESIGN REVISIONS																	
1	Project Management, City Alternate Route Design and Support, and Surveyor Coordination	20		48		60					12	8	148	$ 22,900.00		$ -	$ -	$ 22,900.00
	REVISED DRAWINGS																	
2	Revised Key Plans and Exhibits			8		24		32					64	$ 8,800.00		$ -	$ -	$ 8,800.00
3	Completely Revise Plan & Profile Sheets		8	24		48		88					168	$ 23,200.00		$ -	$ -	$ 23,200.00
4	Specification Revisions (Add HDPE pipe specification)		2	4		8				4			18	$ 2,700.00		$ -	$ -	$ 2,700.00
5	Internal QA-QC on new alignment changes	8	32										40	$ 7,200.00		$ -	$ -	$ 7,200.00
6	Project Task Expenses (Shipping, Supplies, Repro, etc.)													$ -	$ -	$ -	$ 3,240.00	$ 3,240.00
	Subtotal	28	42	84	0	140	0	120	0	4	12	8	438	$ 64,800.00	$ -	$ -	$ 3,240.00	$ 68,100.00
TASK 3.09	CITY OF HOUSTON - FLOW METERING STATION DESIGN CHANGES																	
1	Extra COH DWO, City Engineer, and Permitting Meetings		8	8		8				2			26	$ 4,200.00	$ -	$ -	$ -	$ 4,200.00
2	Design Change Engineering, Control Strategy Change			8	20	8	16			4			56	$ 8,600.00	$ -	$ -	$ -	$ 8,600.00
3	Drawing Revisions (See attached list)			16	24		32	72					144	$ 19,800.00	$ -	$ -	$ -	$ 19,800.00
3	Design Summary Package Creation for COH Reviewers			4	16		32			4	3	4	63	$ 8,900.00	$ -	$ -	$ -	$ 8,900.00
4	COH Permitting Review Coordination, Responding to Multiple Rounds of Review Comments, Face to Face Meetings with Reviewers, etc.			4	8		32				2	4	50	$ 7,000.00	$ -	$ -	$ -	$ 7,000.00
5	Project Task Expenses													$ -	$ -	$ -	$ 2,425.00	$ 2,425.00
	Subtotal	0	8	40	68	16	112	72	0	10	5	8	339	$ 48,500.00	$ -	$ -	$ 2,425.00	$ 51,000.00
TASK 3.10	GENERATOR SET REMOVAL FROM DRAWINGS																	
1	Drawing Revisions to Show Generator and SPCC Containment Area by Others (Record Drawings)		1	4	4		16	32					57	$ 7,600.00	$ 2,500.00	$ 2,750.00	$ -	$ 10,350.00
2	Coordination with Other City Subconsultant			4			4	8					16	$ 2,200.00		$ -	$ -	$ 2,200.00
3	Review of Other City Subconsultant Design Package; email comments to City		2	4	8					4				$ 2,900.00		$ -	$ -	$ 2,900.00
4	Project Task Expenses													$ -	$ -	$ -	$ 780.00	$ 780.00
	Subtotal	0	3	12	12	0	20	40	0	4	0	0	73	$ 12,700.00	$ 2,500.00	$ 2,750.00	$ 780.00	$ 16,300.00

City of League City, Texas
State Highway 3 Booster Pump Station Improvements
CDM Smith P/N 2070-83930
Engineering Fee Proposal for Additional Services

ATTACHMENT A

Item	Description / Task	Estimated Man-hours											Subtotal (hrs.)	Subtotal (cost $)	Subs (cost $)	Subs (cost+10%)	Other Direct Costs	Total Fee (hrs. + Sub Markup of 10% + ODC)
		Principal (hrs.)	Technical Director(s) (hrs.)	Project Manager (hrs.)	Engr. Grade 7/8 (hrs.)	Engr. Grade 5/6 (hrs.)	Engr. Grade 3/4 (hrs.)	Designer (hrs.)	Cost Estimator (hrs.)	Sr. Word Processor (hrs.)	Contract Admin 5/6 (hrs.)	Admin Assistant (hrs.)						
		$ 200.00	$ 175.00	$ 165.00	$ 175.00	$ 150.00	$ 135.00	$ 120.00	$ 150.00	$ 100.00	$ 100.00	$ 90.00						
TASK 4.5	TRANSIENT SURGE ANALYSIS - NEW 36-INCH PIPING - REVISED ALIGNMENT																	
1	Transient Model Update Based on New Alignment and changes to SH3-BPS from City of Houston requirements		2	4	20								26	$ 4,600.00	$ 3,500.00	$ 3,850.00	$ -	$ 8,450.00
2	Rerun Surge CASE Conditions			2	26								28	$ 4,900.00		$ -	$ -	$ 4,900.00
3	Issue Report with Model results and recommendations - QA/QC		4	4	10					6			24	$ 3,800.00		$ -	$ -	$ 3,800.00
4	Project Task Expenses													$ -	$ -	$ -	$ 860.00	$ 860.00
	Subtotal	0	6	10	56	0	0	0	0	6	0	0	78	$ 13,300.00	$ 3,500.00	$ 3,850.00	$ 860.00	$ 18,100.00
TASK 4.6 (New)	ADDITIONAL SURVEY - RE-ROUTE																	
1	Boundary Field work, Research, and Legal Work			2			10					2	14	$ 1,900.00	$ 52,000.00	$ 57,200.00		$ 59,100.00
2	Survey 100ft Cross Sections at 50ft intervals along alignment and water crossings and tying in structures and surface improvements along route			4			10					0	14	$ 2,100.00	$ 46,000.00	$ 50,600.00		$ 52,700.00
3	Coordinate with utility companies and acquire maps			6			12					2	20	$ 2,800.00	$ 5,000.00	$ 5,500.00		$ 8,300.00
4	Provide horizontal and vertical control			2			6					0	8	$ 1,200.00	$ 5,000.00	$ 5,500.00		$ 6,700.00
5	Prepare CAD model			4			8					0	12	$ 1,800.00	$ 9,000.00	$ 9,900.00		$ 11,700.00
6	Construction Control Staking			2			4					0	6	$ 900.00	$ 5,000.00	$ 5,500.00		$ 6,400.00
7	Stake Geotech Bore Holes			1			2					0	3	$ 500.00	$ 2,500.00	$ 2,750.00		$ 3,250.00
8	Project Task Expenses																$ 7,410.00	$ 7,410.00
	Subtotal	0	0	21	0	0	52	0	0	0	0	4	77	$ 11,200.00	$ 124,500.00	$ 136,950.00	$ -	$ 155,600.00
	TOTAL ADDITIONAL SERVICES - CONTRACT SUPPLEMENT																	$ 318,300.00



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CDM

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LEAGUECITY TEXAS

City of League City, Texas
State Highway 3 Booster Pump Station Improvements
Preliminary Engineering Design

2070-83930

ATTACHMENT B

New 36" Distribution Line
State Highway 3 Booster Pump Station
to South Shore Harbor Water Plant

August 2013

ATTACHMENT C

TBPE Firm Registration No. F-3043

Memorandum

To: *Bobby Morrison – City of League City*

From: *Brent W. Nicholas, P.E.*

Date: *August 9, 2013*

Subject: *State Highway 3 Booster Pump Station Improvements Project*
Summary of Changes Required to Obtain City of Houston Approval
CDM Smith P/N 2070-83930

This memorandum presents a summary of all changes made to the original bid set of drawings for the City of League City Booster Pump Station Improvements Project, which were required to obtain necessary approvals from the City of Houston (COH).

City of Houston Permitting Review Process

Obtaining approval for this project from the COH Permitting Department involved extensive coordination, communication, and meetings to understand the scope of COH's required changes. Approval was also obtained from the COH Planning and Development Services Division for operational criteria related to the emergency bypass line. Approval for this project was granted by the COH after several rounds of design phase coordination meetings and design submissions where changes were made to the original bid set of drawings. The following summarizes these events:

1. Meeting with COH on September 1, 2011
2. 90% Milestone Deliverable to the COH on September 20, 2012
3. Received COH Review Comments September 28, 2012
4. Meeting with COH on November 21, 2012
5. Meeting with COH on January 22, 2013
6. 100% Submittal to COH on March 6, 2013
7. Received COH Review Comments on March 19, 2013
8. Revised 100% Submittal to COH on April 25, 2013

9. Received copy of COH City Engineer Approval Letter on June 19, 2013

10. Received signed Mylar drawings from COH on July 15, 2013.

Changes Required for COH Approval

The following list provides a break-down of all changes that were made to the original bid set of drawings since they were 100% Issued For Construction in July of 2012. In addition to the drawings referenced in the items listed below, the updated changes were applied to all associated backgrounds throughout the drawing set:

- Proposed civil site plans were modified to show site drainage details and referenced TxDOT permit and a COH requested gravel driveway was added to the northern corner of the site (see sheet GS-C-2).

- Existing driveway was modified to include expanded turning radius and added associated section cut (see sheets GS-C-2 and STD-C2) as described in updated TxDOT permit.

- Detail added on fuel spill containment basin to meet COH Storm and Stormwater Quality Department requirements (see sheet STD-C-6).

- The 24" bypass line to the 36-inch South Shore Harbor Booster Pump Station facility and associated end-piping directly downstream of the flow control valves was eliminated on the proposed flow metering station to meet COH Water and Facilities Department requirements (see sheet GS-C-5, FMS-M-2 and FMS-M-3).

- A new backflow preventer (BFP) assembly has been included on the 42" emergency bypass line, along with associated isolation valves, air release valves, water quality blow-off hydrants, piping, and appurtenances. The PVC sample lines from the Flow Metering Station were rerouted to accommodate the new BFP (see sheets GS-C-5 and BFP-M-1).

- Underground electrical ductbank was re-routed, associated electrical schedules and one-line diagrams were modified, and terminal cabinets have been re-positioned on electrical site plans to accommodate flow metering station changes and new BFP assembly requirements (see sheets GS-E-4, GS-E-7 and GS-E10).

- Limits of metering station ownership were indicated on the existing flow metering station drawings (see sheet FMS-M-1).

- The layout of the proposed 30-inch chain of custody transfer magnetic flowmeters and League City 30-inch validation magmeters located on the proposed flow metering station has been modified to meet COH standards/recommendations (see sheets FMS-M-2 and FMS-M-3).

- Plan and section views for the updated valve vault have been included with associated appurtenances on the 42" emergency bypass line to provide for maintenance of water quality (see sheet GST-M-5).

- Several Process and Instrumentation Diagrams were updated to account for all changes and additions made to accommodate COH requirements. Same for many electrical drawings which were updated to reflect COH requirements.

Included Documents:

A. Original Bid Set of Drawings that were issued for construction in July of 2012.

B. Revised Conformed Drawing Sets including all City of Houston approval signatures.

   a. One full size conformed drawing set
   b. Three 11"x17" half-size conformed drawing sets
   b. Three CD-ROM copies of the indexed conformed drawing set

cc: Jody Hooks, John Lothrop – City of League City
Jeff Peters, Project File – CDM Smith

City of Houston Review Timeline: ✓= Additional Revisions Made to Drawing per COH Request

Sheet	90% Milestone Deliverable to the COH - 9/20/2012	Received COH Review Comments - 9/28/2012	Meeting with COH -11/21/2013	Meeting with COH - 1/22/2013	100% Submittal to COH - 3/16/2013	Received COH Review Comments - 3/19/2013	Revised 100% Submittal to COH - 4/25/2013	Received signed Mylar drawings from COH - 7/16/201	TOTAL REVISION CYCLES
GP-G-1		✓			✓		✓	✓	4
GP-G-2		✓			✓				2
GP-G-3		✓							1
GP-G-4		✓							1
GP-G-5		✓							1
GP-M-1		✓							1
GP-M-2		✓			✓				2
GP-M-3		✓							1
GS-C-1		✓							1
GS-C-2		✓			✓		✓		3
GS-C-3		✓							1
GS-C-4		✓							1
GS-C-5		✓			✓		✓	✓	4
GS-C-6		✓			✓		✓		3
GS-C-8		✓			✓		✓		3
GS-C-10		✓			✓		✓		3
STD-C-2		✓			✓		✓		3
STD-C-6		✓			✓		✓		3
FMS-M-1		✓							1
FMS-M-2		✓			✓		✓		3
FMS-M-3		✓			✓		✓		3
GST-M-1		✓							1
GST-M-2		✓			✓				2
GST-M-3		✓							1
GST-M-4		✓							1
GST-M-5		✓							1
GST-M-6		✓							1
GST-M-7		✓							1
GST-M-8		✓							1
GST-M-9		✓							1
GST-M-10		✓							1
GST-M-11		✓							1
GST-M-12		✓							1
GST-M-13		✓							1
GST-M-14		✓							1
GST-M-15		✓							1

City of Houston Review Timeline: ✓= Additional Revisions Made to Drawing per COH Request

Sheet	90% Milestone Deliverable to the COH - 9/20/2012	Received COH Review Comments - 9/28/2012	Meeting with COH -11/21/2013	Meeting with COH - 1/22/2013	100% Submittal to COH - 3/16/2013	Received COH Review Comments - 3/19/2013	Revised 100% Submittal to COH - 4/25/2013	Received signed Mylar drawings from COH - 7/16/201	TOTAL REVISION CYCLES
BFP-M-1		✓			✓				2
GS-S-1		✓							1
GS-S-2		✓							1
GS-S-3		✓							1
GS-E-1		✓							1
GS-E-2		✓							1
GS-E-3		✓			✓				2
GS-E-4		✓			✓				2
GS-E-5		✓							1
GS-E-6		✓							1
GS-E-7		✓							1
GS-E-8		✓							1
GS-E-9		✓							1
GS-E-10		✓							1
GS-E-11		✓							1
GS-E-15		✓							1
GS-E-16		✓							1
FMS-E-1		✓			✓		✓		3
GST-E-1		✓							1
GST-E-2		✓							1
GS-I-1		✓							1
GS-I-2		✓							1
GS-I-3		✓							1
GS-I-6		✓							1
GS-I-7		✓			✓				2
GS-I-8		✓			✓				2
GS-I-9		✓			✓				2
GS-I-10		✓			✓				2
STD-I-5		✓							1

ATTACHMENT D

Memorandum

To: *Brent W. Nicholas, P.E*

From: *Peter Barthuly, P.E. (MA)*

Date: *July 12, 2012 (revised 8/7/2012)*

Subject: *City of League City, TX*
State Highway Booster Pump Station & 36-in Pipeline Project
Water Hammer Analysis
36-in Transmission-SH3 HST & BPS to SSH GST
2070-83930

The water hammer analysis performed is for the 36-in diameter transmission main that is supplied by the State Highway 3 Booster Pump Station (SH3 BPS) and conveyed to the South Shore Harbor Booster Pump Station (SSH-BPS) GSTs. The analysis was done for the occasion of power failure to the pumps. The flows used in the analysis were 10,000-gpm (22.3-cfs) and 20,000-gpm (44.6-cfs). The analysis was run for water levels at the SH3 GST that range from 20-ft to 56.25-ft (MSL elevations). The discharge elevation of the transmission main at the SSH-BPS GST is an air break at elevation 47.8-ft MSL.

Three pumps were presumed to be operating to supply 20,000-gpm to the 36-in diameter pipeline (one pump for 10,000-gpm). The control valve (globe style piston valve) at each pump discharge is 16-in diameter. The maximum velocity through each control valve is 10.6-fps. While on the high side, the valve's operation should be okay. The manufacturer of the electric check valve (Golden-Anderson), however, should be consulted. The profile used in the analysis is attached and is assumed to represent the centerline of the 36-in pipeline.

The objective of the analysis is to prevent water column separation along the 36-in transmission main. The worst case for column separation occurs at the low water level condition within the SH3-BPS GST. The analysis was then run at the maximum water level at SH3 GST to estimate the highest pressure surge. The recommended surge control to prevent water column separation is to install a 3-in air inlet valve-AIV (e.g., APCO Model 1500-S or equal) and a 1-in diameter outlet (the larger of the two outlets) air release valve ARV (e.g., APCO Model 142DAT or equal) at each pump discharge. The AIV's and ARV's should be installed on 90 degree vertical tees (**Figure 1**). The valves would be mounted on the blind flange of the tee. In addition, the pump discharge control valve is required to close over a time no less than 180 seconds. The manufacturer should be consulted on this closing time.

A 3-in outlet AIV is required along the pipeline at a location of about 16,200-ft from the SH3 BPS where the transmission main rises to an elevation of 11-ft and cause a "knee" in the profile (**Figure 2**). No air release is required because the admitted air will be carried to the discharge point of the pipeline at the SSH-BPS GSTs.

The type of AIV recommended at each pump discharge tee only admits air. To prevent the expulsion of air the spring assisted disc closes. The ARV's installed along side of each AIV are double acting and the air expulsion rate can be adjusted if necessary to prevent rapid air pocket collapse and subsequent excessive pressure surges.

Without the AIV's installed, the attached graphs (A and B) show water column separation and high pressure surges at the pump control valves along the transmission main at Node J-17 (see **Figure 1** for node location). With the recommended surge controls installed (slow closing pump discharge valves; AIV's; CARV's), the water column separation is prevented and pressure surges mitigated. The highest pressure surge is caused by the air pocket collapse at the ARV's. Attached graphs C and D, respectively show the pressure rise at the outlet of the pump control valve in pressure (psi) and Hydraulic Gradeline Elevation (HGLE) (project datum). Graph E and F, respectively shows the pressure rise at the SH3 BPS AVI valves; and, air volume admitted into the pipeline at each AIV at the SH3 BPS.

The attached Graph G shows the HGLE during the failure of one of the three pumps conveying 10,000-gpm. To provide a safety factor, the recommended pressure surge HGLE for the transmission main is 185-ft which is 71-psi at the pump control valves and 84-psi at the pipeline low elevation (-10-ft). In reality, the friction along the pipeline will cause the pressure surge to be less than 84-psi along the pipeline including its low point.

For the 20,000-gpm analysis during the event of one pump failing while the other two pumps continue to operate, graphs H and I are attached. Graph H shows the HGLE momentarily drops until it recovers to steady state flow; while graph I shows that the operating pumps flow momentarily decreases before flow recovers to steady state.

In case the pump control valve doesn't close during a power failure, the overflow at the GST's should be designed to handle runaway reverse pump flow of at least 17-cfs. This is for the total of three pumps. Before restarting the pumps after a power failure, allow the system to stop surging for about 5 minutes. The pumps should be brought on-line by ramping up the VFD's speed then slowly opening the flow control valve over 120 seconds. The pumps should be restarted staggered 3 minutes apart. Presuming that all three GST's at the SSH BPS are operating simultaneously at the peak flow, the required diameter of their altitude valves is 18-in. The maximum flow to any one tank should be limited to 6700-gpm to avoid excessive velocities though the valves. The altitude valves should be made to close over a range of at least 1-ft of a rising water level for the 1 MG GST's and at least 1/3-ft for the 3 MG GST. The altitude valve must be submerged sufficiently in a vault to allow it to close.

For normal stopping of the pumps, the pump flow control valve should slowly close over 120 seconds before the pumps ramp down. The pumps stops should be staggered by about three minutes apart.

A point of interest is that the pump surge control valve is needed to prevent flow during negative static conditions (i.e., SH3 GST WSEL at 56.25-ft and SSH GST inlet pipe elevation at 47.8-ft). Once installed, however, the valve must allow reverse flow at positive static conditions before slowly closing to be bringing the water column to rest to prevent excessive pressure surges.

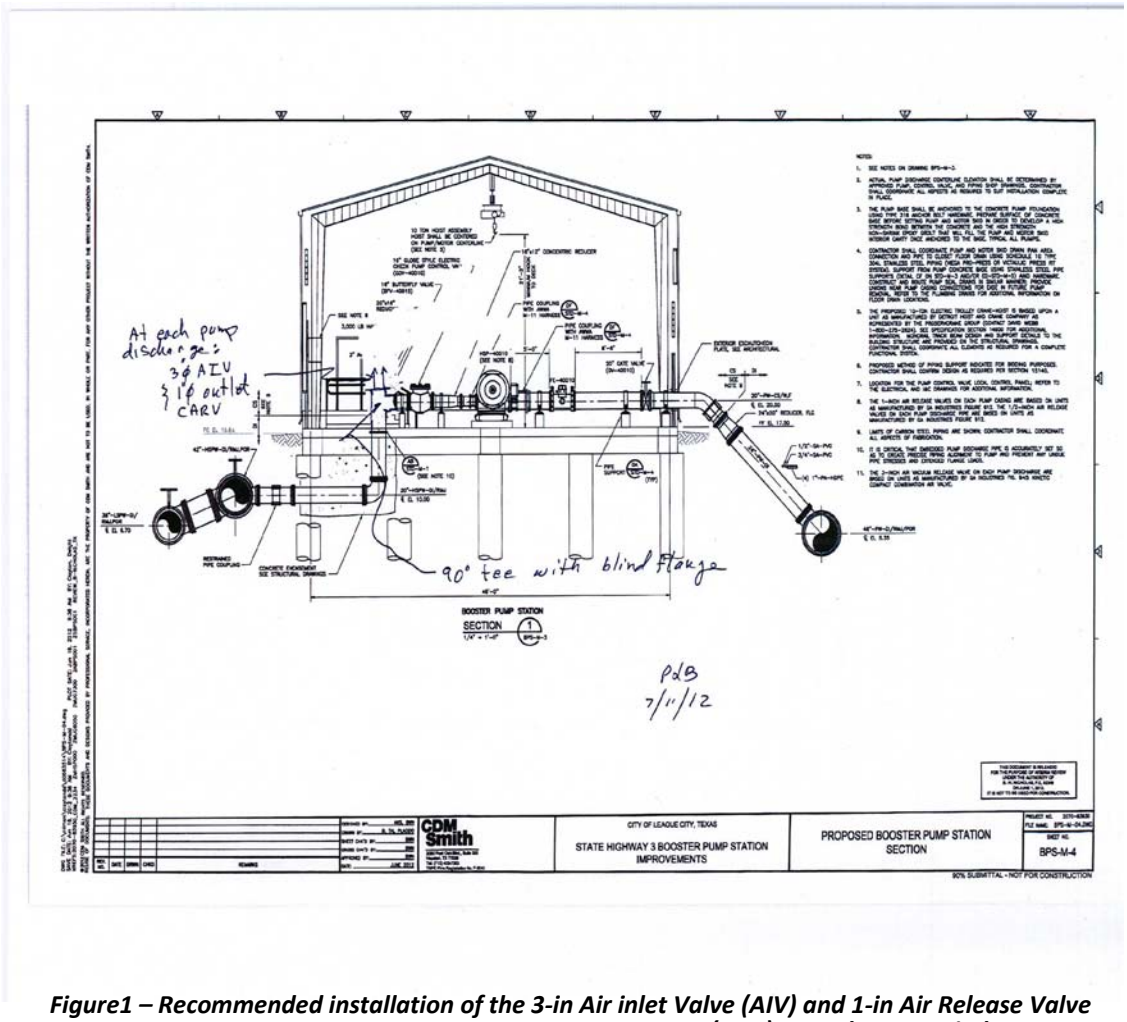


Figure1 – Recommended installation of the 3-in Air inlet Valve (AIV) and 1-in Air Release Valve (ARV) at Each Pump Discharge Tee

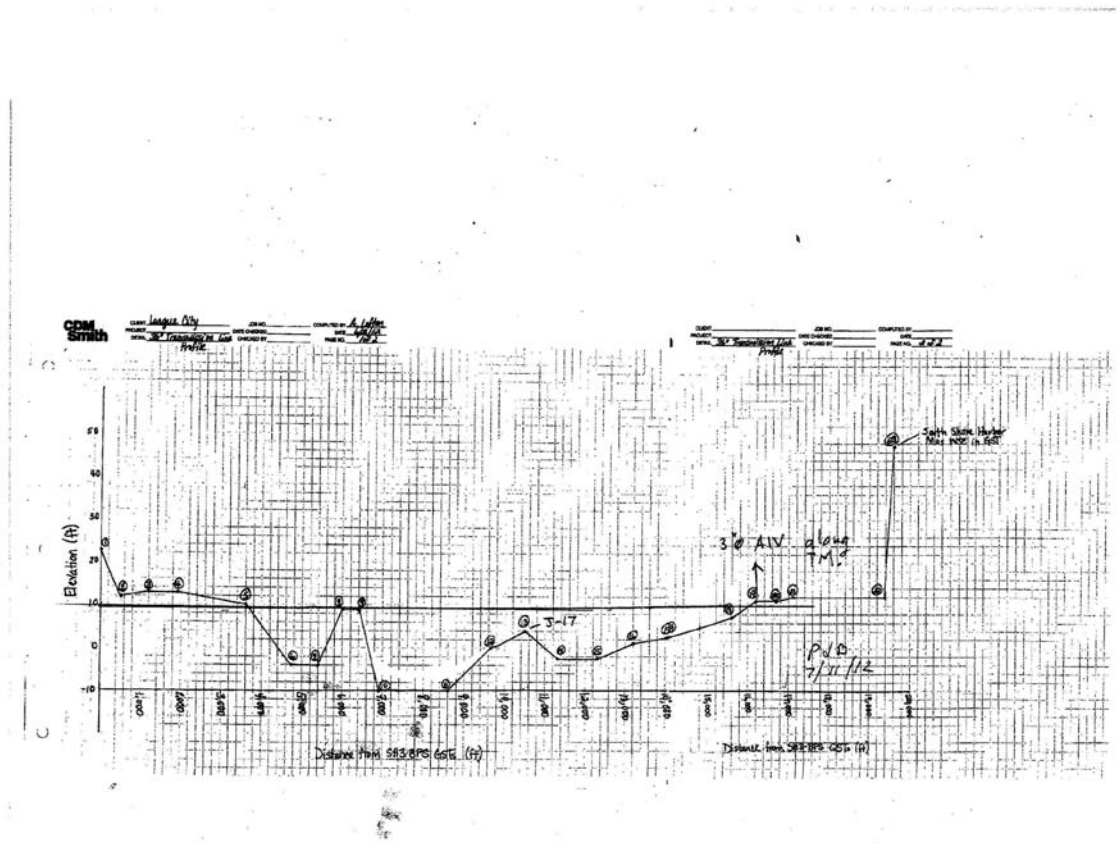
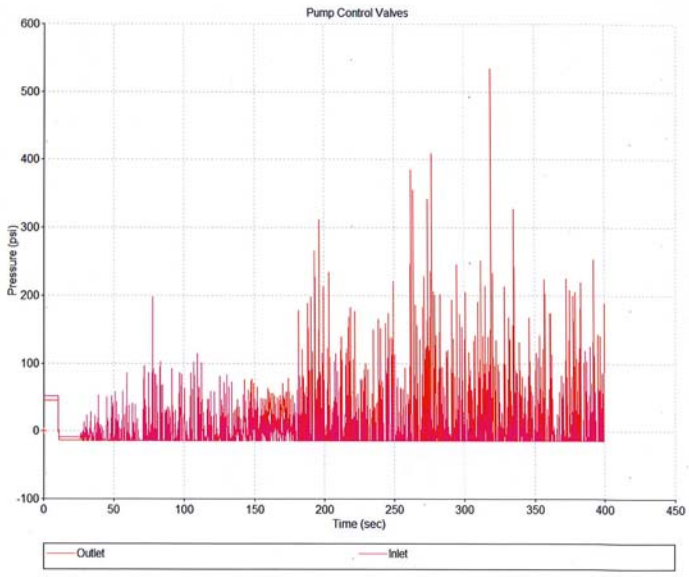
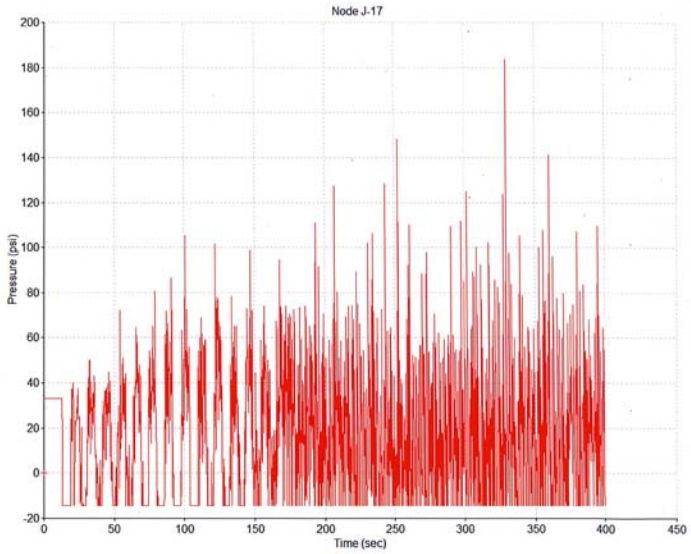


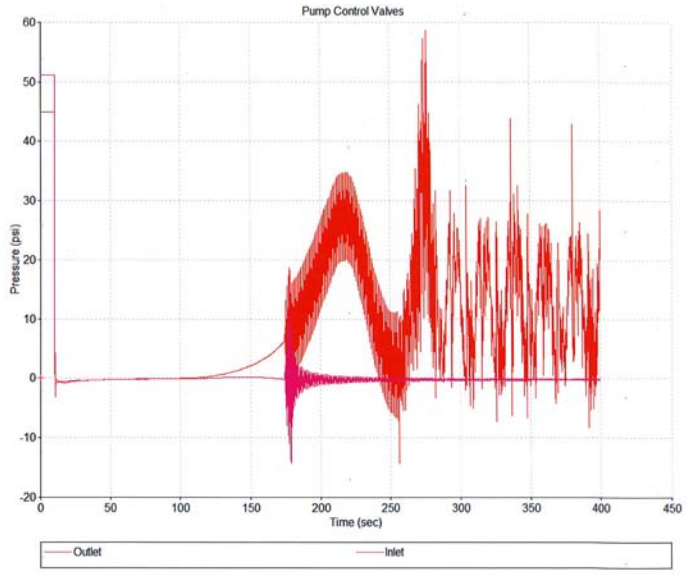
Figure 2 – Profile of the 36-in Diameter Pipeline Showing Location of the Severest Water Column Separation at Node J-17 and Location of the Recommended Pipeline 3-in AIV



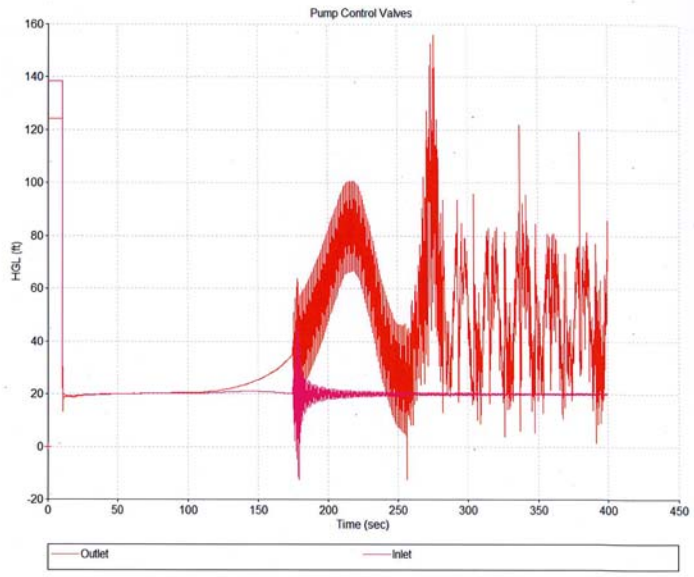
Graph A – Pressure Surges at the Pump Control Valves without Surge Controls (i.e., no AIV's)



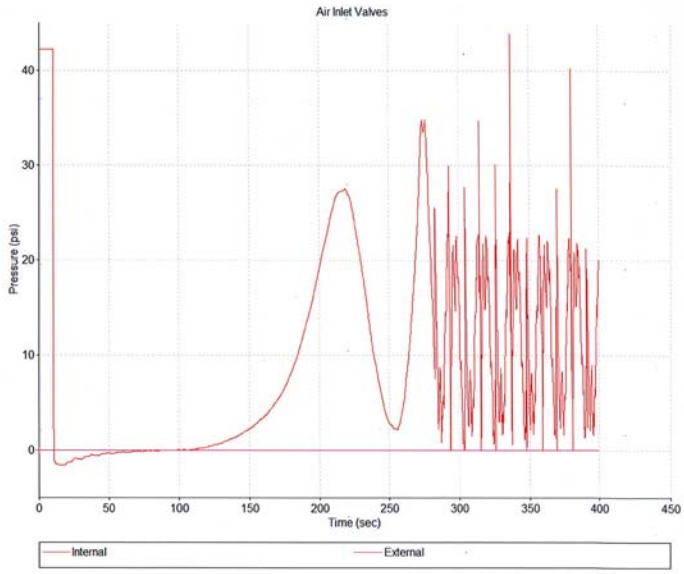
Graph B – Pressure Surges at Node J-17 without Surge Controls



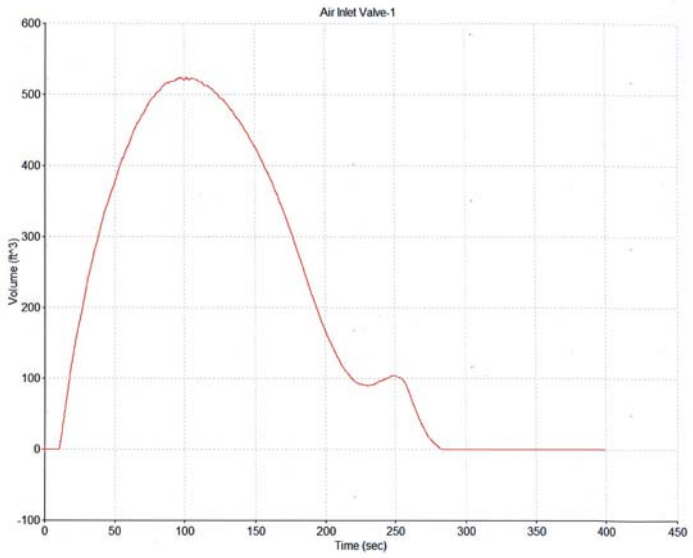
Graph C – Pressure Surges at Pump Control Valves with Recommended Surge Controls Installed



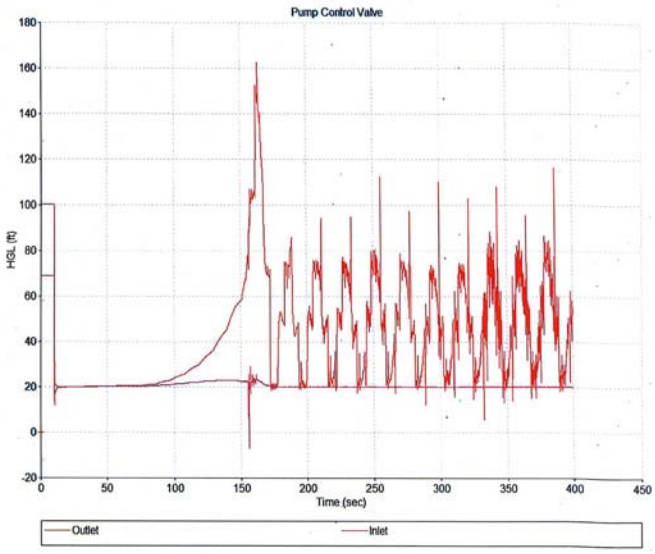
Graph D – HGLE Surges at Pump Control Valves with Recommended Surge Controls Installed



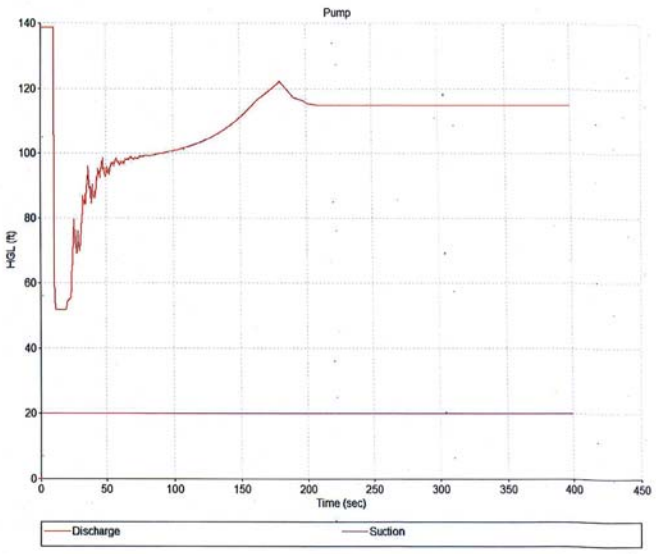
Graph E – Pressure Surges at Recommended AIV's at Pump Discharge Tees



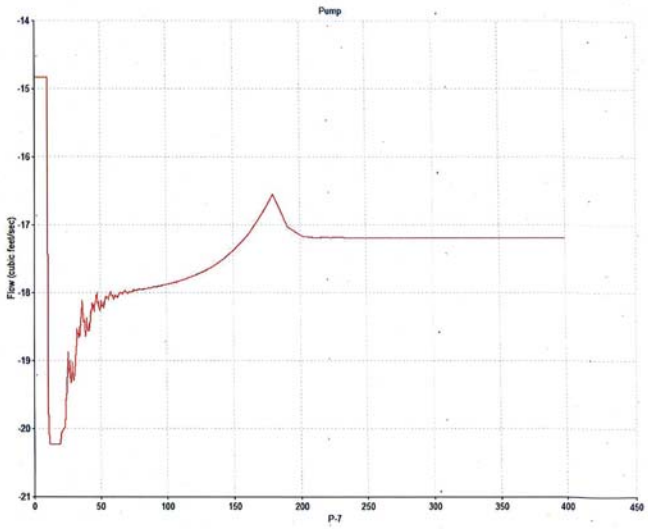
Graph F – Volume of Air Admitted at each Pump Discharge AIV



Graph G – Pressures Surges at Pump Control Valves with Failure of One of One10,000-gpm Pump with Surge Controls Installed



Graph H – HGLE Surge with One of Three Operating Pumps Failing with Surge Controls Installed



Graph I – Flow Surges with One of Three Operating Pumps Failing with Surge Controls Installed