

Purdue Geotechnical Society Workshop

Purdue University, West Lafayette, Indiana

May 7, 2007

Instrumentation Results from Construction of a Utility Tunnel for the New Indianapolis International Airport

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Earth Exploration Inc., Indianapolis, Indiana

Purpose

Representatives of the Indianapolis International Airport are currently building a new terminal and infrastructure elements (parking, roadways, etc.)

Need to provide steam and chilled water (among other utilities) to the new terminal area.

Install utilities via cut-and-cover (at least 3 mi.)

OR

Utilize a tunneling technique



CENTRAL ENERGY
PLANT

NEW TERMINAL
AREA

Quick Stats

Approximate 8-ft diameter tunnel; 2,000 ft long

Earth Pressure Balance (EPB) machine

Steel liner plates

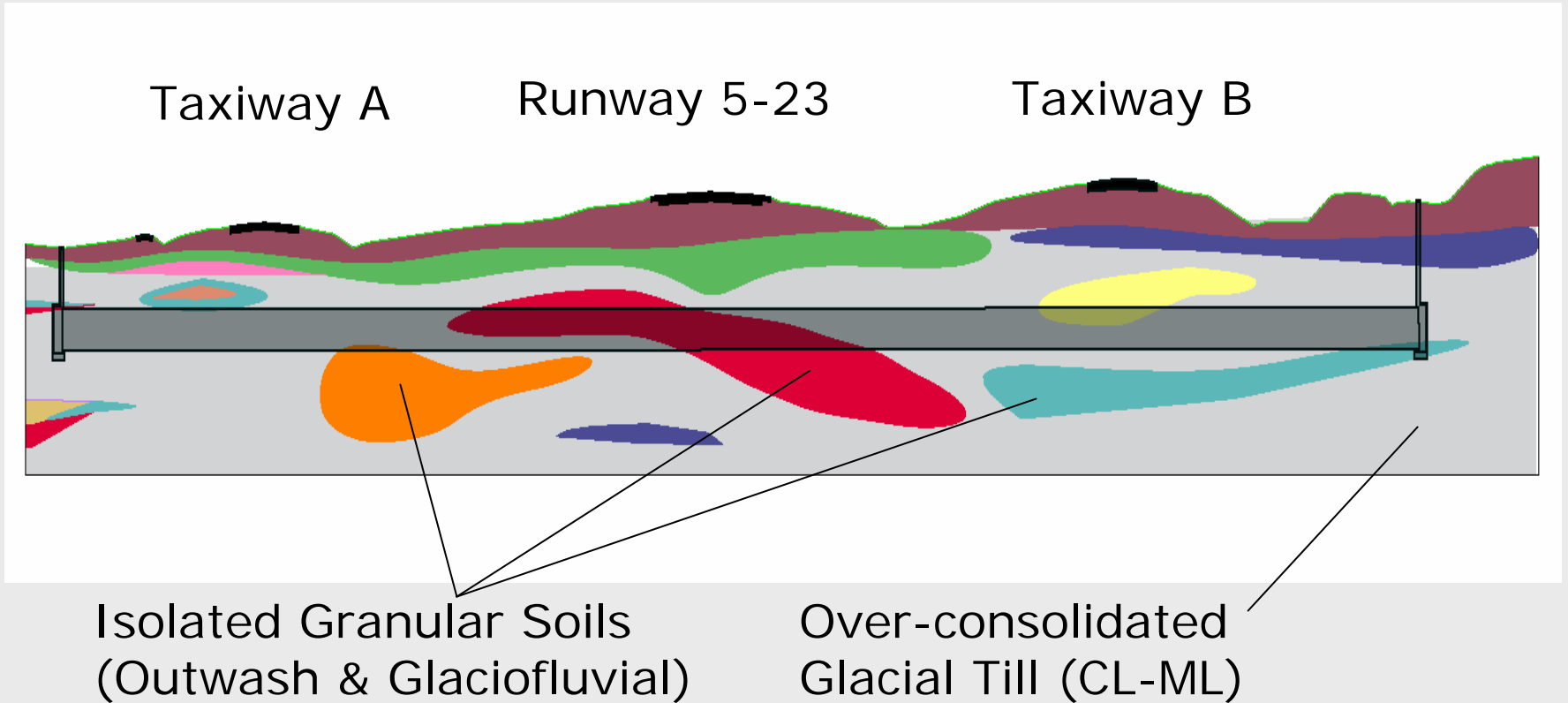
Average 15 ft earth cover

Constructed below two active taxiways and one of the primary runways





Subsurface Profile along Tunnel



Profile provided by Gilco Group, Inc.

Instrumentation

53 surface points on taxiway and runway pavement

48 surface points in non-pavement (grass)

Five single-point borehole extensometers placed to within 3 to 5 ft of crown

Six structure points (placed to observe large culverts)









Instrumentation

Surface Points on Pavement:

Review level $\frac{1}{2}$ in., Alert level 1 in.

Surface Points in Grass:

Review level $\frac{3}{4}$ in., Alert level $1\frac{1}{2}$ in.

Structure Points (Culverts)

Review level $\frac{1}{2}$ in., Alert level $\frac{3}{4}$ in.

Extensometers

Review level 1 in., Alert level $1\frac{3}{4}$ in.

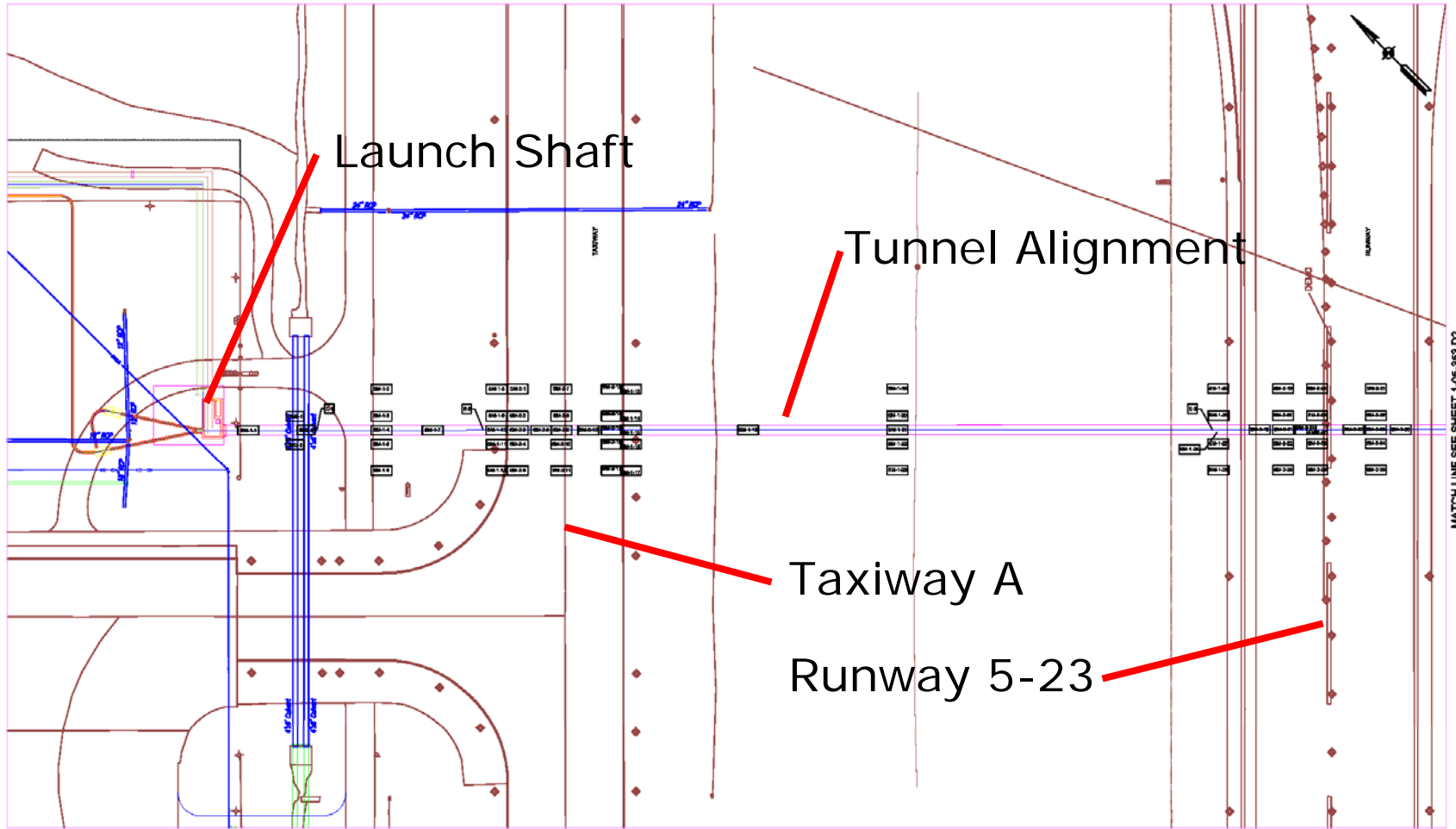
Instrumentation

Monitoring Frequency:

All instruments within 250 ft ahead of and 500 ft behind machine to be monitored on a daily basis.

All instruments to be read bi-monthly regardless of TBM location.

DRAWING NO.: 1-05-353.D1 DATE: 06/06/11 TIME: 12:51:42



MATCH LINE SEE SHEET 1-05-353.D2

Launch Shaft

Tunnel Alignment

Taxiway A

Runway 5-23

- NOTES:
1. Base map developed from an electronic file provided by Parsons Brinckerhoff Cusick & Douglas Inc.
 2. Backfill instrument locations and surface elevations determined by SBI Crane-Bull, Inc.
 3. Instrument installed during the period of March 27 through April 6, 2008.
 4. See Sheet 1-05-353.D2 for a summary of all built locations.



Scott E. Lippert
ENGINEER DATE: 6/6/11

LEGEND	
SB-1 BORE-HOLE EXTENSOMETER	SB-2 SURFACE MONITORING POINT (PAYMENT)
SB-17 SURFACE MONITORING POINT (PARADE)	SB-1 SURFACE MONITORING POINT (COLLECTOR)
PROJECT ENGINEER: <u>MLW</u>	DRAWN: <u>RF</u>
APPROVED BY: <u>SL</u>	APPROVED BY: <u>SL</u>

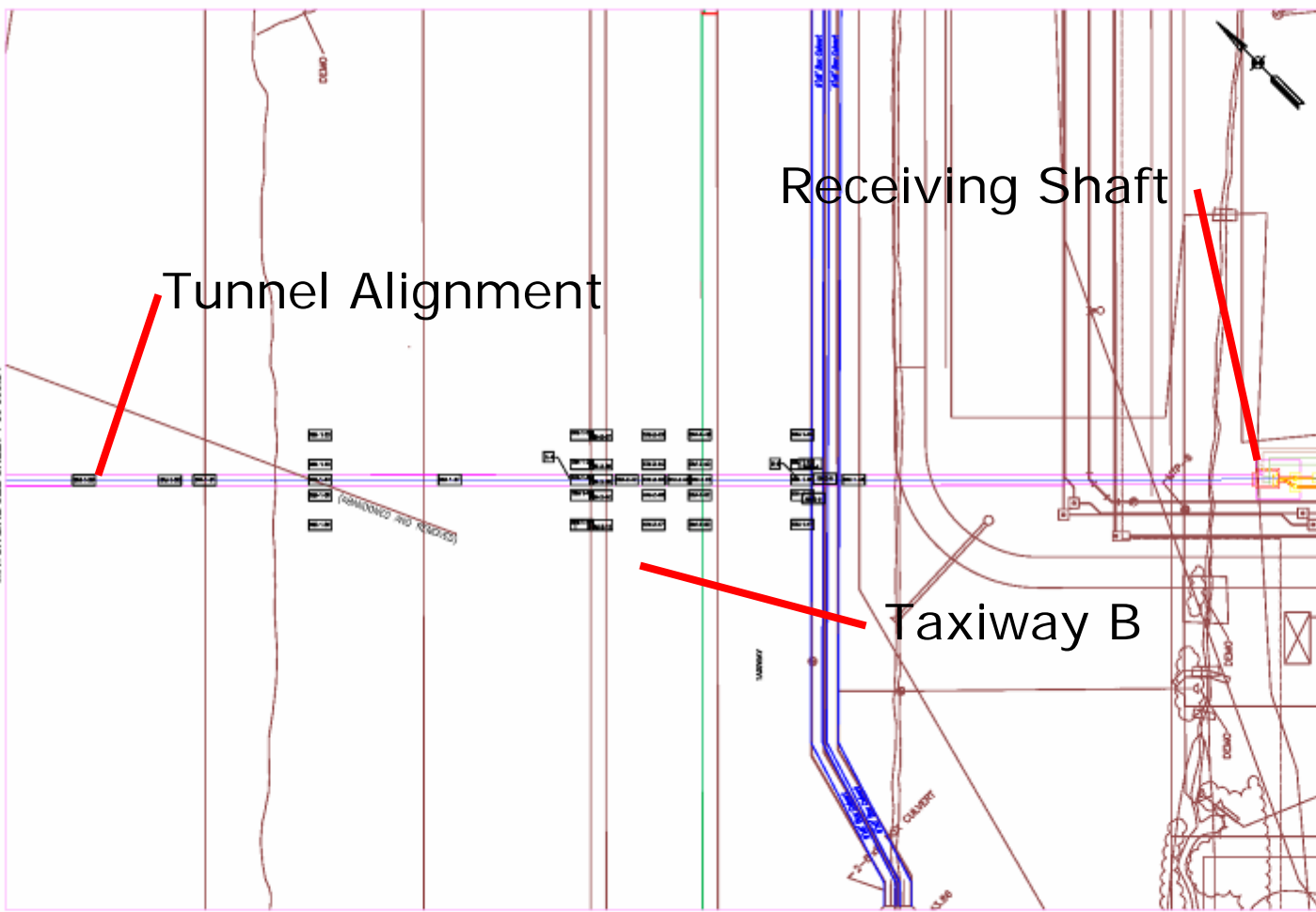
AS-BUILT GEOTECHNICAL INSTRUMENTATION PLAN
UTILITY CONNECTION TUNNELS
Indianapolis Airport
Indianapolis, Indiana

7776 Woodview Park Street
Indianapolis, Indiana 46241-0088
317.473.7000
FAX 317.473.2000

Geo-Engineering
A Geotechnical Engineering & Construction Consulting and Testing & Instrumentation Firm

SCALE: 1" = 40'	CLIENT PROJ. NO.: 031 PROJECT NO.: 1-05-353
PROJECT: U212 Connector Tunnel	
LOCATION: 140th Street, I-90/40	
CLIENT: Brown Engineering Corporation	
DRAWING NO.: 1-05-353.D1	

DRAWING NO. 1-05-353.D2 DATE: 08/08/08 TIME: 10:17:42



WINDYBUSH INTERNATIONAL AIRPORT		TUNNEL TYPING		GENERAL DATA		REVISION DATA	
Client Number:	1008	Contract Name:	IAA	Drawn:	08/08/08	Checked:	
Contract Type:	IAA	Client:	IAA	Design:	IAA	Project Manager:	
Drawn:	08/08/08	Checked:		Project Engineer:		Project Manager:	
Client:	IAA	Design:	IAA	Project Manager:		Project Manager:	
Checked:		Project Engineer:		Project Manager:		Project Manager:	
Project Manager:		Project Manager:		Project Manager:		Project Manager:	
Comments: IPI's installed various locations IPI's - 100m from Taxiway B, 100m from Taxiway C, 100m from Taxiway D							
NO.	DATE	BY	REASON	NO.	DATE	BY	REASON
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- NOTES**
1. Scale 1:10 developed from an electronic file provided by Hansen & Associates Ltd. & Geoquest Inc.
 2. Actual instrument locations and surface elevations determined by IPI Consultants, Inc.
 3. Instrumentation installed during the period of March 27 through April 12, 2008.



[Signature]
 PROJECT ENGINEER
 DATE: 08/08/08

LOGS:

<input checked="" type="checkbox"/> BOREHOLE EXTENSOMETER	<input checked="" type="checkbox"/> SURFACE MONITORING POINT (PNEUMATIC)
<input checked="" type="checkbox"/> SURFACE MONITORING POINT (SURFACE)	<input checked="" type="checkbox"/> SURFACE MONITORING POINT (ELEVATED)
PROJECT ENGINEER: <u>IAA</u>	DRAWN: <u>IAA</u>
APPROVED BY: <u>IAA</u>	APPROVED BY: <u>IAA</u>

AS-BUILT GEOTECHNICAL INSTRUMENTATION PLAN
 AIRPORT CONSTRUCTION
 Windybush International Airport
 Windybush, Ontario

TIC/Consultants Inc. 4000 Highway 7 East, Unit 10, Markham, Ontario L3R 9V7
 TEL: 905-477-7777 FAX: 905-477-7778

CLIENT: IPI Consultants Inc.

SCALE: 1" = 4'

CLIENT PROJ. NO.: IPI PROJECT NO. 1-05-353

PROJECT: IPI Consultants Inc.

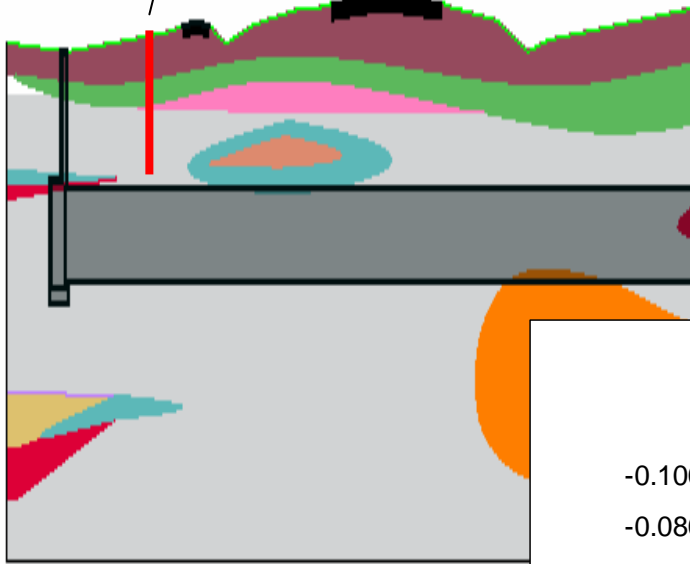
LOCATION: Windybush, Ontario

CLIENT: IPI Consultants Inc.

DRAWING NO.: 1-05-353.D2

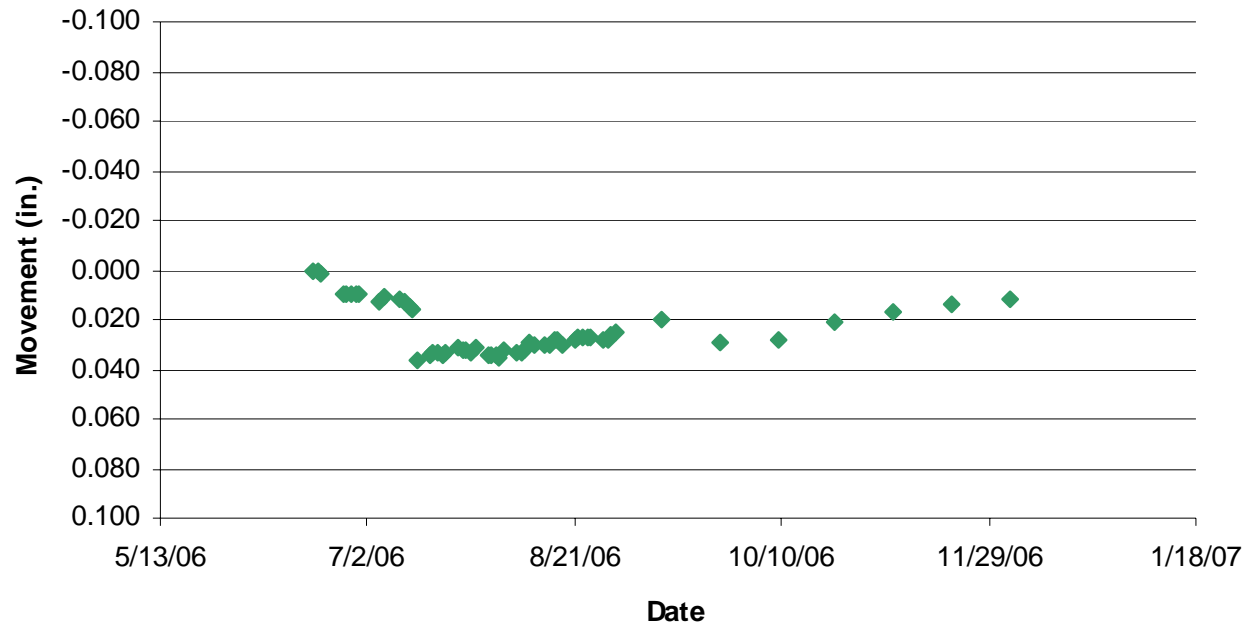
Extensometer

Taxiway A



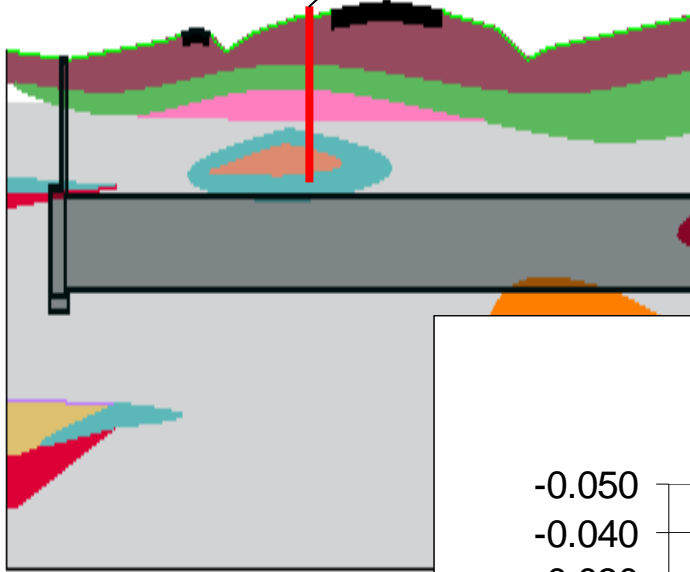
Extensometer Tip and Tunnel
Crown in OC Till (CL-ML)

SPBX-1 Observations



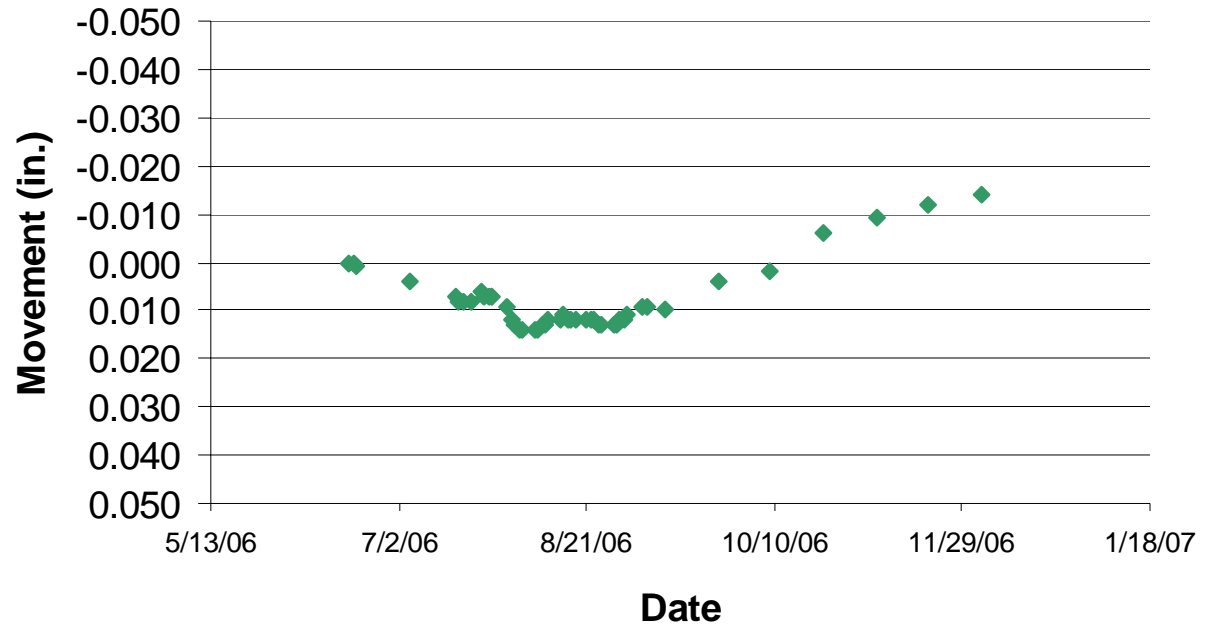
Extensometer

Taxiway A



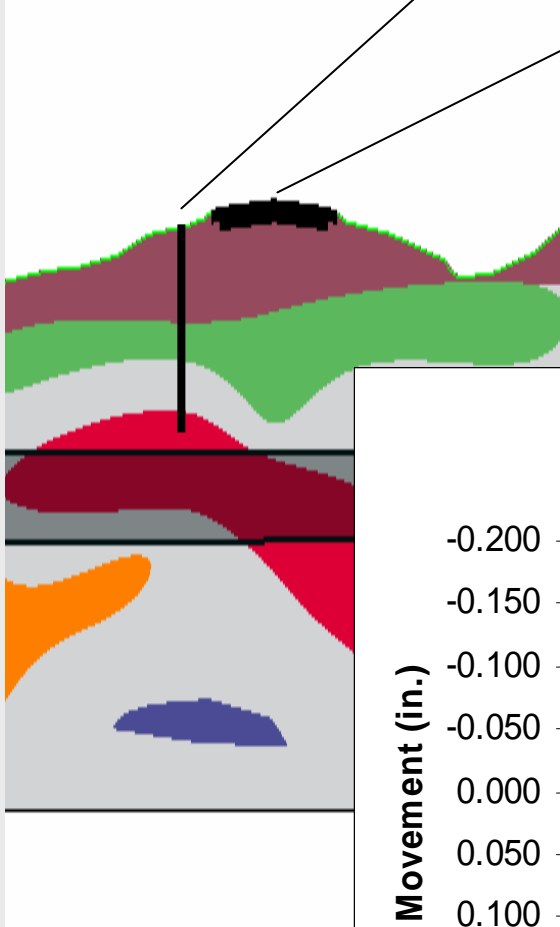
Extensometer Tip and Tunnel Crown near Granular Soils

SPBX-2 Observations



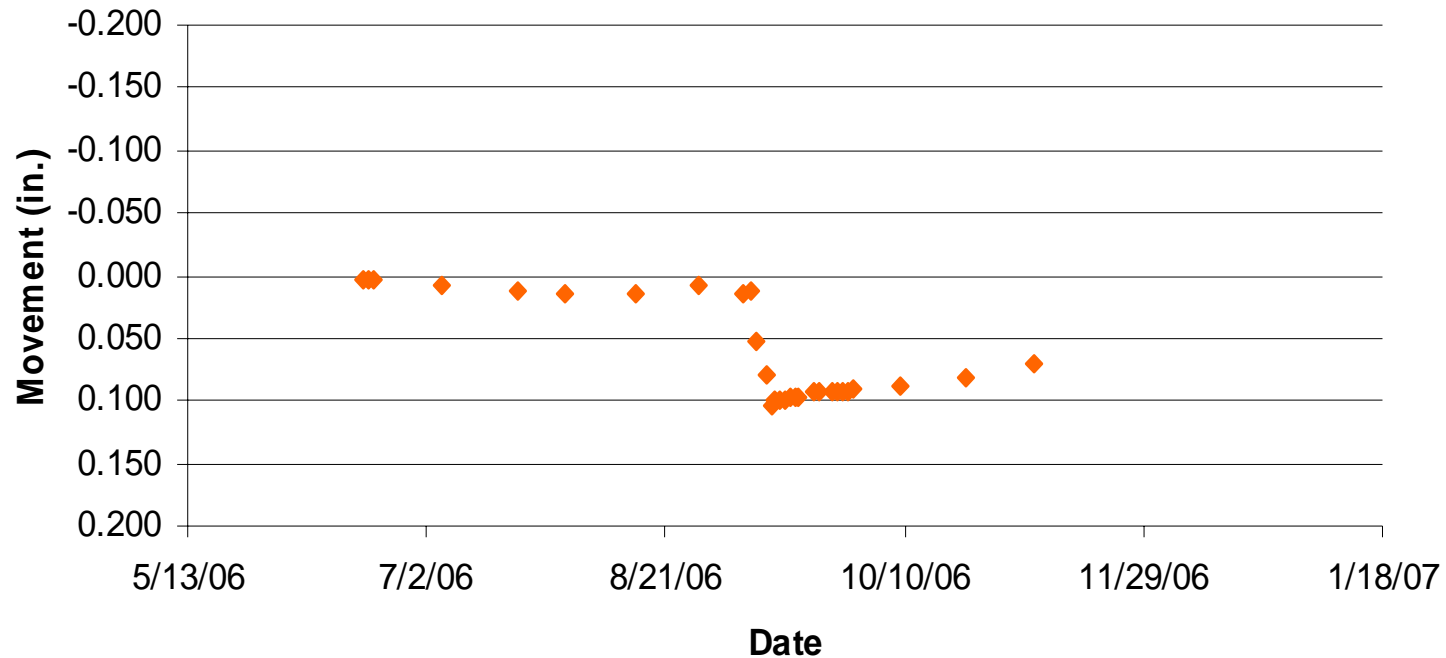
Extensometer

Runway 5-23



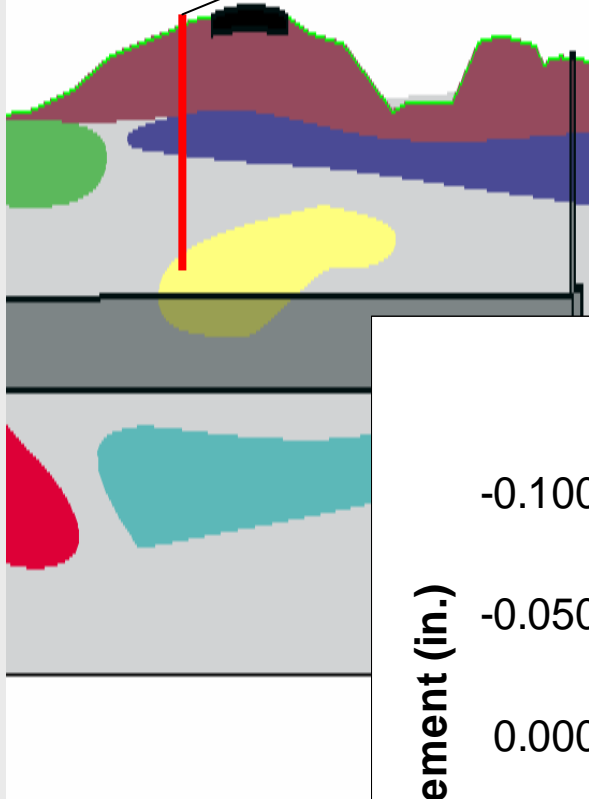
Extensometer Tip and Tunnel
Crown in Granular Soils

SPBX-3 Observations



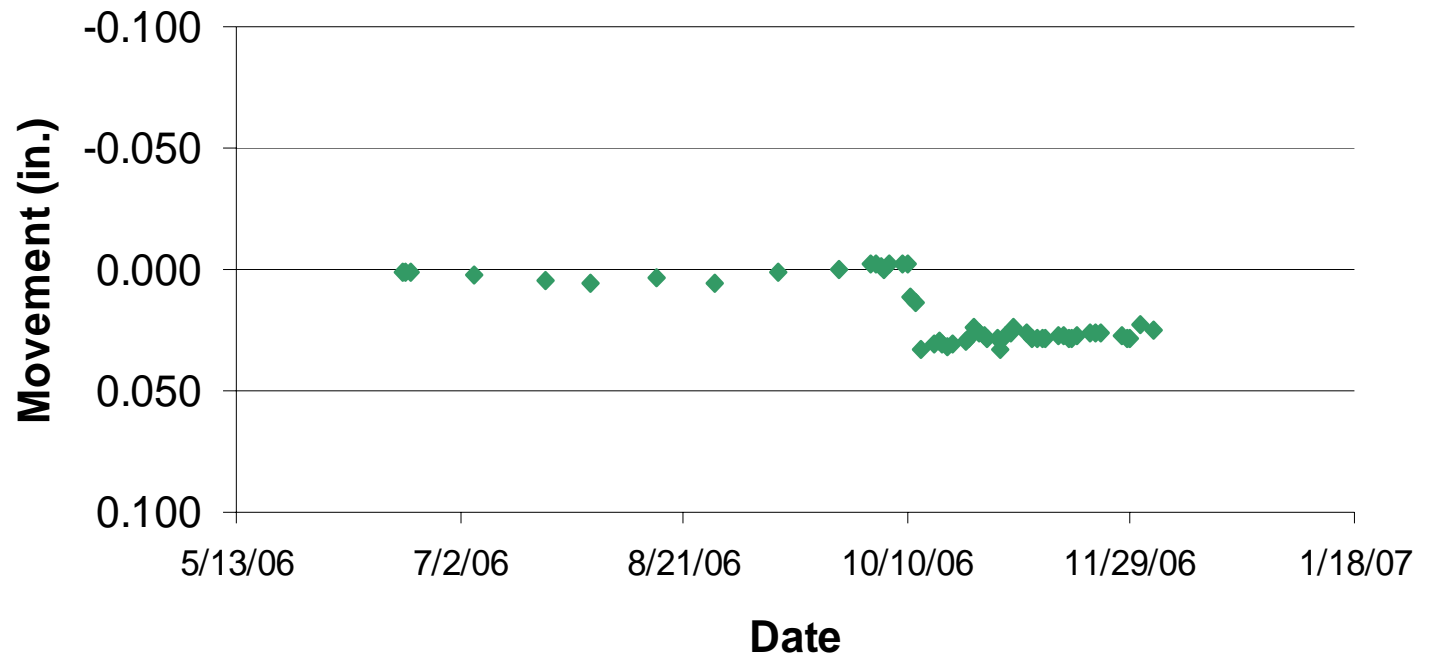
Extensometer

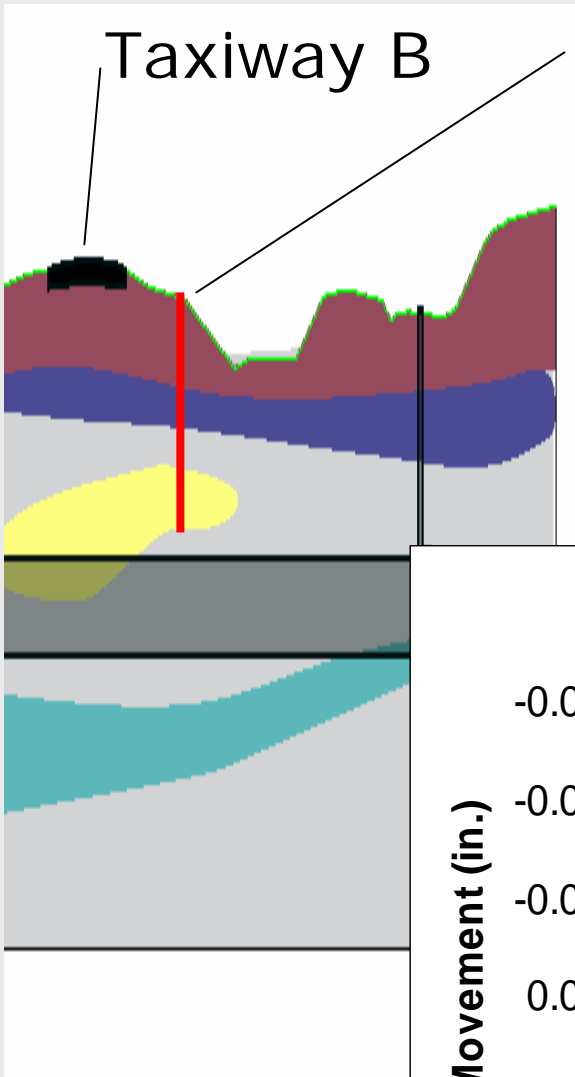
Taxiway B



Extensometer Tip and Tunnel
Crown in Granular Soils

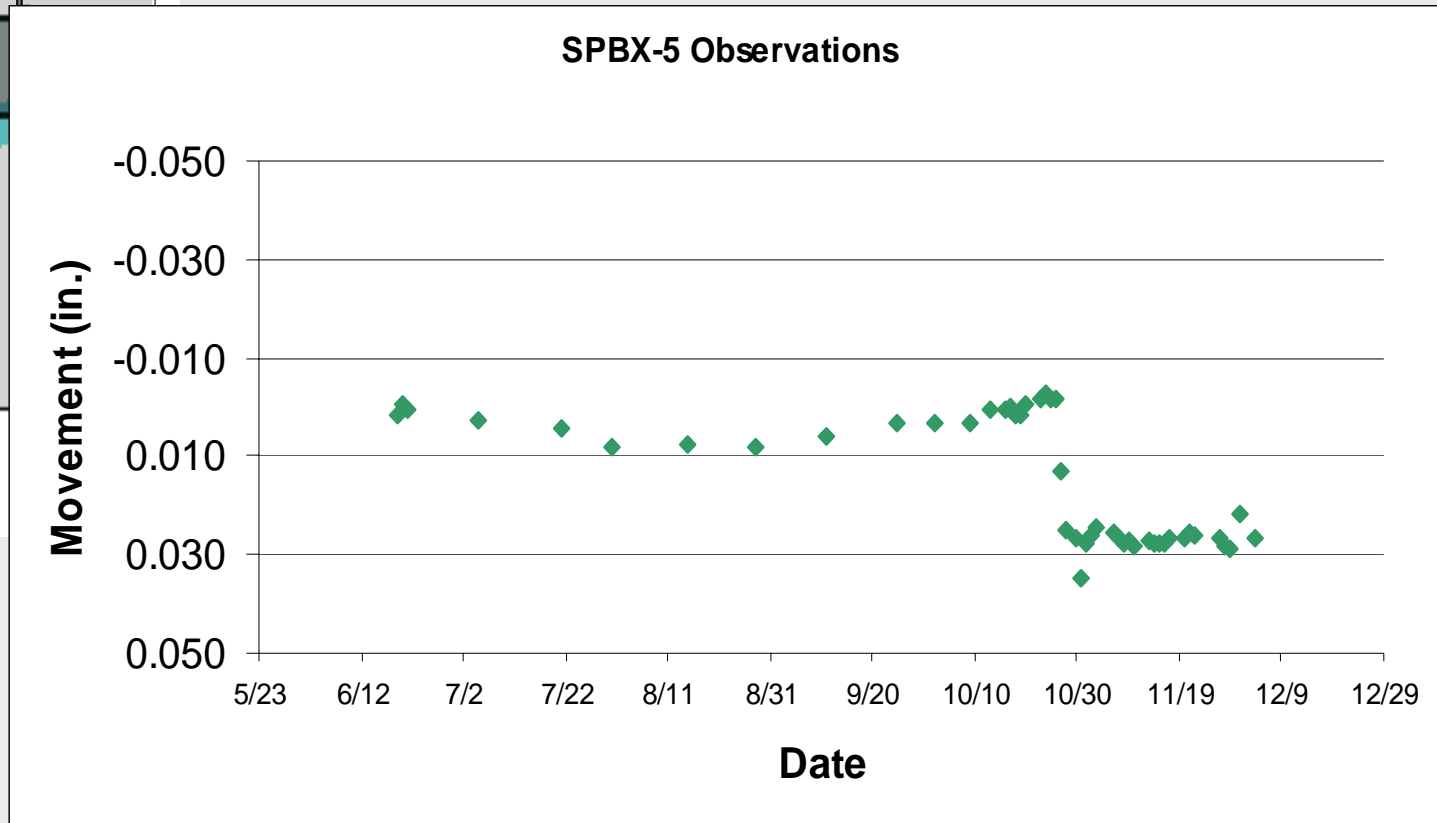
SPBX-4 Observations





Extensometer

Extensometer Tip and Tunnel
Crown in OC Till (CL-ML)
near Granular Soils



Surface Settlement Estimate

Mixed Ground Conditions:

Reasonable prediction of volume loss (V_l) in the range of 0.2% to 1% of tunnel volume.

Therefore, volume of surface settlement trough

$$V_s = V_l * (\pi * D^2 / 4)$$

Surface Settlement Estimate

Mixed Ground Conditions:

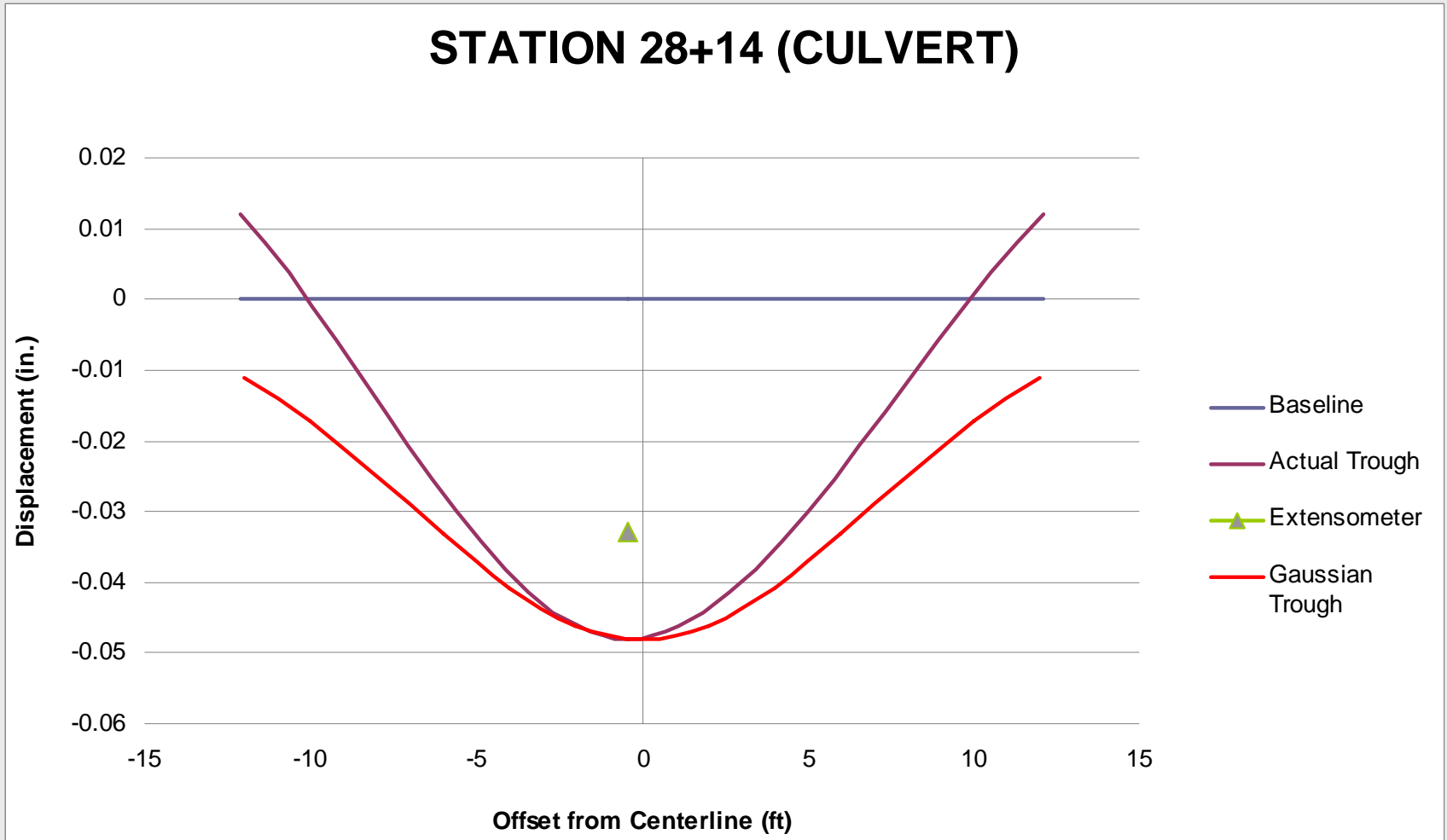
Reasonable prediction of settlement (to assist in establishing review and action levels):

$$S = V_s / [\text{SQRT}(2 * \text{PI}) * i] \quad (\text{Gaussian distribution})$$

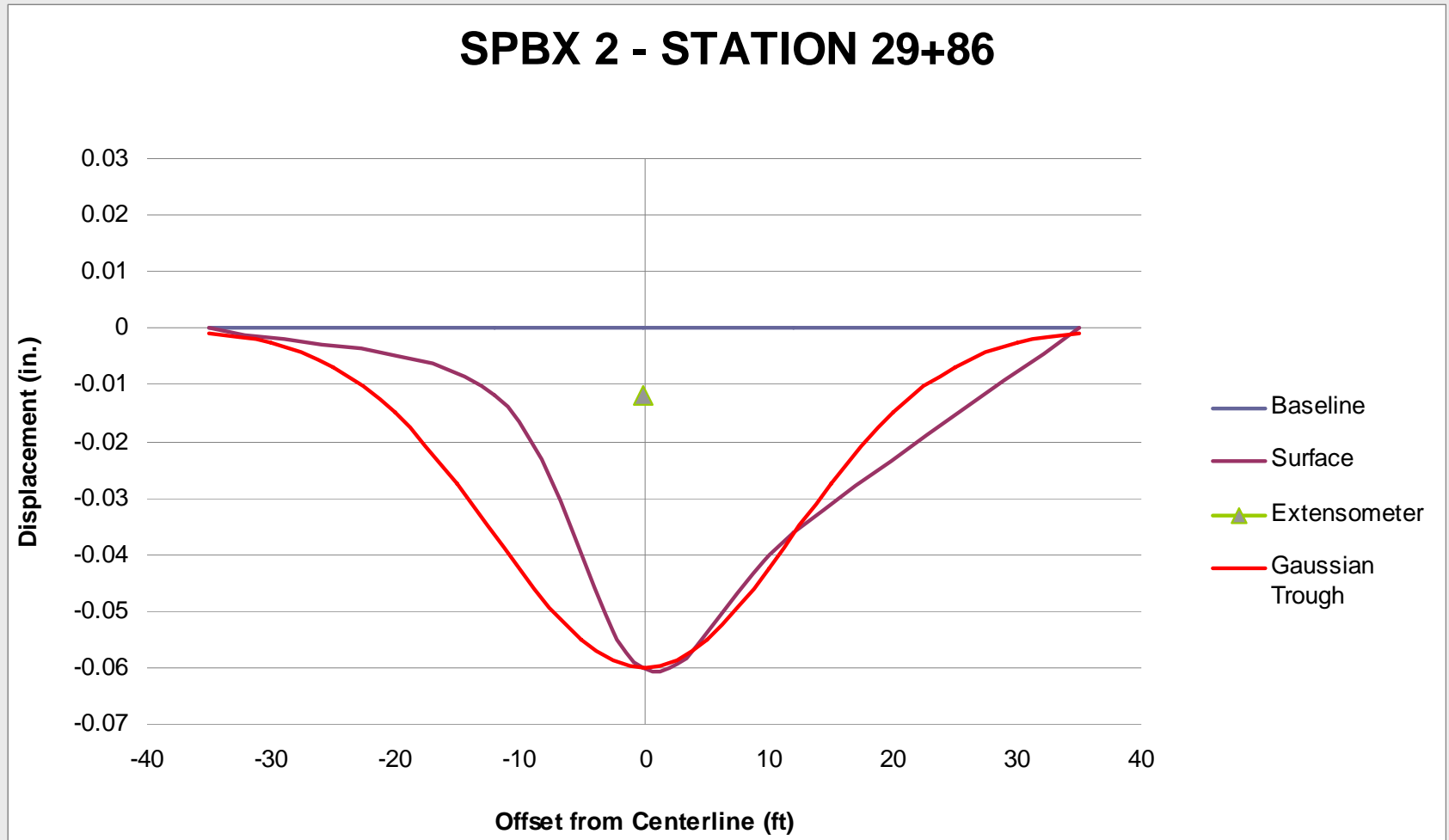
i = function of soil type, depth to crown and tunnel diameter

Predicted settlement in the range of 0.2 to 1 in.

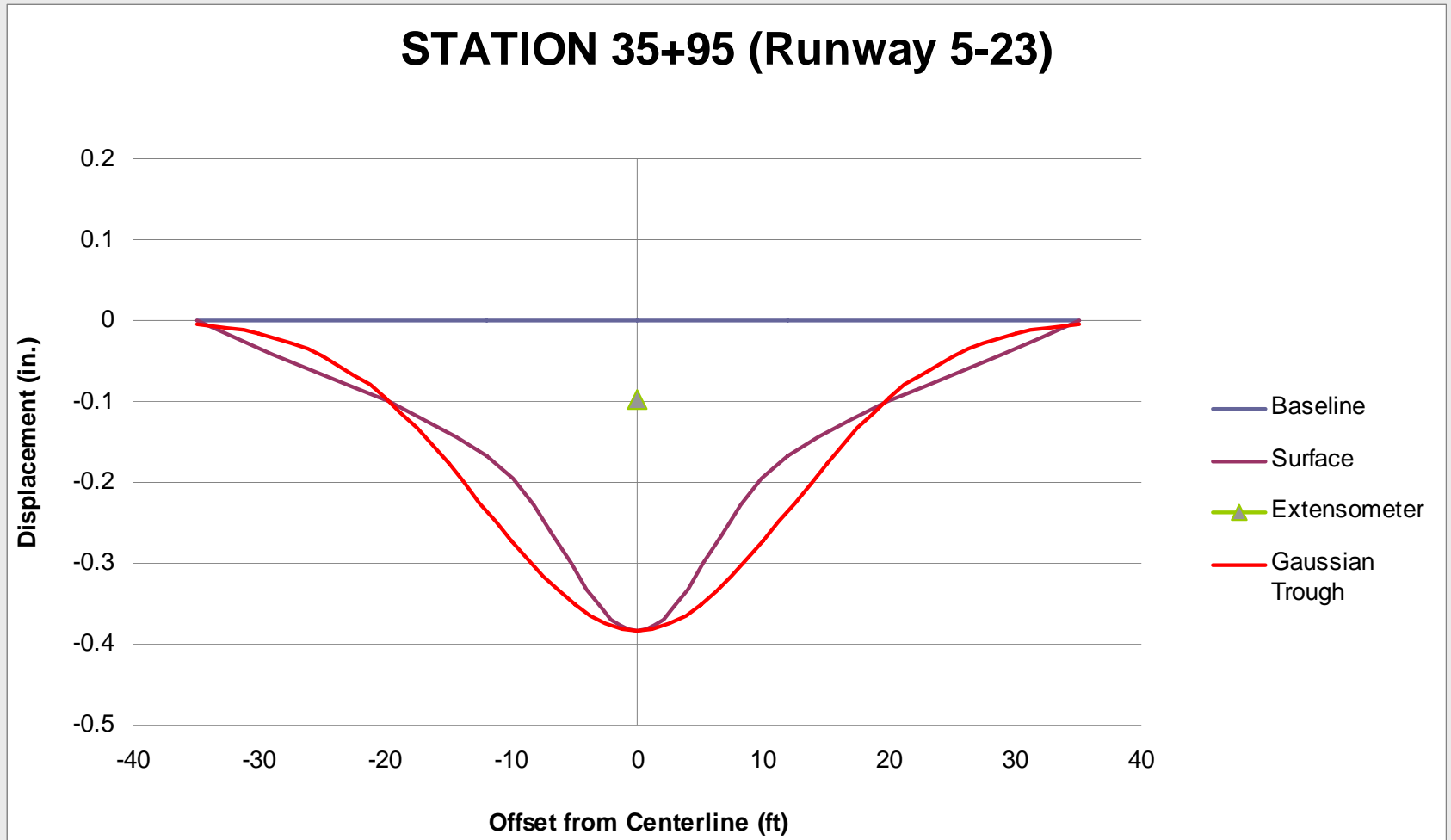
Trough at SPBX-1



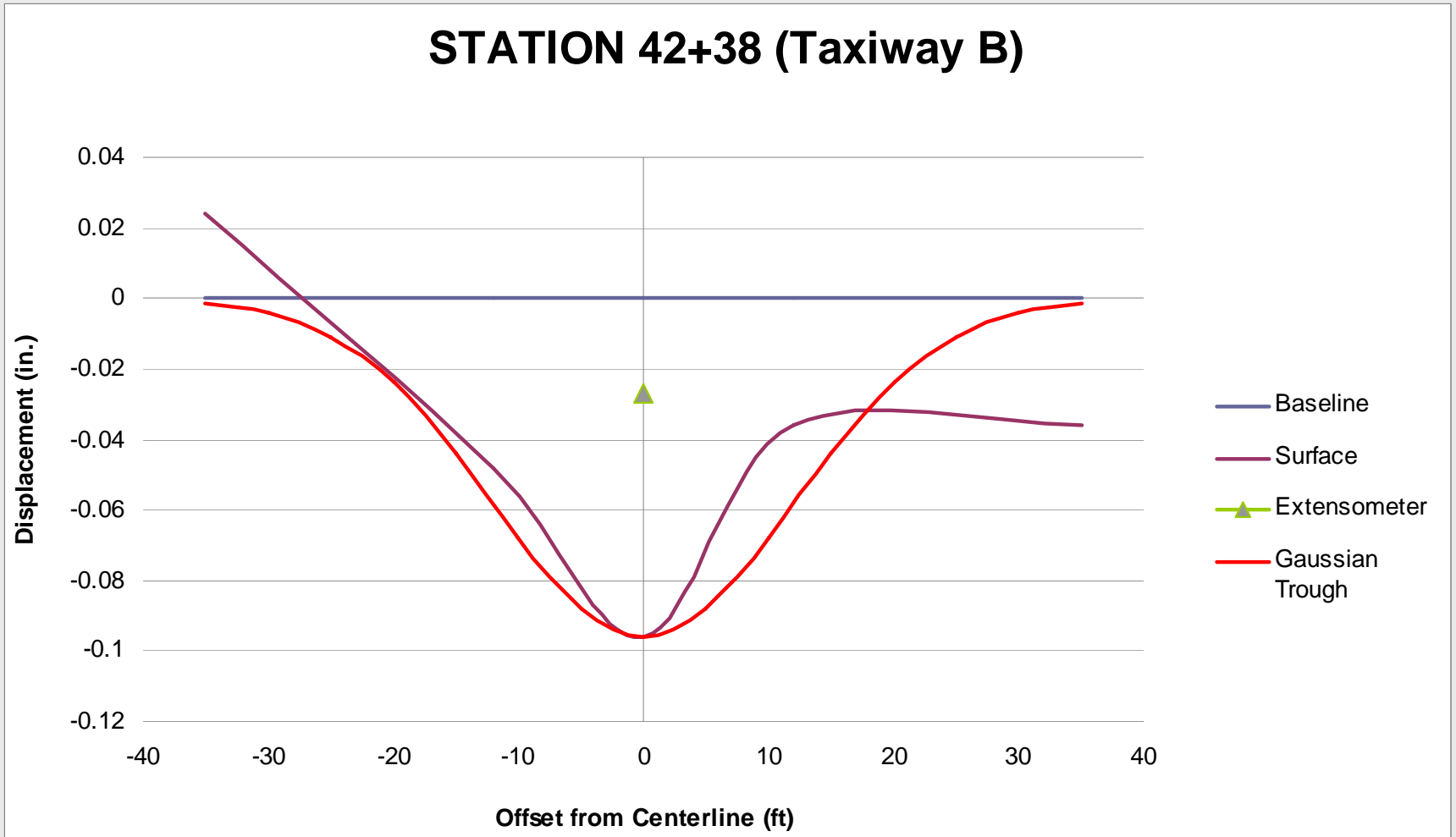
Trough at SPBX-2



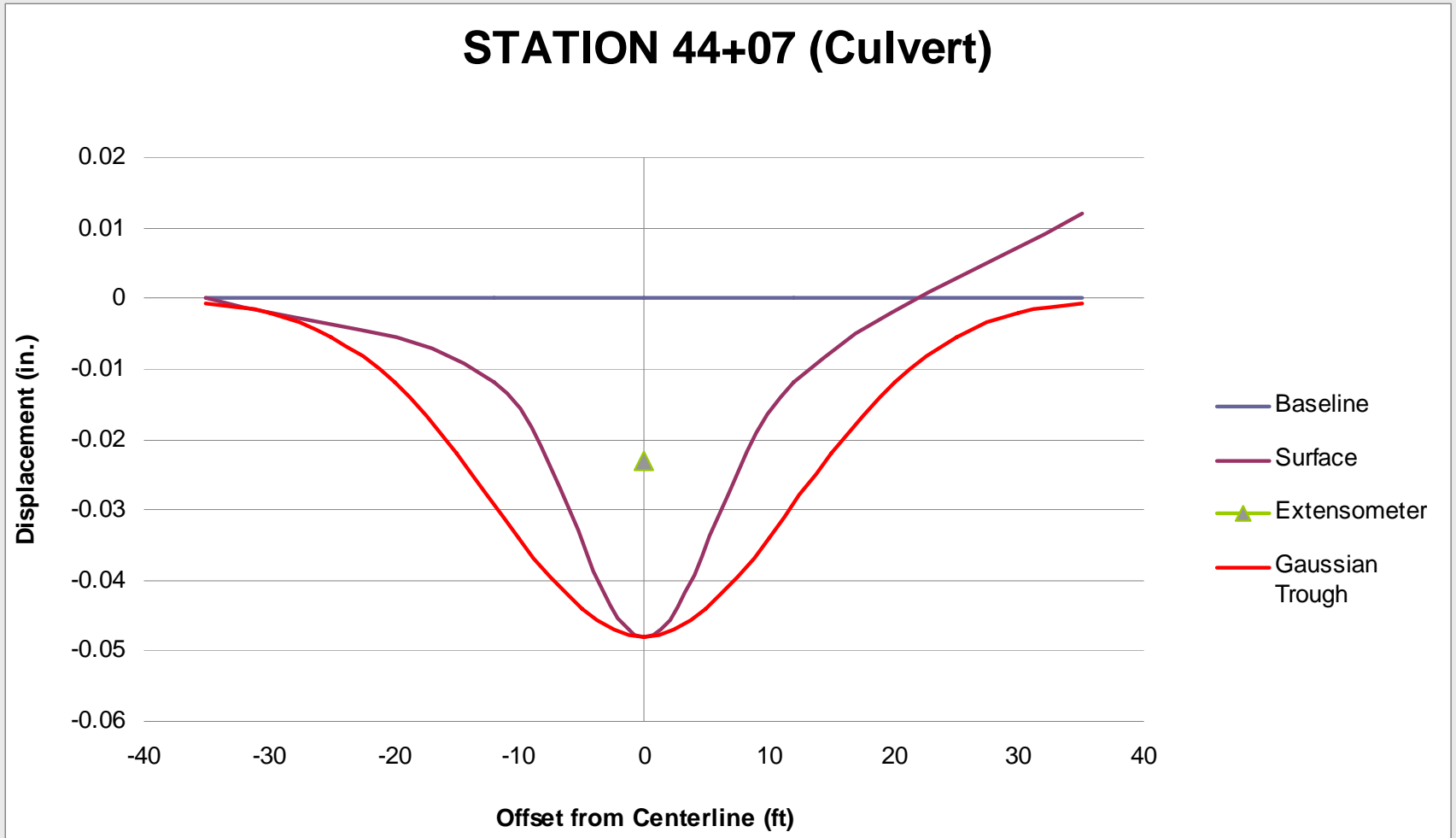
Trough at SPBX-3



Trough at SPBX-4



Trough at SPBX-5



Summary

Very little actual settlement likely due to:

Good control of face pressures and subsequent minimal volume loss.

Highly over-consolidated and hard nature of the soil which likely led to some arching even with low cover.

Grouting procedures around liner plates.

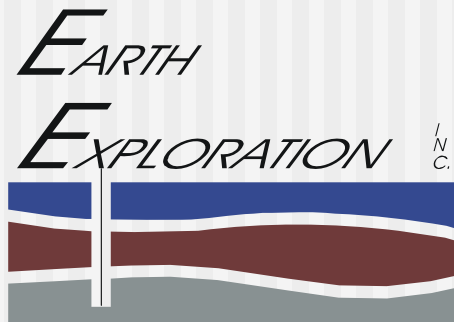
Settlement Trough generally followed Gaussian

Thank You



May 7, 2007

Questions or Comments



7770 West New York Street, Indianapolis, IN 46214-2988

317-273-1690 / (FAX) 317-273-2250

Earth Exploration, Inc.
7770 W. New York Street
Indianapolis, IN 46214

May 7, 2007