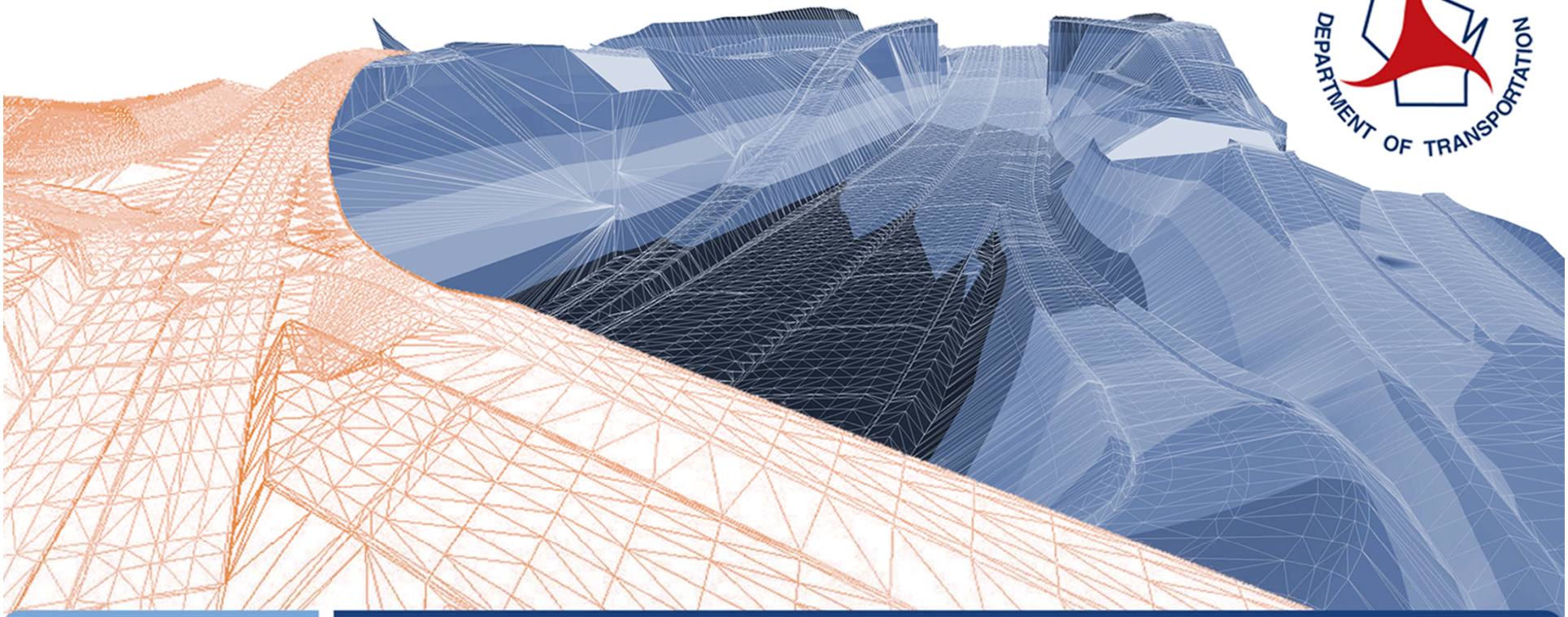
3D MODELING & ROVER USE BY THE MITCHELL INTERCHANGE CONSTRUCTION MANAGEMENT TEAM

August 22, 2012

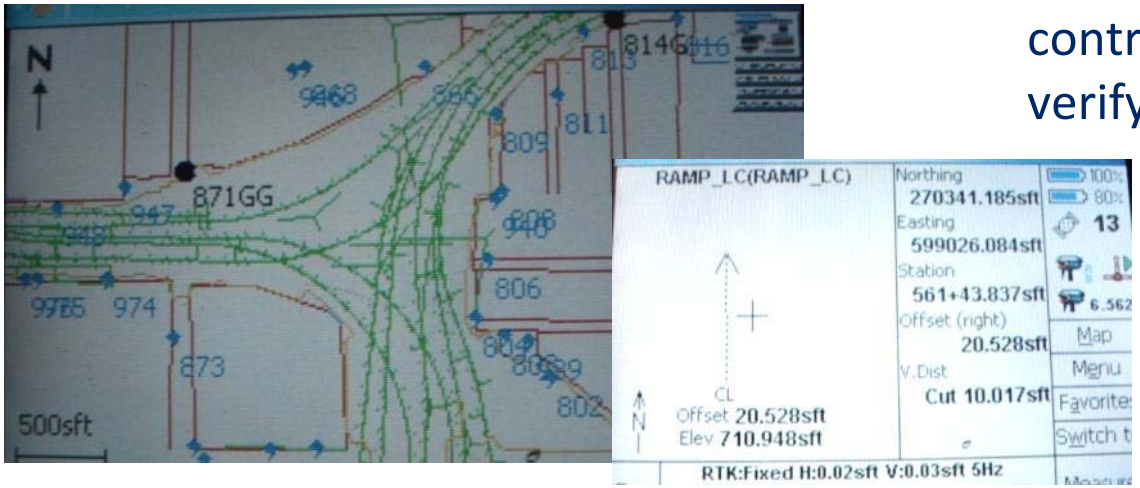


WISCONSIN DEPARTMENT OF TRANSPORTATION

DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA

Design Survey Control

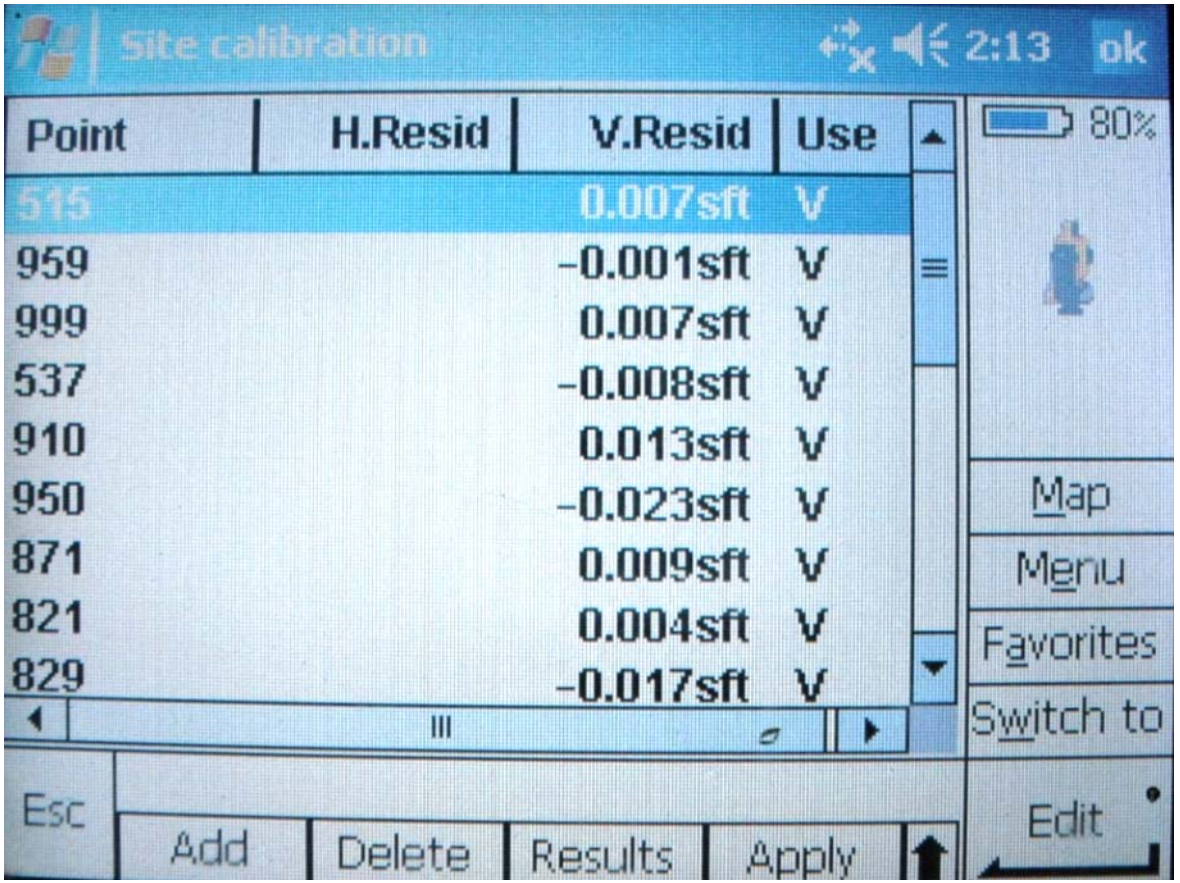
- GPS using WisCORS was highly reliable horizontally
- GPS alone limited the vertical control required for the project
- Preconstruction CM team control checks / densification / vertical improvements



- Digital levels run through all primary control to allow tighter calibrations using corrections from WisCORS, and held Vt only calibration on primary Feno monuments
  - Calibration shared with the contractors and asked to verify and provide the checks

Vertical Control

- Verification
- Densification
- Vertical improvements

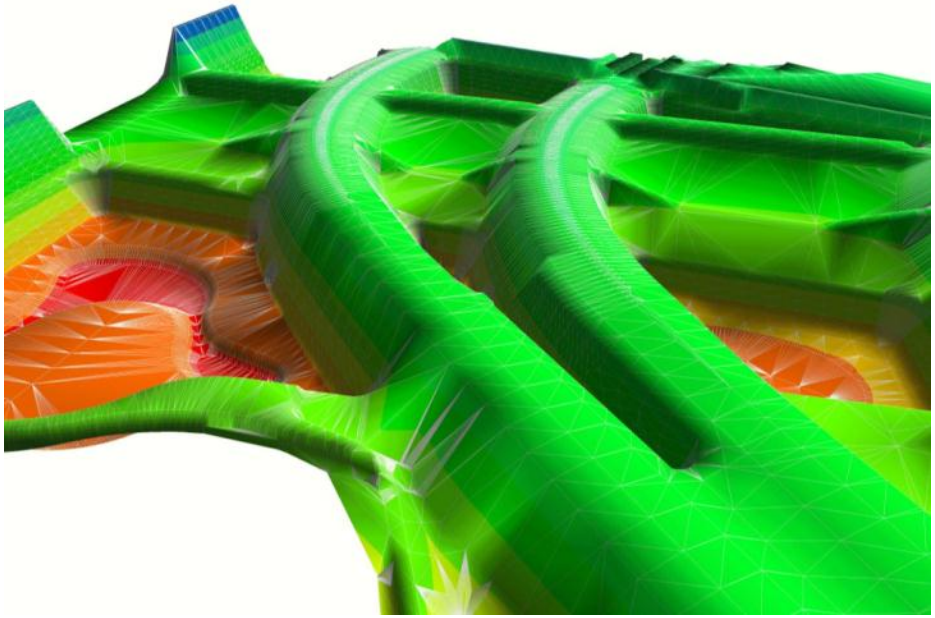


Control Distribution

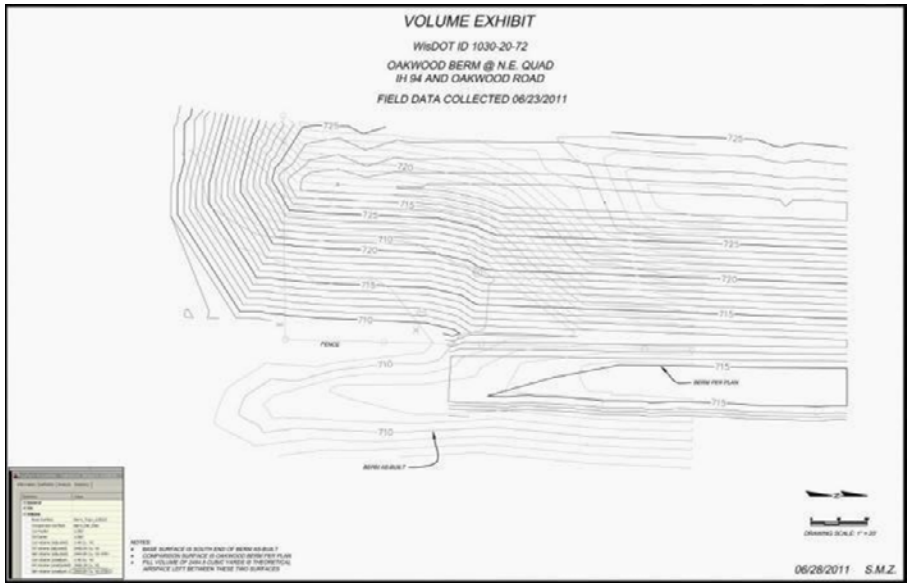
- **Verified control published to all contractors**
- **In a highly GPS machine controlled environment, confidence of all parties in the site calibrations vertical solution is very important financially for both the owner and the contractor**
  - Impact on pay quantities
  - Earthwork volumes
  - Subbase
  - Base course

Topo mapping and existing DTM

- **Overall topographic mapping was very good, but did have areas of vertical error**
  - DTM exported to inspection rovers for field checks
  - 894 west match – DOT and contractor impacts
  - Existing storm tie-in elevations off by 0.4-0.5’
  - $75-100k in change orders
- **Areas graded in between contracts 71 & 72**
  - Volume disputes were managed with information where possible

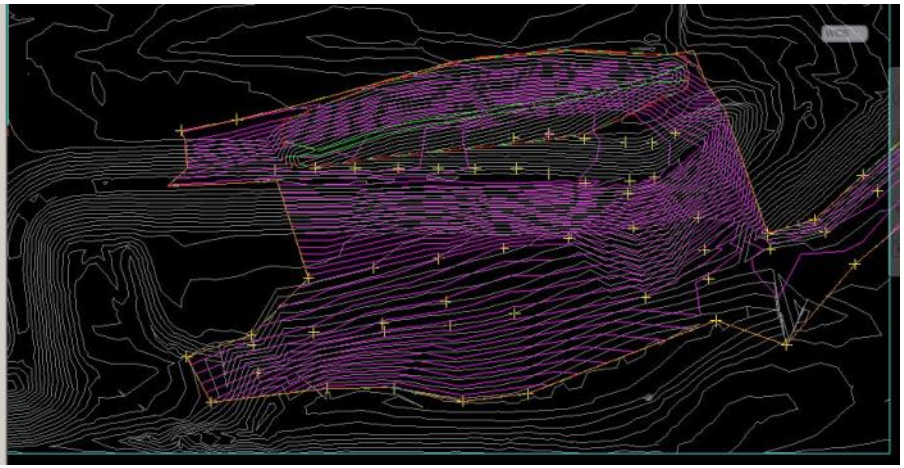


Grading



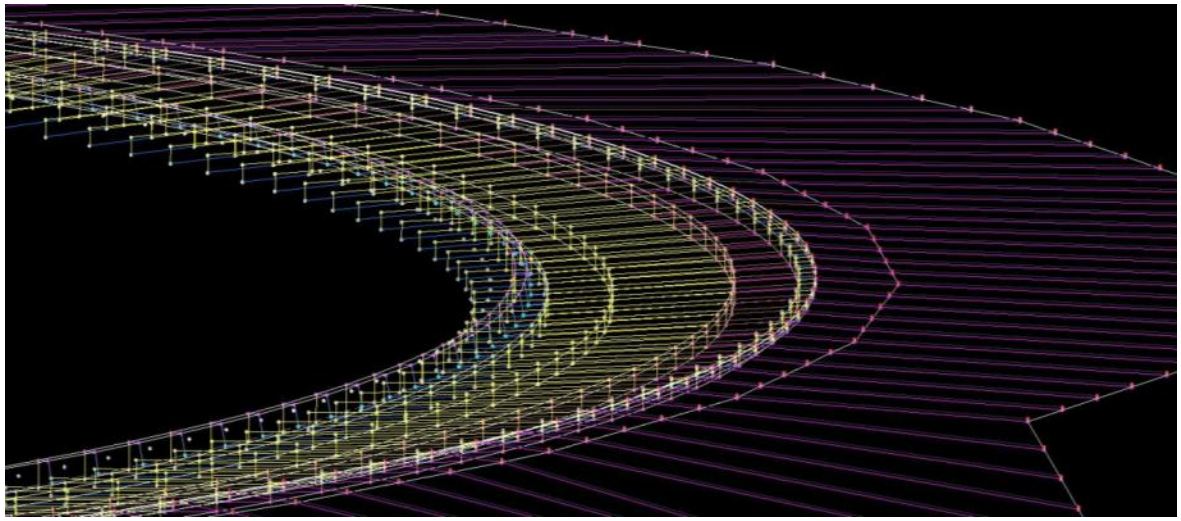
- Some areas graded / changed in breakout contracts
- Disputes were resolved using models and as built shots
- Oakwood berm loss of space due to FTMS
- Villa Mann Creek fill pile

Statistics	Value
⊞ General	
⊞ TIN	
⊟ Volume	
Base Surface	I43894-11
Comparison Surface	BERM_TOPO_101013
Cut Factor	1.000
Fill Factor	1.000
Cut volume (adjusted)	1857.65 Cu. Yd.
Fill volume (adjusted)	4300.93 Cu. Yd.
Net volume (adjusted)	2443.28 Cu. Yd.<Fill>
Cut volume (unadjusted)	1857.65 Cu. Yd.
Fill volume (unadjusted)	4300.93 Cu. Yd.
Net volume (unadjusted)	2443.28 Cu. Yd.<Fill>



Model Creation

- **Civil 3D**
  - CM team wanted to use C3D to work within the new approved software platform and help develop the DOT process. Started with the idea of having an independent model to check against contractor model.
  - Software wasn't ready for a model of this scale.
- **Terramodel**
  - Changed to Terramodel to integrate and collaborate more efficiently with the contractors model

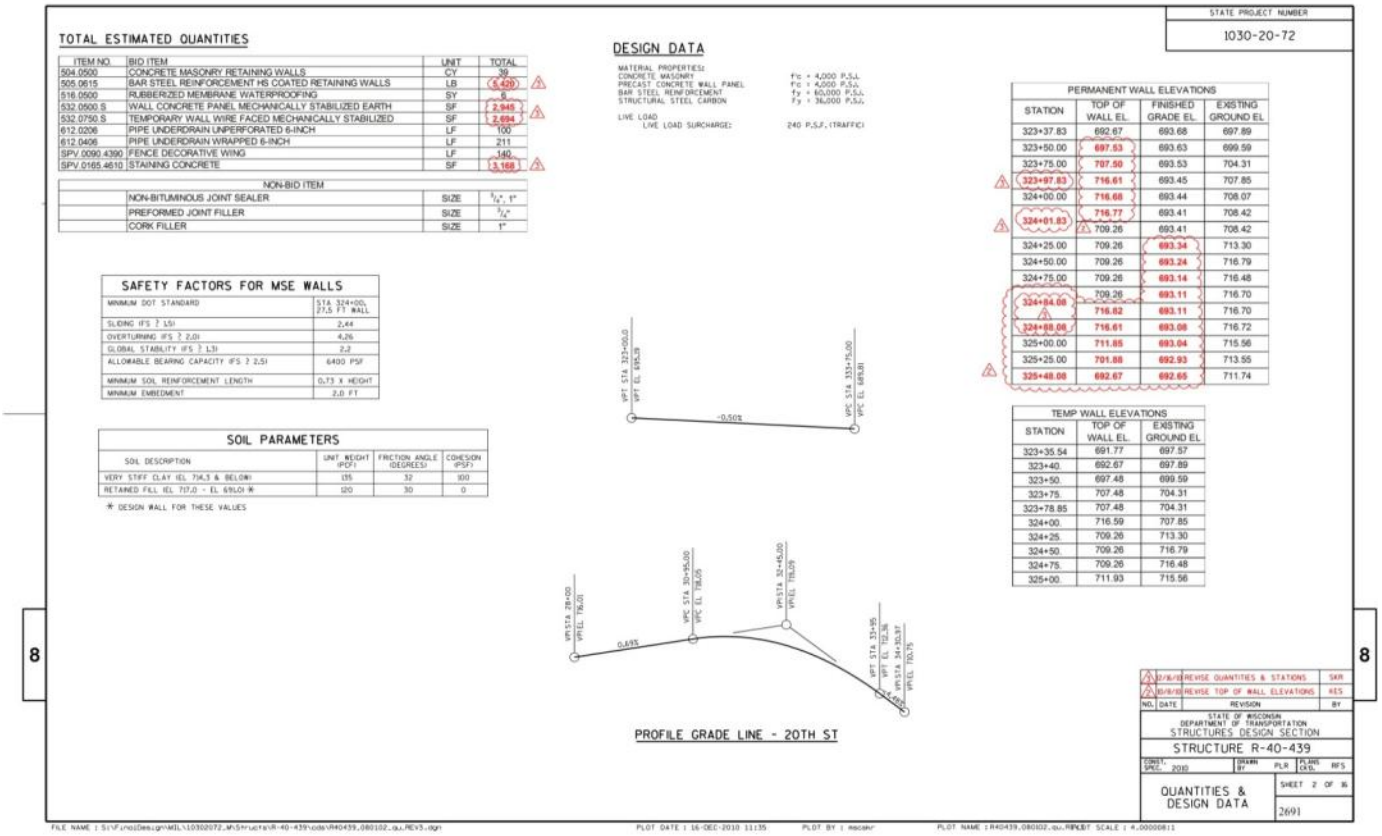


Collaboration on Model Checks

- Creation of separate issue log to track checks, fixes, and vet RFI's before submitting through the formal RFI route
- Challenges using off site modeling techs
- Coordination on priority grading areas

Example Retaining Wall

- **Preconstruction modeling identified 82 RFIs**
- **Wall plan missing vertical transition to match roadway above**



STATE PROJECT NUMBER 1030-20-72

TOTAL ESTIMATED QUANTITIES

ITEM NO.	BID ITEM	UNIT	TOTAL
504.0500	CONCRETE MASONRY RETAINING WALLS	CY	39
505.0615	BAR STEEL REINFORCEMENT HS COATED RETAINING WALLS	LB	5,420
516.0500	RUBBERIZED MEMBRANE WATERPROOFING	SY	6
532.0500.S	WALL CONCRETE PANEL MECHANICALLY STABILIZED EARTH	SF	2,945
532.0750.S	TEMPORARY WALL WIRE FACED MECHANICALLY STABILIZED	SF	2,694
612.0206	PIPE UNDERDRAIN UNPERFORATED 6-INCH	LF	100
612.0406	PIPE UNDERDRAIN WRAPPED 6-INCH	LF	211
SPV.0090.4390	FENCE DECORATIVE WING	LF	140
SPV.0165.4610	STAINING CONCRETE	SF	3,168

NON-BID ITEM			
	NON-BITUMINOUS JOINT SEALER	SIZE	1/2", 1"
	PREFORMED JOINT FILLER	SIZE	1/2"
	CORK FILLER	SIZE	1"

SAFETY FACTORS FOR MSE WALLS

MINIMUM DOT STANDARD	STA 324+00, 27.5 FT WALL
SLIDING IFS ≥ 1.5	2.44
OVERTURNING IFS ≥ 2.0	4.26
GLOBAL STABILITY IFS ≥ 1.3	2.2
ALLOWABLE BEARING CAPACITY IFS ≥ 2.5	6400 PSF
MINIMUM SOIL REINFORCEMENT LENGTH	0.7 X HEIGHT
MINIMUM EMBEDMENT	2.0 FT

SOIL PARAMETERS

SOIL DESCRIPTION	UNIT WEIGHT (PCF)	FRICTION ANGLE (DEGREES)	COHESION (PSF)
VERY STIFF CLAY (EL 734.3 & BELOW)	135	32	100
RETAINED FILL (EL 717.0 - EL 691.0) *	120	30	0

* DESIGN WALL FOR THESE VALUES

DESIGN DATA

MATERIAL PROPERTIES:
CONCRETE MASONRY — f'c = 4,000 P.S.I.
PRECAST CONCRETE WALL PANEL — f'c = 4,000 P.S.I.
BAR STEEL REINFORCEMENT — fy = 60,000 P.S.I.
STRUCTURAL STEEL CARBON — fy = 36,000 P.S.I.

LIVE LOAD
LIVE LOAD SURCHARGE: 240 P.S.F. (TRAFFIC)

PERMANENT WALL ELEVATIONS

STATION	TOP OF WALL EL.	FINISHED GRADE EL.	EXISTING GROUND EL.
323+37.83	692.67	693.68	697.89
323+50.00	697.53	693.63	699.59
323+75.00	707.50	693.53	704.31
323+97.83	716.61	693.45	707.85
324+00.00	716.68	693.44	708.07
324+01.83	716.77	693.41	708.42
	709.26	693.41	708.42
324+25.00	709.26	693.34	713.30
324+50.00	709.26	693.24	716.79
324+75.00	709.26	693.14	716.48
	709.26	693.11	716.70
324+84.08	716.82	693.11	716.70
324+88.08	716.61	693.08	716.72
325+00.00	711.85	693.04	715.56
325+25.00	701.88	692.93	713.55
325+48.08	692.67	692.65	711.74

TEMP WALL ELEVATIONS

STATION	TOP OF WALL EL.	EXISTING GROUND EL.
323+35.54	691.77	697.57
323+40.	692.67	697.89
323+50.	697.48	699.59
323+75.	707.48	704.31
323+78.85	707.48	704.31
324+00.	716.59	707.85
324+25.	709.26	713.30
324+50.	709.26	716.79
324+75.	709.26	716.48
325+00.	711.93	715.56

PROFILE GRADE LINE - 20TH ST

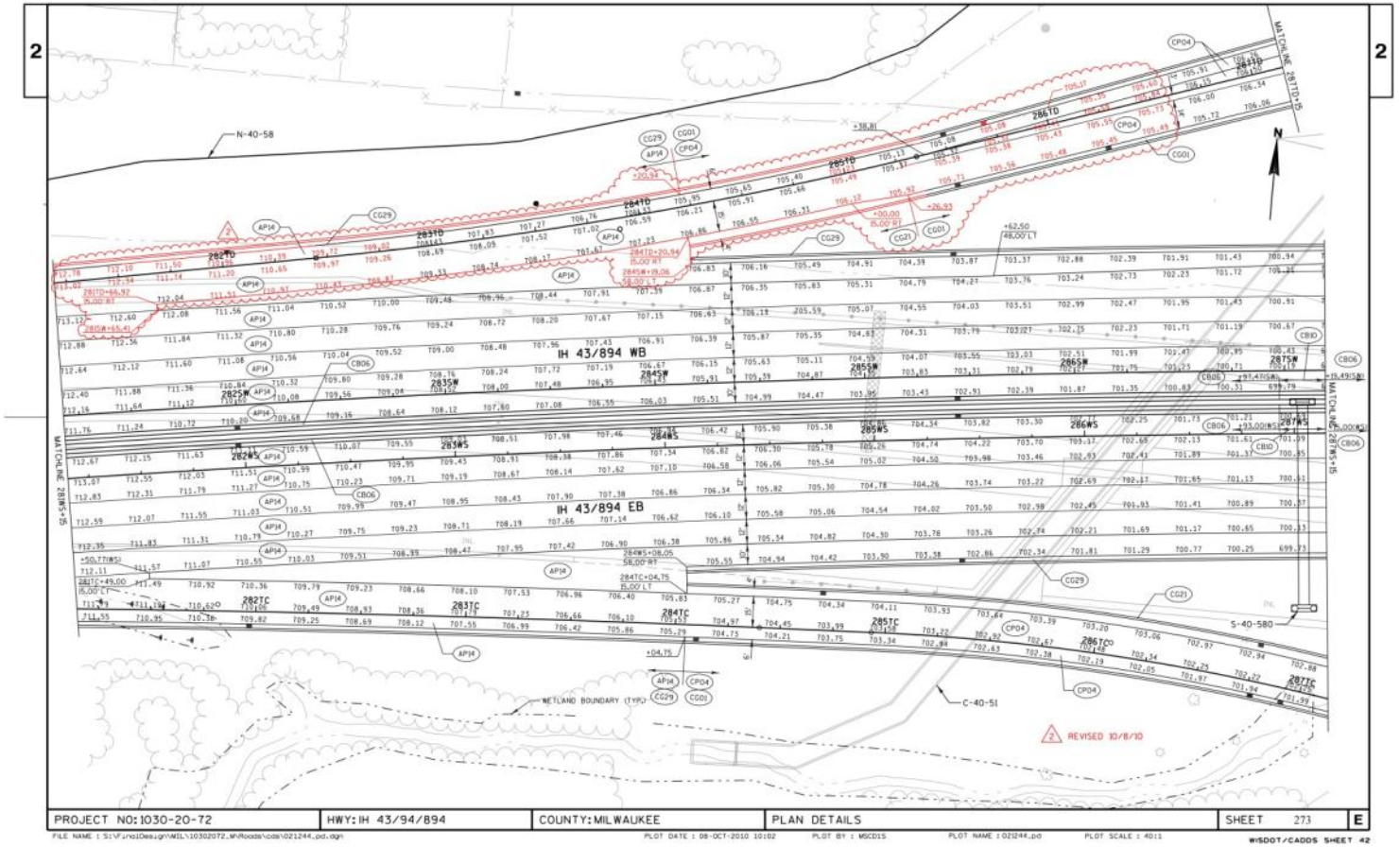
NO.	DATE	REVISION	BY
2	12/6/10	REVISE QUANTITIES & STATIONS	SKR
1	10/8/10	REVISE TOP OF WALL ELEVATIONS	KES

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION
STRUCTURES DESIGN SECTION
STRUCTURE R-40-439
CONST. SPEC. 2010 | DRAWN BY PLR | PLANS DATE RFS
QUANTITIES & DESIGN DATA
SHEET 2 OF 16
2691

FILE NAME : S:\Structures\Design\MEL\10302072_MSStructure\R-40-439\cadd\R40439_080102_qu_REV3.dgn
PLOT DATE : 16-DEC-2010 11:35 PLOT BY : mcoxr PLOT NAME : R40439_080102_qu_RPLOT SCALE : 4.0000011

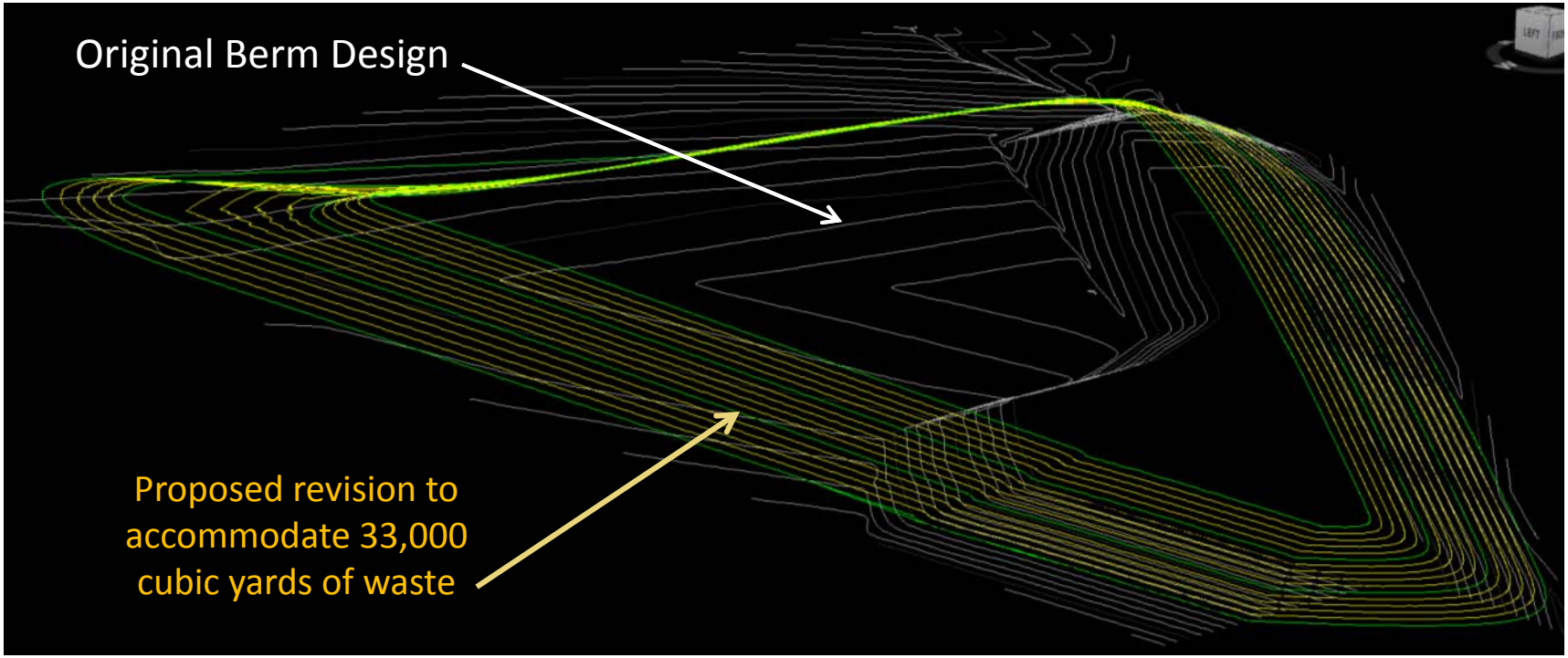
Example Alignment Issues

- **Hz alignment issue caused profile and paving detail revisions**
  - Non-tangent Hz alignment location revised by over four feet



Model Use During Construction

- **Excess fill in 71 Contract**
- **Models modified to help CM staff accommodate excess waste**

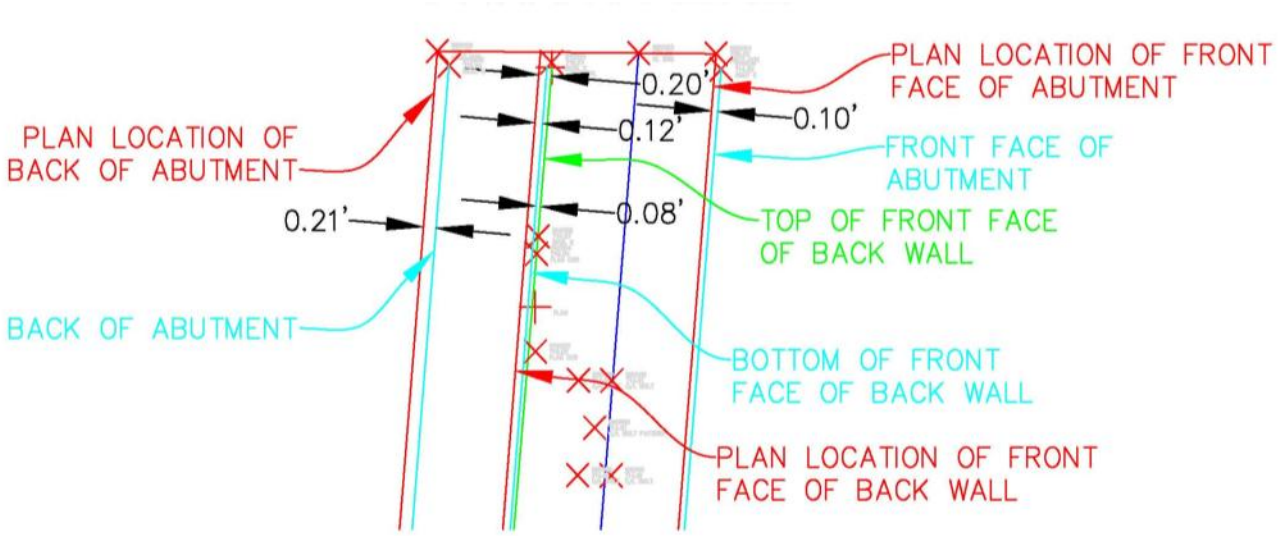


Model Use During Construction

- Staged Berm volume checks 71 contract vs. 72 contract
- Model and as built shots used to mediate disputes between contracts

Model Use During Construction

- Model of Plan of B-40-820 Layton Ave.
- Used to measure deviation of backwall construction and salvage abutment



Rover Use by Inspectors

2 DOT provided & 2 Consultant provided Rovers made available for use by inspection team

- **25 member CM team**
  - 5 avid users
  - 5 casual users
  - 15 non-users
- **Field Uses**
  - Grade checks
  - Structures
    - Wall alignments
    - Sign bridge footings
    - Structure excavation
  - Pavement marking layout
  - Pay quantity measurements

Road Stakeout: CD_ROAD_SB(CD_ROAD_SB)

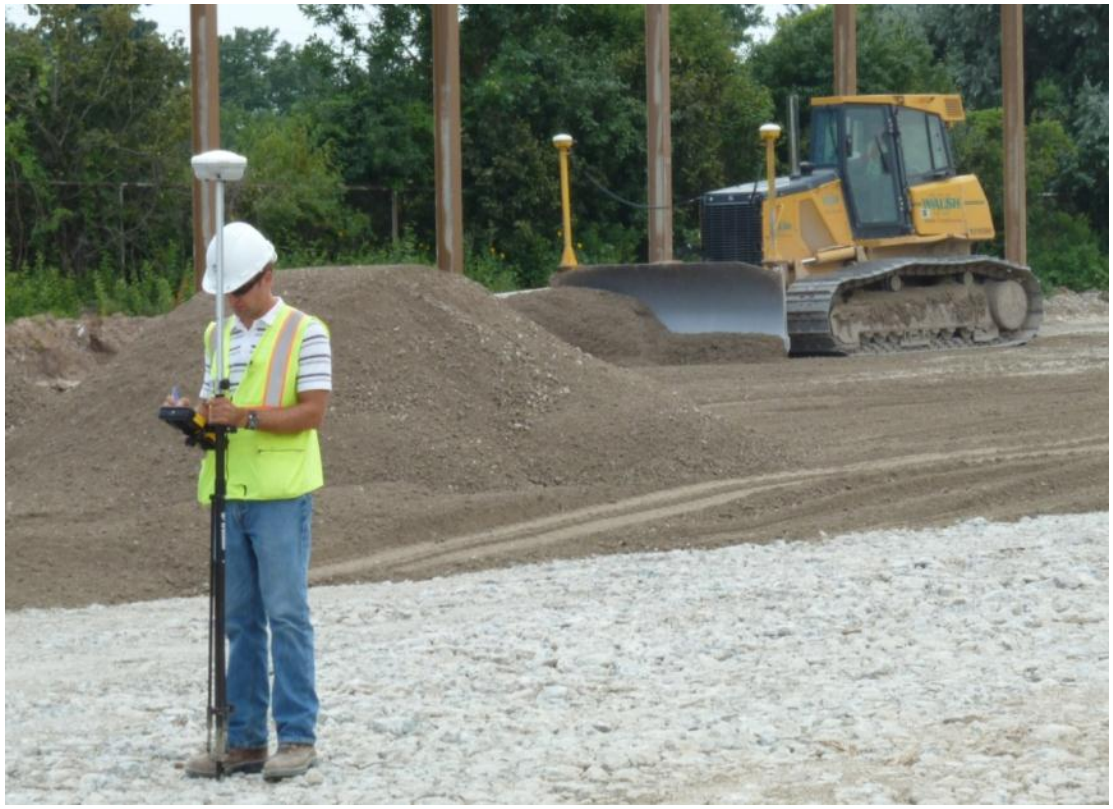
Point Name	Code	Station	Offset	Const O/S (Hz/Vt)	Design Z	Staked Z	Cut/Fill	Δ Station	Δ Offset
1001024	5514+00.000/0.000SUBGRADE	5514+00.000	0.000	0.000/-3.290	724.214	724.300	-0.086	0.114	0.017
1001025	5514+00.000/-12.000	5514+00.000	-12.000	0.000/-3.290	723.990	723.927	0.063	-0.097	-0.101
1001026	5515+00.000/-24.000	5515+00.000	-24.000	0.000/-3.290	723.740	723.689	0.051	0.083	0.139
1001027	5515+00.000/-12.000	5515+00.000	-12.000	0.000/-3.290	723.980	723.866	0.114	0.012	0.026
1001028	5515+00.000/0.000	5515+00.000	0.000	0.000/-3.290	724.220	724.003	0.217	-0.218	-0.037
1001029	5516+75.000/0.000	5516+75.000	0.000	0.000/-3.290	723.586	723.517	0.069	0.187	0.313
1001030	5516+75.000/-12.000	5516+75.000	-12.000	0.000/-3.290	723.346	723.311	0.035	-0.178	0.101
1001031	5516+75.000/-24.000	5516+75.000	-24.000	0.000/-3.290	723.106	722.984	0.122	-0.199	-0.113
1001032	5519+00.000/0.000	5519+00.000	0.000	0.000/-3.290	721.646	721.687	-0.041	-0.314	0.039
1001033	5519+00.000/-12.000	5519+00.000	-12.000	0.000/-3.290	721.406	721.328	0.079	-0.119	-0.030
1001034	5519+00.000/-24.000	5519+00.000	-24.000	0.000/-3.290	721.166	721.253	-0.086	0.139	0.035

Rover Use by Inspectors

- **Project surveyor assigned to CM team**
  - Met with team leaders of Structural, Excavation and Drainage to identify potential areas of benefit.
  - Created protocols for use of rovers by “non-surveyors”
  - Ran brief training sessions
    - Boot up the rover, create log files, navigate collector.
    - Check into field control
    - Staking and checking from exported model files
    - Store points for later use
  - Oversight of all data in and out of rovers

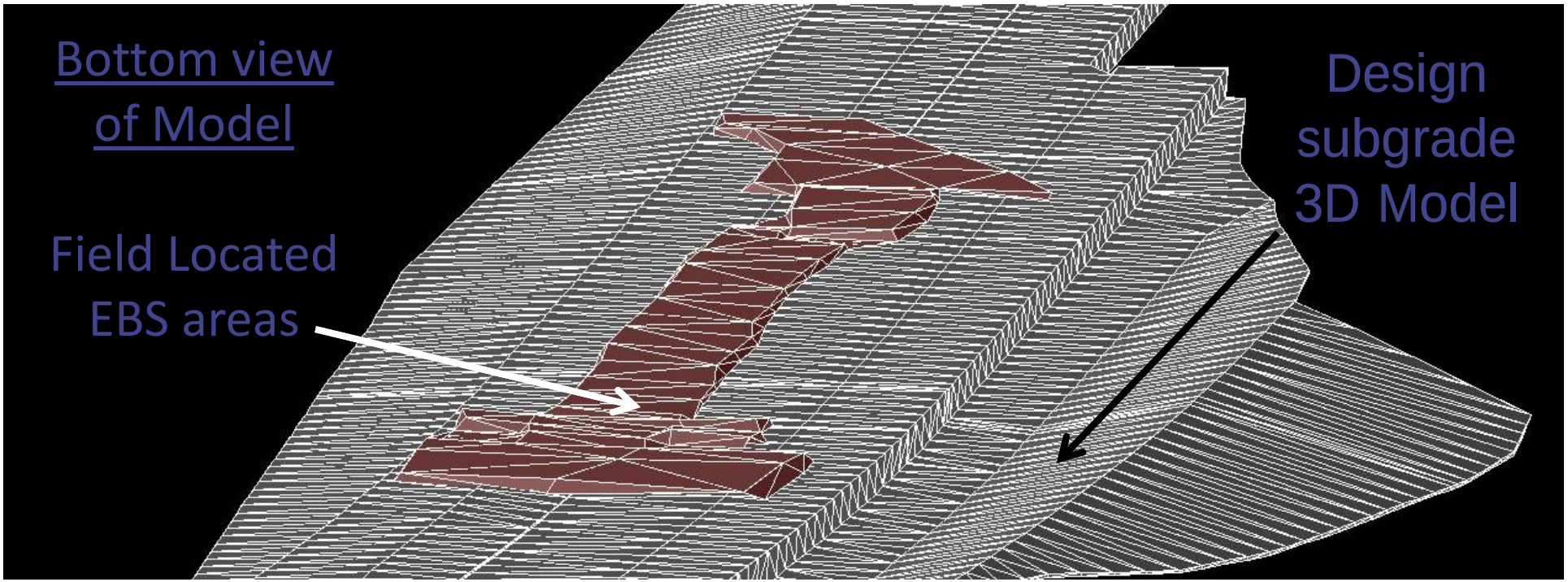
Rover Use by Inspectors

- **Verification of subgrade and stone placement in real time**



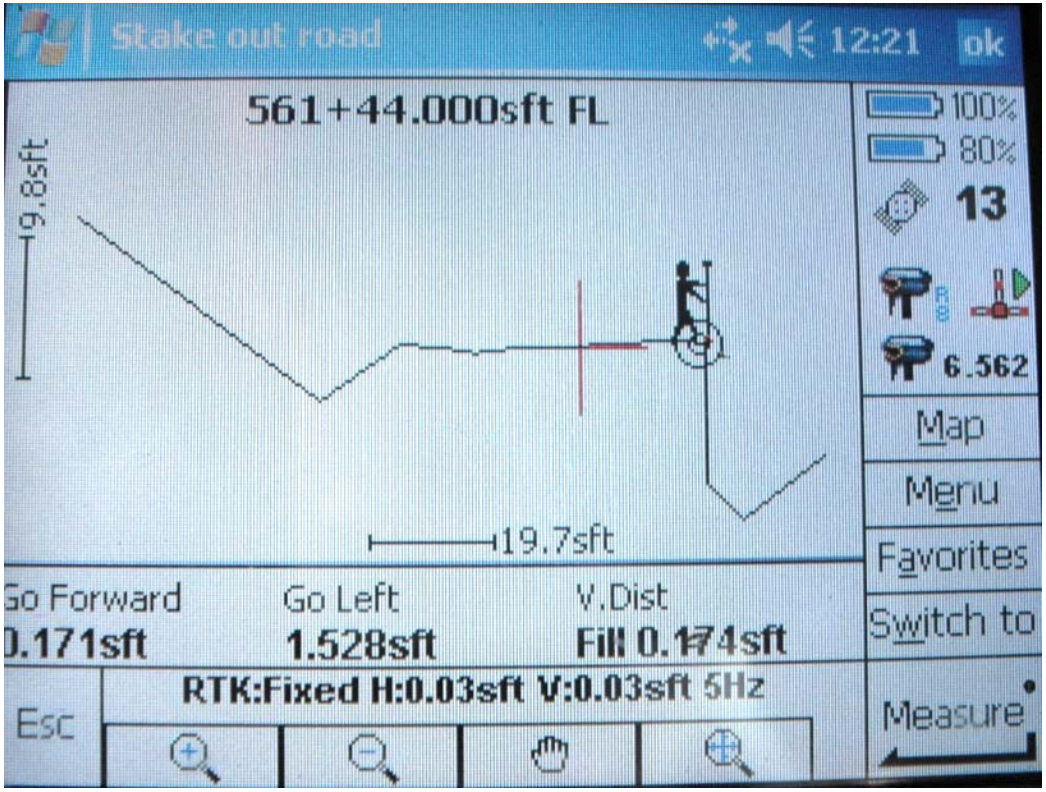
Rover Use by Inspectors

- Excavation Below Subgrade (EBS) measurement for pay quantity
- Structural Excavation. Verification of Location, Size and Depth
- MSE wall leveling pad alignment and elevation



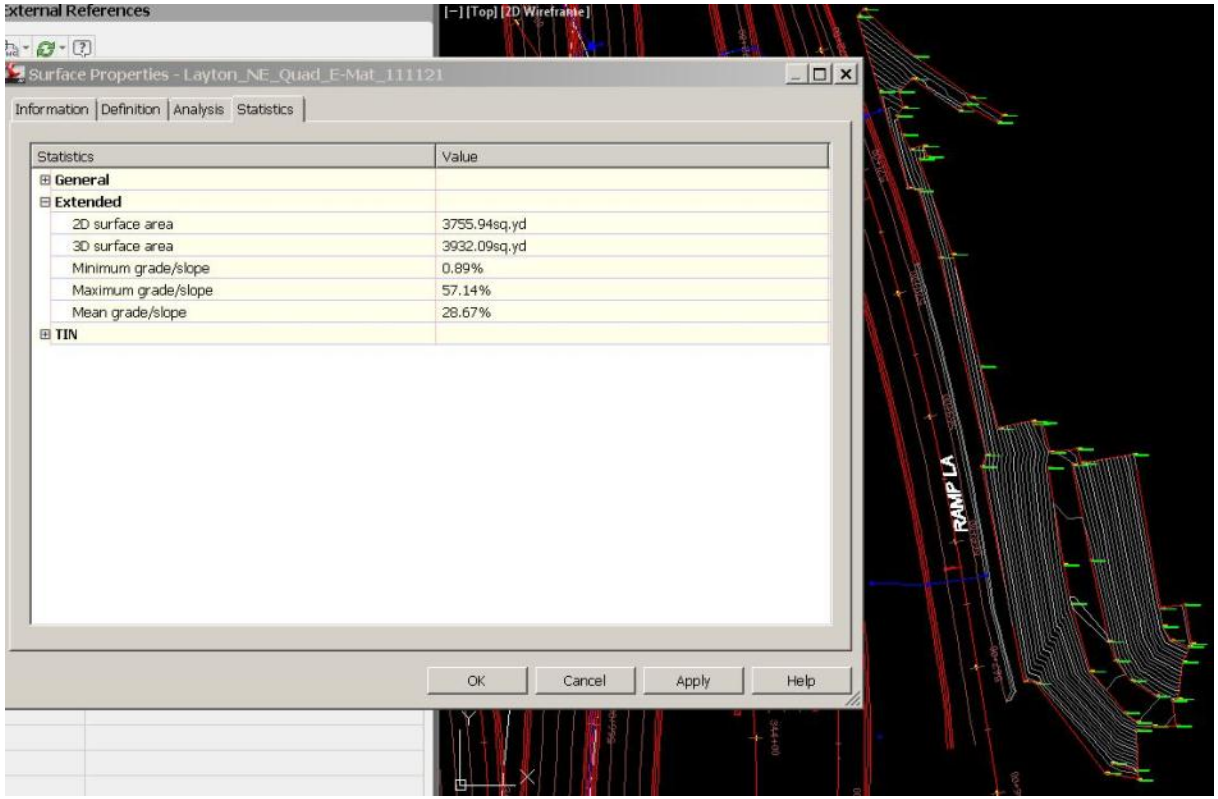
Rover Use by Inspectors

- Slope intercept adjustments in the field. Helped PI effort by allowing adjustments to be made in the field to save trees and other existing features at the project match.



Pay Quantity Measurement

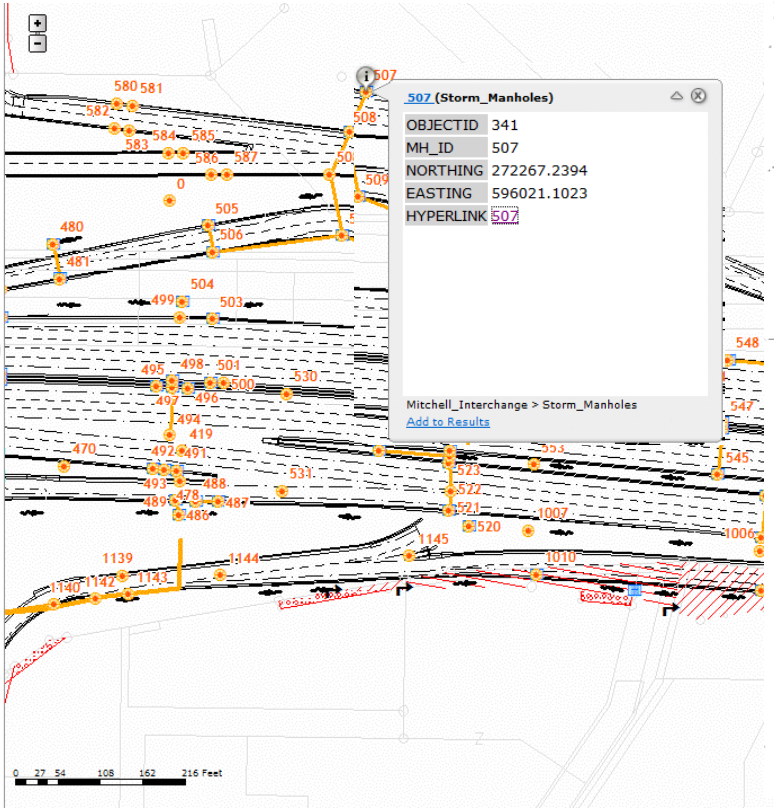
- **Square Yard Measurement**
  - Erosion mat
  - Seed types
  - Sod
  - Mulch
  - Soil stabilizer

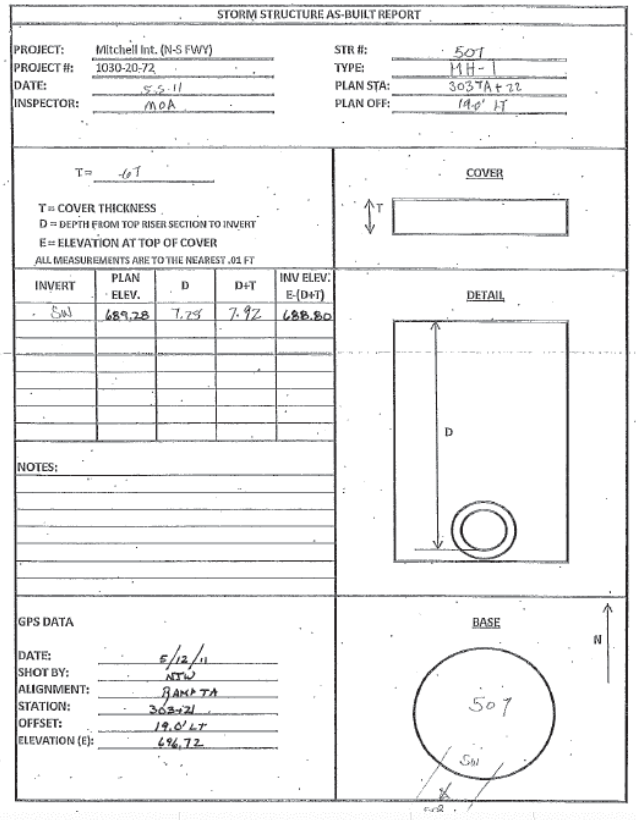


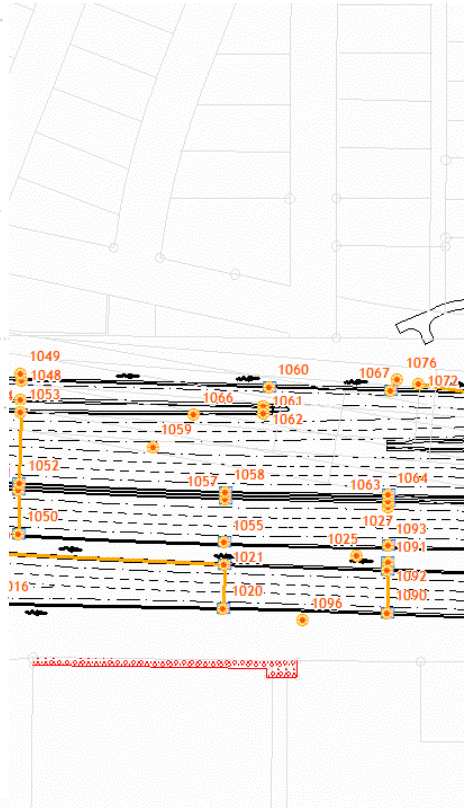
Mitchell Storm As Built

Storm was as built as installed

- Rovers allowed verification in real time
- Created an experimental GIS to log inspection reports

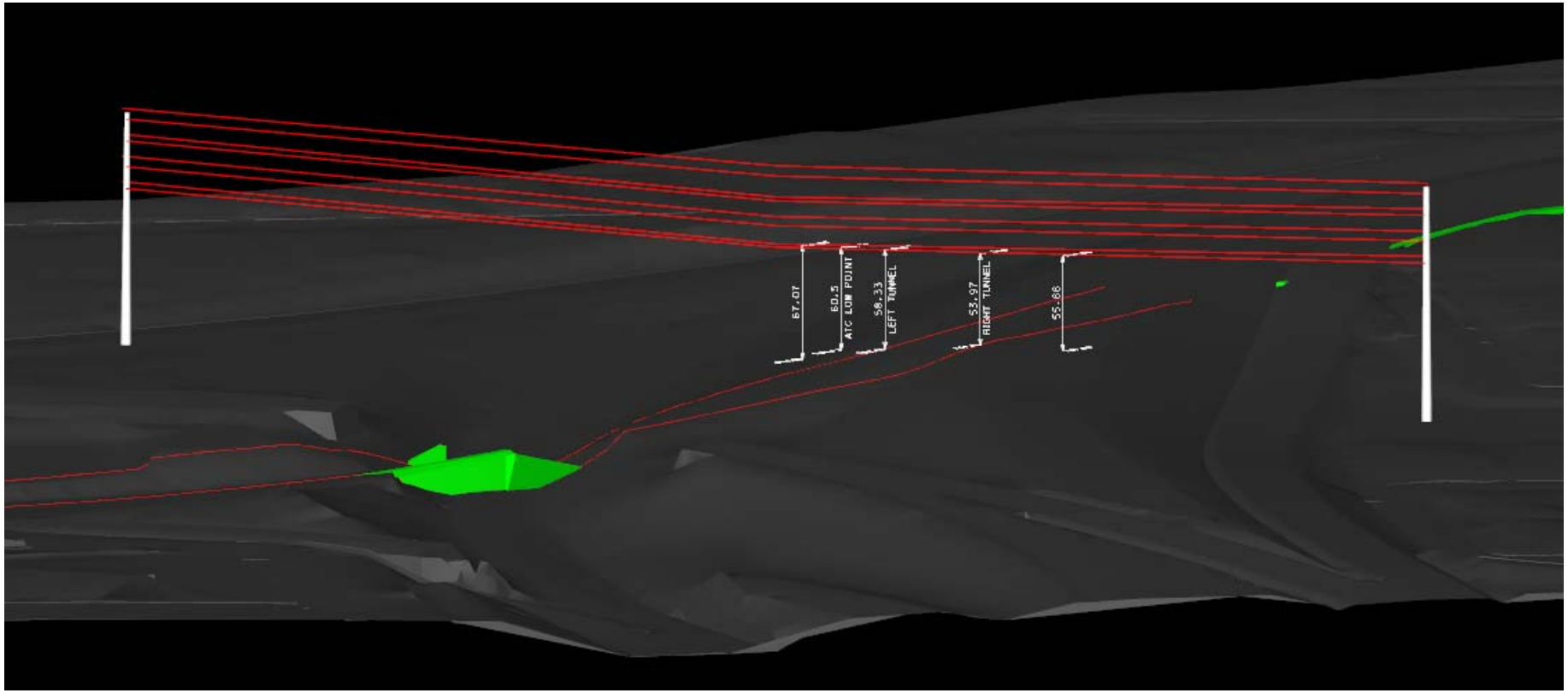






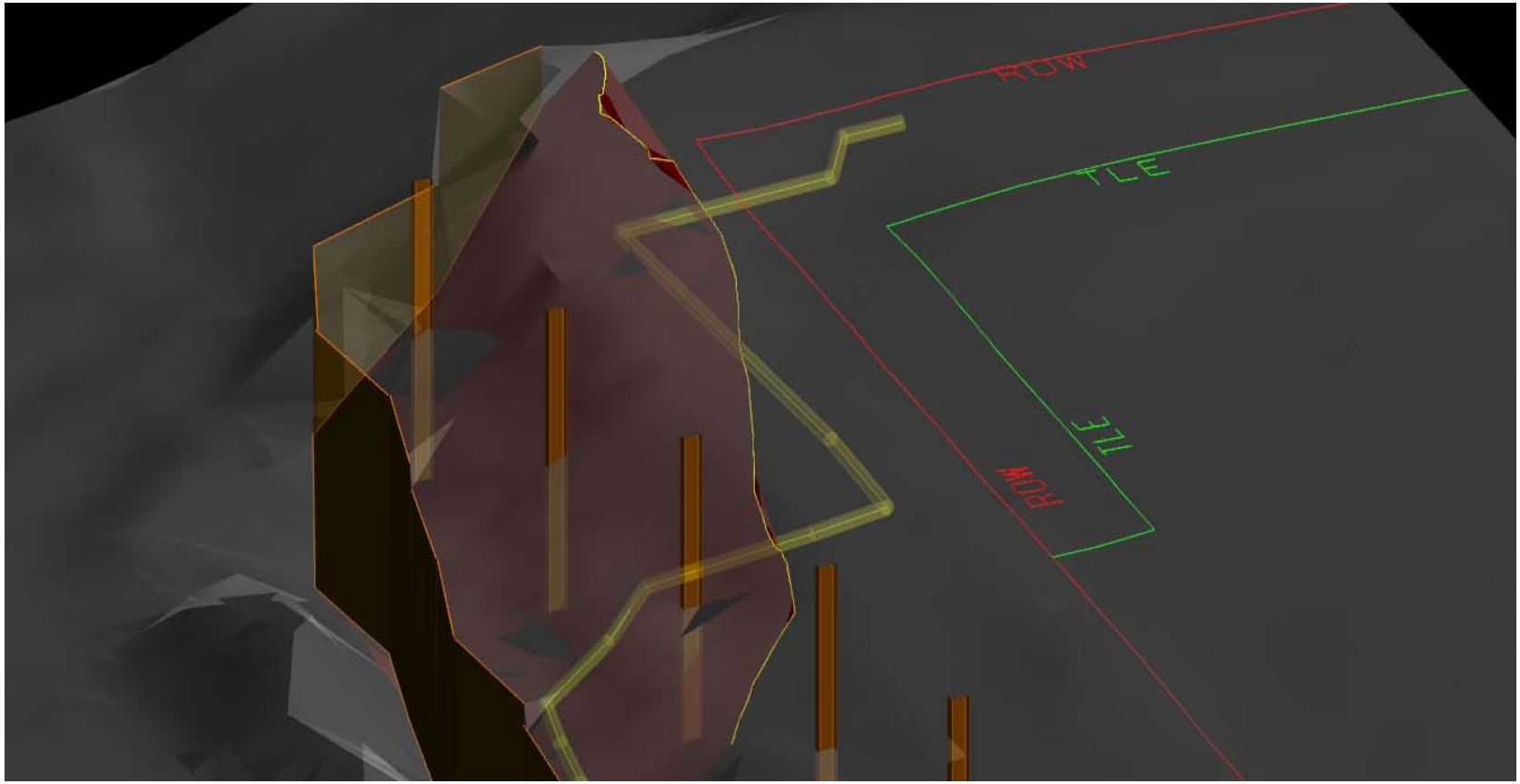
As-Built Mapping

- Fiber optic cables located to document plan changes
- Transmission Lines scanned for drill rig clearance



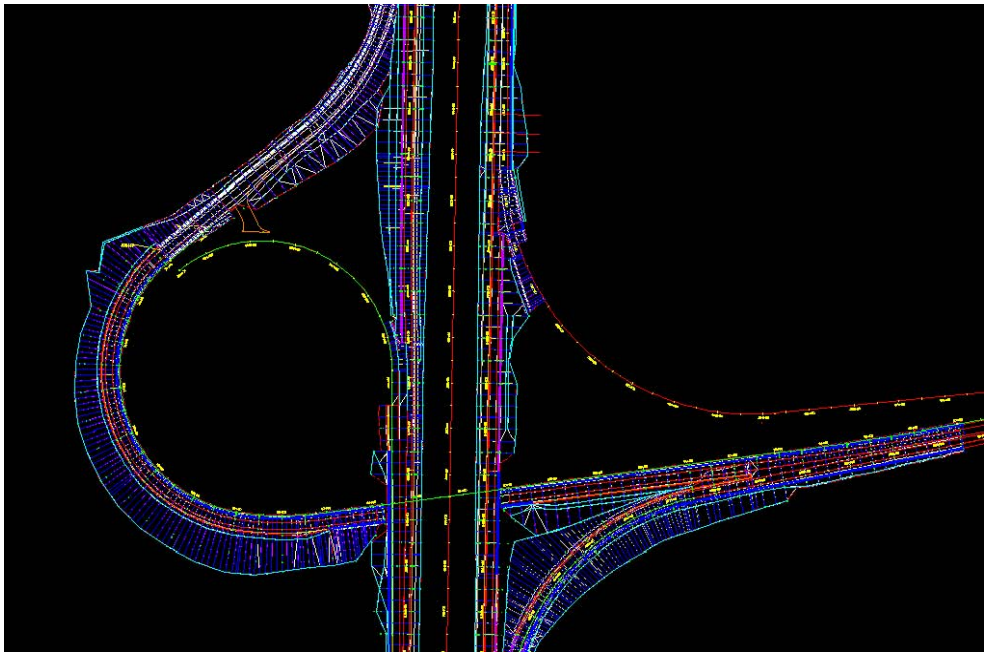
Mitchell Interchange Gas Main

- Gas line as built was later used in an exhibit to determine cost sharing between GC, Utility and DOT



Challenges

- **Stakeholder Buy-In**
  - Investment in tools and training
  - Difficult to adopt change and take risk of an unproven technology in a fast paced and sometimes stressful environment
- **Learning curve**
  - Some inspectors embrace change and some don’t see the need



Questions?