An Alternative to HEC-GEORAS:

Overview & Comparison of AutoCAD River & Flood Analysis Module

Ron Branyon , PE, CFM
George Doubleday, EIT, CFM
Brandon Hilbrich, PE, CFM

TFMA 2015 Spring Conference
April 16, 2015

Overview

- Hydraulic Modeling History
- San Pedro Creek Improvements Project (SPCIP) Background Summary
- AutoCAD River & Flood Analysis Introduction
- Basic Tool Step-by-Step
- River & Flood Analysis Tool vs HEC-RAS
- Implementation with SPCIP
- Summary

Hydraulic Modeling
History & Evolution

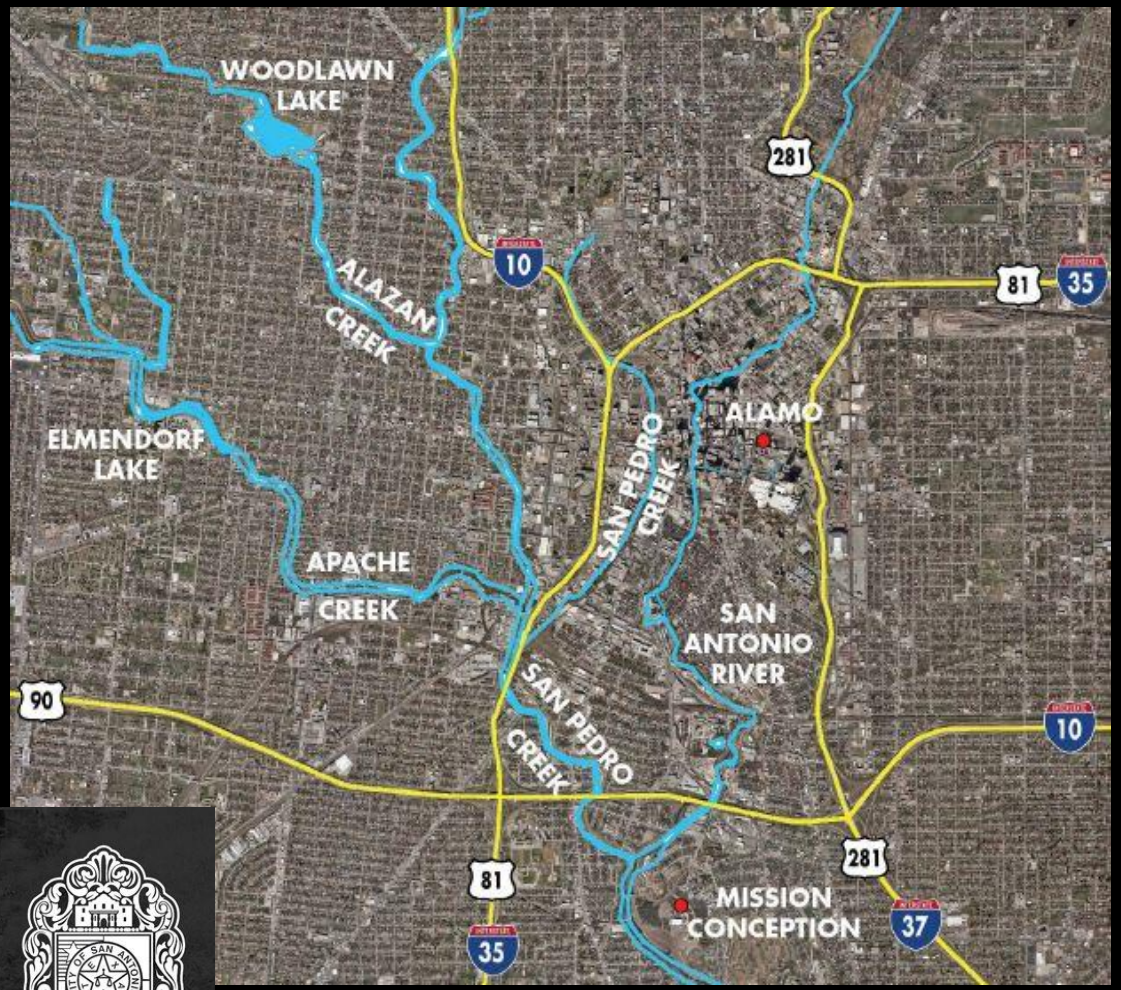
- Timeline of hydraulic model development
  - HEC 2: First hydraulic modeling program released by USACE in 1990.
  - HEC-RAS Version 2.2: USACE releases first graphical hydraulic modeling program in 1995.
  - Six versions released up to the latest approved version 4.1.
  - HEC-GeoRAS: Released in 2006 for ArcGIS 3.2.
- Software available for San Pedro Creek Improvements project:
  - DFIRM HEC-RAS hydraulic model
  - Survey and design in AutoCAD
  - XPSWMM model developed to study area.

San Pedro Creek Improvements Project

Project Background

Project Area:

- Urbanized area located in Downtown San Antonio
- Project approximately 10,350 linear feet
- Includes approximately 1.1 mile tunnel diversion system.
  - Inverted siphon.
  - 24 foot diameter conduit approximately 150 feet below ground.
  - Diverts approximately 4,600 cfs during the 100-year event.



SAN ANTONIO RIVER AUTHORITY
Leaders in Watershed Solutions

THE STATE OF TEXAS · COUNTY OF BEXAR ·

San Pedro Creek Improvements Project

Project Area & Approach

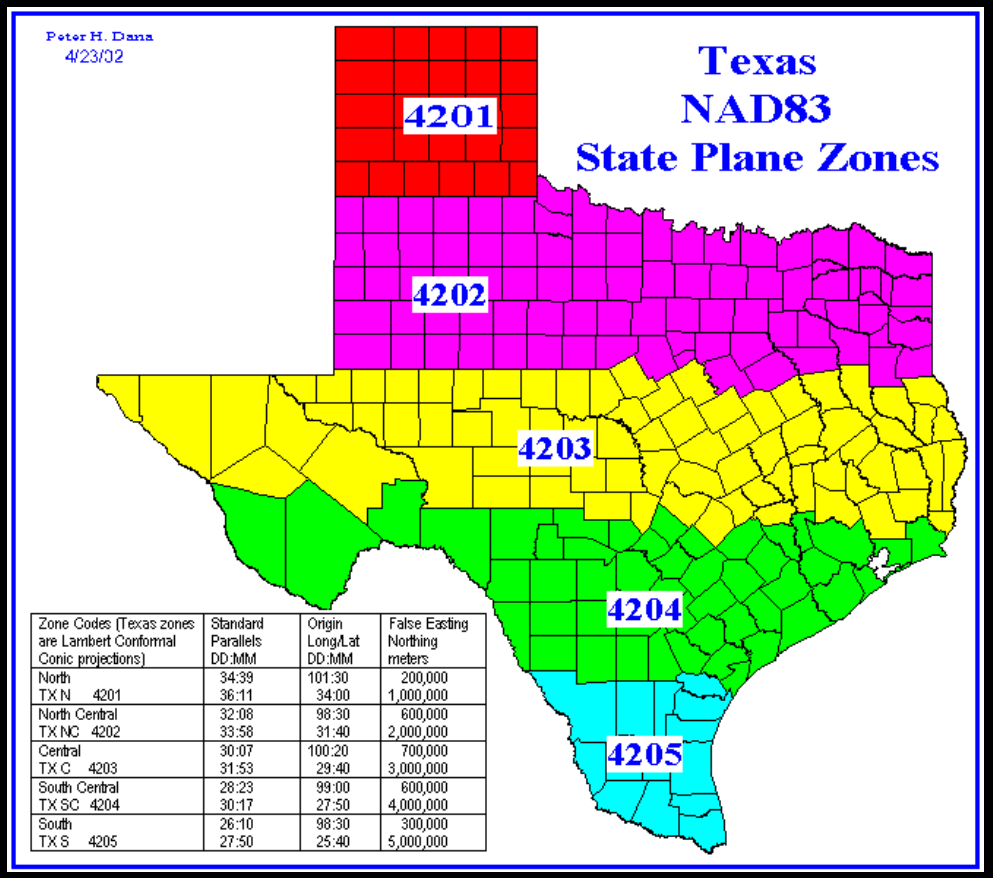
Project Approach:

- Phased modeling approach selected due to time constraints.
- Interim “early design” HEC-RAS developed concurrently with XPSWMM model development.
- HEC-RAS model used to make critical channel design and bridge replacement decisions and build proposed conditions surface.
- XPSWMM model is restudy of area to define new baseline existing conditions and assess project improvements.

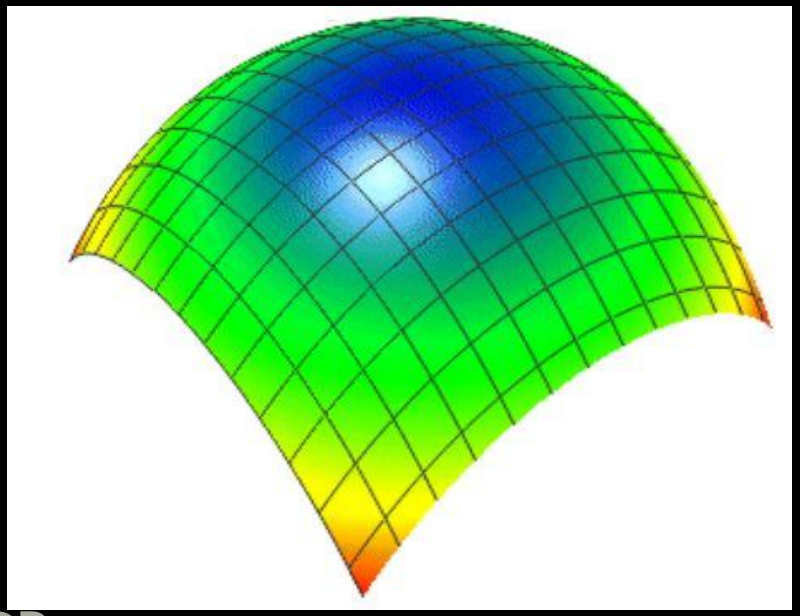
Surface and Grid Coordinates

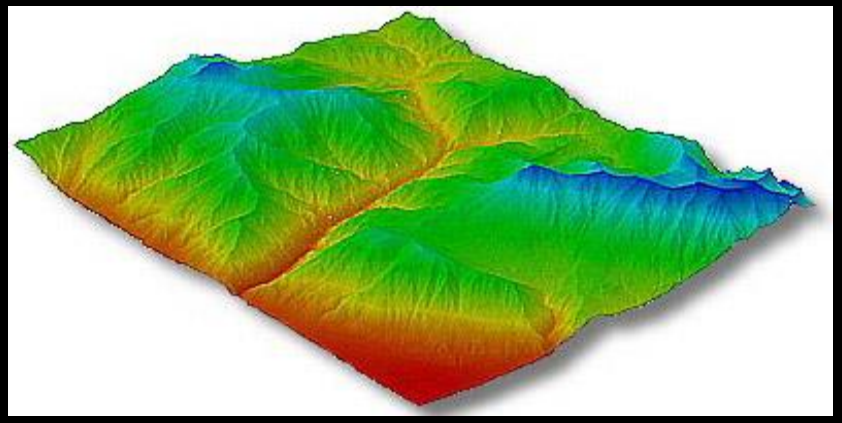
Difficulties

- What's the difference?
- Why does it matter?
  - Time and data storage between AutoCAD and GIS
- Relation to San Pedro Creek Project
  - Opportunity to reduce data processing.



Zone Codes (Texas zones are Lambert Conformal Conic projections)	Standard Parallels DD:MM	Origin Long/Lat DD:MM	False Easting Northing meters
North TX N 4201	34:39 36:11	101:30 34:00	200,000 1,000,000
North Central TX NC 4202	32:08 33:58	98:30 31:40	600,000 2,000,000
Central TX C 4203	30:07 31:53	100:20 29:40	700,000 3,000,000
South Central TX SC 4204	28:23 30:17	99:00 27:50	600,000 4,000,000
South TX S 4205	26:10 27:50	98:30 25:40	300,000 5,000,000



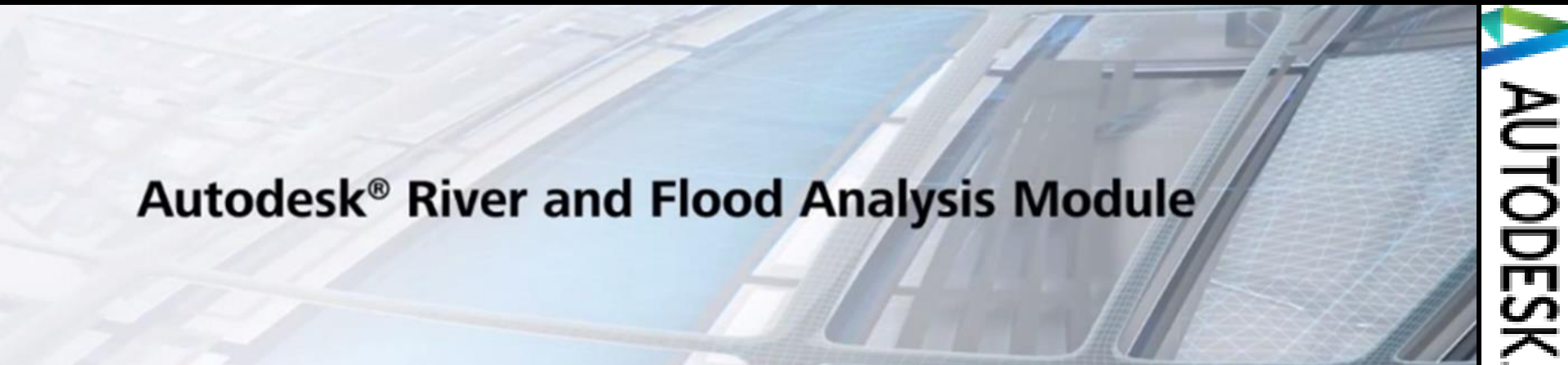


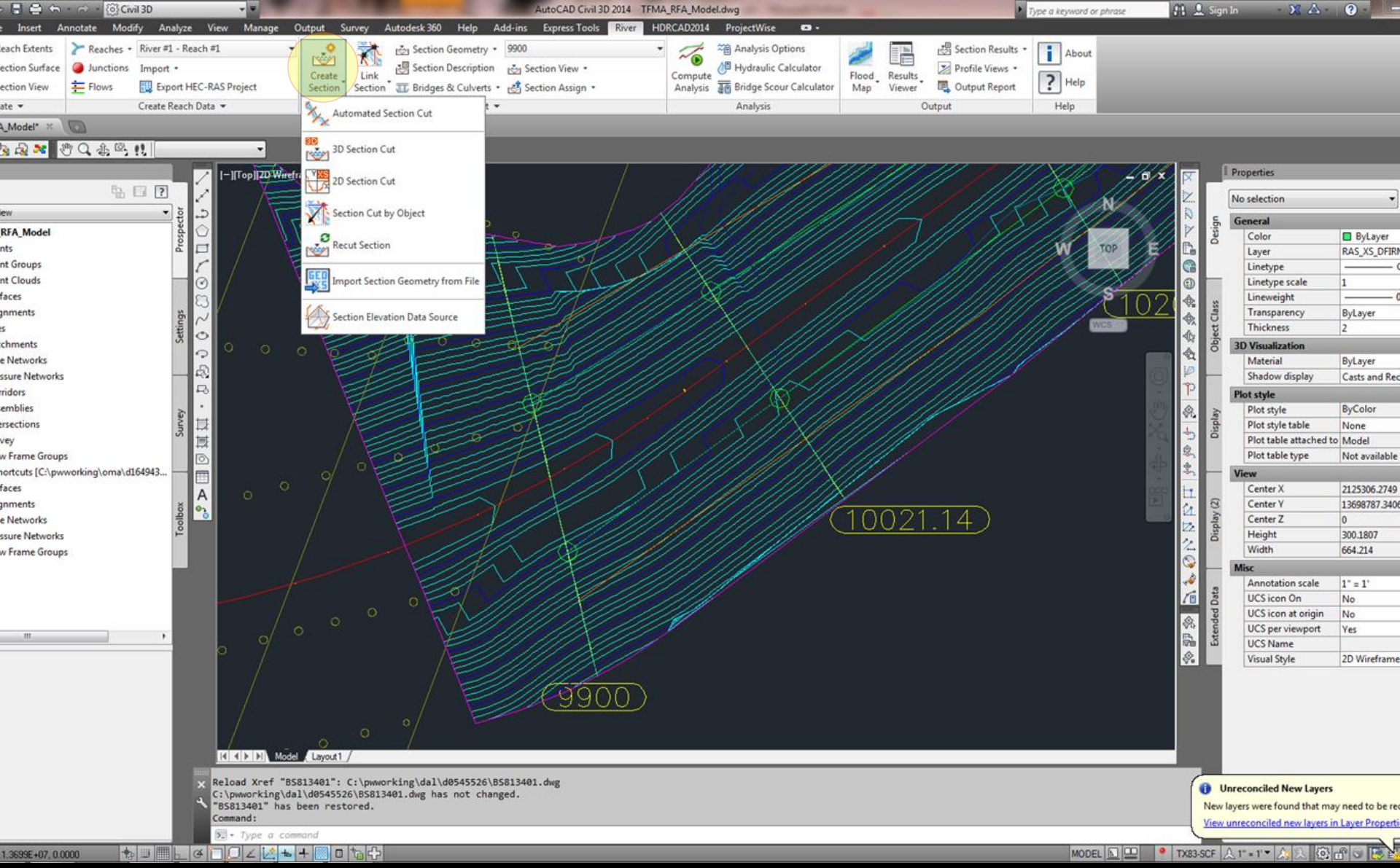
AutoCAD River & Flood Analysis Module

Introduction

- Available with AutoCAD Civil 3D 2012 and included in Infrastructure Design Suite 2016
- Advanced river modeling software supports HEC-RAS within Autodesk AutoCAD Civil 3D
- Automates HEC-RAS cross section cutting, analysis, flood plain modeling, and modeling tasks
- Imports and exports HEC-RAS model files, ready for agency submission
- Terrain processing capability enables use of numerous digital terrain data formats

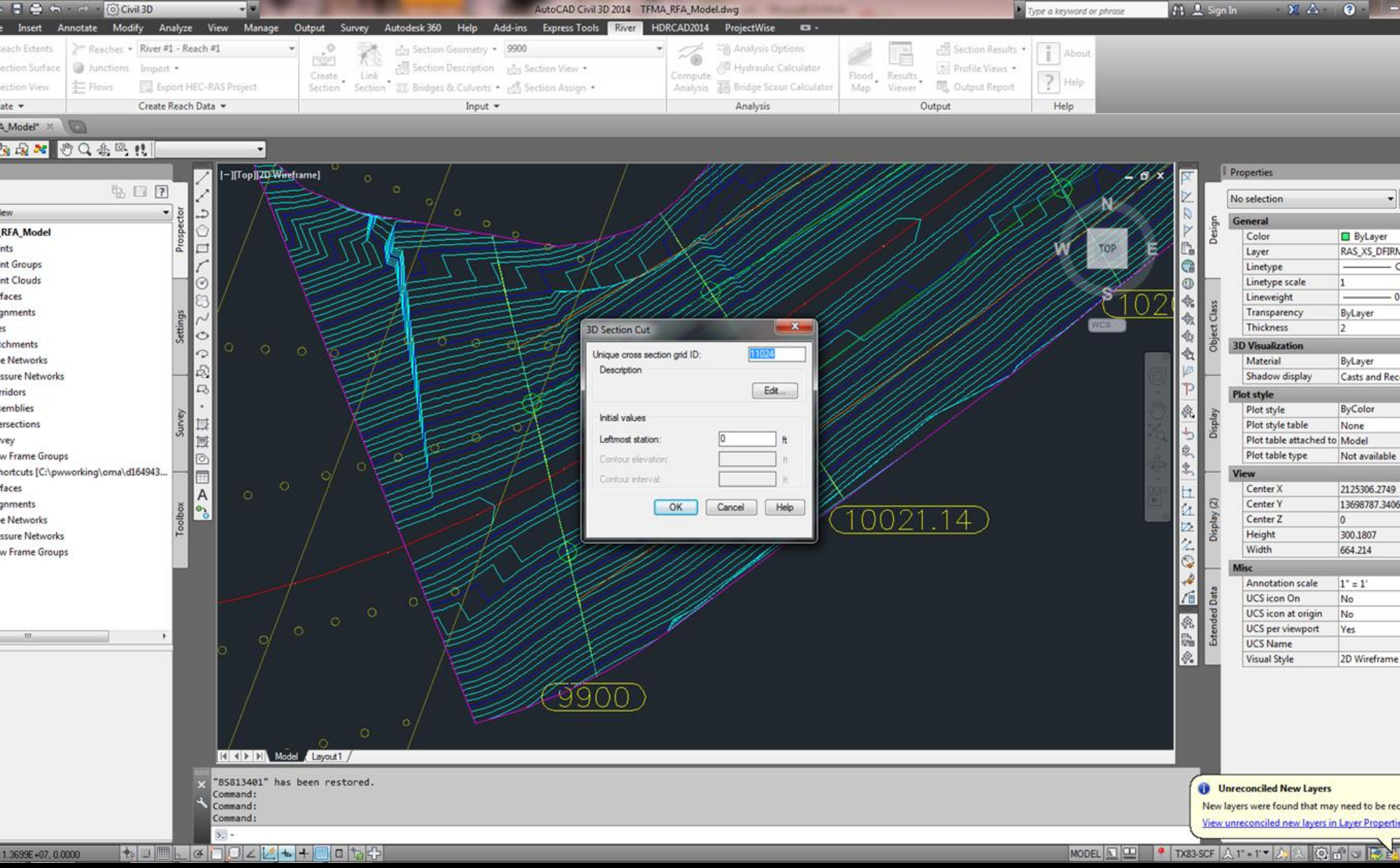
- **Quick overview of tool capabilities**





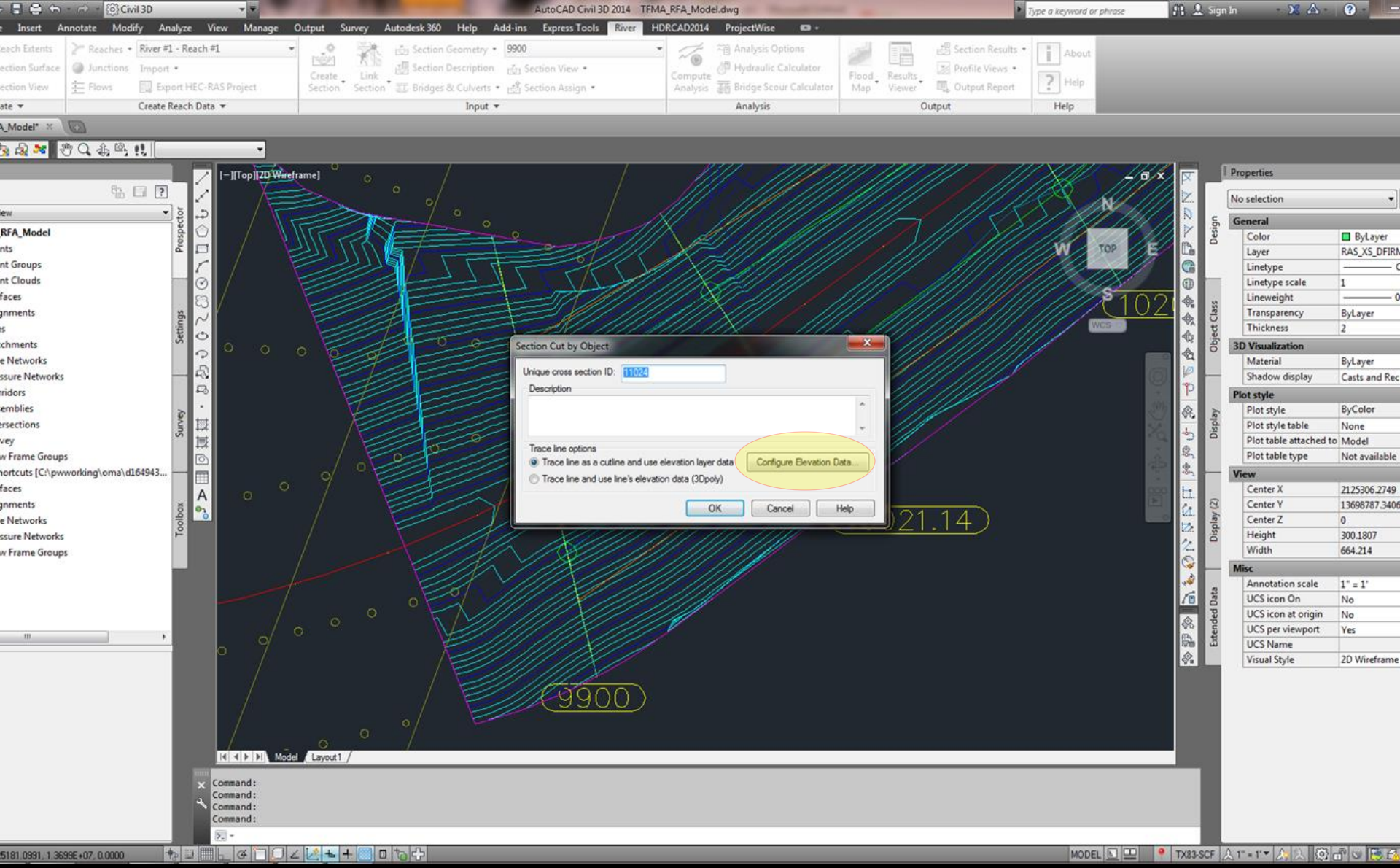
Create Section

Different Options



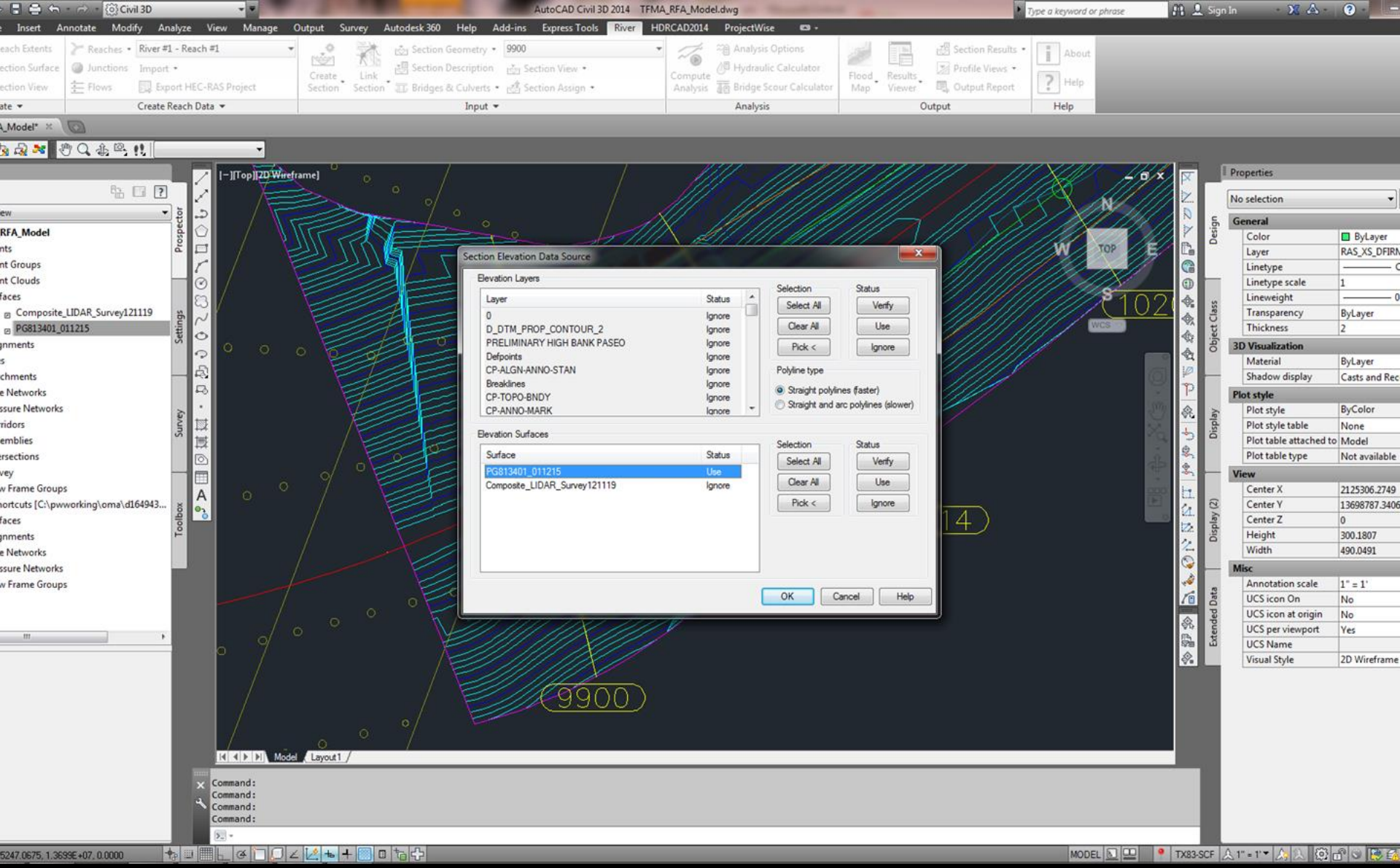
Create Section

3D Section Cut



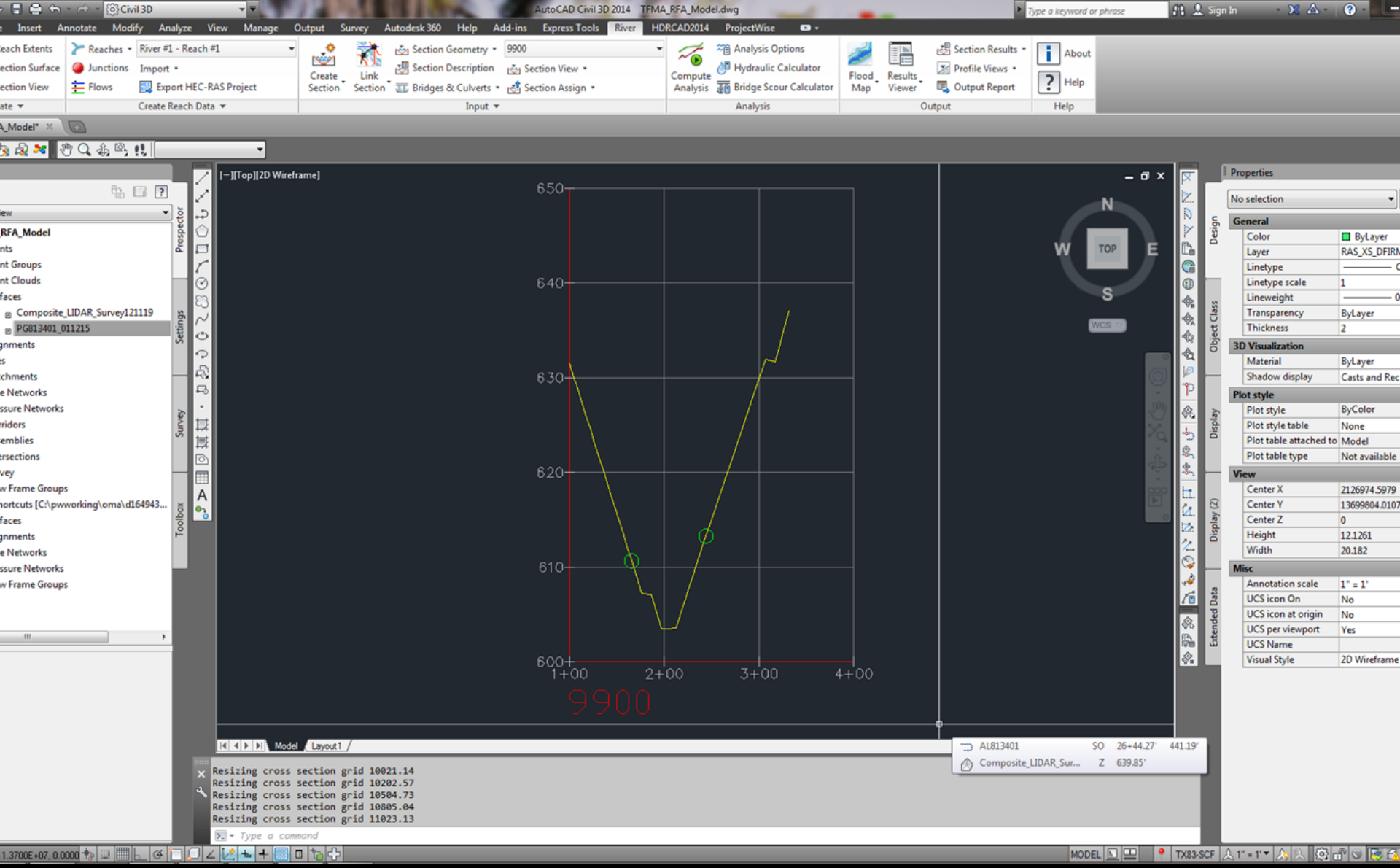
Create Section

Section Cut by Object

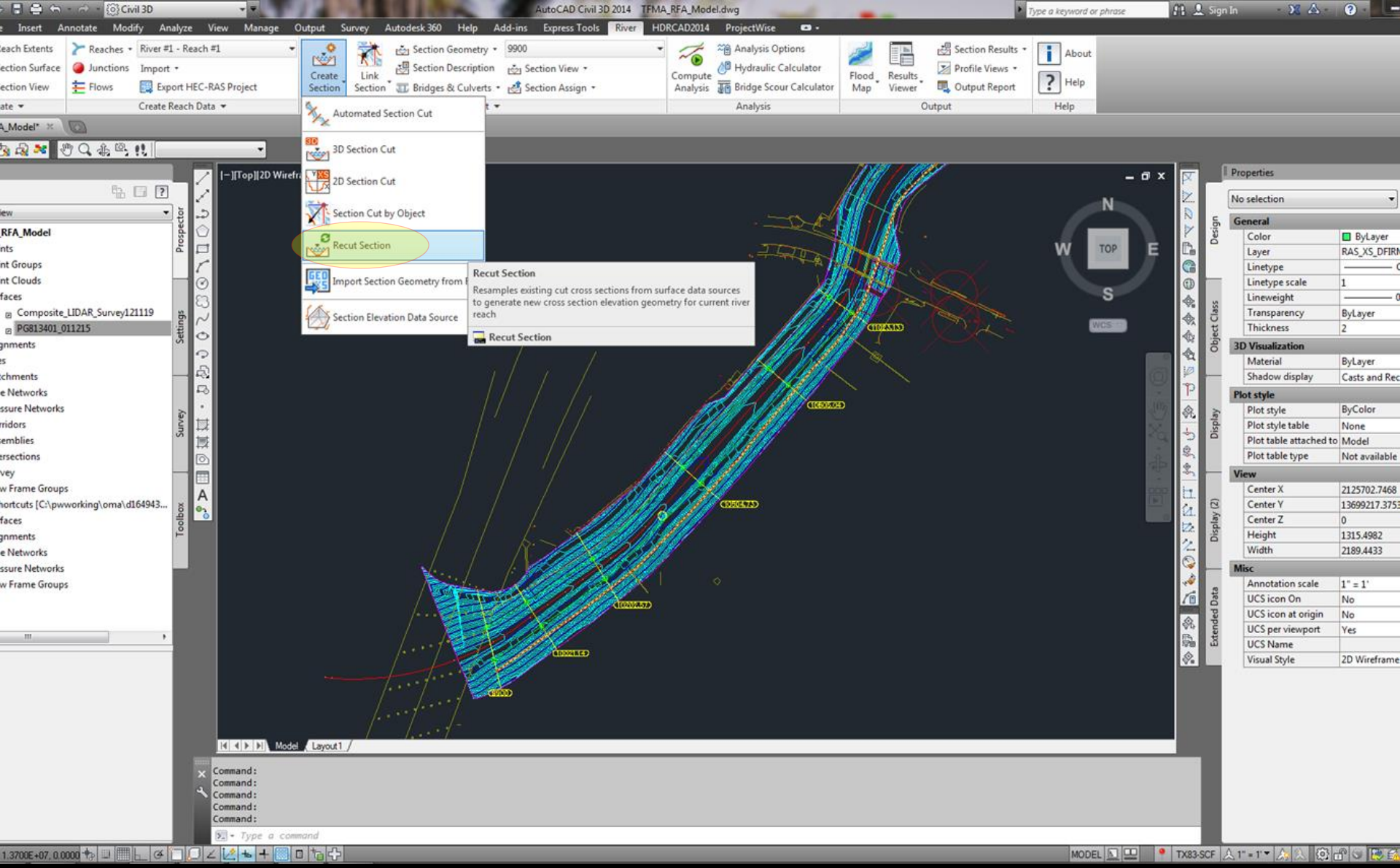


Create Section

Configure Elevation Data

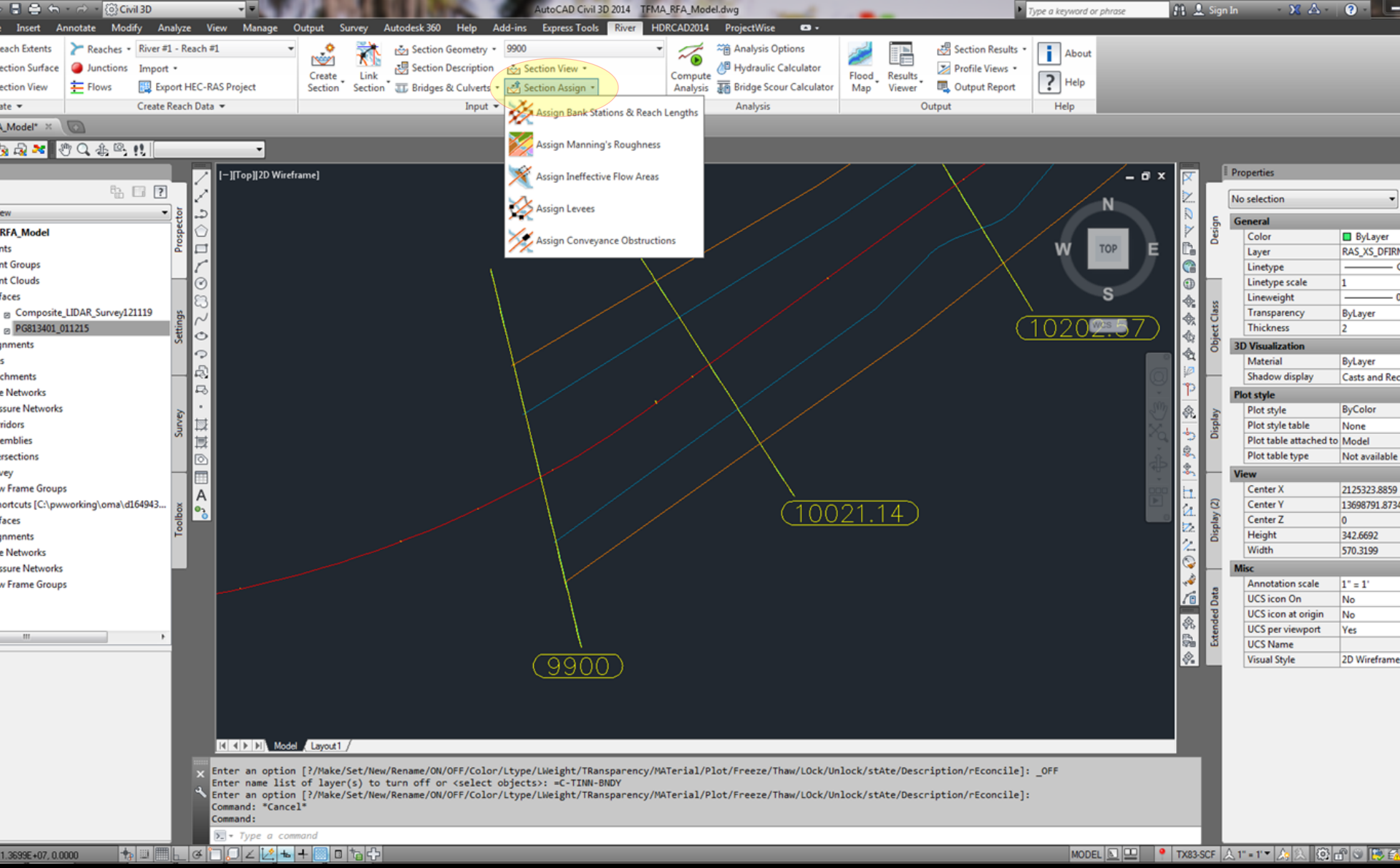


Cross Section Profile

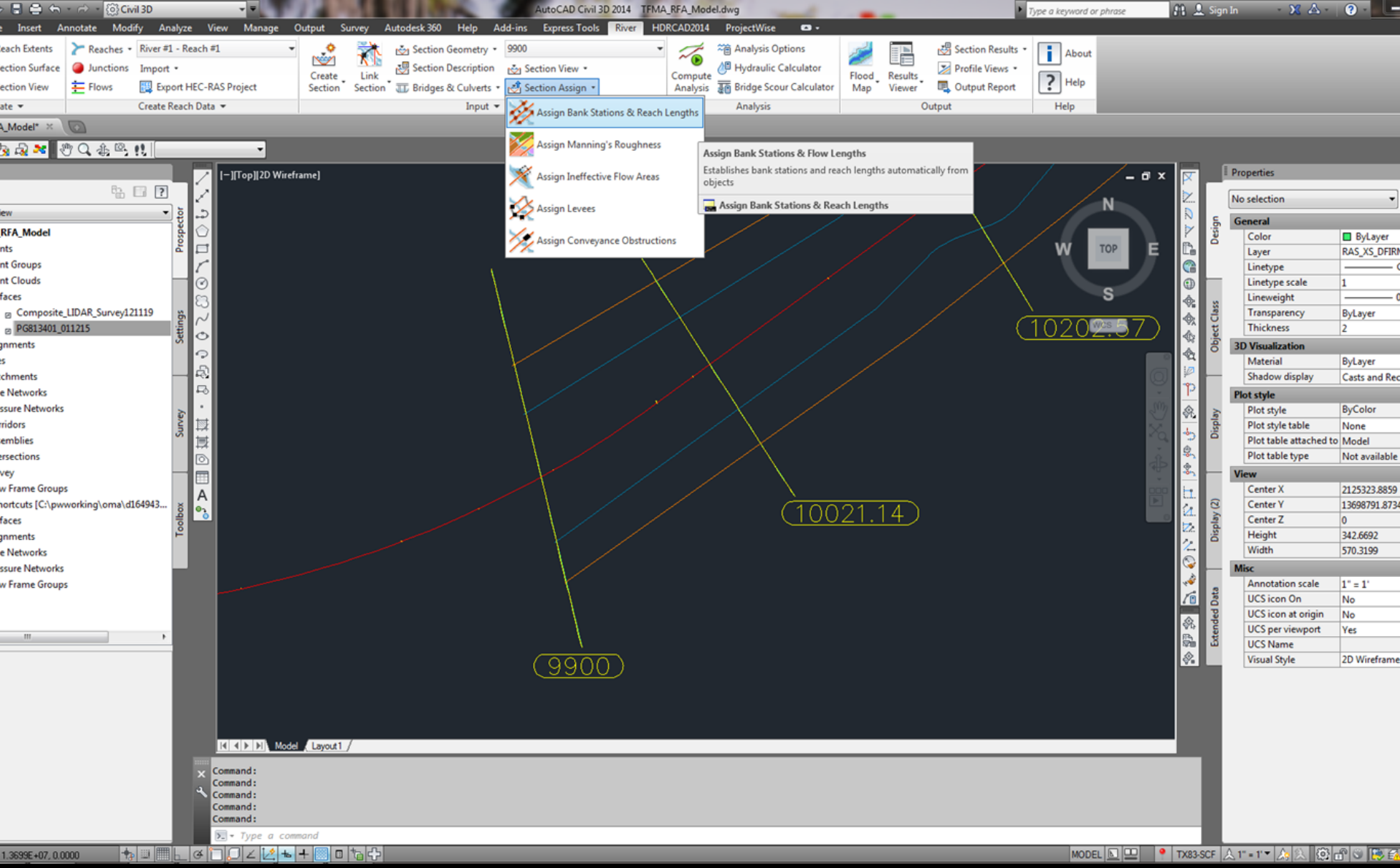


Recut Sections

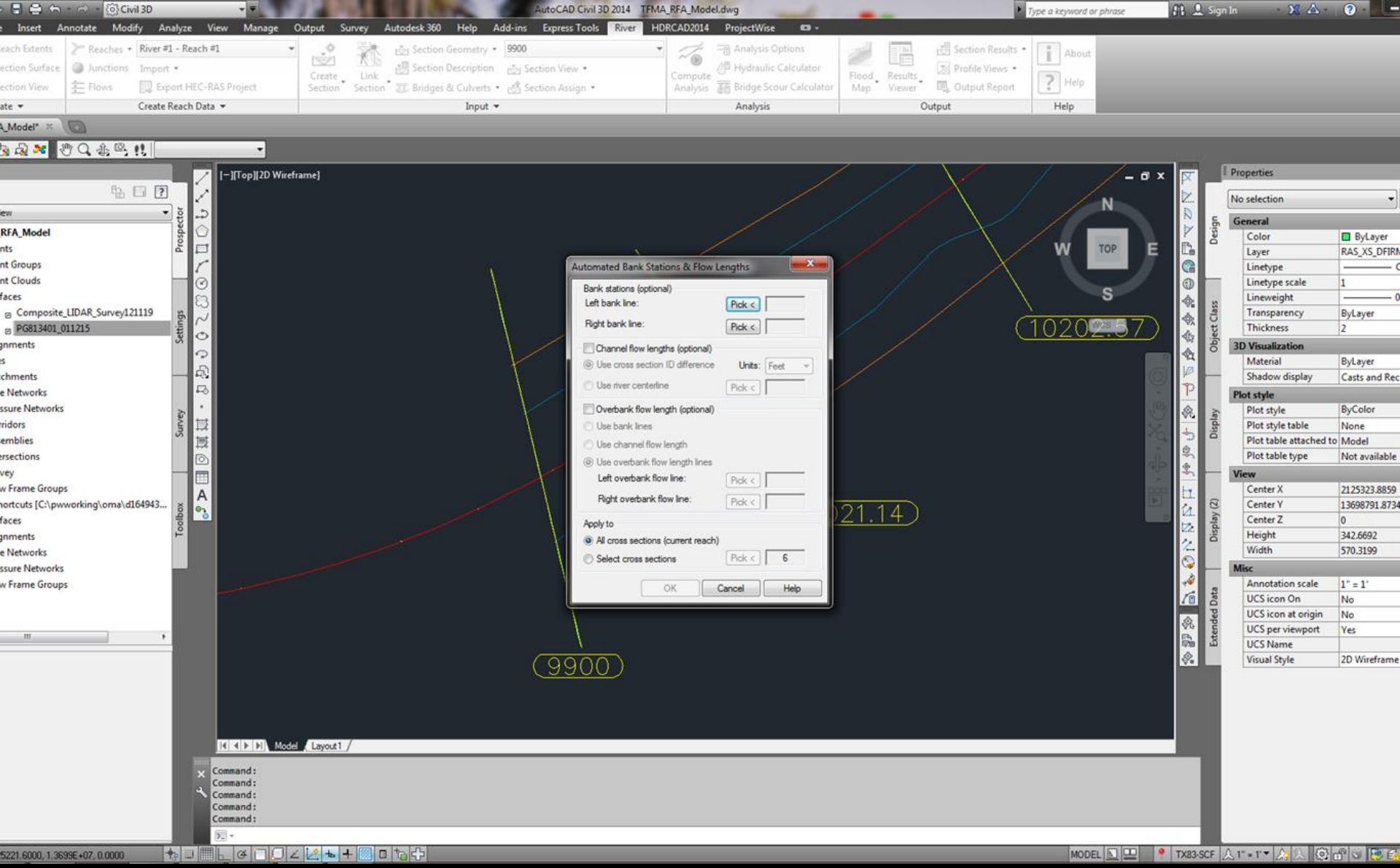
Updated surface



Section Assign Tools

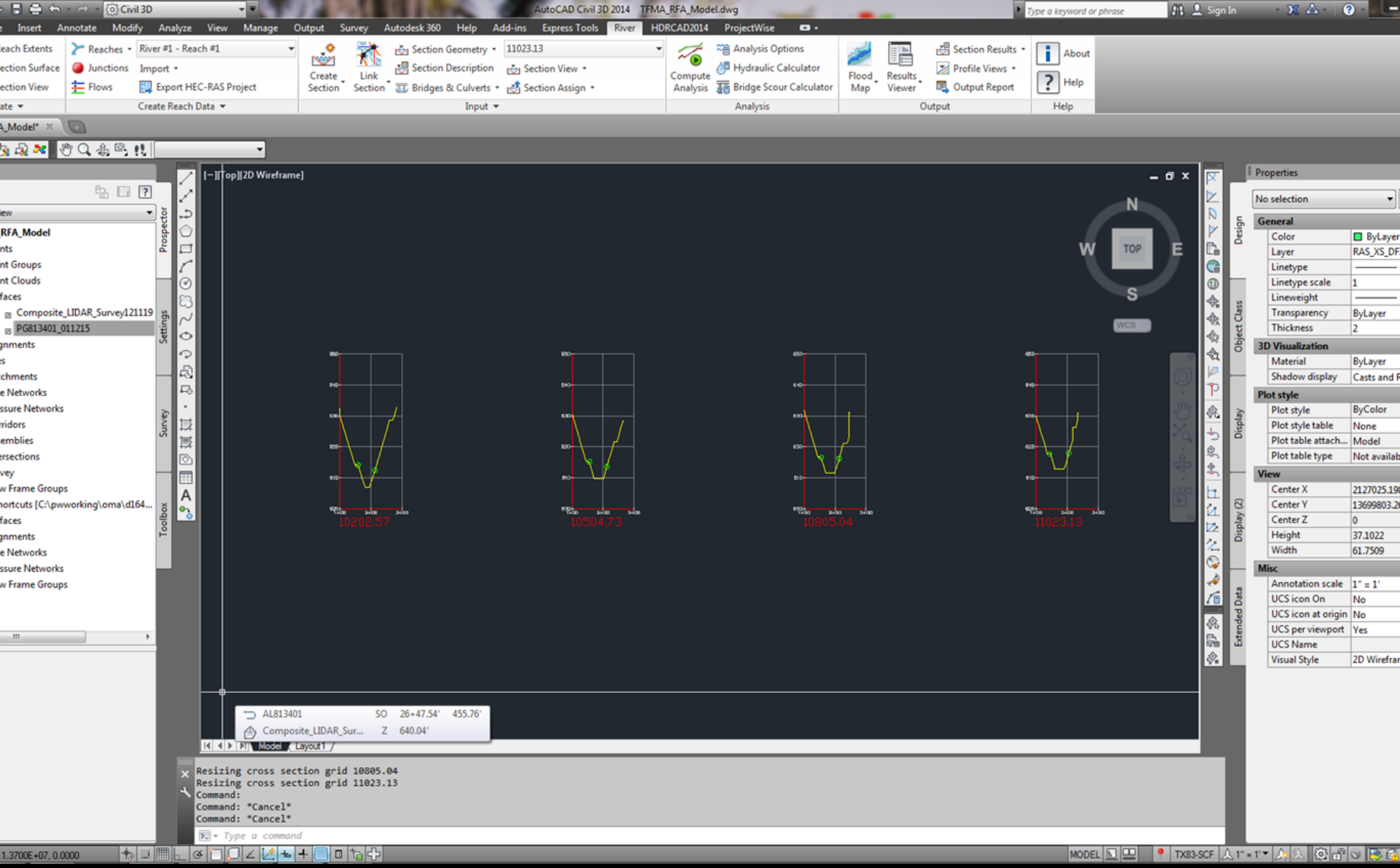


Bank Stations and Reach Lengths

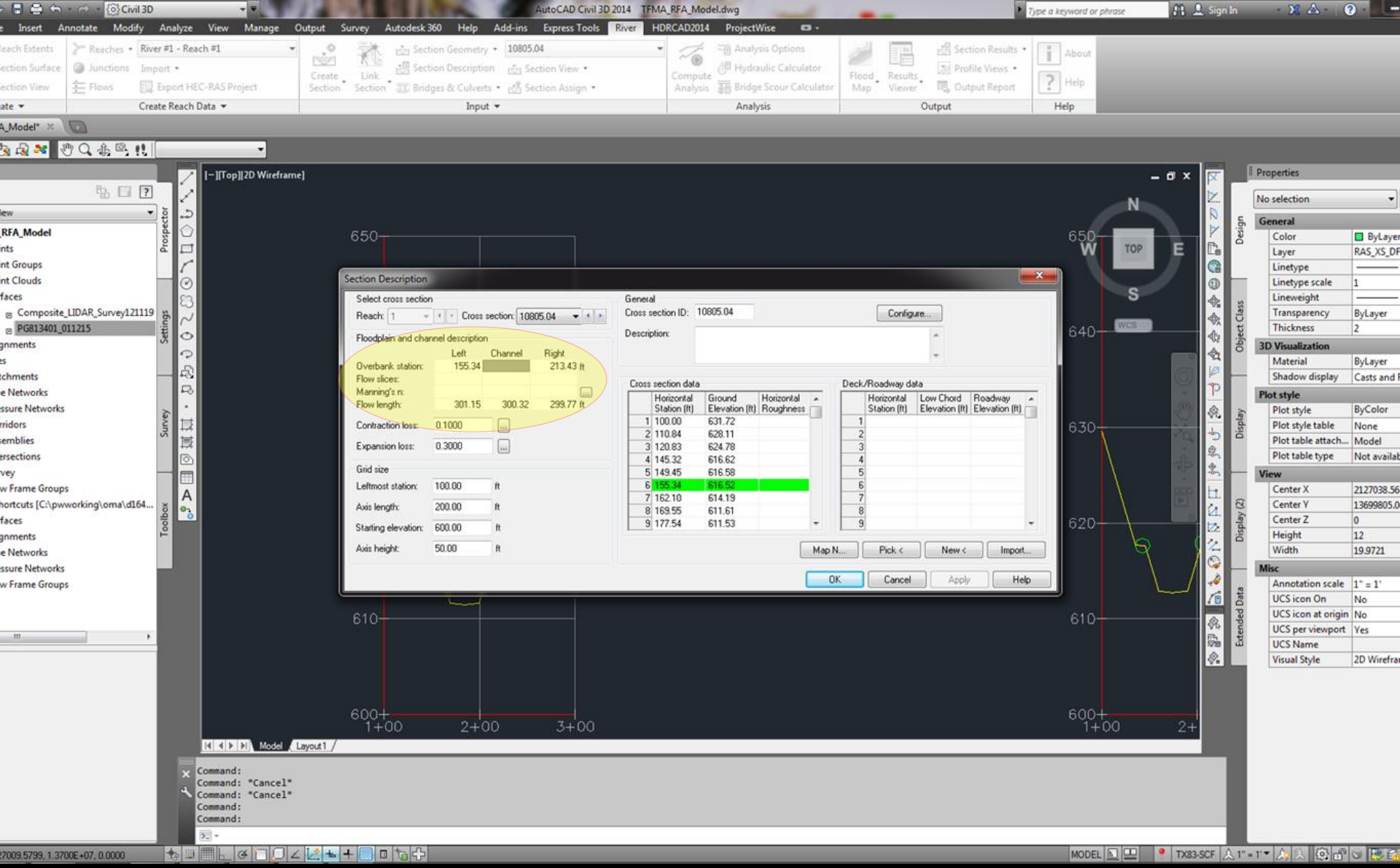


Bank Stations and Reach Lengths

Select Polylines

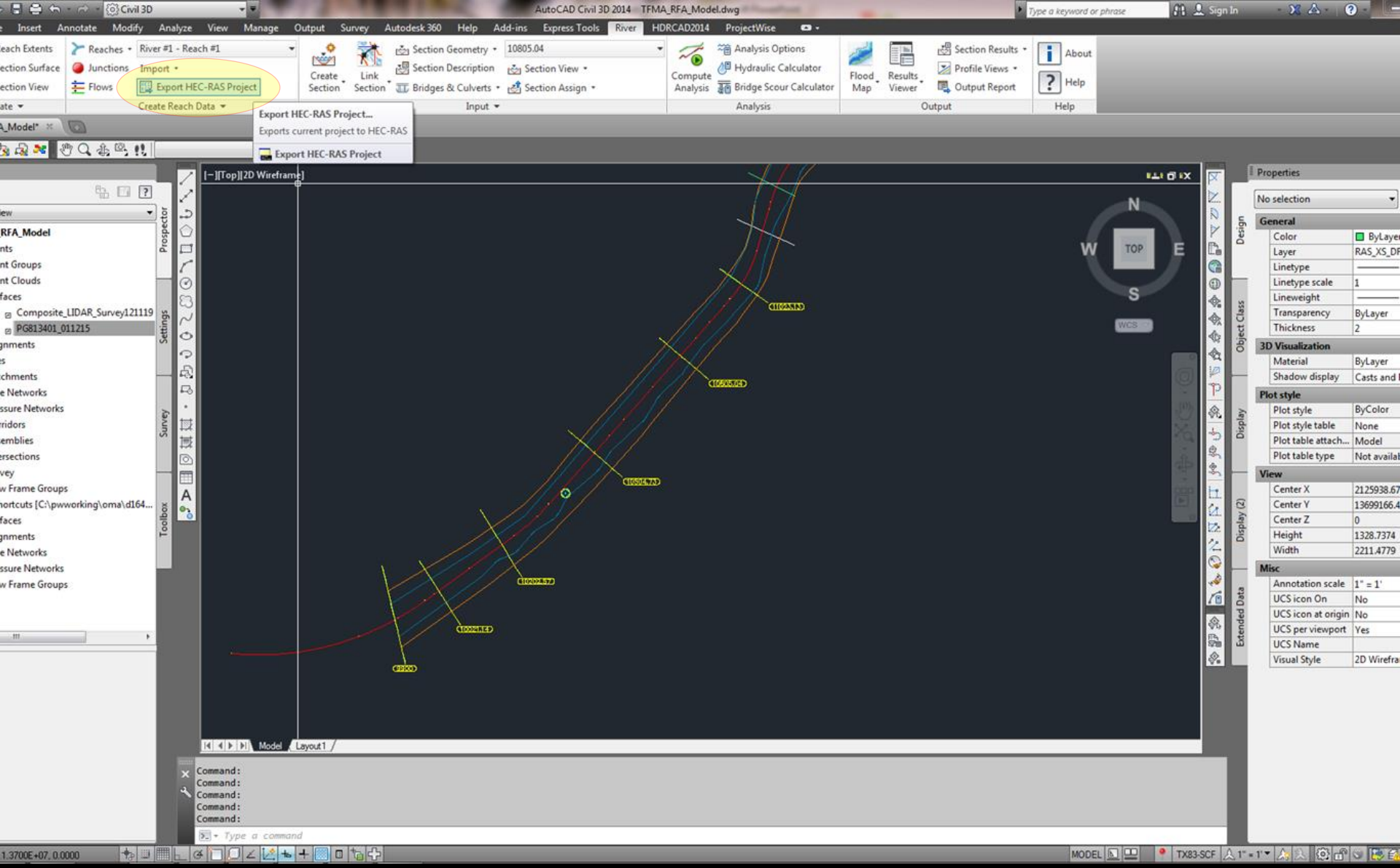


Profile Views

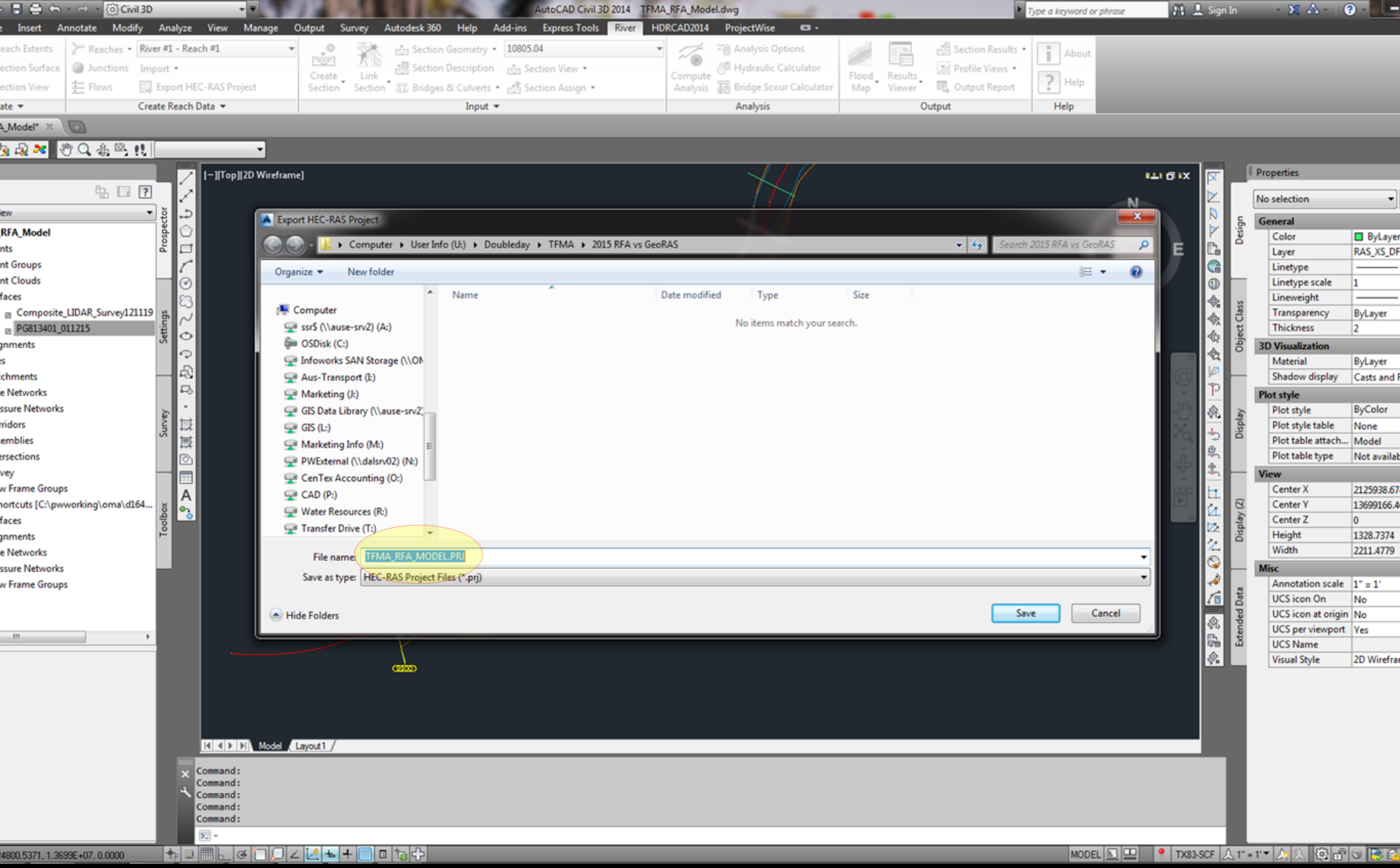


Section Description

Manual entry and verification

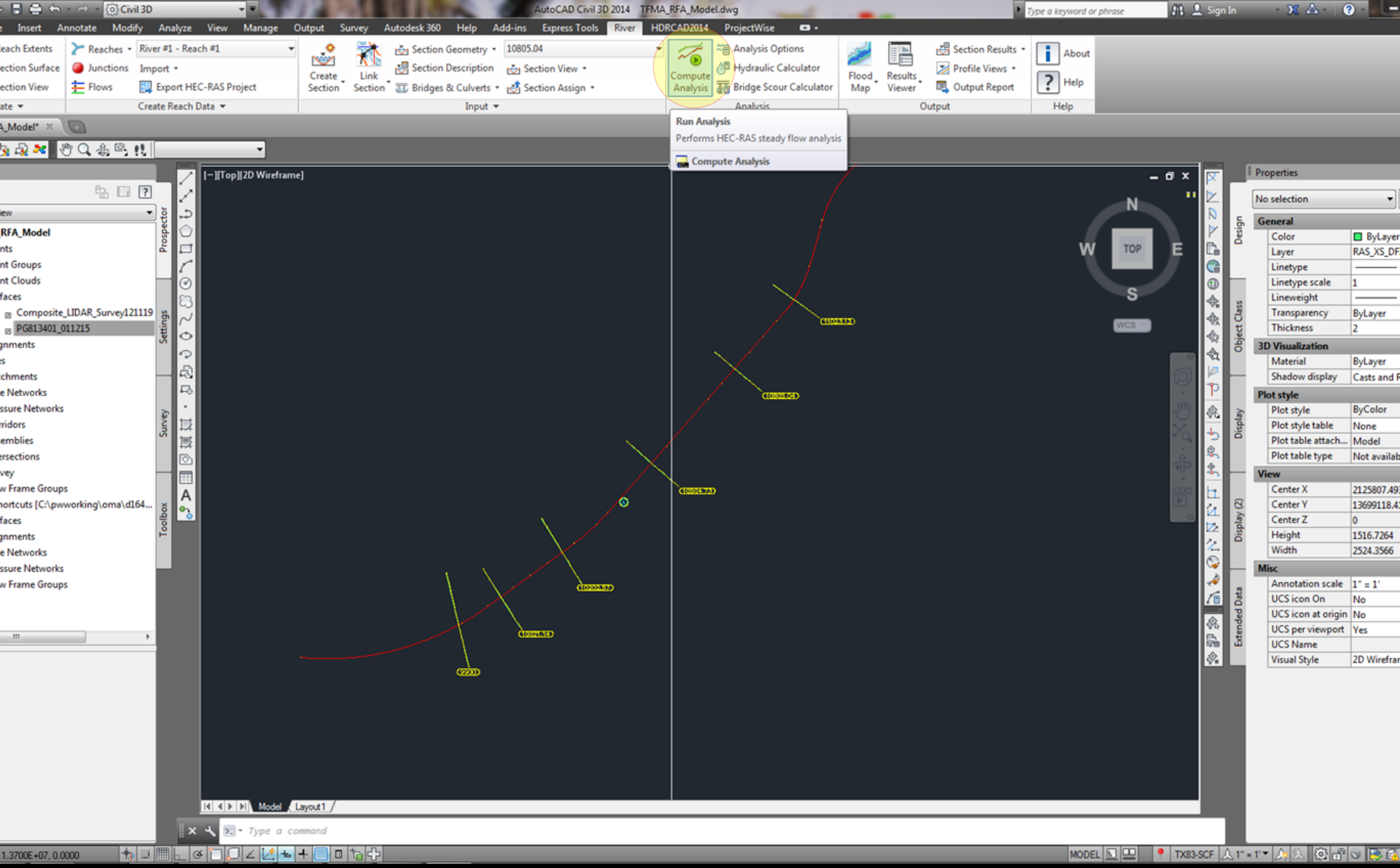


Export HEC-RAS Project



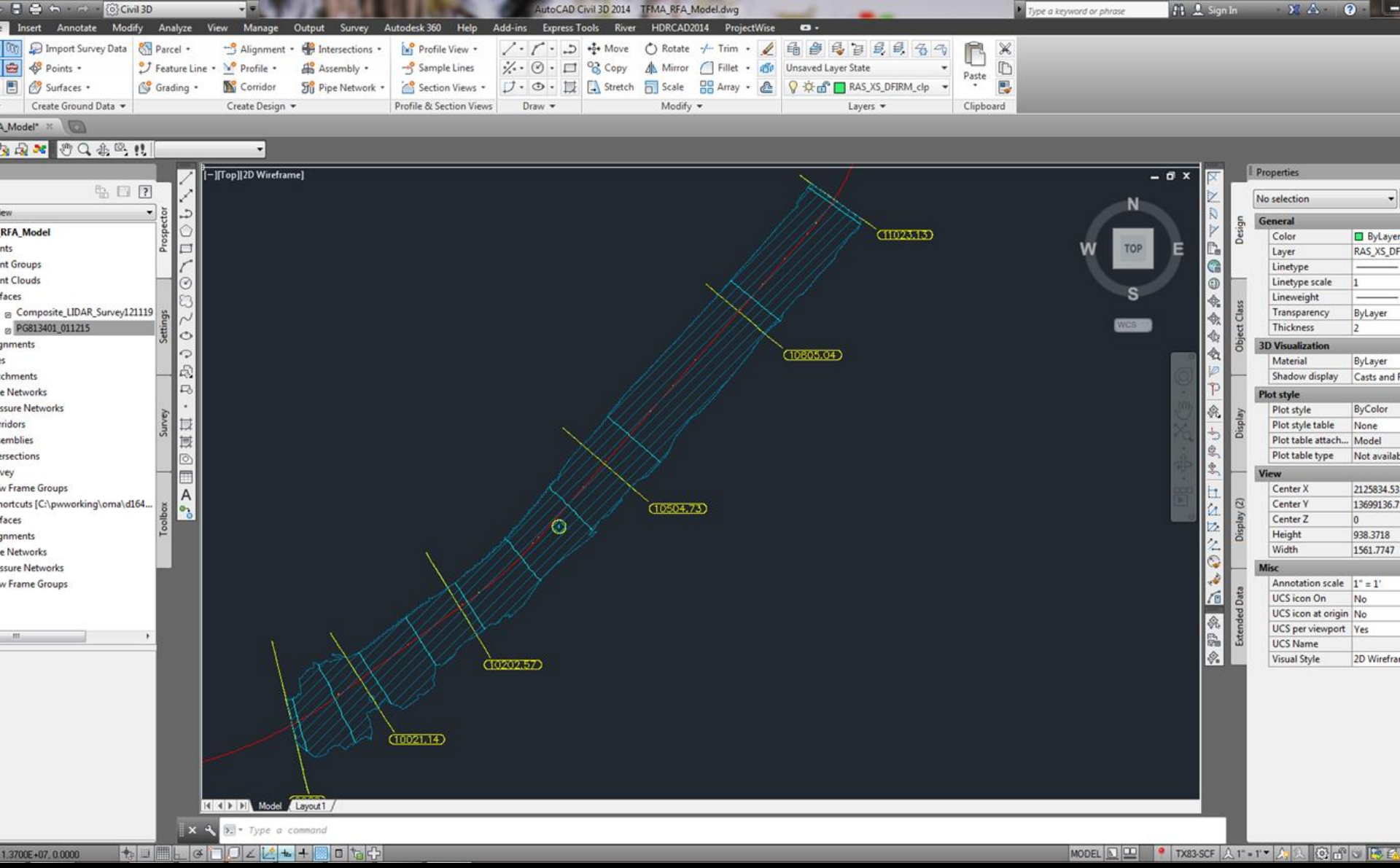
Export HEC-RAS Project

Creates a .prj file for use in HEC-RAS and agency submission



Compute Hydraulic Analysis

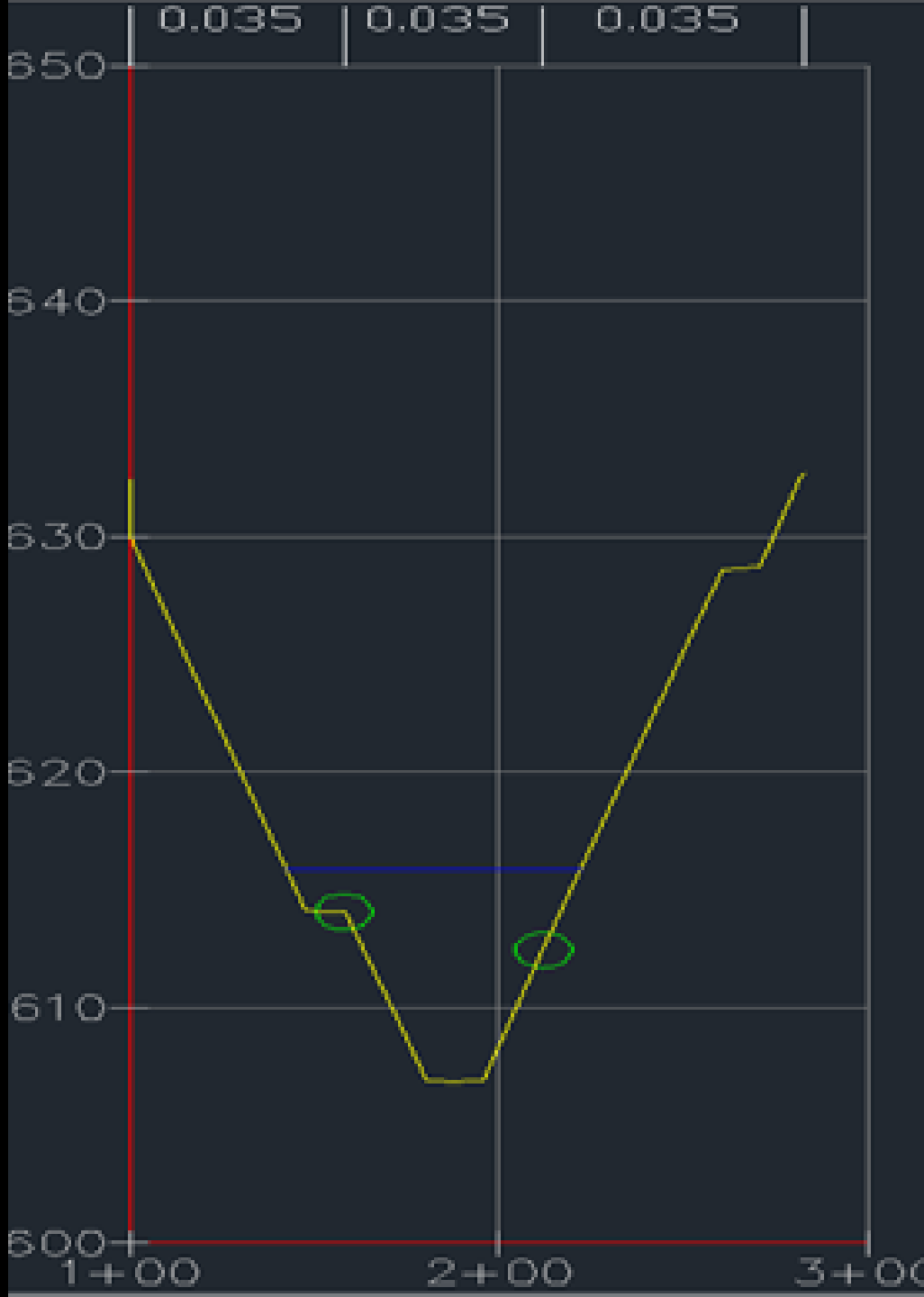
Performs HEC-RAS analysis within AutoCAD

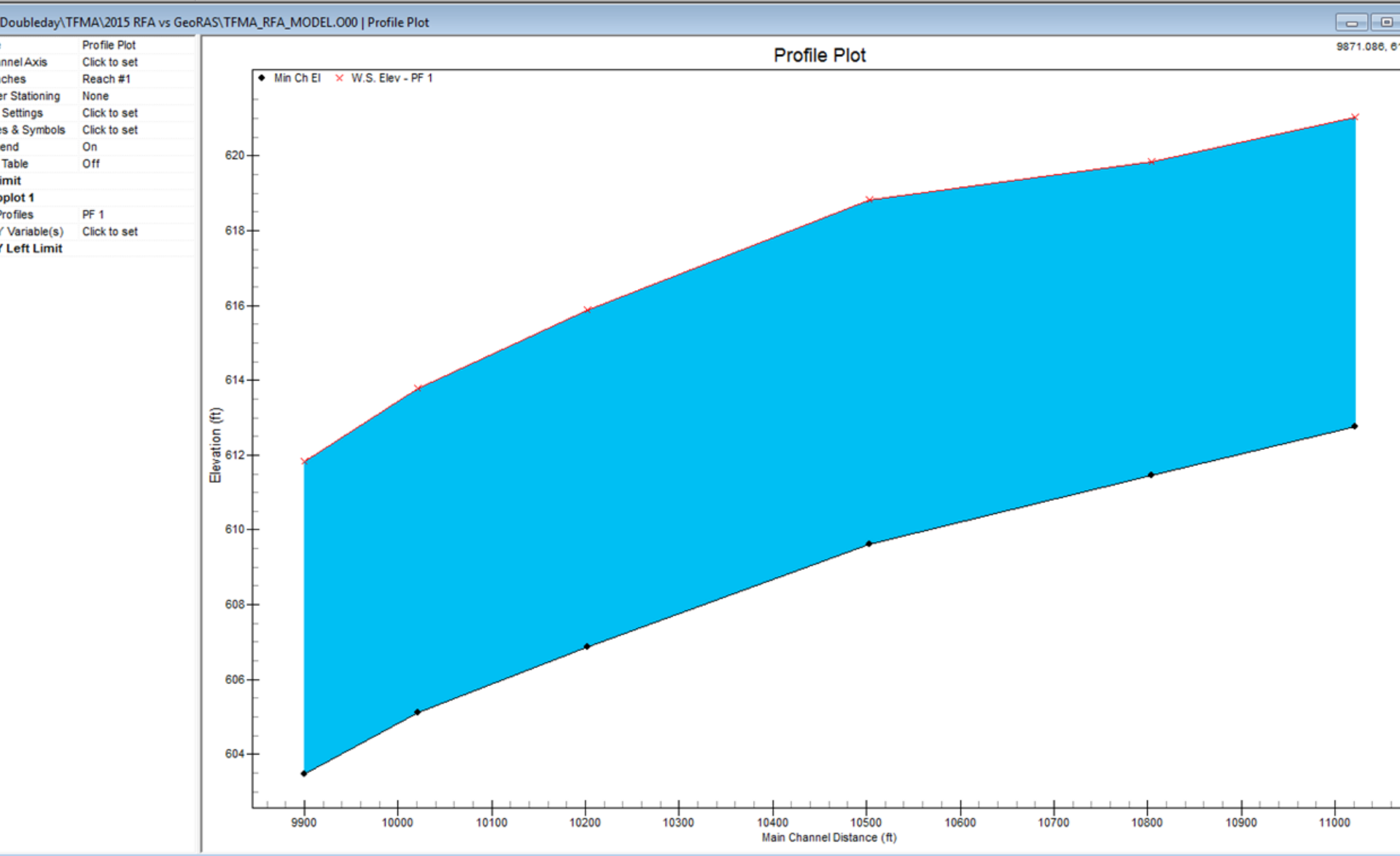


Flood Plain Mapping

Add Section Results

- Water surface elevation shown on cross section profiles
- Could readily be incorporated into design sheets





Results Profile View

U:\Doubleday\TFMA\2015 RFA vs GeoRAS\TFMA_CAD_Model\TFMA_RFA_MODEL.O00 | Standard Table 1

River Station	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
11023.13	PF 1	5000.00	612.75	621.041		622.879	0.005510	11.13	478.98	88.72	0.75180
10805.04	PF 1	5000.00	611.46	619.846		621.700	0.005304	11.24	481.11	88.47	0.74232
10504.73	PF 1	5000.00	609.61	618.806		620.270	0.003666	10.07	546.59	92.85	0.62879
10202.57	PF 1	5000.00	606.86	615.864	615.864	618.546	0.008396	13.38	398.54	79.88	0.91689
10021.14	PF 1	5000.00	605.12	614.116	614.116	616.730	0.009721	13.09	393.43	78.42	0.96251
9900	PF 1	5000.00	603.46	611.825	611.825	614.405	0.010557	12.90	389.38	77.45	0.99204

Profile Summary Output

Detailed Output

U:\Doubleday\TFMA\2015 RFA vs GeoRAS\TFMA_CAD_Model\TFMA_RFA_M...

River: River #1 Reach: Reach #1

Profile: PF 1 River Station: 10021.14

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	616.730	Wt. n-Val.	0.035	0.035	0.035
Vel Head (ft)	2.61	Reach Len. (ft)	142.46	121.09	98.37
W.S. Elev (ft)	614.116	Flow Area (sq ft)	19.75	373.61	0.07
Crit W.S. (ft)	614.116	Area (sq ft)	19.75	373.61	0.07
E.G. Slope (ft/ft)	0.009721	Flow (cfs)	108.88	4891.05	0.06
Q Total (cfs)	5000.00	Top Width (ft)	12.75	65.03	0.65
Top Width (ft)	78.42	Avg. Vel. (ft/s)	5.51	13.09	0.92
Vel Total (ft/s)	12.71	Hydr. Depth (ft)	1.55	5.75	0.11
Max Chl Dpth (ft)	9.00	Conv. (cfs)	1104.4	49608.2	0.7
Conv. Total (cfs)	50713.2	Wetted Per. (ft)	13.07	67.55	0.69
Length Wtd. (ft)	121.34	Shear (lb/sq ft)	0.92	3.36	0.06
Min Ch El (ft)	605.12	Stream Power (lb/ft s)	174.83	0.00	0.00
Alpha	1.04	Cum Volume (acre-ft)	0.04	1.06	0.00
Frctn Loss (ft)	1.23	Cum SA (acres)	0.03	0.19	0.00
C & E Loss (ft)	0.01				

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.

Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates

Hydraulic Results Comparison

- Minor differences in downstream channel length
- Minor variation in calculated flow areas
- Resulting water surface elevations differ by less than 0.01 ft.

AutoCAD River and Flood Analysis

River Sta	Q Total	Length Chnl	W.S. Elev	E.G. Elev	Vel Chnl	Flow Area
	(cfs)	(ft)	(ft)	(ft)	(ft/s)	(sq ft)
6	5000	217.62	621.04	622.88	11.13	478.98
5	5000	300.32	619.85	621.70	11.24	481.11
4	5000	301.10	618.81	620.27	10.07	546.59
3	5000	181.43	615.86	618.55	13.38	398.54
2	5000	121.09	614.12	616.73	13.09	393.43
1	5000		611.83	614.41	12.90	389.38

HEC-GeoRAS

River Sta	Q Total	Length Chnl	W.S. Elev	E.G. Elev	Vel Chnl	Flow Area
	(cfs)	(ft)	(ft)	(ft)	(ft/s)	(sq ft)
6	5000	217.71	621.04	622.88	11.12	479.28
5	5000	300.26	619.85	621.7	11.24	481.16
4	5000	302.09	618.81	620.27	10.07	547
3	5000	181.39	615.87	618.55	13.38	398.55
2	5000	121.13	614.12	616.73	13.09	393.45
1	5000		611.83	614.41	12.9	389.35

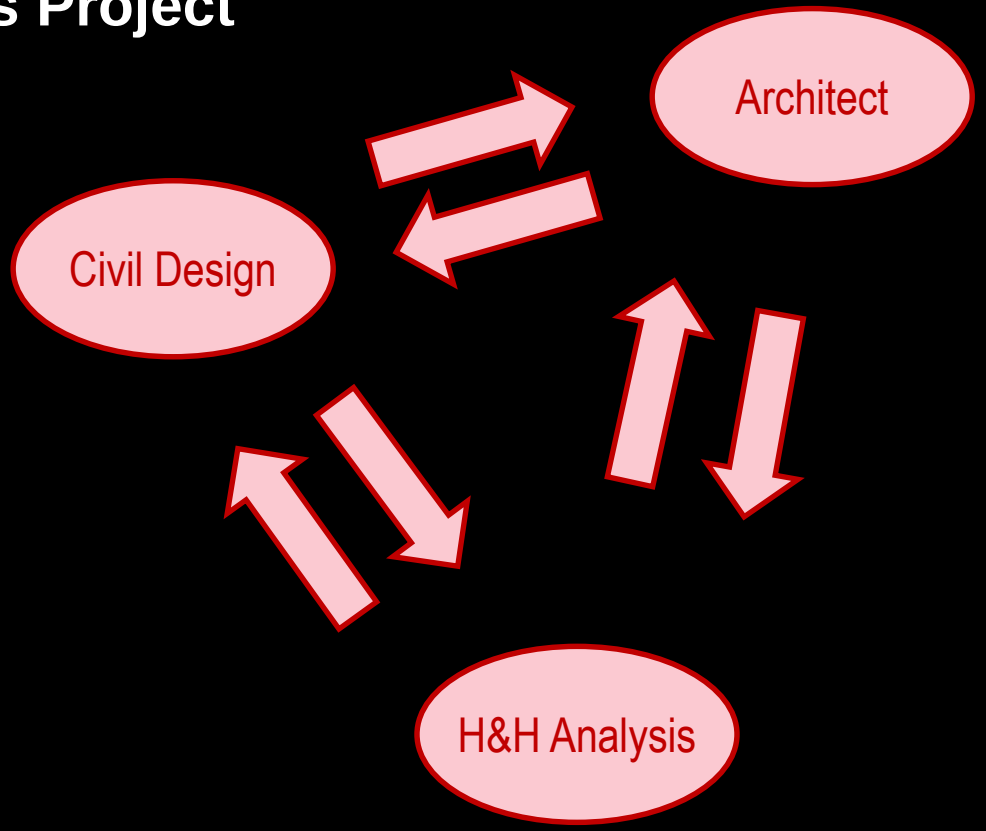
Difference

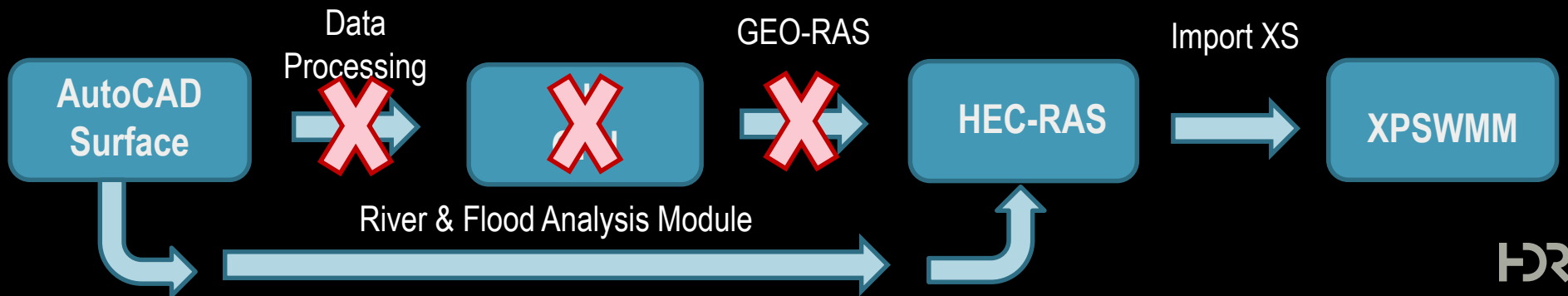
River Sta	Q Total	Length Chnl	W.S. Elev	E.G. Elev	Vel Chnl	Flow Area
	(cfs)	(ft)	(ft)	(ft)	(ft/s)	(sq ft)
6	5000	-0.09	0.001	-0.001	0.01	-0.3
5	5000	0.06	-0.004	0	0	-0.05
4	5000	-0.99	-0.004	0	0	-0.41
3	5000	0.04	-0.006	-0.004	0	-0.01
2	5000	-0.04	-0.004	0	0	-0.02

San Pedro Creek Improvements Project

Design Team & Approach

- Multiple disciplines working simultaneously on design.
- All design and plan construction performed in AutoCAD.
- Anticipating multiple iterations of design, the River & Flood Analysis Module was the most suitable approach for developing H&H geometry data.
- Eliminate multiple steps between design software (AutoCAD) and modeling software (XPSWMM).





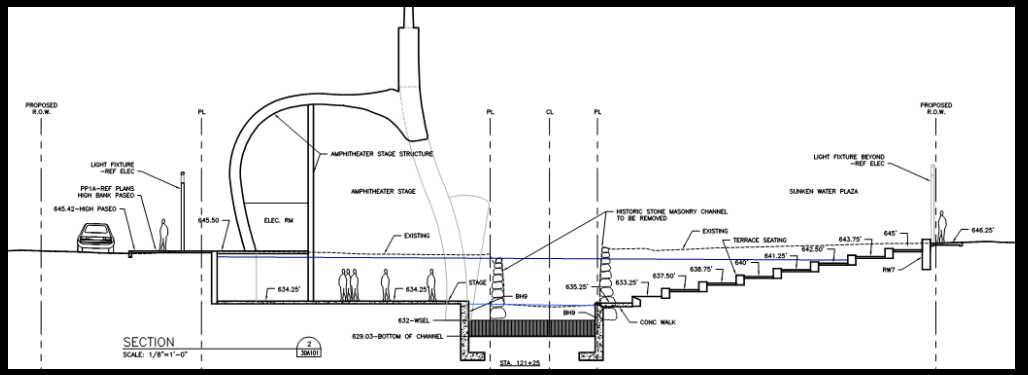
San Pedro Creek Improvements Project

Channel Design Process

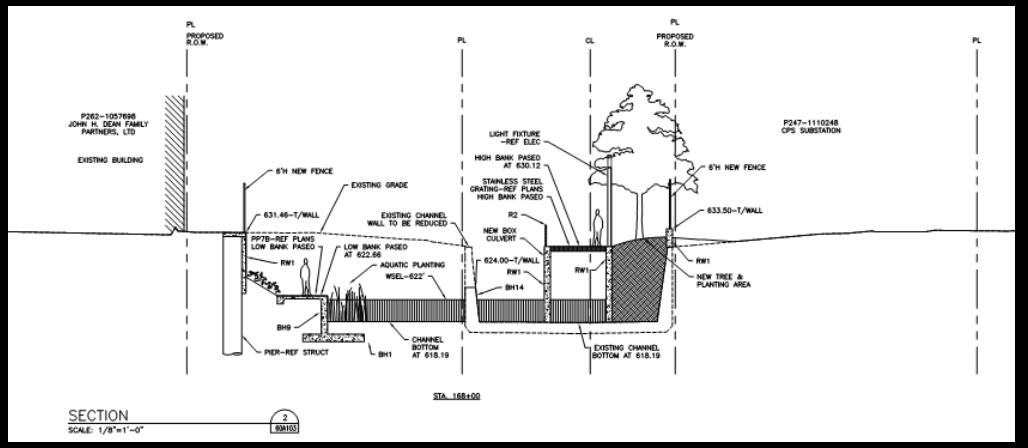
"Early Design" developed in steady-state HEC-RAS but ultimately modeled in XPSWMM.

1. Refined PER proposed conditions HEC-RAS model.
2. Develop proposed grading surface.
3. Re-cut cross sections based on new surface and imported into HEC-RAS.
4. Incorporated architectural features in HEC-RAS and evaluated impacts.
5. Revised channel geometry in HEC-RAS to meet design criteria.
6. Refined proposed surface to include geometry changes and significant architectural features.
7. Continue iteration process until a balance between flood mitigation needs and architectural elements is found.

Proposed Typical Section 1



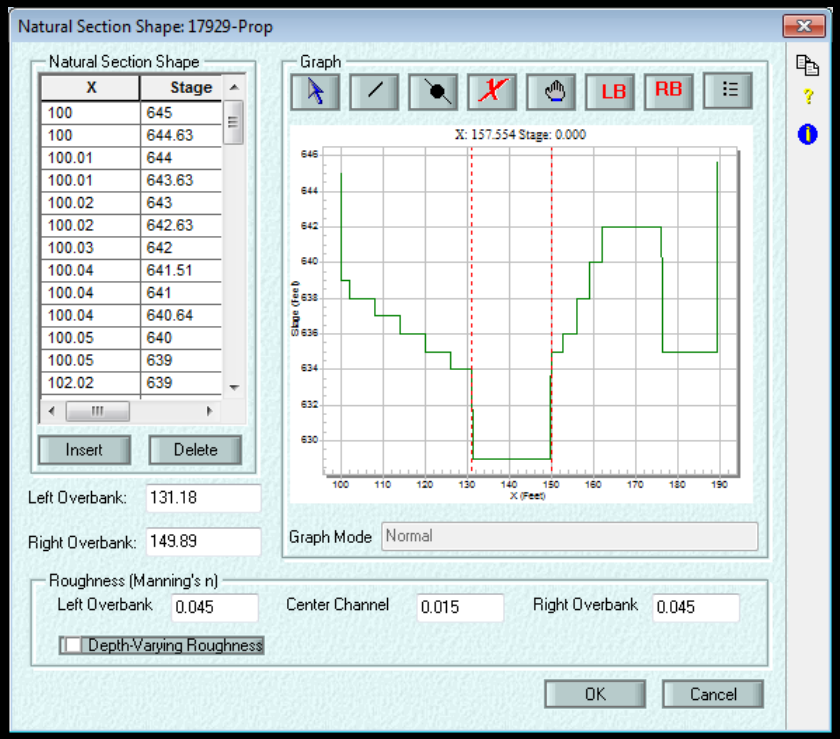
Proposed Typical Section 2



San Pedro Creek Improvements Project

Conversion to XPSWMM Model

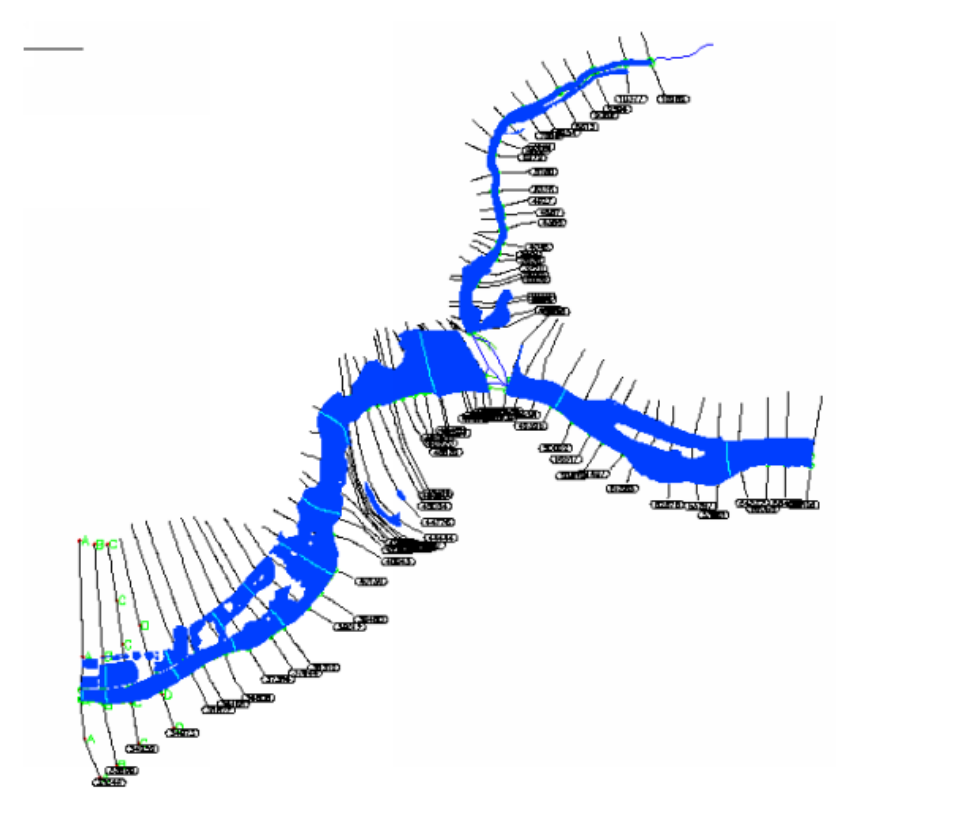
- Final HEC-RAS model geometry imported into XPSWMM.
- XPSWMM used to fully capture local storm drain system impacts and channel storage using a dynamic solution.
- With proposed channel linework, surface, and cross sections in one software, it was much easier to capture all detail during XPSWMM model development



River & Flood Analysis Tool

Summary

- Another useful tool with AutoCAD.
- Same capabilities as GEO-RAS for developing hydraulic model.
- Can simulate model within AutoCAD.
- Great for design purposes.
  - Can reduce data processing effort and iteration time
- Work within one software system.
- Alternative to GIS
- Not the best option for all projects.
  - Type of project
  - Available data
  - Local experience



San Pedro Creek Improvements Project

Status

- 40% Design has been approved by Commissioner's Court.
- Continue on with 70% Design.
  - R & F Analysis tool will continue to be used as further detail will be added and phasing will be evaluated.
- For more information on the SPCIP, visit http://spcproject.org/

Questions?

Ron Branyon, PE, CFM
Ronald.branyon@hdrinc.com
D 210.841.2922

George Doubleday, EIT, CFM
George.doubleday@hdrinc.com
D 512.912.5116

Brandon Hilbrich, PE, CFM
Brandon.hilbrich@hdrinc.com
D 210.841.2835

HDR Engineering, Inc.

1020 NE Loop 410, Suite 400
San Antonio, TX 78209
T 201.841.2800

4401 West Gate Blvd., Suite 400
Austin, TX 78745
T 512.912.5100