GWPC Directional Survey Upload Application
Implementation Considerations

RBDMS Annual Training Conference , Lido Beach, Florida

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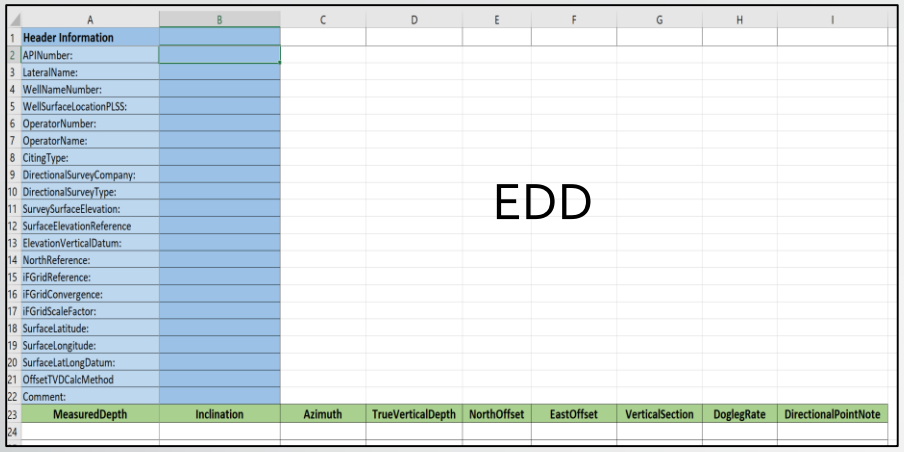
Presentation Outline

- Overview of Directional Survey Project
- EDD Template
- Upload Application
- Workflow Considerations
- GIS Output
- Legacy Data

Overview of Directional Survey Project

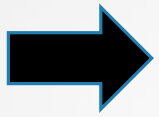
- GWPC initiated the project in June of 2017.
- GWPC designed RBDMS database tables to store directional data.
- GWPC developed a standard EDD for data submittal.
- *Blue Marble Geographics* created stored procedures to calculate lat-longs of survey points and write data point and line features as spatial data types to SQL Server tables.
- *OnCore Consulting* developed the directional data upload application.
- The application is being implemented at the California DOGGR and the Utah DOGM.

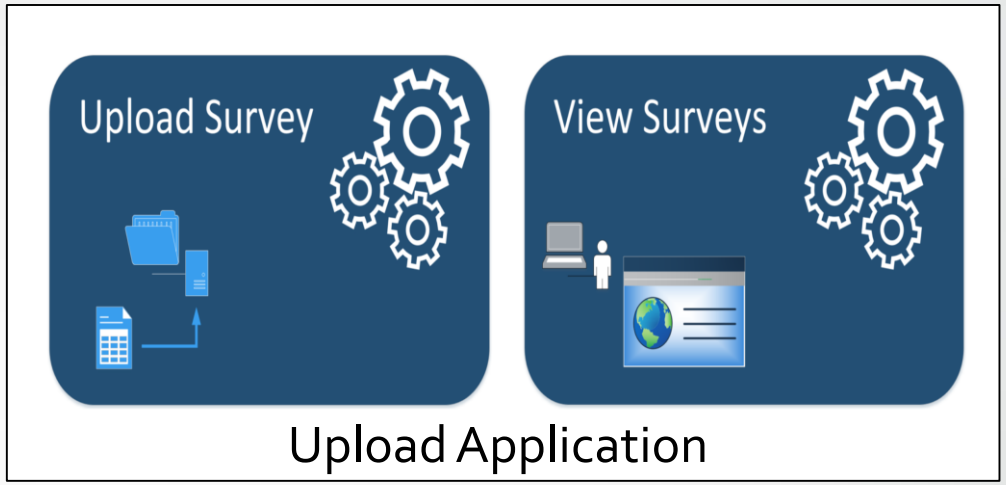
General Data Flow



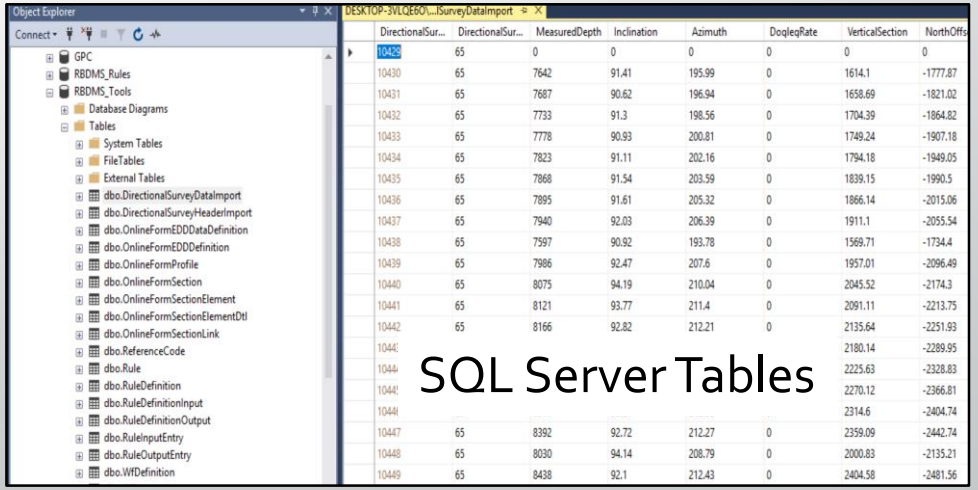
	A	B	C	D	E	F	G	H	I
1	**Header Information**								
2	APINumber:								
3	LateralName:								
4	WellNameNumber:								
5	WellSurfaceLocationPLSS:								
6	OperatorNumber:								
7	OperatorName:								
8	CitingType:								
9	DirectionalSurveyCompany:								
10	DirectionalSurveyType:								
11	SurveySurfaceElevation:								
12	SurfaceElevationReference								
13	ElevationVerticalDatum:								
14	NorthReference:								
15	iFGridReference:								
16	iFGridConvergence:								
17	iFGridScaleFactor:								
18	SurfaceLatitude:								
19	SurfaceLongitude:								
20	SurfaceLatLongDatum:								
21	OffsetTVDCalcMethod								
22	Comment:								
23	**MeasuredDepth**	**Inclination**	**Azimuth**	**TrueVerticalDepth**	**NorthOffset**	**EastOffset**	**VerticalSection**	**DoglegRate**	**DirectionalPointNote**
24									

EDD

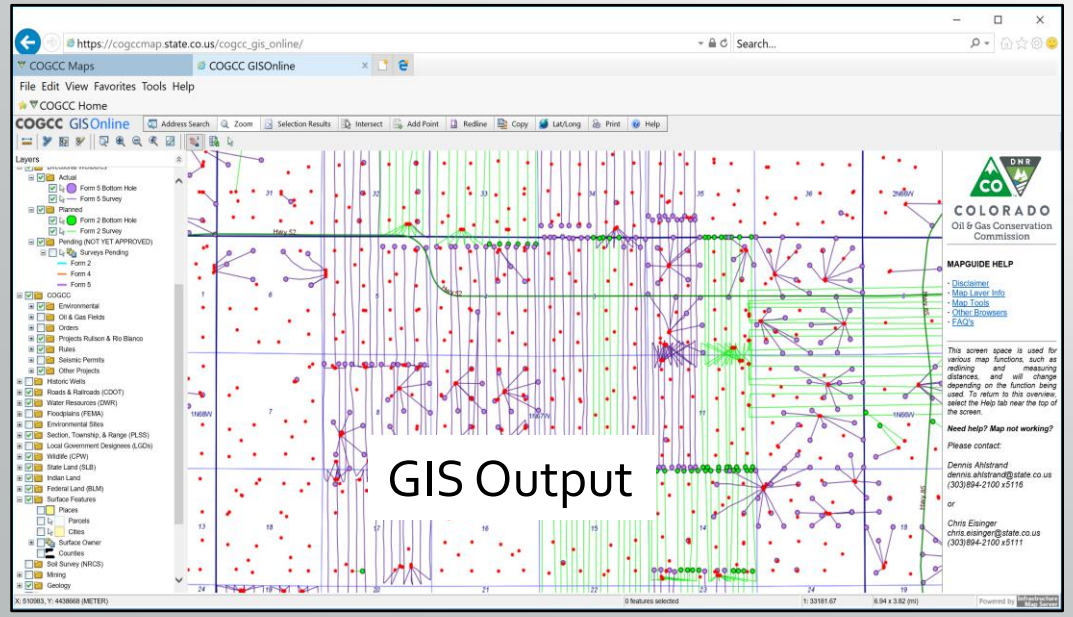




Upload Application



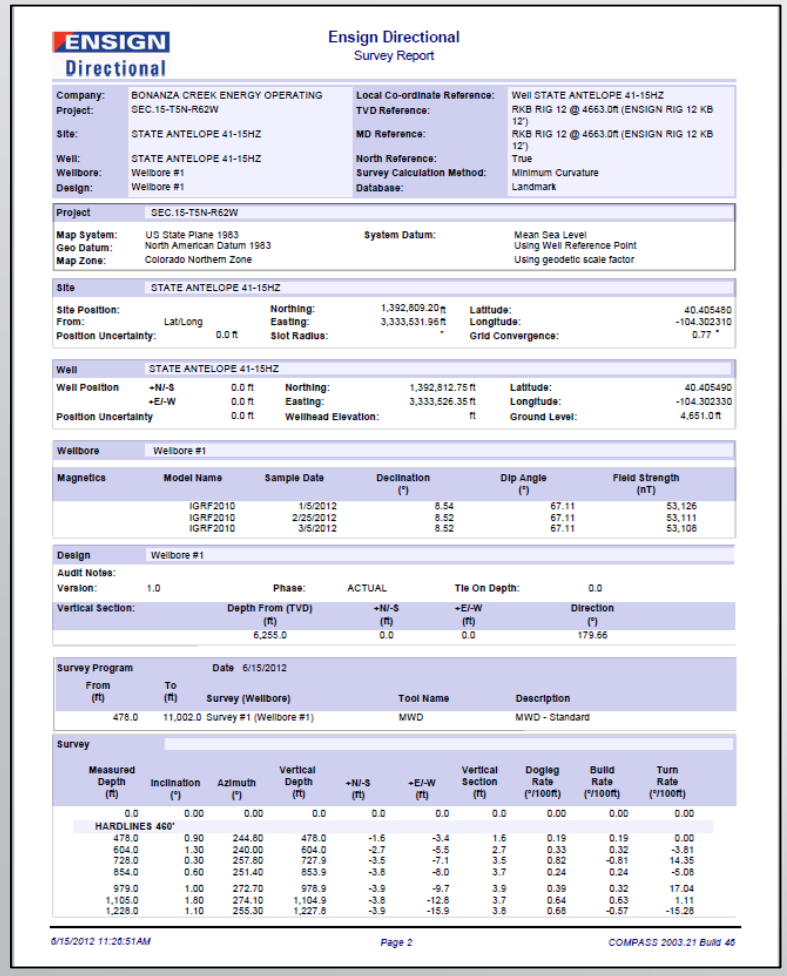
SQL Server Tables



GIS Output

Directional Survey to EDD

Directional Survey



ENSIGN Directional

Ensign Directional
Survey Report

Company:	BONANZA CREEK ENERGY OPERATING	Local Co-ordinate Reference:	Well STATE ANTELOPE 41-15HZ
Project:	SEC.15-T5N-R62W	TVD Reference:	RKB RIG 12 @ 4663.0ft (ENSIGN RIG 12 KB 12')
Site:	STATE ANTELOPE 41-15HZ	MD Reference:	RKB RIG 12 @ 4663.0ft (ENSIGN RIG 12 KB 12')
Well:	STATE ANTELOPE 41-15HZ	North Reference:	True
Wellbore:	Wellbore #1	Survey Calculation Method:	Minimum Curvature
Design:	Wellbore #1	Database:	Landmark

Project	SEC.15-T5N-R62W		
Map System:	US State Plane 1983	System Datum:	Mean Sea Level
Geo Datum:	North American Datum 1983		Using Well Reference Point
Map Zone:	Colorado Northern Zone		Using geodetic scale factor

Site	STATE ANTELOPE 41-15HZ				
Site Position:		Northing:	1,392,609.20 ft	Latitude:	40.405480
From:	Lat/Long	Easting:	3,333,531.96 ft	Longitude:	-104.302310
Position Uncertainty:	0.0 ft	Slot Radius:	"	Grid Convergence:	0.77 °

Well	STATE ANTELOPE 41-15HZ				
Well Position	+N/-S	0.0 ft	Northing:	1,392,812.75 ft	Latitude: 40.405490
	+E/-W	0.0 ft	Easting:	3,333,526.35 ft	Longitude: -104.302330
Position Uncertainty		0.0 ft	Wellhead Elevation:	ft	Ground Level: 4,651.0 ft

Wellbore	Wellbore #1				
Magnetics	Model Name	Sample Date	Declination (°)	Dip Angle (°)	Field Strength (nT)
	IGRF2010	1/5/2012	8.54	67.11	53,126
	IGRF2010	2/25/2012	8.52	67.11	53,111
	IGRF2010	3/5/2012	8.52	67.11	53,108

Design	Wellbore #1				
Audit Notes:					
Version:	1.0	Phase:	ACTUAL	Tie On Depth:	0.0
Vertical Section:	Depth From (TVD) (ft)	+N/-S (ft)	+E/-W (ft)	Direction (°)	
	6,255.0	0.0	0.0	179.66	

Survey Program — Date 6/15/2012

From (ft)	To (ft)	Survey (Wellbore)	Tool Name	Description
478.0	11,002.0	Survey #1 (Wellbore #1)	MWD	MWD - Standard

Survey

Measured Depth (ft)	Inclination (°)	Azimuth (°)	Vertical Depth (ft)	+N/-S (ft)	+E/-W (ft)	Vertical Section (ft)	Dogleg Rate (°/100ft)	Build Rate (°/100ft)	Turn Rate (°/100ft)
0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.00	0.00	0.00
HARDLINES 460'									
478.0	0.90	244.80	478.0	-1.6	-3.4	1.6	0.19	0.19	0.00
604.0	1.30	240.00	604.0	-2.7	-5.5	2.7	0.33	0.32	-3.81
728.0	0.30	257.80	727.9	-3.5	-7.1	3.5	0.82	-0.81	14.35
854.0	0.60	251.40	853.9	-3.8	-8.0	3.7	0.24	0.24	-5.08
979.0	1.00	272.70	978.9	-3.9	-9.7	3.9	0.39	0.32	17.04
1,105.0	1.80	274.10	1,104.9	-3.8	-12.8	3.7	0.64	0.63	1.11
1,228.0	1.10	255.30	1,227.8	-3.9	-15.9	3.8	0.68	-0.57	-15.28

EDD

	A	B	C	D	E	F	G	H	I
1	Header Information								
2	APINumber:								
3	LateralName:								
4	WellNameNumber:								
5	WellSurfaceLocationPLSS:								
6	OperatorNumber:								
7	OperatorName:								
8	CitingType:								
9	DirectionalSurveyCompany:								
10	DirectionalSurveyType:								
11	SurveySurfaceElevation:								
12	SurfaceElevationReference								
13	ElevationVerticalDatum:								
14	NorthReference:								
15	iFGridReference:								
16	iFGridConvergence:								
17	iFGridScaleFactor:								
18	SurfaceLatitude:								
19	SurfaceLongitude:								
20	SurfaceLatLongDatum:								
21	OffsetTVDCalcMethod								
22	Comment:								
23	MeasuredDepth	Inclination	Azimuth	TrueVerticalDepth	NorthOffset	EastOffset	VerticalSection	DoglegRate	DirectionalPointNote
24									

Operators or Directional Survey Companies populate the EDD template with directional survey data.

Electronic Data Deliverable (EDD) – Header Info

	Data Field	Data Format	Units	Description	Valid Values
2	APINumber:	varchar(12)		12 digit API Number; statecode+countycode+sequencenumber+sidetracknumber.	Required ID Field
3	LateralName:	varchar(20)		Name of lateral; if 10 digit API number used, name is required to make wellbore unique.	
4	WellNameNumber:	varchar(50)		Name and Number of Well.	
5	WellSurfaceLocationPLSS:	varchar(50)		QQ-Section-Township-Range of the surface location.	
6	OperatorNumber:	varchar(10)		Unique Operator ID Number.	
7	OperatorName:	varchar(50)		Operator Name.	
8	CitingType:	varchar(10)		Status of directional wellbores. Required Field	e.g. Planned, AsDrilled, Drilling
9	DirectionalSurveyCompany:	varchar(50)		Name of Directional Survey Service Company.	
10	DirectionalSurveyType:	varchar(20)		How survey was conducted; such as MWD, EMS, Gyro.	
11	SurveySurfaceElevation:	float	feet MSL	Surface elevation from which the directional survey measurements are referenced.	
12	SurfaceElevationReference:	varchar(2)		Surface elevation reference such as Kelly Bushing (KB)	
13	ElevationVerticalDatum:	varchar(15)	feet MSL	Elevation Datum for Survey Reference Elevation, usually MSL, could be NGVD 88.	
14	NorthReference:	varchar(4)		North reference for the survey is either TRUE or GRID.	Required: True or Grid **
15	iFGridReference:	varchar(30)		Grid Reference; such as UTM Zone 12, NAD83, or State Plane-Colorado North Zone; Must be provided if North Reference = GRID.	Required if NorthReference= Grid
16	iFGridConvergence:	float	degrees	Grid Convergence at the Surface Location; Must be provided if North Reference = GRID.	Required if NorthReference= Grid
17	iFGridScaleFactor:	float	feet	Scale Factor based on Surface Locations position with respect to the Grid; Must be provided if North Reference = GRID.	Required if NorthReference= Grid
18	SurfaceLatitude:	float	decimal degrees (6 decimal places)	Latitude at the Surface Location.	
19	SurfaceLongitude:	float	decimal degrees (6 decimal places)	Longitude at the Surface Location; Use a negative sign for West longitudes.	
20	SurfaceLatLongDatum:	varchar(15)		Datum of the latitude and longitude values; only NAD83, NAD27, and WGS84 are accounted for in the GWPC directional mapping stored procedure.	Required: NAD83, NAD27, or WGS84 **
21	OffsetTVDCalcMethod	varchar(30)		Method used to calculate North Offset, East Offset, and TVD, such as Minimum Curvature.	
22	Comment:	varchar(1000)		Open comment field; e.g. One of six horizontal wells on Pad XYZ.	

DirectionalSurveyImport | DataDescriptions

**Consider requiring TRUE NorthReference for all surveys, and only allow NAD 83 for SurfaceLatLongDatum to simplify review and data storage.

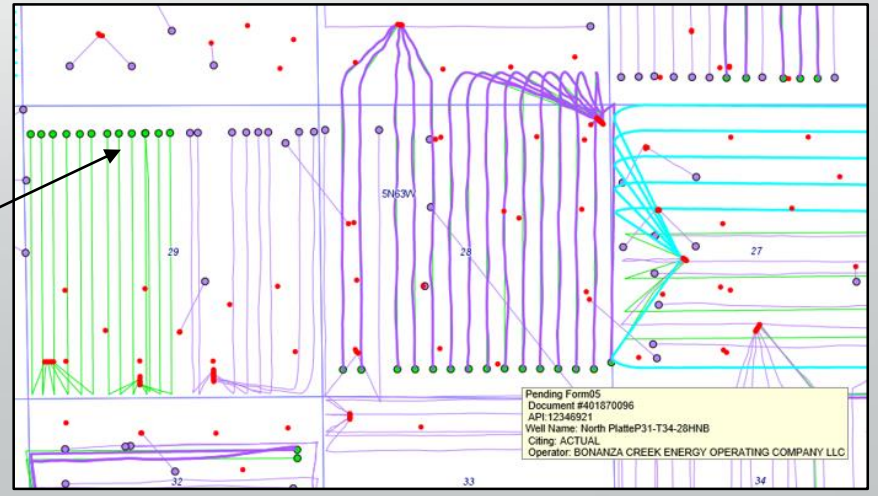
Electronic Data Deliverable (EDD) – Survey Data

1	Data Field	Data Format	Units	Description	Valid Values
23	Measured Depth	float	feet	Measured depth at the survey point.	
24	Inclination	float	degrees	Inclination at the survey point.	
25	Azimuth	float	degrees	Azimuth at the survey point.	
26	TrueVerticalDepth	float	feet	The true vertical depth at the survey point location as refernced to the surface location where the TVD = 0; calculated using various methods such as the minimum curvature	
27	NorthOffset	float	feet	North or South offset from the surface location at the survey point; calculated using various methods such as the minimum curvature method; Use positive (+) values in the north direction and negative (-)values in the south direction.	
28	EastOffset	float	feet	East or West offset from the surface location at the survey point; calculated using various methods such as the minimum curvature method; Use positive (+) values in the East direction and negative (-)values in the West direction.	
29	VerticalSection	float	feet	Vertical Section at the survey point.	
30	DoglegRate	float	degrees/100 feet	Dogleg Rate at the survey point.	
31	DirectionalPointNote	varchar(40)		Field for direction point description, such as "kick off point" and "bottomhole".	**
32					

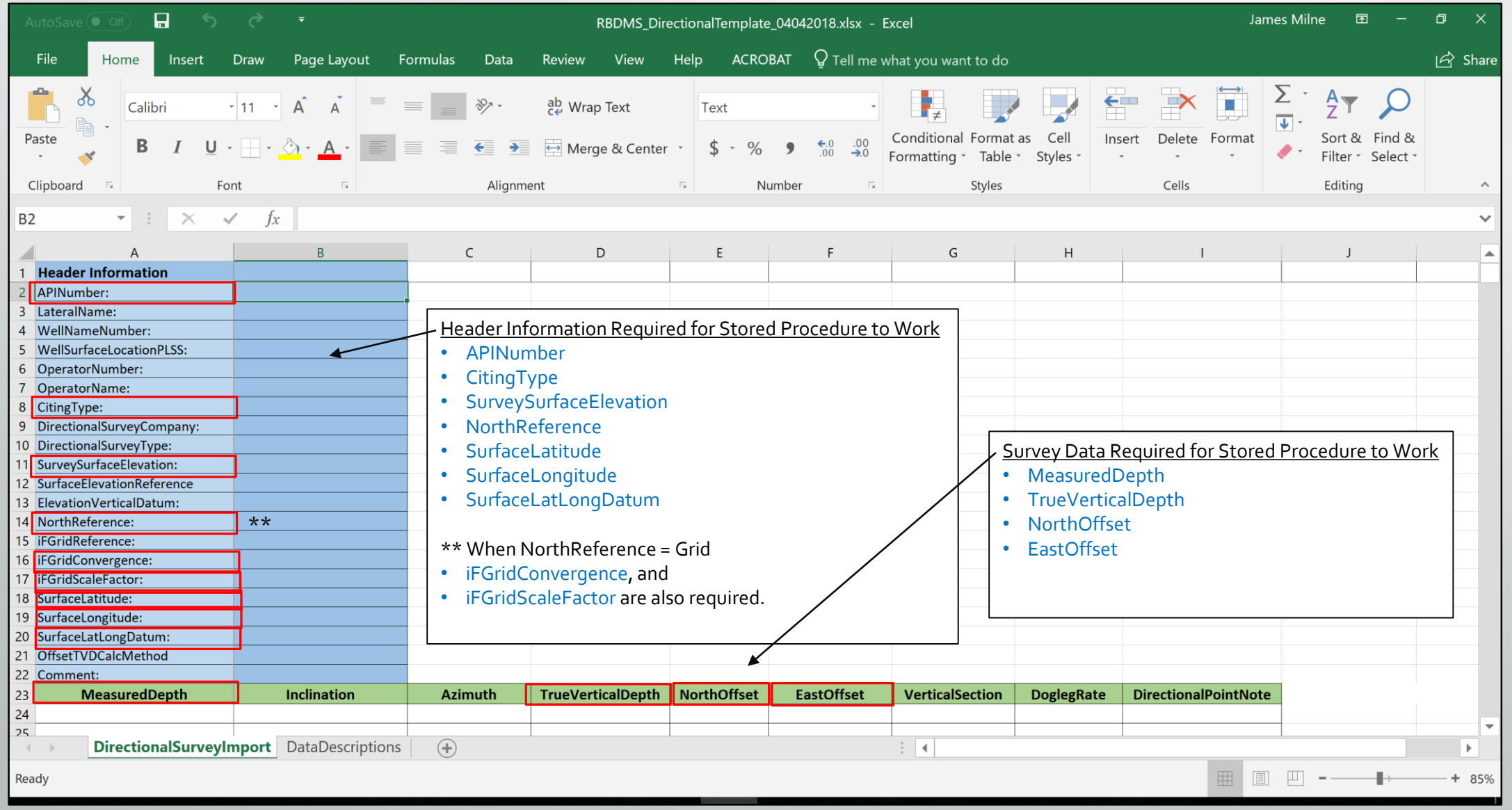
DirectionalSurveyImport | DataDescriptions

**Consider requiring the note *Bottomhole* or *Projected Bottomhole* in the DirectionalPointNote field. This will allow all bottomhole points to be pulled from the database and mapped.

Mapping bottomhole locations as points allows the user to easily see which borehole line is associated with which well. The well record hyperlink can also be attached to the bottomhole points.

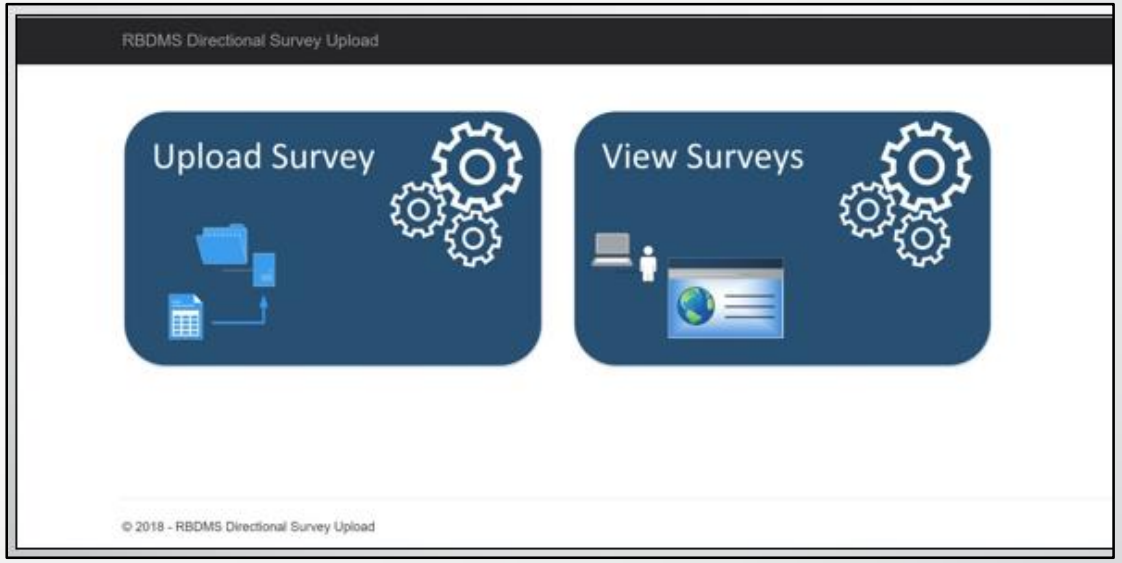


EDD – Absolute Requirements for Stored Procedure



Upload Application

- Interface for Operators and/or State staff to upload directional survey EDD spreadsheets.
- Currently designed for upload of one survey at a time.
- Rules engine included for error flagging.
- Executes Blue Marble Geographic stored procedure to calculate lat-longs of survey points and create point and line features in DB.
- Allows for viewing of all surveys in the DB.



Web-based, automated process, to get directional surveys into RBDMS as tabular data and as spatial data (i.e. line and point features).

Hands-on training for this Application follows presentation.

SQL-Server Tables

DirectionalSurveyHeaderImport

Column Name	Data Type	Allow Nulls
DirectionalSurveyHeaderKey	int	☐
APINumber	varchar(12)	☑
LateralName	varchar(20)	☑
WellNameNumber	varchar(50)	☑
WellSurfaceLocationPLSS	varchar(50)	☑
OperatorNumber	varchar(10)	☑
OperatorName	varchar(50)	☑
CitingType	varchar(10)	☑
DirectionalSurveyCompany	varchar(50)	☑
DirectionalSurveyType	varchar(20)	☑
SurveyReferenceElevation	float	☑
ElevationDatum	varchar(15)	☑
NorthReference	varchar(4)	☑
iFGridConvergence	float	☑
iFGridScaleFactor	float	☑
SurfaceLatitude	float	☑
SurfaceLongitude	float	☑
SurfaceLatLongDatum	varchar(15)	☑
Comment	varchar(1000)	☑
DirectionalLineFeature	geography **	☑

DirectionalSurveyDataImport

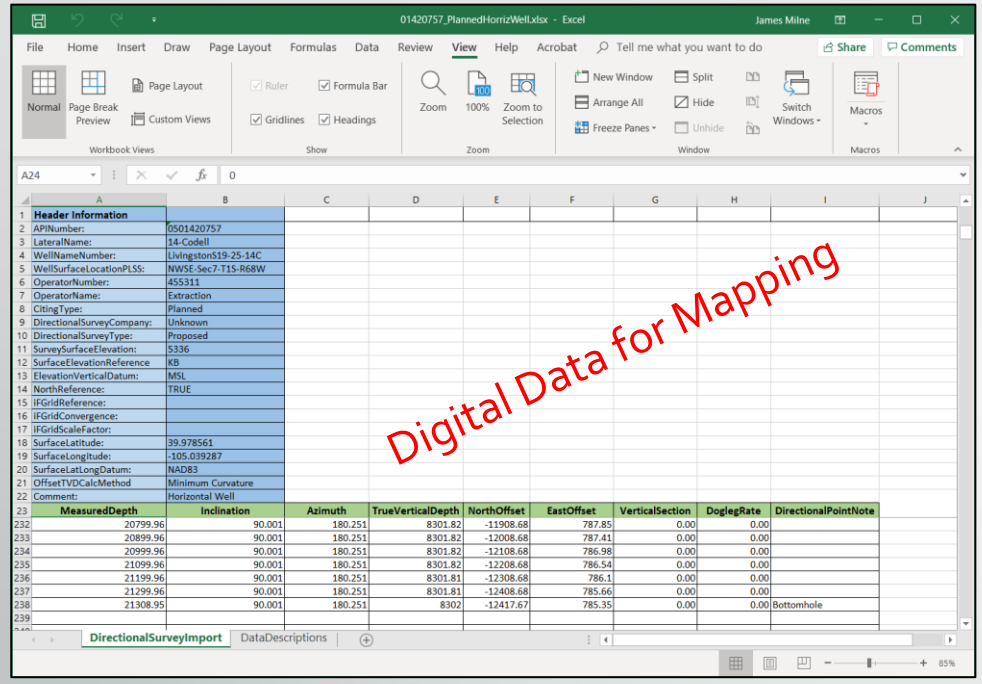
Column Name	Data Type	Allow Nulls
DirectionalSurveyDataKey	int	☐
DirectionalSurveyHeaderKey	int	☐
MeasuredDepth	float	☑
Inclination	float	☑
Azimuth	float	☑
DoglegRate	float	☑
VerticalSection	float	☑
NorthOffset	float	☑
EastOffset	float	☑
TrueVerticalDepth	float	☑
TrueVerticalElevationCalc	float	☑
LatitudeCalc	float	☑
LongitudeCalc	float	☑
DirectionalPointNote	varchar(40)	☑
DirectionalPointFeature	geography **	☑

Tables store EDD imported data along with calculated fields (green) and spatial fields (red).

**The spatial fields will store the coordinate system EPSG codes as SRID integers. Storing multiple SRIDs in a single spatial field may complicate GIS output capabilities.

Workflow - Operator Submittals

Completed EDD



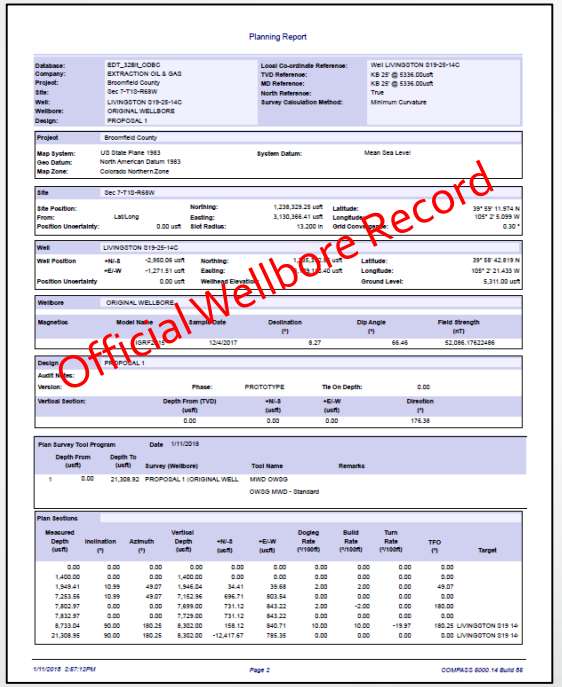
01420757_PlannedHorrizWell.xlsx - Excel

Header Information	
APINumber:	0501420757
LateralName:	14-Codell
WellNameNumber:	Livingston$19-25-14C
WellSurfaceLocationPLSS:	NWSE-Sec7-T1S-R68W
OperatorNumber:	455311
OperatorName:	Extraction
CitingType:	Planned
DirectionalSurveyCompany:	Unknown
DirectionalSurveyType:	Proposed
SurveySurfaceElevation:	5336
SurfaceElevationReference	KB
ElevationVerticalDatum:	MSL
NorthReference:	TRUE
iFGridReference:	
iFGridConvergence:	
iFGridScaleFactor:	
SurfaceLatitude:	39.978561
SurfaceLongitude:	-105.039287
SurfaceLatLongDatum:	NAD83
OffsetTVDCalcMethod	Minimum Curvature
Comment:	Horizontal Well

MeasuredDepth	Inclination	Azimuth	TrueVerticalDepth	NorthOffset	EastOffset	VerticalSection	DoglegRate	DirectionalPointNote
20799.96	90.001	180.251	8301.82	-11908.68	787.85	0.00	0.00	
20899.96	90.001	180.251	8301.82	-12008.68	787.41	0.00	0.00	
20999.96	90.001	180.251	8301.82	-12108.68	786.98	0.00	0.00	
21099.96	90.001	180.251	8301.82	-12208.68	786.54	0.00	0.00	
21199.96	90.001	180.251	8301.81	-12308.68	786.1	0.00	0.00	
21299.96	90.001	180.251	8301.81	-12408.68	785.66	0.00	0.00	
21308.95	90.001	180.251	8302	-12417.67	785.35	0.00	0.00	Bottomhole

Digital Data for Mapping

Directional Survey PDF



Planning Report

Official Wellbore Record

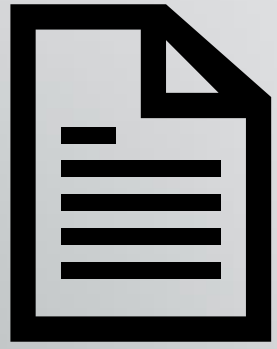
The EDD does not take the place of the PDF.

Option 1: Operator submits EDD and PDF as attachments to an Online Form --- State staff uploads EDD to populate database and create mapping data.

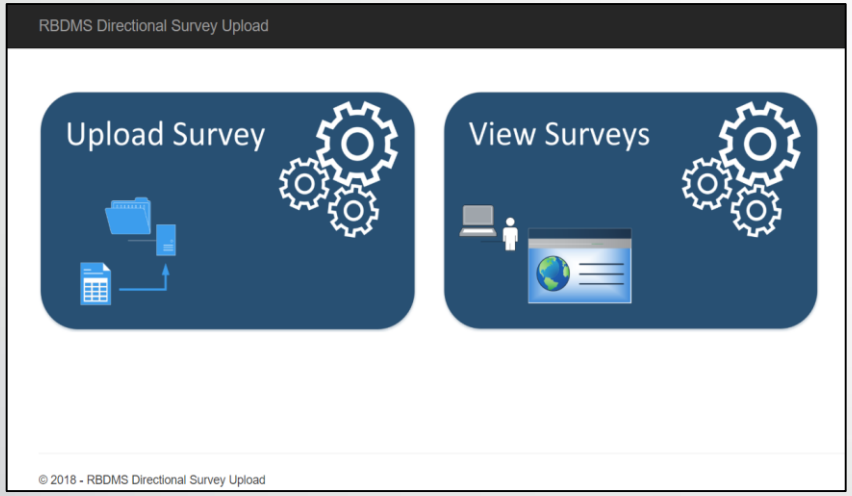
Option 2: Operator logs onto Online Forms --- Clicks link to RBDMS Directional Survey Upload Page --- Uploads EDD file to Online Grid --- Corrects any errors flagged in grid --- Submits final directional data grid --- Operator includes PDF and possibly the EDD spreadsheet as attachments to E-Form.

Workflow – Operator Submittals

Option 2 is probably the best option and some work has been completed to support this option for the Utah DOGM.

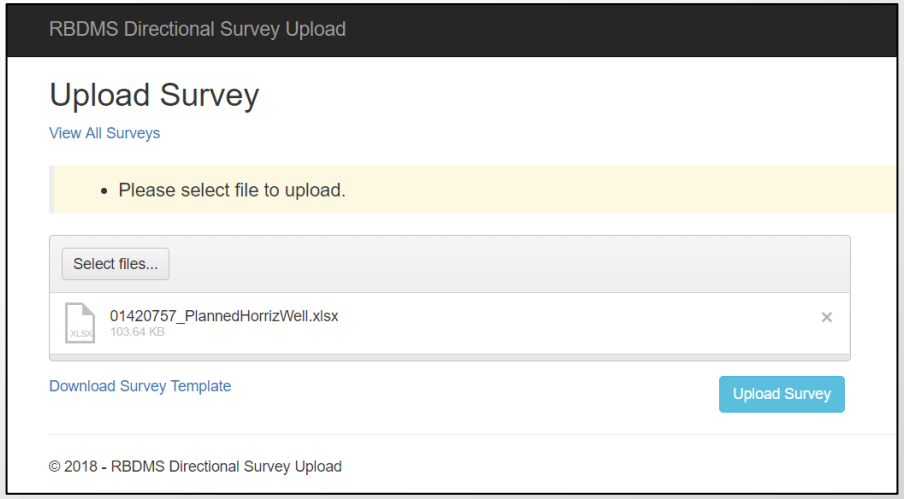


Online Form APD or Completion Rpt



Web-App Home Page

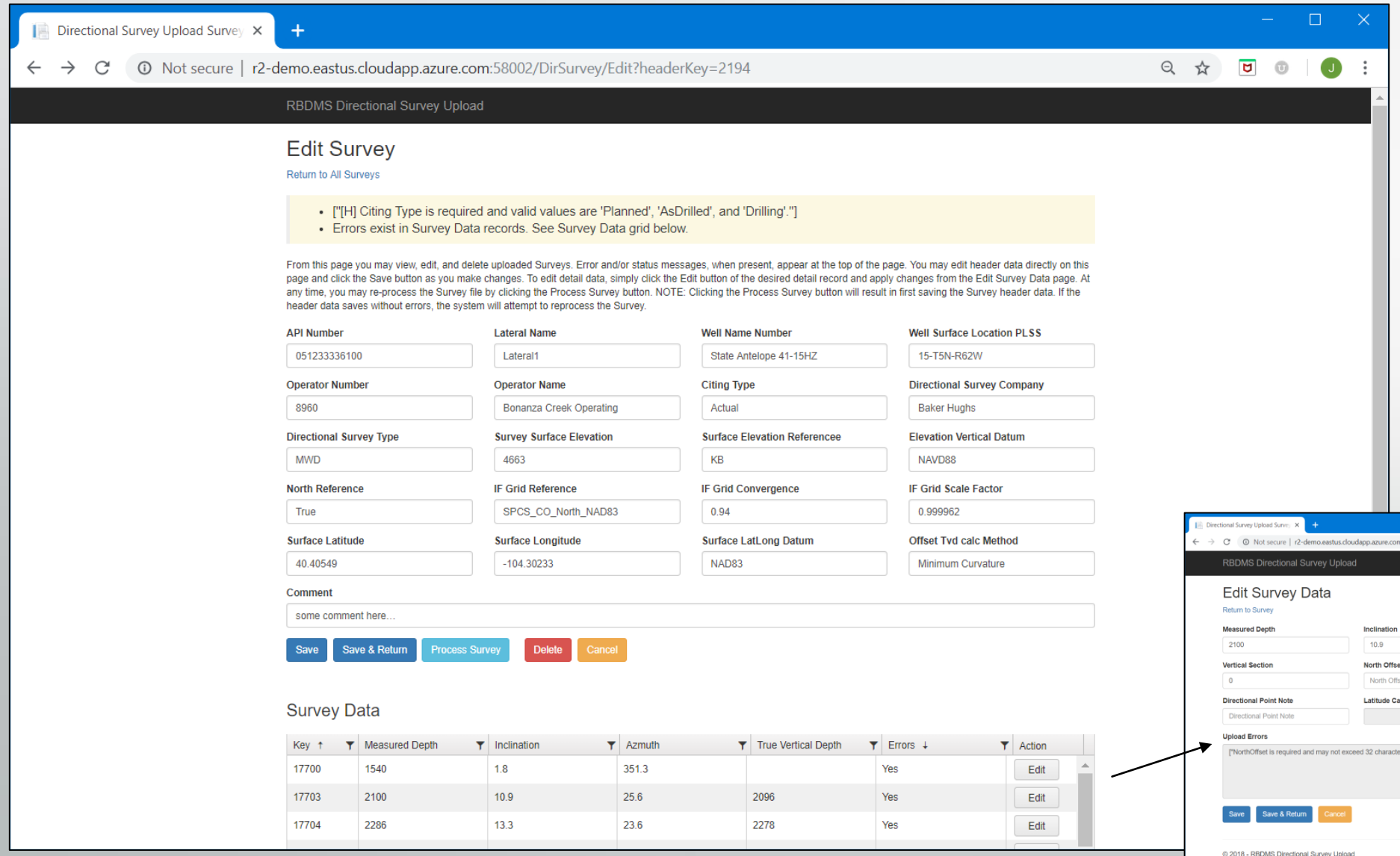
Operator gets to the home page by logging into Online Forms and clicking hyperlink

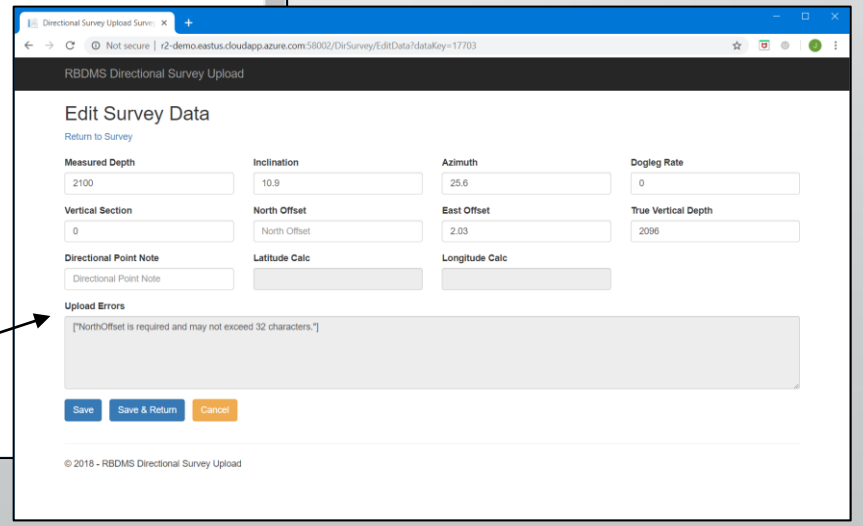


Upload EDD File Page

Operator navigates to a completed EDD on their computer and uploads it through this page. A blank EDD template can also be downloaded from this page.

Workflow – Error Corrections





Errors are flagged and corrected by Operators through these online grids.

Note: Errors that are corrected here will not automatically be be corrected on the original EDD spreadsheet.

Workflow – Staff Review of Data

EDD

	A	B	C	D
1	**Header Information**			
2	APINumber:	05-123-39304		
3	LateralName:			
4	WellNameNumber:	Banded 32-22HZ		
5	WellSurfaceLocationPLSS:	SESE 22 T2N R67W		
6	OperatorNumber:			
7	OperatorName:	Kerr McGee Oil and Gas		
8	CitingType:	AsDrilled		
9	DirectionalSurveyCompany:	Scientific Drilling		
10	DirectionalSurveyType:	Gyro and MWD		
11	SurveySurfaceElevation:	5002		
12	SurfaceElevationReference	KB		
13	ElevationVerticalDatum:	MSL		
14	NorthReference:	TRUE		
15	iFGridReference:			
16	iFGridConvergence:			
17	iFGridScaleFactor:			
18	SurfaceLatitude:	40.117249		
19	SurfaceLongitude:	-104.870655		
20	SurfaceLatLongDatum:	NAD83		
21	OffsetTVDCalcMethod	Minimum Curvature		
22	Comment:			
23	**MeasuredDepth**	**Inclination**	**Azimuth**	**TrueVerti**
24	0	0	0	
25	25	0	0	

Three Sources
of the same data

Elevation
4977 ft Ground
+ 25 ft (KB) = 5002

Surface Lat-Long
40.117249
-104.870655

Database Record

GIS Doc COA Wellbore Orders

Surface Location Data for API # 05-123-39304 Status: PR 12/23/2014

Well Name/No:	BANDED #16N-27HZ	(click well name for production)	
Operator:	KERR MCGEE OIL & GAS ONSHORE LP - 47120		
Status Date:	12/23/2014	Federal or State Lease #:	
FacilityID:	**436872**	LocationID:	**436873**
County:	WELD #123	Location:	SESE 22 2N67W 6 PM
Field:	WATTENBERG - #90750	Elevation:	4,977 ft.
Planned Location	300 FSL 886 FEL	Lat/Long: 40.117249/-104.870655	Lat/Long Source: Field Measured
As Drilled Location	Footages Not Available	Lat/Long: 40.117259/-104.870653	Lat/Long Source: Field Measured

Wellbore Data for Sidetrack #00 Status: PR 12/23/2014

Spud Date:	6/29/2014	Spud Date is:	ACTUAL
Wellbore Permit		HORIZONTAL	
Permit #:		Expiration Date:	4/20/2016 10:04:26 AM
Prop Depth/Form:	12625	Surface Mineral Owner Same:	
Mineral Owner:	FEE	Surface Owner:	FEE
Unit:		Unit Number:	

SURVEY PDF

Scientific Drilling — Survey Report

Company:	US ROCKIES REGION PLANNING	Local Co-ordinate Reference:	Well BANDED 16N-27HZ
Project:	COLORADO NORTHERN ZONE - 83	TVD Reference:	GL 4977 & KB 25 @ 5002.00ft (HP 311)
Site:	BANDED 37-22 HZ PAD	MD Reference:	GL 4977 & KB 25 @ 5002.00ft (HP 311)
Well:	BANDED 16N-27HZ	North Reference:	True
Wellbore:	OH	Survey Calculation Method:	Minimum Curvature
Design:	OH	Database:	Denver Sales

Project COLORADO NORTHERN ZONE - 83, KERR MCGEE OIL & GAS ONSHORE LP

Map System:	US State Plane 1983	System Datum:	Mean Sea Level
Geo Datum:	North American Datum 1983		
Map Zone:	Colorado Northern Zone		

Site BANDED 37-22 HZ PAD, SECTION 22 T2N-R67W

Site Position:		Northing:	1,286,182.29 usft	Latitude:	40.1172480
From:	Lat/Long	Easting:	3,176,038.58 usft	Longitude:	-104.8705480
Position Uncertainty:	0.00 ft	Slot Radius:	13.200 in	Grid Convergence:	0.41 °

Well BANDED 16N-27HZ, 300' FSL 886' FEL

Well Position	+N/-S	0.00 ft	Northing:	1,286,182.43 usft	Latitude:	40.1172490
	+E/-W	0.00 ft	Easting:	3,176,008.66 usft	Longitude:	-104.8706550
Position Uncertainty		0.00 ft	Wellhead Elevation:	0.00 ft	Ground Level:	4,977.00 ft

Wellbore OH

Magnetics	Model Name	Sample Date	Declination (°)	Dip Angle (°)	Field Strength (nT)
	BGGM2014	7/14/2014	8.57	66.69	52,546

Design OH

Audit Notes:

Version:	1.0	Phase:	ACTUAL	Tie On Depth:	0.00

Vertical Section:	Depth From (TVD) (ft)	+N/-S (ft)	+E/-W (ft)	Direction (°)
	0.00	0.00	0.00	180.00

Survey Program Date 8/26/2014

From (ft)	To (ft)	Survey (Wellbore)	Tool Name	Description
25.00	1,667.00	Survey #1 GYRO (OH)	NS-GYRO-MS	North sensing gyrocompassing m/s
1,767.00	13,255.00	Survey #2 SDI MWD PRODUCTION (OH)	SDI_MWD+CRUST_1.0	SDI MWD + Crustal anomaly, Version 1.0

Survey

Measured Depth (ft)	Inclination (°)	Azimuth (°)	Vertical Depth (ft)	+N/-S (ft)	+E/-W (ft)	Vertical Section (ft)	Dogleg Rate (°/100usft)	Build Rate (°/100usft)	Turn Rate (°/100usft)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00

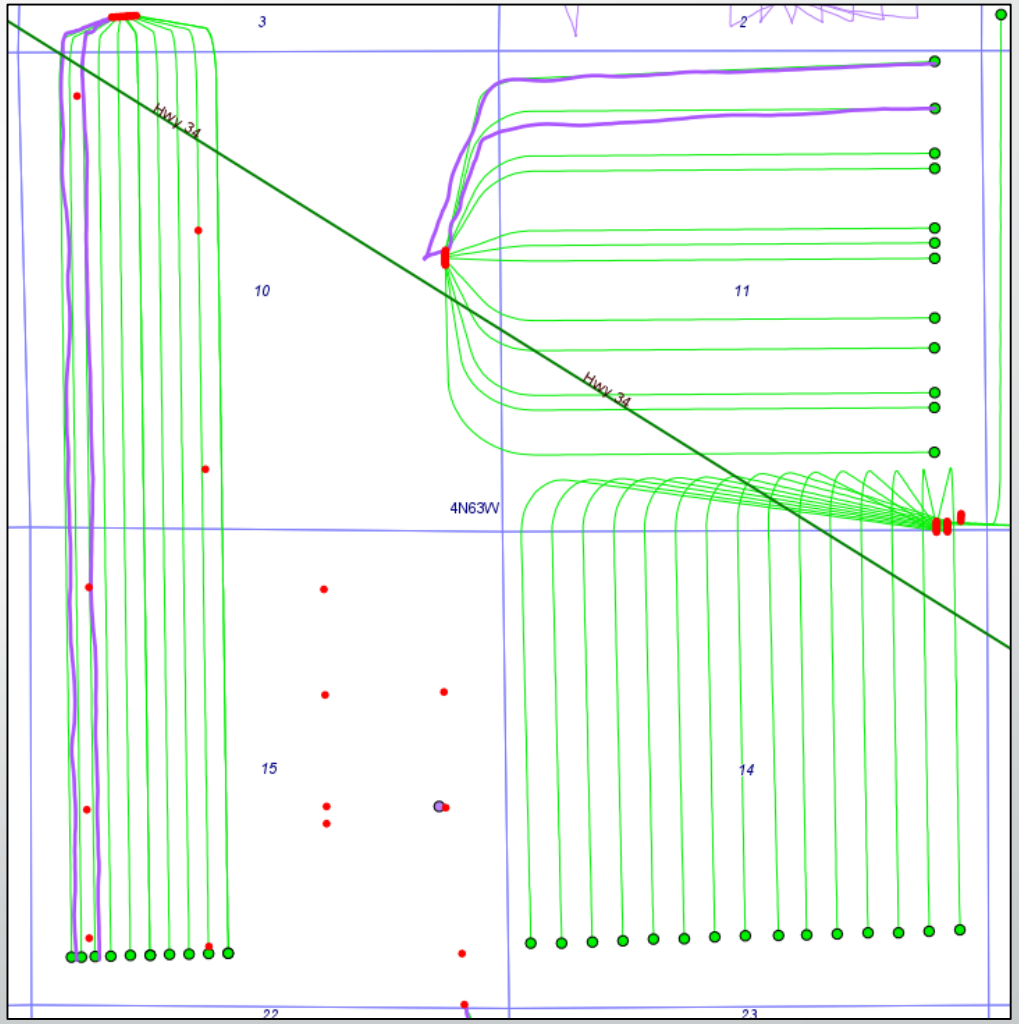
Workflow – Staff Review of GIS Lines

Planned Wellbores (Green Lines)

- Are wells in legal locations and not too close to unit boundaries?
- Is the horizontal well density consistent with the spacing Order?
- Are horizontal wells far enough away from each other and other older vertical wells (red dots)?

AsDrilled Wellbores (Purple Lines)

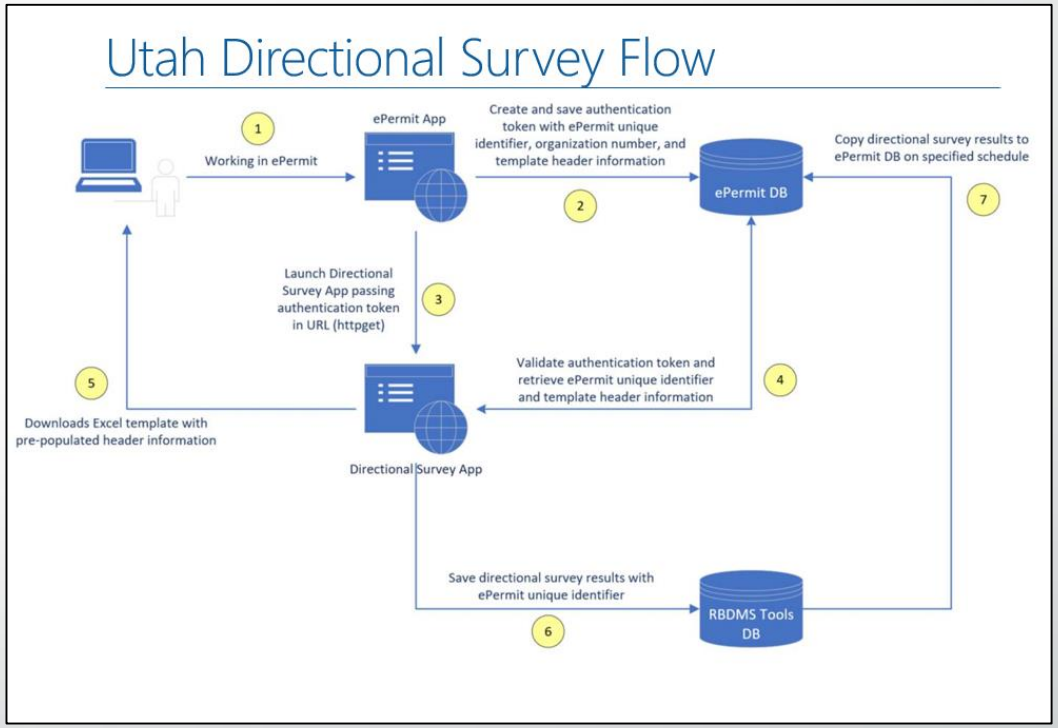
Did the AsDrilled wells get drilled as planned (compare purple and green lines); if not, are the AsDrilled wells still in a legal location?



Workflow – Data Flow Architecture

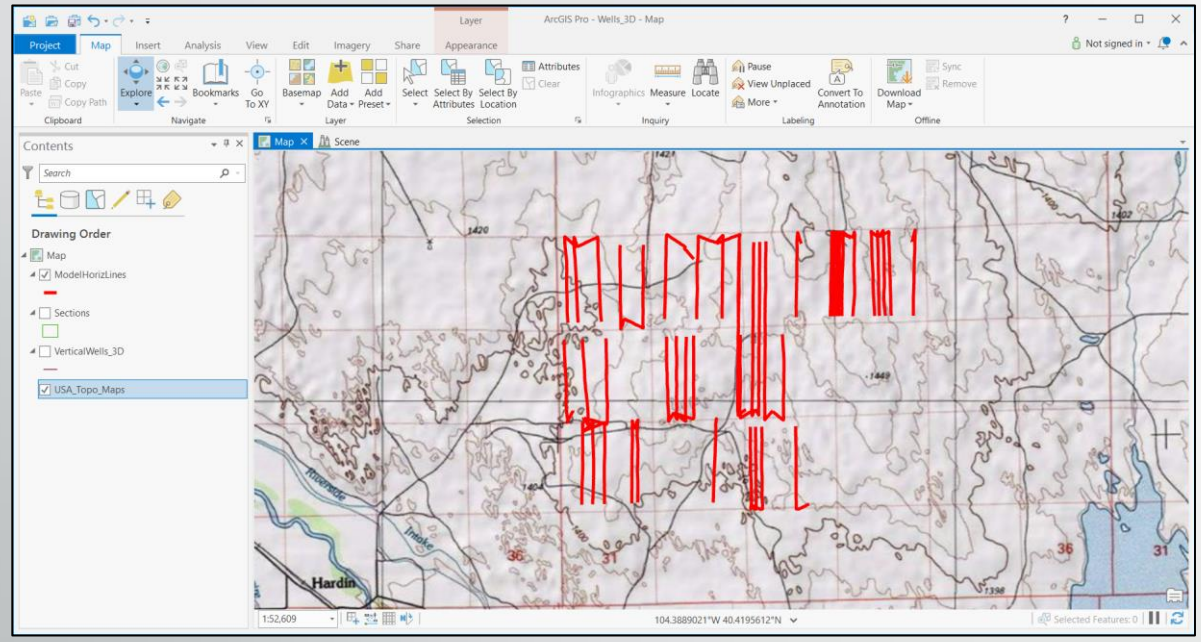
Each State may have a slightly different approach to workflow and architecture. Some basic components are listed below.

- Server(s) to host Directional Survey Upload App.
- Forms, Workflow, or Staging database to accept Operator Submittals
- Method to transfer approved survey data to Main RBDMS database tables
- Security for logged-in users to submit directional survey data
- SQL-Server Views to support GIS system integration



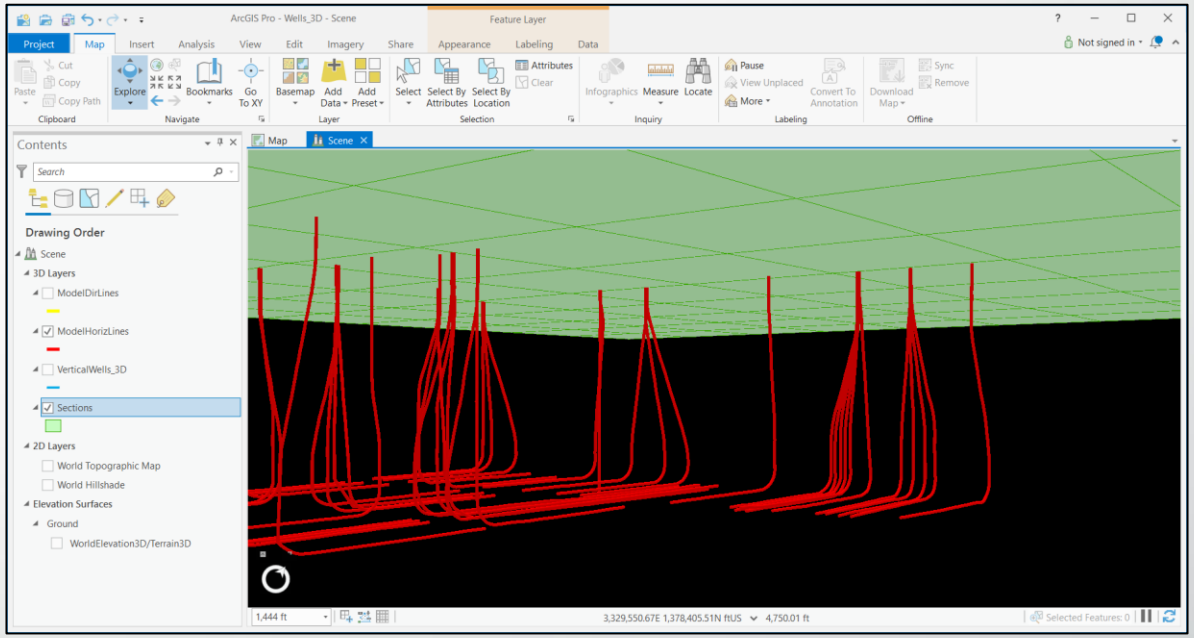
GIS Output

2-D



- Easy to automate mapping of an entire State.
- All users can view and analyze features via Online Maps.
- GIS users can perform complex analysis of features using GIS software.

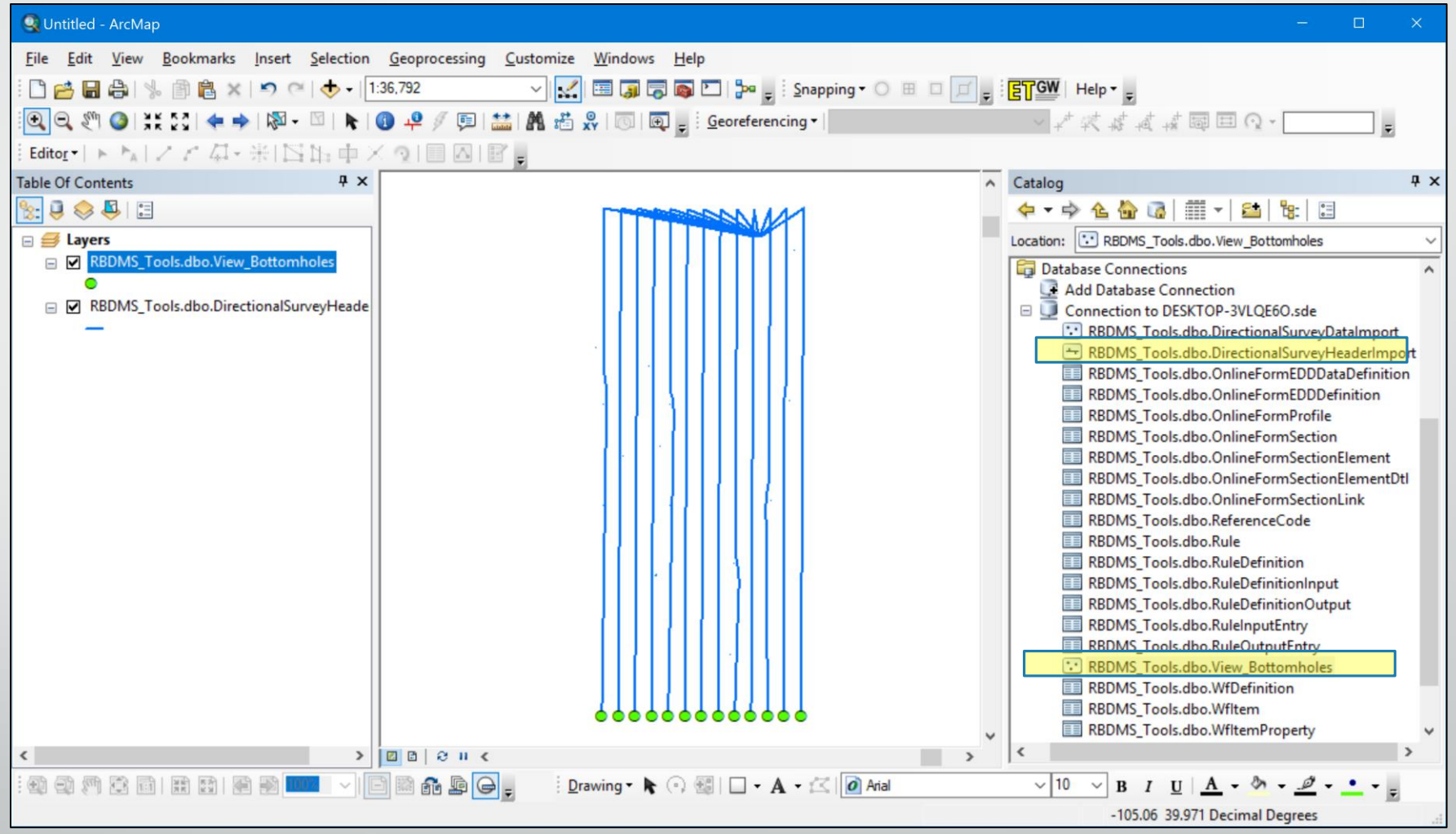
3-D



- In most cases, GIS staff will need to set up specific project areas (local scenes).
- GIS staff can publish 3-D scenes for viewing in browsers if they have advanced ESRI licenses.
- Other users will need 3-D viewing software such as ArcGIS Pro or Global Mapper.

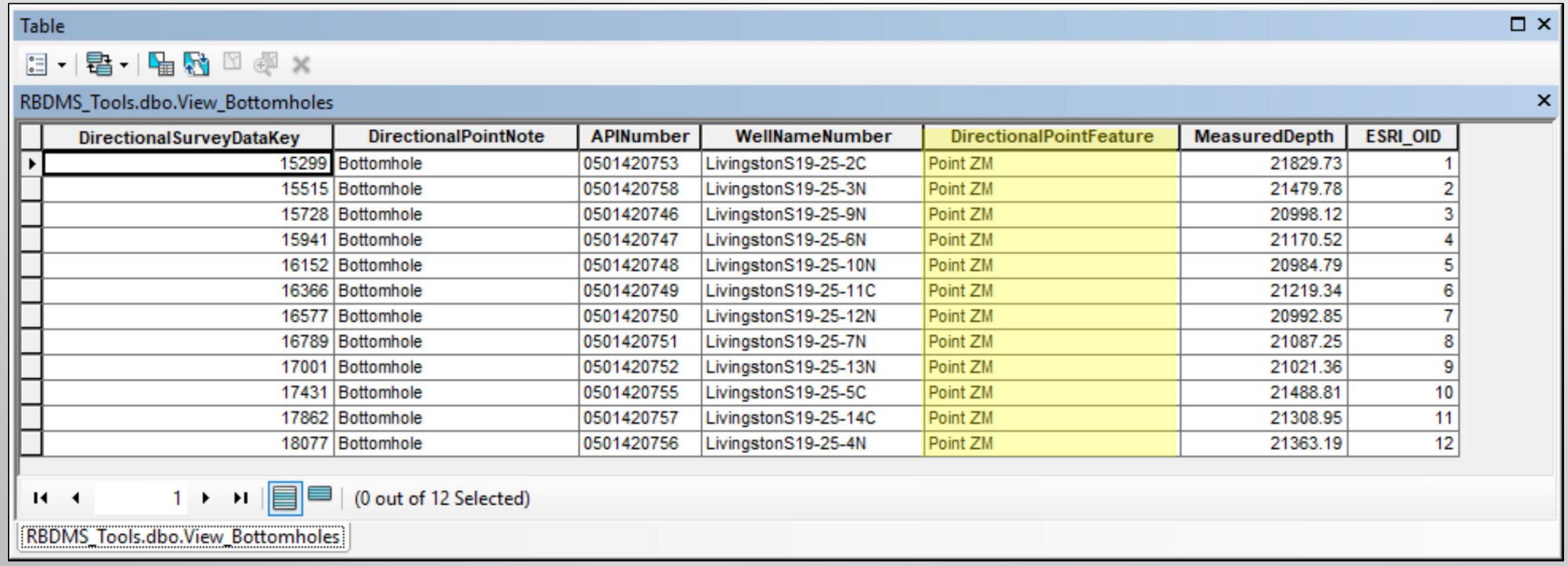
Creating GIS Line and Point Features

1. Connect GIS software to SQL-Server Database.
2. Add horizontal well lines from the Header Import Table.
3. Add bottomhole points from Bottomhole SQL View.
4. Save Lines and Points as Shapefiles or similar.
5. Re-project lines and points to to State Coordinate system (e.g. UTM Zone 12, NAD83)
6. For 3-D displays, it is best to have x, y, and z in the same units (State Plane feet)



Lines and Points from Database *are Lat-Long NAD 83*

Shapefiles are 3-D Features with Measures (Point ZM)



Table

RBDMS_Tools.dbo.View_Bottomholes

	DirectionalSurveyDataKey	DirectionalPointNote	APINumber	WellNameNumber	DirectionalPointFeature	MeasuredDepth	ESRI_OID
▶	15299	Bottomhole	0501420753	LivingstonS19-25-2C	Point ZM	21829.73	1
	15515	Bottomhole	0501420758	LivingstonS19-25-3N	Point ZM	21479.78	2
	15728	Bottomhole	0501420746	LivingstonS19-25-9N	Point ZM	20998.12	3
	15941	Bottomhole	0501420747	LivingstonS19-25-6N	Point ZM	21170.52	4
	16152	Bottomhole	0501420748	LivingstonS19-25-10N	Point ZM	20984.79	5
	16366	Bottomhole	0501420749	LivingstonS19-25-11C	Point ZM	21219.34	6
	16577	Bottomhole	0501420750	LivingstonS19-25-12N	Point ZM	20992.85	7
	16789	Bottomhole	0501420751	LivingstonS19-25-7N	Point ZM	21087.25	8
	17001	Bottomhole	0501420752	LivingstonS19-25-13N	Point ZM	21021.36	9
	17431	Bottomhole	0501420755	LivingstonS19-25-5C	Point ZM	21488.81	10
	17862	Bottomhole	0501420757	LivingstonS19-25-14C	Point ZM	21308.95	11
	18077	Bottomhole	0501420756	LivingstonS19-25-4N	Point ZM	21363.19	12

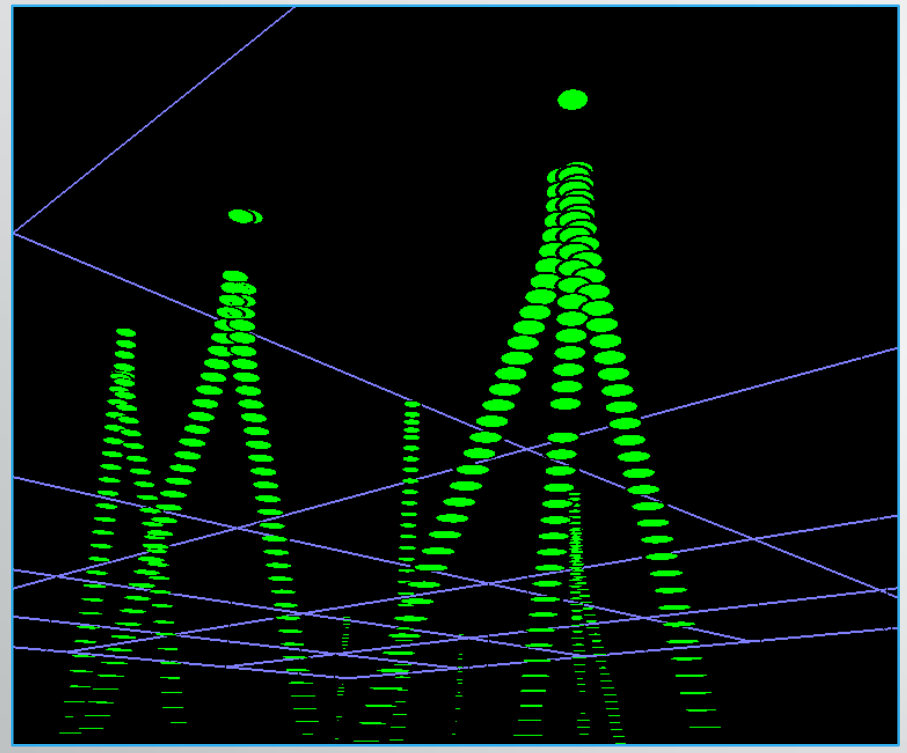
1 (0 out of 12 Selected)

RBDMS_Tools.dbo.View_Bottomholes

Z = 3-D elevation property; M = Measures assigned to lines (Measured Depth)

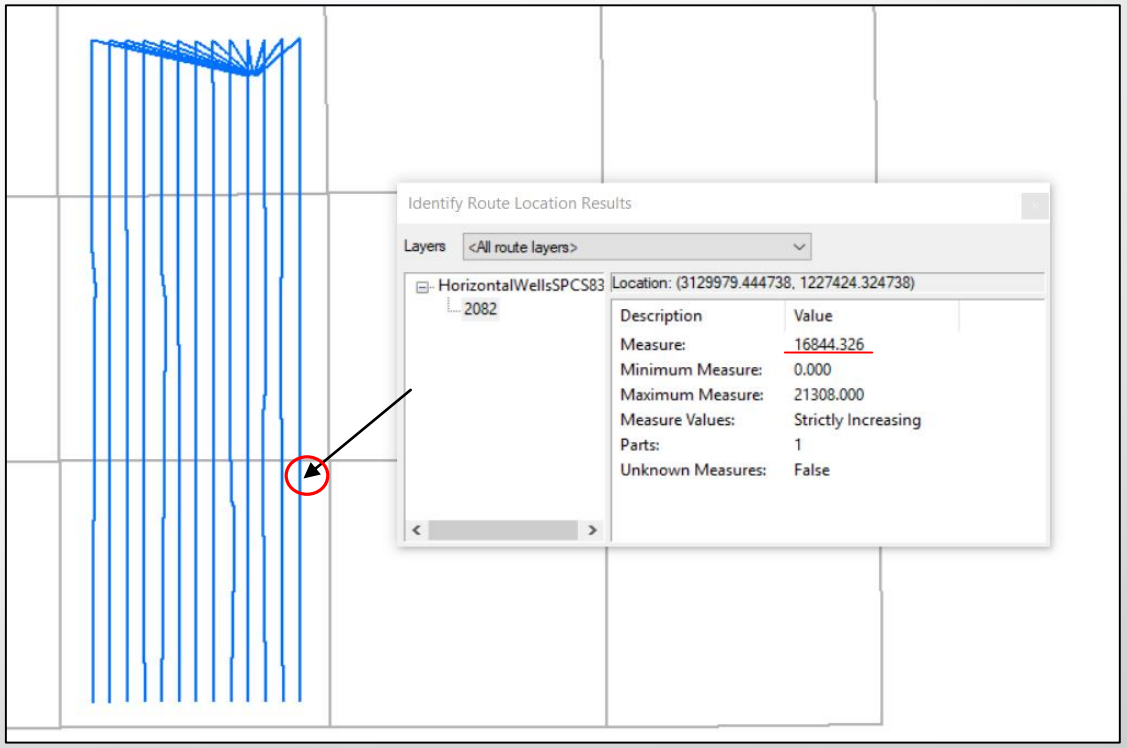
Shapefile Z and M Properties

Z (Elevation Values) for Directional Points



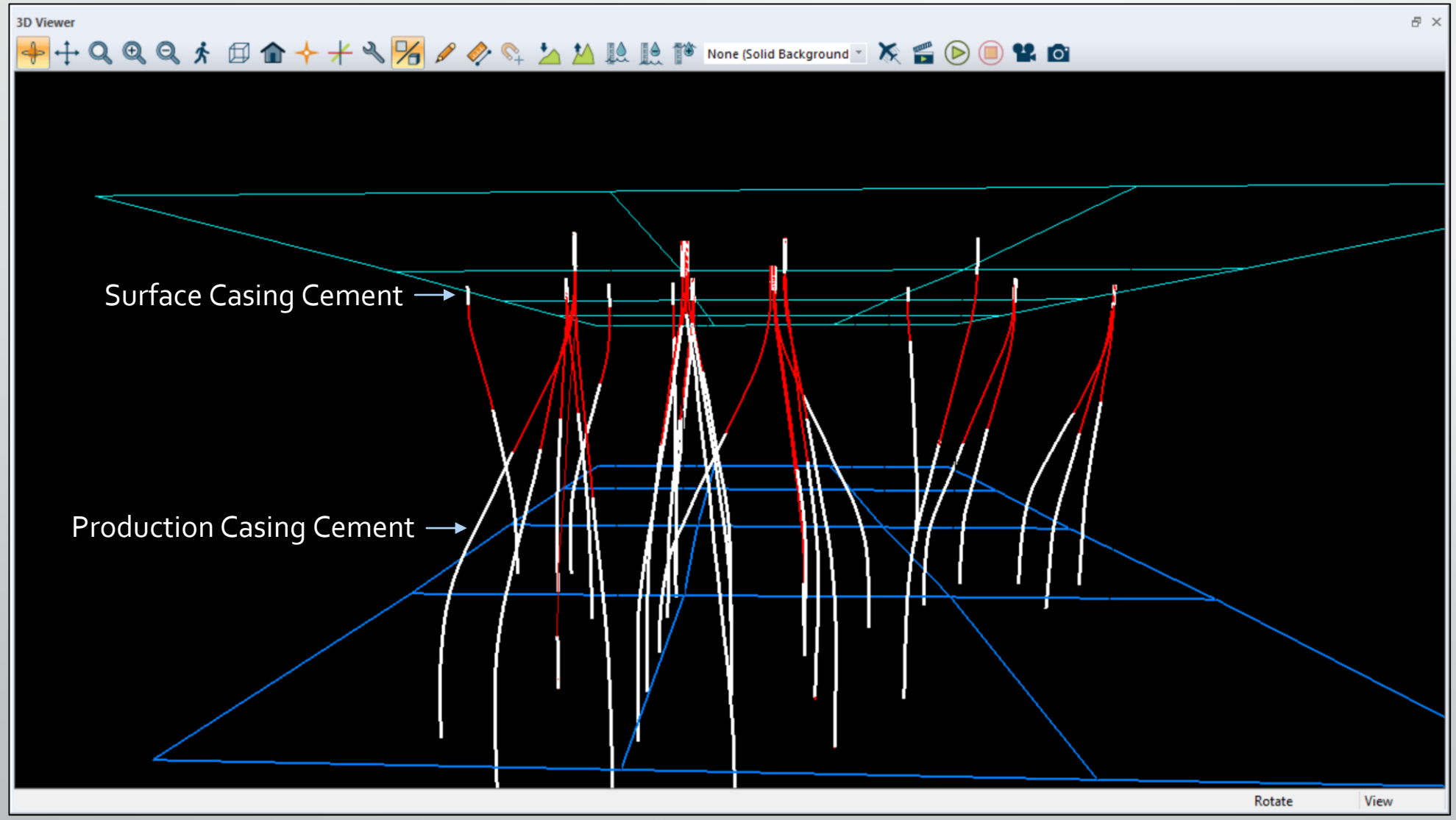
Z Values used for 3-D Viewing

M (Measured Depth Values) for Directional Lines



M values allow for new line segments to be created based on measured depth intervals. Can be used to highlight perforation and cement intervals

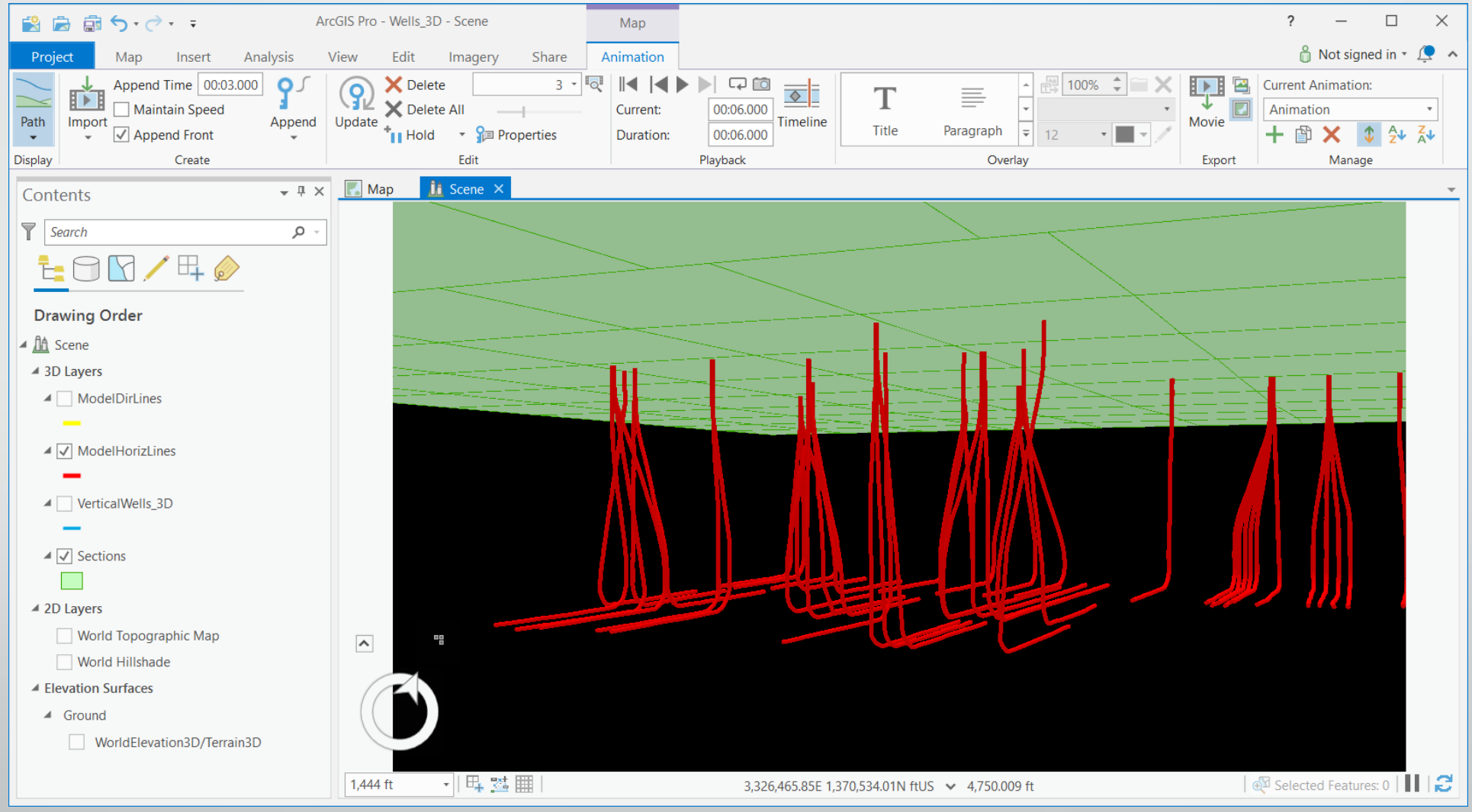
3-D Display with Measured Depth Highlights



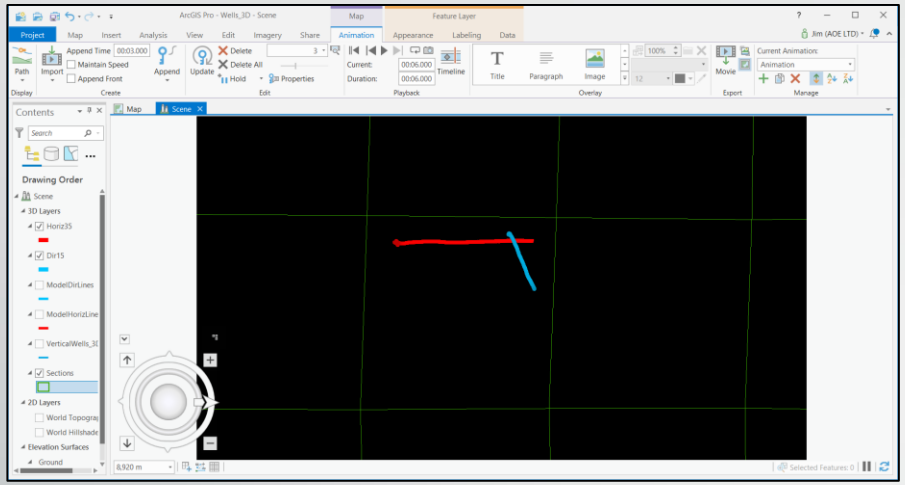
3-D Display of Directional Wellbores in Global Mapper Software

3-D in ESRI ArcGIS Pro

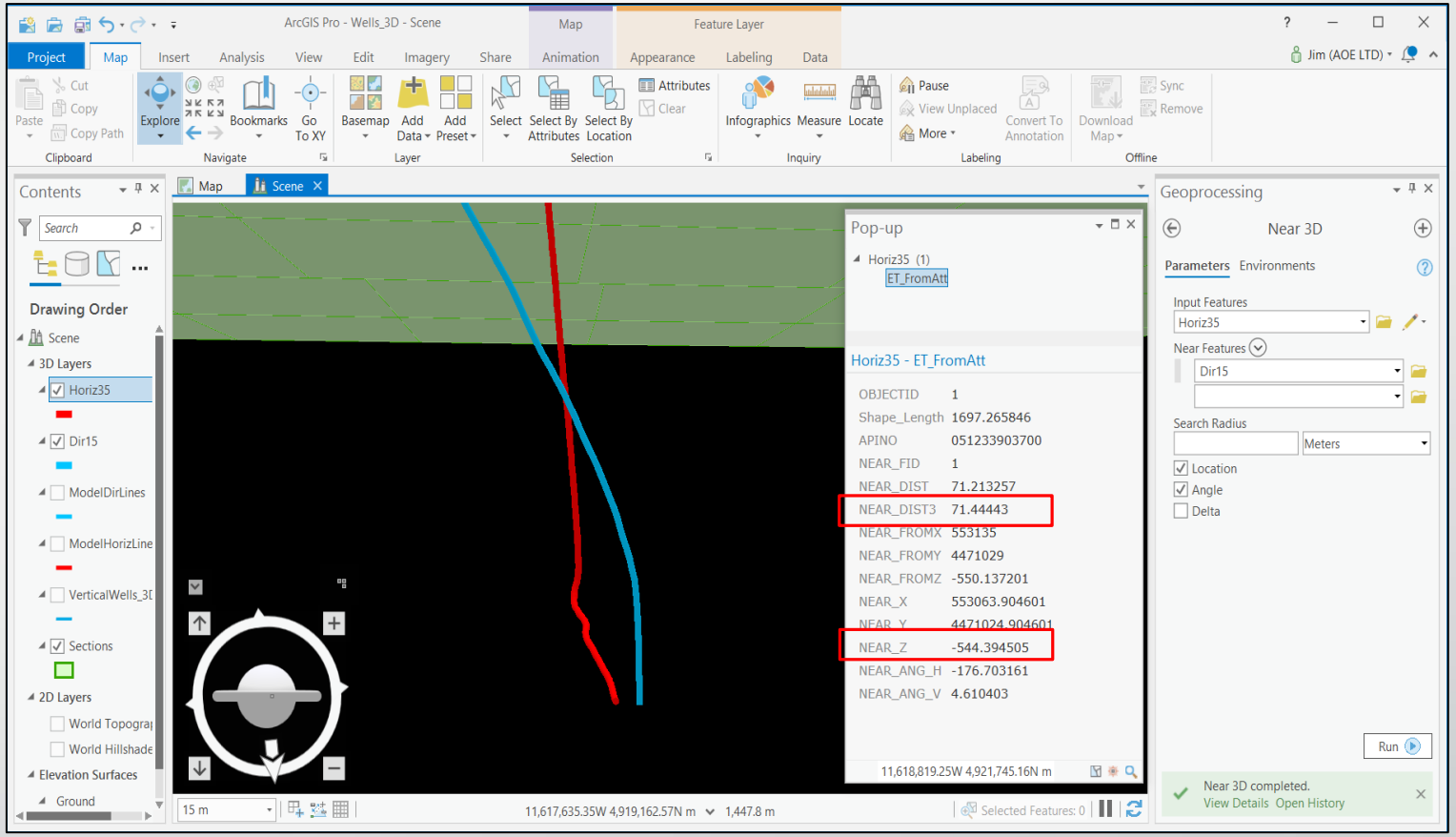
- Can create project and publish to GIS Online or local GIS Server for sharing.
- Can create 3-D Buffers with 3-D Analyst Extension.
- Can conduct a 3-D Proximity Analysis with Built In Tool.



ArcGIS Pro Proximity (Near 3D) Tool



In map view, these 2 wells appear to intersect each other.

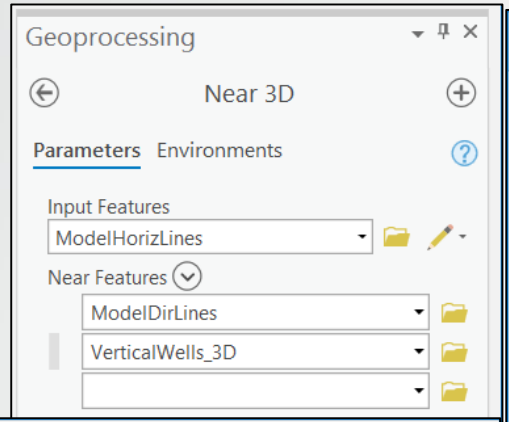


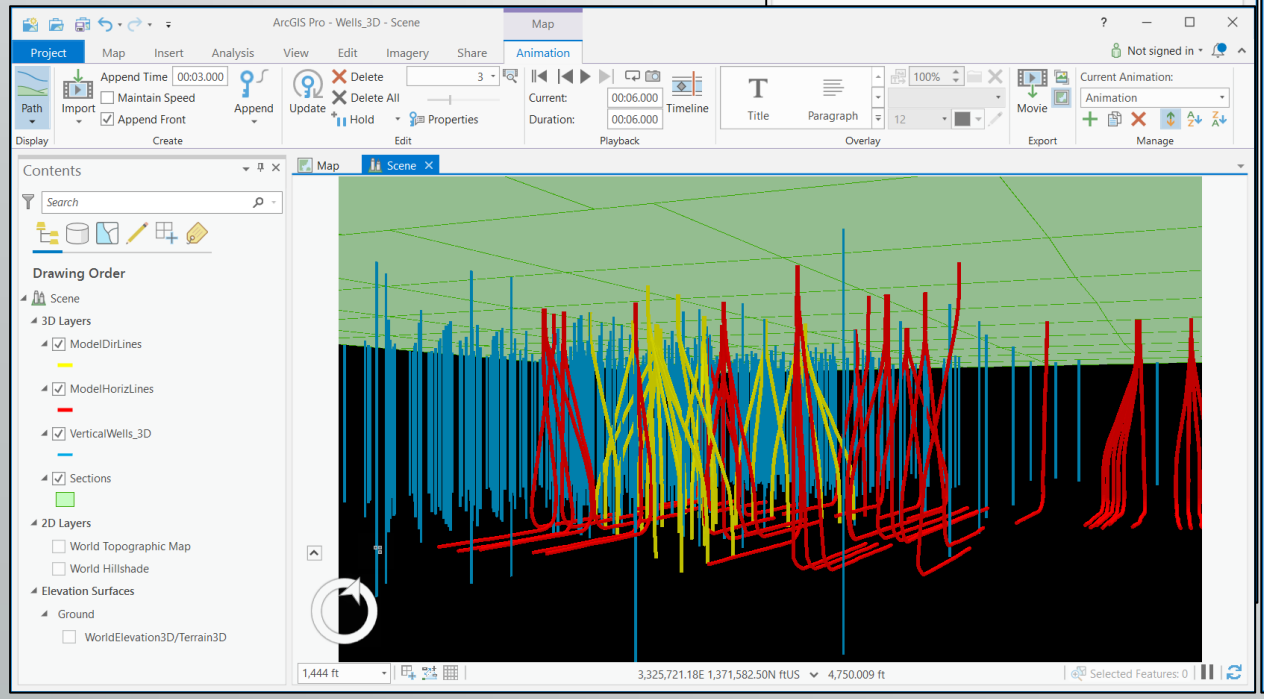
In 3-D View, the wells do not intersect each other. Using the Near 3-D tool, it is determined that the two wells are 71 meters apart at an elevation of -544 meters.

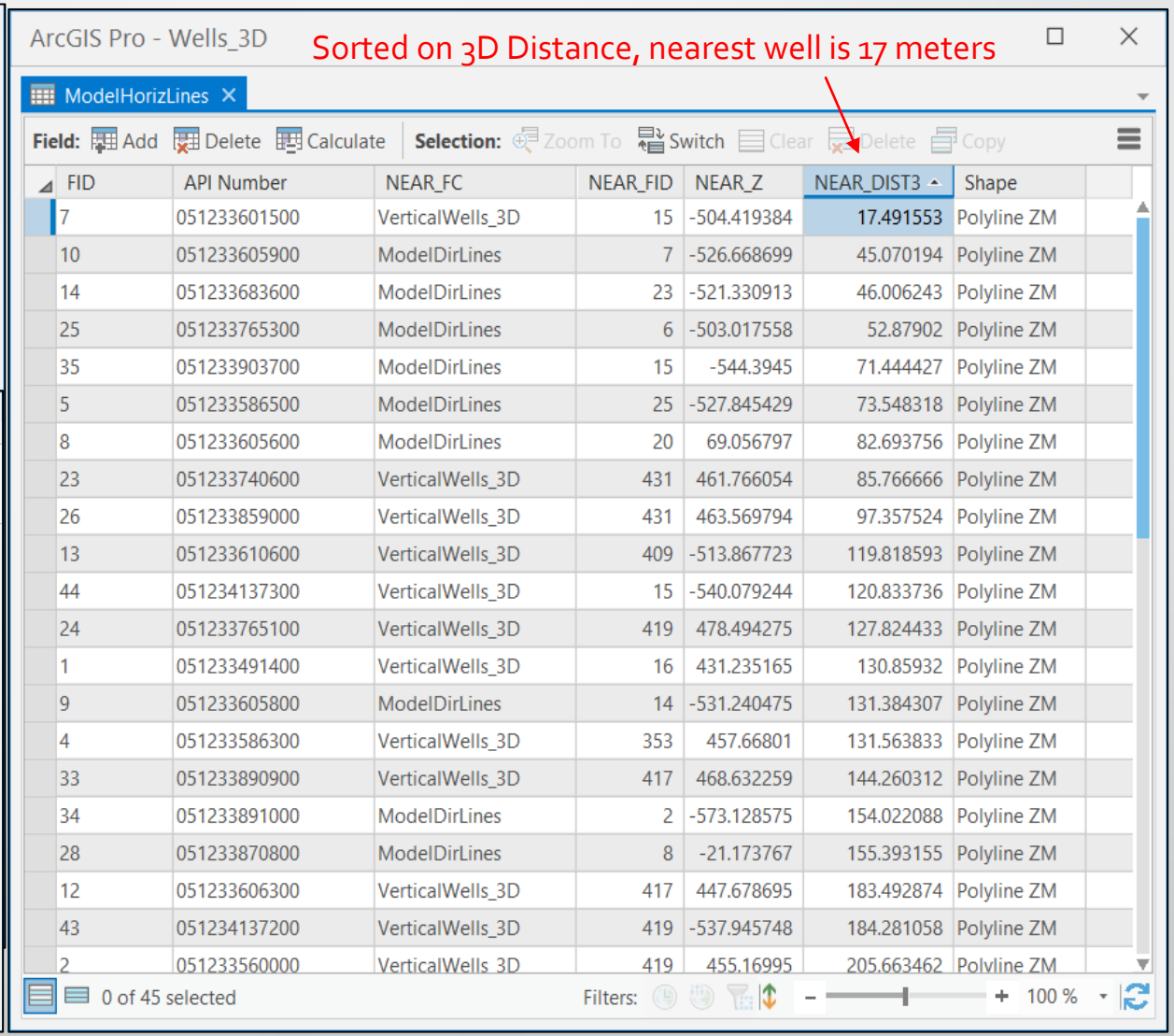
Requires 3-D Analyst Extension

ArcGIS Pro Proximity (Near 3D) Tool Example

Can analyze multiple wells in a 3-D Scene. In this example, the horizontal wells are compared to the directional and vertical wells.



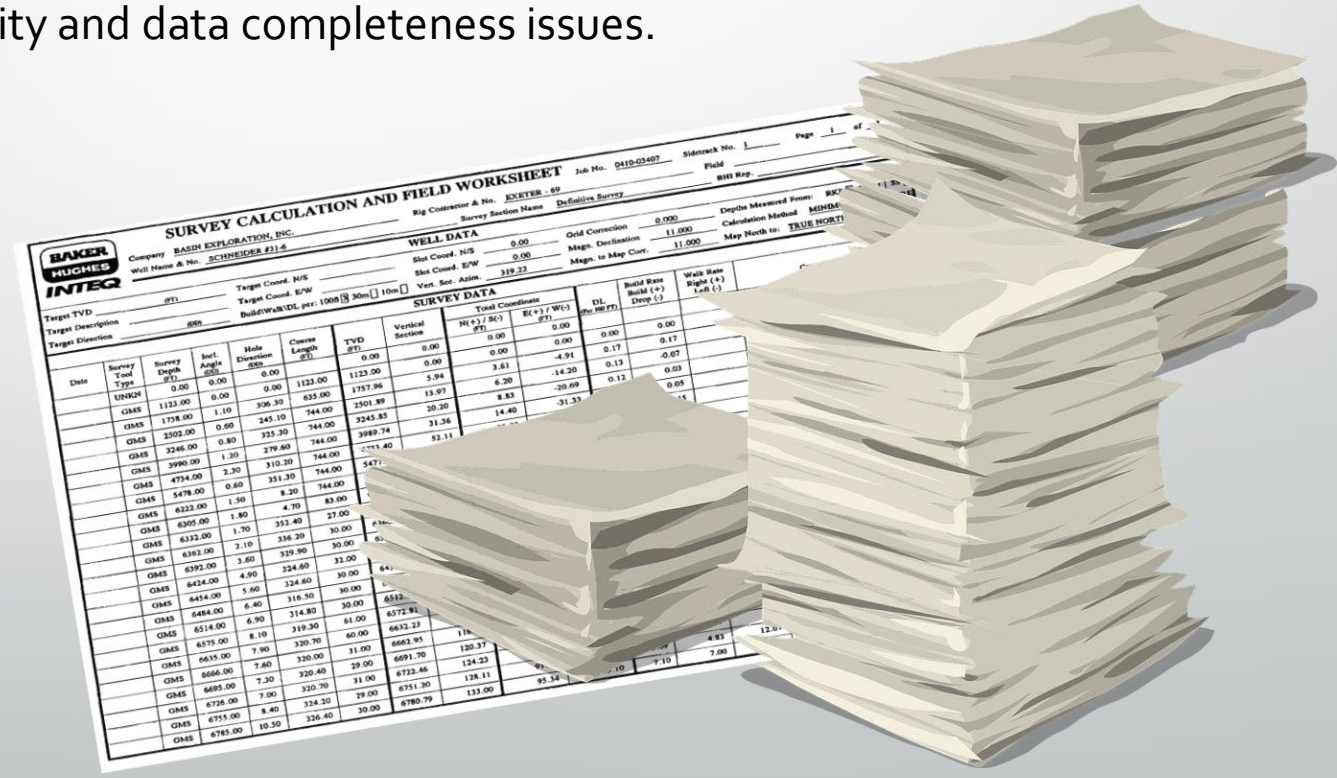




Requires 3-D Analyst Extension

Legacy Data – The Hard Facts

- Many States will have hundreds , if not thousands, of legacy directional surveys to get into the system.
- There is no easy way to get these into the system.
- Hopefully, the legacy directional surveys have been scanned and/or exist as PDFs.
- These surveys could have variety of data quality and data completeness issues.
- It may take awhile to get caught up.

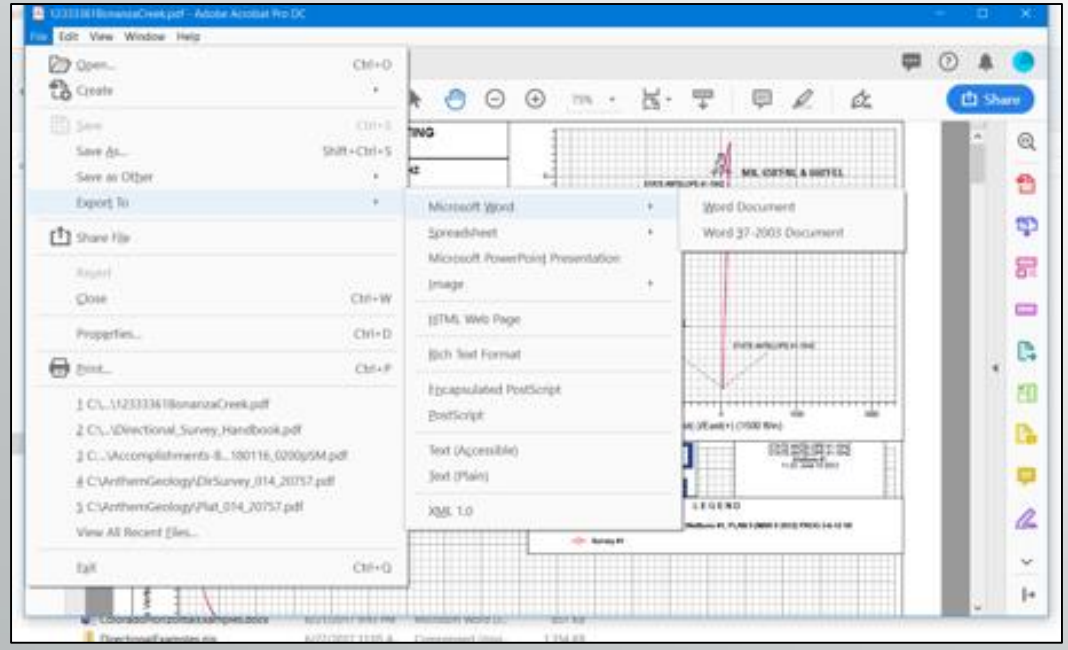


Legacy Data – Some Ideas to Consider

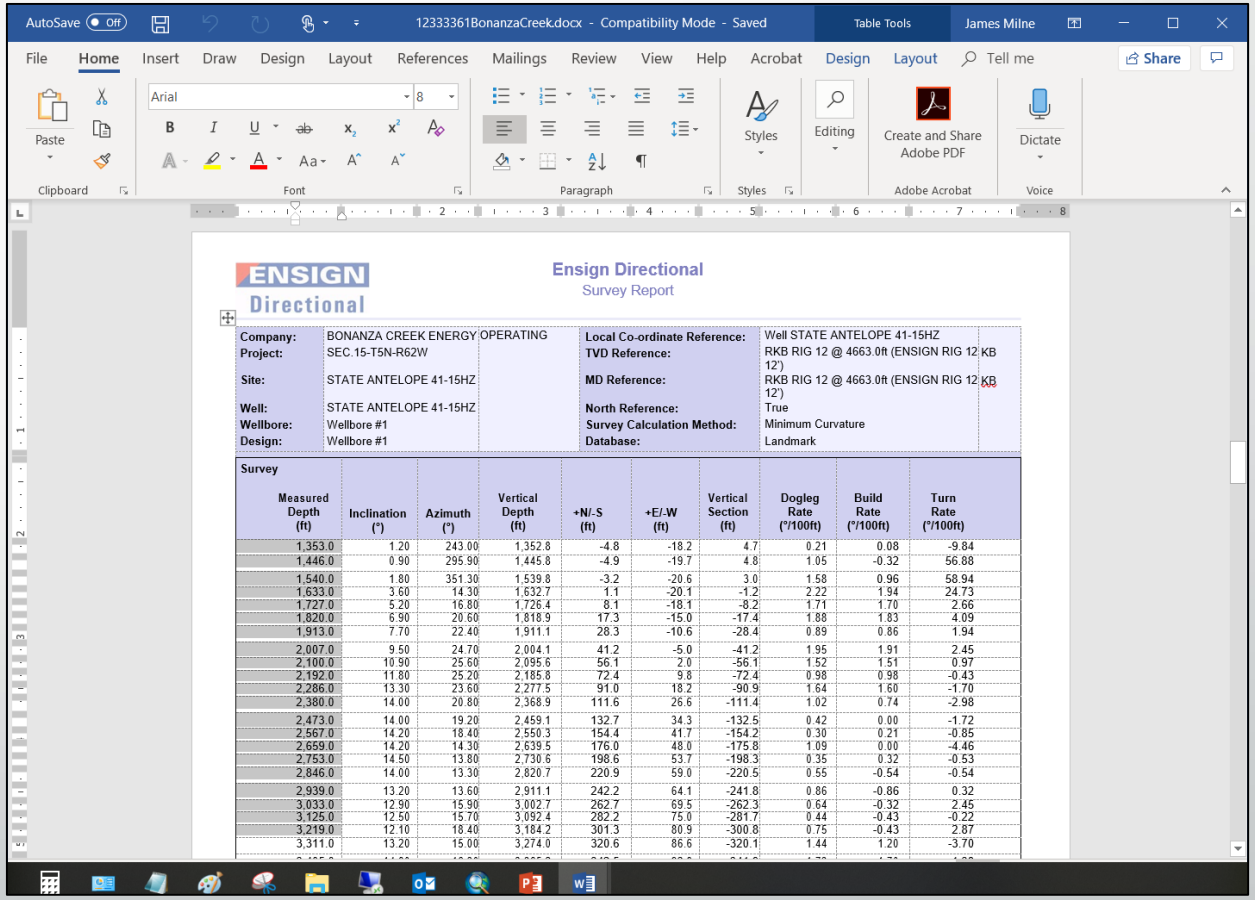
- First Step is to identify which wells are directional wells, and use a map symbol to indicate that a surface point location is actually a directional well that hasn't been mapped yet.
- If you happen to have bottomhole locations, include those on your map with a straight line connecting the surface location to the bottomhole (e.g Utah). If not, a good first step might be to just capture bottomhole locations, and catch the rest of the survey up later.
- Review legacy PDfs and group them by potential issue with respect to creating EDDs for processing through the upload application (e.g. NAD 27 datum, grid north, missing critical data, etc).
- If Lat-Longs, UTM, or State Plane coordinates of the directional points are already included in the directional survey PDF, consider extracted those to GIS environment and creating these lines using GIS tools.
- Upload application could be modified to allow for uploads of multiple EDDs, to allow for batches to be processed when ready.

Legacy Data – A Few Tips

By using Adobe Professional, you can export to a Word Doc which will preserve columns and rows, making it easier to cut and paste to the EDD template.



Adobe Professional



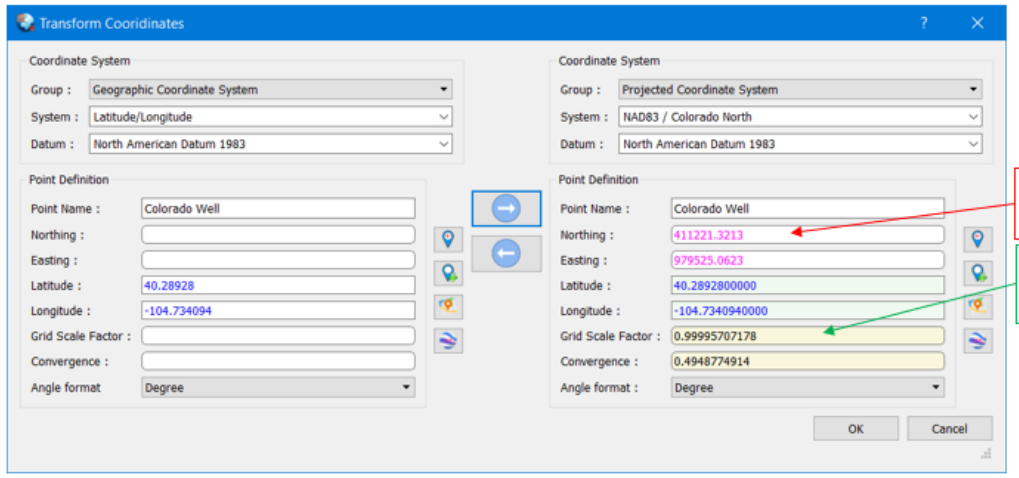
Word Document

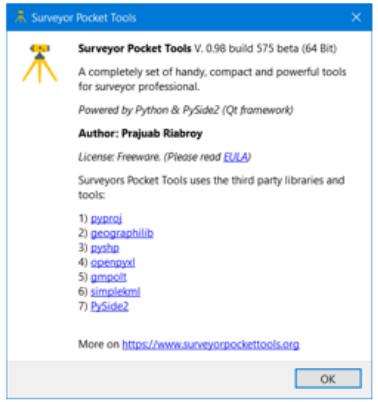
Legacy Data – A Few Tips

If a legacy survey is Grid North with missing Scale Factor and Convergence values, you can use conversion software to convert from the current projection to the old Grid North projection. The scale factor and convergence values are calculated in the process.

In this case *Survey Pocket Tools* were used.

Grid North – Survey Pocket Tools to Get Convergence & Scale Factor





Well Record
Datum: NAD 83
Latitude: 40.28928
Longitude: -104.734094

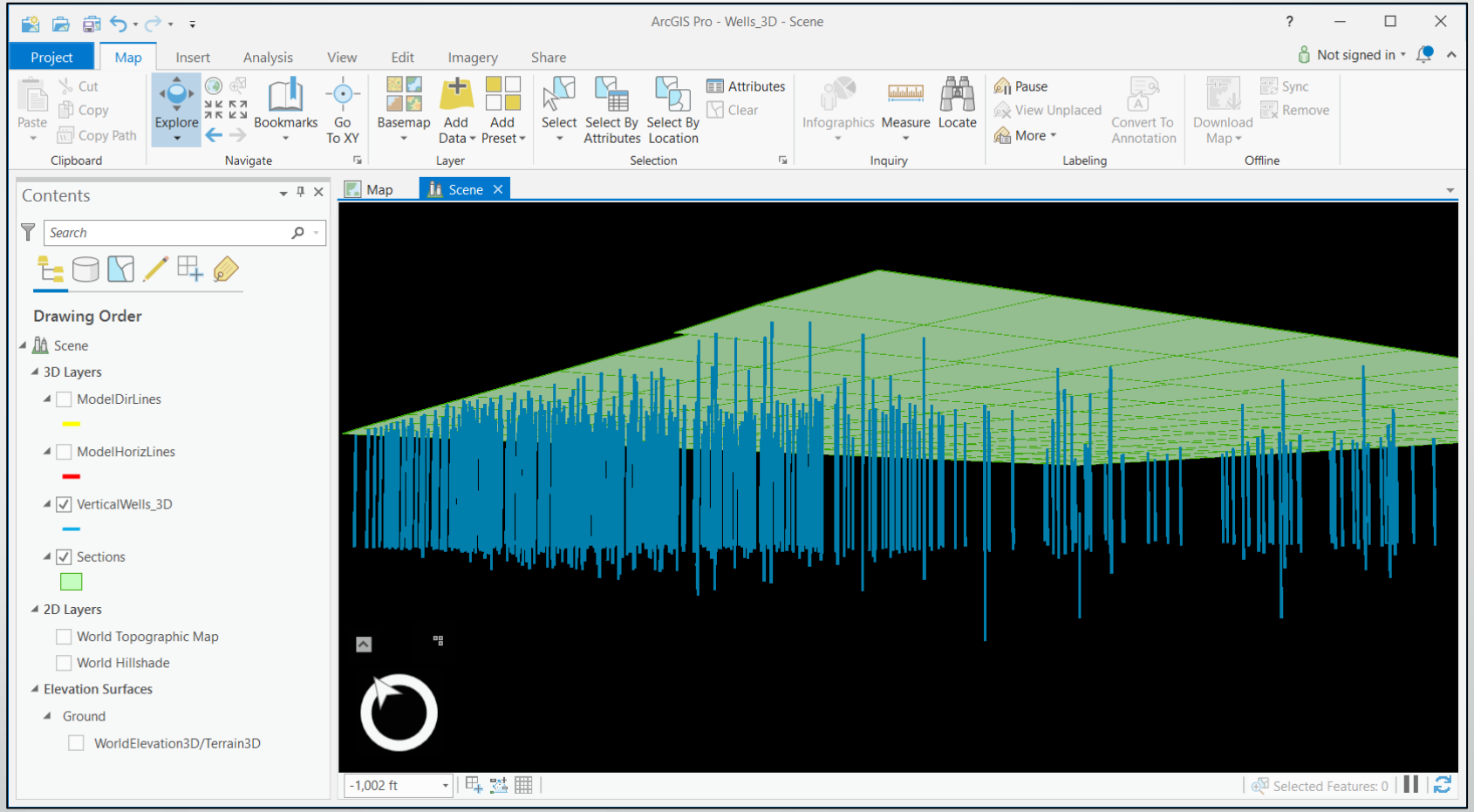
Directional Survey Record
Datum: NAD83
State Plane- Colorado North
1,349,148.68 ft N
3,213,665.17 ft E
411,220.518 meters N
979525.144 meters E

Scale Factor = 0.99995707
Convergence = 0.49 degrees

Note: The File Transform Tool allows for a CSV of multiple records to be processed at one time

Don’t Forget the Vertical Wells

- For 3-D evaluations, the vertical wells will have to be included.
- It not recommended to try to use the directional application to create 3-D vertical well line features.
- Consider using GIS software to create these lines – thousands of these can be created in a short period of time this way.



ArcGIS Basic with the ET GeoWizards add-on was used to create 3-D lines by converting points (surface points and bottomhole points) to lines.

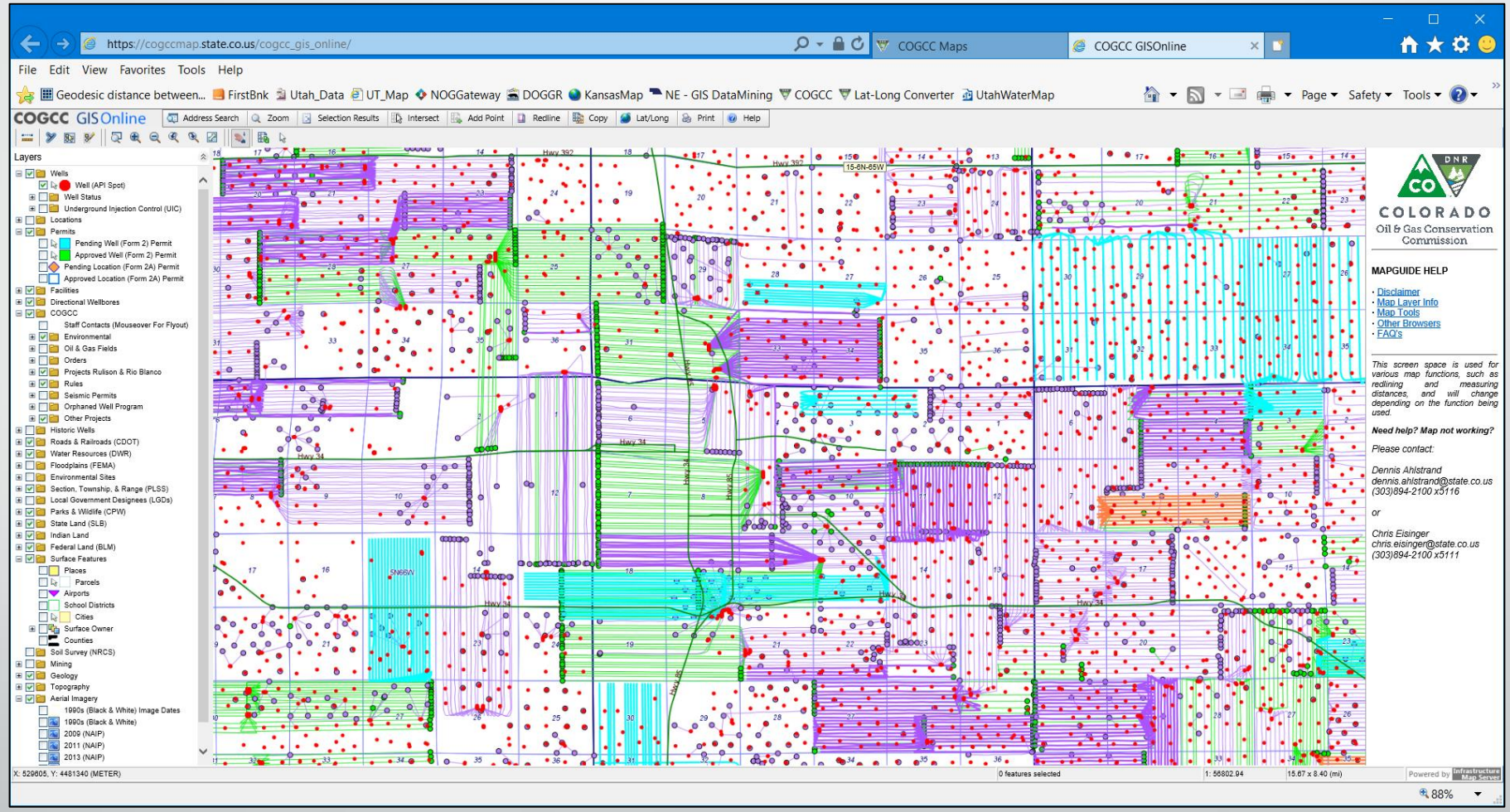
In Summary

- The GWPC Directional Survey Upload Application allows States accept directional survey information as digital data to support mapping directional/horizontal wellbore lines in their GIS systems.
- The automated Application workflow has be designed to streamline data flow from the Operators to State databases and GIS systems.
- These directional/horizontal GIS features can be displayed within Online mapping systems, so that the State, Operators, the public, and other interested parties are aware of the subsurface well paths.
- The GIS features can also be made available for download for further analysis in GIS software.
- The Directional Survey Upload Application is ready to be shared with States that need this capability.

The Sooner the Better

Colorado initiated a similar program in 2012 by requiring Operators to submit directional survey data via an EDD.

49,000 directional surveys have been mapped since then.



Questions?