

Contour Plots for Slab Elevation Data using MathCAD

The screenshot displays the homepage of the Structural Analysis MCAD Store. The header includes the company name, a navigation menu, and a search bar. The main content area features a central banner for 'Structural Analysis MCAD Sheets' with a video player for an 'Example Problem'. To the right, a 'NEW RELEASES' section lists products like 'Wind Load on Pole Design' and 'ACI Anchor Bolt Design'. Below this is a 'Featured Products' section with five product cards, each showing a technical diagram, product name, price, and an 'ADD TO CART' button. The footer contains a disclaimer and copyright information.

Structural Analysis MCAD
MathCAD Sheets written By Engineers For Engineers

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CATEGORY

- Matrix Method BETA
- Fixed Base Plate
- Anchor Bolt
- Wind Load on Pole

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Welcome to Structural Analysis MCAD Store
Add design power to your MathCAD project

Structural Analysis MCAD Sheets

Providing you with the ability to leverage the valuable tools and frequently used functions within MathCAD 15.

Start enjoying the benefit today, to save design time and refine your design development process!

Example Problem

Each sheet will come with step by step, easy to follow directions and a 'how to' video.

NEW RELEASES

- Wind Load on Pole Design (3 seats) **\$75.00**
- ACI Anchor Bolt Design (3 Seats) **\$50.00**
- Fixed Base Plate w/Multiple Rows of Anchor Bolts (3 Seats) **\$50.00**

Featured Products

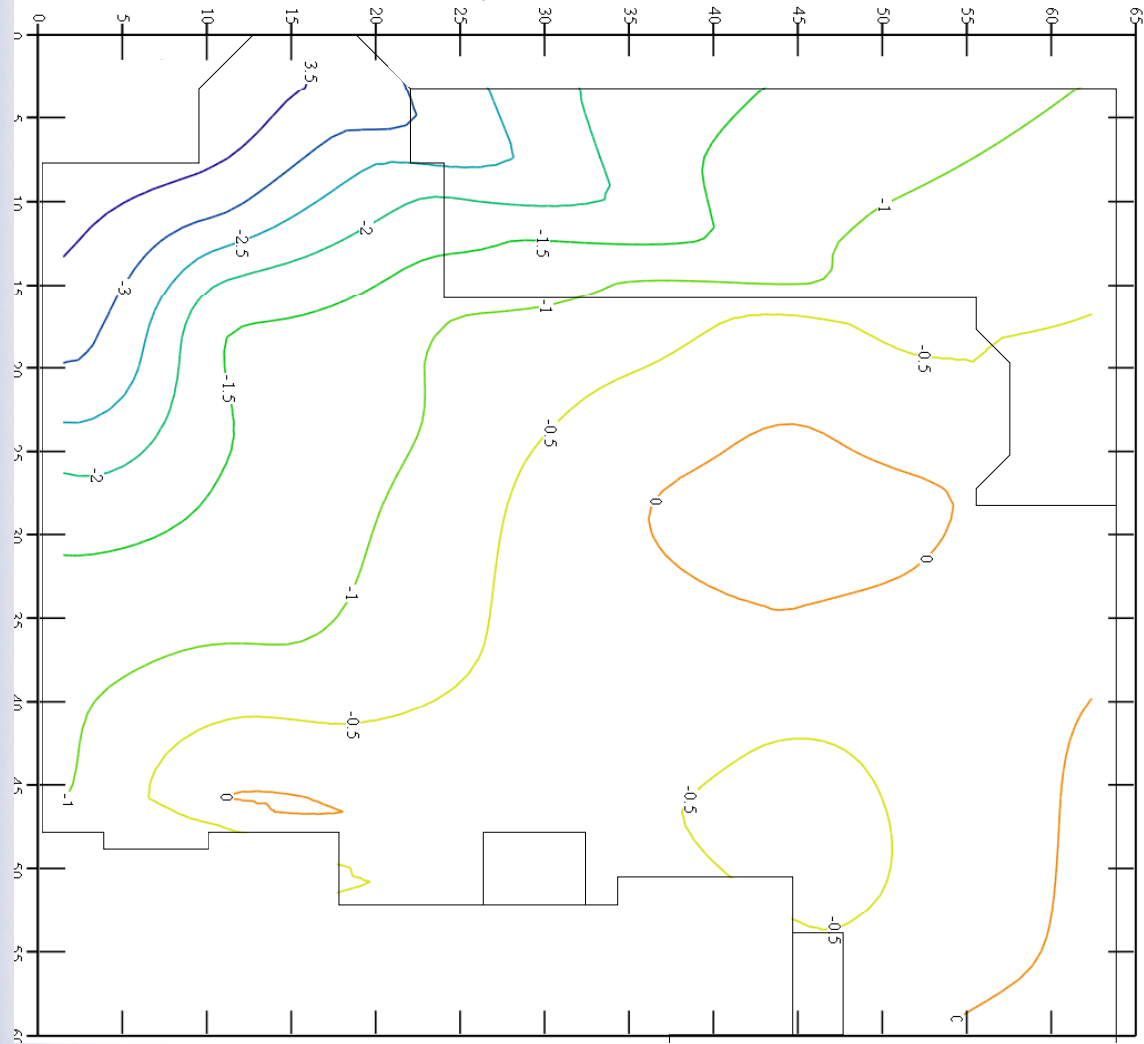
- Matrix Method - BETA (3 Seats)
0 Review(s)
Your Price: \$125.00
- Fixed Base Plate w/Multiple Rows of Anchor Bolts (3 Seats)
0 Review(s)
Your Price: \$50.00
- ACI Anchor Bolt Design (3 Seats)
0 Review(s)
Your Price: \$50.00
- Wind Load on Pole Design (3 seats)
0 Review(s)
Your Price: \$75.00

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John M. Clark
Clark Engineers, Inc.
May 8, 2013

Contour Plots for Slab Elevation Data using MathCAD



Why use MathCAD when there are other contour plotting programs available?

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- **Plots in inches, mm, feet etc.**

Why use MathCAD when there are other contour plotting programs available?

- The power of MathCAD
- Plots in Inches, mm, feet etc.
- **Can be done by competent ACAD operator**

What is MathCAD

- **Live mathematical calculator**

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- **Equations are live**
 - **Not hidden in cells like Excel**

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- **Can define your own units**
 - **eg. pcf**

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- **Can mix units**
 - **eg. lbf * mm = kip * ft**

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 - All physical fields
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 - π , e, R, K, F, c, ∞ ,

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- **Complex Numbers**

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- **Write small programs for special conditions or functions**

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What is MathCAD

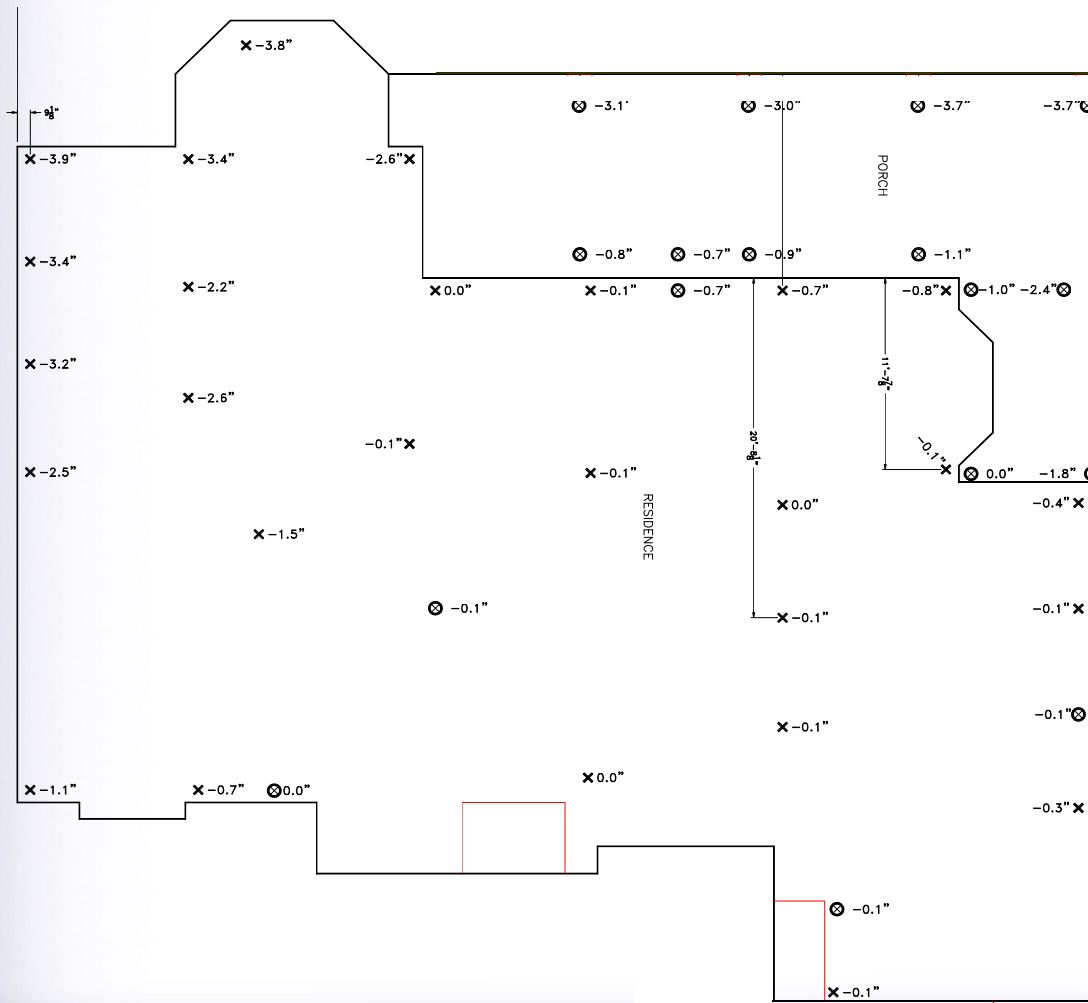
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- Does pretty much all that spreadsheets will do and much more
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- **Built design sheets for our clients**

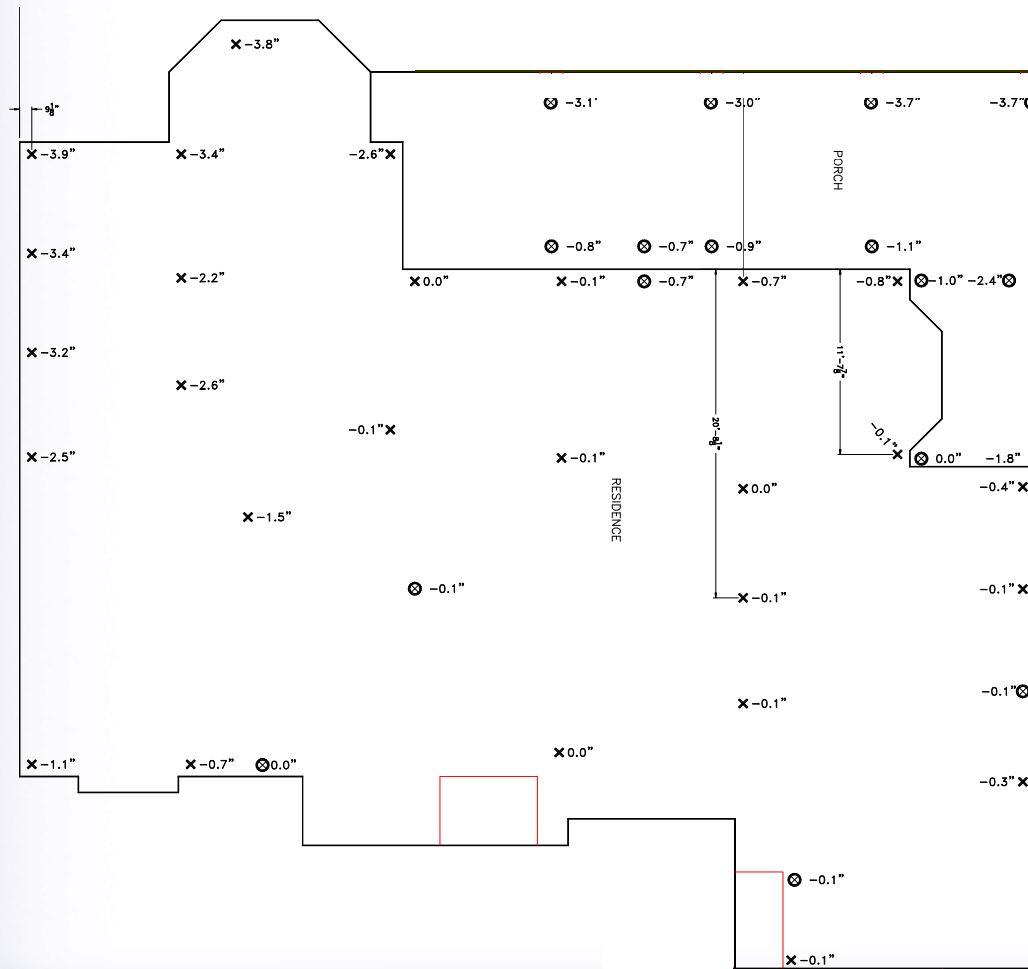
Method

- Plot data in AutoCAD



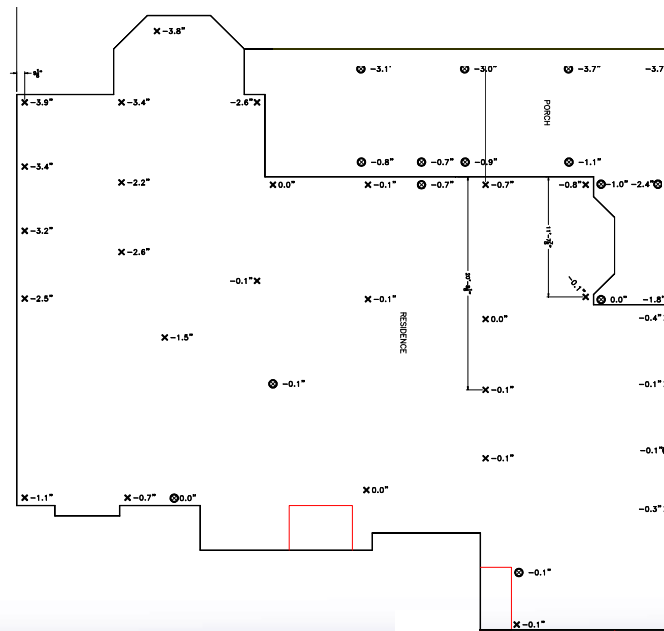
Step 1 continued

- Take accurate elevations of the foundation
 - See [FPA paper SC012](#) for more information on data points



Step 1 continued

- Take accurate elevations of the foundation
 - See FPA paper SC012 for more information on data points
- **Locate points on accurate field drawing to $\pm 6''$ to $12''$ each way**
 - **If there is an architectural floor plan available, use this to record points**



Step 2

- **Make an accurate floor plan in AutoCAD**

Step 2

- Make an accurate floor plan in AutoCAD
- **Set units to decimal**

Step 2

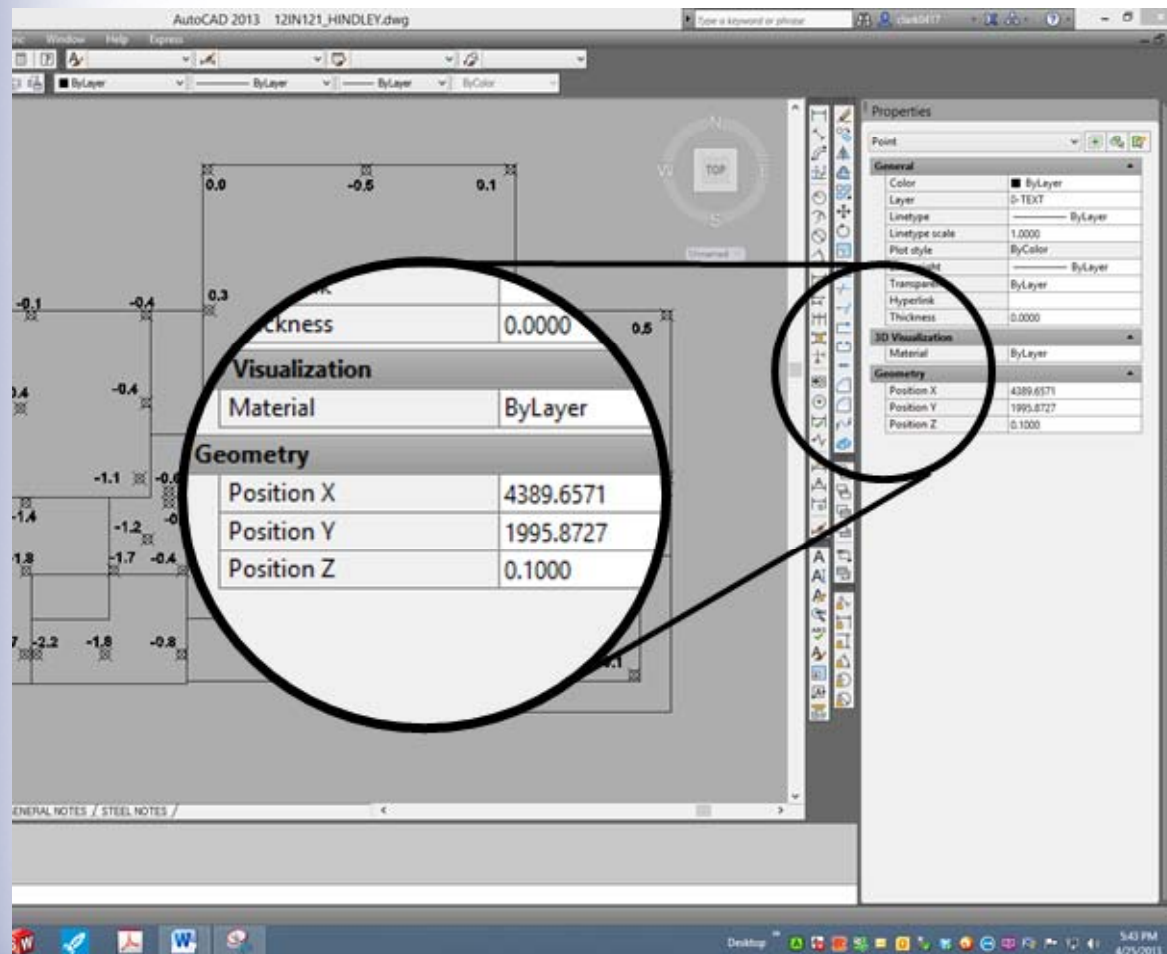
- Make an accurate floor plan in AutoCAD
- Set units to decimal
- **Set bottom left and corner to 0,0**

Step 2

- Make an accurate floor plan in AutoCAD
- Set units to decimal
- Set bottom left and corner to 0,0
- **Add data points to AutoCAD drawing**
 - **Must use AutoCAD point command**
 - **Add Elevation labels as text**

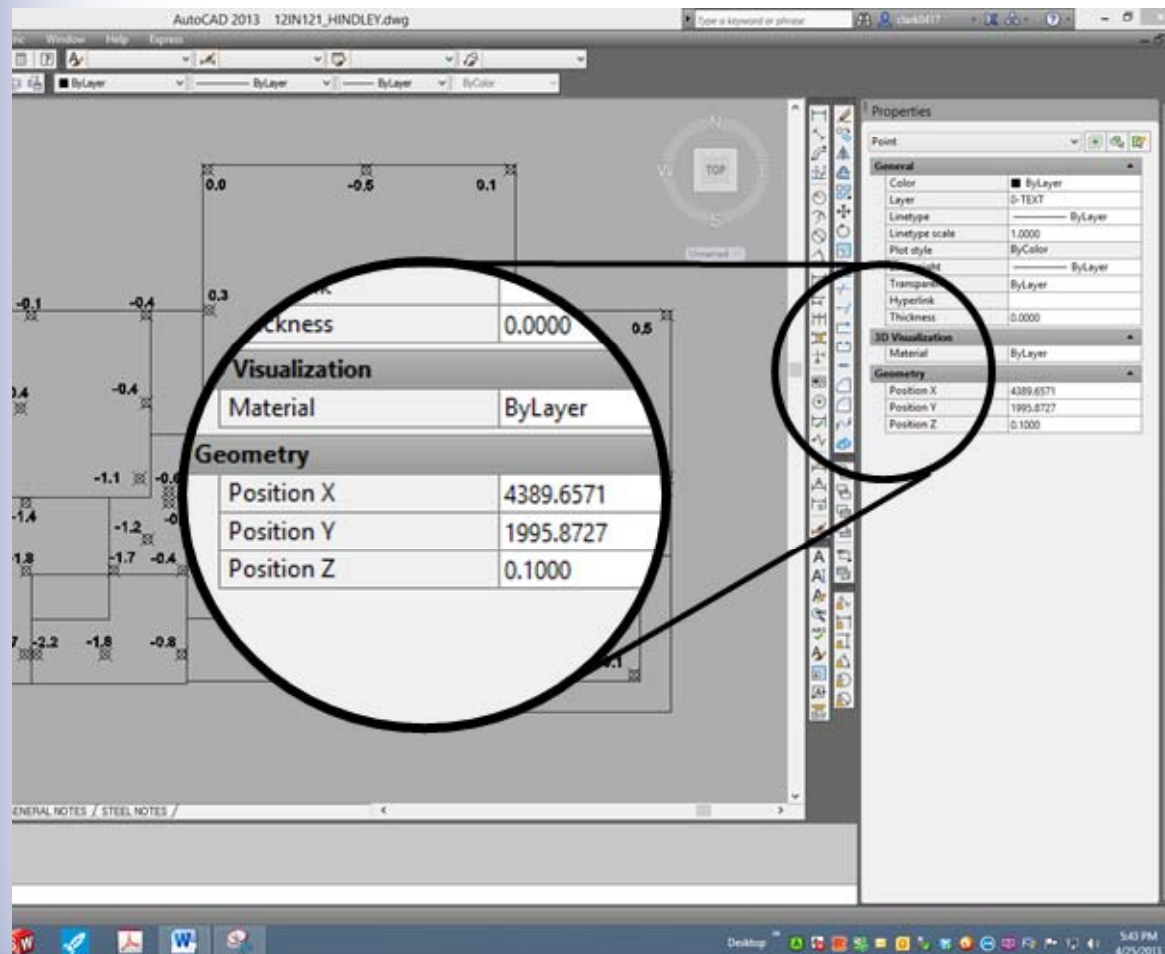
Step 3

- For each elevation point,



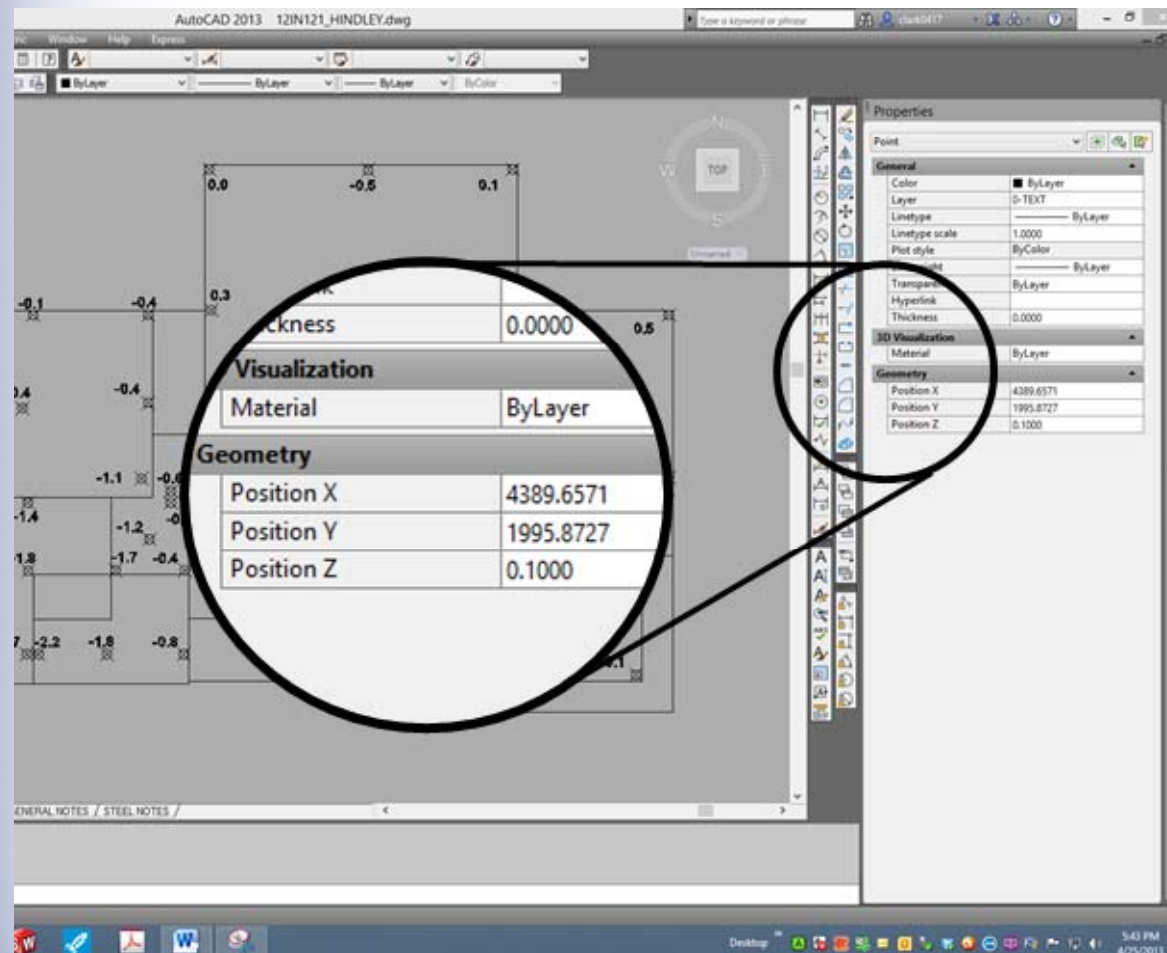
Step 3 continued

- For each elevation point,
- **Click on a single point**



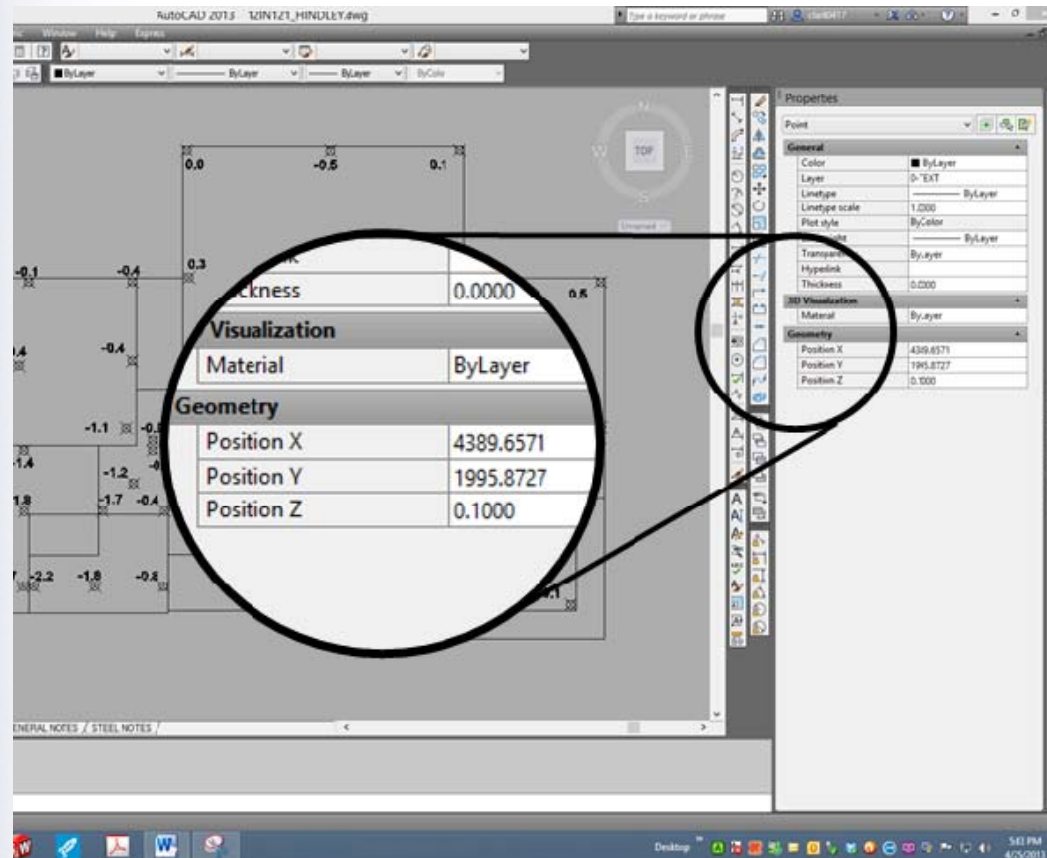
Step 3 continued

- For each elevation point,
- Click on a single point
- **Right click**



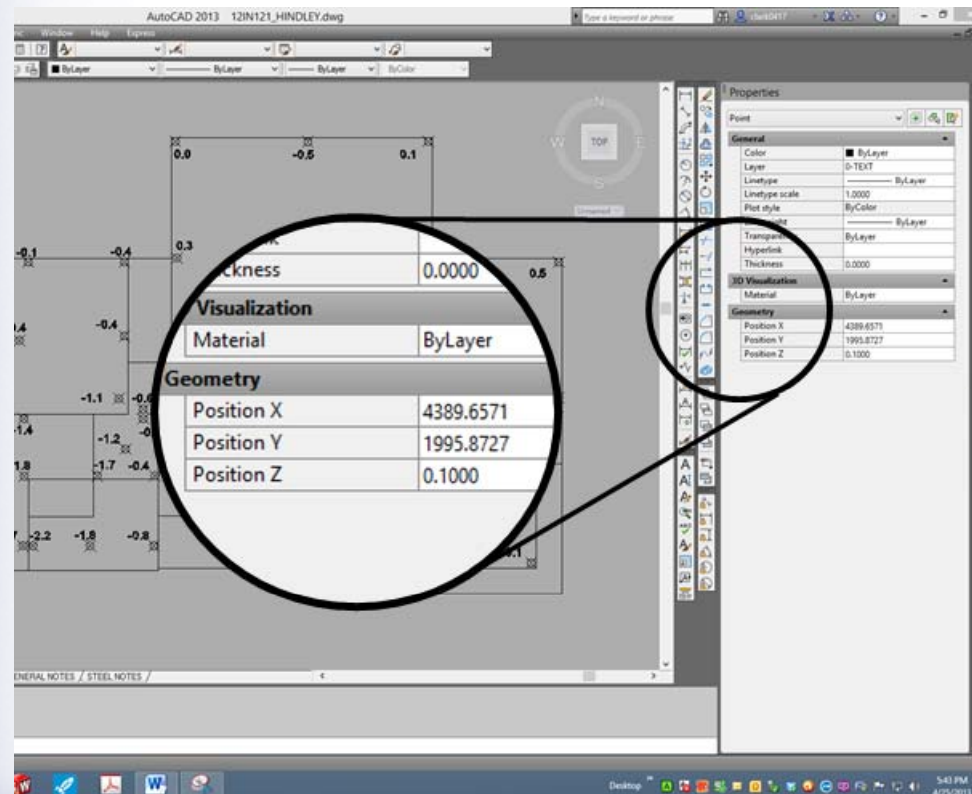
Step 3 continued

- For each elevation point,
- Click on a single point
- Right click
- **Select properties, menu opens**



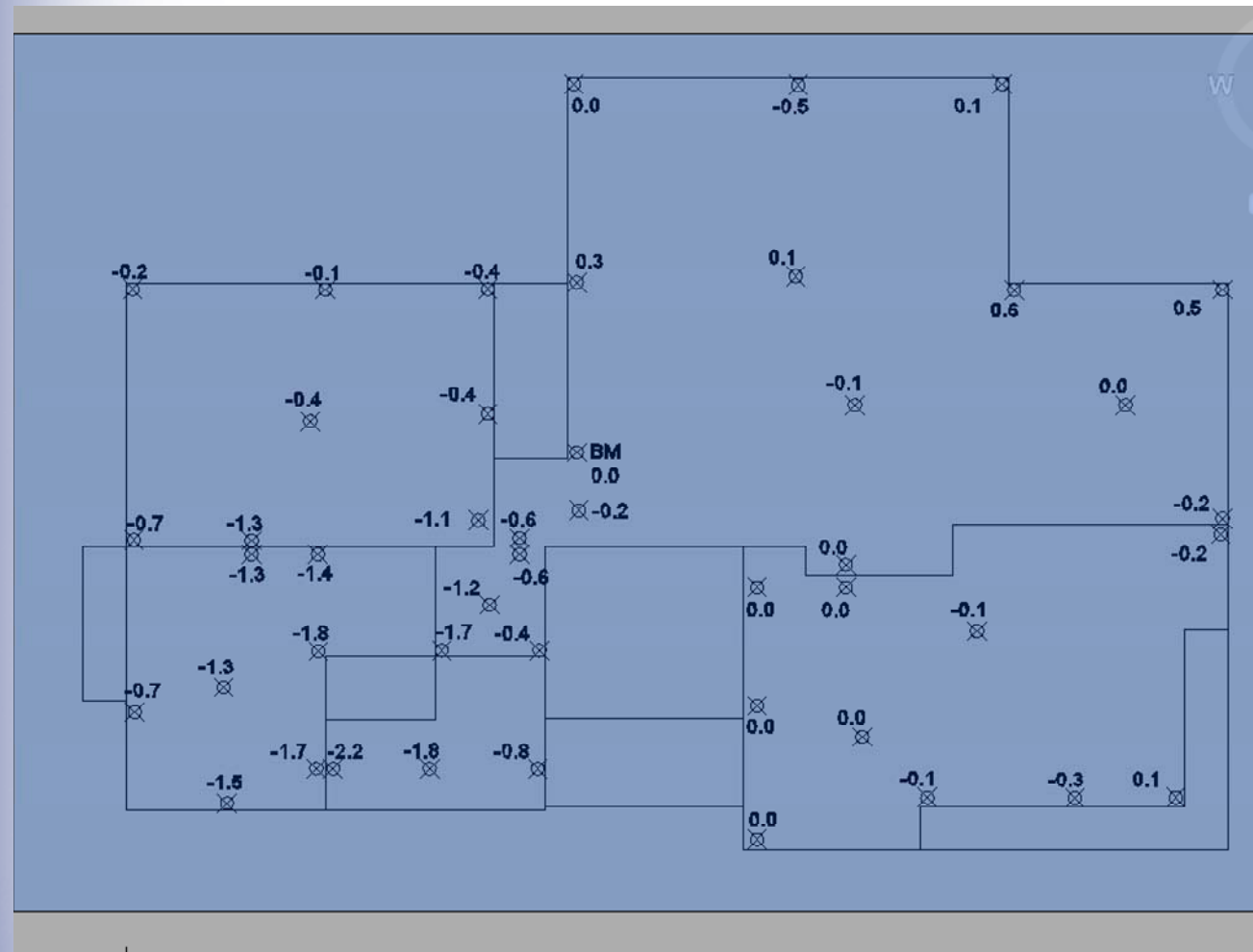
Step 3 continued

- For each elevation point,
- Click on a single point
- Right click
- Select properties, menu opens
- **Edit geometry and record elevation value for "z"**



Step 3 continued

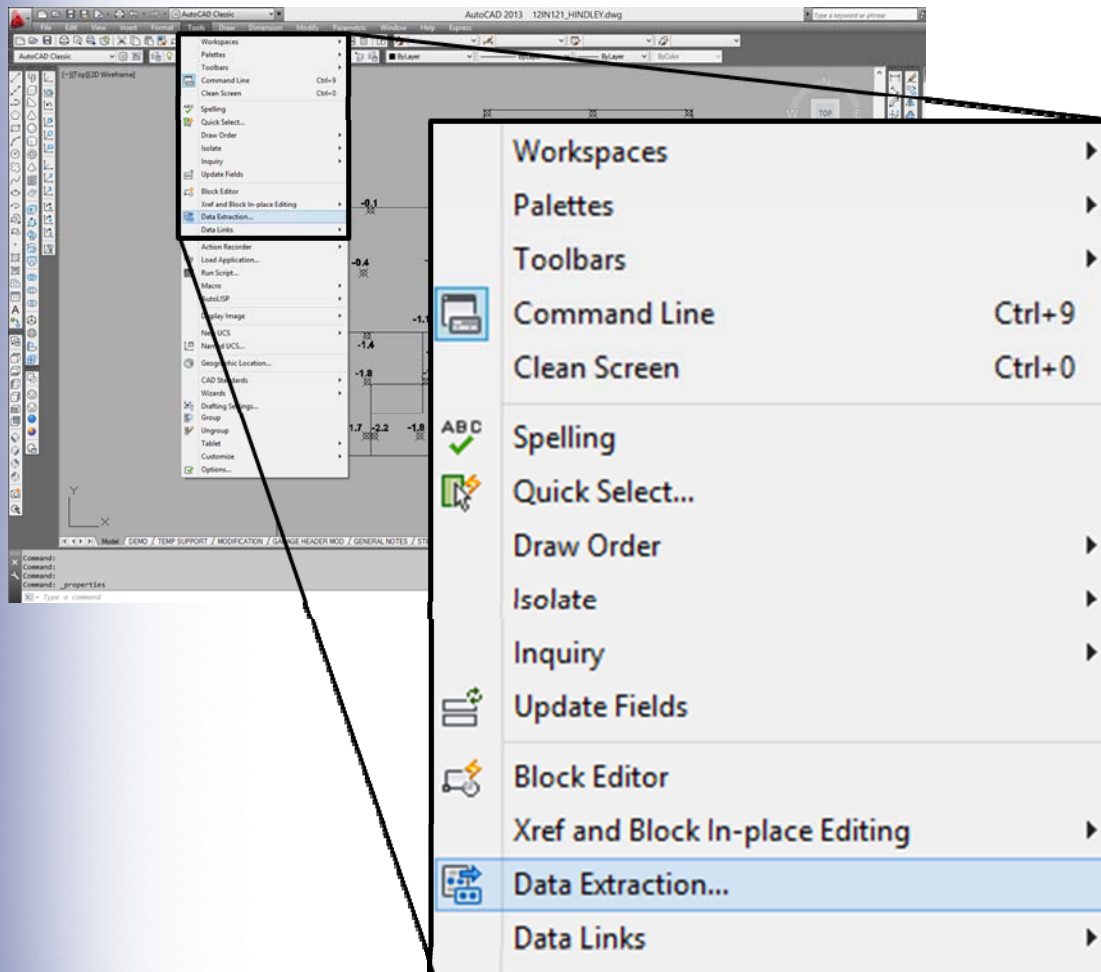
- Completed plot with elevation points and text for values.



Step 4

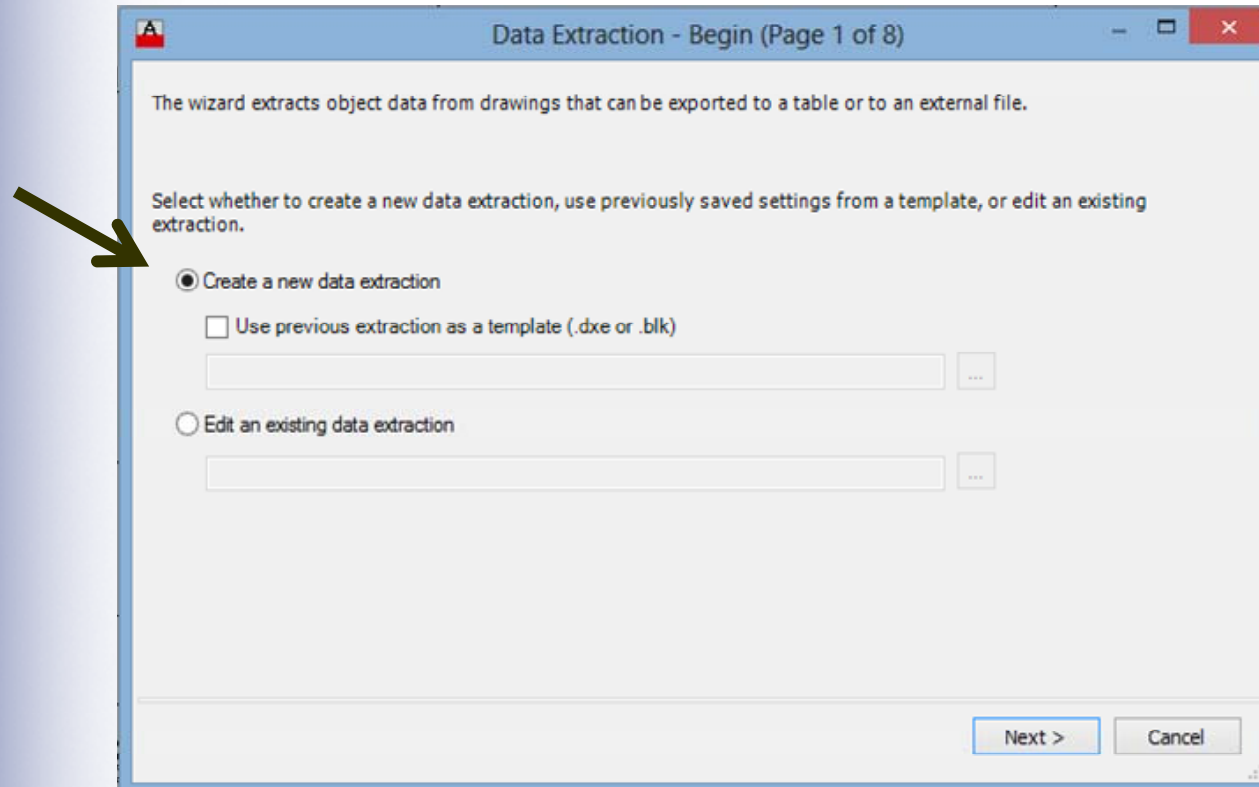
- **Data Extraction**

— **GO TO: Tools > Data Extraction >**



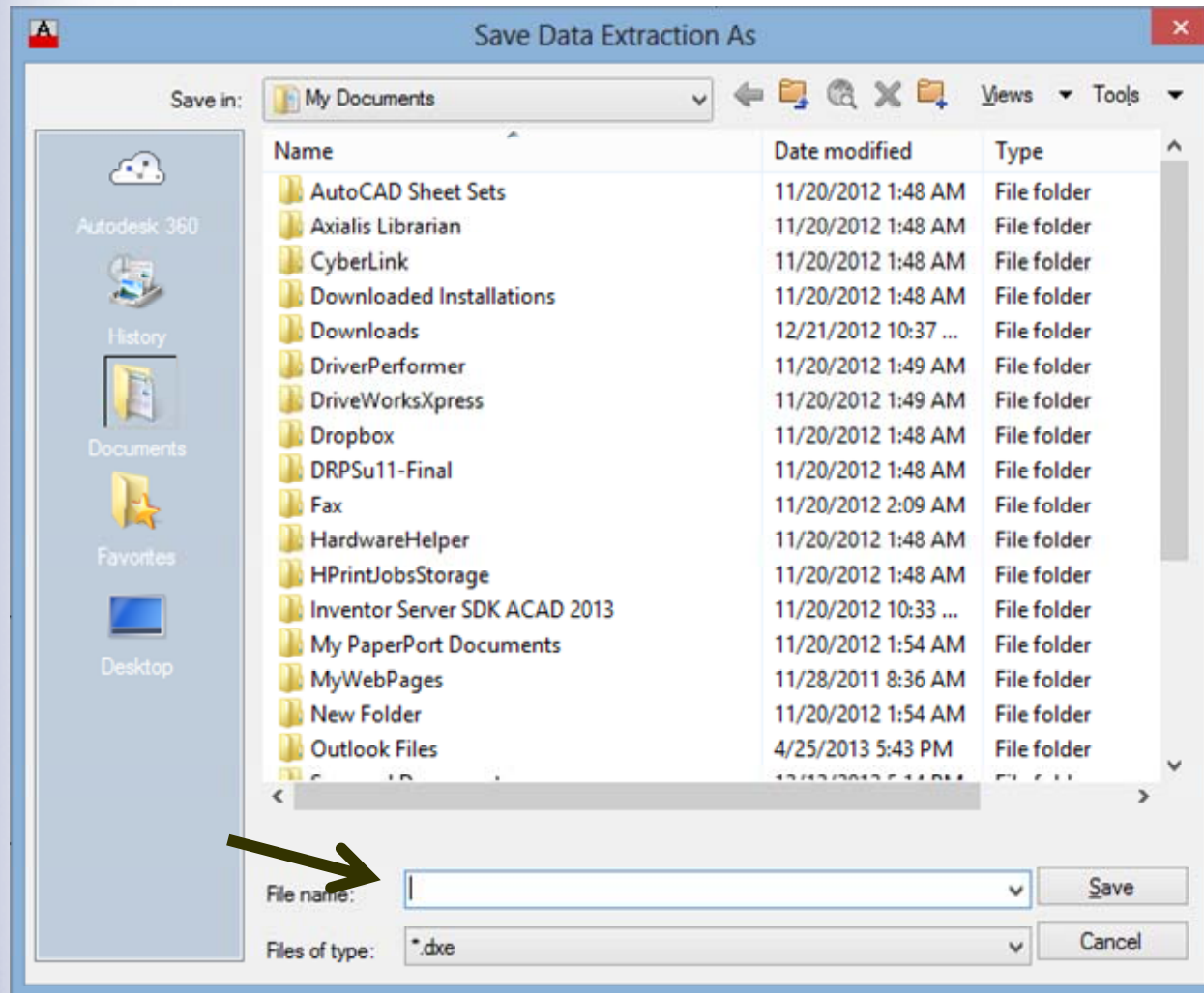
Step 5

- **Select Create a new data extraction**



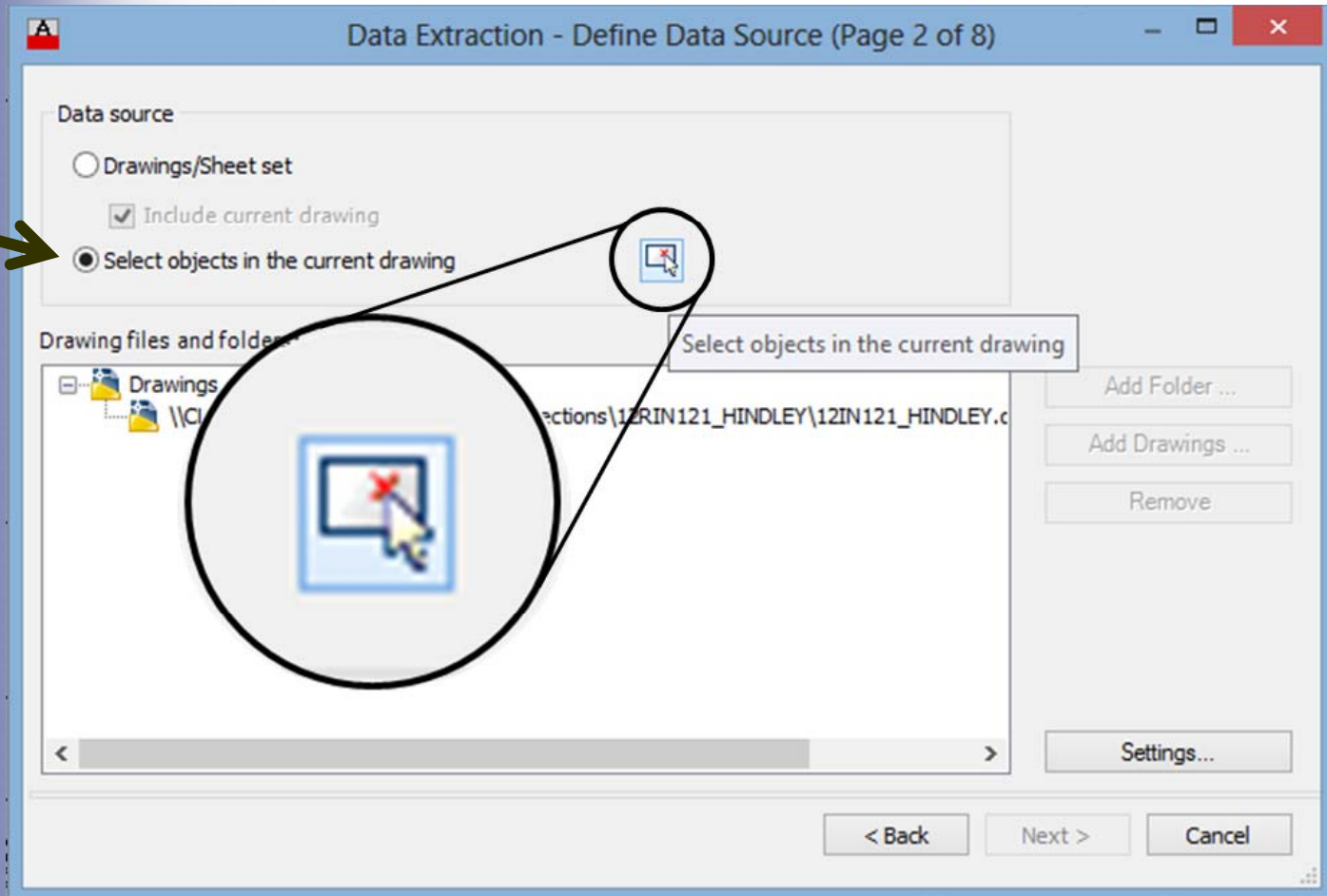
Step 6

- Create a file name for the data extraction: **Projectname_ELDATA**



Step 7

- **Select: Select object in drawing**



Step 8

- “Select entire drawing” to select points for contour plots

The screenshot displays the AutoCAD 2013 interface with a drawing titled "12IN121_HINDLEY.dwg". The drawing is in a 2D wireframe view, showing a complex contour plot. The plot consists of a blue-shaded area with numerous elevation points marked with 'x' and numerical values. The values range from -1.8 to 0.6. A benchmark point labeled "BM 0.0" is also visible. The software interface includes a menu bar (File, Edit, View, Insert, Format, Tools, Draw, Dimension, Modify, Parametric, Window, Help, Express), a toolbar, a command line, and a Properties palette on the right. The Properties palette shows the current selection is "No selection" and displays various properties for the selected object, including General, 3D Visualization, Plot style, View, and Misc. The command line shows the command "_dataextraction" being executed, with the prompt "DATAEXTRACTION Select objects: Specify opposite corner:". The status bar at the bottom indicates the current layer is "0-TEXT" and the drawing is in "Model" space.

Property	Value
Color	ByLayer
Layer	0-TEXT
Linetype	ByLayer
Linetype scale	1.0000
Lineweight	ByLayer
Transparency	ByLayer
Thickness	0.0000
Material	ByLayer
Shadow display	Cast and Receives Shado...
Plot style	ByColor
Plot style table	None
Plot table attached to	Model
Plot table type	Not available
Center X	4244.6911
Center Y	1883.4398
Center Z	0.0000
Height	543.0412
Width	699.7033
Annotation scale	1:1
UCS icon On	Yes
UCS icon at origin	Yes
UCS per viewport	Yes
UCS Name	
Visual Style	2D Wireframe

Step 9 Select objects cont.

- Check point box and select next

Data Extraction - Select Objects (Page 3 of 8)

Select the objects to extract data from:

Objects

Object	Display Name	Type
<input type="checkbox"/> Line	Line	Non-block
<input type="checkbox"/> MText	MText	Non-block
<input checked="" type="checkbox"/> Point	Point	Non-block
<input type="checkbox"/> Polyline	Polyline	Non-block

Preview

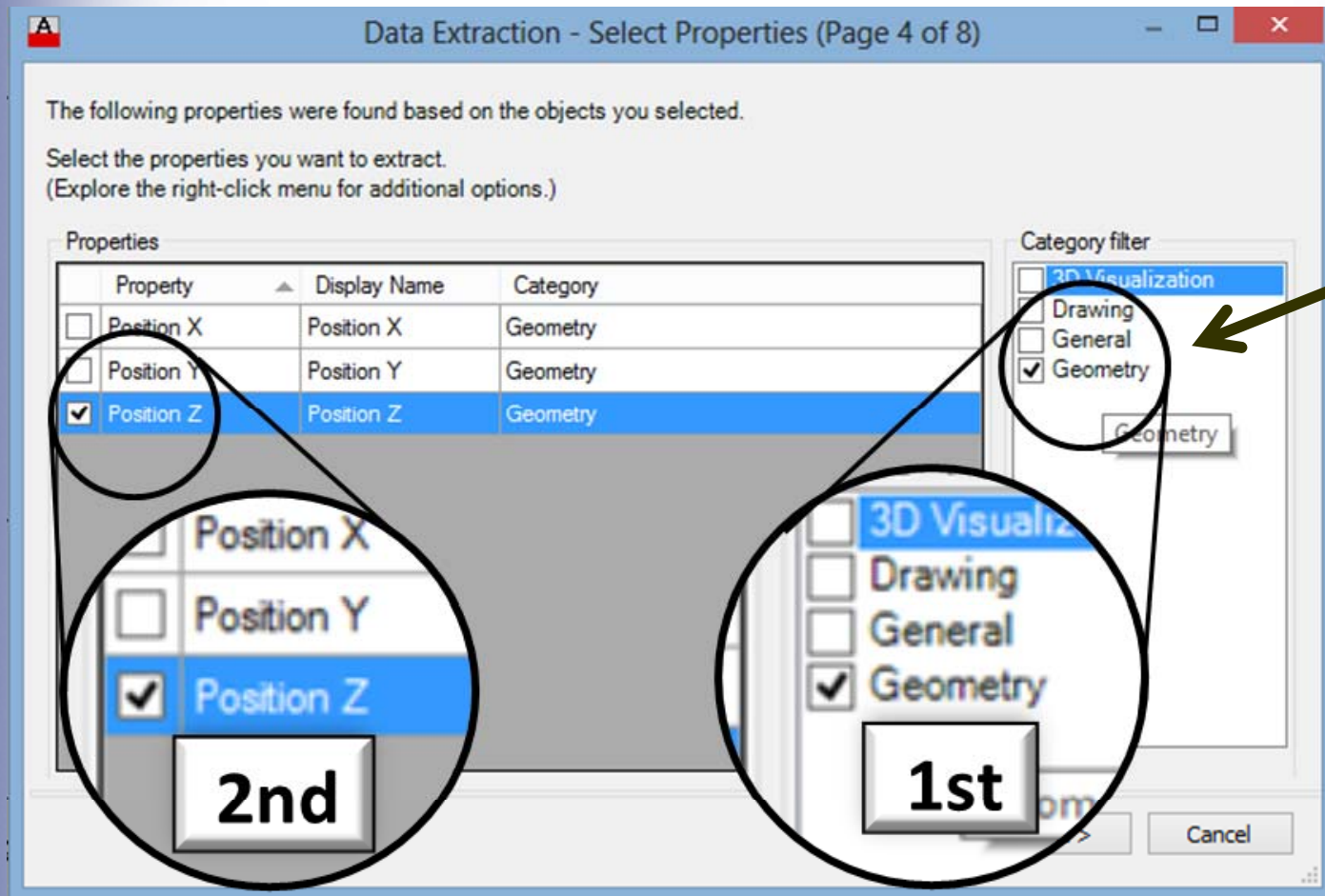
Display options

Display all object types Display blocks with attributes only
 Display blocks only Display objects currently in-use only
 Display non-blocks only

< Back Next > Cancel

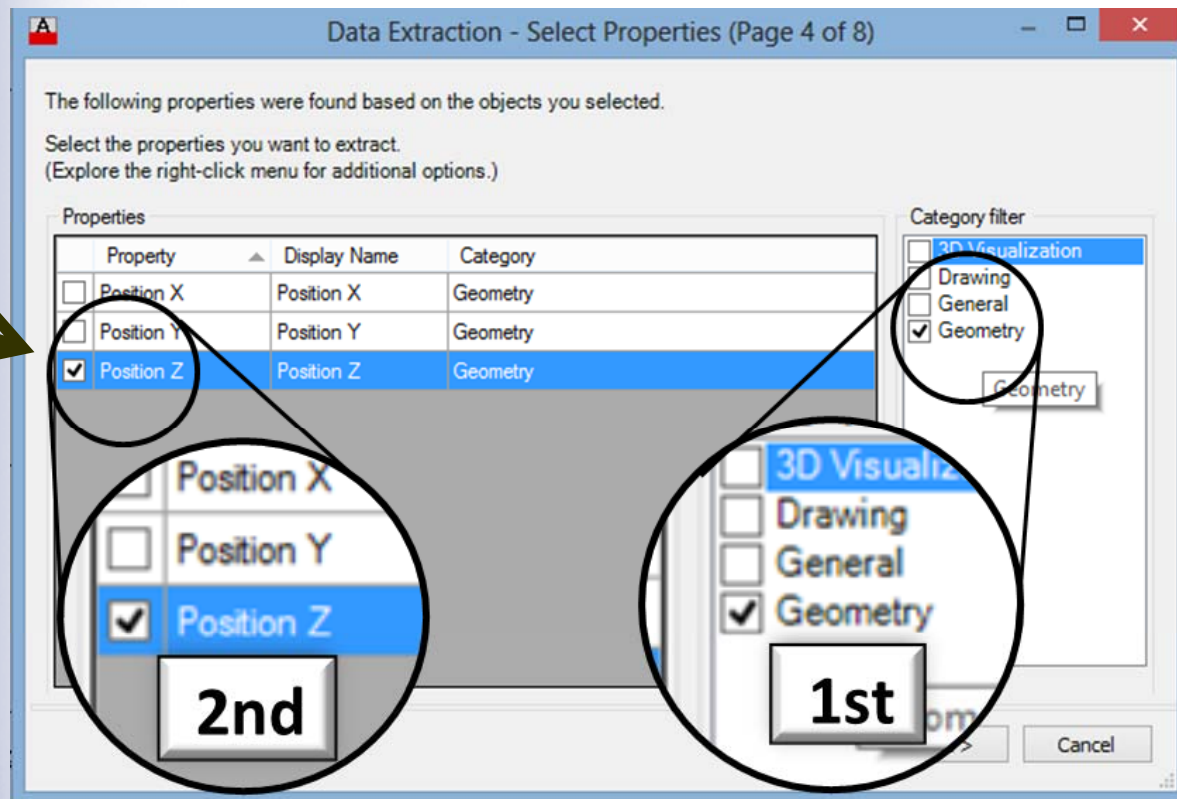
Step 10

- Under Category Filter, uncheck everything except geometry



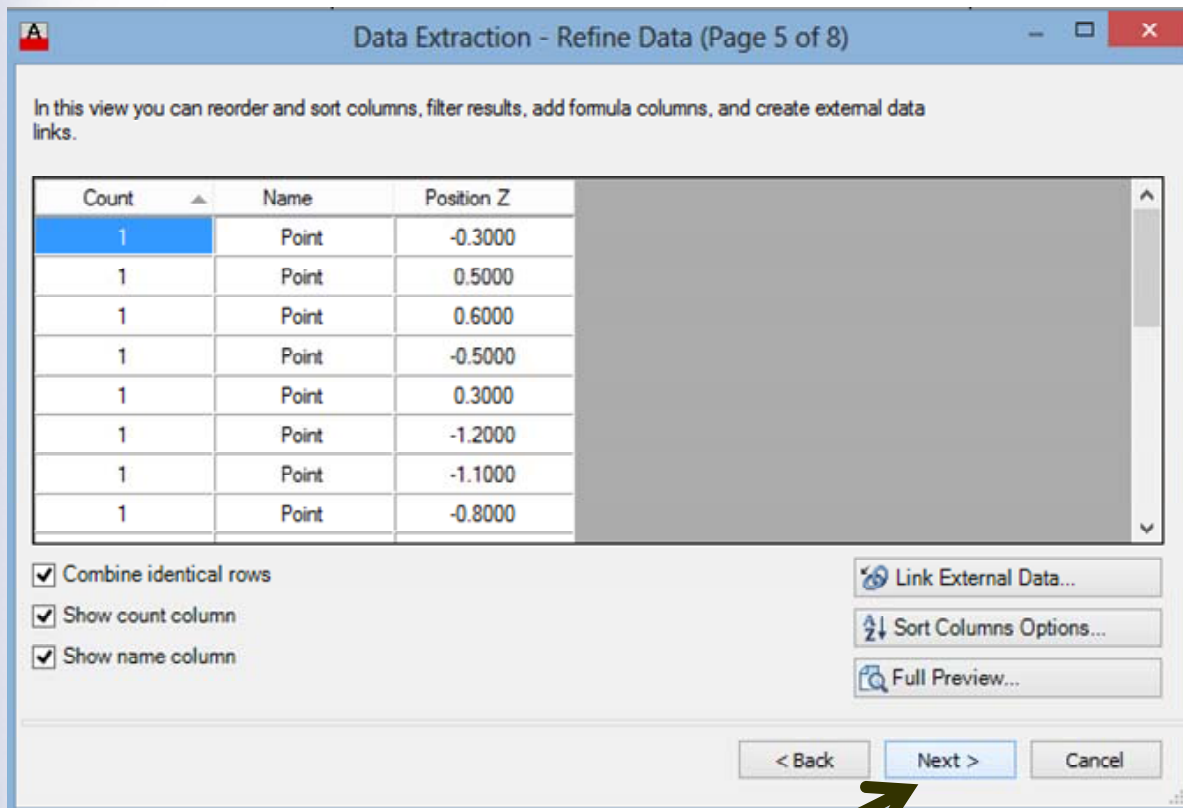
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- Under Category Filter, uncheck everything except geometry
- **Under Properties Filter uncheck X and Y position, leaving only Z position checked**



Step 10

- Under Category Filter, uncheck everything except geometry
- Under Properties Filter uncheck X and Y position, leaving only Z position checked
- **Click next**



Step 11

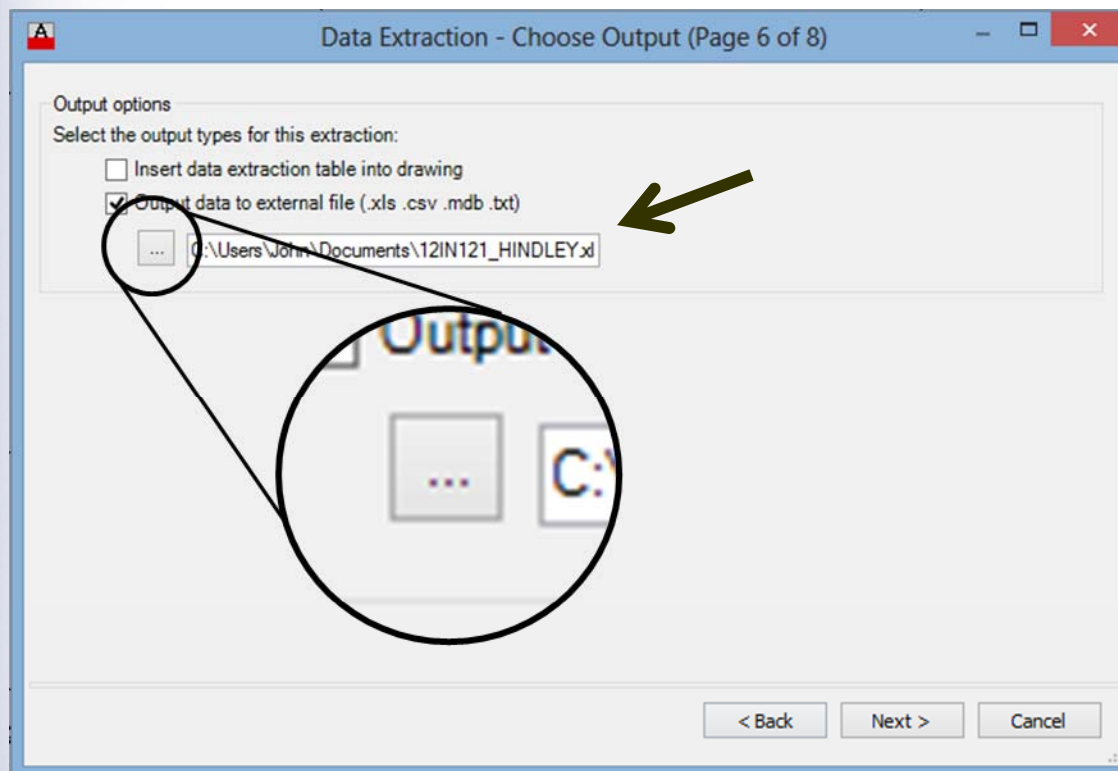
- **On final screen, select:**
 - **Output to external file**

Step 11

- On final screen, select:
 - Output to external file
- **Save as name and file type desired (.xls)**

Step 11

- On final screen, select:
 - Output to external file
- Save as name and file type desired (.xls)
- **Click here to browse**



Step 12

- Data in Excel

Excel Sheet		
436.11	529.89	-0.1
353.7	529.89	0.3
206.11	529.89	-0.4
330.44	406.11	-0.1
290.89	268.89	-1
436.11	189.29	-1
315.11	130.11	-1.5
206.11	130.11	-1.6
552.69	130.1	0
552.89	381.89	-0.2
584.89	529.89	-0.9
709.69	578.1	-0.1
679.5	748.89	0.1
477.25	748.89	0
355.11	748.89	-0.4
330.89	648.89	0
206.11	648.89	-0.6
206.11	406.11	-0.8
206.11	293.11	-1
110.11	268.89	-2.1
18.11	162.08	-3.7
110.11	130.11	-3.3
110.11	18.11	-3.7
248.5	18.11	-2.9
315.11	18.11	-2
436.11	18.11	-1.2
552.69	18.1	-1

Step 13

Paste data into MathCad

- Create a variable for the first data column (usually x values)

X := 

Step 13

Paste data into MathCad

In the red solid box

Right click on
the red box and
select paste

$x :=$  

$x :=$

436.11
353.7
206.11
330.44
290.89
436.11
315.11
206.11
552.69
552.89
584.89
709.69
679.5
477.25
355.11
330.89
206.11
206.11
206.11
110.11
18.11
110.11
110.11
248.5
315.11
436.11
552.69

Step 13

Paste data into MathCad

- Add correct units for the vector
 - In this case inches

Input
vector



x :=
436.11
353.7
206.11
330.44
290.89
436.11
315.11
206.11
552.69
552.89
584.89
709.69
679.5
477.25
355.11
330.89
206.11
206.11
206.11
110.11
18.11
110.11
110.11
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206.11
330.44
290.89
436.11
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552.69
552.89
584.89
709.69
679.5
477.25
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330.89
206.11
206.11
206.11
110.11
18.11
110.11
110.11
248.5
315.11
436.11
552.69

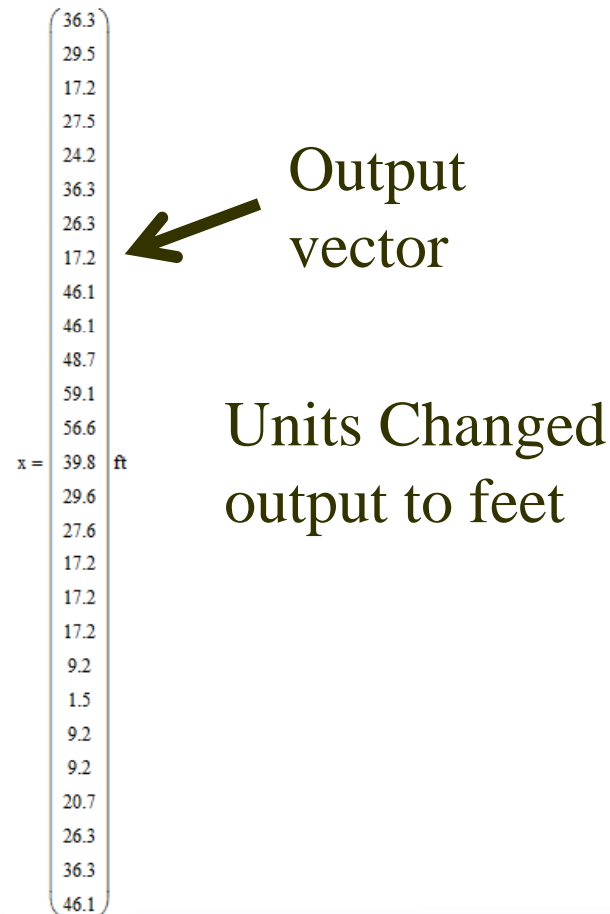


Vector
with units

Step 13

Paste data into MathCad

- Add correct units for the vectors
 - In this case inches
- **Use any desired units**



Step 13

Paste data into MathCad

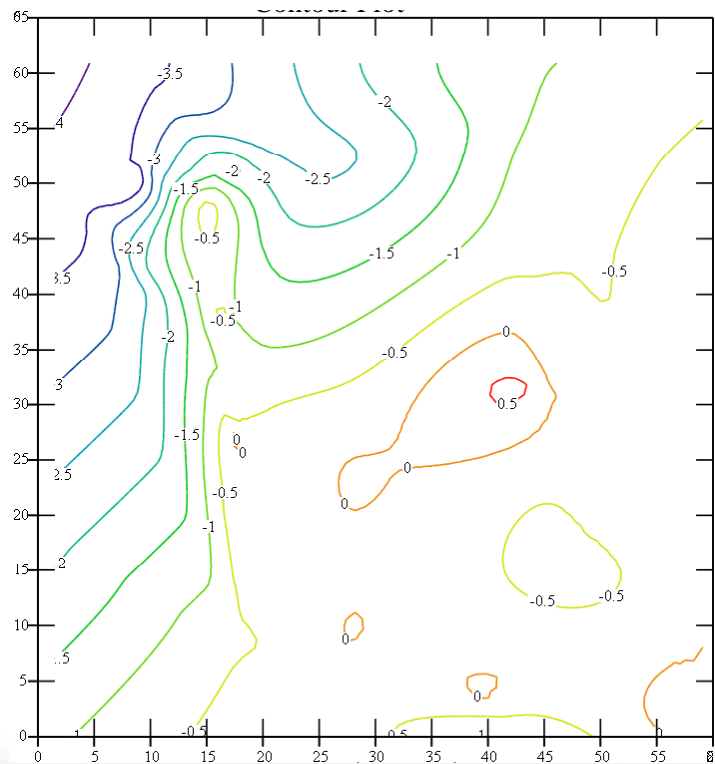
- Repeat steps for Y and Z vector

	36.34		44.16		-0.1
	29.47		44.16		0.3
	17.18		44.16		-0.4
	27.54		33.84		-0.1
	24.24		22.41		-1
	36.34		15.77		-1
	26.26		10.84		-1.5
	17.18		10.84		-1.6
	46.06		10.84		0
	46.07		31.82		-0.2
	48.74		44.16		-0.9
	59.14		48.17		-0.1
	56.62		62.41		0.1
x =	39.77 ft	y =	62.41 ft	z =	0 in
	29.59		62.41		-0.4
	27.57		54.07		0
	17.18		54.07		-0.6
	17.18		33.84		-0.8
	17.18		24.43		-1
	9.18		22.41		-2.1
	1.51		13.51		-3.7
	9.18		10.84		-3.3
	9.18		1.51		-3.7
	20.71		1.51		-2.9
	26.26		1.51		-2
	36.34		1.51		-1.2
	46.06		1.51		-1

Step 14

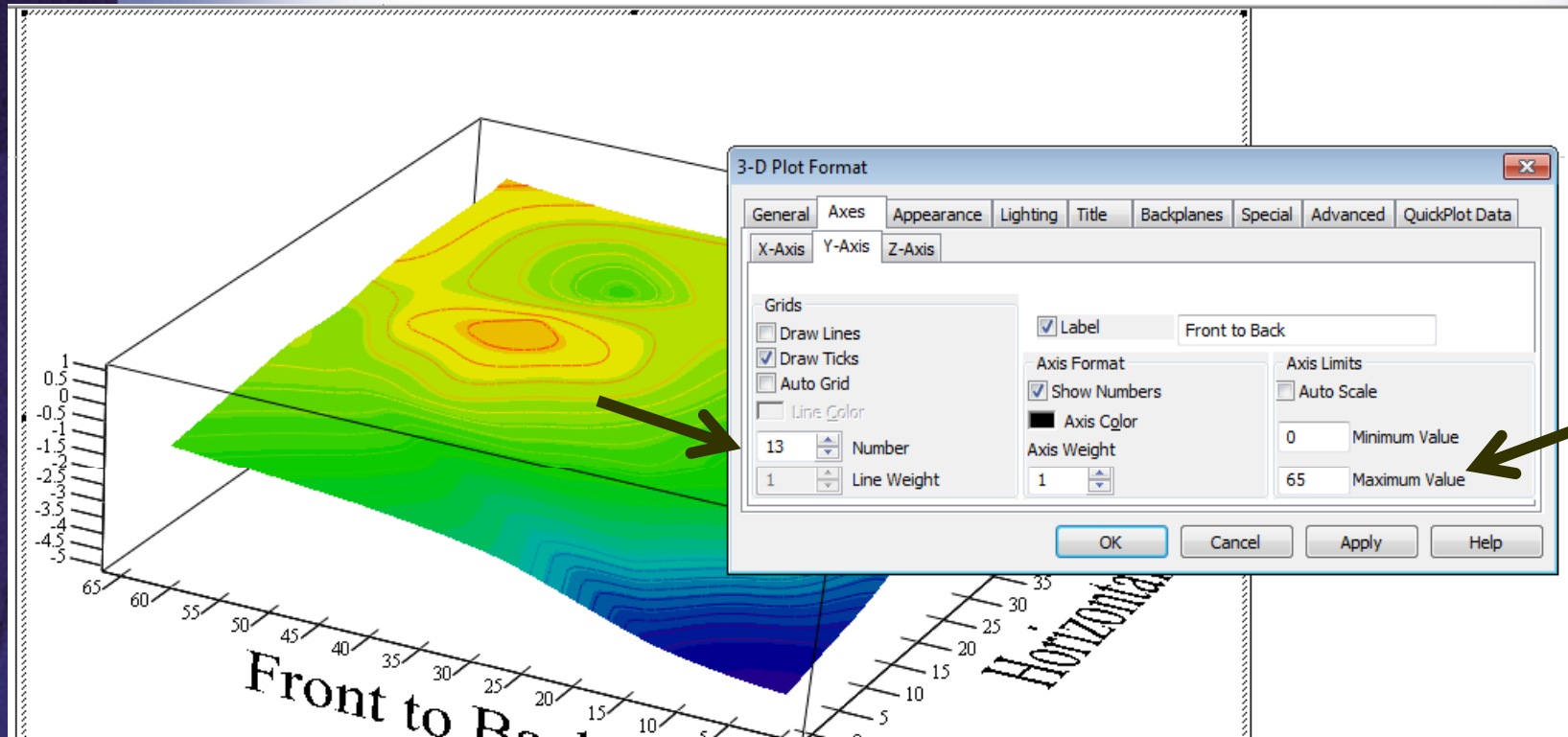
- Data will automatically generate a contour plot, surface plot and polynomial of any selected order (n) data fit plot.
 - Typical order for “n” to use is 1, 2, or 3

Contour Plot



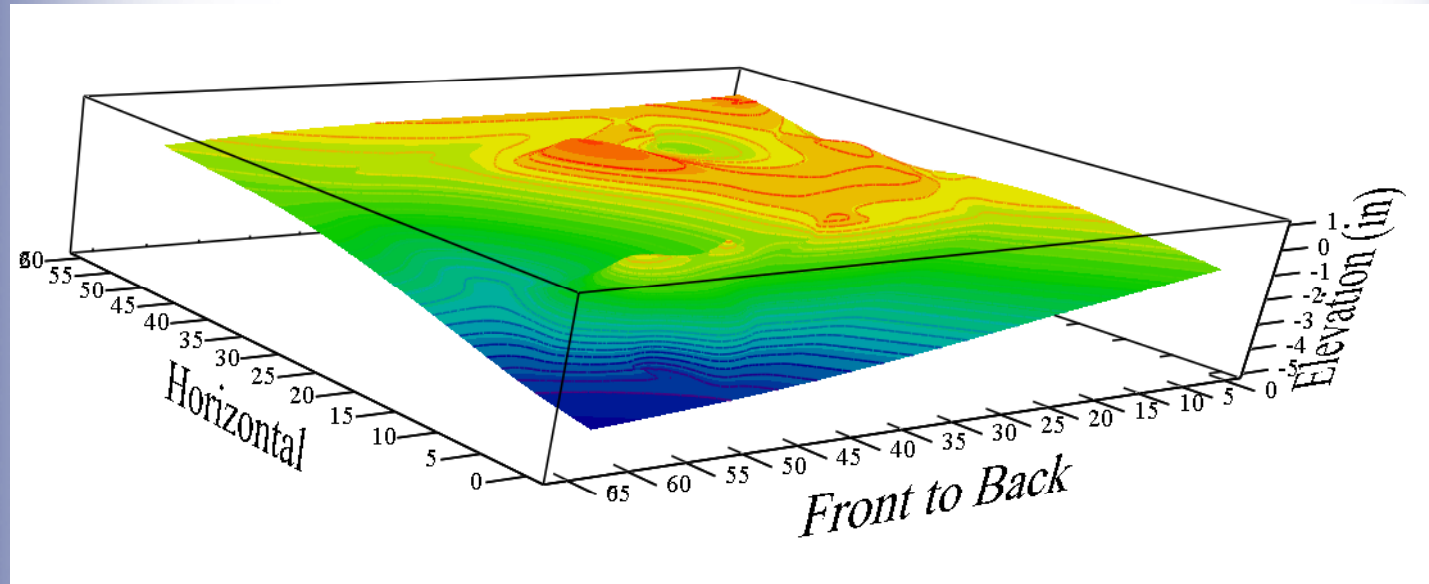
Step 14 continued

- You will probably have to adjust X and Y scale



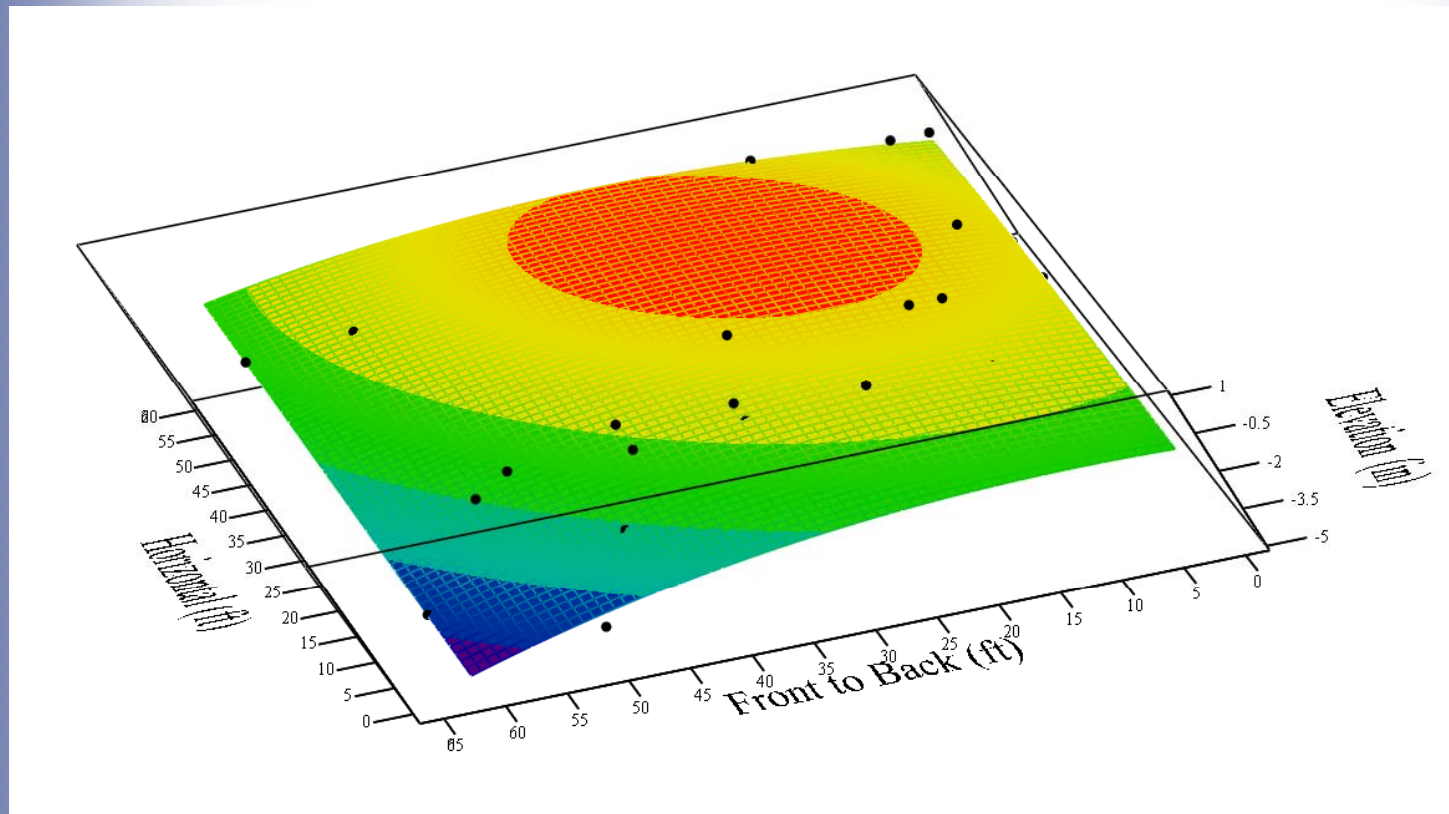
Raw Data Plot

Surface plot



These views can be rotated

Polynomial Plot

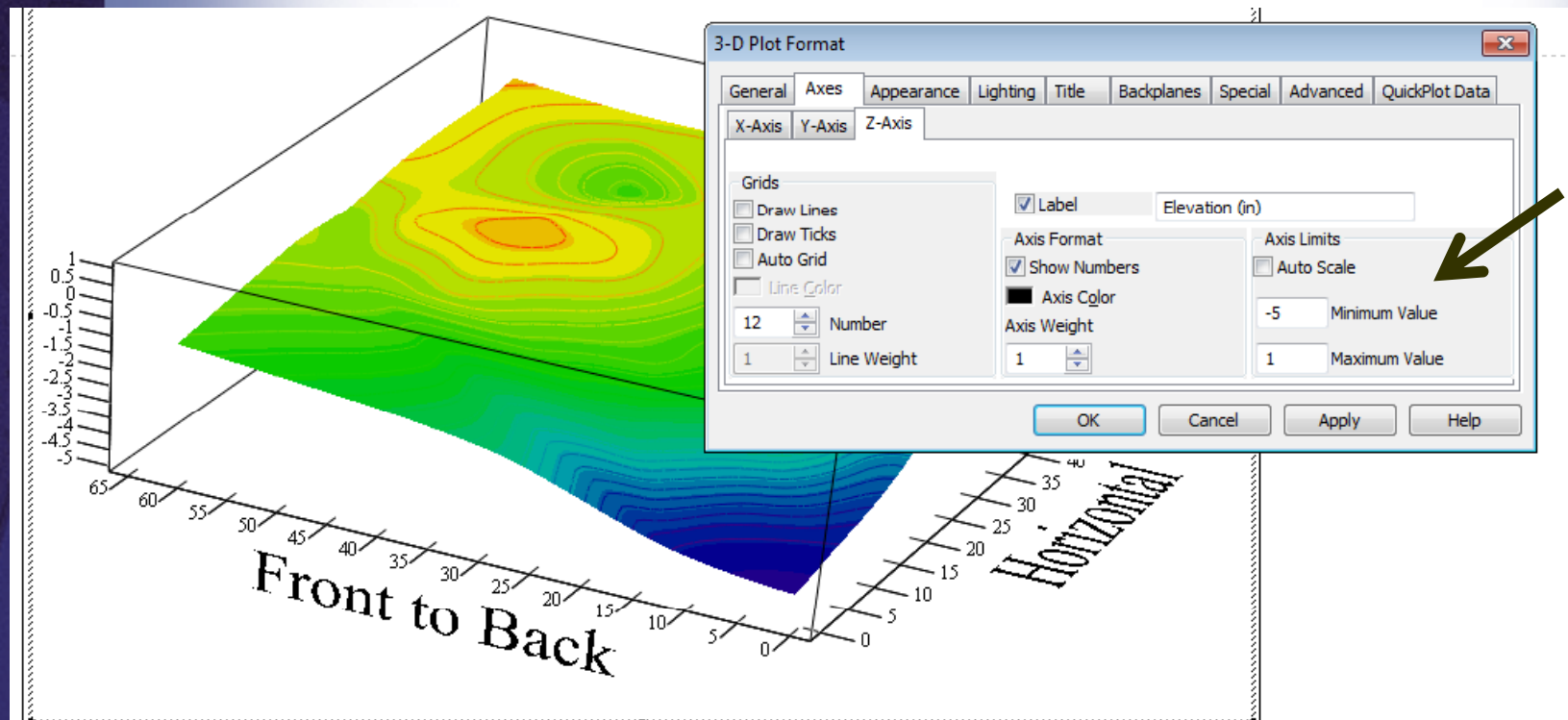


These views can be rotated

Step 15

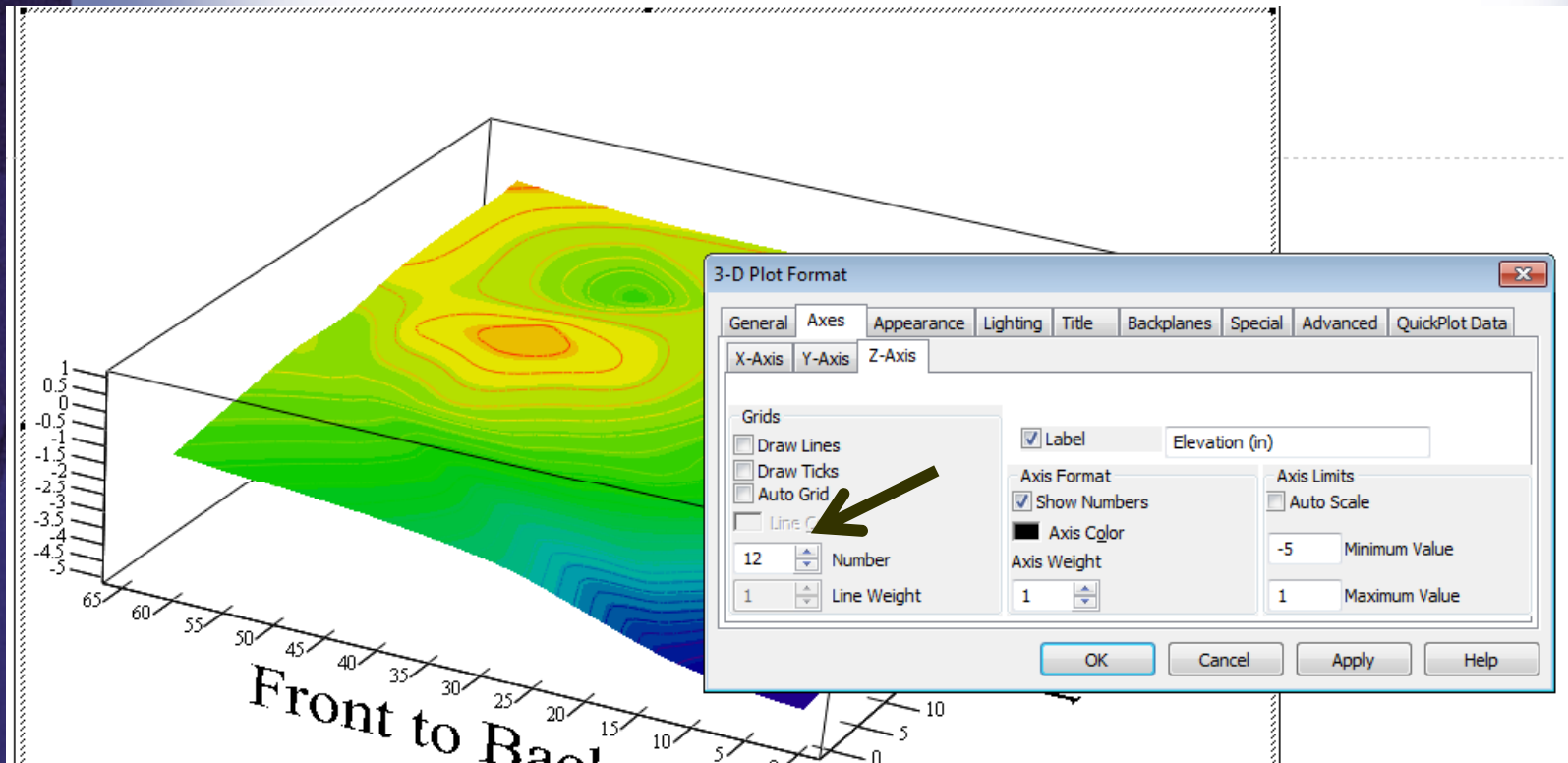
- Adjust scales as required for each plot. For surface plots the Z scale will also have to be adjusted

eg: If min elev = $-4 \frac{3}{4}$ in and max elev = 0.9 in, select say -5 to 1.0 and so on



Step 15 continued

- Select number of spaces for convenient vertical scale
 - In this case 6" or 12"



Step 16

- Iterate on the polynomial order, usually 2nd or 3rd order is ok. Do not use higher than 4th order.

Polynomial Surface Data Fit

$$n := 2$$

$$M := \text{augment}\left(\frac{x}{ft}, \frac{y}{ft}\right)$$

$$R_1 := \text{regress}\left(M, \frac{z}{in}, n\right)$$

$$m_1 := 64$$

$$m_2 := 64$$

$$R_1 = \begin{pmatrix} 3 \\ 3 \\ 2 \\ -0.00099 \\ -0.00062 \\ 0.09792 \\ -5.2337 \\ 0.13151 \\ -0.00099 \end{pmatrix}$$

$$f(x, y) := \text{interp}\left[R_1, M, \frac{z}{in}, \begin{pmatrix} x \\ y \end{pmatrix}\right]$$

$$f(m_1, m_2) = -1.213$$

$$F := \text{CreateMesh}\left(f, \min\left(\frac{x}{ft}\right), \max\left(\frac{x}{ft}\right), \min\left(\frac{y}{ft}\right), \max\left(\frac{y}{ft}\right), m_1, m_2\right)$$

$$n := 3$$

$$M := \text{augment}\left(\frac{x}{ft}, \frac{y}{ft}\right)$$

$$R_1 := \text{regress}\left(M, \frac{z}{in}, n\right)$$

$$m_1 := 64$$

$$m_2 := 64$$

$$R_1 = \begin{pmatrix} 3 \\ 3 \\ 3 \\ 0.00004 \\ 0 \\ -0.00209 \\ 0.15787 \\ -0.00194 \\ -0.00003 \\ -6.22967 \\ 0.23392 \\ -0.00486 \\ 0.00005 \end{pmatrix}$$

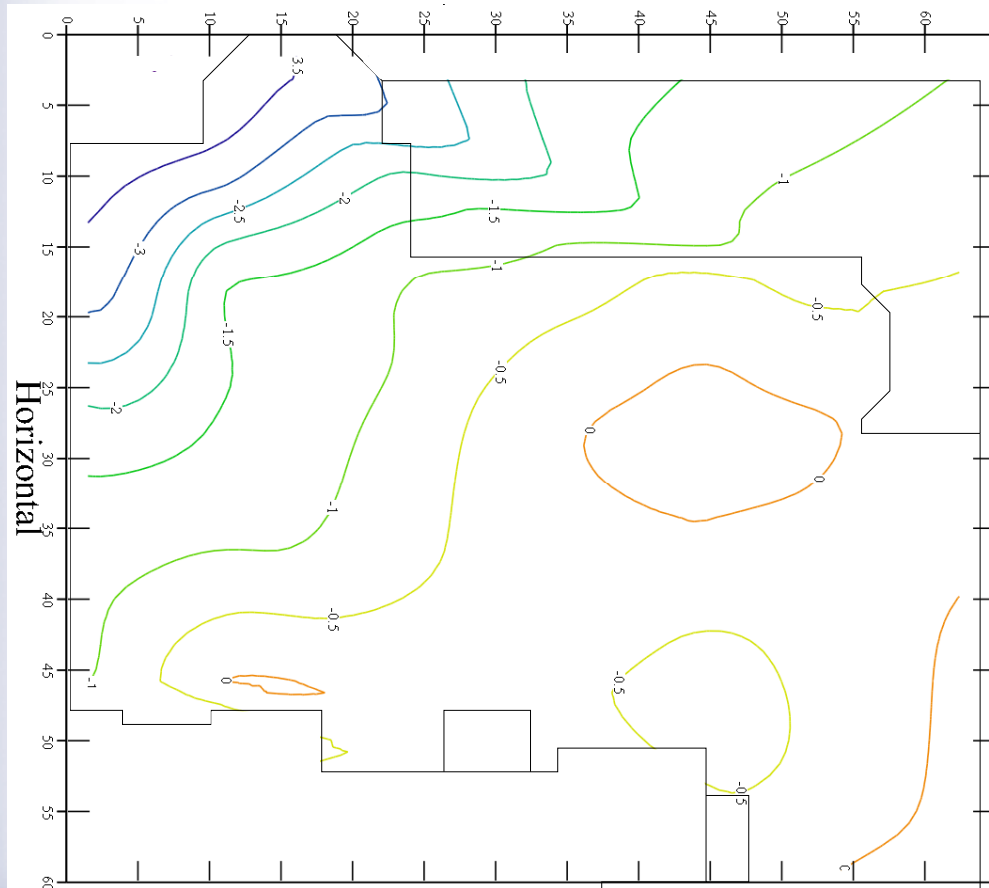
$$f(x, y) := \text{interp}\left[R_1, M, \frac{z}{in}, \begin{pmatrix} x \\ y \end{pmatrix}\right]$$

$$f(m_1, m_2) = -0.078$$

$$F := \text{CreateMesh}\left(f, \min\left(\frac{x}{ft}\right), \max\left(\frac{x}{ft}\right), \min\left(\frac{y}{ft}\right), \max\left(\frac{y}{ft}\right), m_1, m_2\right)$$

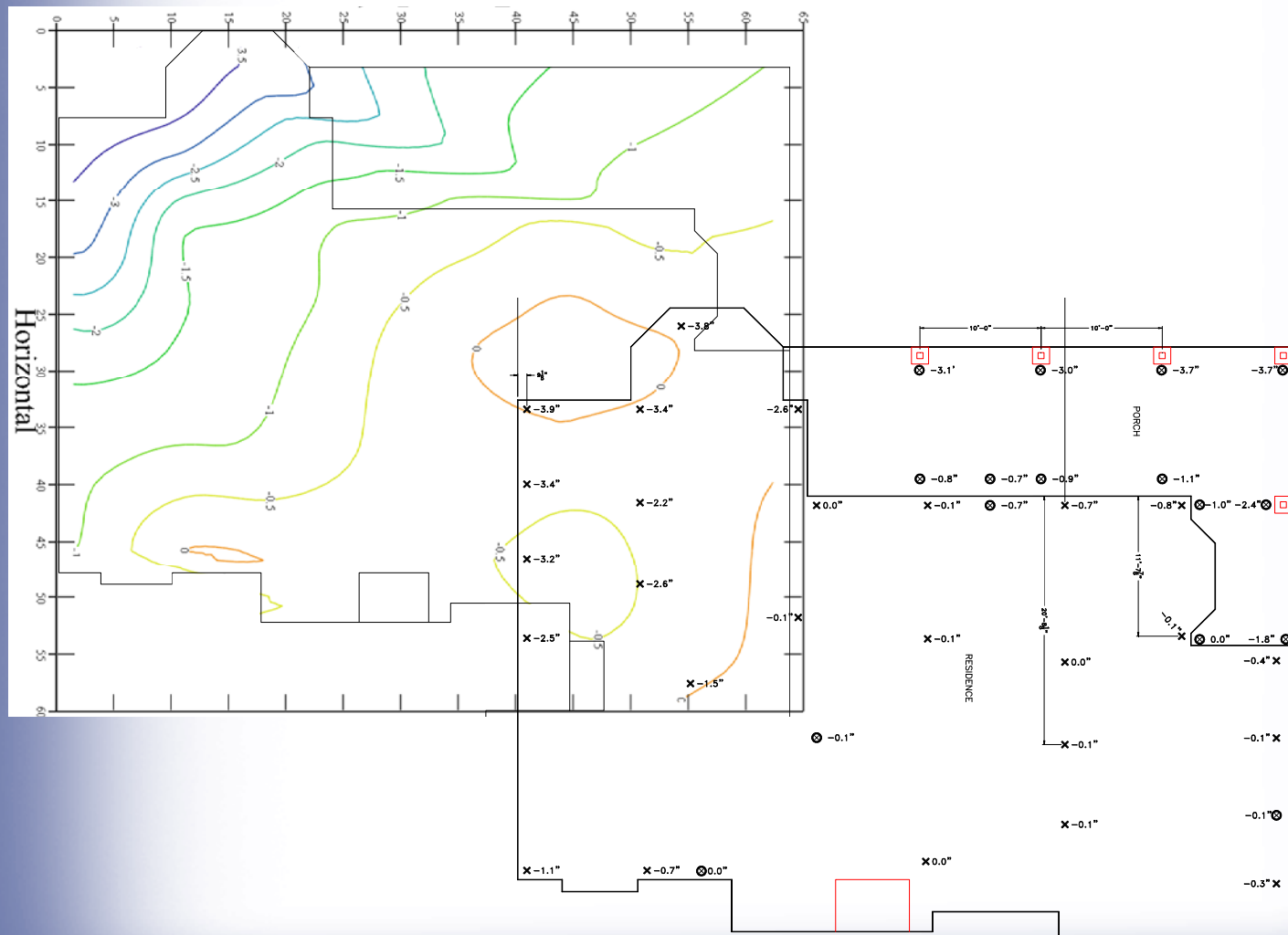
Step 17

- Once the contour plot is set,
 - Copy and Paste floor plan into excel
 - Zoom in on the floor plan and select all desired members
 - Copy and paste contour plot into excel



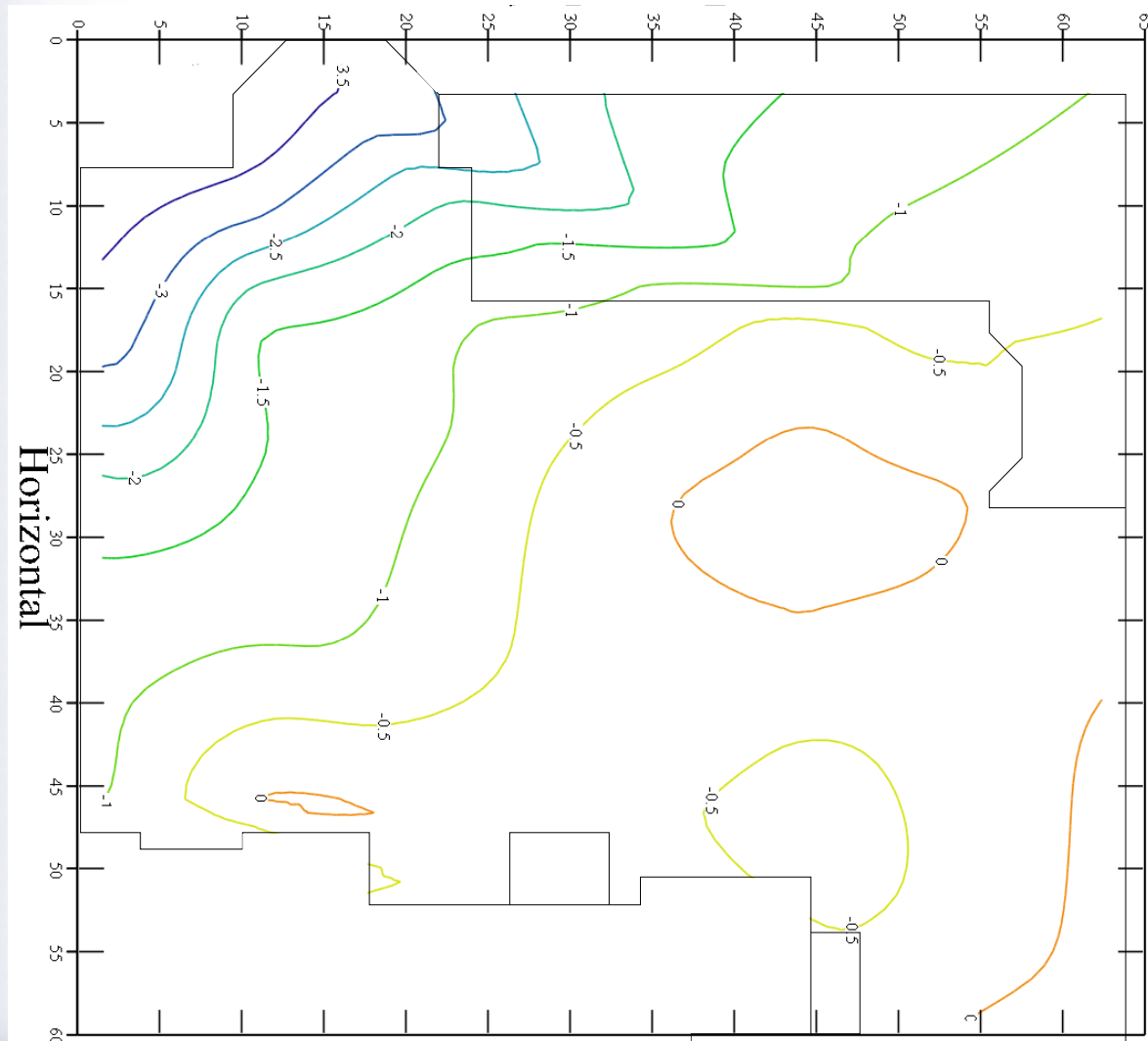
Step 18

- Send the contour plot to the back and the floor plan to the front



Step 19

- Align the plots so that the contour plot is aligned with the floor plan



Step 20

- Areas of the contour that are outside the floor plan can be filled by pasting white filled areas using excel drawing tools, or group pictures and edit in "Paint" what ever is easiest

Step 21

- Select all areas of the final plot and group them

Step 22

- Copy and paste the finished plot to your report document as required

MathCAD Sheet

This MathCAD sheet can be obtained free from www.structuralanalysismcad.com by providing three documented appropriate references (engineers, architects, scientists, CAD technicians, contractors etc.) who are not members of FPA.

The screenshot displays the homepage of the Structural Analysis MCAD Store. The website features a red header with the logo and navigation links. The main content area includes a welcome message, a featured product section, and a new releases section. The featured products are:

- Matrix Method - BETA (3 Seats): Your Price: \$125.00
- Fixed Base Plate w/Multiple Rows of Anchor Bolts (3 Seats): Your Price: \$50.00
- ACI Anchor Bolt Design (3 Seats): Your Price: \$50.00
- Wind Load on Pole Design (3 seats): Your Price: \$75.00

The new releases section includes:

- Wind Load on Pole Design (3 seats): \$75.00
- ACI Anchor Bolt Design (3 Seats): \$50.00
- Fixed Base Plate w/Multiple Rows of Anchor Bolts (3 Seats): \$50.00

The website also includes a category list, a mailing list sign-up form, and a search bar. The footer contains a disclaimer and copyright information for 2013.