KML_3Point-Flow–An Excel application for mapping groundwater flow direction from a few wells in a KML

Groundwater wells, potentiometric surface, and flow direction can be mapped in a KML file with the KML_3Point-Flow.v?.xlsm workbook (Figure 1). Potentiometric surface is simulated by fitting a planar surface to groundwater levels from between 3 and 24 wells. Appropriateness of fitting a 3-point problem to greater than three wells can be evaluated with a scatter plot of measured and simulated water levels. Posting of names, measured water levels, simulated water levels, residuals, and weights are specified by the user.

Figure 1.— Example of wells, potentiometric surface, and flow direction from Greenwater Range that was created with the KML_3Point-Flow.v?.xlsm workbook.

Groundwater-flow direction is depicted with a three-dimensional arrow that can be scaled by the user (Figure 2). Groundwater gradient and downgradient compass heading are reported if arrow is selected in Google Earth.
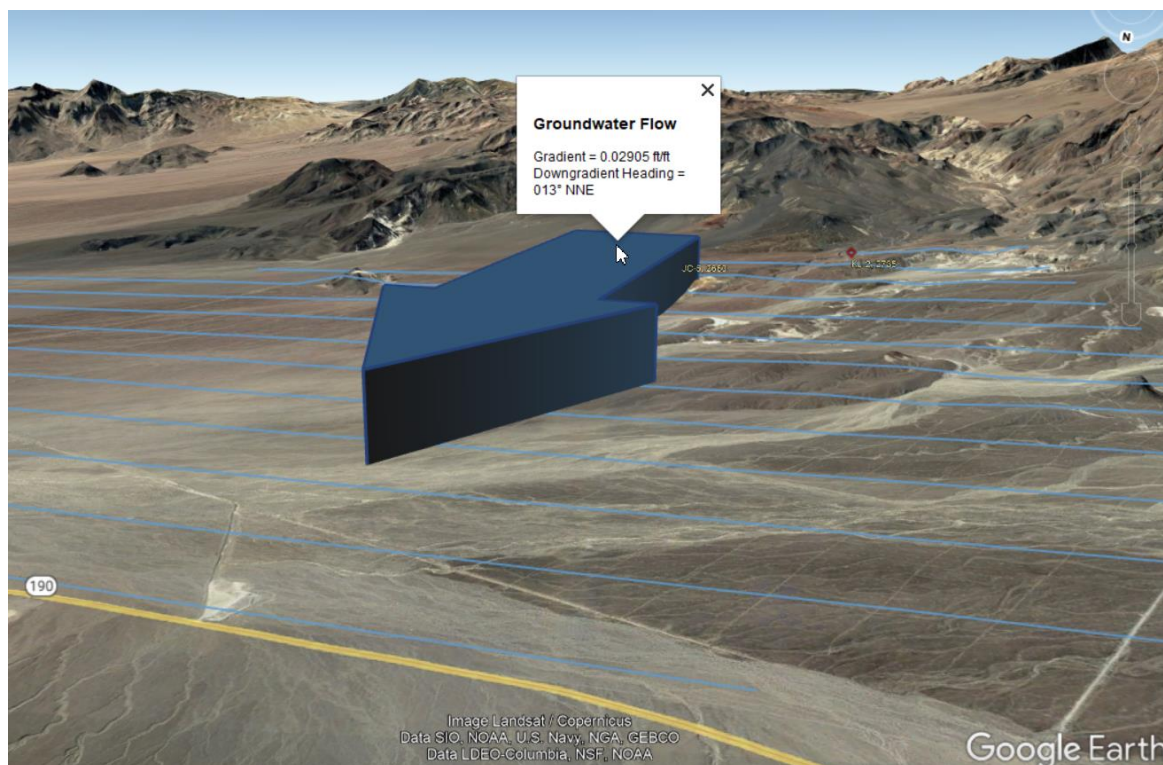
Figure 2.— Displaying groundwater gradient and flow direction while looking upgradient from California highway 190 into Greenwater Range.

KML_3Point-Flow.v3.xlsm and explanatory PDF can be downloaded with the following link.

Revisions

March 8, 2021—Versions 1 and 2 were created during development.

December 7, 2021—Revisions in version 3 include the following. Workbook modified so that well locations can be specified with decimal latitude-longitude or UTM coordinates. Explanatory comments were added to labels on XYZ page.

February 23, 2024—Revisions in version 4 include the following. Safeguards were added to check that the [Solver](#) is [installed](#) and the workbook is not opened from within a zip file.

KML_3Point-Flow.v2.xlsm Workbook

The workbook consists of two pages, XYZ and CONTROL. Site data, mapped symbols and all user options are specified on the XYZ page. The CONTROL page contains lookup tables and code for calculating results. This page can be hidden because users should not need to edit the page.

XYZ page

Site name, location, and groundwater levels are specified as a table (B28:E54) on the XYZ page (Figure 3). Well locations can be specified as decimal longitude-latitude or UTM easting-northing. KML file name, symbol assignment, contents of well labels, contour interval, contour extent, and groundwater-flow arrow dimensions are user specified.
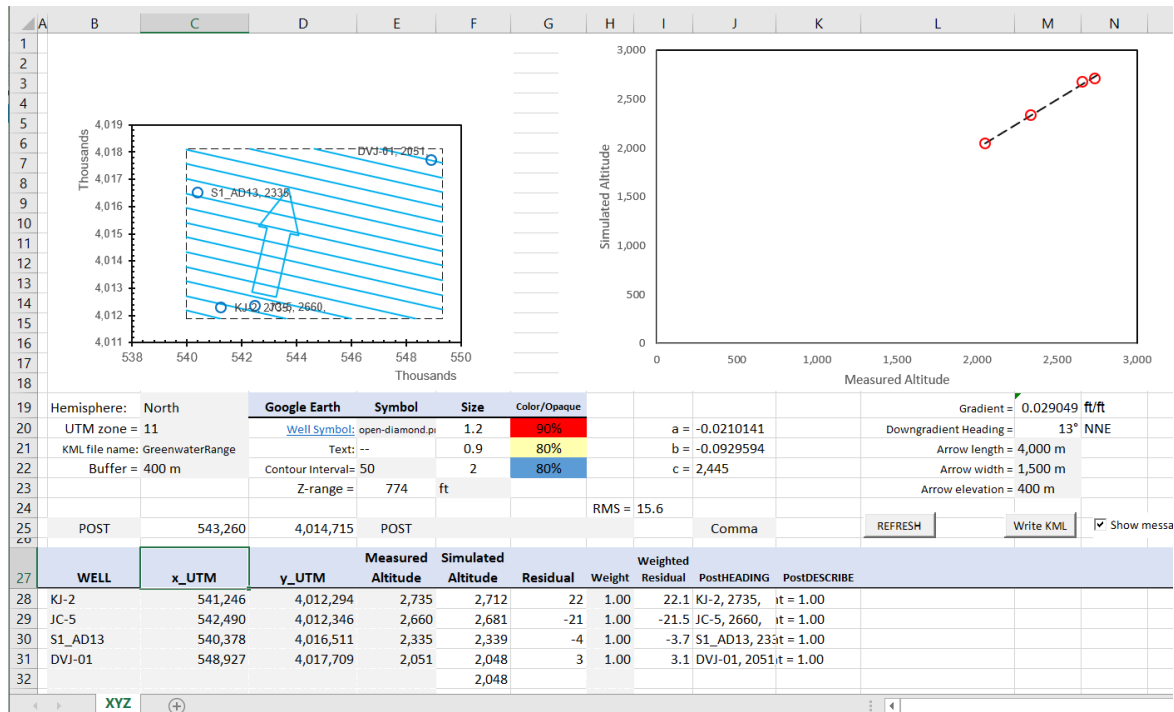
Figure 3.—XYZ page in the KML_3Point-Flow.v2.xlsm workbook where sites to be posted and descriptive information are specified.

XYZ page—Site Data

Site name, location, and measured altitude (columns B:E) must be specified on the XYZ page.	
Site locations (columns C:D) can be specified as either, Decimal longitude-latitude or UTM easting-northing, m.	
If UTM easting-northing are specified, hemisphere and UTM zone also must be specified (C19:C20).	
Measured altitude (column E) can be specified in units of feet (ft) or meters (m), which is specified in cell (F23).	

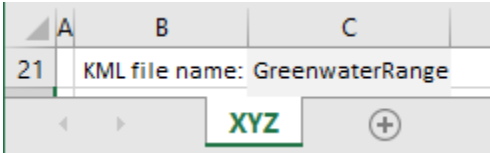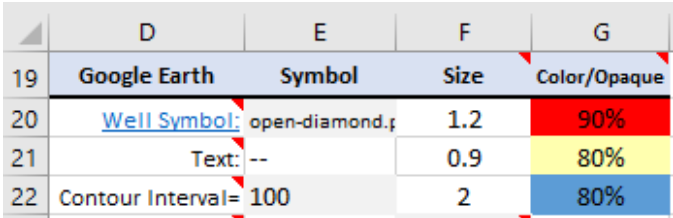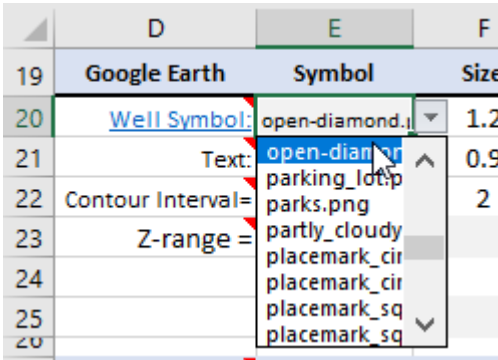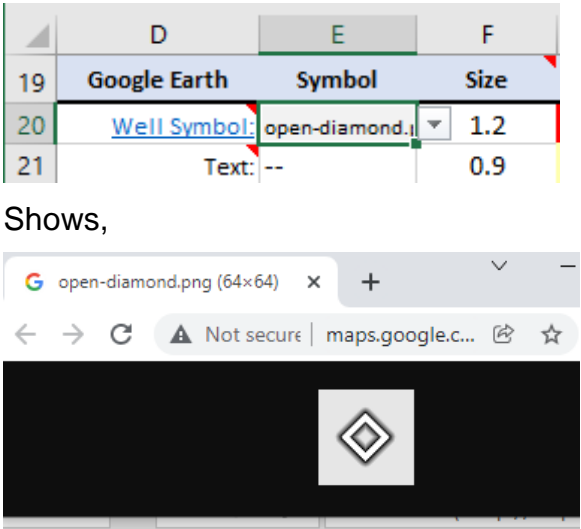|	
Well sites are posted as UTM coordinates in a XY chart (B1:F18) for quickly evaluating composition of objects in map.	
Weights for regression of plane can be assigned in column H. Blank cells are weighted as 1.	
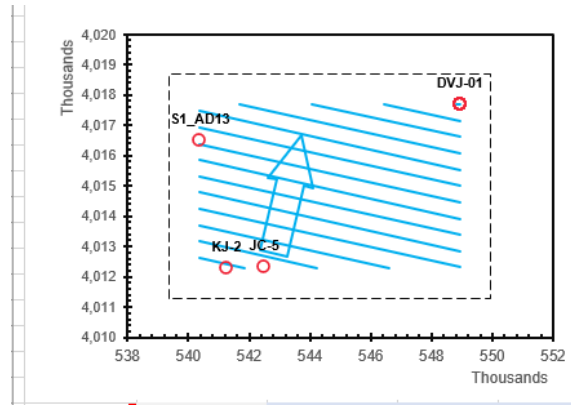
XYZ page— KML file name and symbology

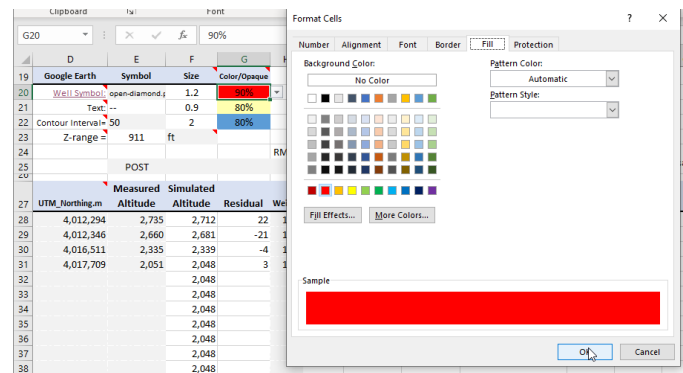|	
KML file name without extension is specified in cell C21 of XYZ page.	
Well symbols, posted text, and contour characteristics are specified in the range E20:G22.	
Well symbol is specified with Google Earth supplied file names. A file is selected with pull-down menu in cell E20.	
Selected symbol in cell E20 can be viewed in a browser by clicking the hyperlink in cell D20. Open-diamond icon shows in this example.	 Shows,

Symbol size, text size, and line weight are specified with pull-down menus in column F, where sizes range from 0.0 (invisible) to 5.0 (really big). Size is in non-specific GE units. Gage selection by knowing that reasonably sized labels range from 0.6 to 0.9.	
Symbol, text, and line color are specified by fill color of cells in column G. For example, cell G20 is formatted and a red fill is assigned.	
Symbol, text, and line opacity are specified with pull-down menus in column G, where opacity ranges from 0% (invisible) to 100% (nothing visible beneath symbol). For example, G20 currently is 90%, which is mostly opaque.	

XYZ page— Well posting

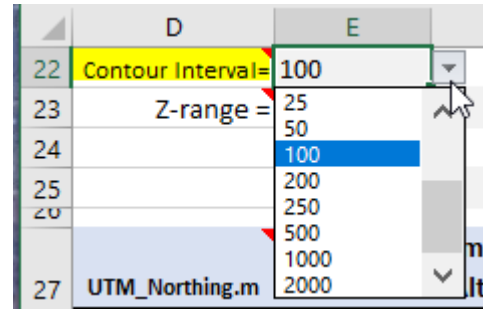|	
Text posted with wells is defined in columns B, E, F, G, and H of row 25.	
Posted text is limited to selected fields on row 25. All entries are reported in the descriptive balloon when a well is selected.	
Delimiters between posted entries can be changed in cell J25.	
Example of underscore between posted entries.	
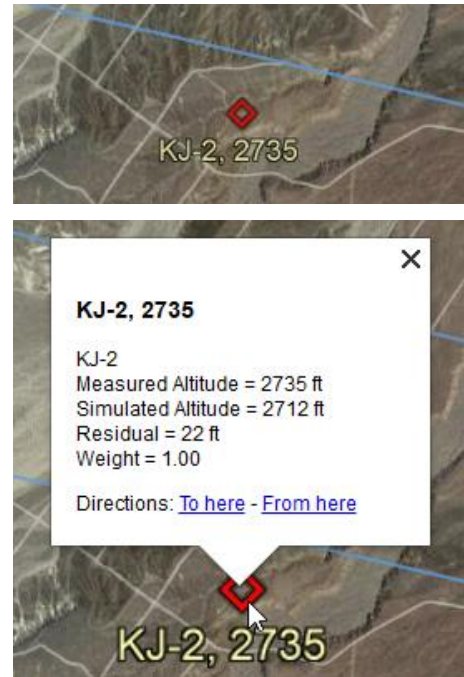
XYZ page— Contour interval and extents

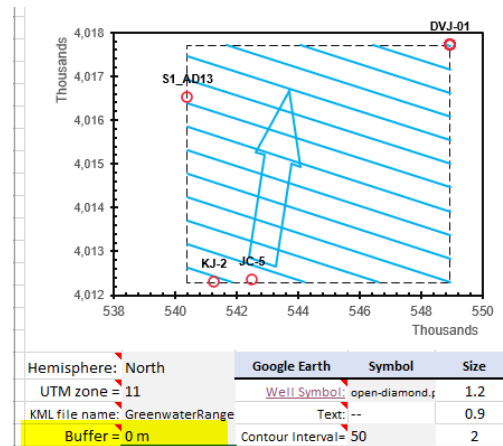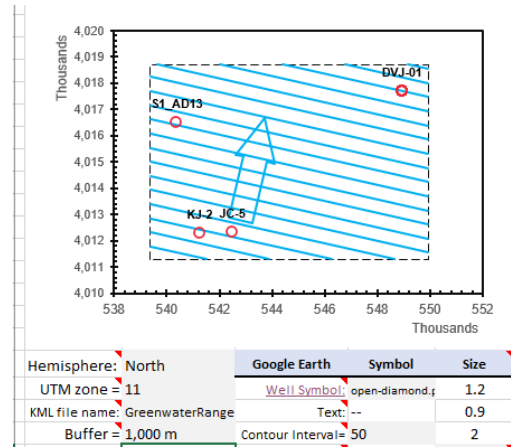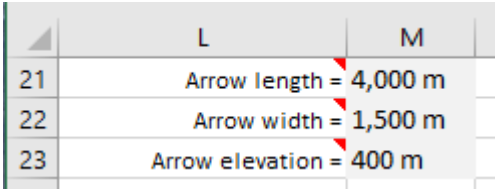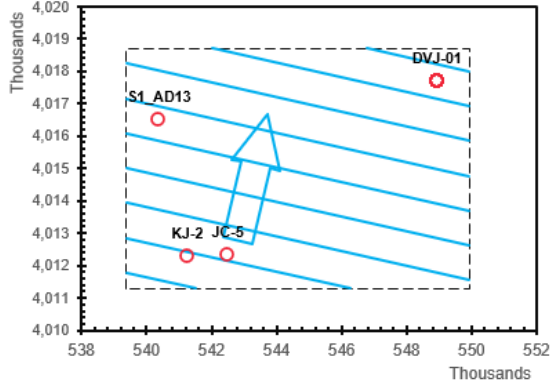|	
Contour interval of planar surface is selected from pull-down menu in cell E22.	
Contour intervals are updated by clicking the REFRESH button in cell L25.	 Contour interval 50 ft > and 100 ft
Buffer in cell C22 defines extent of contours beyond lateral extents of well coordinates. For example, lateral extents intersect wells with a buffer of 0 m.	
Changing buffer from 0 to 1,000 m instantly expands the lateral-extent frame.	
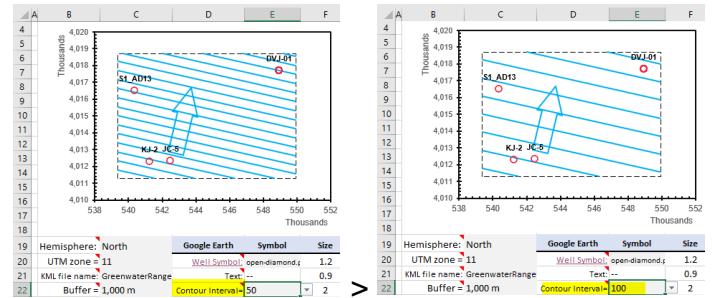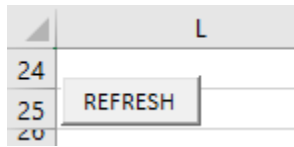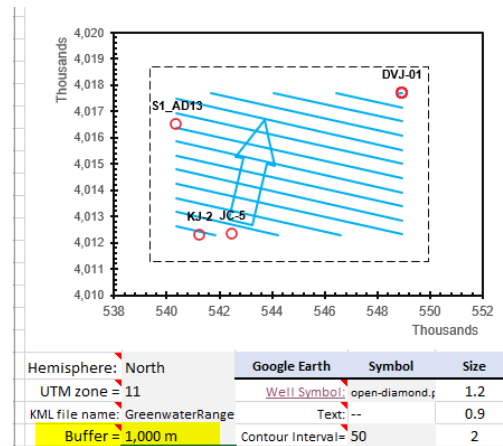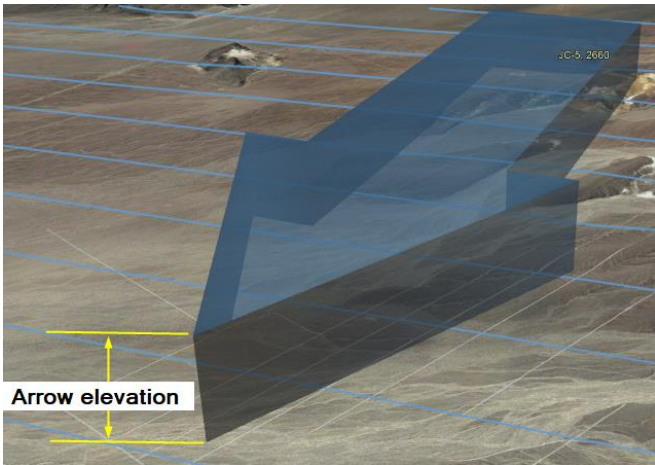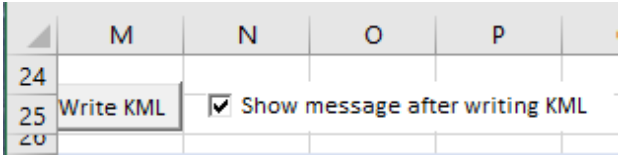
Contours are revised to limits of lateral-extent frame by clicking the REFRESH button in cell L25.

	L
24	
25	REFRESH
26	

	Google Earth	Symbol	Size
Hemisphere: North			
UTM zone = 11	Well Symbol:	open-diamond.p	1.2
KML file name: GreenwaterRange	Text:	--	0.9
Buffer = 1,000 m	Contour Interval=	50	2

XYZ page— Groundwater flow arrow and Writing KML

Groundwater-flow arrow dimensions are defined in range M21:M23.	
Arrow length and width (M21:M22) are revised instantly and can be evaluated in the XY chart (B1:F18).	
Arrow elevation (M23) is relative to land surface and only can be evaluated in Google Earth. A few iterations of writing and viewing KML frequently are needed to scale arrow elevation.	
Wells, contours, and groundwater-flow arrow are written to KML file by clicking the "Write KML" button in cell M25.	
Message with name and location of KML file is reported if option is checked in cell N25.	