

Radiological Data Assessment Guidance for Emergency Response

Job Aid: Detect A Trend over Time

PNNL-34480

This job aid has been developed to guide readers through performing statistical testing for data quality assessment using Visual Sample Plan (VSP)¹. More information about data quality assessment can be found in the Radiological Data Assessment Guidance for Emergency Response² document on CBRN Responder.

Use Case: Determine whether an upward or downward trend in the data exists over time. One example is monitoring flowing water for radionuclide contamination at a single location. This test is described in Section 5.5.5 of the Radiological Data Assessment Guidance for Emergency Response².

Assumptions:

- This test is performed on data collected over time from the same locations.
- The data have all already been transformed into the same units.
- The data have one sample point per time point.
- The reader has already successfully installed VSP on their computer. VSP is currently only compatible with Windows operating systems.
- This test requires at least four measurement values.
- This test detects for linear and exponential trends, but it does not account for repeating patterns (e.g., night/day cycles, seasonal cycles).

If any of the assumptions above are not true for your particular situation or data, this test may not be appropriate. Consult EPA guidance QA/G-9 “Practical Methods for Data Analysis” for more information³.

Throughout this job aid, markers such as “(A)” indicate a highlight in the next VSP screenshot after the marker.

1. **Launch the Mann-Kendall dialog in VSP:** Follow the steps below to launch the design dialog to import data and perform the test.
 - 1.1. In the top-left menu bar, click on (A) “**Sampling Goals**”.
 - 1.2. In the pop-up drop-down menu, hover over each item in order from (B) to (D):
 - (B) “**Detect a Trend**”
 - (C) “**Residuals not required to be normally distributed**”
 - (D) “**No Seasonality**”
 - 1.3. Click on “**No Seasonality**” to launch the Mann-Kendall test in a new **dialog** that will pop up.

Pacific Northwest National
Laboratory

P.O. Box 999

Richland, WA 99352

(509) 372-6357

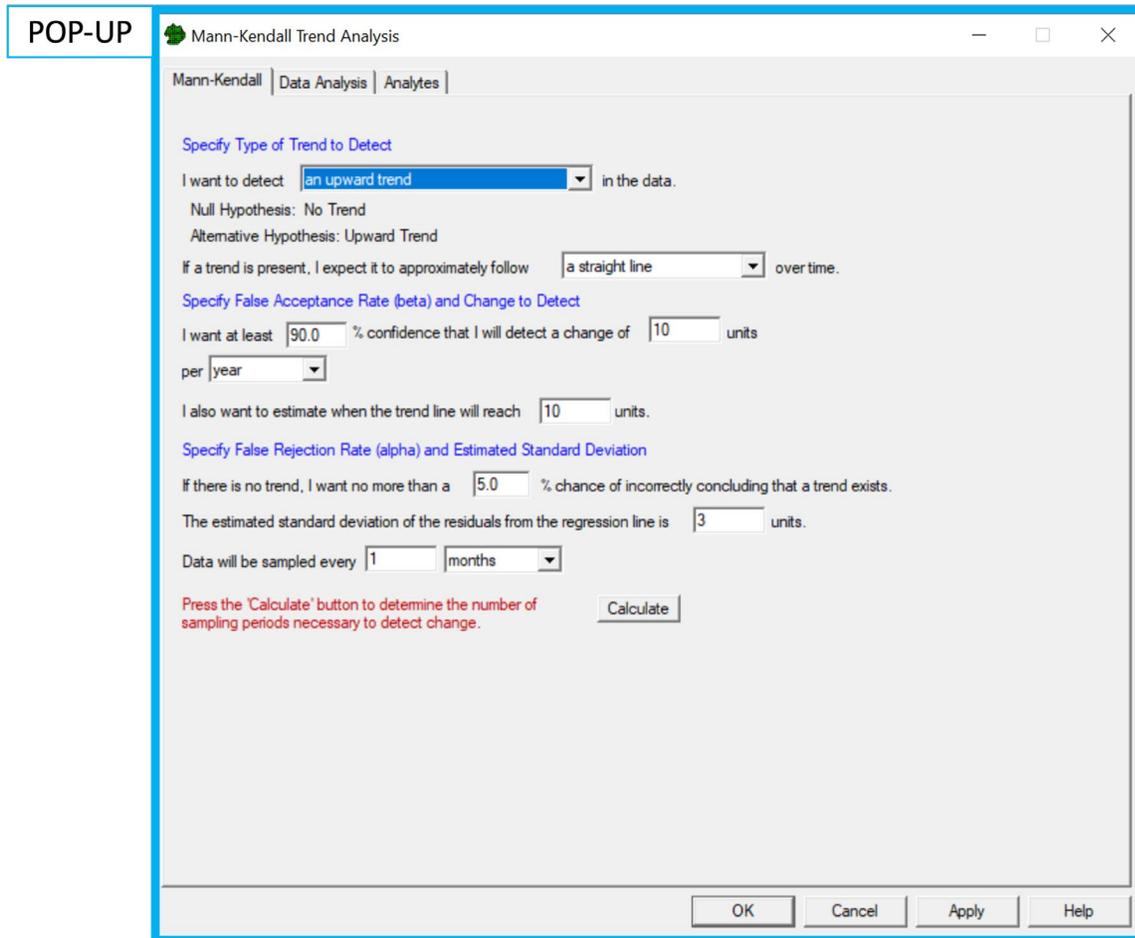
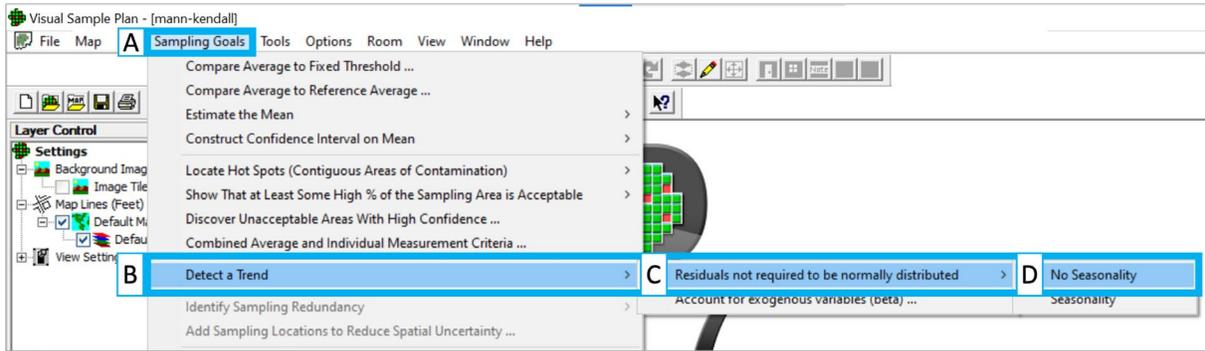
vsp@pnnl.gov

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¹ <https://www.pnnl.gov/projects/visual-sample-plan>

² <https://www.cbrnresponder.net/app/index#resources/documents/download/2308>

³ <https://www.epa.gov/sites/default/files/2015-06/documents/g9-final.pdf>



2. **Specify the type of trend to detect and desired false rejection rate:** Follow the steps below to set the necessary test parameters.

- 2.1. Select the (E) **type of trend** to test for in the first drop down. The test can be performed to detect an upward trend, a downward trend, or either an upward or a downward trend.
- 2.2. Specify the (F) **false rejection rate, α , of the test**. A 95% **confidence, C**, with a rate of 5% can be used as the default. With the default rate, it is expected that the test could falsely conclude that there is no trend when a trend truly exists no more than 5 out of every 100 times. If a percent confidence other than 95% is desired, change the false rejection rate to **100 - C**. For example, if 90% confidence is desired, then **$\alpha = 10.0$** .
- 2.3. None of the other parameters on this dialog will need to be changed to perform the Mann-Kendall test. **“Calculate”** does not need to be clicked to run the test.

Mann-Kendall Trend Analysis

Mann-Kendall | Data Analysis | Analytes |

Specify Type of Trend to Detect

E I want to detect an upward trend in the data.

Null Hypothesis: a downward trend

Alternative Hypothesis: either an upward or a downward trend

Alternative Hypothesis: an upward trend

If a trend is present, I expect it to approximately follow a straight line over time.

Specify False Acceptance Rate (beta) and Change to Detect

I want at least 90.0 % confidence that I will detect a change of 10 units

per year

I also want to estimate when the trend line will reach 10 units.

Specify False Rejection Rate (alpha) and Estimated Standard Deviation

F If there is no trend, I want no more than a 5.0 % chance of incorrectly concluding that a trend exists.

The estimated standard deviation of the residuals from the regression line is 3 units.

Data will be sampled every 1 months

Press the 'Calculate' button to determine the number of sampling periods necessary to detect change.

Calculate

OK Cancel Apply Help

3. **Prepare your data to be loaded into VSP:** Follow the steps below to prepare to load your data into VSP.
 - 3.1. Open your data in **Excel** (recommended) or a text editor.
 - 3.2. **Note on format:** VSP does not accept comma delimited data, only tab delimited. Ensure that the data is in a columnar format (i.e., tab delimited).
 - 3.3. Select and copy the rows to be imported into VSP. The test can still be computed if there are missing data, extra columns, or if the order of the rows differs from the example shown here but ensure that there are columns for the (H) **sample values** and the (G) **date-time** each sample was collected.

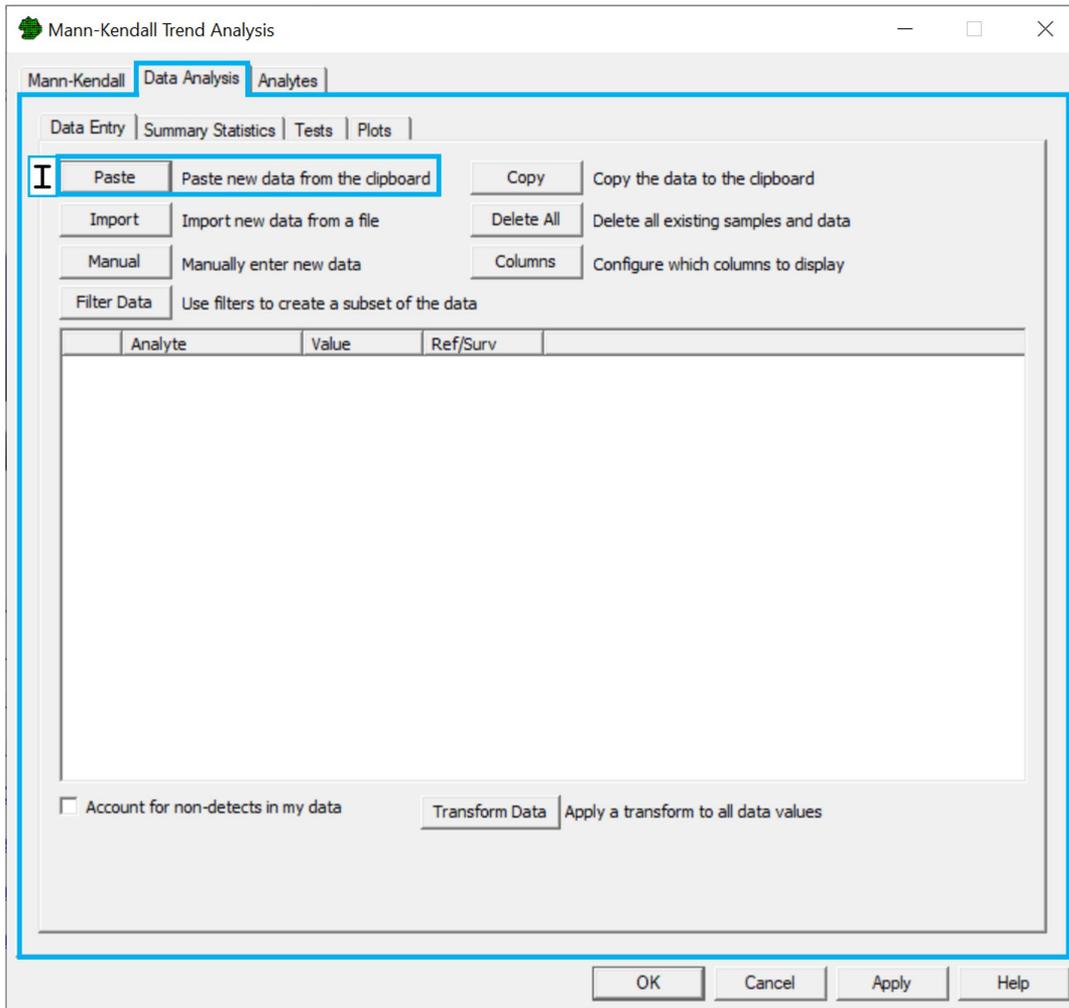
The image shows two windows side-by-side. The left window is Microsoft Excel, displaying a spreadsheet with the following data:

	A	B	C	D
1	7/22/2015 14:35	Gamma	mR/hr	0.01
2	7/22/2015 11:35	Gamma	mR/hr	0.0095
3	7/22/2015 12:35	Gamma	mR/hr	0.0097
4	7/22/2015 17:35	Gamma	mR/hr	0.0098
5	7/22/2015 18:35	Gamma	mR/hr	0.0097
6	7/22/2015 19:35	Gamma	mR/hr	0.0099
7	7/22/2015 20:35	Gamma	mR/hr	0.0097
8	7/22/2015 21:35	Gamma	mR/hr	0.0102
9	7/22/2015 22:35	Gamma	mR/hr	0.0105
10	7/22/2015 23:35	Gamma	mR/hr	0.0102
11	7/23/2015 0:35	Gamma	mR/hr	0.0103
12	7/23/2015 1:35	Gamma	mR/hr	0.0105
13	7/23/2015 2:35	Gamma	mR/hr	0.0103
14	7/23/2015 3:35	Gamma	mR/hr	0.0102
15	7/23/2015 4:35	Gamma	mR/hr	0.0103
16	7/23/2015 5:35	Gamma	mR/hr	0.0105
17	7/23/2015 6:35	Gamma	mR/hr	0.0103
18	7/23/2015 7:35	Gamma	mR/hr	0.0102

The right window is Notepad, titled 'radnet-data2 - Notepad', showing the same data as a tab-delimited text file. A context menu is open over the data, with 'Copy' selected.

4. Load the data into VSP: Follow the steps below to load your data into VSP.

- 4.1. In the “**Mann-Kendall Trend Analysis**” dialog, click on the “**Data Analysis**” tab. Ensure the “**Data Entry**” sub tab is open. If not, click on it.
- 4.2. Click on the (I) “**Paste**” button.



- 4.3. In the new pop-up dialog, preview the pasted data and ensure it matches what was copied in step 3.3. For example, in the data loaded below, 18 samples measuring gamma radiation (mR/hr) were collected at 1-to-3-hour intervals between two dates from a monitoring station.
- 4.4. Click on the column headers to map the appropriate columns to **Date/Time** and **Value**.
- 4.5. Check the box “**Ignore header row during import**” if copied data has a header row.
- 4.6. Press **OK** to import data.
- 4.7. Ensure the data has been imported as expected. If data was not imported correctly and needs to be reimported, click on the (J) “**Delete All**” button and follow steps 4.1 - 4.6 again.

POP-UP

Add Data

Ignore header row during import
 Data contains multiple analyte entries per row

	Date/Time	Ignore Column	Ignore Column	Value
1	7/22/15 14:35	Gamma	mR/hr	0.01
2	7/22/15 11:35	Gamma	mR/hr	0.0095
3	7/22/15 12:35	Gamma	mR/hr	0.0097
4	7/22/15 17:35	Gamma	mR/hr	0.0098
5	7/22/15 18:35	Gamma	mR/hr	0.0097
6	7/22/15 19:35	Gamma	mR/hr	0.0099
7	7/22/15 20:35	Gamma	mR/hr	0.0097
8	7/22/15 21:35	Gamma	mR/hr	0.0102
9	7/22/15 22:35	Gamma	mR/hr	0.0105
10	7/22/15 23:35	Gamma	mR/hr	0.0102
11	7/23/15 0:35	Gamma	mR/hr	0.0103
12	7/23/15 1:35	Gamma	mR/hr	0.0105
13	7/23/15 2:35	Gamma	mR/hr	0.0103
14	7/23/15 3:35	Gamma	mR/hr	0.0102
15	7/23/15 4:35	Gamma	mR/hr	0.0103
16	7/23/15 5:35	Gamma	mR/hr	0.0105
17	7/23/15 6:35	Gamma	mR/hr	0.0103
18	7/23/15 7:35	Gamma	mR/hr	0.0102
19				

OK Cancel

Mann-Kendall Trend Analysis

Mann-Kendall | Data Analysis | Analytes

Data Entry | Summary Statistics | Tests | Plots

Paste Paste new data from the clipboard Copy Copy the data to the clipboard
Import Import new data from a file **J** Delete All Delete all existing samples and data
Manual Manually enter new data Columns Configure which columns to display

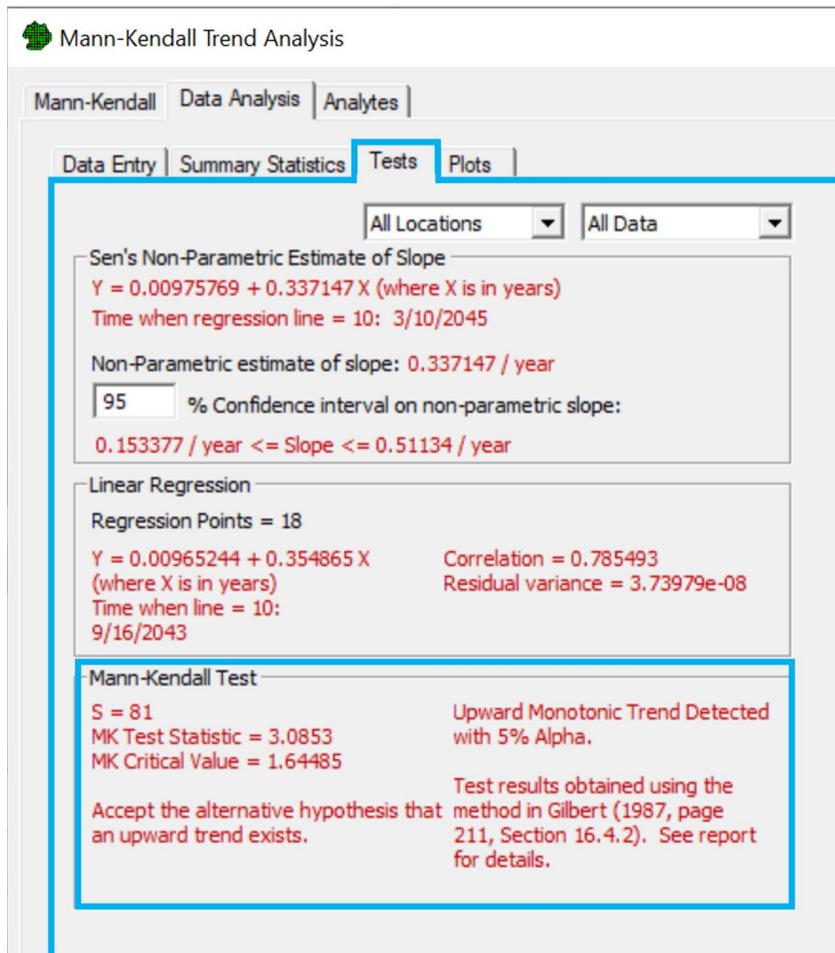
Filter Data Use filters to create a subset of the data

	Analyte	Value	Ref/Surv	Date/Time
1	Analyte 1	0.010000	Undefined	7/22/2015 2:35:00 PM
2	Analyte 1	0.009500	Undefined	7/22/2015 11:35:00 AM
3	Analyte 1	0.009700	Undefined	7/22/2015 12:35:00 PM
4	Analyte 1	0.009800	Undefined	7/22/2015 5:35:00 PM
5	Analyte 1	0.009700	Undefined	7/22/2015 6:35:00 PM
6	Analyte 1	0.009900	Undefined	7/22/2015 7:35:00 PM
7	Analyte 1	0.009700	Undefined	7/22/2015 8:35:00 PM
8	Analyte 1	0.010200	Undefined	7/22/2015 9:35:00 PM
9	Analyte 1	0.010500	Undefined	7/22/2015 10:35:00 PM
10	Analyte 1	0.010200	Undefined	7/22/2015 11:35:00 PM
11	Analyte 1	0.010300	Undefined	7/23/2015 12:35:00 AM
12	Analyte 1	0.010500	Undefined	7/23/2015 1:35:00 AM
13	Analyte 1	0.010300	Undefined	7/23/2015 2:35:00 AM
14	Analyte 1	0.010200	Undefined	7/23/2015 3:35:00 AM
15	Analyte 1	0.010300	Undefined	7/23/2015 4:35:00 AM
16	Analyte 1	0.010500	Undefined	7/23/2015 5:35:00 AM
17	Analyte 1	0.010300	Undefined	7/23/2015 6:35:00 AM
18	Analyte 1	0.010200	Undefined	7/23/2015 7:35:00 AM

Account for non-detects in my data Transform Data Apply a transform to all data values

OK Cancel Apply Help

5. **Perform the test:** The name of the statistical test used here is called the “Mann-Kendall test”. Follow the steps below to perform this test in VSP.
 - 5.1. Click on the “**Tests**” tab on the Mann-Kendall Trend Analysis dialog.
 - 5.2. View the test results in the section of the Tests tab labeled **Mann-Kendall Test**.

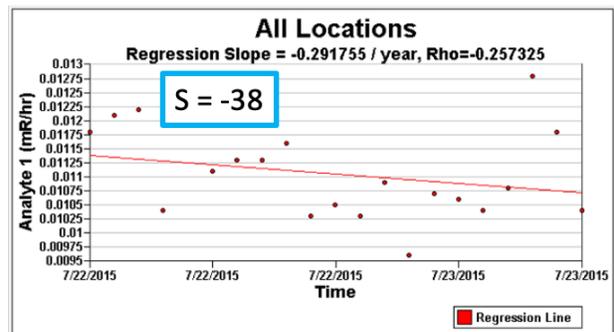
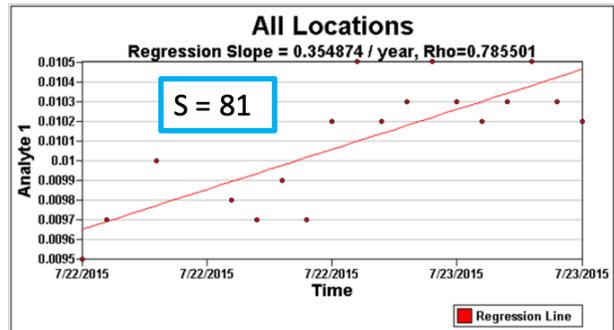


5.3. The sum of signs **S**, **Mann-Kendall Test Statistic**, and **Mann-Kendall Critical Value** are displayed in this section.

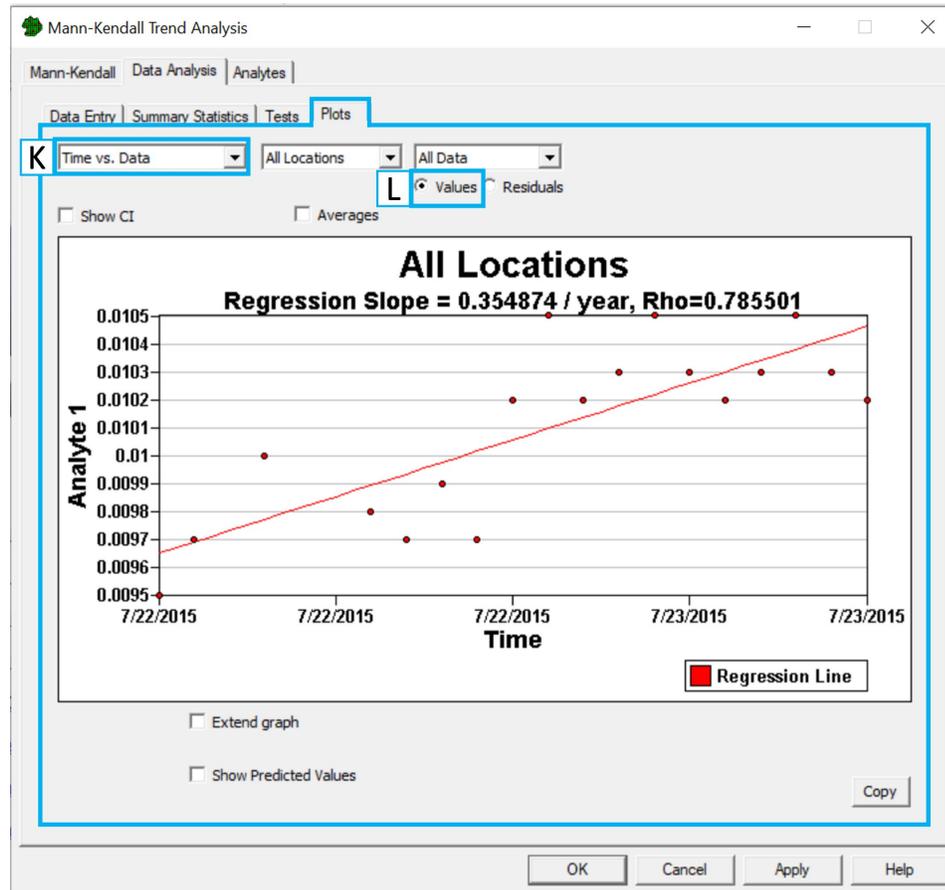
MK Critical Value	False rejection rate	Interpretation
Closer to 0	> 5%	More likely to incorrectly detect a trend
+/-1.64485	5%	Default
> +/-1.64485	< 5%	Less likely to incorrectly detect a trend

MK Test Statistic vs. MK Critical Value	Interpretation	Example
MK Test Statistic > MK Critical Value	Trend exists	S = 81 MK Test Statistic = 3.0853 MK Critical Value = 1.64485
MK Test Statistic <= MK Critical Value	Trend does not exist	S = -38 MK Test Statistic = -1.20467 MK Critical Value = -1.64485

Sum of Signs, S	Interpretation
Positive (+)	Trend is increasing
Negative (-)	Trend is decreasing
High Magnitude	Large Slope
Low Magnitude	Small Slope
Zero Magnitude	No trend



5.3.1. For additional visual aids, click on the **“Plots”** tab adjacent to the **“Tests”** tab. Select (K) **“Time vs. Data”** and check the (L) **“Values”** option button to visualize data and its fitted slope. Observing the visual alone will NOT be able to determine whether there exists a statistically significant trend, only the test can. However, the visual can show any periodicity, outliers, or other suspicious behaviors in the data that may need further investigation when running the test.



5.4. Use the statement provided in VSP to appropriately state the statistical conclusion that can be drawn from this test.

5.4.1. If data are sufficient to conclude with a desired confidence that a trend exists, the conclusion text will read **“Upward/Downward Monotonic Trend Detected with 5% Alpha.”** This means that a trend most likely exists.

5.4.2. If the data are NOT sufficient to conclude with the desired confidence that a trend exists, the conclusion text will read **“No Upward/Downward Monotonic Trend Detected with 5% Alpha.”** This may mean no trend exists or that there is insufficient data to say with certainty that one exists or not.

Appendix A – Description of Test Parameters

Additional explanation of the Mann-Kendall test parameters displayed in VSP are presented here:

The **S** value indicates the slope and magnitude of any detected trend. A **positive S** value indicates that the trend is increasing. A **negative S** indicates a trend is decreasing. The larger the magnitude of S, the larger the slope of the trend. S is calculated from the differences between consecutive observations.

The **MK Critical Value** defines the cutoff between accepting or rejecting the null hypothesis that there is no detected trend. It depends on the false rejection rate defined in step **2.2**. For example, at a 5% α for detecting an upward trend, the MK Critical Value is 1.64485, but increasing the false rejection rate to 10% results in a critical value of 1.28155 that is closer to zero, which would make it more likely to reject the null hypothesis.

The **MK Test Statistic** indicates the confidence in whether a trend truly exists. The larger the statistic, the more confidence that a trend is present in the data. The MK Test Statistic is calculated based on the value of **S** and is evaluated against the MK Critical Value. If the absolute value of the MK Test Statistic is larger than the absolute value of the MK Critical Value, then there was a trend detected in the data.