TUTORIAL - Importing & Analysing Water Levels
using the ESdat Environmental Database System

For use with ESDAT version 5
Tutorial 3-4 Importing and Analysing Water Levels

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Summary

This tutorial:

- details the method for importing, storing and calculating reduced ground water levels (i.e. relative to a datum) in ESdat
- presents some ESdat functionality that can be used to analyse water levels and trends
- applies to both Access and SQL Server versions of ESdat
- uses the *Sample Hydrogeology and Contam* database (and therefore can be used with the demonstration version of ESdat)
- requires approximately 60-90 minutes to complete

Key Learning

Following completion of this tutorial, the user will have developed skills in the following:

- importing a combination of raw and reduced groundwater level data
- viewing water level data from within ESdat
- analysing water level data using maps, graphs and trend analysis

Pre-requisites

It is assumed the user has previously completed:

- *Tutorial 1 – Introducing ESdat*
- *Tutorials 2 & 3 – Competent usage skills*

It is recommended Tutorials 3-4a and 3-5 be completed in conjunction with this current tutorial as the same imported data is used for exercises.

In addition, these three tutorials should be completed in a single day as the demonstration dataset *Sample Hydrogeology and Contam* resets to the original state daily.

For a full list of the Tutorials available for use with ESdat, please see the Tutorial List.
Introduction

Water level data can be stored and analysed in ESdat, including both historical reduced water levels and raw field water level data (i.e. depths below a datum).

ESdat is able to convert depths to elevations (or elevations to depths), using the common well ‘TOC’ elevation. TOC (or Top Of (well) Casing) is a commonly used water level measurement reference point which is generally surveyed against an established datum such as metres above Australian Height Datum (mAHD) or against an arbitrary datum.

These exercises simulate calculation of reduced water levels and back calculating water depths using raw water depth field records and some historical reduced water level data.

Relative levels against which reduced water levels are determined are already present in the database.

In addition, water levels can be presented on the ESdat internal mapping function, using the graphing function and trends identified and highlighted. The functions explored in these exercises is generally not limited to just manipulating and analysing water levels – they can be applied to many other data types, such as laboratory analytical data or field data.

Each exercise is summarised below:

Exercise 1
Importing field and historic groundwater data.

Exercise 2
View water depths and reduced water relative levels in ESdat.

Exercise 3
Displaying well locations with water levels on the ESdat internal mapping function.

Exercise 4
Creating water level graphs in MS Excel using the ESdat Graph function.

Exercise 5
Updating created water level graphs directly from ESdat.

Exercise 6
Assess time series water level data for the presence of statistical trends and highlight data demonstrating trends.
Exercises

Exercise One: Importing Water Level Data

In this exercise water level data will be imported into ESdat.

- Review the water level (and LNAPL) data in the table below

Note locations BH01 (A&B Wells) and BH05 have both water depth and product depth, while location BH07 has only water depth and locations BH10-BH12 only have historic water level.

<table>
<thead>
<tr>
<th>Location Code</th>
<th>Date/Time</th>
<th>Water Elevation</th>
<th>Units</th>
<th>Water Depth</th>
<th>Product Depth</th>
<th>Measurement Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH01A</td>
<td>1/03/2010</td>
<td>m</td>
<td></td>
<td>6.05</td>
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<td>BH01A</td>
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<td>m</td>
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<td>dip</td>
</tr>
</tbody>
</table>

- Open ESdat
- Select the existing Sample Hydrogeology & Contam database in ESdat (refer to previous tutorials if guidance is needed)
• Select Import from the View Type tool bar (the top tool bar, as shown in the figure below)

![ESdat Interface](image)

• Click Water/NAPL Levels from the Blank Import Templates.

A groundwater data import template will open in Excel.

• Copy data from the table of the previous page into the Import Table, as per the figure below:

<table>
<thead>
<tr>
<th>LocCode</th>
<th>WellCode</th>
<th>Date_Imag</th>
<th>Water_Depth</th>
<th>Water_Elevation</th>
<th>Product_Depth</th>
<th>Well_Depth</th>
<th>Dry</th>
<th>Units</th>
<th>Measurement_Method</th>
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<td>m</td>
<td></td>
<td></td>
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<td></td>
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<td>BH11</td>
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<td>28/04/2010</td>
<td>24.14</td>
<td></td>
<td>m</td>
<td></td>
<td></td>
<td>dip</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>m</td>
<td></td>
<td></td>
<td>dip</td>
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<td>26.7</td>
<td></td>
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<td>dip</td>
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</tr>
<tr>
<td>BH12</td>
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<td>1/01/2010</td>
<td>25.88</td>
<td></td>
<td>m</td>
<td></td>
<td></td>
<td>dip</td>
<td></td>
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<td>BH12</td>
<td>-</td>
<td>5/02/2010</td>
<td>26.61</td>
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<td>m</td>
<td></td>
<td></td>
<td>dip</td>
<td></td>
</tr>
<tr>
<td>BH12</td>
<td>-</td>
<td>12/03/2010</td>
<td>26.65</td>
<td></td>
<td>m</td>
<td></td>
<td></td>
<td>dip</td>
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</tr>
<tr>
<td>BH12</td>
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<td>28/04/2010</td>
<td>26.65</td>
<td></td>
<td>m</td>
<td></td>
<td></td>
<td>dip</td>
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<tr>
<td>BH12</td>
<td>-</td>
<td>8/05/2010</td>
<td>26.61</td>
<td></td>
<td>m</td>
<td></td>
<td></td>
<td>dip</td>
<td></td>
</tr>
</tbody>
</table>

• Click the Upload button (located under the Add-Ins tab)

• From the Upload Data select Add New and Create Missing Parent Records options prior to clicking Import to upload data into ESdat

(note – Create Missing Parent Records was selected because Wells for BH05 – BH12 needed to be created). Data that has successfully been imported will be highlighted green.

• Close the Excel spreadsheet without saving
Exercise Two: Viewing Water Level Data

From within ESdat, different Data Types are viewed using the row of blue buttons near the top of the ESdat interface (as shown in the figure below).

ESdat has a Water Level Data Type Button used to view water level data.

Water level calculations require elevation data and TOC (top of well casing) data from the Location and Wells data tables (i.e. Water Levels comprises a query that calls upon these two tables).

- Go to Water Levels Data Type Button, hover the cursor and select WL1_Waterlevels_AHD table
- View the data in Data Panel

Notice that ESdat has calculated water level for all locations even where it was entered as a depth.

- Click WL2_WaterDepths table and review the data

Notice that ESdat has calculated water depth for all locations even where it was entered as an elevation.

The field (column) Water_Depth_bTOC presents the water depth below the Well’s TOC and the Water_Depth_bgl field presents water level below ground level.

Verifying the water level calculation

- Viewing WL2_WaterDepths table, generate a filter as follows:
  - double click on Location Code cells containing BH07 and BH10
  - double click on Well Code cells containing ‘-’

Text forming the filter will appear in the white panel above the data as follows:

```python
LocCode In ( 'BH07' , 'BH10' ) AND
WellCode = '-'
```

- Click on the blue Apply Filter button
- Hover above the Boreholes/Wells data type button and select BH2_Wells
- Click the Edit button from the left vertical toolbar to enter Edit mode
- Update the TOC cells as follows:
  - BH07 – 35.07
BH10 – 35.00

- Go to Data Tables button (top right of ESdat interface) and select the WaterLevel table
- View the input data, noting BH07 rows only contain water depths, while BH10 rows contain water elevation

- Open a new, empty worksheet in Excel
- Copy the BH07 and BH10 data to the Excel worksheet and add the appropriate headings (as shown below)

<table>
<thead>
<tr>
<th>Location Code</th>
<th>Date</th>
<th>Water Depth (below TOC)</th>
<th>Water Level (RL mAHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH07</td>
<td>9-Mar-10</td>
<td>7.07</td>
<td></td>
</tr>
<tr>
<td>BH07</td>
<td>10-Mar-10</td>
<td>8.06</td>
<td></td>
</tr>
<tr>
<td>BH07</td>
<td>11-Mar-10</td>
<td>6.05</td>
<td></td>
</tr>
<tr>
<td>BH10</td>
<td>8-Dec-09</td>
<td>26.55</td>
<td></td>
</tr>
<tr>
<td>BH10</td>
<td>1-Jan-10</td>
<td>26.54</td>
<td></td>
</tr>
<tr>
<td>BH10</td>
<td>5-Feb-10</td>
<td>26.52</td>
<td></td>
</tr>
</tbody>
</table>

Hover above the Boreholes/Wells Data Type button and select the BH2_Wells table

- Copy TOC and Elevation data of BH07 and BH10 to the Exercise Table (column E & F, as shown below)

<table>
<thead>
<tr>
<th>Location Code</th>
<th>Date</th>
<th>Water Depth (below TOC)</th>
<th>Water Level (RL mAHD)</th>
<th>TOC (mAHD)</th>
<th>Elevation (mAH)</th>
<th>Water Depth (below ground)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH07</td>
<td>9-Mar-10</td>
<td>7.07</td>
<td>35.07</td>
<td>33.89</td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
<td>BH10</td>
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<td>26.55</td>
<td>35.00</td>
<td>34.21</td>
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<td>BH10</td>
<td>1-Jan-10</td>
<td>26.54</td>
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<tr>
<td>BH10</td>
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<td>26.52</td>
<td>35.00</td>
<td>34.21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Calculate Water Level (mAHD) for BH07 and enter the results in Column D:
  o Water Level = TOC – Water Depth
- Calculate Water Depth (below TOC) for BH10 and enter the results in Column C:
  o Water_Depth_bTOC = TOC – Water Level
• Calculate *Water Depth (m below ground)* based on ground level using the following formula:

Water Depth (below ground) = Water Depth (below TOC) – {TOC – Elevation}

or

Water Depth (below ground) = C – (E-F)

• Enter the results in Column G
• Select *WL2_WaterDepths* from the *Water Levels* Data Type button
• Check results against the ESdat calculated data
Exercise Three: Mapping Water Levels

Analysis of Water Levels can be completed using the internal mapping function of ESdat. The ESdat mapping function was introduced in Tutorial 1.

A filter will be created to in order to present all monitoring points relating to the upper aquifer only.

- Navigate to the ESdat Data Views
- From the Water Levels Data Type, select the WH1_WaterLevels_AHD data type
- Select the Map Panel to observe the full data set (prior to filtering)
- Return to the data panel
- Double click on any cell containing the text Upper Aquifer within the MonitoringUnit field
- Return to the Map Panel
- Click Apply Filter and note the reduced number of locations (corresponding to Upper Aquifer locations)
- Click the Labels button directly above the map
- In the dialogue box that appears, check the Show Values box and from the adjacent drop down lists, select Water_Level and Range
- In addition, check the Colour points by box and from the adjacent drop down lists, select Water_Level and Max
- Click OK

The map should appear consistent with the figure below (note – individual labels can be repositioned manually by clicking OK + Allow Moving).

Note that the range of water levels recorded for each of the Upper Aquifer points is presented within the labels and location points (circles) are coloured according to the water level range.
Exercise Four: Graphing Water Levels

The following exercise graphs water levels against time for the various wells in the Sample Hydrogeology and Contam dataset.

- From the Water Levels data type, select WH1_WaterLevels_AHD
- Click the Data Panel to view the data
- If necessary, remove the filter
- click the drop-down arrow at the right of the Graph button in the Exports toolbar (extreme right of the ESdat window)

The default graph setting will appear in the Graph data in Excel dialogue box (as presented below).

Note that the form Water Level will be plotted on the Y-axis, Date-Time on the X-axis and that a new series (i.e. a line on the graph) will be generated for each combination of LocCode and WellCode.

- Click the check box which reads New Chart for changes in and select Monitoring Unit
- Change the Chart Format to MultiChart Template
- Click Plot

Excel will open and the Water Level data will be plotted. Note the two tabs at the bottom of the Excel window – Upper_Aquifer and Lower_Aquifer. Each tab opens a worksheet containing the graphs corresponding to the tab names.

As there is a lot of data, it may be difficult to distinguish any trends. Identifying trends using ESdat is explored in a subsequent exercise.
Exercise Five: Updating Charts

The data used to create the graphs in Exercise Four is also contained within in the worksheets *Data_Upper_Aquifer* and *Data_Lower_Aquifer* in the same Excel file created when the data was plotted in graphs.

The following demonstrates how graphs can be updated from ESdat without the need to recreate the plots.

- Navigate (via the relevant tab) to one of the Excel worksheets containing the plotted data (either *Data_Upper_Aquifer* and *Data_Lower_Aquifer*).
- Delete part of the data.
- View the corresponding graph and note some data will be missing.
- Select the graph from which the data was removed by clicking on the graph once.
- Via the Add-Ins tab towards the top of the Excel window, click the Chart Options button.

A dialogue box labelled *Change the Displayed Data Series* will open (as shown below).

- From the red highlighted drop down, select the source worksheet (in this case it will be *Data_Upper_Aquifer*).
- Each of the wells will appear in the Data Series window, corresponding to the wells with water levels appearing in the chart.
- Click update and note chart is updated with the data stored within ESdat.

The same approach can be used to update existing charts when new data is imported into the database.

- Close Excel.
Exercise Six: Trend Analysis

ESdat includes modules to undertake Mann-Kendall and Linear Regression trend analysis. The following exercise applies these statistical techniques to the water level data.

- From the Water Levels data type, select WH1_WaterLevels_AHD (also remove any filters if present)
- Click the drop-down arrow next to the Graph button in the Exports toolbar to open the Graph data in Excel dialogue box
- Click the New Chart for changes in check box and select Monitoring Unit
- Change the chart template to MultiChart Template
- Click the Trend Analysis tab and select Calculate Linear Regression Trend

![Graph data in Excel](image)

- Click the Setup tab and click the Plot button to generate the Excel chart

An Excel workbook will launch with the first worksheet presenting a Trend Summary Table. Briefly review this data.

- Select the Upper_Aquifer worksheet containing charts pertaining to the Upper Aquifer data – note there are many series displayed on the charts

The following steps will modify the graph to only include the data series displaying a trend.

- Select the Upper Aquifer graph by clicking on it
- Click on the Chart Options button (under Add Ins)
- The Change Displayed Data Series dialogue box will launch
- From the Data Worksheet drop down list select Data_Upper_Aquifer to populate the Data Series list
- From Data Series list select those series labelled as having a trend upwards (labelled as TUp; LH stands for Last Value is Highest, as shown in the figure below)
- Click the **Replace**
- The series of interest (i.e. showing a statistical upward trend) are now much easier to study, as there are only two series of data showing (as shown in the figure below)

- Close Excel without saving