**Self-Paced Training Exercises: South Africa**

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# Introduction to BenMAP-CE

**What is air pollution benefits analysis, and how can BenMAP-CE help?**

Air pollution benefits analysis is the process of applying the findings of epidemiological and economics studies to estimate the health impacts and economic value of air pollution changes in a policy setting. The environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) software allows users to conduct benefits analysis for an area of interest by aggregating multiple data sets to calculate the quantity and economic value of premature deaths and illnesses associated with changes in air pollution. The program includes a subset of air quality monitoring data, recent and projected demographic and baseline health data, concentration-response relationships drawn from the published epidemiological literature, and economic value estimates based on the published economics literature. Linking these data together allows users to more easily answer an array of policy questions (see Box 1).

**Box 1: What kinds of questions can BenMAP-CE answer?**

You can use BenMAP-CE to answer a variety of questions regarding air pollution exposure and risks. For example:

* What levels of pollution are people exposed to?
* How do health or economic benefits differ across regulatory programs?
* What are the health impacts and costs of current air pollution concentration?
* What would be the health benefits of alternative ambient air quality standards?

# About These Exercises

These self-paced training exercises were designed to provide the foundation needed to perform a basic benefits assessment. There are a total of seven exercises, each focusing on a policy scenario within one of seven different regions around the world that can be analyzed using BenMAP-CE. While each of the self-paced exercises covers the basics of BenMAP-CE, you are encouraged to try multiple exercises to get a better understanding of the breadth of data types and analysis options. Self-paced training exercises are available for four countries (China, India, Nigeria, and South Africa) and three cities (Mexico City, Mexico; Santiago, Chile; and Bangkok, Thailand). The data files necessary to complete these exercises can be found on the BenMAP-CE website. The examples described in these self-paced training exercises rely upon assumptions and input data that the United States Environmental Protection Agency (EPA) has historically used in its analyses. As you begin to conduct benefits assessments for your own area of interest, you can replace these assumptions and input data with your own values.

Each self-paced exercise is divided into five sections. In Section 1, you will install the BenMAP-CE software and familiarize yourself with the basic structure of the program. In Section 2, you will learn about the “setup” and how it should be used. You will create a new setup to use in this exercise. In Section 3 you will load the data necessary to perform benefits analysis. This will involve loading both data used to estimate health impacts and data to estimate economic values. In Section 4, you will estimate these health impacts, and in Section 5 you will estimate the economic values associated with those estimated health impacts. Throughout this document, you will see “Questions for Students” to help you think about how the steps you are taking to use the BenMAP-CE tool guide you through the overall benefits analysis process.

# Exercise Scenario and Data Requirements

In this exercise, you will be performing a benefits analysis for South Africa. In this scenario, the government is considering implementing new air quality standard that would cut total PM2.5 emissions, reducing PM2.5 concentrations by 20 percent. The cost of this program is estimated to be 17 billion South African rand. The government has asked you to quantify the benefits of this program in terms of the number of avoided air pollution-related deaths. They want to know if the potential benefits of this program outweigh its costs. This is a simplified, hypothetical scenario that demonstrates how policy makers can use information from the BenMAP-CE tool to evaluate the economic viability of a policy.

**Data Requirements**

You will need the following data files in order to complete this analysis. They can be found on the BenMAP-CE website.

|  |  |
| --- | --- |
| INPUT DATA | PURPOSE |
| Krewski\_2009\_Mortality\_Health\_Impact\_Functions.xlsx | U.S. – based health impact functions for long-term PM exposure-related lung cancer and ischemic heart disease mortality (published in Krewski et al., 2009) |
| South\_Africa\_Baseline\_Mortality\_Incidence\_2009.csv | Baseline mortality rate |
| South\_Africa\_Population\_2009.csv | 2009 population organized by demographic units |
| South\_Africa\_Monitor\_PM25\_2005.csv | PM monitoring data for South Africa |
| South\_Africa\_Border.shp | Defines border of South Africa |
| South\_Africa\_Province.shp | Defines provinces in South Africa |

# Additional Resources

In the future, you may decide to add your own data to BenMAP-CE to carry out different types of analyses. The articles listed at the end of this section can help you think through considerations for selecting studies from the epidemiological and economics literature. Please note that BenMAP-CE does not contain its own air quality dispersion modeling capabilities and instead relies on externally created air quality models and monitoring data to create air quality surfaces.

After you finish the self-paced training exercise, you should have an understanding of the datasets and data formats required to run BenMAP-CE. You should also be able to use BenMAP-CE to conduct simple benefit analyses.

We encourage you to consult the following resources for questions related to BenMAP-CE or environmental benefits analysis:

* BenMAP-CE User’s Manual and Appendices (available at <https://www.epa.gov/benmap/manual-and-appendices-benmap-ce>). This manual has been prepared for the current version of BenMAP-CE.
* Visit the BenMAP-CE Discussion Forum (<https://forum.benmap.org/>) to get updates on BenMAP related events, ask questions to other BenMAP users, and receive technical support.
* “Methodological considerations in developing local-scale health impact assessments: balancing national, regional, and local data” by Hubbell, Fann and Levy (2009) that describes the best practices for performing a local-scale health impact assessment.
* “Improving the linkages between air pollution epidemiology and quantitative risk assessment” by Fann, Bell, Walker and Hubbell (2012) that considers the type of data reported in epidemiological studies that would be most useful for risk assessments.
* “A multi-pollutant, risk-based approach to air quality management: Case study for Detroit" by Wesson, Fann, Morris, Fox and Hubbell (2010) that considers approaches for developing city-scale air quality management plans.

# Section 1: Getting Started

## 1.1 Installing BenMAP-CE

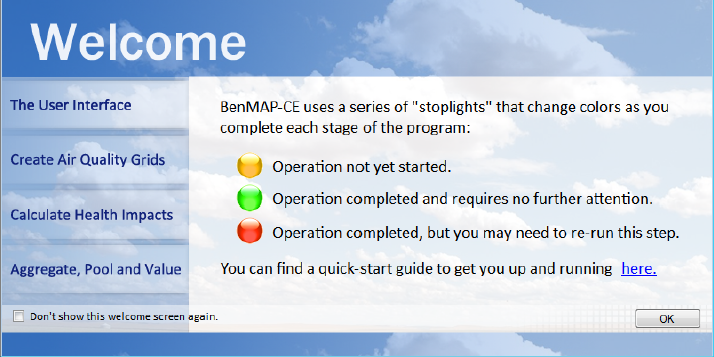
Before you start using the self-paced training materials, you need to install BenMAP-CE on your computer. (The BenMAP-CE installer is available at <https://www.epa.gov/benmap/benmap-downloads>). Detailed instructions on how to install BenMAP-CE including system requirements can also be found on the website. Please note that if you have an earlier version of BenMAP-CE, you should archive any important data and uninstall before installing the CE software release.

## 1.2 Downloading Necessary Data Files

The example datasets required to complete this analysis can be found on the BenMAP-CE website as well. Save these files to your computer in a folder to which you can easily navigate. We recommend storing them within a folder titled South Africa Self-Paced Training Exercises Data Files within your “My Documents” directory.

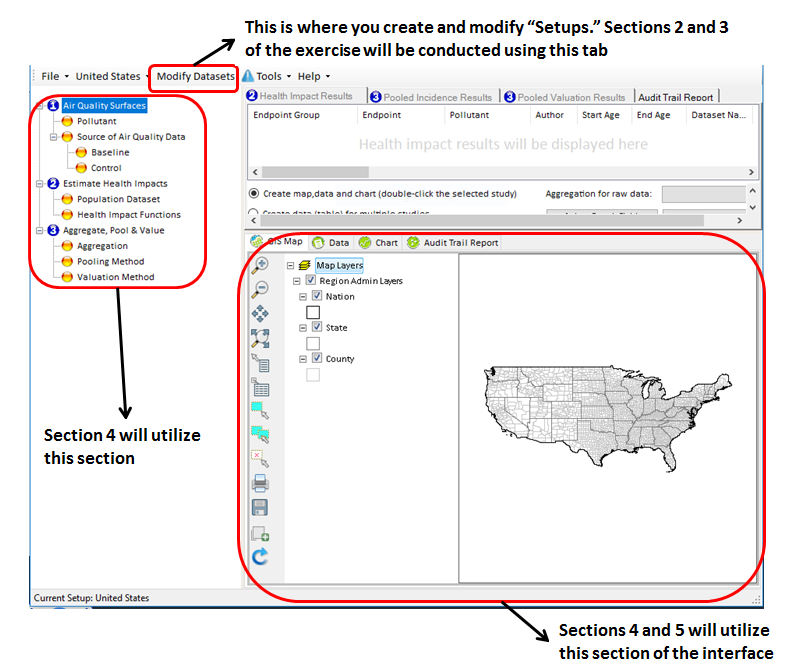
## 1.3 Opening BenMAP-CE

Once installed, BenMAP-CE will open to the Welcome Window (shown below). The tabs on the left of the Welcome Window provide an overview of the processes you will use to run the Benefits Mapping and Analysis Program software. The Welcome Window opens to the User Interface tab which highlights the stoplight metaphor in BenMAP-CE. When first launching the program you will notice a series of yellow circles on the left-hand window pane that correspond to various program analytical steps. These circles change colors based on the status of each step. Click through each of the remaining tabs and take a quick look. You will work through each of these steps in detail in these self-paced training exercises.



## 1.4 The BenMAP-CE Main Window

After closing the Welcome Window, you will see the BenMAP-CE main screen. As you work through these self-paced training materials you will interact with different parts of the BenMAP-CE interface. First, you will generate a new setup and load data into BenMAP-CE (Sections 2 and 3). This process occurs within the **Modify Datasets** window**,** which is opened by clicking the *Modify Datasets* button in the upper toolbar of the main screen. You will then generate the air quality grids, calculate health impacts, and aggregate the results (Section 4). These steps will occur in the left pane of the main window and represent the core functionality of the BenMAP-CE software. Section 5 is the final component of the process where economic value is assessed and reports are generated. These results are displayed in the right-hand mapping pane of the BenMAP-CE interface.



**After you finish Section 1, Sections 2** and **3** describe how to interact with the **Modify Datasets** windowto load data for South Africa. Once you have loaded the data, you will use it in the analysis you perform in **Section 4**. To help you understand where you use your newly loaded input data in a BenMAP-CE analysis, you will see the graphic at right throughout the user guide. This graphic shows you how the data from the setup stage is linked with each analytical step. To help you keep track of where you are in the exercise, a red box will be drawn around the step modified by the data you have input.

## 1.5 Saving BenMAP-CE Files

At various stages of the self-paced training materials you will be prompted to save a BenMAP-CE project file (.projx), which will save the file names and locations of the air quality grid (.aqgx), configuration (.cfgx), and aggregation, pooling and valuation (.apvx) that you have selected. Note that the project file does not contain these other BenMAP-CE data, but rather records their physical location on your computer.

The figure on the right, which is used throughout this exercise, displays the key elements of a health impact function. A red box will highlight the particular element affected by the curren****t step.

# Section 2: Creating a Setup

A “setup” is the collection of databases of geographic, air quality, demographic, health, and economic information that are necessary to conduct an analysis. BenMAP-CE calculates the health impacts associated with changes in air pollution using health impact functions. An example equation for a health impact function is depicted above.

As a first step in this analysis, you determine the change in air quality and how this change will affect the number of PM2.5-related deaths. The South Africa air quality monitor data is derived and adapted from modeled PM2.5 concentrations from the Global Burden of Disease (GBD) study. These data will be treated in this analysis as monitor data; that is, you assume each GBD modeled PM concentration occurs at a “monitor” at the centroid of each grid cell. The PM2.5 dataset will be used to simulate air quality conditions under the proposed policy scenario (this is done using the “Rollback Tool” in BenMAP-CE). As stated in the figure above, because you are using monitor data for this analysis, you will have to specify the geographic area from which to aggregate monitoring data and how you want BenMAP-CE to aggregate values from neighboring monitors. For example, you will need to specify whether BenMAP-CE should use air quality data from the closest monitor to a region or a distance-weighted average of multiple monitors.

Epidemiological studies document how pollutant concentrations impact the incidence of a variety of health outcomes. In this example, you will use a dose-response parameter derived from a health impacts study conducted by Krewski et al. (2009) in the U.S. to estimate how changes in PM2.5 concentrations affect the all-cause mortality incidence. Finally, by multiplying the change in incidence by the population you are able to estimate the total *number* of deaths avoided in our area of interest.

If the geographic region of your study area is small and all the data inputs are at the same spatial scale, this calculation can be done fairly easily by hand. However, if you have a large study area or if your demographic and health data are reported at variable spatial scales, this approach becomes unfeasible. BenMAP-CE allows users to do this calculation for many smaller areas within the area of interest simultaneously and has built in algorithms to address data at different spatial scales. BenMAP-CE stores all the data needed to run an analysis in a setup. In the steps below, you will create a new setup for the South Africa data.

## 2.1 Create a Blank Setup

A “setup” is a collection of databases that work together when you conduct an analysis. It is frequently helpful to divide these setups by geographic area. While there is an existing United States setup, creating a new setup will help you organize the databases you import. In these self-paced training materials, you will perform an analysis using data from South Africa, so you will create a South Africa setup. To begin:

* Start BenMAP-CE.
* Click *Modify Datasets* at the top left. This will bring up the **Modify Datasets** window.
* Click the *Add* button to the right of the *Available Setups* box.
* Type “South Africa*”* into the *New Setup Name* box in the *New Setup* window and click the *OK* button.
* Confirm that *South Africa* is listed in the *Available Setups* drop-down menu and that all other windows in the *Modify Datasets* window are blank when *South Africa* is selected.
* Click the *OK* button at the bottom right to close the **Modify Datasets**window.

**Question for Students**

**What data are required to create a new setup and run an analysis?**

# Section 3: Load Data into BenMAP-CE

The figure below lists the types of data required to conduct a health impact analysis; the first step in estimating the health impacts of any scenario is to input these data sets into the appropriate setup. In BenMAP-CE each data type is associated or linked with one or more of the other data types (data types that are linked are connected with a black line in the figure below). This means that choices made for one data type must be compatible with decisions made for other linked data types. For example, a desired health impact function may require average daily PM2.5 measurements. Therefore, the chosen monitor dataset must include values in that format, and the pollutant definition should specify that daily averages are being used.

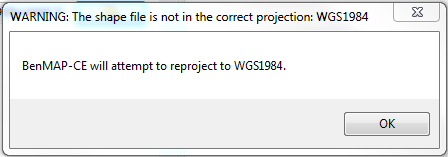
## 3.1 Adding a Grid Definition

Box 2: BenMAP-CE Terminology

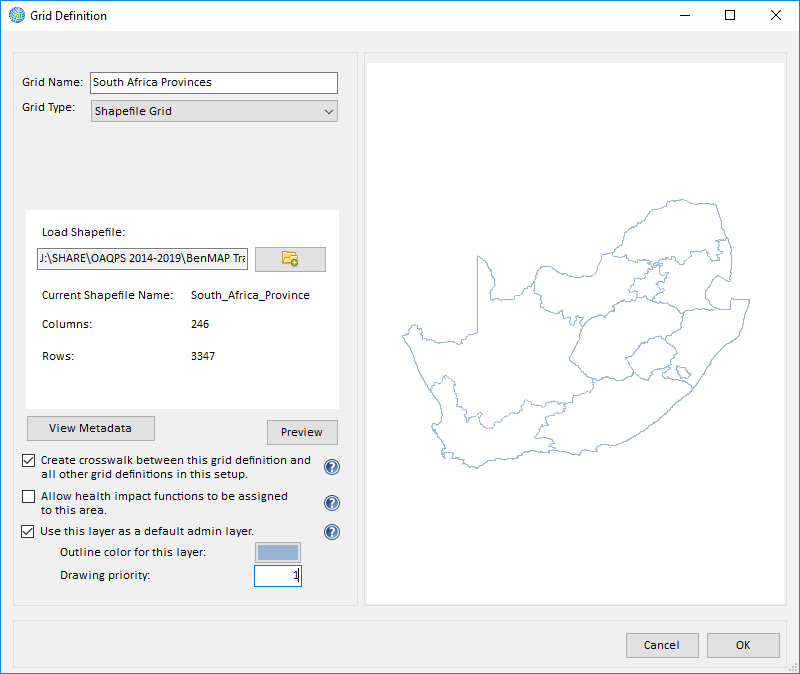
A BenMAP-CE **Grid Definition** provides a method of breaking a geographic region into areas of interest (grid cells) when conducting an analysis. This can be done in two ways – by loading a Shapefile (a particular type of GIS file) or by specifying a regular shaped grid pattern. These are referred to as **Shapefile Grid Definitions** and **Regular Grid Definitions**, respectively. Typically a Shapefile Grid Definition is used when the areas of interest are political boundaries with irregularly shaped borders, while a Regular Grid Definition is used when the areas of interest are uniformly shaped grids (e.g., rectangles). All grid definitions must have a unique (i.e., non-repeating) column and row index.

Selecting your shapefile: BenMAP-CE uses shapefiles to define the geographic areas in which the program will allocate air quality data, calculate health impacts, and aggregate results.

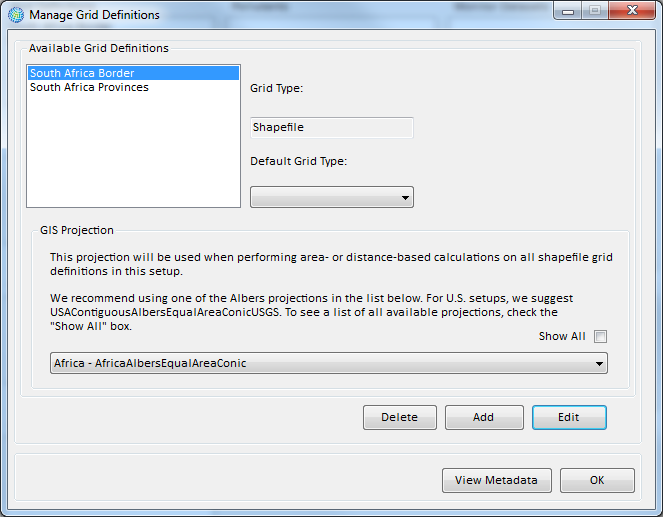
* Ensure you have BenMAP-CE open and that *South Africa* is listed as the active setup. You can confirm this by verifying that *South Africa* is selected in the drop-down box next to *File* in the menu bar.
* A message box indicating “Missing Admin Layers” may pop up on the screen. Press *OK*; admin layers will be assigned in the grid definition input section.
* Select *Modify Datasets* and click the *Manage* button under the *Grid Definitions* box. This will bring up the **Manage Grid Definitions**window.
* Select an appropriate GIS projection for your setup. For South Africa, you will use “AfricaAlbersEqualAreaConic”.
* Click the *Add* button, which will bring up the **Grid Definition**window.
* In the *Grid Name* box, type “South Africa Provinces*”.* This will be the name of one of the two new Grid Definitions you are going to add.
* Select *Shapefile Grid* from the Grid Type menu.
* Select the open folder icon , and open the “South\_Africa\_Province.shp” file.
* If your shapefile wasn’t in the correct projection, BenMAP-CE will reproject it, and the following warning message may appear. Click OK and wait for the reprojection to complete.



* Select the box next to “Create crosswalk between this grid definition and all other grid definitions in this setup.” This step may take some time, but it will allow BenMAP-CE to aggregate results at various geographic resolutions.
* Select the box next to "Use this layer as a default admin layer" and type "1" in the "Drawing Priority" box. Admin layers are displayed on the homescreen of the setup and the drawing priority dictates which grid definition is brought to the front of the map. You can change the outline color here.
* Confirm that the South Africa Provinces display correctly in the preview window. Your screen should now look like this:



* Click *OK*to return to the**Manage Grid Definitions**window***.*** Wait for the data to load. This process may take several minutes.
* Using the same steps as above, add the “South\_Africa\_Border.shp”shapefile and give it the Grid Name “South Africa Border”. Be sure to select the box next to “Create crosswalk…” for each of the Grid Definitions that you create. If you would like these grid definitions to display on the home screen, check the box next to “Use this layer…” and assign priority level 2.
* When you are done, your screen should look like this:



* Click the *OK* button to return to the **Modify Datasets** window, and the two Grid Names should appear in the Grid Definitionsbox.

**Question for Students**

**What is the relationship between the BenMAP data inputs and the grid definitions column/row index?**

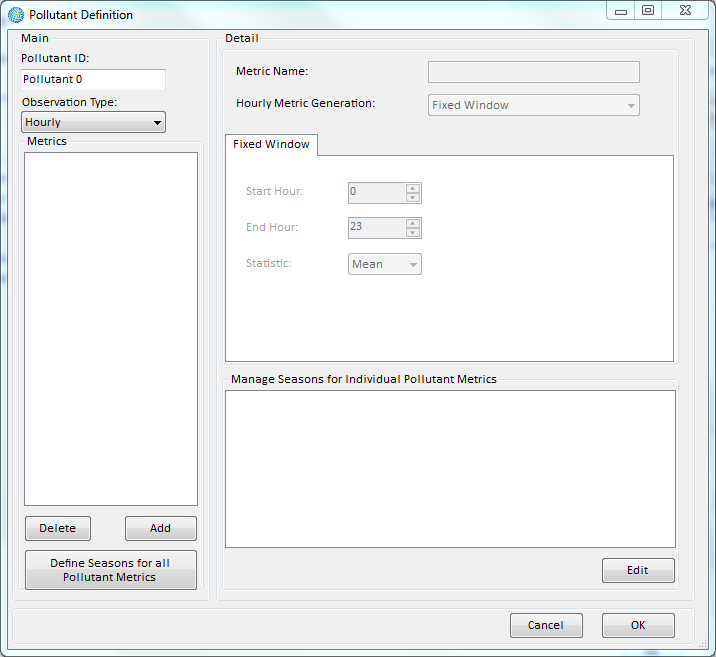
## 3.2 Define a Pollutant and Add Pollutant Data

In this step you will specify the key attributes of the pollutant for which you will later estimate health impacts, such as the time period over which the pollutant is measured or modeled. While BenMAP-CE can theoretically estimate health impacts for any pollutant, this exercise will focus on fine particulate matter (PM2.5).



### 3.2.1 Define a Pollutant

* In the **Modify Datasets** window, click the *Manage* button under the *Pollutants* box. This will bring up the **Manage Pollutants**window.
* Click the *Add* button under the *Available Pollutants* box. This will bring up the **Pollutant Definition** window, shown below.



* In the *Pollutant ID* box, type “PM2.5”. This will be the name of the new pollutant. (Note: It is very important to spell the name of the pollutant correctly, as this same will serve as a unique ID that the program links to Health Impact Functions, Model Data, etc.)

### 3.2.2 Add Multiple Metrics for a Pollutant

**Box 3: BenMAP-CE Terminology**

The **air quality metric** expresses the time period over which air quality values are modeled or observed and whether that modeled or observed air quality value is an average, maximum or minimum. For example, the metric **DailyMean** represents the average concentration for the sampling day. This could be taken directly from a single 24-hour observation or from an average of hourly (or more frequent) observations. In addition to the time period, some metrics also specify the method used for averaging or aggregation. For example, the typical ozone metric **D8HourMax** represents the maximum 8-hour moving average during the day. In general, the pollutant air quality metric should correspond to the metric as it is defined in the epidemiologic study used to quantify risks.

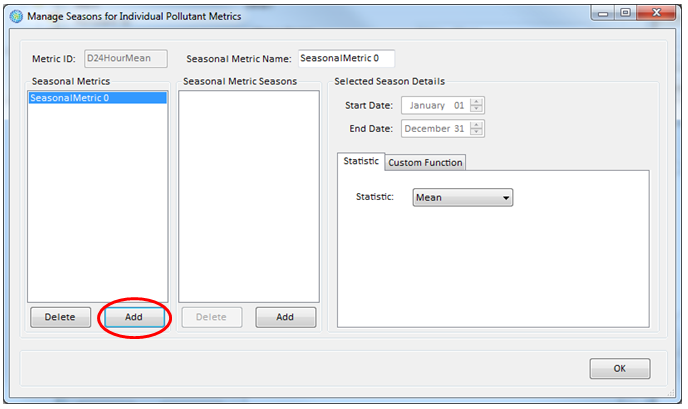
You can add multiple metrics for a single pollutant. Here you will add a PM2.5 metric averaged both daily and quarterly.

* Select *Daily* as the *Observation Type* in the drop-down menu.
* Click the *Add* button under the *Metrics* box. You will see “Metric 0”shown in the *Metrics* box.
* In this exercise, the pollutant metric is a 24-hour daily mean and you must create a name for the metric that matches across input datasets. In the monitor dataset you will import later, the metric is already labelled as “D24HourMean”. You use the same label as the Metric Name in this step to ensure compatability.
* Click in the *Metric Name* field at the top of the window and change the name from “Metric 0” to “D24HourMean”*.* This tells BenMAP-CEthat PM2.5 is a pollutant averaged over a 24 hour period each day. If you were to specify a pollutant that was averaged over part of the day (e.g. ozone), then you would change the *Hourly Metric* from *Fixed Window* to *Moving Window.* For more on metrics, you can refer to section 4.1.2 of the BenMAP-CE User’s Manual.

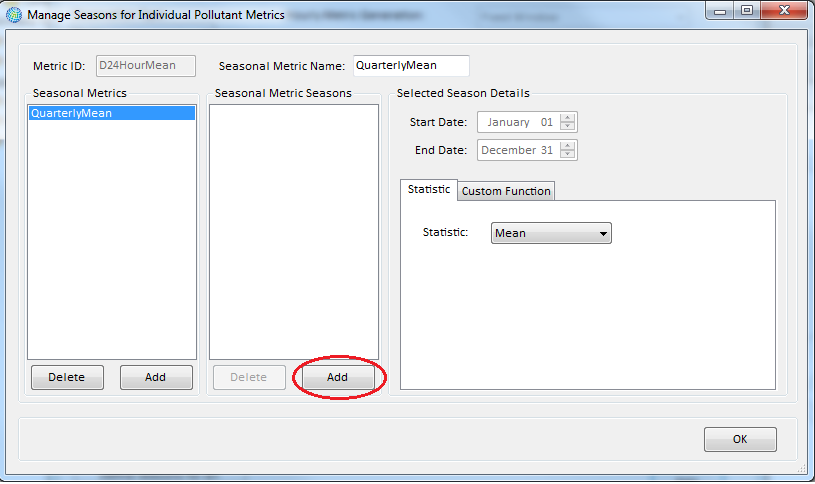
### 3.2.3 Define a Seasonal Metric

Seasonal metrics are useful for areas that experience substantial seasonal variation in pollution levels and for accommodating health impact functions which vary seasonally. You can choose to add any number of seasons to best represent the patterns in a given area. In this example, you will add four seasons of equal length. A seasonal metric tells BenMAP-CE that there is a subset of the year over which the pollutant metric should be averaged – in this case, the daily averages are compiled and averaged for each of the four seasons. For more on seasonal metrics, you can refer to section 4.1.2.2 of the BenMAP-CE User’s Manual. To add a seasonal metric:

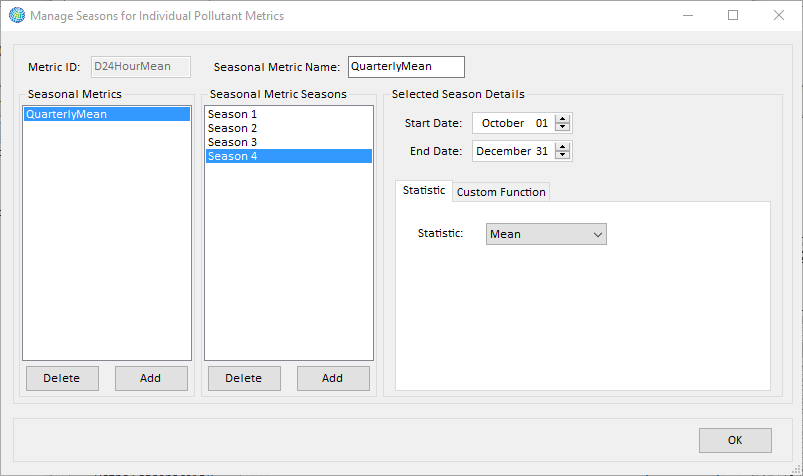
* While still in the **Pollutant Definition** window, click *Edit* at the bottom right of the box titled *Seasonal Metrics (Seasons for Individual Pollutant Metrics)*.
* This will bring up the **Manage Seasons for Individual Pollutant Metrics** window. At the bottom of the column titled *Seasonal Metrics*, click the *Add* button (circled in red below). You should see a new seasonal metric appear titled *SeasonalMetric0*. Rename this to “QuarterlyMean”.



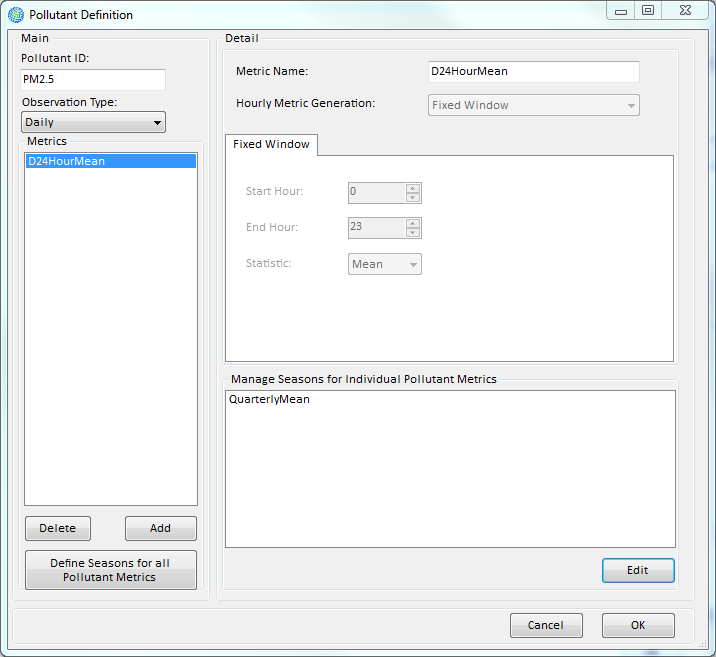
* At the bottom of the column titled *Seasonal Metric Seasons*, click the *Add* button (circled in red below). You should see a new season titled *Season 1* appear in the column to the right.



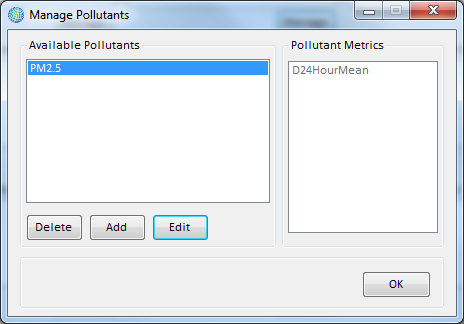
* You will add four seasons and must specify the length of each. For *Season 1* set the *End Date* to “March 31”, using the *Selected Season Details* section to adjust the season length. To change the date, highlight either month or the day and use the up and down arrows to increase or decrease the highlighted value.
* Once *Season 1* has been properly defined, click *Add* at the bottom of the *Seasonal Metric Seasons* column to add the next season. Note that the *Start Date* value is automatically set to one day after the previous season’s *End Date* value. For *Season 2* set the *End Date* to “June 30”.
* To add a third season, click *Add.* Set the *End Date* to “September 30”. To add the final season, click *Add.* The final end date will be automatically set to “December 31”. The Manage Seasons for Individual Pollutant Metrics window should look like this:



* Click *OK* to close the Manage Seasons for Individual Pollutant Metrics window. Your Pollutant Definition window should now look like this:



* Click *OK* to close the **Pollutant Definition**window. The window should look like this:



* Click *OK* to close the **Manage Pollutants** window.

*Optional:* You can go through the same steps as above to add other pollutants as needed (you may find it helpful to check the pollutant definitions in the *United States Setup*). Note that you can use other observation types (e.g., hourly) and metrics (e.g., D1HourMax, D8HourMax, seasonal metrics).

**Question for Students**

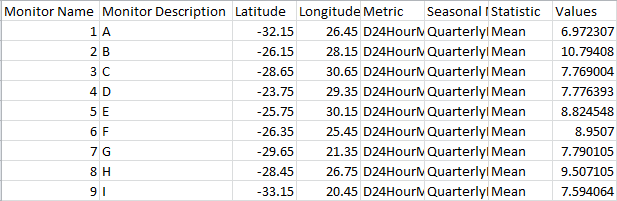
**What is the difference between a pollutant and a metric?**

## 3.3 Add Pollutant Data

**Note:** If you are using model data rather than monitor data for your analysis, you can skip this step. Monitor data may be formatted as an Excel or CSV (comma-separated values) file. For more information on the correct format for model data, see section 5.1 of the BenMAP-CE User’s Manual. This exercise will use monitor data, so continue with the steps that follow.

Locate the file that contains information from South Africa’s air quality monitors (“South\_Africa\_Monitor\_PM25\_2005.csv”) and open it in Excel or a text editor. You will see eight variables in the file: Monitor Name, Monitor Description, Latitude, Longitude, Metric, Seasonal Metric, Statistic, and Values. Monitor Name, Latitude, Longitude and Values must have values for BenMAP-CE to be able to use the file.

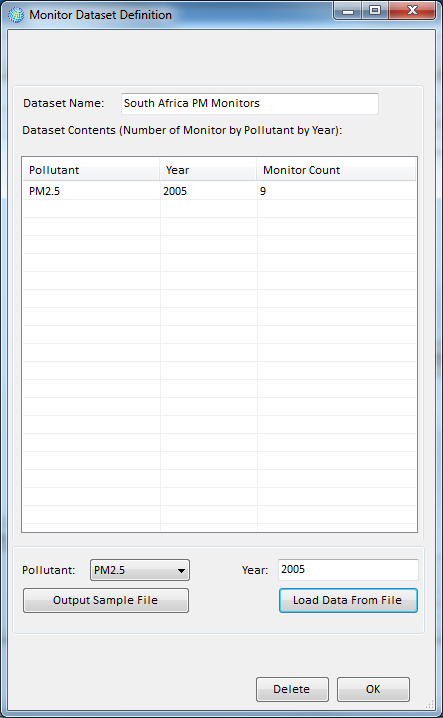
This file has one value for each monitor corresponding to annual mean PM2.5 concentrations. The “Values” variable contains a string of comma separated values. Missing values are signified with a period ('.'). The “Values” field can have one or multiple values for each monitor, corresponding to an annual statistic, or seasonal, daily, or hourly metrics. The South Africa pollution monitor file is shown below.



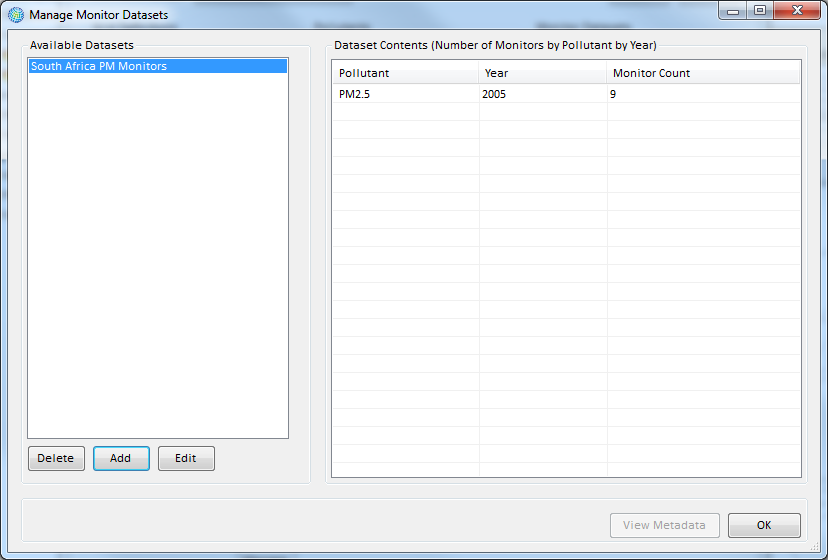
**Note:** Air pollution data that can be used in BenMAP-CE are of two types - point source monitoring data and grid-definition-based modeling data. Whichever data you use, they must be associated with a particular pollutant that you have defined. Only the point source monitoring data are stored in the setup database, whereas the modeling data are loaded into BenMAP-CE only when you conduct an analysis, and are not stored as part of the setup.

Close the “South\_Africa\_Monitor\_PM25\_2005.csv” file and begin adding it to BenMAP-CE. Make sure you are in the **Modify Datasets** window and *South Africa* is selected in the *Available Setups* drop-down menu.

* Click the *Manage* button under the *Monitor Datasets* box. This will bring up the **Manage Monitor Datasets** window.
* Click the *Add* button under the *Available Datasets* box. This will bring up the **Monitor Dataset Definition** window.
* Name the dataset by entering “South Africa PM Monitors” in the *Dataset Name* box.
* Use the Pollutant drop-down menu to select *PM2.5* (the pollutant you defined in the previous step).
* In the *Year* box, type “2005” to indicate that the PM data are from the year 2005.
* Click *Load Data From File* and use the *Browse* button to select the “South\_Africa\_Monitor\_PM25\_2005.csv” file. Click *Open*.
* Click *Validate* to run the validation tool. This ensures that the data are in a format acceptable for BenMAP-CE. This will open the **Validating Data Import** window.
* Confirm that there were 0 errors and 0 warnings. Click *OK* to close validation results. If BenMAP-CE has found errors in the validation step, details about those errors will be provided for you to make changes to the data file.
* Click *OK* in the **Load Monitor Dataset** window.
* Click *Yes* when prompted to “Save this file associated with PM2.5 and 2005.”
* Confirm that *PM2.5* is listed in the *Dataset Contents* box. The window should look like this:



* Click *OK* to close the **Monitor Dataset Definition** window and return to the **Manage Monitor** **Datasets** window. Your **Manage Monitor Datasets** screen should look like the following:



* Click the *OK* button to return to the **Modify Datasets** window. You will see *South Africa PM Monitors* appear in the *Monitor Datasets* box.

**Note:** If the purpose of your analysis is to examine air quality data, you can directly go to Section 4 now to create and map air quality grids. If you want to estimate health benefits, you will need to continue using this Guide to add a few more datasets.

**Question for Students**

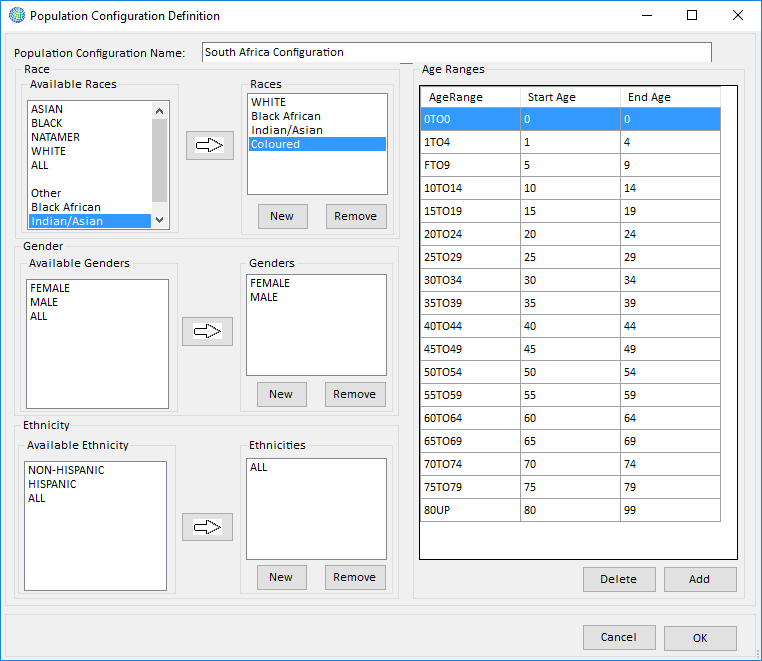
**What is the air quality metric for the South Africa PM2.5 monitor data?**

## 

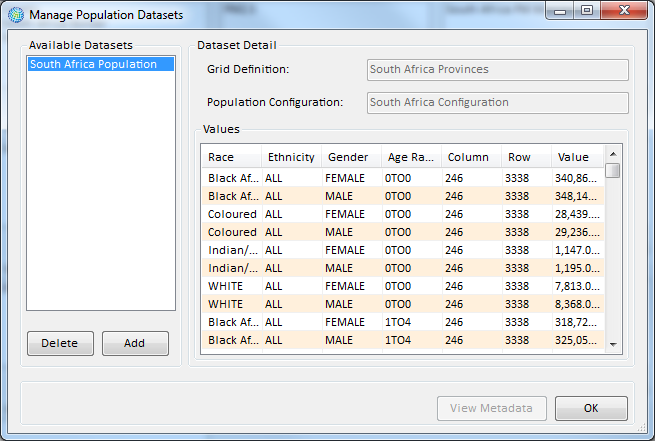
## 3.4 Add Population Data

BenMAP-CE requires population data in order to calculate the number of health outcomes over a period of time, based on the supplied incidence rates. To familiarize yourself with the required format for this data, open the South Africa population file (“South\_Africa\_Population\_2009.csv”) in Excel or a text editor. Information on the proper setup for a population file is also available in section 4.1.5 of the BenMAP-CE User’s Manual. Note that race has four categories (“Black African”, “Coloured”, ”Indian/Asian”, and “White”), gender is identified as “Male” or “Female”, and ethnicity is identified as “ALL”. There are 18 age ranges (“0TO0”, “1TO4”,”5TO9”, “10TO14”, “15TO19”,”20TO24”,”25TO29”, “30TO34”, “35TO39”, “40TO44”, “45TO49”, “50TO54”, “55TO59”, “60TO64”, “65TO69”, “70TO74”, “75TO79”, and “80TO99”). You are going to add this this configuration to this population dataset. To add the file to BenMAP-CE, close the file and return to the **Modify Datasets** window.

* Click the *Manage* button under the Population Datasets box. This will bring up the **Manage Population** Datasets window.
* Click the *Add* button under the Available Datasets box. This will bring up the **Load Population Dataset** window.
* In the Population Dataset Name box, type “South Africa Population”. This will be the name of the new population dataset.
* In the Grid Definition drop-down window, select *South Africa Provinces,* because the population data is reported at the Province level.
* Next, you need to define the population data that you are loading into BenMAP-CE. In the Population Configuration box, select *Add* to open up the dialogue box.
* In the Population Configuration Name box, type “South Africa Configuration”.This will be the name of the new population configuration dataset.
* Click *New* under the Races box and enter “Black African” as the New Race Name. Repeat this step to define “Coloured” and “Indian/Asian” as new race names. Select “WHITE” under Available Races, “FEMALE” and “MALE” under Available Genders, and “ALL” in the Available Ethnicity box. You must press the white arrow to advance the selection into the empty box to the right of each list.
* Note: While BenMAP-CE should be able to handle case differences between the population file and population configuration, to ensure that you do not have any problems loading in your data and conducting an analysis check that the cases between the population file and configuration match.
* Click *Add* under the Age Ranges box to manually type in the incremental ages that correspond to the age ranges from the CSV file. You must use exactly the same name as in the .csv file (in this case “0TO0”, “1TO4”,”5TO9”, “10TO14”, “15TO19”,”20TO24”,”25TO29”, “30TO34”, “35TO39”, “40TO44”, “45TO49”, “50TO54”, “55TO59”, “60TO64”, “65TO69”, “70TO74”, “75TO79”, and “80UP”). Enter the complete age range as the Age Range ID, and the start and end ages for the range in the “Low Age” and “High Age” fields. Note the difference between a zero (“0”) and a capital “O” when entering the Age Range ID’s. For the “80UP” category, enter “99” in the “High Age” field.
* Your **Population Configuration Definition** window should now look like the one below.



* Click OK to close the window. Confirm that South Africa Configuration is selected in the Population Configuration drop-down menu then click Browse to select the file “South\_Africa\_Population\_2009.csv”. Click Validate to confirm that the input file is configured correctly. Click OK to close the validation window. Next, select OK to import the population data. Your Manage Population Datasets window should look like the one below.



* Click *OK* to close the **Manage Population Datasets** window and return to the **Modify Datasets** window.

You have now finished adding the population data necessary for our analysis. The population data will be used in Step 2 of the analysis, Estimate Health Impacts. Because you have only loaded the data, the stoplight should still be yellow, as pictured to the right.

**Question for Students**



**What races are included in the South Africa Population data?**

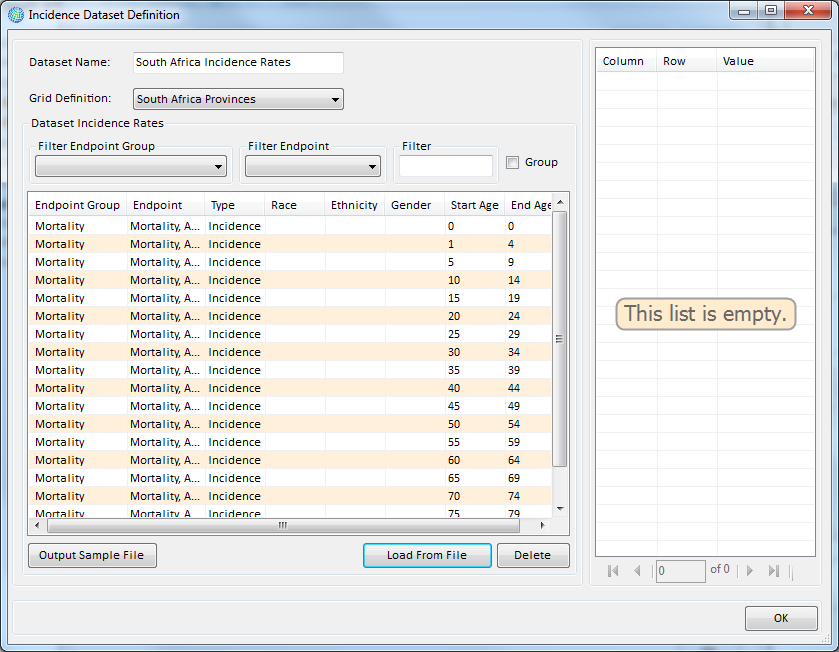
## 3.5 Add Incidence Data



The incidence rate is the number of health outcomes (e.g., number of hospital visits or deaths) per person, per unit of time (generally a day or a year)—from air pollution as well as all other causes. In this exercise you are ultimately interested in quantifying and monetizing the number of avoided deaths associated with a reduction in PM2.5 concentrations. Therefore, you will utilize a baseline all-cause death (mortality) rate.

Locate and open the incidence rate file for mortality in South Africa (“South\_Africa\_Baseline\_Mortality\_Incidence\_2009.csv”). Note the configuration of the names of the columns and rows in the file for future evaluations when you might need to use incidence rates for other endpoints or populations. To add mortality rates to BenMAP-CE:

* Click the *Manage* button under the *Incidence/Prevalence Rates* box. This will bring up the **Manage Incidence Datasets** window.
* Click the *Add* button under the *Available Datasets* box. This will bring up the **Incidence Dataset Definition** window.
* In the Dataset Name box, type “South Africa Incidence Rates”*.* This will be the name of the new incidence dataset.
* Select *South Africa Provinces* from the Grid Definition menu. This is appropriate for incidence data reported at the Provincial level.
* Click the *Load from File* button. Click the *Browse* button, locate the CSV file with the incidence dataset (“South\_Africa\_Baseline\_Mortality\_Incidence\_2009.csv”), and click *Open.*
* Click *Validate* to run the validation tool before importing the file. This is a required step that ensures the data is in the correct format for BenMAP-CE to use. Confirm that there were no errors or warnings found in the validation process. If errors are found in a file you are importing, consult section 4.1.4.1 of the BenMAP-CE User’s Manual for information regarding the required format for files imported into BenMAP-CE. Click *OK* to close the validation results.
* Click *OK* in the **Load Incidence/Prevalence Database** window.
* Once BenMAP-CE is finished loading the data, the **Incidence Dataset Definition** window should look like this:



* Click *OK* to return to the **Manage Incidence Datasets** window.
* Click *OK* to return to the **Modify Datasets** window.

You have now finished adding the baseline incidence data necessary for our analysis. The baseline incidence data will be used in Step 2 of the analysis, Estimate Health Impacts. Because you have only loaded the data, the stoplight should still be yellow, as pictured to the right.



**Question for Students**

**What health endpoints are included in the South Africa Incidence Rates?**

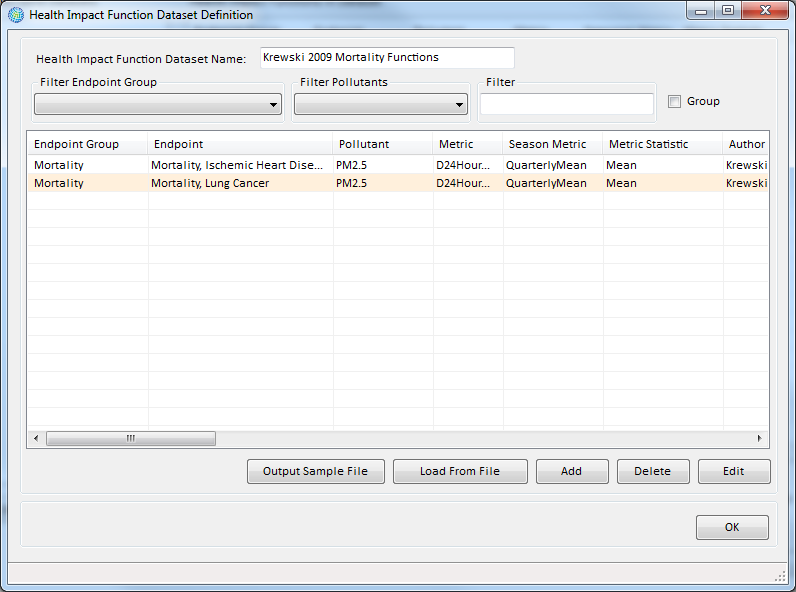
## 3.6 Add Health Impact Functions



BenMAP-CE contains a large library of health impact functions developed using risk estimates reported in peer-reviewed epidemiology studies. There are two ways to add health impact functions to BenMAP-CE. The first technique imports a .csv or .xlsx file. This approach is best when you wish to import a large number of functions. The second is to program a function manually, using the BenMAP-CE function editor. You will learn both techniques here.

### 3.6.1 Technique 1: Importing Health Impact Functions as .csv or .xlsx Files

* First, select *Manage* under *Health Impact Functions*. Select *Add* and then enter “Krewski 2009 Mortality Functions” as the *Health Impact Function Dataset Name*.
* Next, select *Load From File* and then select *Browse.* Confirm that *All Files* is chosen under file type. Select the file titled “Krewski\_2009\_Mortality\_Health\_Impact\_Functions.xlsx”. Click *Open*. Next, select *Validate* and then select *OK* to close the data validation window. Click *OK* again to load the file. Your screen should look something like this:

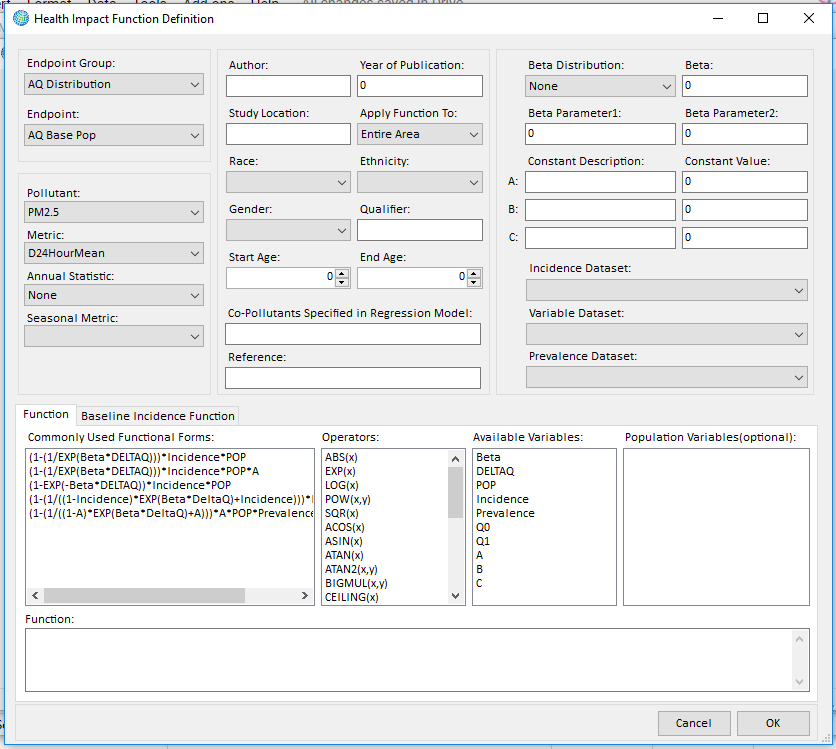


* Click *OK* to close the **Health Impact Function Dataset Definition** window. Click *OK* to return to the **Modify Datasets** window.
* You may find it helpful to review the study “Extended analysis of the American Cancer Society study of particulate air pollution and mortality” by Krewski et al. (2009) as an example epidemiological study used to develop health impact functions. The effect estimates for lung cancer and ischemic heart disease mortality from this study are part of the function that you just imported into BenMAP-CE using the .xlsx file.

### 3.6.2 Technique 2: Entering Health Impact Functions Using the Health Impact Function Editor

You will now practice entering a health impact function into BenMAP-CE using the function editor. Previously, you imported two mortality functions from Krewski et al. (2009) for lung cancer and ischemic heart disease using an Excel file. Now, you will add a function from the same study for all-cause mortality using the function editor.

* Click *Manage* in the *Health Impact Functions* section of the **Modify Datasets** window.
* You should see *Krewski 2009 Mortality Functions* listed in the Available Datasets box. Click the *Edit* button, located at the bottom of the Available Datasets box. This will bring up the **Health Impact Function Dataset Definition** window. Click *Add* at the bottom right of the box.
* This will bring up the Health Impact Function Definition window. It should look like this when you begin:

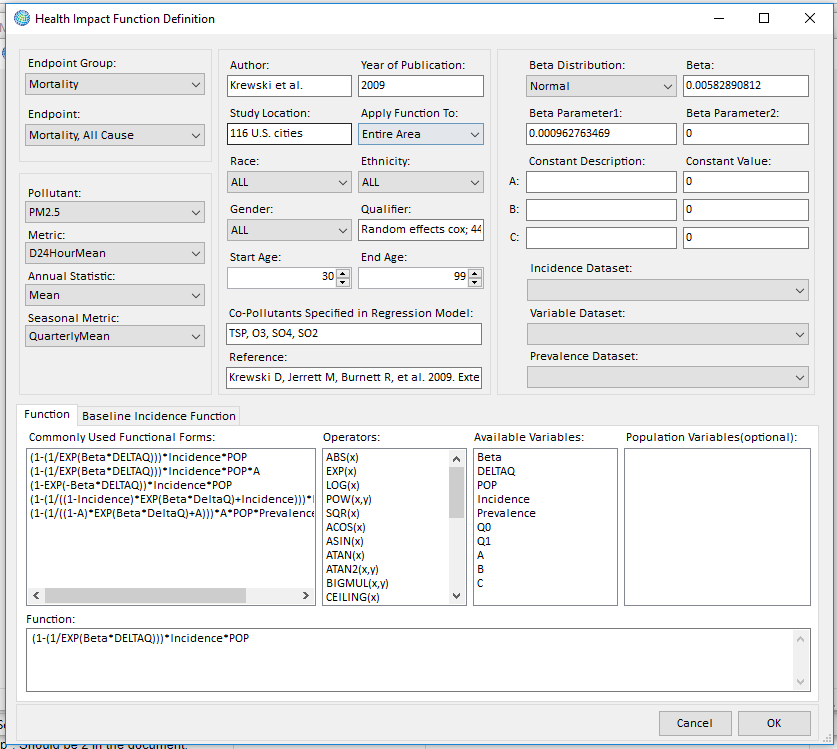


* Record the following information in each corresponding field. Do not enter anything into a field if it says “Blank” next to the field name below**.**

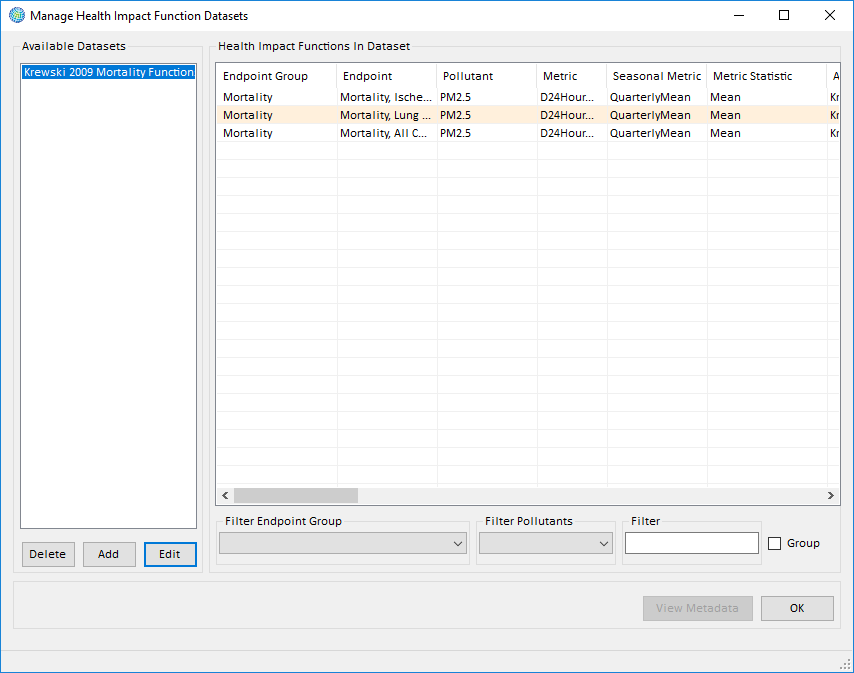
**Table 1: Details to Manually Enter a Health Impact Function**

| FIELD NAME | TEXT/VALUE | VARIABLE DESCRIPTION |
| --- | --- | --- |
| Endpoint Group | Mortality | Health impact endpoint group |
| Endpoint | Mortality, All Cause | Specific health impact within that endpoint group |
| Pollutant | PM2.5 | Pollutant analyzed in the study |
| Metric | D24HourMean | Pollutant measurement type |
| Annual Statistic | Mean | Annual statistic for which pollutant is analyzed in study |
| Seasonal Metric | QuarterlyMean | Seasonal metric for which pollutant is analyzed in study |
| Author | Krewski et al. | Study author |
| Year of Publication | 2009 | Year of study publication |
| Study Location | 116 U.S. cities | Study location type |
| Apply Function To | Entire Area | Determines area to apply health impact function |
| Race | ALL | Race of study population |
| Ethnicity | ALL | Ethnicity of study population |
| Gender | ALL | Gender of study population |
| Qualifier | Random effects cox; 44 individual and 7 ecologic co-variates; '99--'00 follow-up (Commentary table 4) | Additional information about the study that can be helpful when choosing health impact functions within your analysis |
| Start Age | 30 | Start age of study population |
| End Age | 99 | End age of study population |
| Co-Pollutants Specified in Regression Model | TSP, O3, SO4, SO2 | Other pollutants included in regression model as covariates (not including the pollutant being analyzed as the main effect) |
| Reference | Krewski D, Jerrett M, Burnett R, et al. 2009. Extended Follow-Up and Spatial analysis of the American Cancer Society Linking Particulate Air Pollution and Mortality. Health Effects Institute, Cambridge MA | Study reference information |
| Beta Distribution | Normal (You will get a pop-up window called Edit Distribution Values. Click OK to close it.) | Distribution of study’s beta value |
| Beta | 0.00582890812 | Beta value, as determined by study’s relative risk, odds ratio, or hazard ratio |
| Beta Parameter 1 (the standard error) | 0.000962763469 | Standard error of that beta value, as determined by the study’s standard error estimate |
| Beta Parameter 2, Constant Description, Constant Value, Incidence Dataset, Variable Dataset and Prevalence Dataset | Blank (or zero) | Parameter that can be used to include additional constants into the health impact equation |
| Function | (1-(1/EXP(Beta\*DELTAQ)))\*Incidence\*POP (Double click this function to move it from the function list to the bottom box.) | Study equation functional form |
| Baseline Incidence Function | Incidence \* POP (Double click this function to move it to the bottom box.) | Baseline incidence functional form |

* Your **Health Impact Function Definition**window should look like this:



* Click *OK* twice to close the two **Health Impact Function Dataset Definition**windows.
* The **Manage Health Impact Function Datasets** window should now have all three Krewski et al. functions listed and look like this:



* Click *OK* to close the **Manage Health Impact Function Datasets**window. You now have entered three Krewski et al. (2009) mortality functions into BenMAP-CE -- two (lung cancer and ischemic heart disease mortality) imported via an Excel file and one (all-cause mortality) entered manually using the function editor. You will use these three functions to estimate mortality incidence for South Africa in the final steps of this exercise.

You have now finished adding the health impact function data necessary for your analysis. The health impact functions will be used in Step 2 of the analysis, Estimate Health Impacts. Because you have only loaded the data, the stoplight should still be yellow, as pictured to the right.



**Question for Students**

**What are the health endpoints of the Krewski et al. (2009) health impact functions?**

## 3.7 Add Valuation Functions

Box 4: BenMAP-CE Terminology

The value of an avoided premature mortality is generally calculated using the **Value of Statistical Life** (VSL). The value of a statistical life is the monetary value that a group of people are willing to pay to slightly reduce the risk of premature death in the population

Mortality valuation estimates for this exercise are derived from a US estimate for the value per statistical life (VSL). The US estimate should be adjusted to obtain a country- and year-specific VSL estimate prior to entering it in BenMAP-CE. The adjusted estimate accounts for both differences across countries and differences in income and inflation over time. In this case, you will convert the VSL to South African rand. We recommend that you carefully follow each step and calculate the value of each term separately, as shown.

If the original VSL estimate is in 1990 US dollars:

Assuming that , the income elasticity of the VSL (i.e., how sensitive VSL is to changes in income), is the same for income adjustments across countries () and over time (), the above equation simplifies to:

= **A \* B \* C \* D**

Where:

* is the VSL value for South Africa in 2015 South African rand
* is the VSL value for the US in 1990 US dollars
* is the per capita GDP of the specified country in the specified year, expressed in constant international (PPP-adjusted) dollars
* is the income elasticity of the VSL ; BenMAP-CE default = 0.4
* is the Purchasing Power Parity index in 1990 in units of South African rand per international dollar
* is the consumer price index in the specified country in the specified year

Using the values presented in Table 2 (or equivalent data for the country for which you are making the calculations), calculate the values for A, B, C, and D and record your results in Table 3. This can be done using a calculator, Microsoft Excel or OpenOffice Calc.

**Table 2. Values to Adjust United States VSL Estimates to South Africa VSL Estimates**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| COUNTRY | YEAR | VSL  (MEAN) | GDP PER CAPITA (CONSTANT 2010 US $)[[1]](#footnote-1) | PPP (SOUTH AFRICAN RAND PER INTERNATIONAL $)1 | CONSUMER PRICE INDEX (2010 = 100)[[2]](#footnote-2) |
| United States | *1990* | $4,800,000[[3]](#footnote-3) | $36,312 | *-* | *-* |
| South Africa | *1990* | *-* | $6,058 | 1.27 | 23.75 |
| *2015* | *Estimated by equation* | $7,605 | 5.56 | 130.14 |

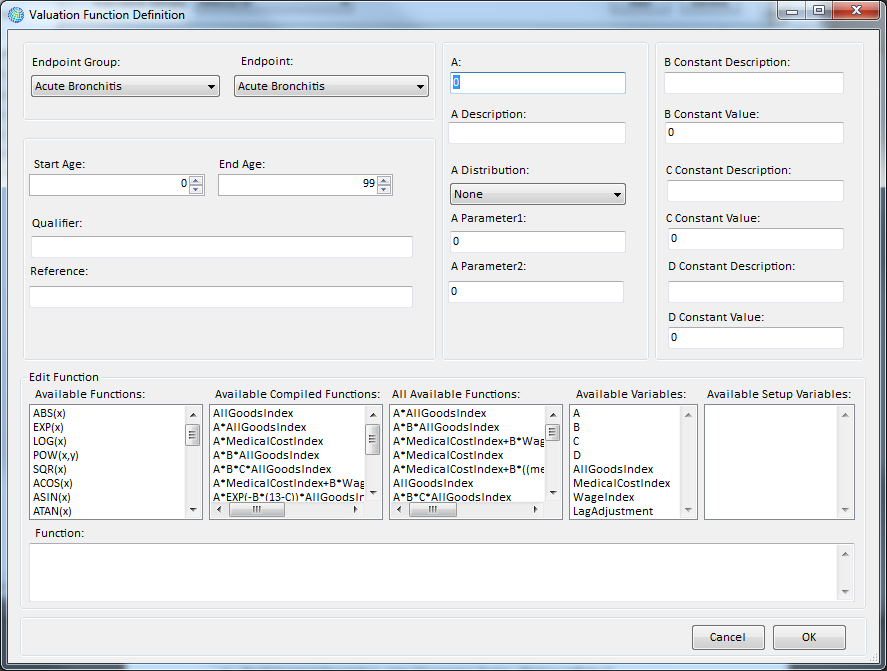
**Table 3. Calculated Values for VSL Adjustment from the United States (1990) to South Africa (2015)**

|  |  |
| --- | --- |
| PARAMETER | VALUE |
| A: | $4,800,000 |
| B: | 0.5351 |
| C: | 1.27 |
| D: | 5.48 |

**Table 4. Sources for Values Used in Valuations Adjustments**

|  |  |
| --- | --- |
| SOURCE | URL |
| World Bank (CPI, PPP, and GDP per capita) | http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators |
| OECD (Alternate CPI source) | https://data.oecd.org/price/inflation-cpi.htm |
| FRED (Alternate CPI source) | <https://fred.stlouisfed.org/categories/32264>​ |

* In the **Modify Datasets** window, click *Manage* under the *Valuation Functions* box. This will bring up the **Manage Valuation Function Datasets** window. Click *Add*. This will open the **Valuation Function Dataset Definition** window. Enter “South Africa Valuation” in the *Valuation Function Dataset Name* field. [[4]](#footnote-4)
* Click *Add*. This will bring up the **Valuation Function Definition** window, which looks like this:

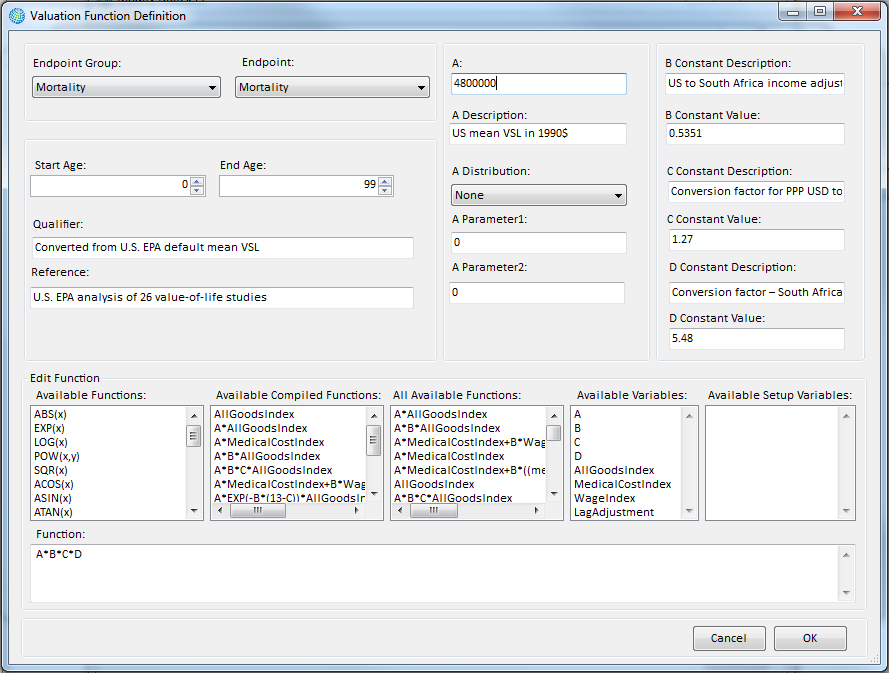


Record the information in Table 5 for each corresponding field:

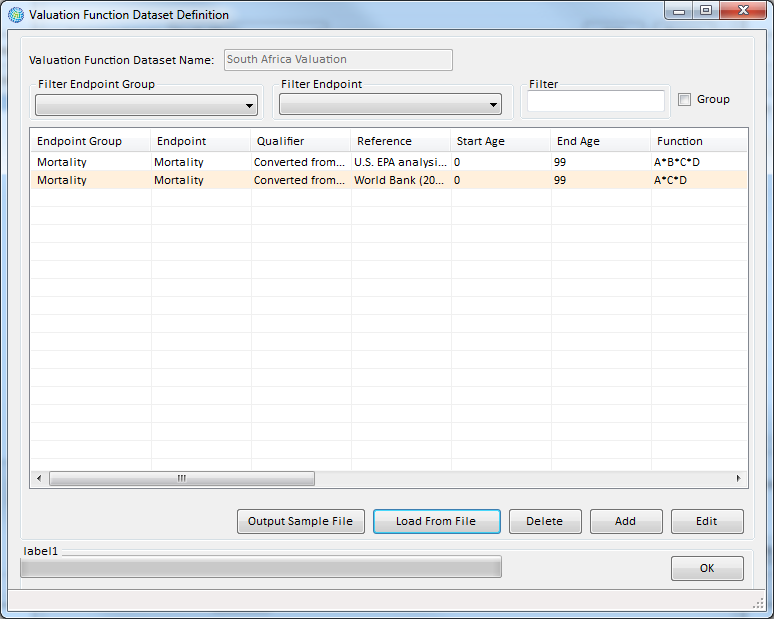
**Table 5. Details to Enter the Valuation Function Manually**

| FIELD NAME | TEXT/VALUE |
| --- | --- |
| Endpoint Group | Mortality |
| Endpoint | Mortality |
| A | US VSL in 1990; In Table 2 above 4800000 |
| Start Age | 0 |
| End Age | 99 |
| Qualifier | Converted from U.S. EPA default mean VSL |
| Reference | U.S. EPA analysis of 26 value-of-life studies |
| A Description | US mean VSL in 1990$ |
| B Constant Description | US to South Africa income adjustment |
| B Constant Value | Calculated value “B” from Excel spreadsheet; in Table 3 above |
| C Constant Description | Conversion factor for PPP USD to South African rand |
| C Constant Value | Calculated value “C” from Excel spreadsheet; in Table 3 above |
| D Constant Description | Conversion factor – South Africa Inflation |
| D Constant Value | Calculated value from Excel spreadsheet; in Table 3 above |
| A Distribution | None |
| A Parameter 1 | 0 |
| A Parameter 2 | 0 |
| Function | A\*B\*C\*D |

* After all the information has been entered, verify that the **Valuation Function Definition** window looks like the completed one below:



* Click *OK*. At this point, the *Valuation Function* Dataset box should look like this:



In some instances, a country-specific VSL estimate may already exist. A local study or government agency may provide such estimates. In these cases, no adjustment is necessary for differences in income levels across countries. However, it may be necessary to convert to local currency units or adjust for income growth over time. You will use a local VSL estimate from World Bank (2016), a study that transferred an OECD (2012) VSL estimate of $3,830,000 (2011$) to other countries using an income elasticity of 0.8. For estimates in International (PPP-adjusted) dollars:

= **A \* B \* C \* D**

Where:

* is the VSL value for South Africa in 2015 South African rand
* is the VSL value for South Africa in 2011 international dollars
* is the per capita GDP of the specified country in the specified year, expressed in constant international (PPP-adjusted) dollars
* is the purchasing power parity index in 2011 in units of South African rand per international dollar
* is the income elasticity of the VSL ; OECD assumption = 0.8
* *CPI* is the consumer price index in the specified country in the specified year

Using the values presented in Table 6(or equivalent data for the country for which you are making the calculations), calculate the values for A, B, C, and D and record your results in Table 7. This can be done using a calculator, Microsoft Excel or OpenOffice Calc.

**Table 6. Values to Adjust From 2011to 2015 South Africa VSL**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| COUNTRY | YEAR | VSL  (MEAN) | GDP PER CAPITA (CONSTANT 2010 INTERNATIONAL $)[[5]](#footnote-5) | PPP (CHILEAN PESOS PER INTERNATIONAL $)4 | CONSUMER PRICE INDEX (2010 = 100)[[6]](#footnote-6) |
| South Africa | *2011* | $1,026,724[[7]](#footnote-7) | $7,494 | 4.77 | 105.00 |
| *2015* | *Estimated by equation* | $7,605 | 5.56 | 130.14 |

**Table 7. Calculated Values for South African VSL Adjustment from 2011 to 2015**

|  |  |
| --- | --- |
| PARAMETER | VALUE |
| A: | $1,026,724 |
| B: | 1.012 |
| C: | 4.77 |
| D: | 1.24 |

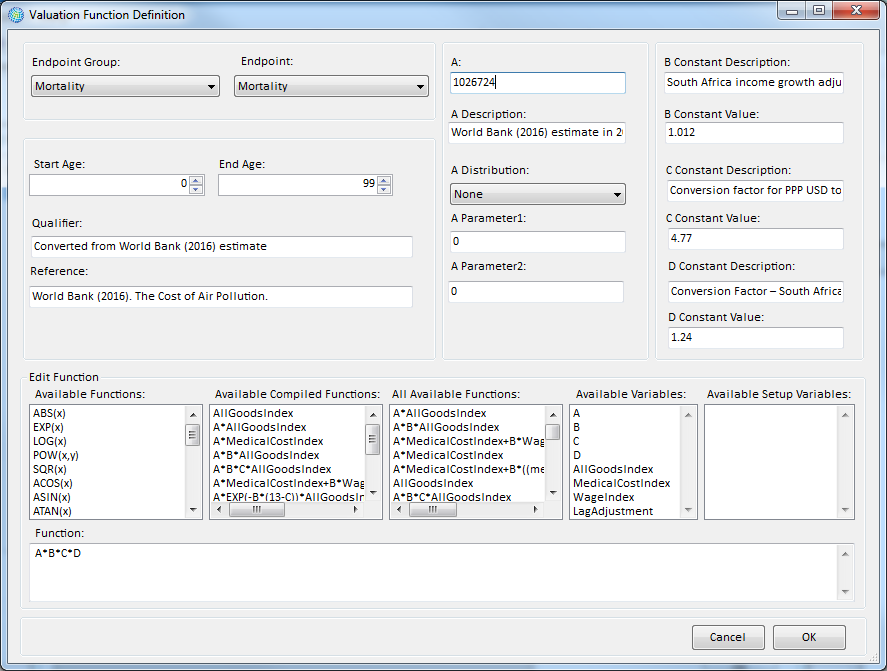
Now return to the Valuation Function Dataset Definition window:

* Click *Add* to bring up a new **Valuation Function Definition** window and repeat these steps to enter the valuation function above. For this estimate, you will have new values for A, B, C, and D, derived in Table 7 above. Record the information in Table 8 for each corresponding fields:

**Table 8. Details to Enter the Valuation Function Manually**

|  |  |
| --- | --- |
| FIELD NAME | TEXT/VALUE |
| Enpoint Group | Mortality |
| Endpoint | Mortality |
| Start Age | 0 |
| End Age | 99 |
| Qualifier | Converted from World Bank (2016) estimate |
| Reference | World Bank (2016). The Cost of Air Pollution. |
| A | Provided as value “A” in table 7 above |
| A Description | World Bank (2016) estimate in 2011 international dollars |
| B Constant Description | South Africa income growth adjustment |
| B Constant Value | Calculated value “B” from Excel spreadsheet; in Table 7 above |
| C Constant Description | Conversion factor for PPP USD to South African rand |
| C Constant Value | Calculated value “C” from Excel spreadsheet; in Table 7 above |
| D Constant Description | Conversion Factor – South African Inflation |
| D Consant Value | Calculated value “D” from Excel spreadsheet; in Table 7 above |
| A Distribution | None |
| A Parameter 1 | 0 |
| A Parameter 2 | 0 |
| Function | A\*B\*C\*D |

* Click *OK*. With the addition of this new valuation function, the *Valuation Function Dataset* should look like this:



* Click *OK* to return to the **Modify Datasets** window. Confirm that both converted VSL functions appear in the *Valuation Functions* box in the **Modify Datasets**window, as shown below.

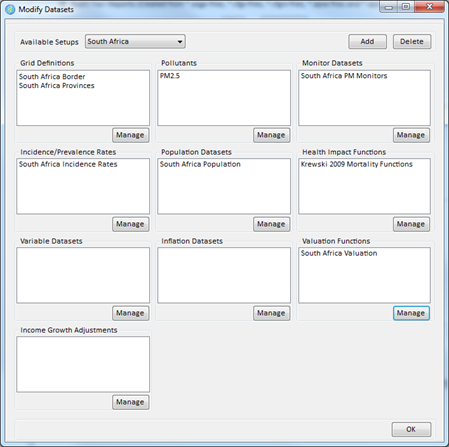


You have now finished adding the valuation data necessary for our analysis. The valuation data will be used in Step 3 of the analysis, Aggregate, Pool & Value. Because you have only loaded the data, the stoplight should still be yellow, as pictured to the right.

**Question for Students**

**What are the sources for the valuation estimates? Why is it necessary to adjust these estimates for use in South Africa?**

You have now successfully added all the necessary data to BenMAP-CE in order to conduct a comprehensive analysis. The **Modify Datasets** window should look like the window below. It is important that each section is complete and contains data.



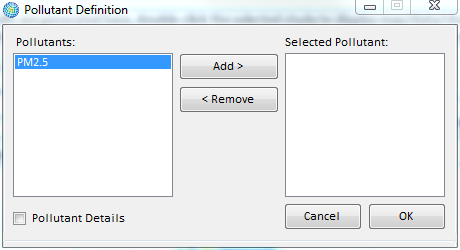
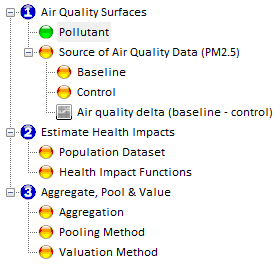
# Section 4: Estimating Health Impacts

**4.1 Create Air Quality Grids**

BenMAP-CE estimates health impacts with user-supplied air quality data; the program is not and does not contain an air quality model. BenMAP-CE provides three options for creating air quality grids: Model Direct, Monitor Direct, and Monitor Rollback. You will use a Monitor Rollback in this analysis. A Model Direct analysis uses two separate modeled air quality grid surfaces and compares them to calculate an air quality delta by grid cell. A Monitor Direct analysis uses two separate monitoring-based air quality surfaces and compares them to calcualte an air quality delta by the grid cell or adminstrative boundary for which the monitored data surfaces are created. A Monitor Rollback uses a monitored air quality surface over a gridded area or administrative boundary and “rolls back” the measured pollutant values either by a percentage, increment, or rolls those values back to a known air quality standard.

Now that you have loaded all the necessary files to create a new South Africa setup, you can begin your analysis. The first step of this process is creating air quality grids.

* Start on BenMAP-CE’s main screen, and verify that *South Africa* is selected from the drop-down menu next to the File menu.
* You will first define the pollutant for your analysis. Double click on *Pollutants*. The following window will appear:

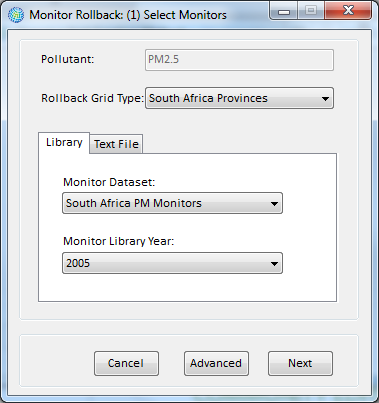


* With PM2.5 highlighted, click the *Add* button to move it to the *Selected Pollutant* box.
* Click *OK.* The stoplight indicator for *Pollutant* should change from yellow to green as shown on the figure to the right.
* Next, you will select your baseline and control air quality data. First, double click on *Baseline* to open the **Choose a Grid Creation Method** dialogue box.
* Choose *Monitor Rollback* and for Grid Type, select *South Africa Provinces*, which will interpolate the air quality monitoring data at the Province level. Click *Next*.

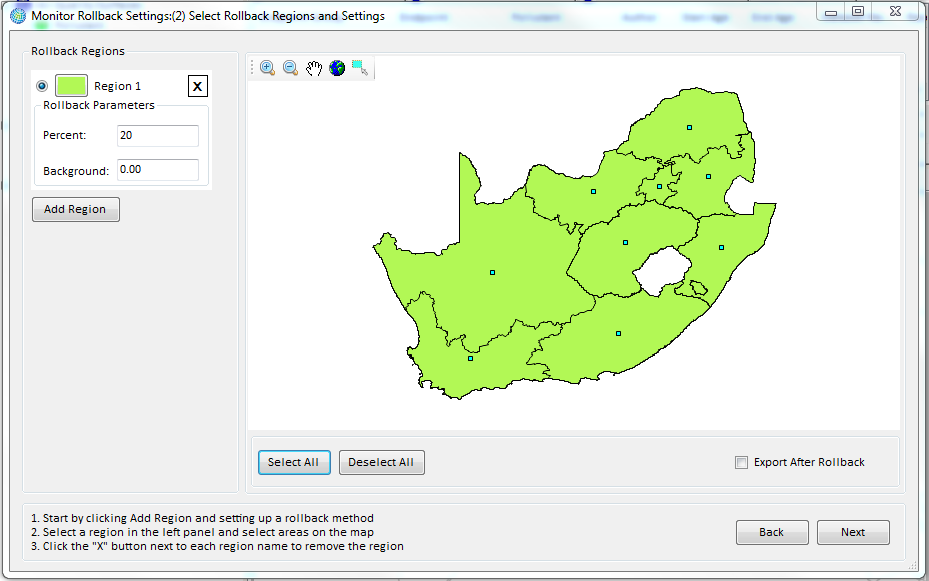
Box 5: BenMAP-CE Terminology

A **rollback** is the process by which monitor data are reduced to a different level. BenMAP-CE rolls back monitor data in three ways. **Percentage rollback** reduces all monitor observations by the same percentage**. Incremental rollback** reduces all observations by the same increment. **Rollback to a standard** reduces monitor observations so that they just meet a specified standard.

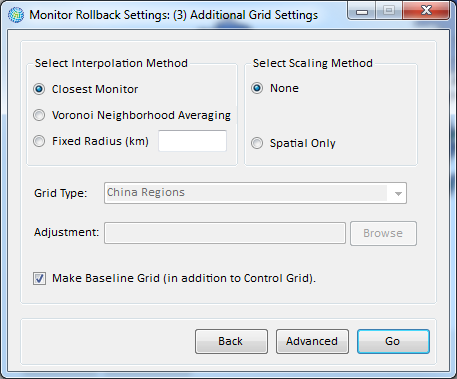
* In the **Monitor Rollback** dialogue box, the *Rollback Grid Type* menu will determine how you can specify rollback regions (for South Africa as a whole or by South African Provinces). Select *South Africa Provinces* as the Grid Type (this allows us to specify different rollback options for different portions of the country, although you will not be doing that in this analysis).
* Next, select *South Africa PM Monitors* from the *Monitor Dataset* menu. Select *2005* from the Monitor Library Year menu. The window should look like this:

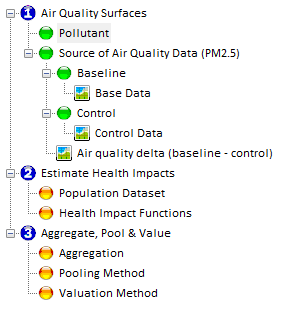


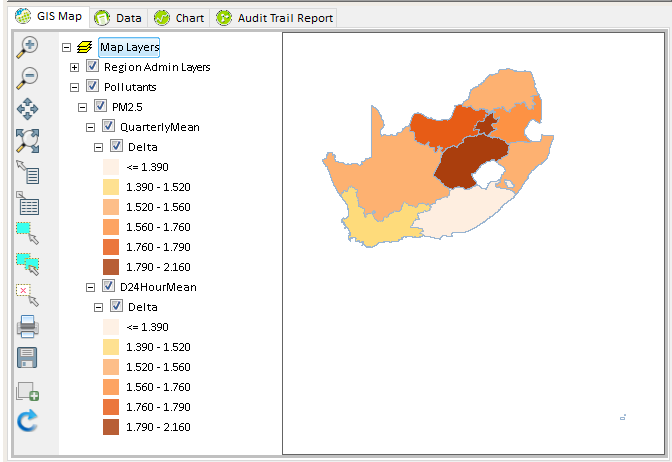
* Click *Next.* The **Monitor Rollback** window will now open with the map of South Africa Provinces and the location of the monitoring stations. Press *Add Region,* and the *Select Region Rollback Type* dialogue box will open.
* Three rollback options are available. Select *Percentage Rollback* and press *OK*, then enter a percentage to which you would want the pollution to be reduced. For example, for 20%, enter “20” in the *percent* field. You wil leave the background concentration at 0 for demonstrative purposes in these training materials.
* Next, select the *South Africa Provinces* by clicking *Select All*. Your screen should look like this (the colors may vary):



* Click *Next*. The **Monitor Rollback Settings: (3) Additional Grid Settings** window will appear. Select “Closest Monitor” as the interpolation method, as shown below. The closest monitor is used because the South African air quality monitor data is derived from model data, meaning it is already an average for each region with the hypothetical monitor placed in the center of each region. Click *Go*.



* Next, two windows will open, the first for baseline, and the second for control. Enter “South Africa\_PM\_Baseline” as the file name for the baseline and “South Africa\_PM\_20\_percent\_Rollback” as the file name for the control air quality grid.
* BenMAP-CE will now roll-back and interpolate the monitor concentrations. Once it has completed this step, you will be returned to the main screen. Double-click *Air quality delta (baseline-control)*. Your screen should look something like this (the colors may vary and numbers may vary, but the pattern should be the same):



* Determine the air quality change in one of the grid cells by using the Identify tool (), located in the vertical toolbar, and clicking on a location on the colored map. This will bring up the **Identify** window and provide more information about that place on the air quality map.[[8]](#footnote-8)
* Save the .shp file by selecting the *Save shapefile* button () in the vertical toolbar.

**Note:** If the purpose of your analysis is to examine air quality data only, you are done! You can then save the maps you generated and create an audit trail report for your analysis (Go to Section 5.2.2 to generate an audit trail report). For most BenMAP-CE users, however, the goal may be to estimate health benefits and/or value them. If so, go to the next step now.

**4.2 Estimate Health Impacts**

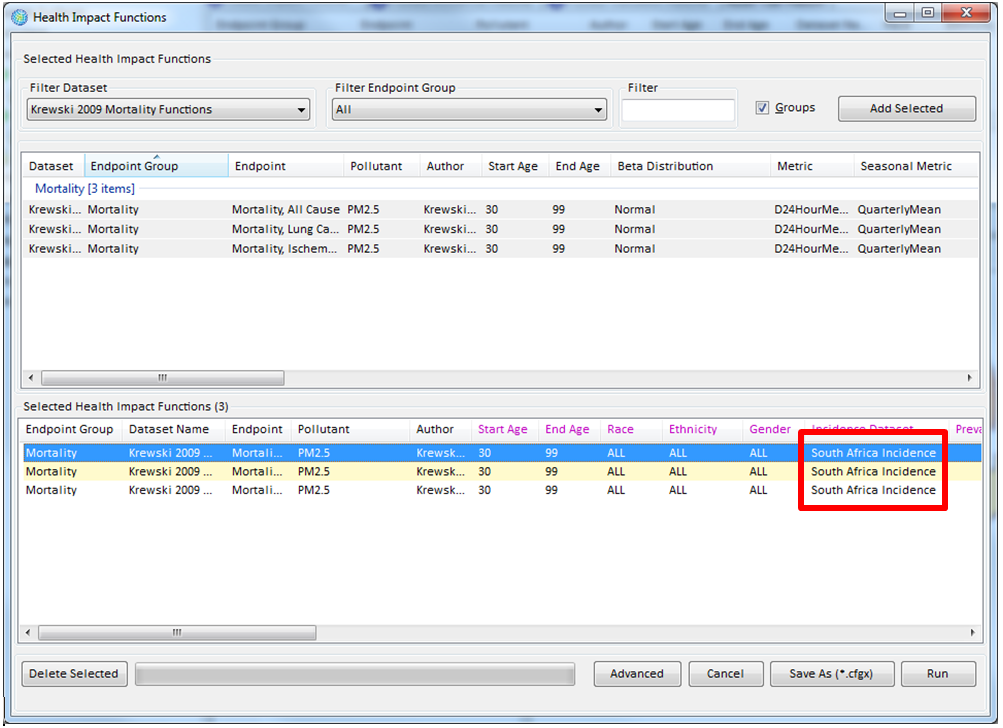
When you estimate health benefits, the results will be stored in a file with the extension “\*.cfgrx”. This file includes the BenMAP configuration specifying the air quality grids, health impact functions, population data, and other parameters necessary for an analysis. The results included in the file are the estimated health impacts associated within each air quality grid cell for a given scenario. In this example, you are estimating the number of avoided health impacts associated with a 20% reduction in PM2.5 concentrations. Here you will create a configuration for an analysis of the effect of PM2.5 on premature deaths and respiratory hospital admissions. Earlier, you loaded U.S. health impact functions from Krewski et al. (2009) into BenMAP-CE for premature mortality.

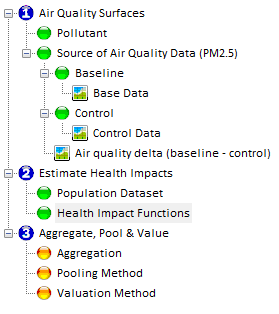
* You have already drawn the air quality grids for South Africa. The stoplight indicators for Pollutant, Source of Air Quality Data, Baseline, and Control should all now be green, indicating that the baseline and control grids for the percentage rollback have been loaded.

Box 6: BenMAP-CE Terminology

An **air quality surface** (or grid) contains modeled or monitored air pollution data in a series of cells; these cells may be a regular shape (like a 12km by 12km grid) or an irregular shape (like a county or census tract). These surfaces are also referred to as air quality grids. BenMAP-CE uses one air quality grid to represent the baseline scenario and a second grid to represent the control scenario. These baseline and control grids must share the same geographic structure. The program calculates the difference between baseline and control grids as an input to the health impact function. Air Quality Grids are stored in files with an .aqgx file extension.

* The *South Africa Population* data must first be selected before the health impact functions can be determined. Double click on *Population Dataset* next to the yellow stoplight indicator under Step 2. Choose *South Africa Population*. The only year available to select will be *2009*. If you’d like, you can map the population by clicking the *Map* button. Click *OK* and the stoplight will turn green.
* Next, double-click *Health Impact Functions*. Select all three Krewski functions displayed and drag them down to the *Selected Health Impact Functions* section of the window.
* Under the *Incidence Dataset* column for each function selected, make sure that *South Africa Incidence Rates* is selected (In the figure below, the area where you need to click to view a hidden drop-down menu is outlined in red. This is a step which is often missed and can result in errors).



* Click *Run* and *Yes* and save the new .cfgrx file as “South\_Africa\_PM\_20\_percent\_Rollback.”
* When BenMAP-CE finishes generating results, you will be returned to the BenMAP-CE main window and the stoplight indicator next to *Health Impact Functions* will be green. 

**Note:** Using the CFGRX file you just created, you could now skip to the Generate Tabular Reports section to show the endpoint-specific health benefits due to air pollution reduction if:

1. You do not want to pool your incidence results. For many of the health endpoints (e.g., mortality), BenMAP-CE contains several different health impact functions from different studies that you could choose to include in your configuration. Pooling refers to combining the results of two or more health impact functions into single results.

2. You don’t want to monetize the health benefits.

If you would like to conduct either of these analyses, continue to the next section directly below.

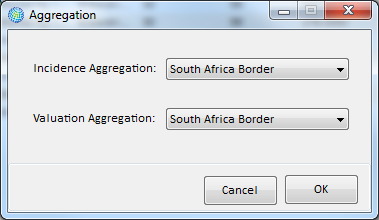
**4.3 Aggregate Incidence Results**

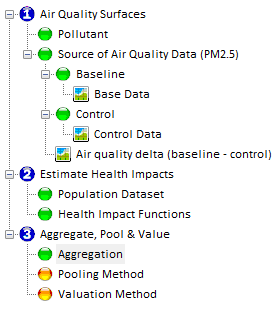
In this step, you will create a file that aggregates, pools, and values (APV) your health impact estimates; this file will save your preferences and can generally be used for other analyses. Aggregating refers to the process of summing values from a smaller to a larger space—for example, from 1km grid cells to counties. Pooling (a type of quantitative meta-analysis) is the practice of combining the results of two or more health impact functions into a single result. For many of the health endpoints (e.g., respiratory hospital admissions), the pre-made setups in BenMAP-CE contain many different functions from different studies that you could choose to include in your configuration. For a number of reasons, it is often impractical or impossible to combine the original datasets.

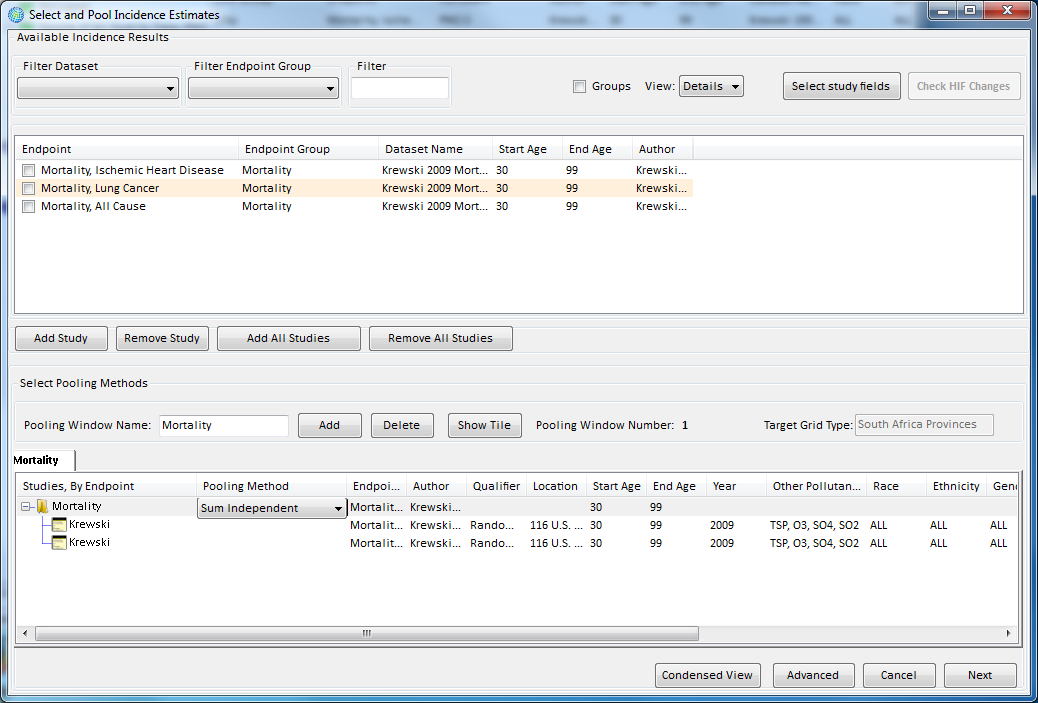
Pooling the results of studies provides a way to synthesize information. BenMAP-CE allows users to pool the estimated incidence changes predicted by several studies for the same pollutant-health endpoint group combination (e.g., PM2.5-related cardiovascular hospital admissions). It also allows for the pooling of the corresponding study-specific estimates of monetary benefits. You will perform the valuation and pooling in subsequent sections.

To create an APVX file, BenMAP-CE works by first aggregating results to the level that you have specified. It then pools the aggregated incidence results. Finally, it values the aggregated and pooled incidence. You can aggregate results to whatever grid is stored in your dataset.

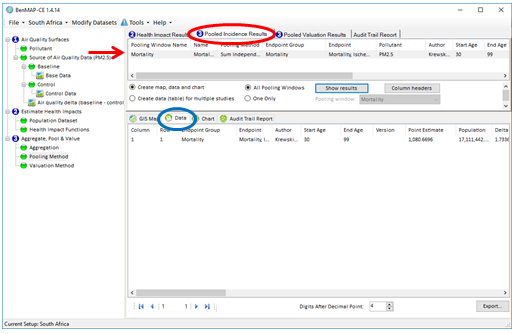
* Double-click the *Aggregation* button in the main BenMAP-CE window. This will bring up the **Aggregation** window. Select *South Africa Border* for both Incidence and Valuation aggregation. Your window should look like this:



* Click *OK* to close the window. The stoplight next to *Aggregation* should now be green.
* Double-click the *Pooling Method* button in the main BenMAP-CE window. This will open the **Select and Pool Incidence Estimates** window.
* Click the checkbox next to the *Ischemic Heart Disease* and *Lung Cancer* endpoints and click the *Add Study* button to add both studies to the lower pooling window. Since both of these belong to the Mortality endpoint group, you can pool them. You have not included All-Cause Mortality because All-Cause Mortality contains both the Ischemic Heart Disease endpoint and the Lung Cancer endpoint. Select *Sum Independent* from the pooling method drop-down menu.
* The **Incidence Pooling and Aggregation** window should look something like this:



* Click *Next*. The next window prompts you to select economic value functions. The two valuation functions you entered earlier will appear in the **Valuation Methods** window, but do not select either method. You will perform a valuation in the next step. Click *Run As (.apvrx)* to generate pooled incidence results. Click *Yes* to save the APVRX file and name the file “South Africa\_PM\_20\_percent\_Rollback”.
* To view the pooled results, click the *Data* tab in the lower results window (circled in blue below). Then click the *Pooled Incidence Results* tab in the upper part of the window (circled in red below). Double click the row that contains the information about the analysis (indicated with a red arrow), and the results will be displayed in the lower window. You can also click the *Show Results* button. The *Point Estimate* column in the lower window contains the incidence results.

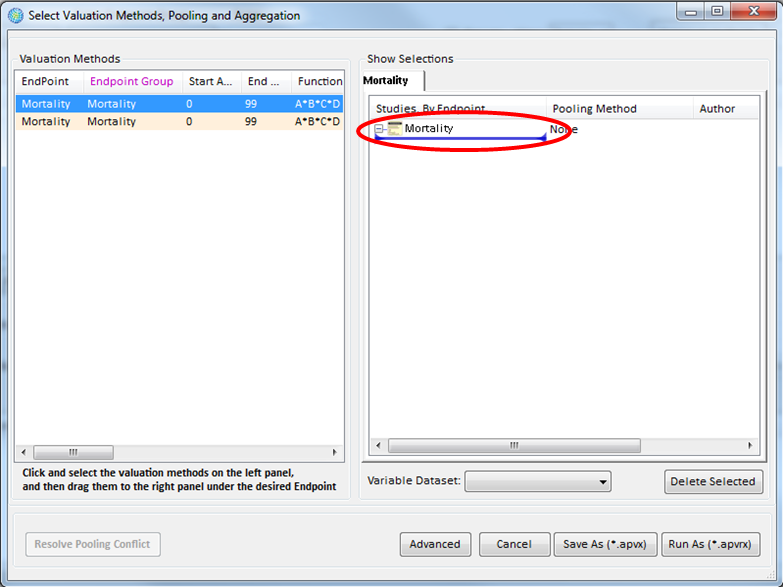


* At this point, you can export the results by clicking on the *Export* button at the bottom right of the screen.
* If you would like to estimate economic values, continue to the next section.

**Section 5: Estimating Economic Values**

**5.1 Estimate Economic Values**

As described above, the APV Configuration (.apvx) is a reusable file that records your aggregation, pooling and valuation choices. In this section, you will learn how to select and apply economic valuation functions, which assign a monetary value to the pooled and aggregated health impacts you estimated in the step above.

* Double-click *Pooling Method.* This will bring up the **Select and Pool Incidence Estimates** window.
* Select the functions for which you would like to calculate a valuation. If you would like to pool multiple functions, add multiple functions to the lower window. In this case, we will simply calculate valuation for the All-Cause Mortality function.If you have just completed step 4.4, you will need to remove the Krewski Ischemic Heart Disease endpoint and Lung Cancer endpoint and select the Krewski All-Cause Mortality function. To do this, press the *Remove All Studies* button. Select the All-Cause Mortality function and click the *Add Study* button.
* Click *Next.* A window may appear asking if you would like to load the previous valuation settings. Select *Reset valuation settings* to continue. The valuation functions you created earlier (*South Africa Valuation*) should appear in the window on the left. Select the function that utilizes the EPA Mean VSL values and drag it to the right hand window, releasing it when a purple line appears just below the endpoint in the right hand window. This purple line will appear when you drag the function to the area indicated by the red circle in the figure below.
* Click the *Run As (\*apvrx)* button, click *Yes* and save the file as “South\_Africa\_PM\_20\_percent\_Rollback\_Valuation”.
* After your file has been saved, you will be returned to the main BenMAP-CE screen.
* The lower right portion of the window should now display the results of your analysis. In order to export these results as a CSV file, select the *Export* button and save the results.

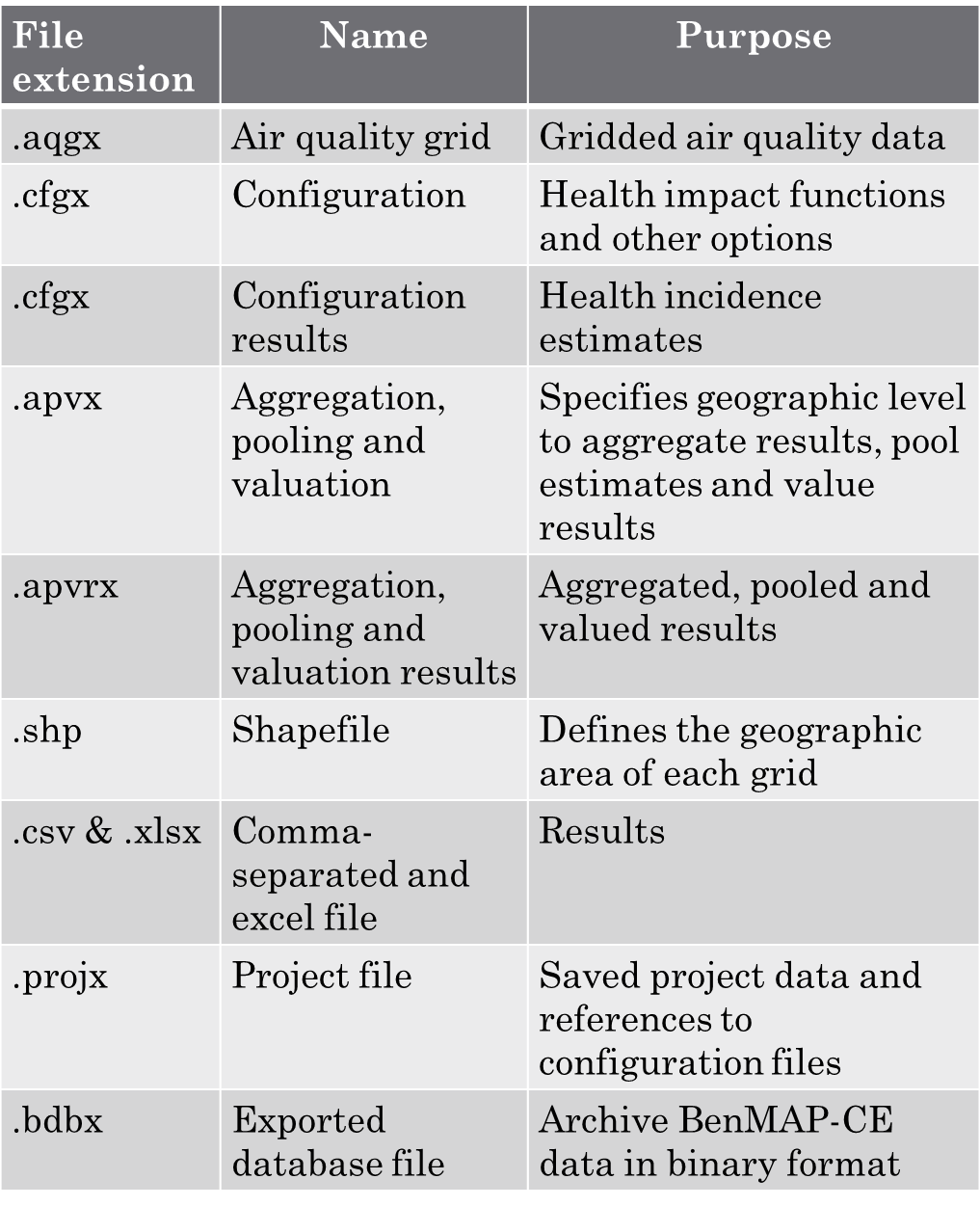
**Question for Students**

**What is the economic value for the benefits of the South African government enforcing a 20% rollback of PM2.5 concentrations?**

**5.2 Generate Reports**

**5.2.1 Generate Tabular Result Reports**

This step will allow you to generate tabular reports from the aggregation, pooling and valuation data, reflecting how you chose to aggregate, pool and value your results.

* Click the *Pooled Incidence Results* tab in the upper portion of the screen.
* Select *Show results* and the mortality results should appear in the window at the bottom of the screen.
* The lower right portion of the window should now display the results of your analysis. In order to export these results as a CSV file, select the *Expo**rt* button and save the results.

### 5.2.2 Generate Audit Trail Reports

Audit Trail Reports facilitate transparency and reproducibility by reporting a summary of your assumptions underlying each of five types of files generated by BenMAP-CE: Air Quality Grids (with the “.aqgx” extension), Incidence Configurations (with the “.cfgx” extension), Configuration Results (with the “.cfgrx” extension), Aggregation, Pooling, and Valuation Configurations (with the “.apvx” extension), and Aggregation, Pooling, and Valuation Results (with the “.apvrx” extension). These types of files are described in further detail in the table at right. We encourage you strongly to generate an audit trail for each BenMAP-CE analysis you perform, and to save the resulting file with the rest of the program outputs.

* Click the Audit Trail Report button in the upper portion of the window. Select Current Audit Trail Report. Click OK.
* Carefully review the report, ensuring that the air quality grids, population data, health incidence data, health impact functions and economic value estimates appear as you expected.
* Examine the audit trail to determine: the version of BenMAP-CE you used; the population year; the start and end age for the mortality functions.
* Click Export to save the audit trail report as “South\_Africa\_PM\_20\_percent\_Rollback\_ATR”.

**Question for Students**

**Based on the analysis you performed, what would your final policy recommendation be to the South African government as to whether they should implement the new air quality standard? What information makes you support this recommendation?**

1. World Bank. World Development Indicators Database. Accessed on February 15, 2017. [↑](#footnote-ref-1)
2. OECD (2017), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en . Accessed on 15 February 2017. [↑](#footnote-ref-2)
3. U.S. EPA VSL. [↑](#footnote-ref-3)
4. If you have a preexisting BenMAP-ready valuation function dataset, you can import this file by: (1) selecting the *Load From File* option in the **Valuation Function Dataset Definition** window, (2) selecting *Browse* and setting *File Type* to *All Files* to ensure that your dataset is visible in the load window, (3) selecting *Validate* and then *OK* to close the data validation window, and (4) clicking *OK* again to load the file. [↑](#footnote-ref-4)
5. World Bank. World Development Indicators Database. Accessed on February 15, 2017. [↑](#footnote-ref-5)
6. OECD (2017), Inflation (CPI) (indicator). doi: 10.1787/eee82e6e-en . Accessed on 15 February 2017. [↑](#footnote-ref-6)
7. World Bank (2016). The Cost of Air Pollution. [↑](#footnote-ref-7)
8. A shapefile of this map can be exported by right-clicking on the layer you wish to export, selecting Data, then selecting Export Layer. [↑](#footnote-ref-8)