User Guide

SuperSD (Version 1.0), A pool-based stochastic simulation program for modelling the spatial distribution of undiscovered petroleum resources

Geological Survey of Canada Open File 1465

GSC, Calgary
2003

TABLE OF CONTENTS

INTRODUCTION

SuperSD (Simulating Undiscovered PEtroleum Spatial Distribution) is an object-based stochastic simulation program desired for predicting locations of undiscovered petroleum accumulations and associated uncertainties in a play. This program simultaneously considers the necessary geological conditions and spatial correlation of petroleum accumulations, as well as the consistency of all relevant geoscience information with respect to petroleum occurrence. This program can be used to study the spatial distribution characteristics of oil and gas resources and to evaluate exploratory risk in a play.

FILE LIST

Two types of files are needed to run the SuperSD application: common files used to support Windows application and SuperSD files. The common files come from Microsoft Windows System and Microsoft Visual Studio System, and include:

Mfc42.dll,
Msvcp60.dll,
Msvcrt.dll,
Atl.dll,
Regsvr32.exe

The SuperSD files are listed and explained as follows:

PetroObjects.dll,
ModelData.dll,
MCMCObjects.dll,
PetroReport.dll,
PetroChartCtrl.ocx,
MFCWrapper.dll,
SuperSD.exe,
SuperSD.bat.

PetroObjects.dll contains most of the pool-related COM components, including:

- Petroleum pools;
- Petroleum wells;
- Polygons;
- Grid data definition;
- Grid data;
- Grid lines;
- Gray map partition; and
- Discovered pool statistics

ModelData.dll contains some COM components to hold all of the user interface data.

MCMCObjects.dll contains three COM components related to Monte Carlo Simulations. The first component is a wrapper for simulating the undiscovered pool distribution. The second component is a wrapper for calculating the undiscovered pool probability map. The last component is designed to validate the simulation results.

PetroReport.dll contains two COM components. The first one is for the report option, and the other one is for generating a SuperSD report and dumping it into Excel.

PetroChartCtrl.ocx contains an ActiveX control for implementing all the graph related functionalities.

MFCWrapper.dll is a static library and contains some MFC derived classes that are used in the **SuperSD.exe.**

SuperSD.exe is the SuperSD executable file.

SuperSD.bat is a batch file used to register all the required dynamic libraries explained above.

A complete data set, consisting of three required input files, can be found in the example data subdirectory (.\Documents\..). Two papers referred to in this Guide are also listed in ..\Documents\.. of this CD-ROM.

INSTALLATION

Auto Install:
Step 1) Click 'Install SuperSD' button on the Autostart screen.
Step 2) Click 'Run SuperSD' button on the Autostart screen to run SuperSD.exe.

Manual Install:
Step 1) Create a directory, for example, SuperSD, on your machine.
Step 2) Copy all files from the SuperSD directory on the CD-ROM to the newly created directory.
Step 3) Run SuperSD.bat from windows explorer to register all the required dynamic libraries.
Step 4) Double-click SuperSD.exe to start a SuperSD application.

DATA INPUT REQUIREMENT AND DATA FILE FORMAT

Data Input Requirement

SuperSD needs three input data files. They are play boundary file, favorability map file, and discovery pool file. The formats of these files are explained in this section.

Play Boundary File

The play boundary file is used to defined the play boundary and has the following format:

strTitle			
strDesc1		numPlayBoundaries	
strDesc2		n1	flag1
x11	y11	xu11	yu11
x12	y12	xu12	yu12
…	…	…	…
$x1n_1$	$y1n_1$	$xu1n_1$	$yu1n_1$
strDesc3		n2	flag2
x21	y21	xu21	yu21
x22	y22	xu22	yu22
…	…	…	…
$x2n_2$	$y2n_2$	$xu2n_2$	$yu2n_2$
…	…	…	…

Table 1 explains the variables for the play boundary file.

Table 1 Variables in play boundary file

Variable	Description
strTitle	A string for describing the play boundary file.
strDesc1	A string for describing the parameter, numPlayBoundaries.
numPlayBoundaries	An integer indicating the number of play boundary polygons.
strDesc2	A string for describing the first boundary polygon.
n1	Number of points on the first boundary polygon.
flag1	An indicator, the inside area of the polygon is the inside of the play if flag1 is 0, otherwise, the inside area of the polygon is the outside of the play.
x1?, y1?	Latitude and longitude coordinates of the first play boundary points. Not used.

xu1?, yu1?	UTM/Lambert/Polyconic projections of the Lat. and Long. The current version uses this coordinate system in computation.
strDesc3	A string for describing the second boundary polygon.
n2	Number of points on the second boundary polygon.
flag2	An indicator similar to flag1 for the second play boundary.
x2?, y2?	Latitude and longitude coordinates of the second play boundary points. Not used.
xu2?, yu2?	UTM coordinates of the second play boundary points. Used.

The following is an incomplete play boundary file in the example data sets.

```
THE_BOUNDARY_OF_RAINBOW_PLAY
NO._of_Boundaries:      1
Boundary:               7               0
58.13860        119.96330       443278.8        -95507.3
58.12398        119.87330       448557.2        -97207.0
58.12397        119.79045       453437.1        -97267.9
58.24375        120.16562       431569.2        -83613.5
58.22708        120.15312       432271.2        -85481.6
58.18541        120.09063       435866.9        -90181.4
58.13860        119.96331       443278.8        -95507.3
```

A complete list of the play boundary file can be found in the example data subdirectory.

Discovery Pool File

The discovery pool file contains information about the discovery history and properties of the discovered pools in the play, which has the following format.

```
strTitle
strDesc  numWells
ID_UWI STATS X_lat   Y_long  X_UTM   Y_UTM   TIME_date   AREA    NETPAY
ID1     S1      X1      Y1      XU1     YU1     Date1       Area1   Netpay1
ID2     S2      X2      Y2      XU2     YU2     Date2       Area2   Netpay2
…       …       …       …       …       …       …           …       …
```

Table 2 explains the variables in the discovery pool file.

Table 2 Variables in the discovery pool file

Variable	Description
strTitle	A string for describing the discovery pool file.
strDesc	A string for describing the parameter, numWells.
numWells	An integer indicating the number of discovery wells.
All strings in the 3rd record	Variable titles.
After the 3rd record	Variables for each exploratory well.
The 1st column, ID_UWI	Well ID.
The 2nd column, STATS	Exploratory well status. Possible values include D (dry), G (gas), O (oil), and B (gas and oil).
The 3rd and 4th columns, X_lat and Y_long	Latitude and longitude coordinates of wells. Not used.
The 5th and 6th columns, X_UTM and Y_UTM	UTM/Lambert/Polyconic projections of the Lat. and Long. Current version uses this type of coordinates in computation.
The 7th column, TIME_date	Discovery date with format yyyymmdd, that is, the first four digits for year, the next two digits for month, and the last two digits for day.
The 8th column, AREA	Discovery pool area with unit hectare. If the area is 0.0, the well will be treated as dry.
The 9th column, NETPAY	Discovery pool net-pay, unit in meter. If the net-pay is 0.0, the well will be treated as dry.

The following is an example of the discovery pool file list.

```
Descriptions_of_the_data
No._of_Wells            8
ID_UWI              STATUS  X_lat    Y_long   X_UTM     Y_UTM     TIME_date  AREA   NETPAY
100062710709W600    D       58.31    119.41   475916.3  -76056.8  19400000   0      0
100102710909W600    D       58.49    119.40   476438.9  -56232.6  19540310   0      0
100111010707W600    D       58.27    119.07   495521.5  -80591.8  19560312   0      0
100103311009W600    G       58.59    119.43   474885.8  -44901.6  19631213   32     10
100061211205W600    D       58.70    118.69   517801.5  -32395.8  19640121   0      0
100062811104W600    D       58.66    118.60   522725.6  -37214.5  19640205   0      0
100073210908W600    B       58.50    119.29   482948.0  -55060.4  19650111   253    142
100073210908W600    G       58.50    119.29   482948.0  -55060.4  19650111   113    25
```

In this example, there are only three discovery pools. A complete list of the data file can be found in the example data subdirectory.

Favorability Map File

Favorability map file has the following format.

```
strTitle
X0    Y0
X1    Y1
Nx    Ny
Default
z1
z2
…
```

Table 3 explains the variables in the favorability map file.

Table 3 Variables in the favorability map file

Variable	Description
strTitle	A string for describing the favorability map file.
X0, Y0	The left-bottom location coordinates of the area of the interest with UTM/Lambert/Polyconic system.
X1, Y1	The right-upper location coordinates of the area of the interest with UTM/Lambert/Polyconic system.
Nx, Ny	The number of grid lines along x axis and y axis, respectively.
Default	A user defined value for missing data
z?	Grid values. There are Nx * Ny grid values. Stored with y axis index goes first. In other words, the grid values are saved with orders: z(1,1), z(1,2), …. z(1,Ny), z(2,1), z(2,2), … z(2,Ny),…… z(Nx,1), z(Nx,2),…z(Nx,Ny).

The following is an incomplete list of a favorability map file.

```
Saved_gridded_data
434000.0   -90000.0
529000.0   -22000.0
250   200
-1.0
-1.0
-1.0
-1.0
-1.0
-1.0
-1.0
 ……
```

Note that the first –1.0 is the default or invalid value. A complete list of this data file can be found in the data example subdirectory.

STARTING AN APPLICATION

Double clicking **SuperSD.exe** will launch the SuperSD application. From the **Help** menu, you can check the current version of SuperSD from Chart 1 as below.

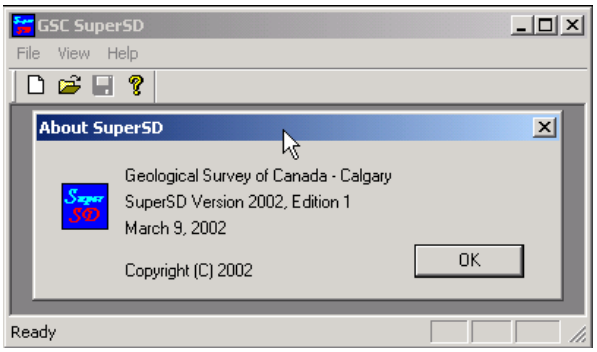


Chart 1. About SuperSD dialog

There are three sub menus under **File** menu. They are **New**, **Open**, and **Exit**. There may be several previously opened applications between Open and Exit as in Chart 2 below.

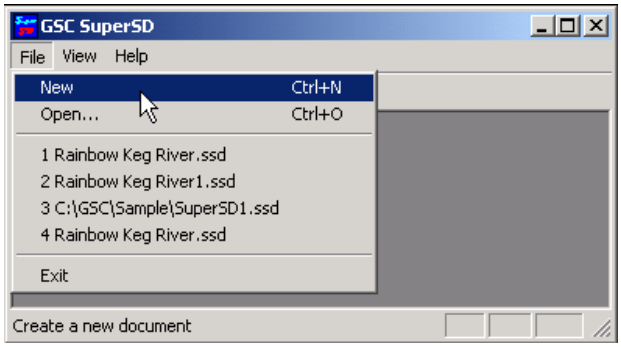


Chart 2. File Menu

Clicking **New** will start a new application. Click **Open** will pop up a new dialog for selecting existing applications. Clicking **Exit** will end the application. Directly click one of listed applications will open that application. You can also use the new application icon and open existing application icon below the main menu to create a new application or open an existing application.

Main Tabs

Create a new application by clicking **File** | **New.** You will see immediately four main tabs appearing in the left portion of the SuperSD application (Chart 3). They are

Parms: General parameters setup and favorability map display;
Simulation: Setup simulation parameters and do simulations;
Result Stat: Result statistics, including calculating and displaying probability map and validating the simulated probability map; and
Report: Generate SuperSD report and dump it into Excel.

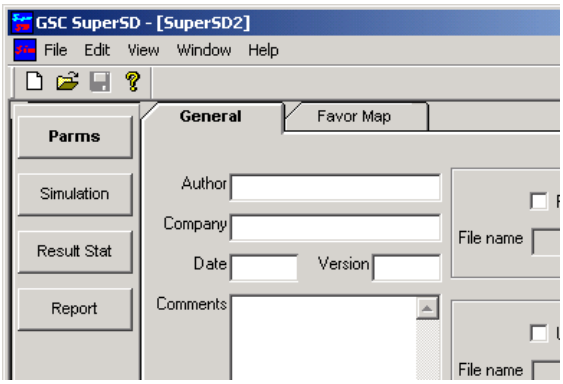


Chart 3. SuperSD main tabs

Each of the four main tabs has several sub-tabs. For example, **Parms** tab has two: **General** and **Favor Map**. These main tabs and related sub tabs will be explained in turn.

PARMS TAB

Once a new or an existing SuperSD application is opened, you will see the first user interface page of the SuperSD, i.e., the main tab **Parms**. There are two sub-tabs: **General** and **Favor Map,** under **Parms**. This section explains these two sub-tabs.

General Tab

Under General tab, you can input some general information of the application (Chart 4). By default, **Play boundary cutoff** and **Use favorability map** two check boxes are unchecked. By checking the two checkboxes, you are able to select the play boundary file and favorability file from **Browse** button or directly typing in the filenames in the filename windows. You will need to input the value for the **Reliability index of the favorability map**. Usually, this value should be greater than 0 and smaller than or equal to 1.0 (see Gao et al, 2000b for how to chose a value).

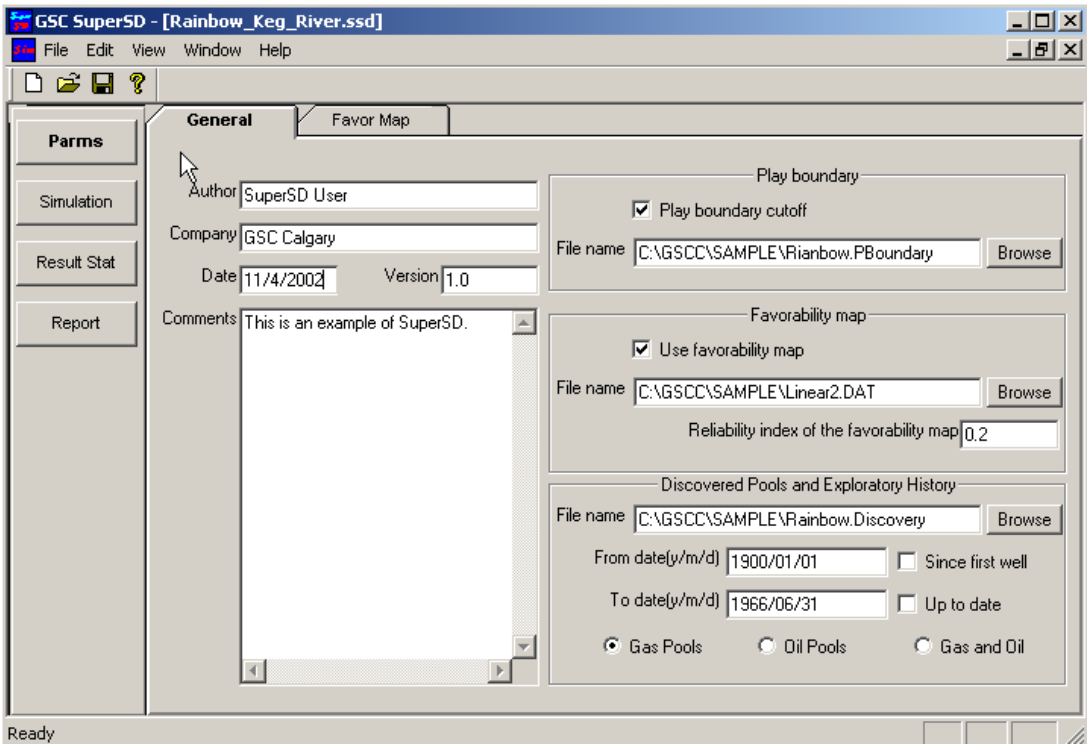


Chart 4. General tab

The last portion of the information in this page is related to the discovery pools. You will need to select a file name that stores the discovered pools, and to specify the discovery time period and petroleum types. The discovery time period includes **From date (y/m/d)** and **To date (y/m/d)**. If you check **Since first well** or **Up to date**, you would not be necessary to input the date then. However, if the checkbox **Since first well** is not checked, a start date needs to be inputted in **From date (y/m/d)**. Similarly, if **Up to date** is not checked, a date needs to be inputted in **To date (y/m/d)**. Note that a forward slash (/) is used to separate the year, month, and day. In addition, the date format shall be in **yyyy**/**mm**/**dd** format, that is, the year should have four digits, and month and day should have 2 digits.

Favor Map Tab

After setting the **General** page, you can view the favorability map (Chart 5) by clicking the **Favor Map** tab.

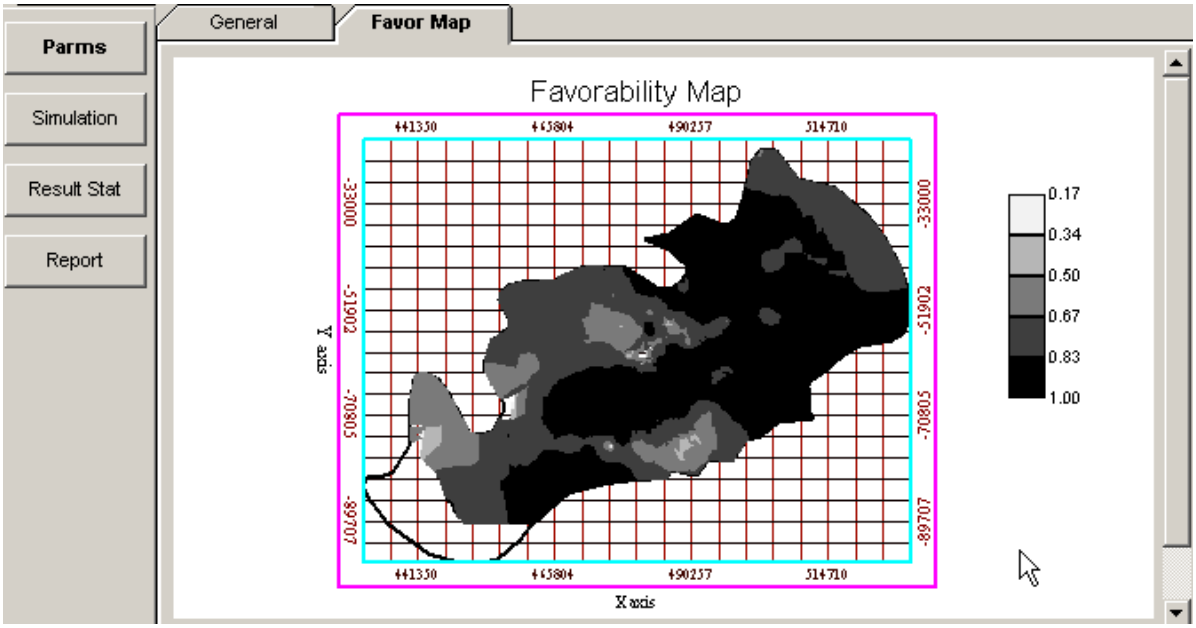


Chart 5. Favorability map

At this time, some of the graph setup such as grid lines and gray map are automatically calculated based on the input data. Mouse right-click inside of the chart area would pop up a menu so that the user can change graph properties and copy graph/data into clipboard. The picture in Chart 6 shows the right-click menu. If there is no favorability map loaded, the two sub-menus of the **Copy data to clipboard** would be disabled.

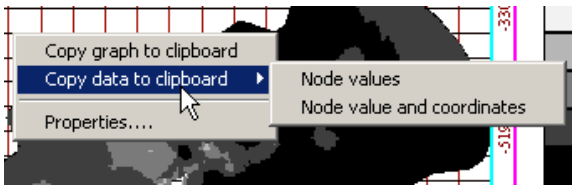


Chart 6. Chart right-click menus

The first menu item and the two submenu items allow user to copy graph/data into clipboard, and paste it into Excel, Word, or PowerPoint. Since the data use tabs to separate individual value, so, it is better to view them in Excel. Whatever a submenu item of the **Copy data to clipboard** is selected, a related dialog window similar to the one shown in Chart 7 below will be popped up and will be automatically disappeared when the process is finished.

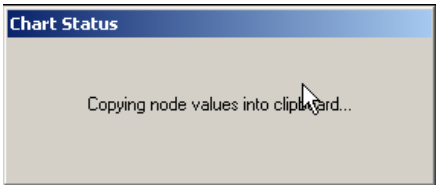


Chart 7. Copy data to clipboard waiting message

General Page

If the "**Properties…**" item is selected in the right-click menu, a property dialog window with four options will be popped up (Chart 8).

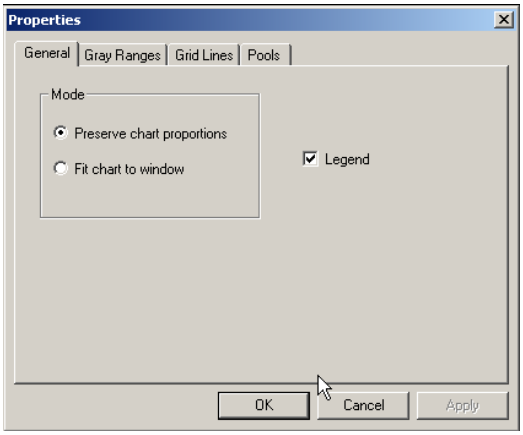


Chart 8. General page of the chart property

In the first **General** page, you may select the display mode **Preserve chart proportions** or **Fit chart to window**. If the **Preserve chart proportions** mode is selected, the scales on the chart along both x axis and y axis are the same. If the **Fit chart to window** mode is selected, the chart would fit the entire chart area. If the **Legend** check box is unchecked, there will be no gray partition legend in the chart. If the default set-up is changed, the **Apply** button would be enabled. Then, click **Apply** button to redraw the graph.

Gray Ranges Page

The page **Gray Ranges** (Chart 9) is used to set-up the gray map partitions. The minimum and the maximum of the gridded data are displayed on the top of the **Gray Ranges** page. The **Add** and **Remove** buttons are used to add or remove gray partitions.

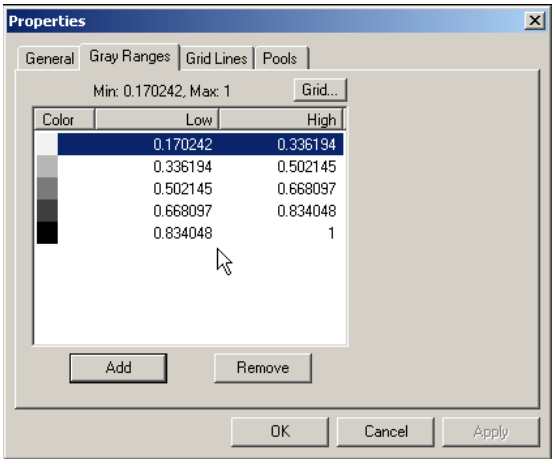


Chart 9. Gray ranges page of the chart property

The **Grid…** button is used to display the grid definition. Clicking the **Grid…** button will open a message box shown on Chart 10 below.

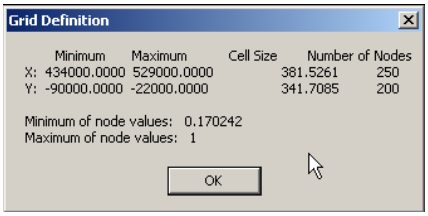


Chart 10. Grid definition data dialog

Double click any gray partitions listed in the list box on the **Gray Ranges** page (Chart 9), the low value, high value and color of the selected partition will be displayed on the right portion of the page (Chart 11), so that user can change them. The low and high values can be changed directly in the editing box.

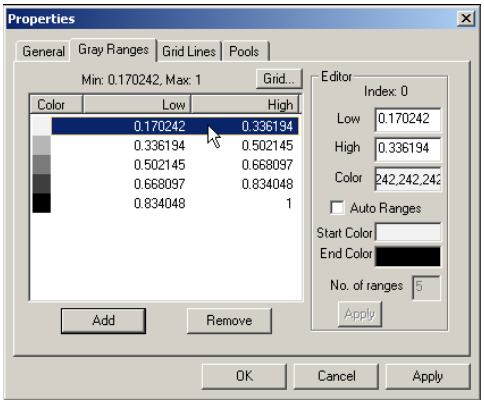


Chart 11. Edit gray range dialog

The three integers shown in the **color** edit box are the RGB (red, green, and blue) color components. Clicking in the **color** edit box, the color wizard dialog (Chart 12) will be popped up, showing the current selected color. After the new color is selected, click **OK** button to conform the change. If any parameter is changed, the **Apply** button will be enabled so that the user can redraw the graph.

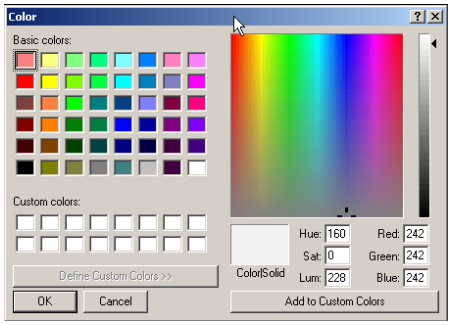


Chart 12. Color wizards

You may just set-up the low value such as 0.0 for the first gray partition, and high value such as 1.0 for the last gray partition. Set-up the **Start Color** and **End Color**. Check the **Auto Ranges** check box. Put a number in the **No. of Ranges** edit box, for example 5. Then, click the little **Apply** button on the page. The ranges and related colors would be automatically generated (Chart 13).

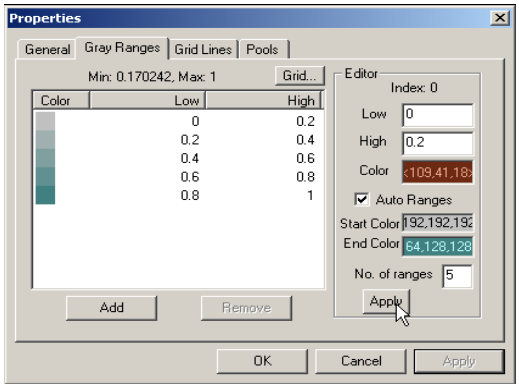


Chart 13. Auto range generation

Grid Lines Page

Grid lines page (Chart 14) is used to setup the graph title and the grid lines for the X axis and Y axis. If the radio of **X axis** is checked, the parameters are shown for the X axis. Similarly, if the **Y axis** is checked, the parameters are shown for the y axis. The parameters on the left portion are for the grid lines, and the parameters on the right portion are for the labels. Parameters **Delta** is unchangeable and is determined by the minimum and maximum values, and the number the lines on the axis.

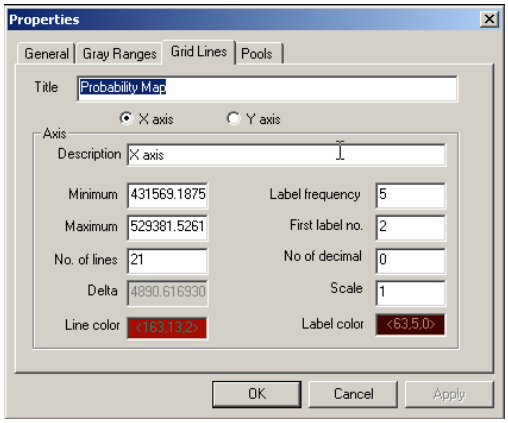


Chart 14. Grid lines page of the chart property

Similar to changing the gray partition color, click on the **Line color** and **Label color** edit boxes to change the colors for grid lines and labels.

If the coordinate values are very large, you may use the **scale** parameter to change the scale of the values. For example, if the **scale** parameter is 1000.0, then, the coordinate digit divided by 1000.0 would be displayed on labels.

Pools Page

Pools page (Chart 15) is used to set-up display properties for the selected discovered pools. The **Editor** group in the right portion of the Pools page is shown only when one of items in the list box is double-clicked. If the **Show** is checked, the related pool type will be displayed on the chart. Otherwise, they will not be displayed. Similarly, user can click the **Color** edit box to change the display colors for each pool type.

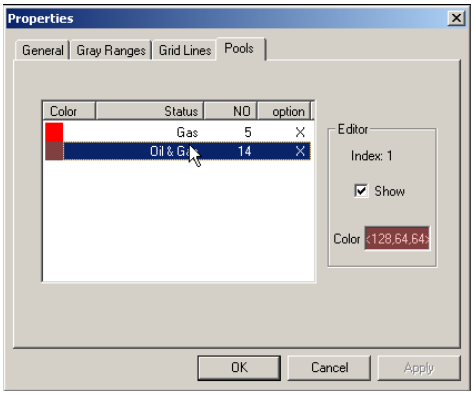


Chart 15. Pools page of the chart property

SIMULATION TAB

Pool Stats Tab

There are three tabs under **Simulation**: **Pool Stats**, **Constraints**, and **Iteration** (Chart 16). If it is the first time of accessing to this page after setting up the discovery pool file name, all displayed parameters are automatically calculated from the selected discovery pools.

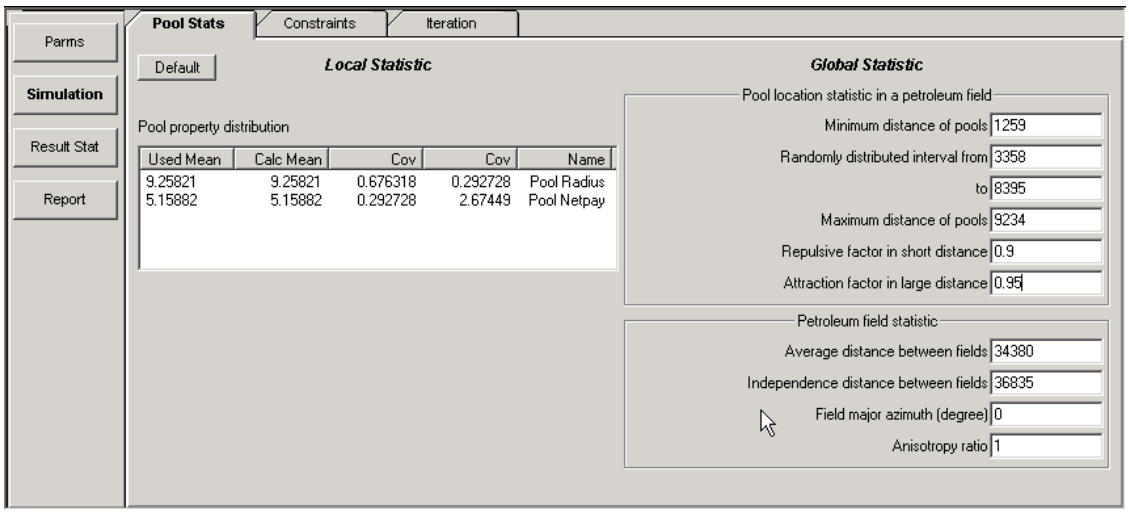


Chart 16. Pool statistics tab

The local statistical data are display on the left side. The statistics include the means and covariance matrixes of the radius and net pay of existing pools and are calculated from the logarithmically transformed variables of base 2. In other words, pool radiuses and net-pay measurements are transformed to logarithmic value first. Then mean and covariance matrixes are calculated.

In the **Pool property distribution** list box, the first column, **Used Mean,** is the means that will be used in the simulation. The second column and third to fourth columns are the means and covariance matrix calculated from selected discovery pools, respectively. The last column is the pool size property name: Pool Radius (unit: m^2) or Pool Netpay (unit: m). User can change the means which will be used in the simulation, but not the covariance matrixes. Clicking on the item in the list box, there will be an editor box showing the current used mean with the pool size property name aside just below the list box (Chart17). In the following example, we change the Used Mean to 9.0 and 4.8 for **Pool Radius** and **Pool Netpay**, respectively.

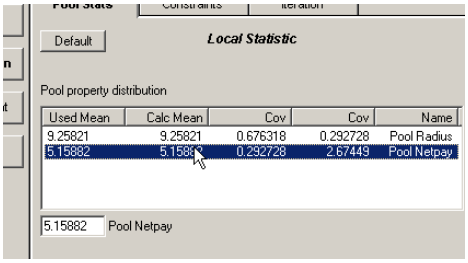


Chart 17. Edit means of pool size property

The right portion of chart 16 shows the global statistics. The first six parameters describe the pool location statistics in an oil/gas field. The last four parameters describe the oil/gas field statistics. Chart 18 shows a step function of the first 8 parameters. The unit for all distance parameters is meter.

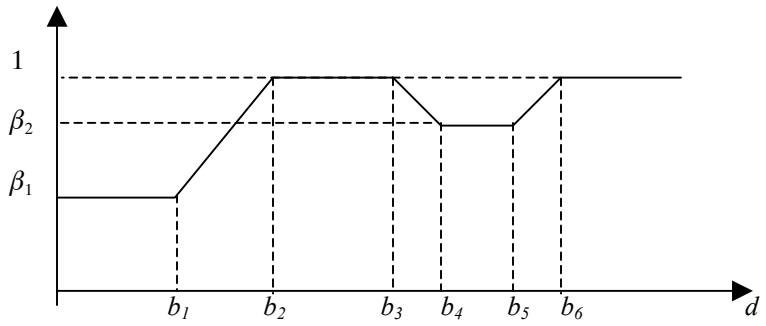


Chart 18. Pool global statistics step function

in which

β_1 is **Repulsive factor in short distance**; default is 0.9,
β_2 is **Attraction factor in large distance**; default is 0.95,
b_1 is **Minimum distance of pools**; default is 0.7 * MinDist,
b_2 is **Randomly distributed interval from**; default is 2.0 * MinDist,
b_3 is **to**; default is 5.0 * MinDist,
b_4 is **Maximum distance of pools**; default is 5.5 * MinDist,
b_5 is **Average distance between fields**; default is the maximum of 0.7 * MaxDist and b_4,
b_6 is **Independence distance between fields;** default is the maximum of 0.75 * MaxDist and b_5,
MinDist is the minimum distance between selected discovered pools, and
MaxDist is the maximum distance between selected discovered pools.

For this example, let's set the parameters like in Chart 19 below. Last two parameters in the right portion are **Field major azimuth (degree)** and **Anisotropy ratio**. We leave these two parameters as default.

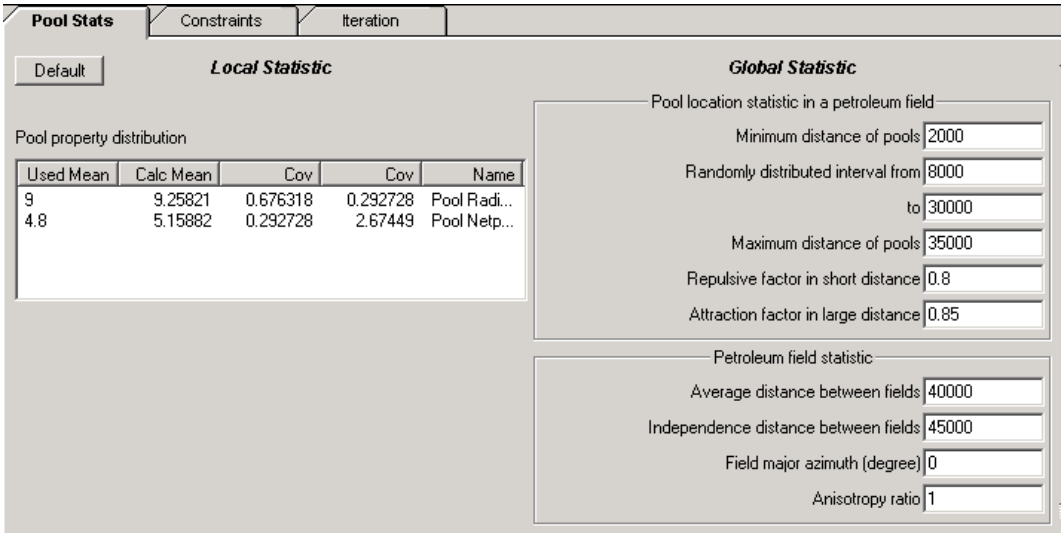


Chart 19. Edited parameters for pool statistics

If you click the **Default** button on the left upper corner, a message box (Chart 20) will pop up. Then, if you click **Yes** button, all existing parameters, including some of the parameters in the next tab (**Constraints)**, will be replaced by default parameters.

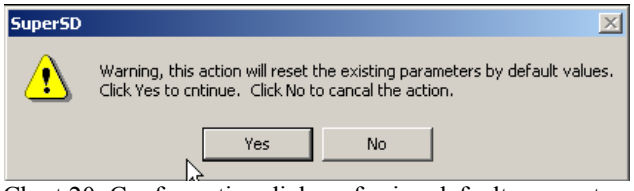


Chart 20. Conformation dialog of using default parameters

Constraints Tab

Clicking **Constraints** tab, displays some constraints parameters. Similarly, if this is the first time of accessing to this page, the parameters on the right portion are automatically calculated from the selected discovered pools (Chart 21). In the left portion, the **Use pool size constraints** is unchecked by default. Some general information about the selected discovered pools is displayed, including the number of pools discovered, pool size mean and standard deviation (logarithm with base 2), and the minimum and maximum of pool sizes. Note that, currently, the pool size means the pool area value with square meter as unit. On the right side, you will see parameters for **Exclusion domain.** There are three parameters, long semi-axis, short semi-axis and azimuth (degree), which define an ellipse with the major axis at the direction determined by the azimuth. Default values for the long and short axes are minimum pool distance scaled by 0.3, and the azimuth is 0.

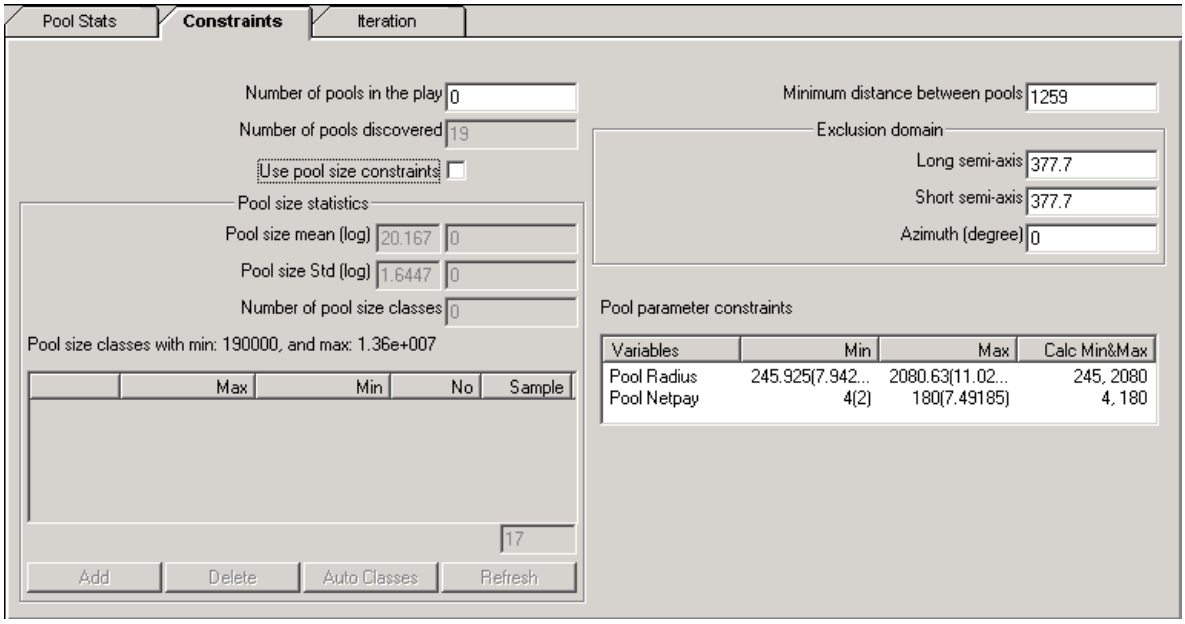


Chart 21. Parameters in Constraints tab

In the **Pool parameter constraints** box, the first column is the pool property name. The second and third columns are minimum and maximum values that will be used in the simulation, respectively. The values inside of the brackets are the logarithm values with base 2 of the same statistics. The fourth column is approximately the minimum and maximum values of the selected pools from the exploratory data file. The minimum and maximum values in the second and third columns equal to the values in the fourth column by default. Clicking items in the **Pool parameter constraints** list box, two edit boxes will be shown up for editing the minimum and maximum values (Chart 22).

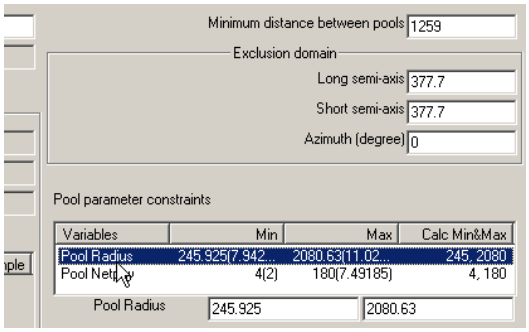


Chart 22. Edit the minimum and maximum values for pool property parameters

If the **Use pool size constraints** box is checked, you will be able to setup the desired distribution for pool size (equals to pool area in this version) classes. For example, let the **Number of pool size classes** be 7. Click **Add** button once. Click the added item in the pool size class list box. Then, there will be three edit boxes below the list box (Chart 23), in which the first edit box is for maximum pool size, the second one is for minimum pool size, and the last one is for the number of pools for the pool size class. Let the maximum pool size be 14,500,000 (m^2), a little greater than the maximum pool size (13,600,000) of the selected discovered pools , and the minimum pool size be 150,000 (m^2), a little smaller than the minimum pool size (190000) of the selected discovered pools. Click the **Auto Classes** button. The specified number (7 here) of pool size classes will be automatically generated based on the maximum and minimum pool size values (Chart 24), in which the maximum value of a pool size class equals to the maximum value of the previous pool size class divided by 2. You are also free to edit the values in columns 2, 3, and 4 by clicking the item listed in the list box of pool size classes, or click **Add/Delete** button to add/delete pool size class item.

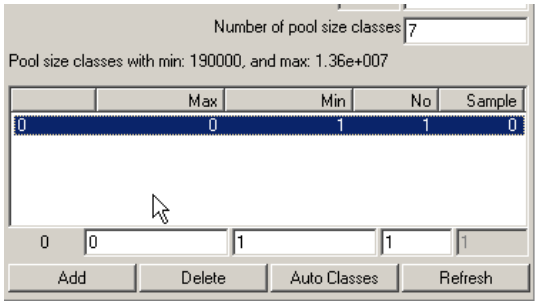


Chart 23 Edit Pool size classes

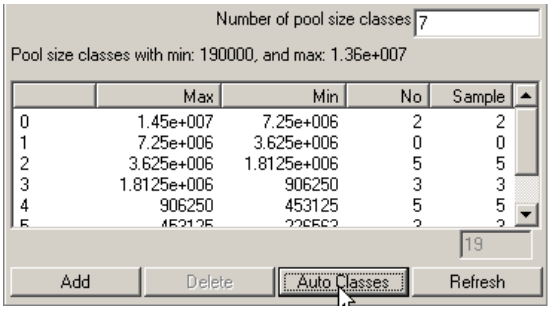


Chart 24 Automatically generated pool size classes

In the list box of pool size classes, the first column is the class index. The second and third columns are the maximum and minimum pool size values for the class. The fourth column is the desired number of pools in the class. The fifth column is the number of selected discovered pools in the class. So, the pool size class definitions in columns 2 and 3, and the desired number of pools in the column 4 will be used in the simulation as pool size distribution constraints. The values in the fifth column are numbers of discovered pools in the selected data. For each pool size class, the number on column 4 should be greater or equal to the number on column 5.

After editing the pool size class definitions in columns 2 and 3, the number of selected discovered pools in each class can be recalculated by clicking **Refresh** button. The number displayed in the gray edit box above the **Refresh** button is the sum of desired numbers of pools in all pool size classes. This number is supposed to be equal to the value in the edit box **Number of pools in play**. So, it is user's responsibility to edit the numbers in the fourth column so that the sum of them should equal to the value in the edit box **Number of pools in play**.

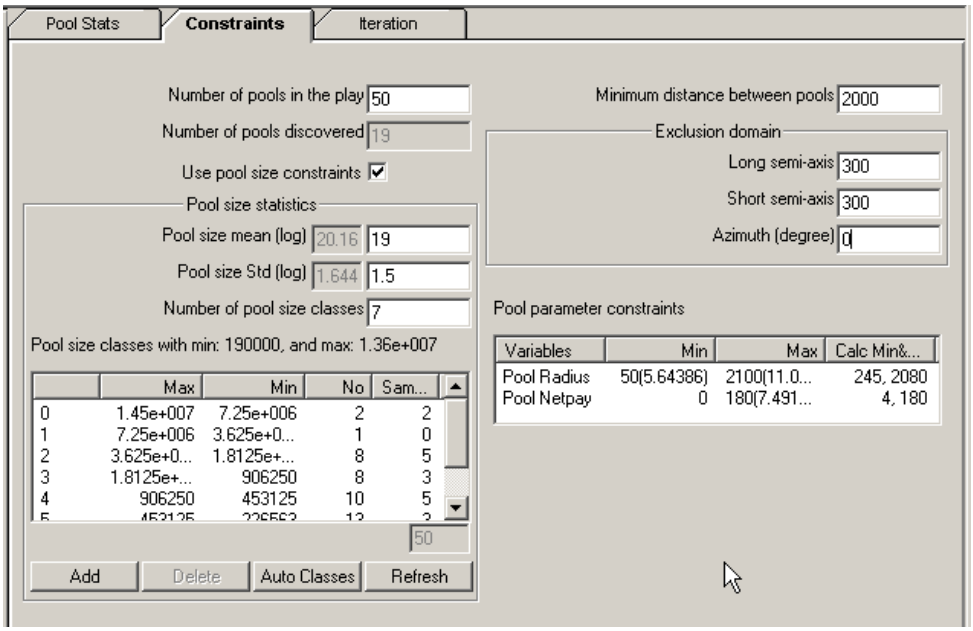


Chart 25. Parameters used in constraints dialog

For this example, we setup the constraints parameters as in Chart 25. Please note that the pool size constrains use pool area rather than pool volume in the current version.

Iteration Tab

Clicking the **Iteration** tab, you will get in the iteration setup dialog (Chart 26). If it's the first time of accessing to this dialog, the default values may not look like the values displayed in Chart 26. For a new application, a **Random number seed** is automatically generated based on the computer clock. **New seed** button is used to generate a new seed. **Number of iterations** and **Number of acceptable iterations** are 2000 and 1000 by default, respectively. **Number of iterations** is the maximum number of pool combinations that will be generated in the simulation. **Number of acceptable iterations** is the maximum number of pool combinations that will be accepted in the simulation. The simulation will stop whichever of the two numbers is reached.

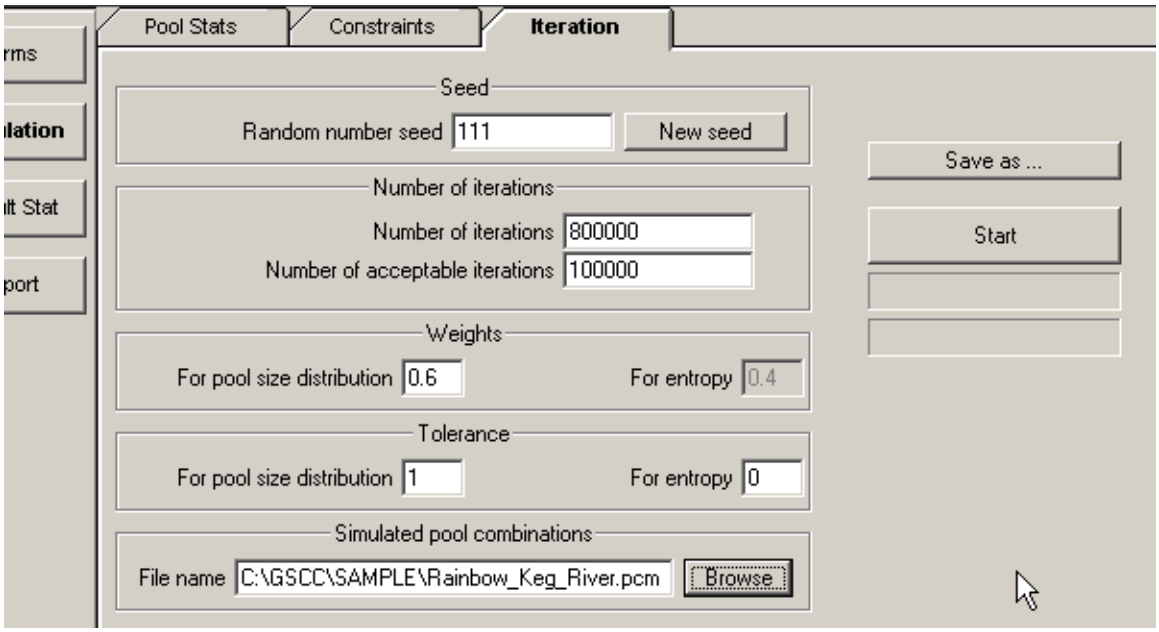


Chart 26. Dialog under Iteration tab

If the **Use pool size constraints** under the **Constraints** tab is unchecked, the two edit boxes with the same name **For pool size distribution** in **Weights** group and the other in **Tolerance** group would be disabled. The edit box **For entropy** in **Weights** group is always read-only, since the sum of two weights, one for pool size distribution and the other one for entropy, is 1.0. The next two parameters are the tolerances for pool size distribution and for entropy.

During simulation, the weights and tolerances are used as follows:

- For a generated pool combination, calculate the relative distribution error: DistError and relative entropy: Entropy.
- If the DistError is less than or equal to the tolerance in edit box **For pool size distribution** and Entropy is greater than or equal to the tolerance in edit box **For entropy**, then the pool combination satisfies the tolerance conditions and will proceed to the next step. Otherwise, it will discard this pool combination.
- Calculate the objective function value that is a linear combination of DistError and Entropy with weights as scales. The objective function value is used to calculate the acceptance probability that will be accordingly used to determine whether or not the pool combination will be accepted.

The following equation is used to calculate the relative distribution error, DistError:

$$\text{DistError} = \text{DistErrorAverage} * m / N \quad (1)$$

$$\text{DistErrorAverage} = \sum_{i=1}^{m} [\, y_i - y_i^*(u)] / (m\,|C_i|) \quad (2)$$

where y_i is the sum of the desired sizes of discovered and undiscovered pools within the i^{th} size class or interval C_i, in which size classes $C_i = (\rho 2^i, \rho 2^{i+1}]$ is a commonly used example, (i =0, 1, …, m), m is the specified number of size classes, and ρ is a parameter. Value $y_i^*(u)$ is the sum of the sizes of discovered and simulated pools within the i^{th} size classes for a simulated pool combination numerical model u. $|C|$ is the length of interval C. Parameter N is the number of discovered and undiscovered pools. For our case, size classes C_i are defined by the second and third columns in the list box of the pool size classes in Chart 24.

The factor in equation (1) is used so that most of the calculated values, DistError, are within interval [0, 1]. See Gao et al, 2000a for the method of calculating the relative entropy. Usually, the calculated relative entropy varies between 0 and 1 as well. Notice the differences between the two tolerances. The desired pool combinations would have both a small relative pool size distribution error and a large relative entropy. In this example, we set 1 and 0 as the tolerances for relative pool size distribution error and for relative entropy, respectively. This means that almost all of the generated pool combinations satisfy the tolerance conditions. In addition, those two tolerance values are recommended.

In Chart 26, the file name in the **Simulated pool combinations** group is required. All accepted pool combinations will be saved into this binary file. It is recommended to use pcm (pool combination model) as the extended name.

Before starting the simulation, you may want to click the **Save as…** button in Chart 26 to save the parameters you have inputted. Click button **Start**, the simulation will start, and the **Start** button will change to **Stop** button. Two process bars are activated during the simulation (Chart 27). The first process bar is for the number of generated pool combinations compared to the value in the edit box of **Number of iterations**. The second one is for the number of accepted pool combinations compared to the value in the edit box of **Number of accepted iterations**. The numbers displayed by the process bars are the numbers of generated/accepted pool combinations.

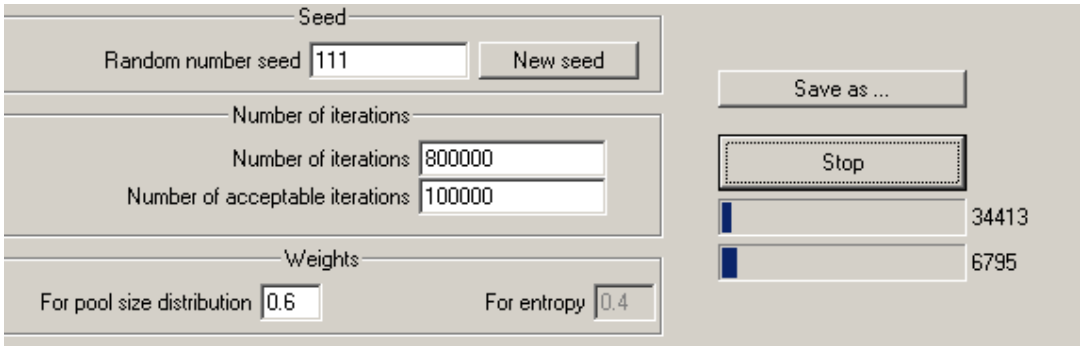


Chart 27. Simulation process dialog

Before finishing the simulation, you can stop the simulation by clicking **Stop** button, and the already accepted (simulated) pool combinations will be saved. Once the number of generated pool combinations or the number of accepted pool combinations reaches the inputted up limitations, the simulation will stop/finish, and the **Stop** button will change back to **Start** button. Make sure that the box of pool combinations file name is filled before starting a simulation.

RESULT STAT TAB

Calc Prob Tab

Clicking the main **Result Stat**, four sub tabs: **Calc Prob**, **Overlay**, **Prob Map**, and **Validation** appear on screen. If the **Calc Prob** is highlighted (Chart 28), the dialog under **Calc Prob** tab is for calculating the probability map from the simulated or accepted pool combinations.

Once the simulation is finished, the same filename in the edit box **Simulated pool combination** (Chart 26) appears in the **Simulated pool mode file** of Chart 28. The list box beside **Apply** button is empty, and the **Calculation** button

is disabled. If file name in the **Simulated pool mode file** is correct, clicking **Apply** button, summary information of the simulation will be displayed in the list box. This includes the calculation date and time, number of accepted pool combinations, and mean and variance of the objective function values. The last two lines in the list box are three of the greatest relative entropy values, and three of the smallest relative pool distribution error values. In addition, the number of accepted pool combinations after subtracting by 1 will be automatically passed into the edit box **to No**, and the **Calculation** button is then enabled.

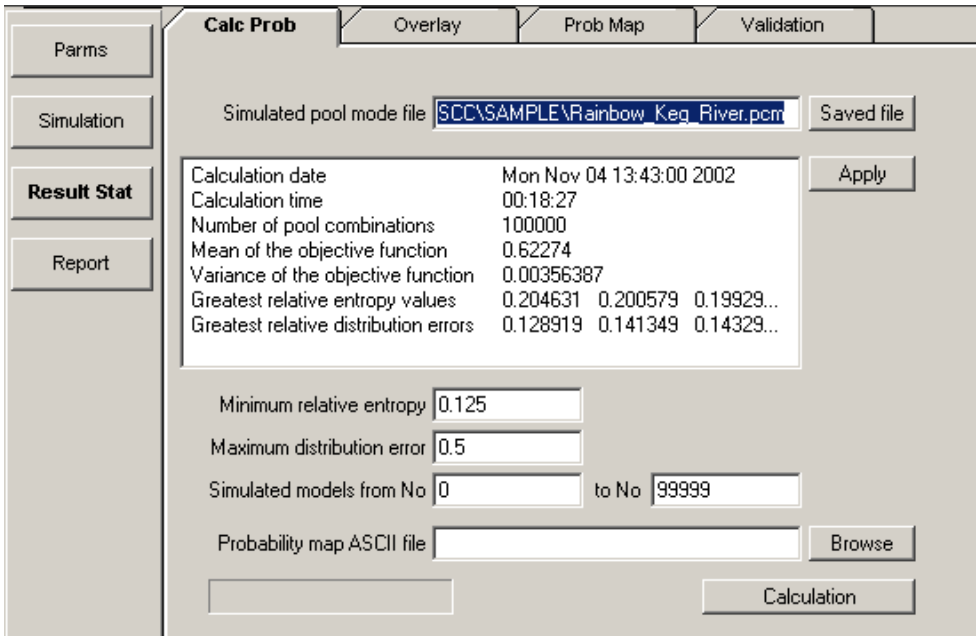


Chart 28. Dialog under Calc Prob tab

Set two cutoff values, one as the minimum relative entropy and the other as the maximum relative pool size distribution error into the related edit boxes, say 0.125 and 0.5 for this example, respectively. The numbers in **Simulated models from No** and in **to No** are the ranges of the pool combination index that will be used to calculate the probability map. In other words, the pool combinations with indexes beyond the range of these two numbers will not be used in the probability map calculations. The file name in **Probability map ASCII file** is optional. If you want to save the calculated probability map into an ASCII file, you will need to specify the file name. Otherwise, you shall leave the edit box empty as in Chart 28. The output file name format here is the same as the input favorability map file.

Clicking the **Calculation** button will start the calculation of the probability map. Before the calculation is finished, the **Calculation** button is disabled. Once the calculation is done, the **Calculation** button will be enabled again. The process bar shows the process of the calculation. A number followed by the process bar indicates the number of pool combinations were used in the calculations. In this example (Chart 29), 13,193 out of 100,000 pool combinations were used in the probability map calculations.

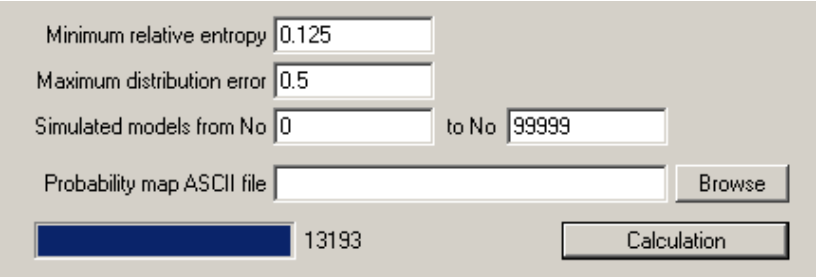


Chart 29. Number of pool combinations used in the probability map calculation

Calculated probability map is held by the SuperSD application, and will be used to draw the probability graph and to validate the simulation results in the following sub tabs. Clicking **Saved file** button (Chart 28) allows user to calculate a probability map based on a previously saved pool combination file.

Overlay Tab

The dialog under **Overlay** tab is used to specify the discovered pools that will be used in the validation of the probability map. By default, the file name in **Discovery Pools and Exploratory History** group (Chart 30) is the same file name for the discovery pools in Chart 4. However, user can change it. The start date and end date are not set by default. It's user's responsibility to setup them in **From date(y/m/d)** and **To date(y/m/d)** with format **yyyy**/**mm**/**dd**. You will also need to select the pool type: Gas pools, or Oil Pools, or Gas and Oil.

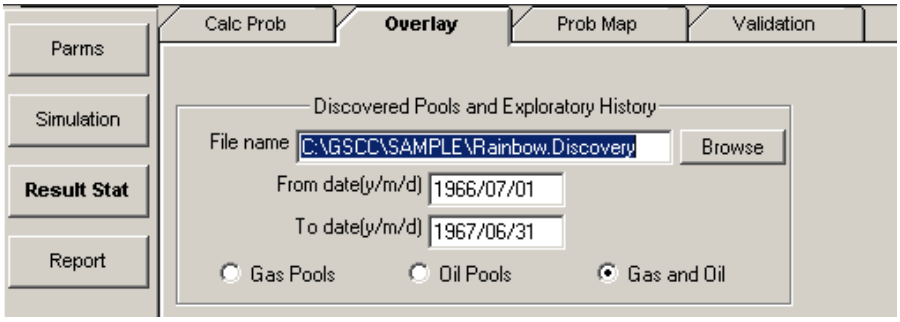


Chart 30 Dialog under Overlay tab

The discovered pools selected from this dialog (Chart 30) will be displayed on the probability map, and will be used to validate the probability map. Therefore, these discovered pools could be called **validation pools**.

Prob Map Tab

Click **Prob Map** tab, you may see the probability map. Similar to the favorability map, you may change the properties for probability map, or copy graph/data into clipboard. Probability map inherits some setups, such as grid lines, from the favorability map before you manually change them. In addition, favorability and probability maps share the same play boundary file specified under **General** sub tab of **Parms** main tab. Favorability map gets all information from the **General** sub tab of **Parms** main tab. However, for probability map, the gridded probability data is calculated from the **Calc Prob** sub tab, and the discovered pools are the validation pools that are specified under the **Overylay** sub tab, as mentioned above.

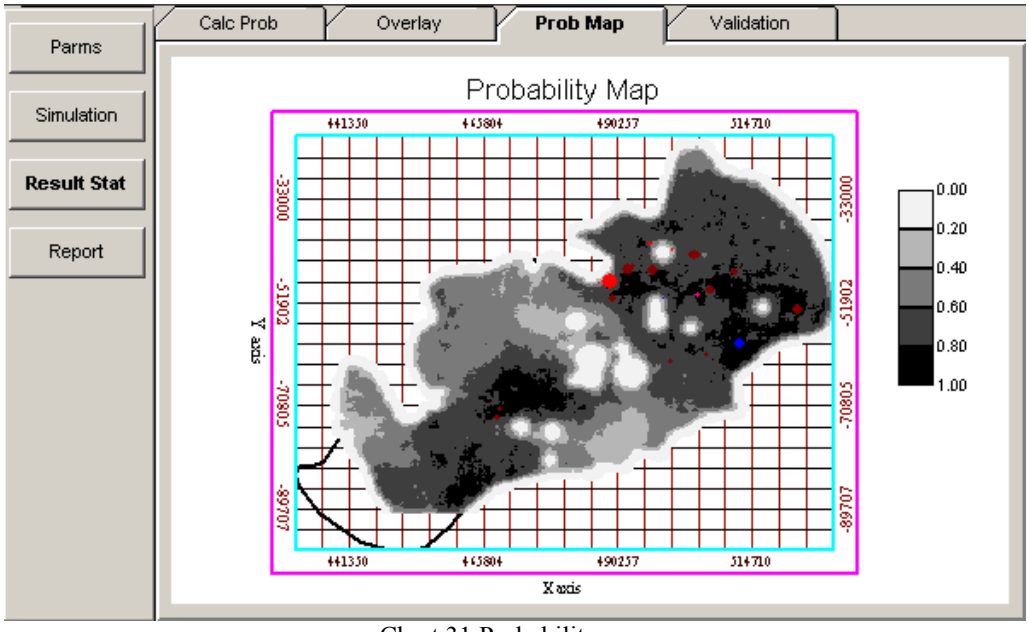


Chart 31 Probability map

You may need to change the probability map properties such as gray ranges (partitions) to analyze how the validation pools are distributed on the simulated probability map.

Validation Tab

The dialog in the **Validation** sub tab allows user to calculate the statistics of validation pools distributing on both favorability map and probability map. Note that the node values in both favorability map and probability map vary between 0 and 1. The value in **Number of combined intervals** (Chart 32) is the number of divided bins of range [0, 1]. For example, if the number of combined intervals is 5, the divided bins would be [0. 0.2], (0.2, 0.4], (0.4, 0.6], (0.6, 0.8], and (0.8, 1].

After clicking the **Calculate** button, the statistics of validation pools distributing on both favorability map and probability map will be calculated and displayed in the two list boxes (Chart 32). The number of combined intervals in the boxes is 8, and the divided bins are listed in the first two columns of the two list boxes. The legend of the bottom explains the meanings of the columns 3 to 9.

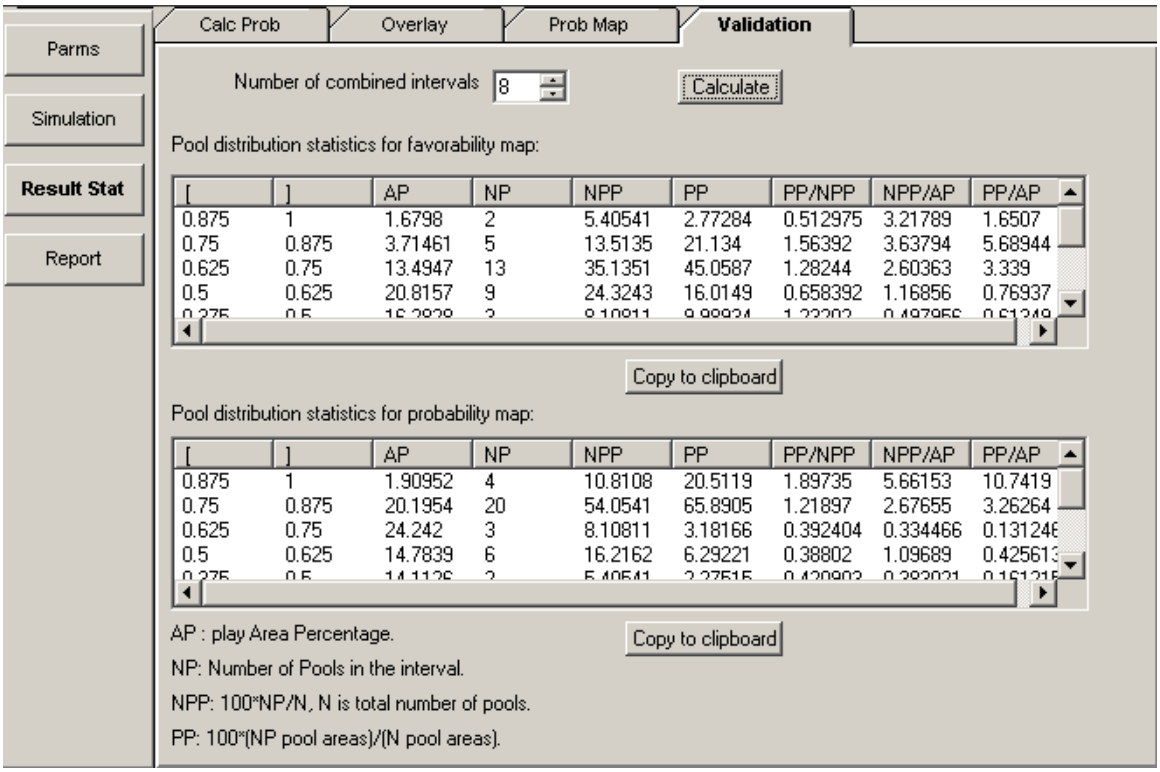


Chart 32. Pool distribution statistics dialog

Two **Copy to clipboard** buttons allow user to copy the statistical data into clipboard and then into Word or Excel accordingly.

REPORT TAB

There is only one sub tab, **Option**, under **Report** main tab. Several check boxes are in the dialog under the **Option** sub tab (Chart 33). After checking the report options and clicking button **Dump to Excel**, SuperSD will generate a report, launch Excel application, and dump the report into an Excel workbook. Depending on the report options selected, the whole process may take a minute or two.

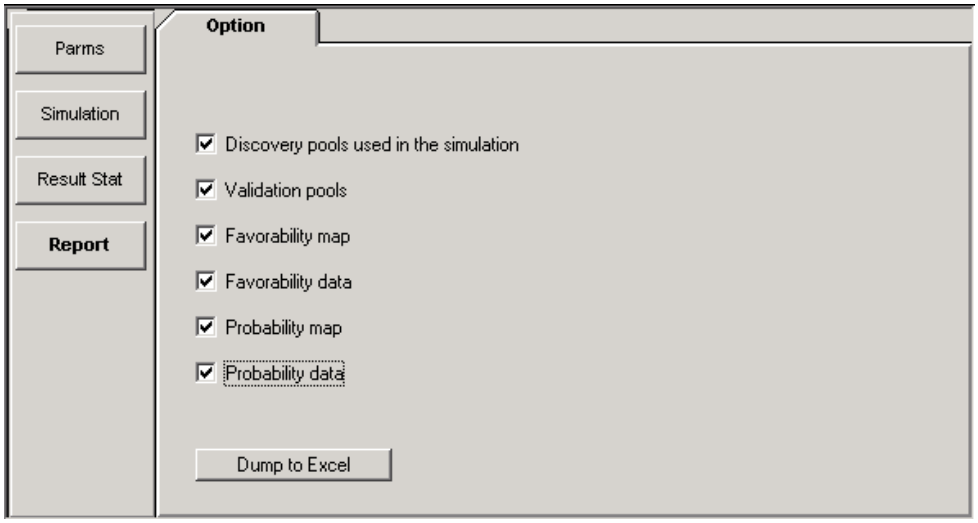
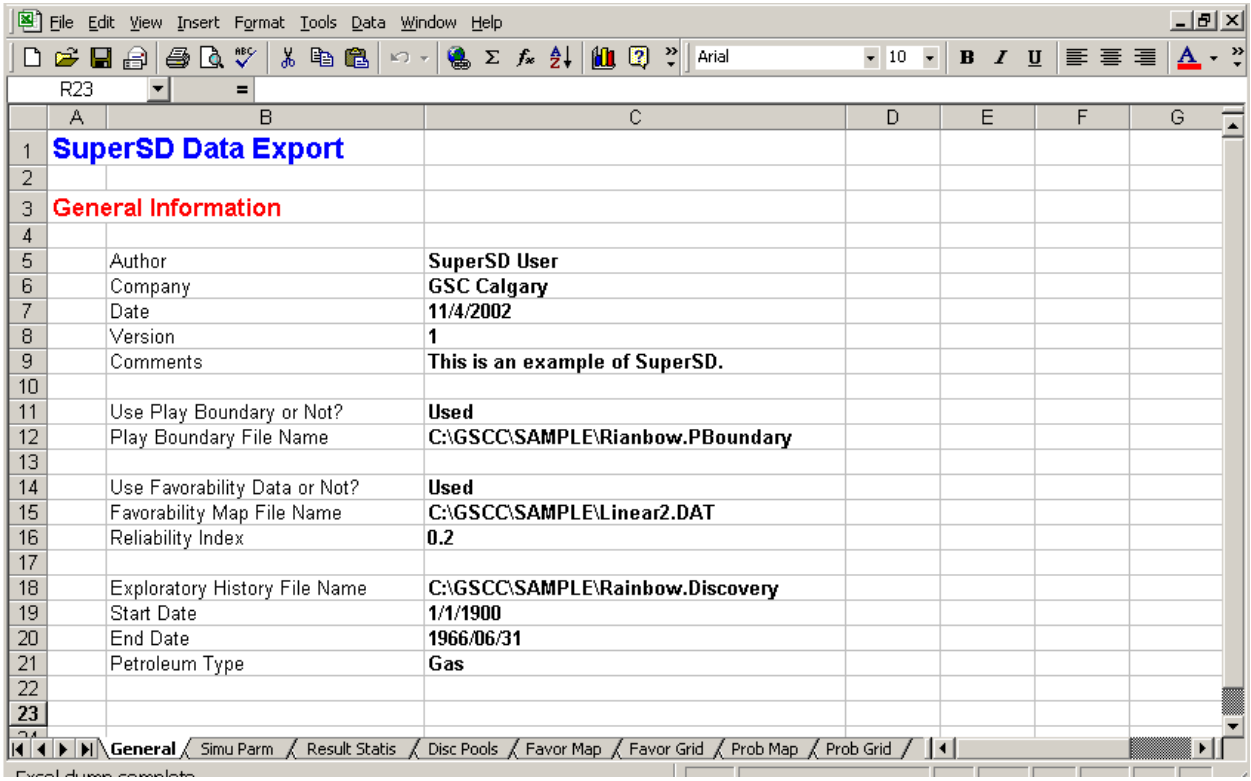


Chart 33. Report options

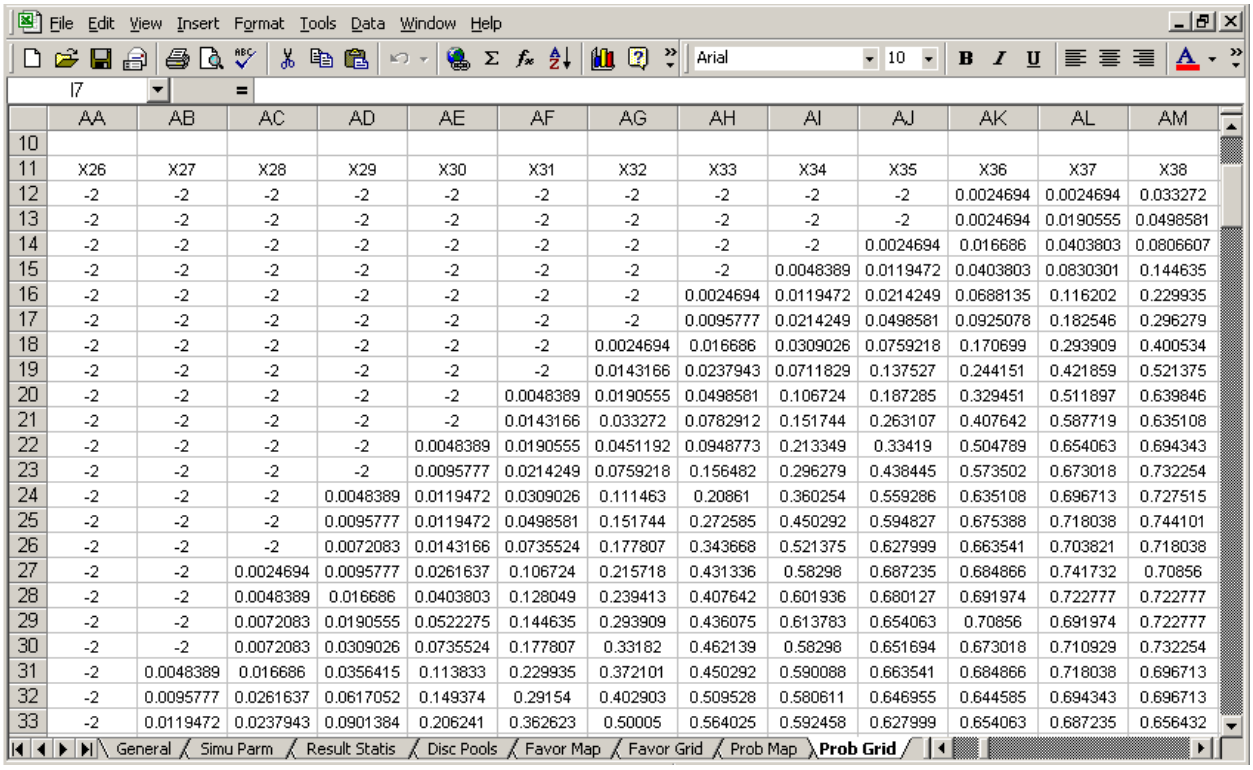
Chart 34 displays an example of the dumped SuperSD report if all check boxes in Chart 33 are checked. The maximum Excel work-sheets include **General**, **Simu Parm**, **Result Statis**, **Disc Pools**, **Favor Map**, **Favor Grid**, **Prob Map**, and **Prob Grid**. The first three work-sheets are the minimum. The first work-sheet, **General**, contains the parameters under the **General** sub tab of the **Parms** main tab. The second work-sheet, **Simu Parm**, contains the parameters under the sub tabs (**Pool Stats**, **Constraints**, and **Iteration**) of the **Simulation** main tab. The third work-sheet, **Result Statis**, contains the parameters under the sub tabs **Calc Prob**, **Overlay**, and **Validation** of the **Result Stat** main tab.



	A	B	C
1	**SuperSD Data Export**		
2			
3	**General Information**		
4			
5		Author	**SuperSD User**
6		Company	**GSC Calgary**
7		Date	**11/4/2002**
8		Version	**1**
9		Comments	**This is an example of SuperSD.**
10			
11		Use Play Boundary or Not?	**Used**
12		Play Boundary File Name	**C:\GSCC\SAMPLE\Rianbow.PBoundary**
13			
14		Use Favorability Data or Not?	**Used**
15		Favorability Map File Name	**C:\GSCC\SAMPLE\Linear2.DAT**
16		Reliability Index	**0.2**
17			
18		Exploratory History File Name	**C:\GSCC\SAMPLE\Rainbow.Discovery**
19		Start Date	**1/1/1900**
20		End Date	**1966/06/31**
21		Petroleum Type	**Gas**
22			
23			

Chart 34 Dumped SuperSD report in Excel

Disc Pools work-sheet contains the discovered pools used in the simulation and the validation pools. Other worksheets contain data corresponding to respective SuperSD options. Chart 35 shows the dumped probability data format. The data format in **Favor Grid** and **Prob Grid** worksheets is the same.



	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
10													
11	X26	X27	X28	X29	X30	X31	X32	X33	X34	X35	X36	X37	X38
12	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0.0024694	0.0024694	0.033272
13	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0.0024694	0.0190555	0.0498581
14	-2	-2	-2	-2	-2	-2	-2	-2	-2	0.0024694	0.016686	0.0403803	0.0806607
15	-2	-2	-2	-2	-2	-2	-2	-2	0.0048389	0.0119472	0.0403803	0.0830301	0.144635
16	-2	-2	-2	-2	-2	-2	-2	0.0024694	0.0119472	0.0214249	0.0688135	0.116202	0.229935
17	-2	-2	-2	-2	-2	-2	-2	0.0095777	0.0214249	0.0498581	0.0925078	0.182546	0.296279
18	-2	-2	-2	-2	-2	-2	0.0024694	0.016686	0.0309026	0.0759218	0.170699	0.293909	0.400534
19	-2	-2	-2	-2	-2	-2	0.0143166	0.0237943	0.0711829	0.137527	0.244151	0.421859	0.521375
20	-2	-2	-2	-2	-2	0.0048389	0.0190555	0.0498581	0.106724	0.187285	0.329451	0.511897	0.639846
21	-2	-2	-2	-2	-2	0.0143166	0.033272	0.0782912	0.151744	0.263107	0.407642	0.587719	0.635108
22	-2	-2	-2	-2	0.0048389	0.0190555	0.0451192	0.0948773	0.213349	0.33419	0.504789	0.654063	0.694343
23	-2	-2	-2	-2	0.0095777	0.0214249	0.0759218	0.156482	0.296279	0.438445	0.573502	0.673018	0.732254
24	-2	-2	-2	0.0048389	0.0119472	0.0309026	0.111463	0.20861	0.360254	0.559286	0.635108	0.696713	0.727515
25	-2	-2	-2	0.0095777	0.0119472	0.0498581	0.151744	0.272585	0.450292	0.594827	0.675388	0.718038	0.744101
26	-2	-2	-2	0.0072083	0.0143166	0.0735524	0.177807	0.343668	0.521375	0.627999	0.663541	0.703821	0.718038
27	-2	-2	0.0024694	0.0095777	0.0261637	0.106724	0.215718	0.431336	0.58298	0.687235	0.684866	0.741732	0.70856
28	-2	-2	0.0048389	0.016686	0.0403803	0.128049	0.239413	0.407642	0.601936	0.680127	0.691974	0.722777	0.722777
29	-2	-2	0.0072083	0.0190555	0.0522275	0.144635	0.293909	0.436075	0.613783	0.654063	0.70856	0.691974	0.722777
30	-2	-2	0.0072083	0.0309026	0.0735524	0.177807	0.33182	0.462139	0.58298	0.651694	0.673018	0.710929	0.732254
31	-2	0.0048389	0.016686	0.0356415	0.113833	0.229935	0.372101	0.450292	0.590088	0.663541	0.684866	0.718038	0.696713
32	-2	0.0095777	0.0261637	0.0617052	0.149374	0.29154	0.402903	0.509528	0.580611	0.646955	0.644585	0.694343	0.696713
33	-2	0.0119472	0.0237943	0.0901384	0.206241	0.362623	0.50005	0.564025	0.592458	0.627999	0.654063	0.687235	0.656432

Chart 35 Dumped probability data format

Note that the maximum number of columns in current Excel is 256.

ACKNOWLEDGEMENTS

This work was supported by Geological Survey of Canada Project #950003 and the Panel for Energy Research and Development, Natural Resources Canada. This User Guide was benefited from constructive comments of Dr. M. Obermajer of Geological Survey of Canada, Calgary.

REFERENCES

Gao, H., Chen, Z., Osadetz, K.G., Hannigan, P., and Watson, C., 2000a, A Pool-based model of the spatial distribution of undiscovered petroleum resources, Math. Geology, v.32, n0.6, p. 725 – 749.

Gao, H, Osadetz, K.G., Chen, Z., Hannigan, P., and Watson, C., 2000b, Evaluating the reliability of a petroleum-bearing favorability map for pool-based modeling, in Kleingeld and Krige (eds.), Proceedings of Geostatistics 2000, Volume I, Cape Town, 2000 April, p. 369-380.