User Guide for the Clive PA Model

version 1.0

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Prepared by

Neptune and Company, Inc.

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CONTENTS

FIGURES

1.0 Introduction

This User Guide accompanies the Clive DU PA Model v1.0 computer model (the model).

This radiological performance assessment (PA) computer model, written using the GoldSim systems modeling platform, has been developed to assess the effects of specific proposed disposals of depleted uranium (DU) at the Clive low-level radioactive waste (LLW) disposal facility, operated by Energy*Solutions*, LLC (Energy*Solutions*). The model presents calculations useful in comparison to performance objectives specified by the State of Utah, in UAC 313-25-8.(2)(a), and for comparison to groundwater protection limits (GWPLs) identified in the site's groundwater discharge permit.

The intent of this model is to inform decisions regarding this proposed disposal, considering its possible effects on local groundwater and estimated risk, in terms of radiological dose and uranium toxicity, to human receptors. A complete description of the Model and its purpose is provided in the *Conceptual Site Model* (CSM) white paper, provided as part of the reference set as `Clive DU PA CSM.pdf`.

1.1 Objectives

Effects within the first 10,000 years are measured as concentrations of radionuclides from these wastes in groundwater, and estimates of possible radiological doses and uranium toxicity hazards to hypothetical receptors.

Effects beyond 10,000 years until peak activity is reached (at secular equilibrium—about 2.1 million years) are measured as concentrations of radionuclides from these wastes in water of a future lake, and concentrations of radionuclides from these wastes in sediments deposited by future lakes.

1.2 Model Development

The model was developed by Neptune and Company, Inc. (Neptune) for Energy*Solutions*, with the first version (v1.0) delivered in May 2011. It was developed using the GoldSim probabilistic system modeling platform, developed by GoldSim Technology Group (GTG) of Issaquah, Washington. While the full version of the GoldSim modeling software is required to build and modify the model, full functionality of the model is also available through use of the GoldSim Player, freely downloadable from the GTG web site at http://www.goldsim.com

2.0 Getting Started

It is the intent of the model developers that anyone with access to a personal computer can run the Clive DU PA model, and examine its inner workings. This section covers what is needed to get up and running with the model.

2.1 System Requirements

The GoldSim software is designed to run under the Microsoft Windows operating system, and can run under wither 32- or 64-bit versions of Windows XP, Windows Vista, or Windows 7. A current and more definitive description of the operating constraints under various versions of Windows is available at the GTG website. Running the model in a simple deterministic mode requires modest resources in terms of disk space and random access memory (RAM), but more ambitious runs of perhaps thousands of realizations would be better handled by a computer with a 64-bit version of Windows and at least 4 GB of RAM.

Electronic references supplied with the model are in Adobe Portable Document Format (PDF) and as Microsoft Excel workbooks. In order to view these resources, the user will need to have Acrobat or Acrobat Reader installed, as well as Excel or the Excel Viewer. Acrobat Reader is available at http://get.adobe.com/reader/, and the Microsoft Excel Viewer at http://www.microsoft.com/downloads.

2.2 Installation of GoldSim and the GoldSim Player

The installation of GoldSim or the GoldSim Player is straightforward, much like any other contemporary computer software. The installation files for both the licensed version and the free Player are available for download at the GTG web site. Evaluation and academic versions are also available. An install file for the GoldSim Player is also provided on the distribution disc for the convenience of the user, though it is advised to check the GTG web site for more recent service packs or versions.

2.2.1 Installation on a personal computer running Microsoft Windows

After obtaining the installation file, simply run it like any other software installation, and GoldSim will be ready to run. Licensed versions will require license activation with GTG, and the user will be prompted to go through this process upon running GoldSim for the first time.

2.2.2 Installation on an Apple Macintosh computer

GoldSim runs well on Macintosh computers that have been outfitted with virtual machines (VMs) running Windows. One such platform that has been successfully implemented at Neptune is VMWare, but others may also work. See http://www.apple.com/macosx/compatibility/ for compatibility with your Macintosh system. Once VMWare is installed, the Microsoft Windows operating system is to be installed within it, and GoldSim installed within that.

2.2.3 Installation on computers running Linux

Although Neptune has not tested the running of GoldSim on Windows VMs under other Linux or Unix platforms, given our experience with VMWare and Macintosh, we expect that this could work.

2.3   Installation of the Clive DU PA Model

The Clive DU PA Model is provided on the distribution DVD. The disc includes all files needed to run the model, including the model file in full GoldSim form (*.gsm) and as a Player version (*.gsp). After installing GoldSim or the GoldSim Player, the installation of the model is straightforward.

In order to run the full model or the player version, create a directory on your computer hard drive where the model will reside. The location of the model on your hard drive(s) can be easily changed at any time, since there is no complex installation procedure for the model. Copy the Clive DU PA Model v1.0.gsm and/or the Clive DU PA Model v1.0.gsp file from the DVD (in the \model directory) to the chosen directory on your hard drive, and run the model or the player version in GoldSim.

The model comes with a collection electronic references—mostly PDF documents and URLs to document sources. To facilitate locating supporting information, the Clive DU PA Model contains links to these references in appropriate locations in the model. In order for the model to find these reference materials from links embedded in the model, the user must also copy the entire \model\references directory from the disc to the directory where the model resides. That is, the model always looks for a directory called \references relative to its installed location.

For example, if you copied the model into a directory named

        D:\CliveDU\

then the model will expect to find references here

        D:\CliveDU\references\

The reference set includes PDFs of white papers written by Neptune that describe details of the CSM, processes included in the model, statistical techniques used, and model calculations and inputs. While many papers are provided in PDF format, many other are subject to copyright and cannot be provided. These are available, however, from their respective publishers, and links to sources for these papers are provided. In total, nearly 1 GB of information is provided on the DVD, all of it relevant to the Clive DU PA.

A complete list of Neptune white papers is provided at the end of this User Guide, in Table 1.

3.0 Running the Model

Run the model as you would other Windows software, either by double-clicking on the `.gsm` or `.gsp` model file name, or by launching GoldSim or the Player from a shortcut, and loading the file by navigating to the directory that contains the models. If you are running the Player version, the Welcome screen will appear, depicted in Figure 1.

If you are running the full version of GoldSim, the model will open to its top level page, as shown in Figure 2. This is also available to the Player user by clicking the Browse Model button.
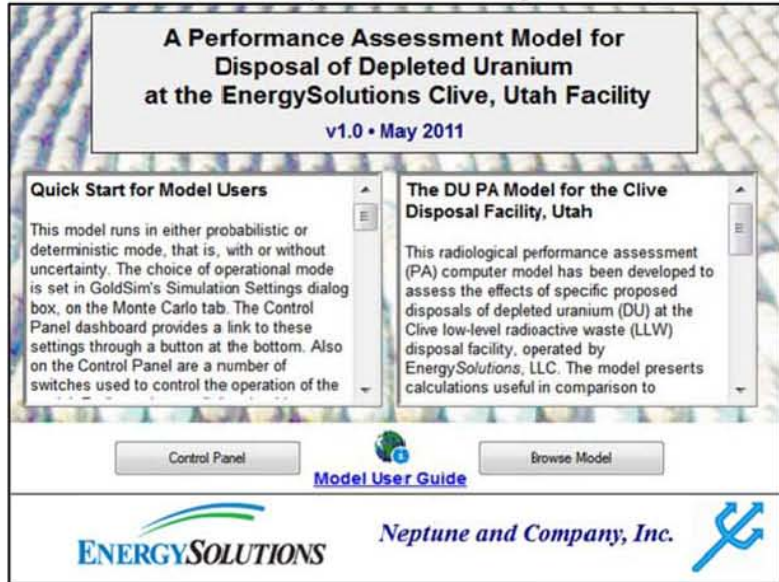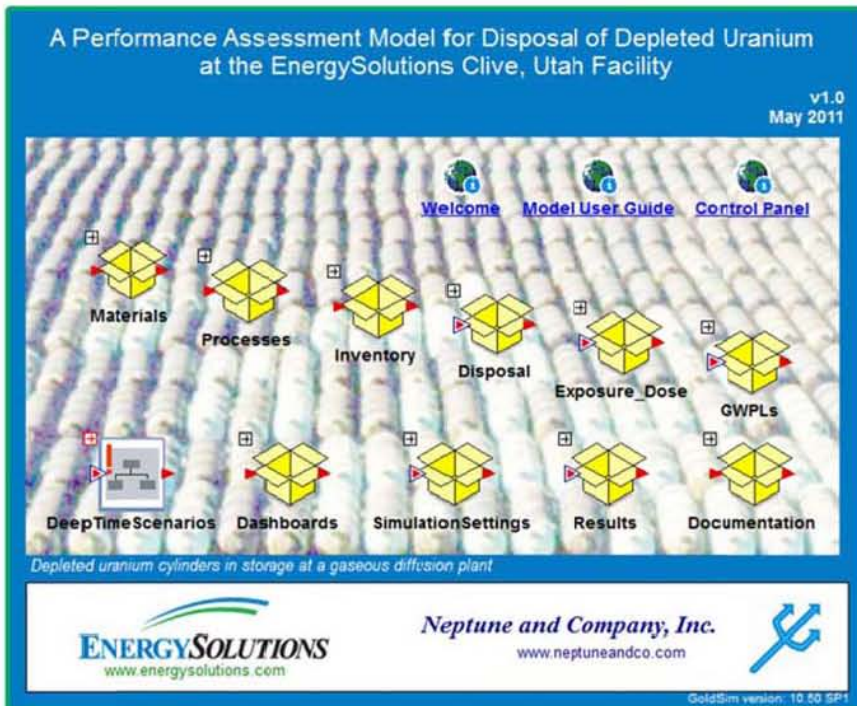
Either way, the user can switch between the two views by selecting the "Browse Model" button from the Welcome screen, or the "Welcome" icon from the top level page.

3.1   Control Panel Setup

From either a button on the Welcome screen or the icon on the top level page, the user can access the model's main Control Panel, shown in Figure 3. The Control Panel is an example of what GoldSim calls a dashboard, which is dialog box-like interface for model users. Dashboards provide information about the model, and buttons that take the user to other dashboards, model controls, or to the model itself, and a number of controls such as check boxes and edit boxes. Each of these controls sports fly-out explanatory text that appears when the user floats the mouse over the control.

Discussion of each of the Control Panel settings follows. A scrolling paragraph of explanatory text is provided at the top of the Control Panel.

3.1.1 Model Duration

☑ Model duration [10000] yr   Upon checking the Model duration checkbox, the user may enter the number of years to be simulated. If the box is not checked, then the full 2.1 million years (My) is simulated. If the user puts in a shorter duration, the model stops calculations at that time, and makes no new calculations out to the end of the 2.1 My. Using this option saves in computation time. This is the preferred method for running simulation durations shorter than the full 2.1 My.

3.1.2 Disposal Cell Selection

The current version of the Clive DU PA Model considers only the Class A South disposal cell, or embankment. The checkbox selecting this disposal cell is permanently checked. Subsequent versions of the Clive PA Model are expected to include other disposal cells, hinted at by the grayed text listing them below the Class A South Cell. See the *Embankment Modeling* white paper for more details.

Disposal Cell Selection

☑ Class A South Cell
☐ Class A Cell
☐ LARW Cell

The model is currently configured for the Class A South embankment, so this disposal cell cannot be deselected.

3.1.3 Inventory Selection

Similarly, the current model is configured to examine the effects of only that DU proposed for disposal. There are three principal sources of this material: the DUO_3 waste in drums from the Savannah River Site (SRS DU) and the two types of DU_3O_8 waste in process cylinders from the gaseous diffusion plants (GDP DU) at Portsmouth, Ohio and Paducah, Kentucky. These GDP DU wastes are subdivided into "clean" DU, which contains only uranium and its decay products, and "contaminated" DU, which has been contaminated with fission and activation products present in uranium from reactor returns that was introduced to the process. All of the SRS DU is contaminated with such reactor returns. The user can select different combinations of these waste streams, and both are assumed to be disposed in the Class A South Cell. Subsequent versions of the

Inventory Selection

☑ SRS DU Waste
☑ "Clean" GDP DU Waste
☑ "Contaminated" GDP DU Waste
☐ Generic Class A LLW
　　This Generic waste has no inventory.

Be sure to define a disposal location to any specified inventory:

[Waste Layering Definition]

Clive PA Model are expected to include other Class A LLW as well, as suggested by their listing in gray below the two DU waste types. For more information about the various waste types in the model, see the *Waste Inventory* white paper.

In addition to selecting the various types of waste to be included in a given realization, the user can select where, in a vertical stack, these wastes are to be emplaced. The Waste Layering Definition dashboard, shown in Figure 4, offers a layer-by-layer choice of waste types.

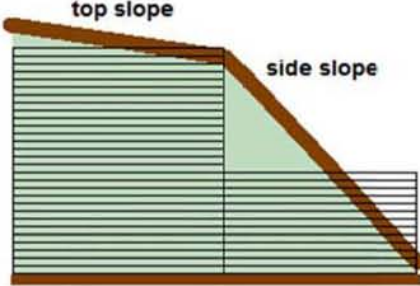## Definition of Waste Layering for the Class A South Embankment

The embankment consists of top slope and side slope sections, each of which is represented by a column of cells with a total thickness equal to the average thickness of the respective column. Each column is broken down into cells of like thickness (within the column), roughly 0.5 m. Each cell may

Top Slope column

	Top Slope Waste Cell Contents
Waste01	no waste (clean soil)
Waste02	no waste (clean soil)
Waste03	no waste (clean soil)
Waste04	no waste (clean soil)
Waste05	no waste (clean soil)
Waste06	no waste (clean soil)
Waste07	no waste (clean soil)
Waste08	no waste (clean soil)
Waste09	no waste (clean soil)
Waste10	no waste (clean soil)
Waste11	DUOx: GDP (contaminated)
Waste12	DUO3: SRS (contaminated)
Waste13	DUOx: GDP (clean uranium)
Waste14	DUOx: GDP (clean uranium)
Waste15	DUOx: GDP (clean uranium)
Waste16	DUOx: GDP (clean uranium)
Waste17	DUOx: GDP (clean uranium)
Waste18	DUOx: GDP (clean uranium)
Waste19	DUOx: GDP (clean uranium)
Waste20	DUOx: GDP (clean uranium)
Waste21	DUOx: GDP (clean uranium)
Waste22	DUOx: GDP (clean uranium)
Waste23	DUOx: GDP (clean uranium)
Waste24	DUOx: GDP (clean uranium)
Waste25	DUOx: GDP (clean uranium)
Waste26	DUOx: GDP (clean uranium)
WasteOut	DUOx: GDP (clean uranium)

	thickness	volume
each waste cell	0.504 m	8.79e4 m3
entire waste layer	13.61 m	2.373e6 m3

[Exit to Top Slope Wastes]

Side Slope column (currently disabled)

No DU wastes are allowed in the side slope in this model.

	thickness	volume
each waste cell	0.483 m	2.961e4 m3
entire waste layer	5.792 m	3.553e5 m3

[Exit to Side Slope Wastes]

Summary information

	Top slope volume	Side slope volume	CAS total volume		bare waste volume	packing efficiency (should be <= 1)	
no waste	8.79e5 m3	3.553e5 m3	1.234e6 m3				
Class A Low-Level Waste	0 m3	0 m3	0 m3	✓			
DUO3: SRS (contaminated)	8.79e4 m3	0 m3	8.79e4 m3	✓	2157 m3	0.0245	✓
DUOx: GDP (contaminated)	8.79e4 m3	0 m3	8.79e4 m3	✓	1.334e4 m3	0.152	✓
DUOx: GDP (clean uranium)	1.318e6 m3	0 m3	1.318e6 m3	✓	3.27e5 m3	0.248	✓

A red X indicates that an inventory volume problem requires resolution.

[Go to Material Properties]   [CAS Inventory Definitions]   [Exit to Class A South]   [Control Panel]

In the example of waste layering shown, Clean GDP DU wastes are on the bottom several layers, overlain by a layer of SRS DU wastes, all of which are contaminated, and that by a layer of Contaminated GDP DU waste. These can be rearranged in any combination that accommodates the volumes of wastes. The information necessary to assure such accommodation is posted at the bottom of the Waste Layering Dashboard. As each waste layer is assigned a material, the volume of that layer is allocated to that waste. If the total volume of the allocated layers is insufficient to contain the volume of the waste type, a red **X** is displayed in the volume calculation table. Assigning more layers to the waste in question will spread it evenly among the layers. Volume should be added by adding layers until the waste volume is exceeded by the total layer volume assigned to that waste type, or a packing efficiency is achieved that is within range of what can be expected in disposal operations. The packing efficiency is the ratio of the volume of the waste type to the assigned layer volume, so therefore must be < 1 in order to accommodate even a perfectly packed waste form, having no voids to contend with.

Waste placement is limited to the layers available in the dashboard. Each of the 27 layers can contain only one waste type at a time. Each is about 50 cm (20 in) thick, and covers the entire Top Slope area of the embankment. For the purposes of this PA, the side slope column is not considered for waste disposal.

3.1.4 Exposure/Dose Controls

A few options are available to the user for controlling the calculation of human exposures and resulting doses and uranium hazards:

Perform dose calculations enables the dose calculations. This would ordinarily be checked, but if the user is interested only in groundwater concentrations or deep time scenarios, for example, computational effort can be saved by not calculating doses.

Duration: If Perform dose calculations is checked, then the user can select the duration of the dose simulation, up to 10,000 yr, in accordance with UAC 313-25-8.(2)(a).

Granularity: If Perform dose calculations is checked, then the user can also select the "granularity" of the calculations for individual receptors. The individual receptor calculations run at a finer time step than the rest of the model, and this setting defines that time step. This could be as low as 1 yr, which brings in a new set of receptors (ranchers and recreationalists, including hunters and off-highway vehicle enthusiasts) each year for the duration of the dose calculations. Doing so will be more computationally intensive, but the dose to each receptor is calculated and compiled with doses to all receptors, so that individual physiological differences are accounted for. The user might also consider setting this to 10 yr (a new set of receptors is determined every 10 years) to save computational time. A choice of granularity of 0 yr tells the model to use no

granularity at all, defining a new set of receptors only at each of the larger modeling time steps, defined in Simulation Settings. The model runs fastest with the granularity = 0 yr setting.

Use probabilistic DCFs: The user can select between using the fixed (deterministic) and uncertain (probabilistic) values for dose conversion factors (DCFs) with this checkbox. By choosing the probabilistic DCFs, the uncertainty inherent in DCFs is accounted for in the calculations. If the model is run in probabilistic mode. DCFs come from EPA's Federal Guidance Report (FGR) 13. Details on the effects of this and other Exposure/Dose controls are provided in the *Dose Assessment* white paper.

Enable institutional control: The institutional control period is a time when receptors are kept off the site. If this is unchecked, receptors may gain access to the site at any time. Institutional control is otherwise assumed to be effective for 100 yr.

3.1.5 Simulation Settings

GoldSim provides model users and developers with a number of tools for modifying the simulation. These are available through the Simulation Settings dialog, a part of GoldSim. Users of the full version of GoldSim can access these controls with the F2 key, or by Run | Simulation Settings on the GoldSim menu. Users of the Player version of the Clive DU PA Model can access simulation settings from a button on the model's Control Panel dashboard.

The simulation settings of greatest utility to the user for this probabilistic model are on the Monte Carlo tab. Here, the user can selected between probabilistic and deterministic modes of operation. Deterministic modeling, while not offering a sense of the uncertainty in any given results, is a quick way to experiment with model behavior given different scenarios. The user can also choose whether to use the deterministic values set in each Stochastic element definition (these are generally means values), or force the use of mean values, or any given percentile of values from the input distributions. Median values would be selected by specifying the quantile 0.5. Many cases can be considered in
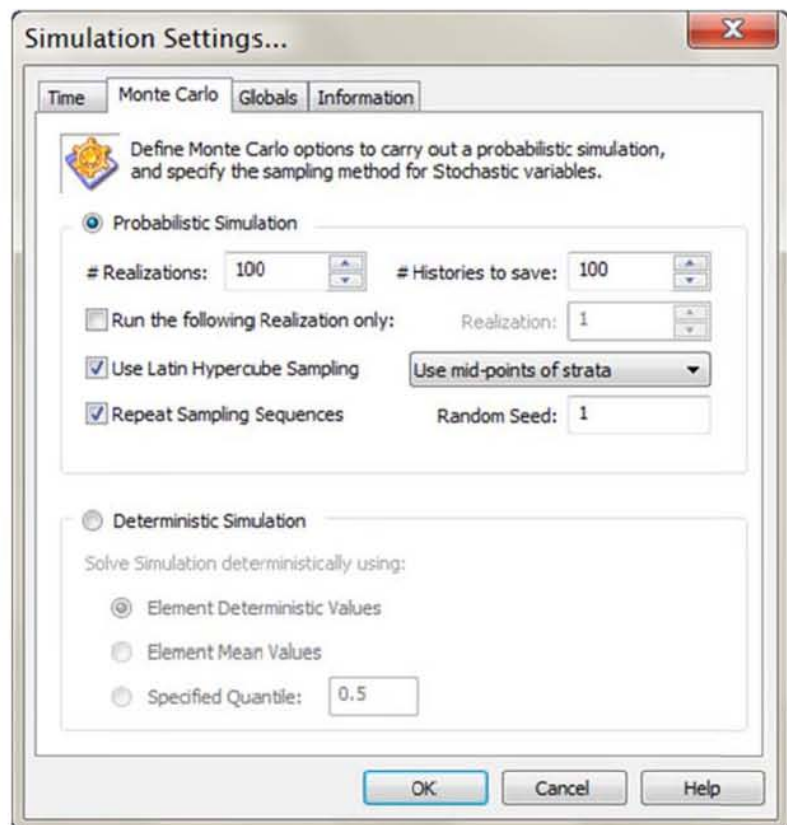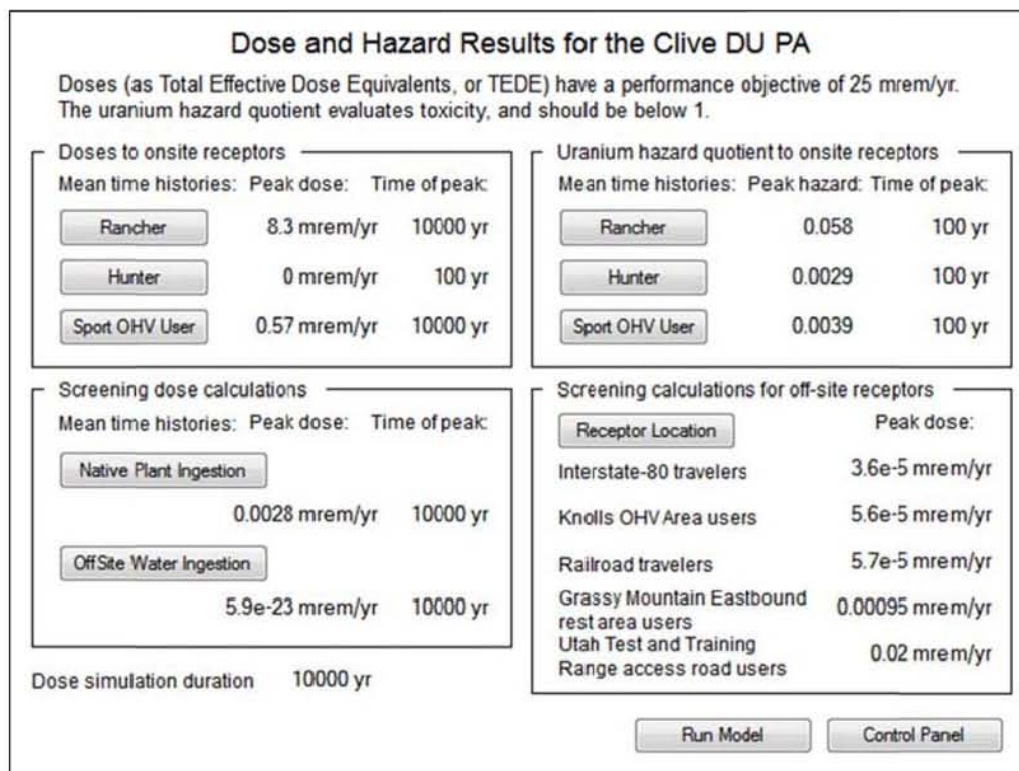
manipulating the settings on the Control Panel. Some of the more common cases to be considered are discussed in the following section.

For users interested in the uncertainty surrounding a particular scenario or result, the model can be run in probabilistic mode. On the Monte Carlo tab, the number of realizations to run can be selected. 100 is a reasonable starting point, offering a rough span of the uncertainty in a short amount of time. A global sensitivity analysis should use something more like 5000 realizations. The # Histories to save should generally be set to be the same number. Latin Hypercube Sampling should be enabled.

More information on these settings and others in the dialog is available in the GoldSim User Manual that is installed with the software.

3.2 Displaying Results

Model results are available in a variety of forms. Time histories show the value of one or more outputs as they change in time. Maximum values show the peak value an output has reached over the duration of the simulation. Final values show outputs values at the end of the simulation. If the model is run probabilistically, each of these results will also include the statistical summary of the value, indicating the uncertainty surrounding its estimation. Most outputs of interest are available through the dashboards linked from the control panel. For example, outputs related to human exposures (dose and hazard) are shown on the Dose Results dashboard (Figure 6), with final values displayed and full time histories available via buttons. As the model runs through

Dose and Hazard Results for the Clive DU PA

Doses (as Total Effective Dose Equivalents, or TEDE) have a performance objective of 25 mrem/yr. The uranium hazard quotient evaluates toxicity, and should be below 1.

Doses to onsite receptors

Mean time histories:	Peak dose:	Time of peak:
Rancher	8.3 mrem/yr	10000 yr
Hunter	0 mrem/yr	100 yr
Sport OHV User	0.57 mrem/yr	10000 yr

Uranium hazard quotient to onsite receptors

Mean time histories:	Peak hazard:	Time of peak:
Rancher	0.058	100 yr
Hunter	0.0029	100 yr
Sport OHV User	0.0039	100 yr

Screening dose calculations

Mean time histories:	Peak dose:	Time of peak:
Native Plant Ingestion	0.0028 mrem/yr	10000 yr
Off Site Water Ingestion	5.9e-23 mrem/yr	10000 yr

Dose simulation duration   10000 yr

Screening calculations for off-site receptors

| Receptor Location	Peak dose:
Interstate-80 travelers	3.6e-5 mrem/yr
Knolls OHV Area users	5.6e-5 mrem/yr
Railroad travelers	5.7e-5 mrem/yr
Grassy Mountain Eastbound rest area users	0.00095 mrem/yr
Utah Test and Training Range access road users	0.02 mrem/yr

Run Model   Control Panel

various realizations, the displayed values are updated. In a probabilistic run, therefore, the values displayed on the dashboard are from only the final realization, and do not represent the entire suite of realizations.

3.2.1 Time History graphs

A time history of a deterministic estimate of dose to a ranch hand receptor is shown in Figure 7. Time is shown along the abscissa (the horizontal axis), and dose is shown on the vertical. Both axes may be linear or logarithmic scales. Since this is a deterministic simulation, only a single realization is shown. This graph shows the dose time history over the full 10,000 yr, and represents the annual dose that a ranch hand would receive if he were to show up in any given year. In very early time, the effect of 100 years of institutional control can be seen, where receptors are kept off the site and no doses are achievable. After the loss of institutional control, the dose steadily increases to its maximum value at 10,000 yr, which can be seen by positioning the computer mouse over the graph: 8.3 mrem in a year, in this example. This value is also seen on the dashboard as the peak dose to this receptor.
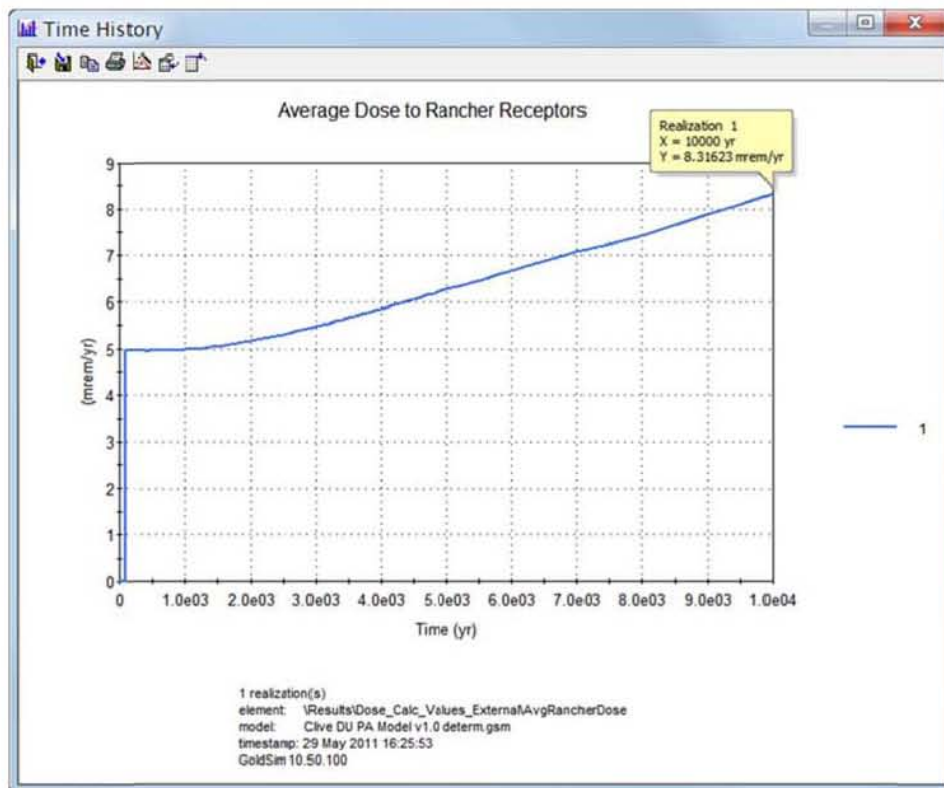
At the bottom of the graph window is displayed information about the simulation, including

- the number or realizations run,
- the name of the GoldSim model element whose output is displayed (in this case, AvgRancherDose),
- the exact name of the model file that was run (Clive DU PA Model v1.0 determ.gsm),
- the date and time of the model run, and
- the version of GoldSim used to run the model.

This information aids in recording and reproducing information from model simulations. The user is strongly advised to save different simulations using descriptive file names.

To continue with our example of dose to the ranch receptor, several additional results not available directly from dashboards are available in the **Results** container. For example, the contributions to dose from individual radionuclides is shown in Figure 8. Clearly, U238 is the leading contributor, followed by Rn222.
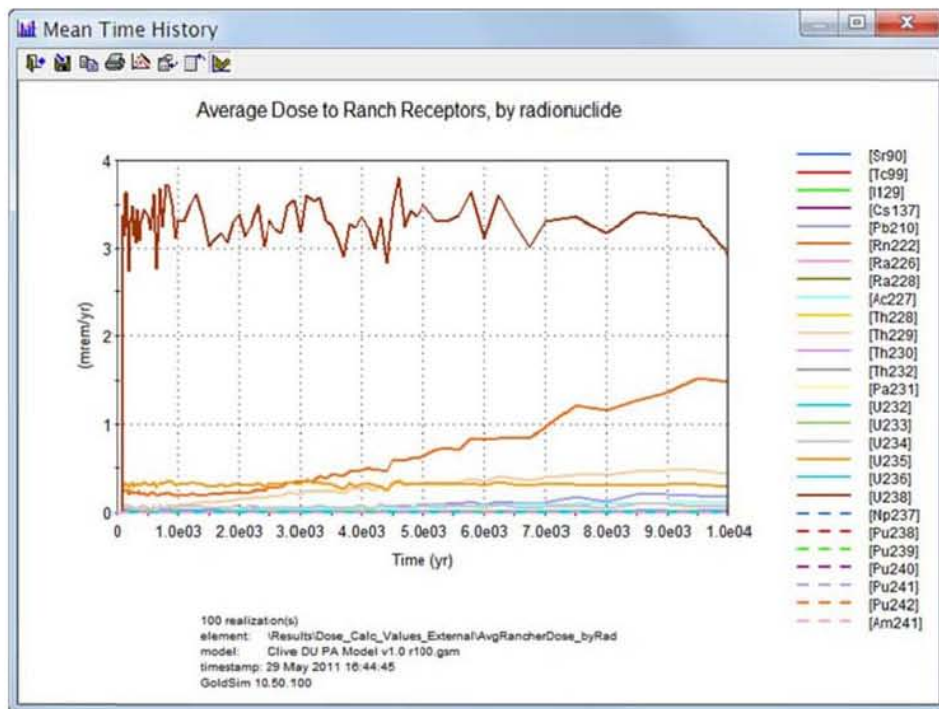
de

A probabilistic simulation of the same output (rancher dose) is shown in Figure 9, having run 100 realizations. Here, the vertical axis (dose) has been displayed as using a logarithmic scale, in order to aid in viewing the results. The peak mean dose is seen to be just over 6 mrem in a year at 9500 yr. The legend identifies various percentiles of the dose at each time step.
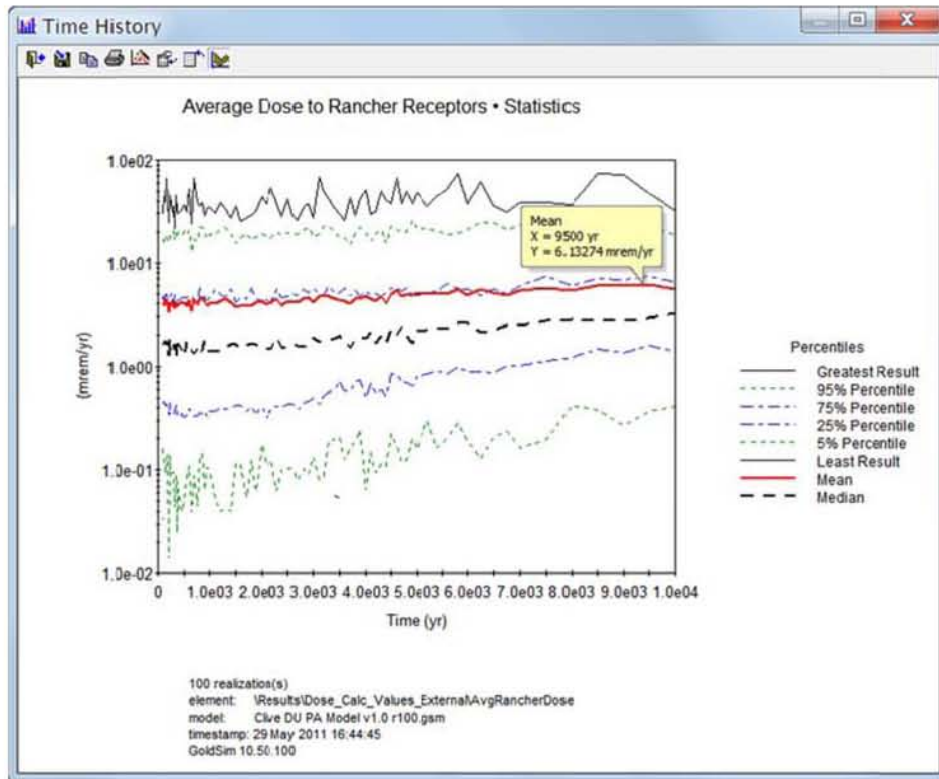
See the GoldSim User Manual for information about manipulating time history plots.

3.2.2 Outputs of values directly on the results dashboards

Many dashboards display values for results directly. These output values are useful for showing deterministic simulation results, but not for probabilistic ones. After a probabilistic simulation, the values displayed are the final values for the last realization, not mean values or any other representation of probabilistic results.

3.2.3 Intermediate Model Results

One feature in GoldSim that aids in transparency is that any model output can be examined to see how it behaves in the simulation. Most element definition dialogs have options for saving results either as final values or as full time histories. In order to examine results from any particular GoldSim element, simply check the Save Final Values or Save Time History checkboxes in the element. More information on saving specific results is available in the GoldSim Manuals or Help.

The Player version does not allow the user to select specific time histories or final values to record.

3.3 Executing Common Scenarios

Depending on the user's particular interest, various simulation scenarios may be run, as discussed in this section.

3.3.1 Selecting Waste Types and Layering

The selection of waste types to be included in a simulation is discussed in Section 3.1.3, and is done using the Control Panel dashboard (Figure 3). As shown in Figure 4, the user can also specify where specific waste types are to be layered. In general, arranging wastes deeper in the embankment will reduce their influence on doses, but may increase their groundwater concentrations, and *vice versa*.

3.3.2 Optimizing Simulations for Specific Endpoints of Interest

If a large number of probabilistic realizations needs to be run, it is often desirable to disable unnecessary calculations to improve computer run time. The scenarios presented below represent the most common methods of streamlining calculations.

3.3.2.1 Comparisons to Groundwater Protection Limits

If one is interested solely in groundwater concentrations, for example to compare to GWPLs, there is no need to run the dose calculations, or even to run the model past 500 yr, the duration of GWPL applicability. Therefore, the Control Panel could be set up as shown in Figure 10: The model duration is set to 500 yr, and dose calculations are turned off.

3.3.2.2 Human Exposure Scenarios

If the user is interested only in evaluating human exposures, the dose calculations should be enabled, and the duration could be limited to only 10,000 yr, so as to save time in not calculating to 2.1 My. The granularity of the dose calculations, described in Section 3.1.4, should be set to the desired value.

3.3.2.3 Deep Time Results

For examining deep time results, the Model duration checkbox should be left unchecked, so that the full 2.1-My simulation is run. The dose calculations should be disabled, as was done for the groundwater calculations.

Control Panel for the Modeling of the Clive Disposal Facility

This control panel allows the user access to several settings and processes in the model. Individual embankments can be enabled and disabled, and specific disposal inventories can be engaged. Some exposure/dose controls are available. Scroll down for more information on using the Control Panel:

☑ Model duration   500   yr

Disposal cell selection

☑ Class A South Cell
☐ Class A Cell
☐ LARW Cell

The model is currently configured for the Class A South embankment, so this disposal cell cannot be deselected.

Inventory selection

☑ SRS DU Waste
☑ "Clean" GDP DU Waste
☑ "Contaminated" GDP DU Waste
☐ Generic Class A LLW
    This Generic waste has no inventory.

Be sure to define a disposal location to any specified inventory:

[Waste Layering Definition]

Exposure/dose controls

☐ Perform dose calculations
Duration   10000   yr
Granularity   0   yr

☑ Use probabilistic DCFs
☑ Enable institutional control

Results
[Groundwater Results] [Dose Results] [Deep Time Scenarios] [Miscellaneous Results]

[Diagnostics] [Browse Model] [Simulation Settings] [Run Model] [Welcome Screen]

is alone

3.3.2.4 Comprehensive Simulations

Unless the user is running on a particularly slow computer, or desired to run a large number of realizations, it may be fine to leave all the calculations enabled. This allows exploration of all results within a single model. In this case, the Control Panel should be set up as shown in Figure 3, with consideration given to dose calculation granularity, as described in Section 3.1.4.

3.4 Diagnostics

The diagnostics dashboard (Figure 11) provides access to model controls that enable or disable a number of physical, chemical, and biological processes in the model. The principal use of these is to verify that certain modeled processes are working in response to the controls, and it is of little value in running simulations for information. The result elements accessed by button controls on this dashboard show various outputs that indicate whether a process is working or not.

4.0 Error Messages, Alerts, and Warnings

The Clive DU PA Model has a few interrupts and warnings that alert the user to certain situations that may require attention. The GoldSim software produces its own set of warnings and errors as well.

4.1 Messages from the Model

4.1.1 Waste Requires Layering

If a waste inventory is selected, then it must be assigned to the waste layering. If no layer has been specified to host a selected waste type, the model issues a message to the user about how to fix the problem. An example of such a message is shown here.

4.1.2 Waste Packing Efficiency Warning

The Waste Layering dashboard (Figure 4) displays information at the bottom regarding the packing of the waste into the selected volume. A table of values is calculated by the model, as discussed in Section 3.1.3. A detail of this table is shown below:

The red **X** indicates that one of the selected inventories has an estimated volume that exceeds the volume allocated to it using the Waste Layering controls—that is, the packing efficiency is greater than 1. The user must add more layers for the indicated inventory type ("DUOx: GDP (clean uranium)" in this example) until the packing efficiency drops below 1, or within the range of estimated packing efficiency that could be achieved in disposal operations.

4.1.3 Run Log Warnings and Error Messages

After every simulation, GoldSim generates a run log to document it. This information, which is stored within the model in results mode, includes metadata (software version, model name, run time, etc.) as well as a record of warnings and errors that GoldSim encountered during the run. These warnings are intended to indicate problems in the model, but most are benign. For example, most of them identify differences in fluid fluxes that are intentionally programmed. For reasons that are explained in the model itself, some material balances are deliberately crafted this way, and doing so does not indicate a mathematical mass balance error.

Specifically, references to the "Footprint" cells, or cells called Cap03, Cap04, etc. are expected to display warnings, and will be found in the Run Log file. These are not errors, and apparent mass balance errors are accounted for in the model design.

4.2 GoldSim Error Messages

The GoldSim software may generate its own error messages, independent of any messages generated by the model. These messages may refer to something occurring in the model, or something in GoldSim itself. Should such a message appear, consult the GoldSim help. If the problem cannot be resolved, try to reproduce it and contact GoldSim support. Methods of contact

are found by selecting Help | Contact Technical Support or Help | Report a Problem from the GoldSim menu.

5.0 Supporting References

A number of references, or "white papers" have been developed as background information supporting the development of the performance assessment model. These are listed below, and are to be found in the `\model\references` directory on the DVD. If this `\references` subdirectory is installed in the same directory as the GoldSim model, these reference papers and others referenced from within the model itself will be found through hyperlinks.

Table 1. White papers supporting the Clive DU PA Model

white paper title	file name
Model Parameters for the Clive DU PA	Clive PA Model Parameters.pdf and Clive PA Model Parameters.xls
Features, Events, and Processes for the Clive DU PA	Clive DU PA FEP Analysis.pdf
Conceptual Site Model for the Clive DU PA	Clive DU PA CSM.pdf
Atmospheric Transport Modeling for the Clive DU PA	Atmospheric Modeling.pdf
Biologically-Induced Transport for the Clive DU PA	Biological Modeling.pdf
Decision Analysis for the Clive DU PA	Decision Analysis.pdf
Deep Time Assessment for the Clive DU PA	Deep Time Assessment.pdf
Dose Assessment for the Clive DU PA	Dose Assessment.pdf
Embankment Modeling for the Clive DU PA	Embankment Modeling.pdf
Erosion Modeling for the Clive DU PA	Erosion Modeling.pdf
Geochemical Modeling for the Clive DU PA	Geochemical Modeling.pdf
Probability Distribution Development for the Clive DU PA	Probability Distributions.pdf
Saturated Zone Modeling for the Clive DU PA	Saturated Zone Modeling.pdf
Sensitivity Analysis for the Clive DU PA	Sensitivity Analysis.pdf
Unsaturated Zone Modeling for the Clive DU PA	Unsaturated Zone Modeling.pdf
Radioactive Waste Inventory for the Clive DU PA	Waste Inventory.pdf