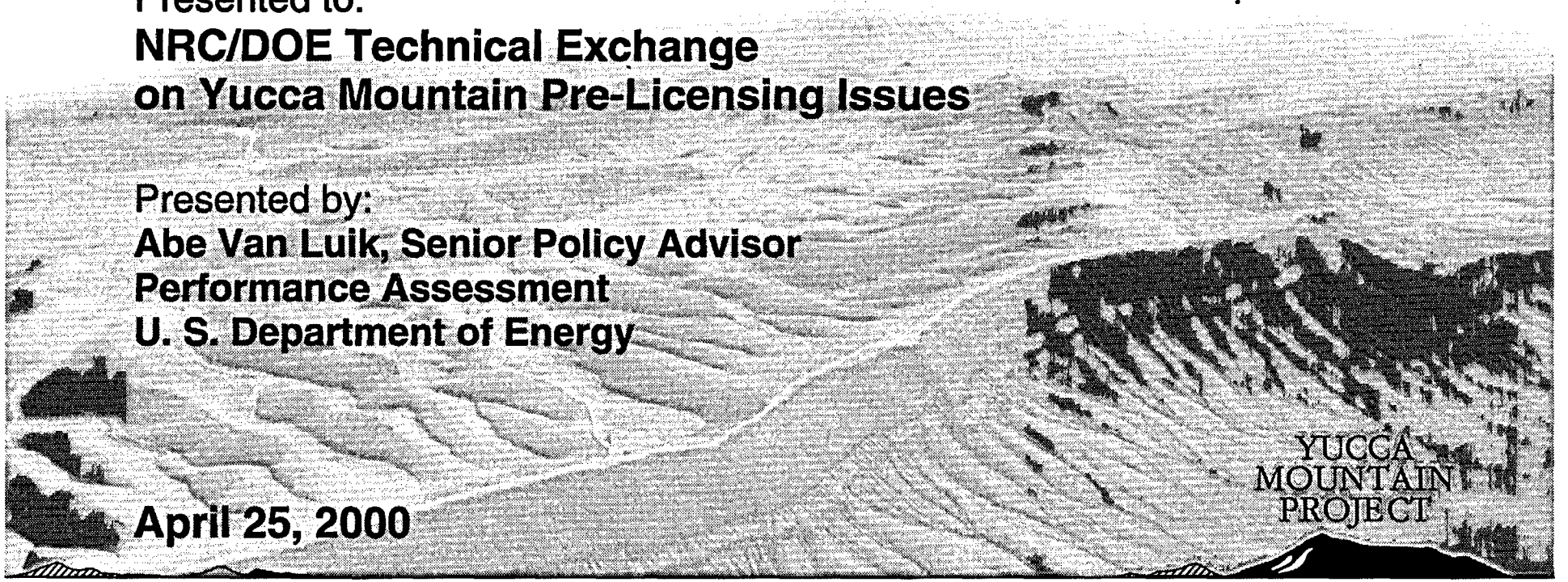
[5]

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Total System Performance Assessment and Integration

Presented to:
NRC/DOE Technical Exchange
on Yucca Mountain Pre-Licensing Issues



Presented by:
Abe Van Luik, Senior Policy Advisor
Performance Assessment
U. S. Department of Energy

April 25, 2000

Legacy / Main-Ku

Key Technical Issue: Total System Performance Assessment and Integration Presentation Overview

- DOE General Approach to Issue Resolution
- Statement of Total System Performance Assessment and Integration (TSPAI) Objective
- Discussion of Approach to Addressing TSPAI Subissues
  - System Description and Multiple Barriers
  - Scenario Analysis
  - Model Abstraction
  - Overall Performance Objective
- Summary

DOE Approach to Issue Resolution

- DOE is committed to an approach to resolution in the context of NRC's risk-informed, performance-based method
- DOE is reviewing the TSPAI Issue Resolution Status Report, Revision 2
- Issues will continue to be addressed through formal interactions and correspondence - including the upcoming NRC/DOE Technical Exchanges

Objective of TSPAI Key Technical Issue

Outline the elements of an acceptable methodology and approach for conducting assessments of repository performance to demonstrate compliance with total-system performance and multiple barrier requirements

possible to close on methodology

Subissues Supporting the TSPAI KTI Objective

KTI SUBISSUES	IMPORTANCE TO REPOSITORY PERFORMANCE
1 System Description and Demonstration of Multiple Barriers	Demonstrates the effectiveness and diversity of the barriers as a measure of the resiliency of the repository
2 Scenario Analysis	Describes what can reasonably happen to the repository and the processes and events that can affect the system
3 Model Abstraction	Provides for a systematic examination, in the context of the total system performance, whether models, assumptions, and input data have been appropriately identified, incorporated and analyzed in the TSPA
4 Demonstration of the Overall Performance Objective	Provides for a transparent demonstration of compliance with the overall performance objective

Status of Issues Related to the TSPAI KTI

- **32 Site Characterization Analysis (SCA) issues are identified in the TSPAI Issue Resolution Status Report, Revision 2:**
  - **27 are resolved**
  - **5 remain open** agree that are not closed
    - **DOE expects that the open issues related to weighting of alternative conceptual models, scenario screening, and clarifying the TSPA method will be resolved by the TPSA-Site Recommendation (SR)**
    - **The data related to expert judgement and to information supporting scenario elimination will be dealt with by other Project activities**

Subissue 1, System Description and Demonstration of Multiple Barriers

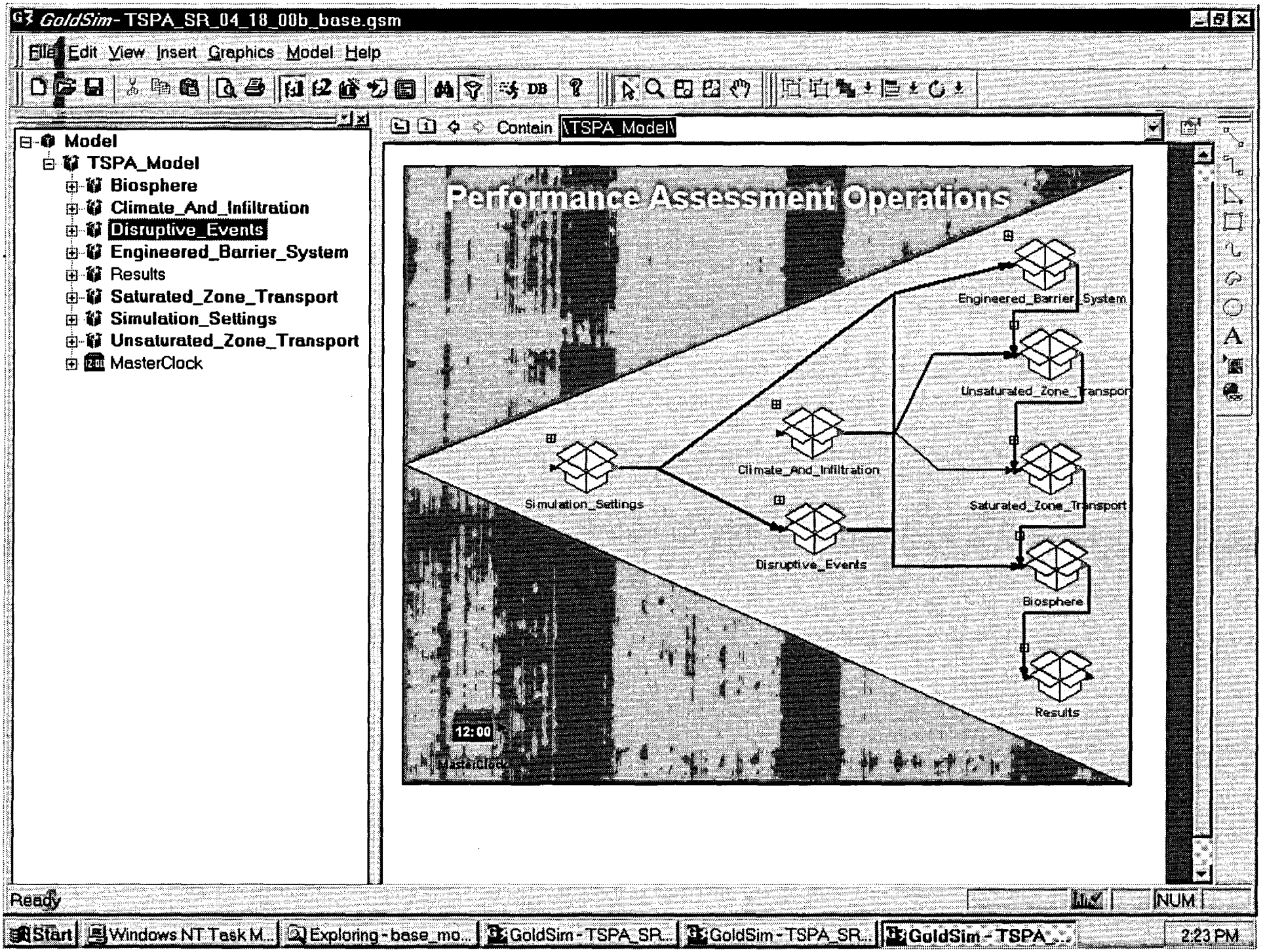
- Three major elements of this subissue are related to:
  - Transparency of documentation
  - Traceability of information used in analyses, including code design and flow
  - Demonstration of the resilience of the system with respect to multiple barriers
- Other elements of the subissue, such as features, events, and processes (FEPs) screening, are addressed under Subissue 2 in this presentation and are also addressed in subsequent presentations

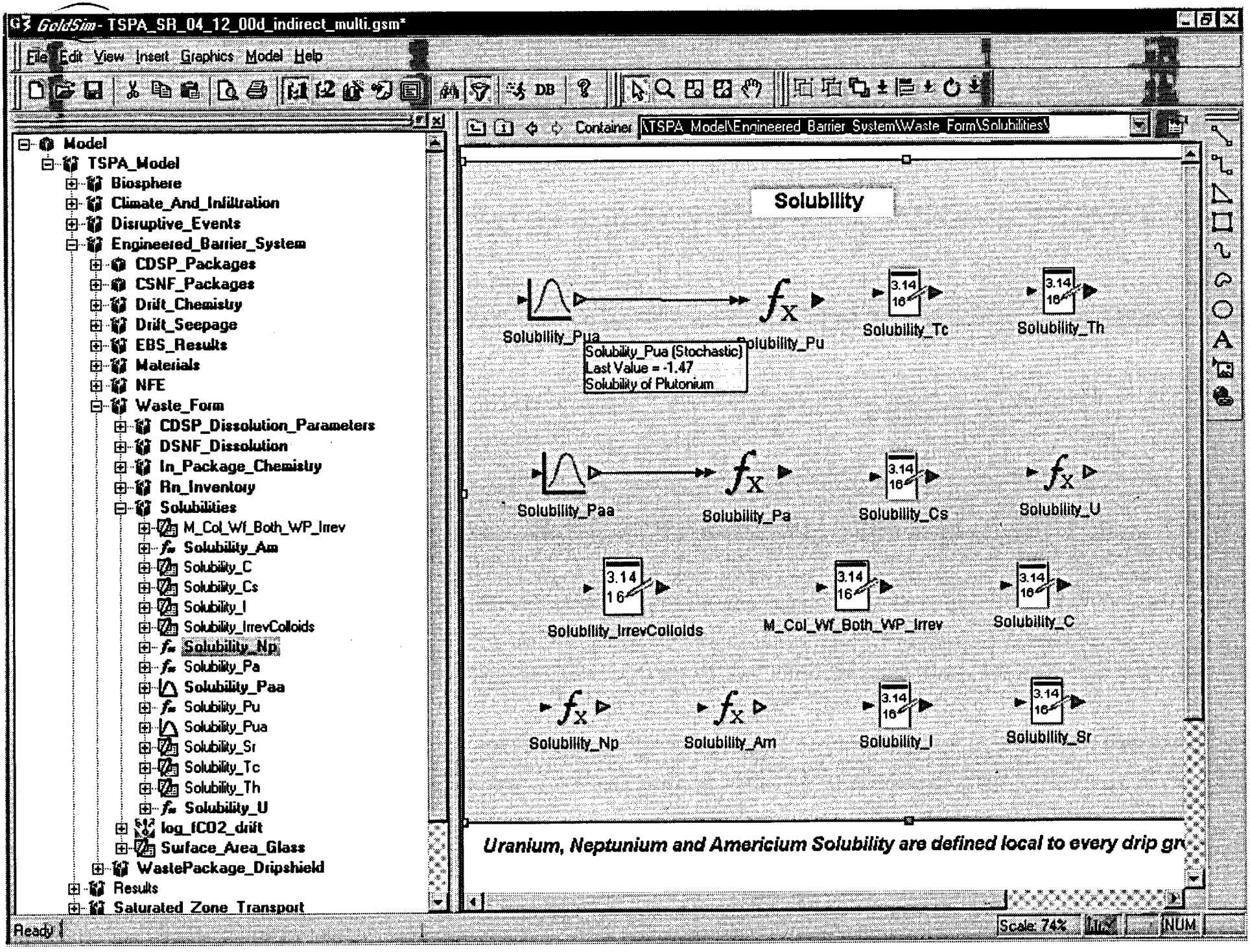
Addressing Transparency

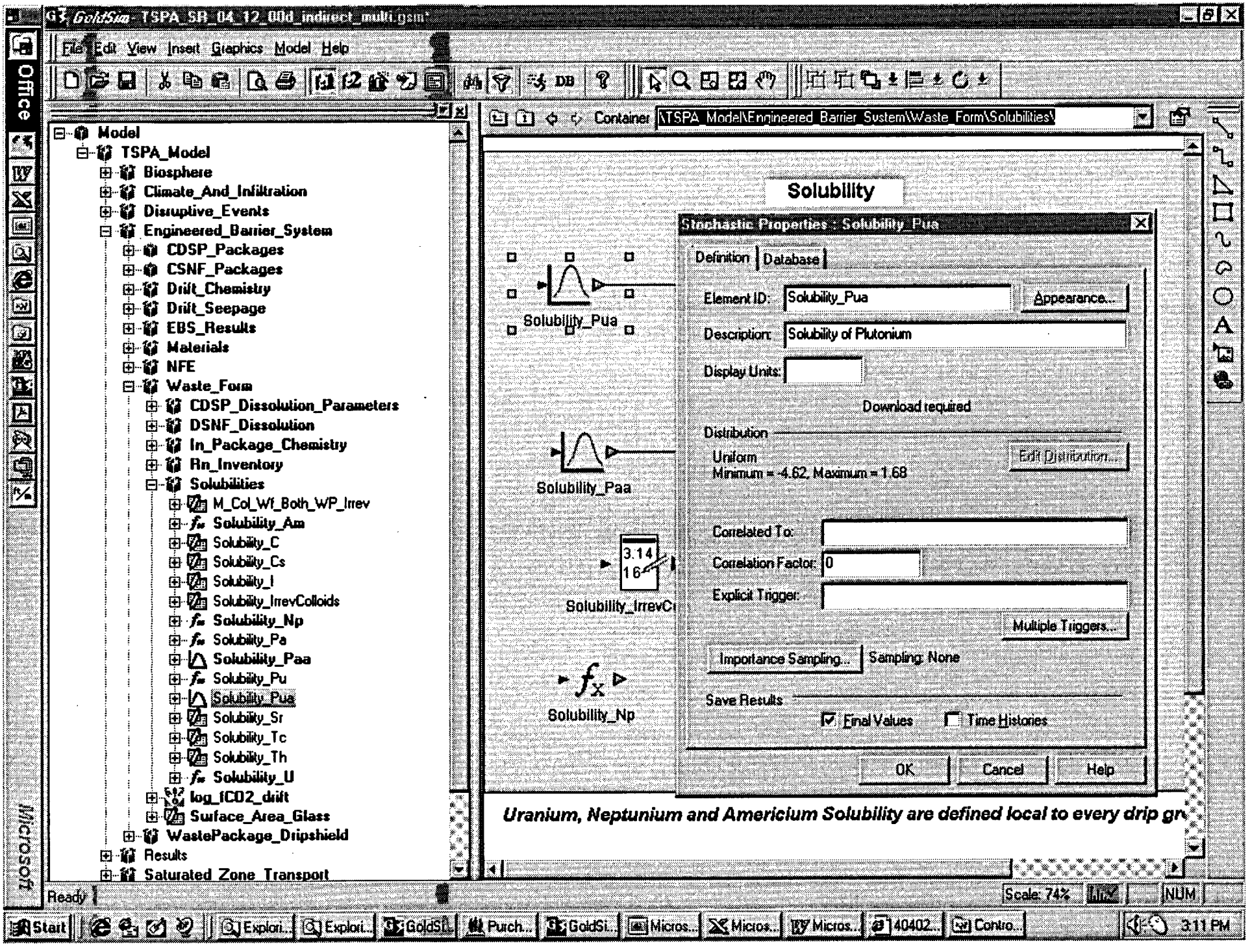
- The TSPA Methods and Assumptions document provided a roadmap for development of the TSPA-SR
  - no surprises → some tweaks in implementation
- The TSPA-SR document is tied directly through text, table, and graphics to the supporting Analysis and Model Reports (AMRs) and Process Model Reports
- Explicit discussions of the TSPA methodology and treatment of uncertainty are also part of the TSPA-SR

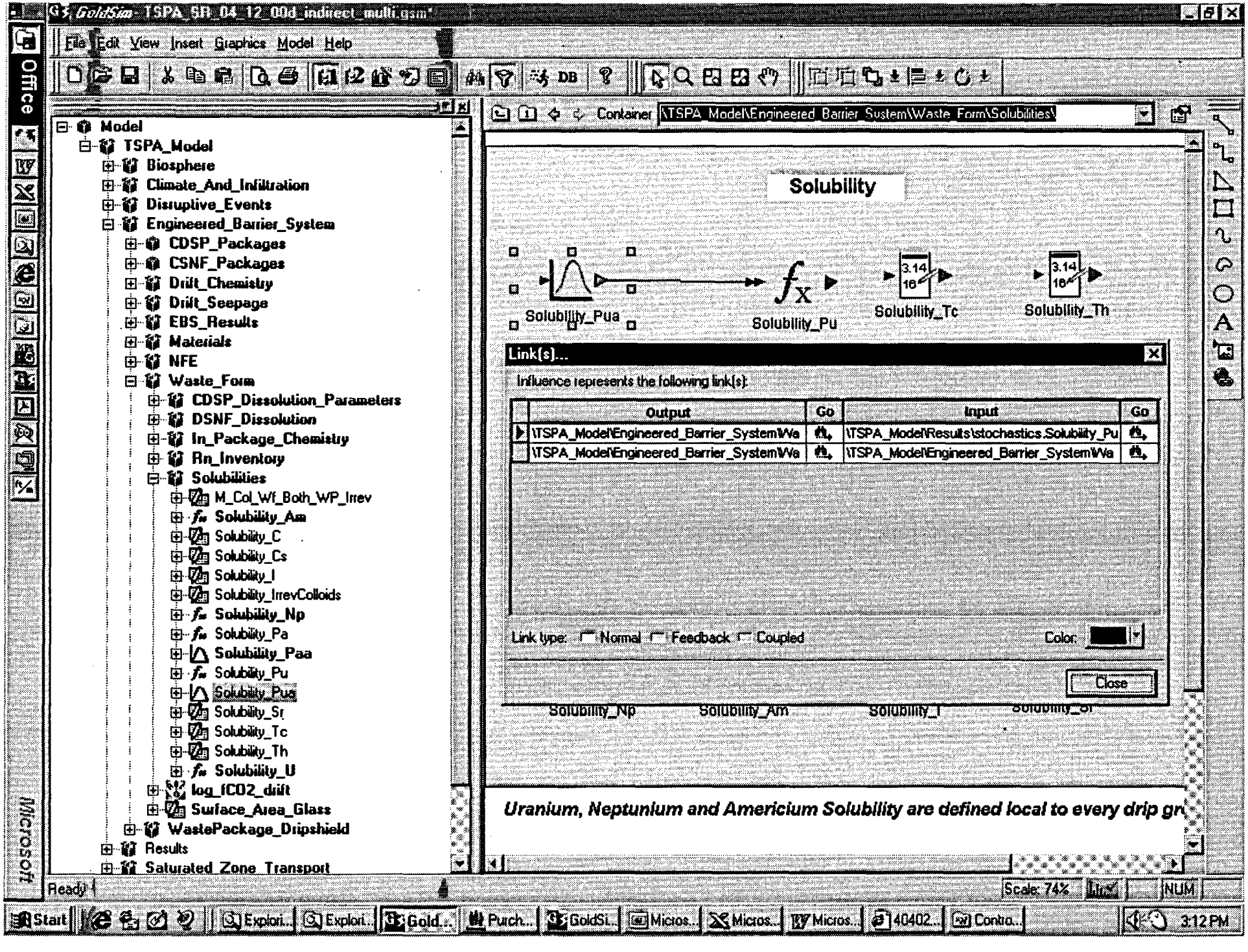
Addressing Traceability

- Assumptions and details of the analysis will be in the TSPA-SR document and supporting AMRs
- The TSPA analysis tool allows direct tracking of information along its entire path through the analysis. This hierarchy allows for tracing information flow, as follows use of model outputs
  - TSPA model output
  - TSPA subsystem model outputs
  - Component abstraction model inputs
  - Individual parameter distribution inputs
- All of the above have unique data tracking numbers for traceability and control of Q-status


GoldSim - TSPA_SR_04_18_00b_base.gsm
File Edit View Insert Graphics Model Help
Model
TSPA_Model
Biosphere
Climate_And_Infiltration
Disruptive_Events
Engineered_Barrier_System
Results
Saturated_Zone_Transport
Simulation_Settings
Unsaturated_Zone_Transport
MasterClock
Contain \TSPA_Model\
Performance Assessment Operations
Engineered_Barrier_System
Unsaturated_Zone_Transport
Climate_And_Infiltration
Saturated_Zone_Transport
Simulation_Settings
Disruptive_Events
Biosphere
Results
12:00
MasterClock
Ready
NUM
Start
Windows NT Task M...
Exploring - base_mo...
GoldSim - TSPA_SR...
GoldSim - TSPA_SR...
GoldSim - TSPA_...
2:23 PM


GoldSim - TSPA_SR_04_12_00d_indirect_multi.gsm*
File Edit View Insert Graphics Model Help
Container \TSPA_Model\Engineered_Barrier_System\Waste_Form\Solubilities\
Model
TSPA_Model
Biosphere
Climate_And_Infiltration
Disruptive_Events
Engineered_Barrier_System
CDSP_Packages
CSNF_Packages
Drift_Chemistry
Drift_Seepage
EBS_Results
Materials
NFE
Waste_Form
CDSP_Dissolution_Parameters
DSNF_Dissolution
In_Package_Chemistry
Rn_Inventory
Solubilities
M_Col_Wf_Both_WP_Irrev
Solubility_Am
Solubility_C
Solubility_Cs
Solubility_I
Solubility_IrrevColloids
Solubility_Np
Solubility_Pa
Solubility_Paa
Solubility_Pu
Solubility_Pua
Solubility_Sr
Solubility_Tc
Solubility_Th
Solubility_U
log_fCO2_drift
Surface_Area_Glass
WastePackage_Dripshield
Results
Saturated_Zone_Transport
Solubility
Solubility_Pua
Solubility_Pua (Stochastic)
Last Value = -1.47
Solubility of Plutonium
Solubility_Pu
Solubility_Tc
Solubility_Th
Solubility_Paa
Solubility_Pa
Solubility_Cs
Solubility_U
Solubility_IrrevColloids
M_Col_Wf_Both_WP_Irrev
Solubility_C
Solubility_Np
Solubility_Am
Solubility_I
Solubility_Sr
Uranium, Neptunium and Americium Solubility are defined local to every drip gr
Ready
Scale: 74%
NUM


GoldSim - TSPA_SR_04_12_00d_indirect_multi.gsm*
File Edit View Insert Graphics Model Help
Container \TSPA_Model\Engineered_Barrier_System\Waste_Form\Solubilities\
Model
TSPA_Model
Biosphere
Climate_And_Infiltration
Disruptive_Events
Engineered_Barrier_System
CDSP_Packages
CSNF_Packages
Drift_Chemistry
Drift_Seepage
EBS_Results
Materials
NFE
Waste_Form
CDSP_Dissolution_Parameters
DSNF_Dissolution
In_Package_Chemistry
Rn_Inventory
Solubilities
M_Col_Wf_Both_WP_Irrev
Solubility_Am
Solubility_C
Solubility_Cs
Solubility_I
Solubility_IrrevColloids
Solubility_Np
Solubility_Pa
Solubility_Paa
Solubility_Pu
Solubility_Pua
Solubility_Sr
Solubility_Tc
Solubility_Th
Solubility_U
log_fCO2_drift
Surface_Area_Glass
WastePackage_Dripshield
Results
Saturated_Zone_Transport
Solubility
Solubility_Pua
Solubility_Paa
Solubility_IrrevC
Solubility_Np
Stochastic Properties : Solubility_Pua
Definition
Database
Element ID: Solubility_Pua
Appearance...
Description: Solubility of Plutonium
Display Units:
Download required
Distribution
Uniform
Minimum = -4.62, Maximum = 1.68
Edit Distribution...
Correlated To:
Correlation Factor: 0
Explicit Trigger:
Multiple Triggers...
Importance Sampling...
Sampling: None
Save Results
Final Values
Time Histories
OK
Cancel
Help
Uranium, Neptunium and Americium Solubility are defined local to every drip gr
Ready
Scale: 74%
NUM
Start
3:11 PM

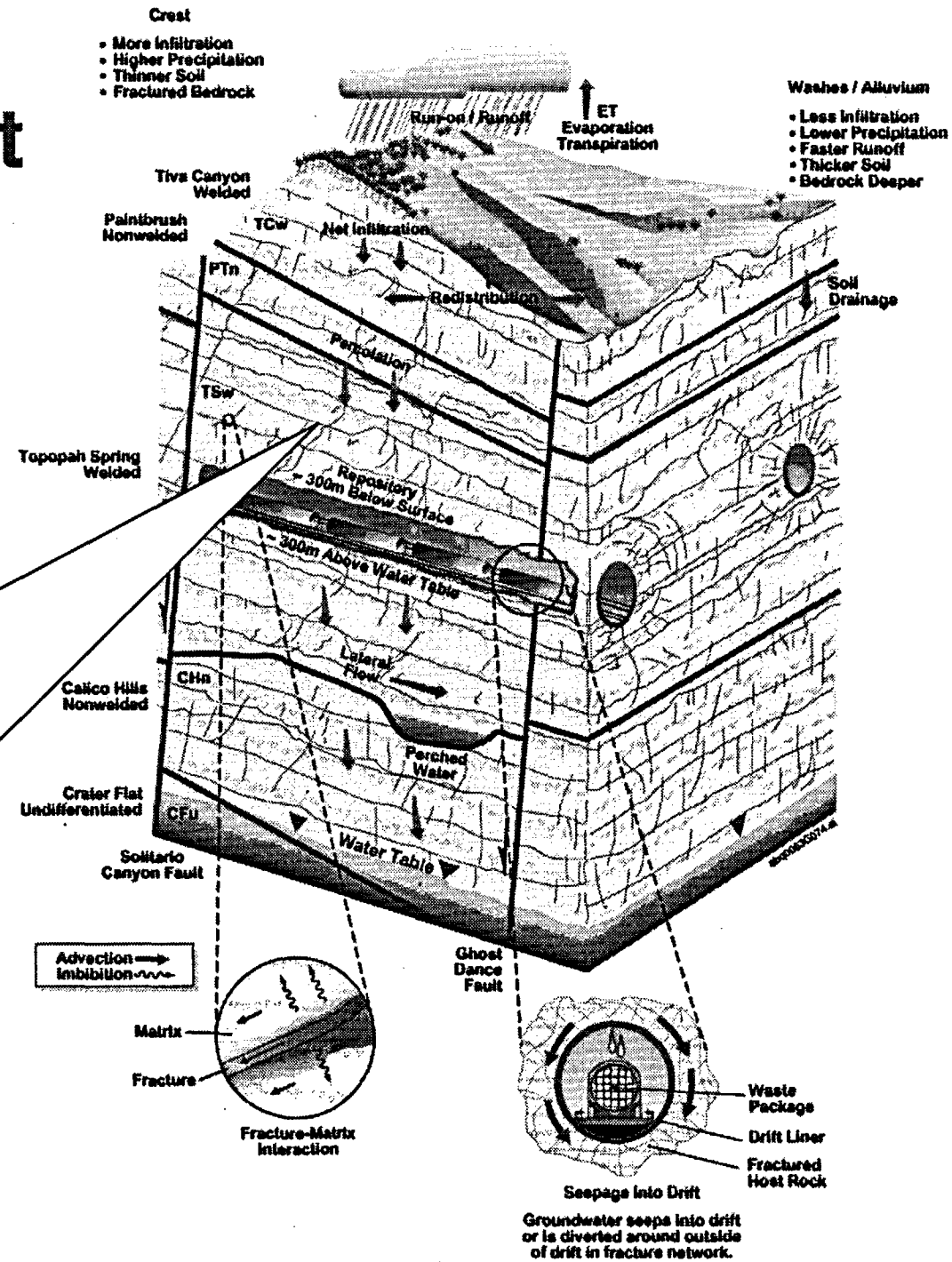

GoldSim - TSPA_SR_04_12_00d_indirect_multi.gsm*
File Edit View Insert Graphics Model Help
Model
TSPA_Model
Biosphere
Climate_And_Infiltration
Disruptive_Events
Engineered_Barrier_System
CDSP_Packages
CSNF_Packages
Drift_Chemistry
Drift_Seepage
EBS_Results
Materials
NFE
Waste_Form
CDSP_Dissolution_Parameters
DSNF_Dissolution
In_Package_Chemistry
Rn_Inventory
Solubilities
M_Col_Wf_Both_WP_Irrev
Solubility_Am
Solubility_C
Solubility_Cs
Solubility_I
Solubility_IrrevColloids
Solubility_Np
Solubility_Pa
Solubility_Paa
Solubility_Pu
Solubility_Pua
Solubility_Sr
Solubility_Tc
Solubility_Th
Solubility_U
log_fCO2_drift
Surface_Area_Glass
WastePackage_Dripshield
Results
Saturated_Zone_Transport
Container \TSPA_Model\Engineered_Barrier_System\Waste_Form\Solubilities\
Solubility
Solubility_Pua
Solubility_Pu
Solubility_Tc
Solubility_Th
Link(s)...
Influence represents the following link(s):
Output
Go
Input
Go
\TSPA_Model\Engineered_Barrier_System\Wa
\TSPA_Model\Results\stochastics.Solubility_Pu
\TSPA_Model\Engineered_Barrier_System\Wa
\TSPA_Model\Engineered_Barrier_System\Wa
Link type: Normal Feedback Coupled
Color:
Close
Solubility_Np
Solubility_Am
Solubility_I
Uranium, Neptunium and Americium Solubility are defined local to every drip gr
Ready
Scale: 74%
NUM
Start
3:12 PM

Demonstrating the Effectiveness of Multiple Barriers

- The entire TSPA analysis is built on a succession of process-level and abstracted models that represent the various parts of the natural and engineered system
- TSPA-SR will show performance analysis results for the total system and also will include intermediate results for the various components of the system
- TSPA-SR sensitivity studies and barrier importance analyses will evaluate the contribution and the relative importance to system safety of major system components and barriers
- The following slides illustrate the major system components

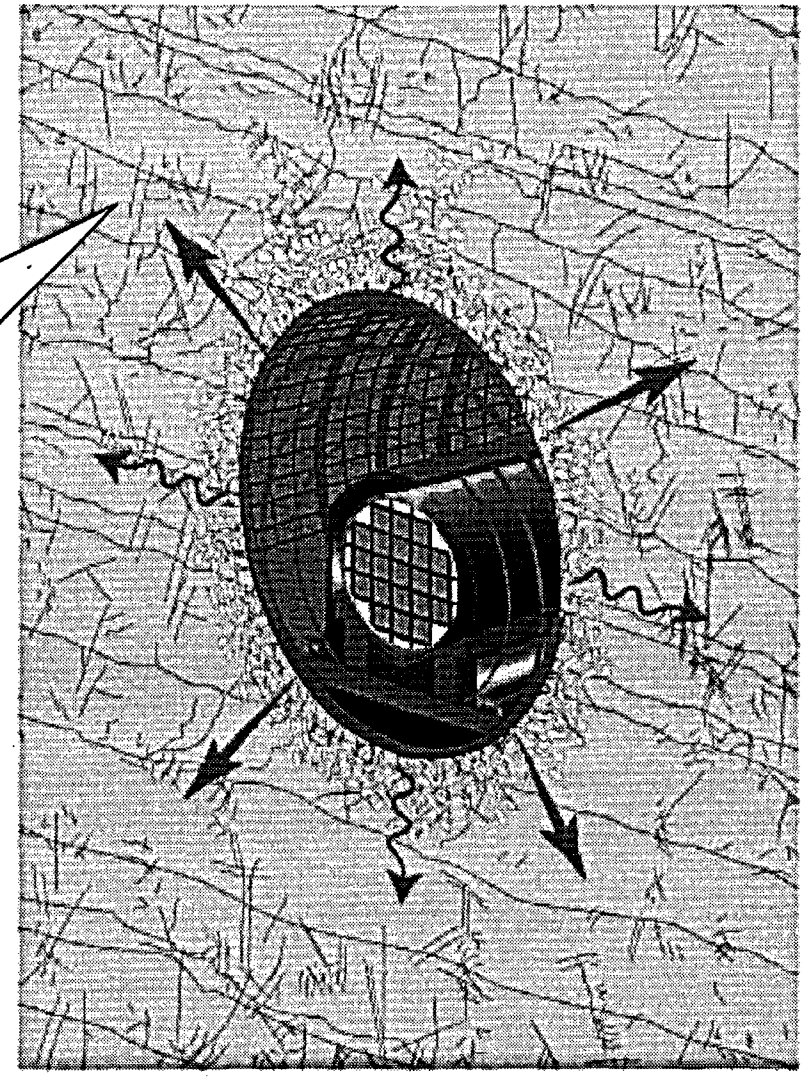
Unsaturated Zone Flow and Transport in TSPA-SR

- 3 climate states - present day, monsoonal, and glacial transition
- Infiltration average over repository ~ 6mm/year
- Flow model includes active fracture-matrix interaction and treatment of perched water
- Model includes matrix diffusion processes
- Transport includes colloids and focuses on mass breakthrough at the water table

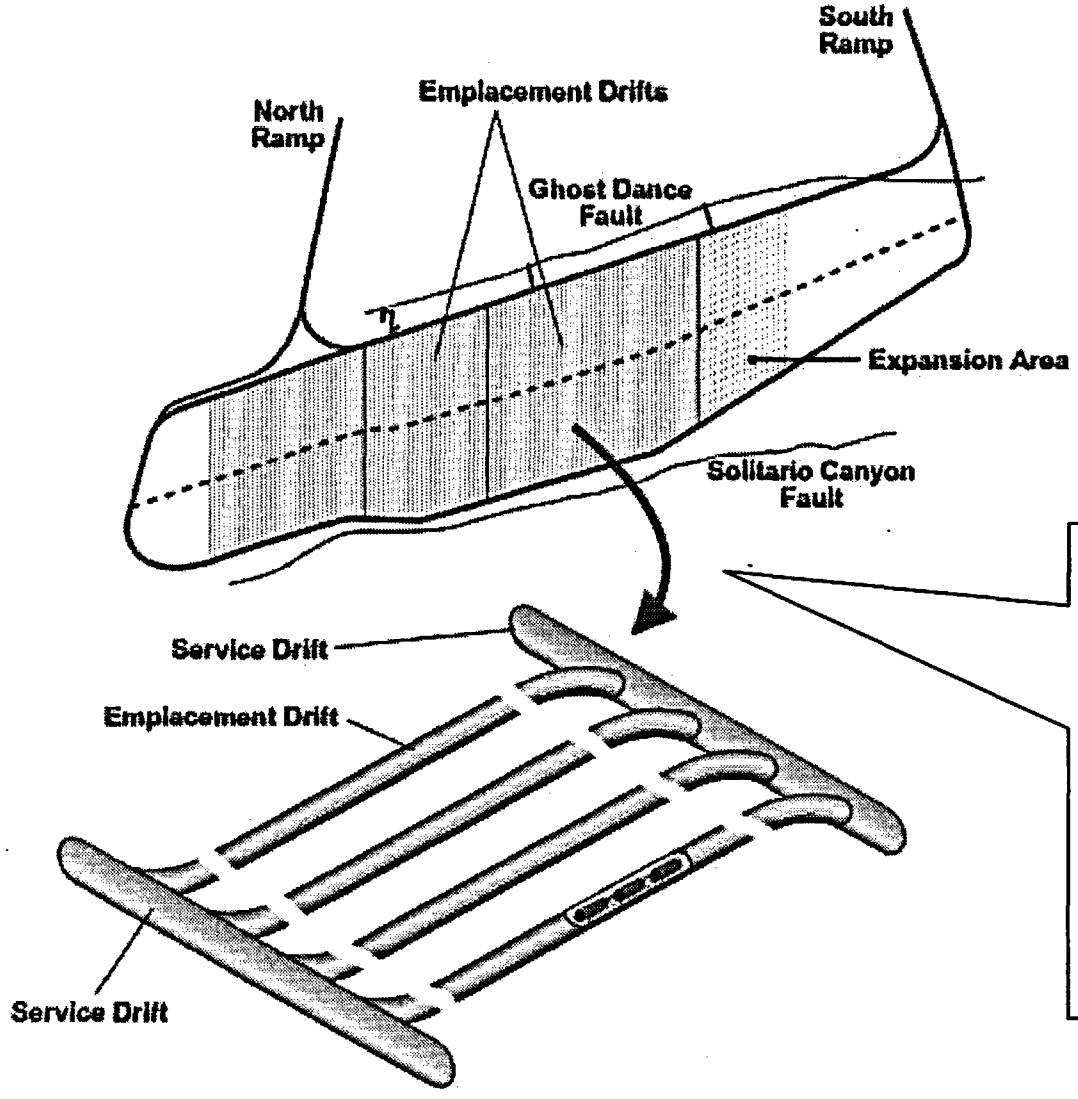


Coupled Processes in TSPA-SR

- Coupled process model includes thermal chemistry effects
- Boiling fronts do not propagate far into the pillars and have a short duration
- Flow focusing and uncertainty in fracture characteristics included in seepage model

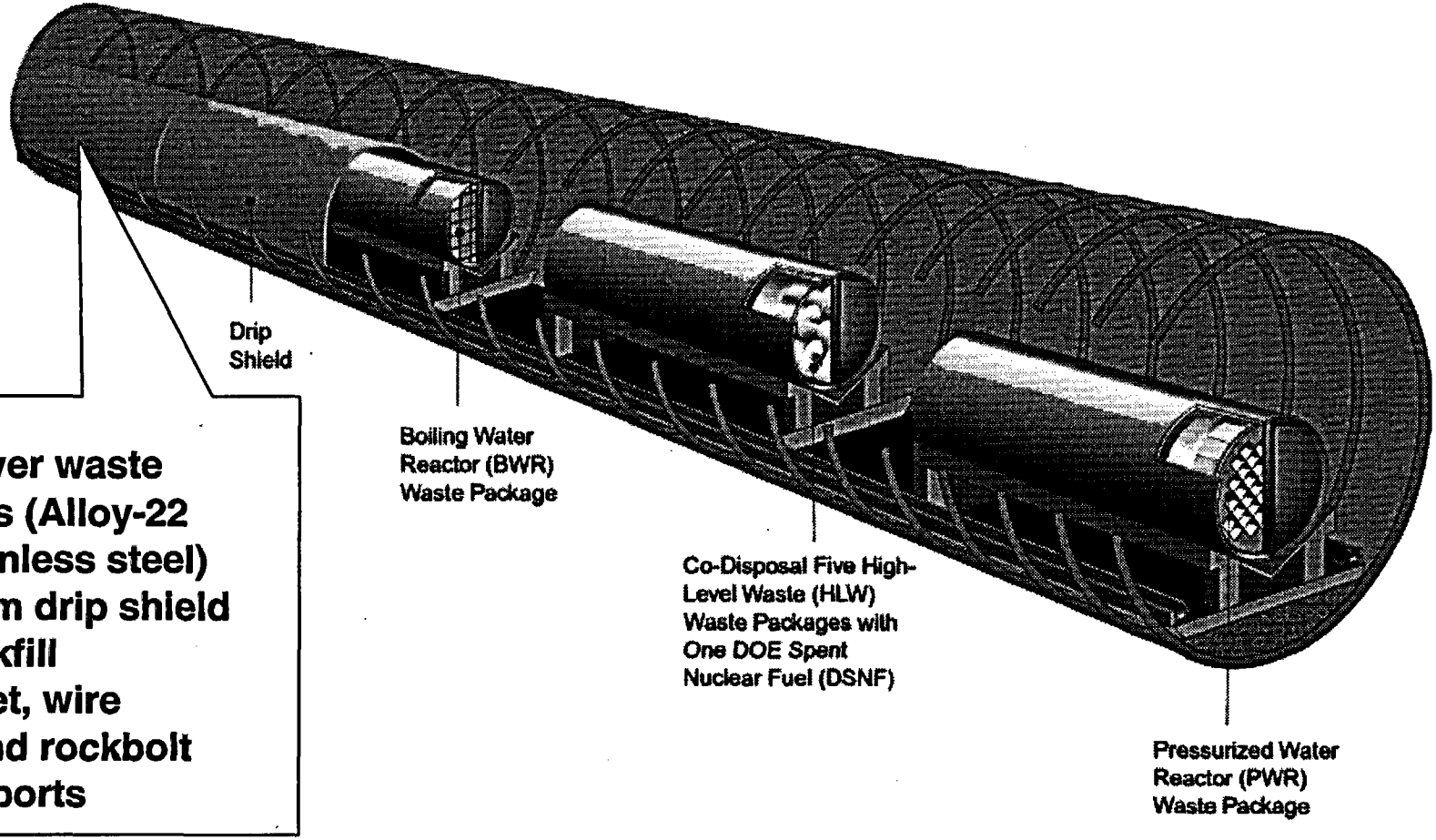


Repository Design in TSPA-SR



- Current analysis assumes 50 years of ventilation
- Thermal load is ~64 MTHM/acre
- Line load, ~1.4 kW/m
- 70,000 MTHM (includes Commercial and DOE-owned Spent Nuclear Fuel, and Defense High-level Waste)

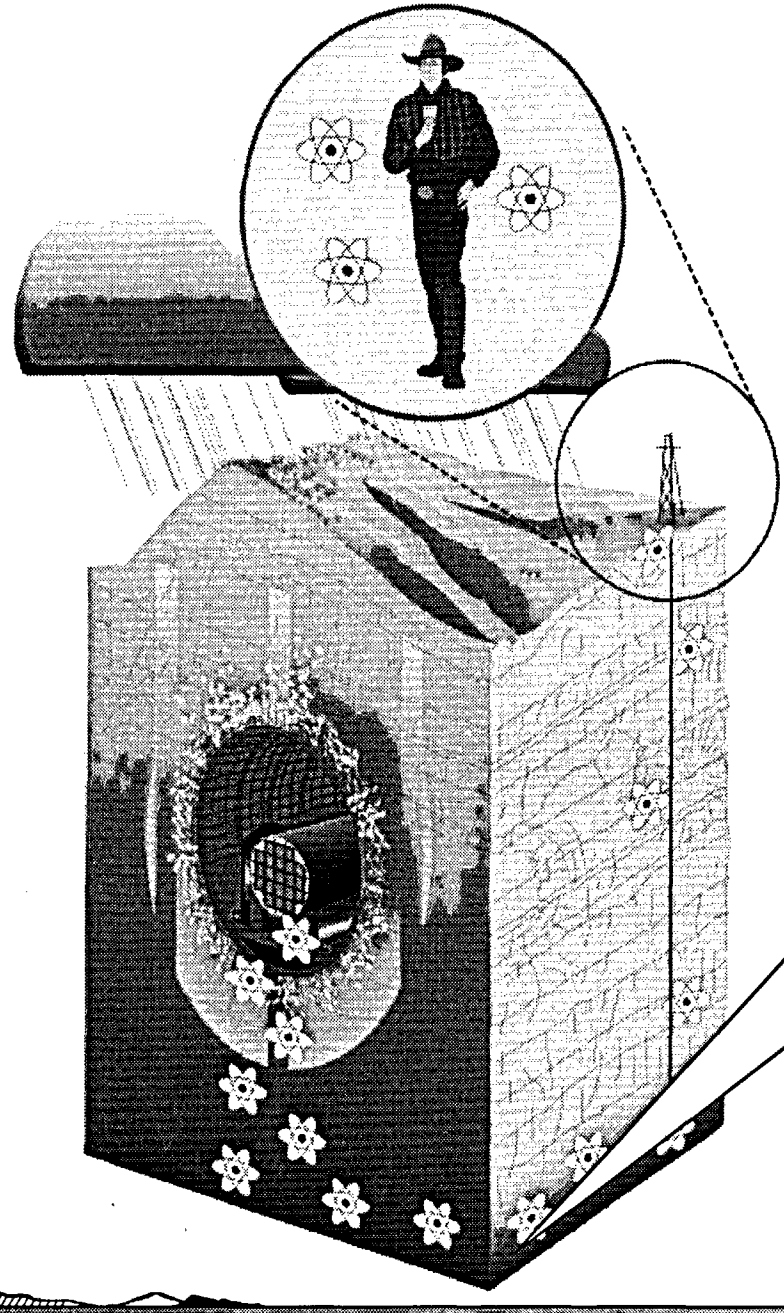
Engineered Barrier Design in TSPA-SR



- Two layer waste packages (Alloy-22 over stainless steel)
- Titanium drip shield
- No backfill
- Steel set, wire mesh, and rockbolt wall supports

abq0083G116.ai

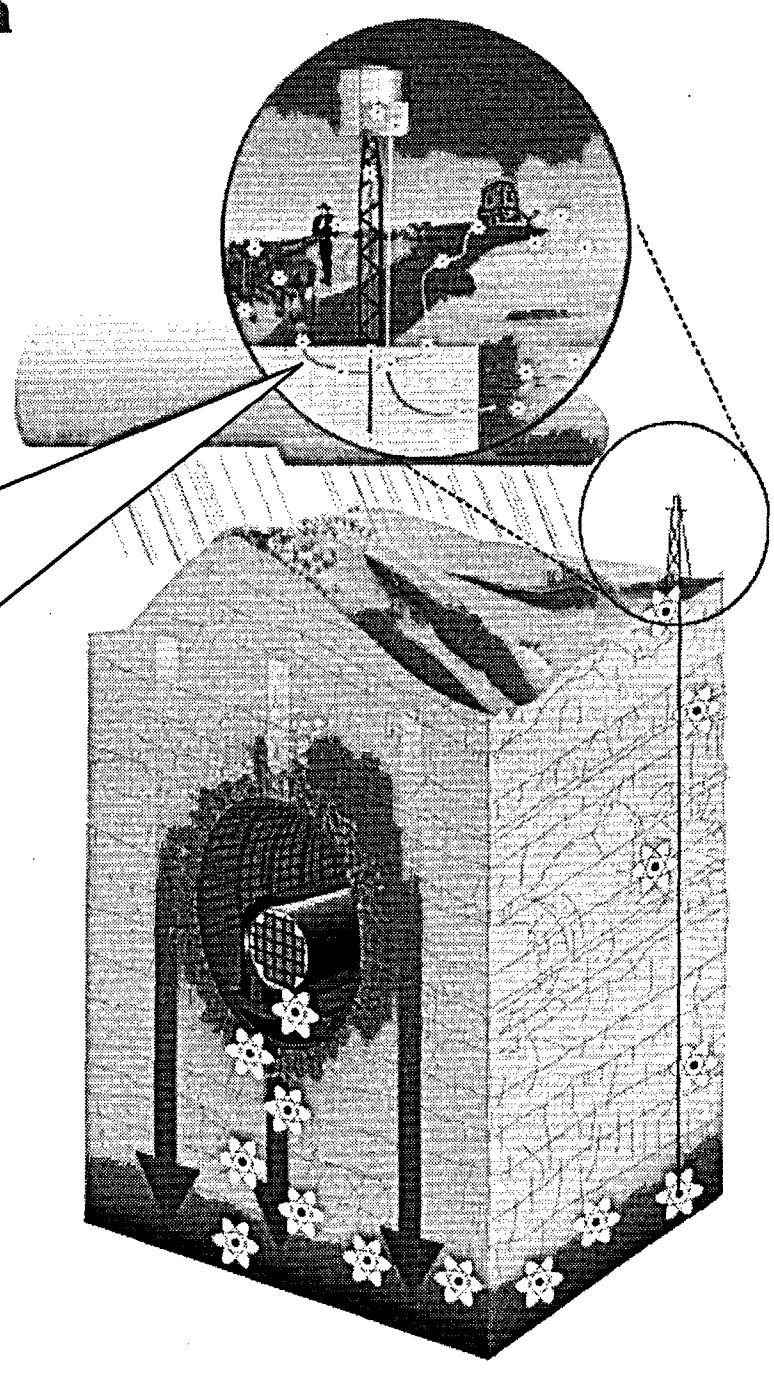
Saturated Zone Flow and Transport in TSPA-SR



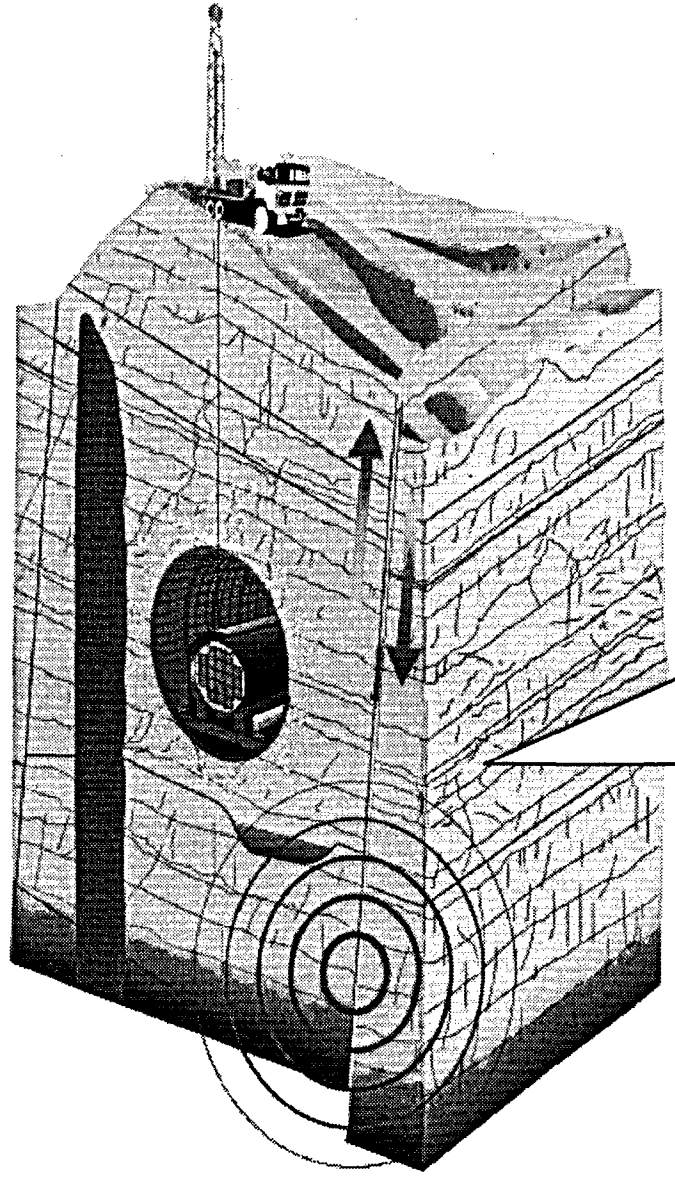
- 3-D model uses geologic framework model
  - Includes variable location of tuff-alluvium contact
  - Anisotropy yields more southerly flow paths
  - TSPA calculates mass flux across boundaries

Biosphere in TSPA-SR

- Critical group water usage consistent with 10 CFR Part 63 approach
- Includes uncertainty in plant uptake factors
- Using Reasonably Maximally Exposed Individual for Biosphere Dose Conversion Factors (BDCF) development consistent with 10 CFR Part 197
- BDCFs developed for nominal release and direct release scenarios



Disruptive Events in TSPA-SR



- Model for characteristics of volcanic eruptions has been modified from Viability Assessment
- Seismic effects are generally screened out, except for effects on cladding
- Nuclear criticality is screened out
- Human intrusion is a stylized analysis

Subissue 2, Scenario Analysis

- **This subissue addresses the method used to develop the suite of plausible scenarios used in the TSPA to represent the evolution of the repository system**
  - **Discussion of scenario methodology is included in the TSPA-SR document (Chapter 1.6)**
  - **Description of the individual FEPs for each process, including the screening analysis results, is included in the associated PMR and supporting AMR**
  - **The FEPs database has been revised to enhance the understanding of the database structure**

Subissue 3, Model Abstraction

- **This subissue addresses the adequacy with which the various components of the engineered system, geosphere, and biosphere are treated in the TSPA-SR (Chapter 3) and supporting analyses (AMRs)**
  - **PMRs summarize the technical basis supporting each process model and abstraction feeding the TSPA**
  - **Data and model justification, data uncertainty, model uncertainty, model support, and integration of relevant features, phenomena, and couplings at the process model level are also included in the PMRs and the underlying AMRs**
  - **Subsequent discussions at this Technical Exchange will cover the details of the various component models**

Subissue 4, Demonstration of the Overall Performance Objective

- **Integration of the components, identification of the most important information, and illustrating the assessment of the system performance measure is the objective of this subissue**
  - **The TSPA is constructed to ensure that information is appropriately represented and sampled at every step in the analysis**
  - **TSPA-SR will be conducted to comply with proposed 10 CFR Part 963, 10 CFR Part 63, and 40 CFR Part 197 in terms of addressing the prescribed requirements for the total system**
  - **Chapter 4 of the TPSA-SR will consist of the nominal, disturbed, and combined performance results**

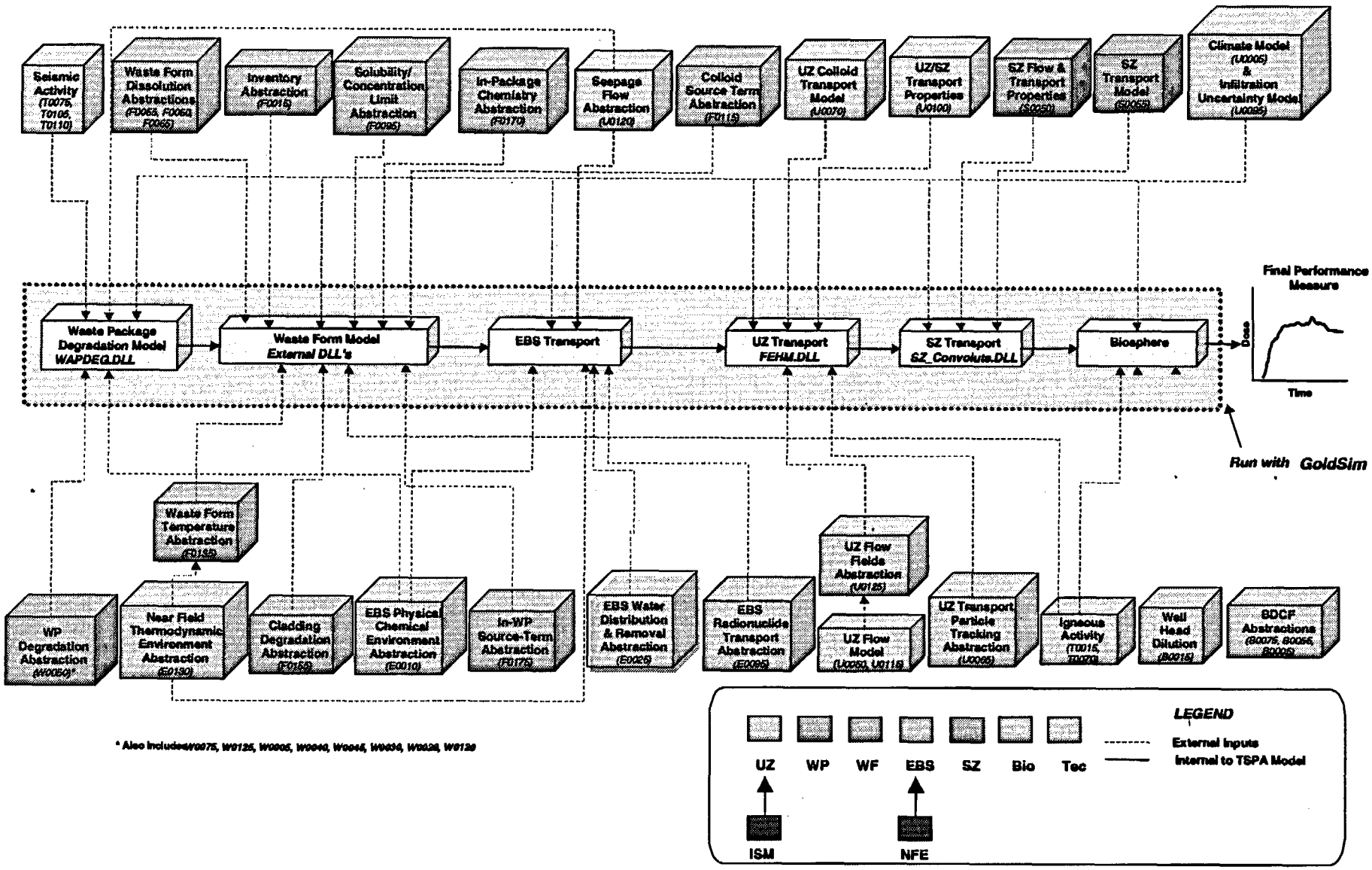
Subissue 4, Demonstration of the Overall Performance Objective

(Continued)

- Chapter 5 shows the results of uncertainty analyses, sensitivity analyses, and barrier importance analyses

- TSPA results are used to define the more important factors determining system performance. These analyses contribute to the determination of the Principal Factors for the safety case

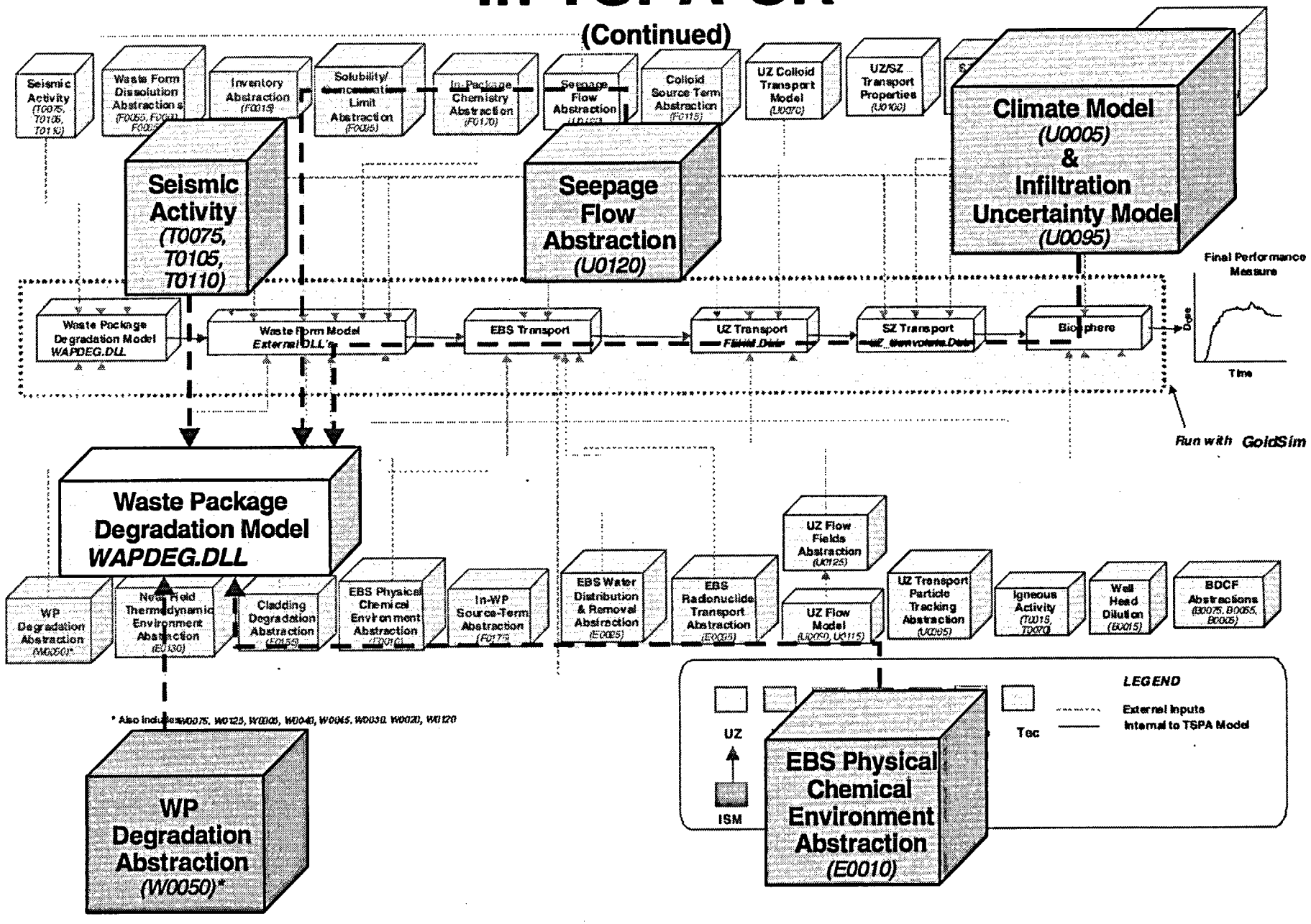
Integration of Component Models in TSPA-SR



* Also includes W0075, W0125, W0005, W0040, W0045, W0030, W0026, W0120

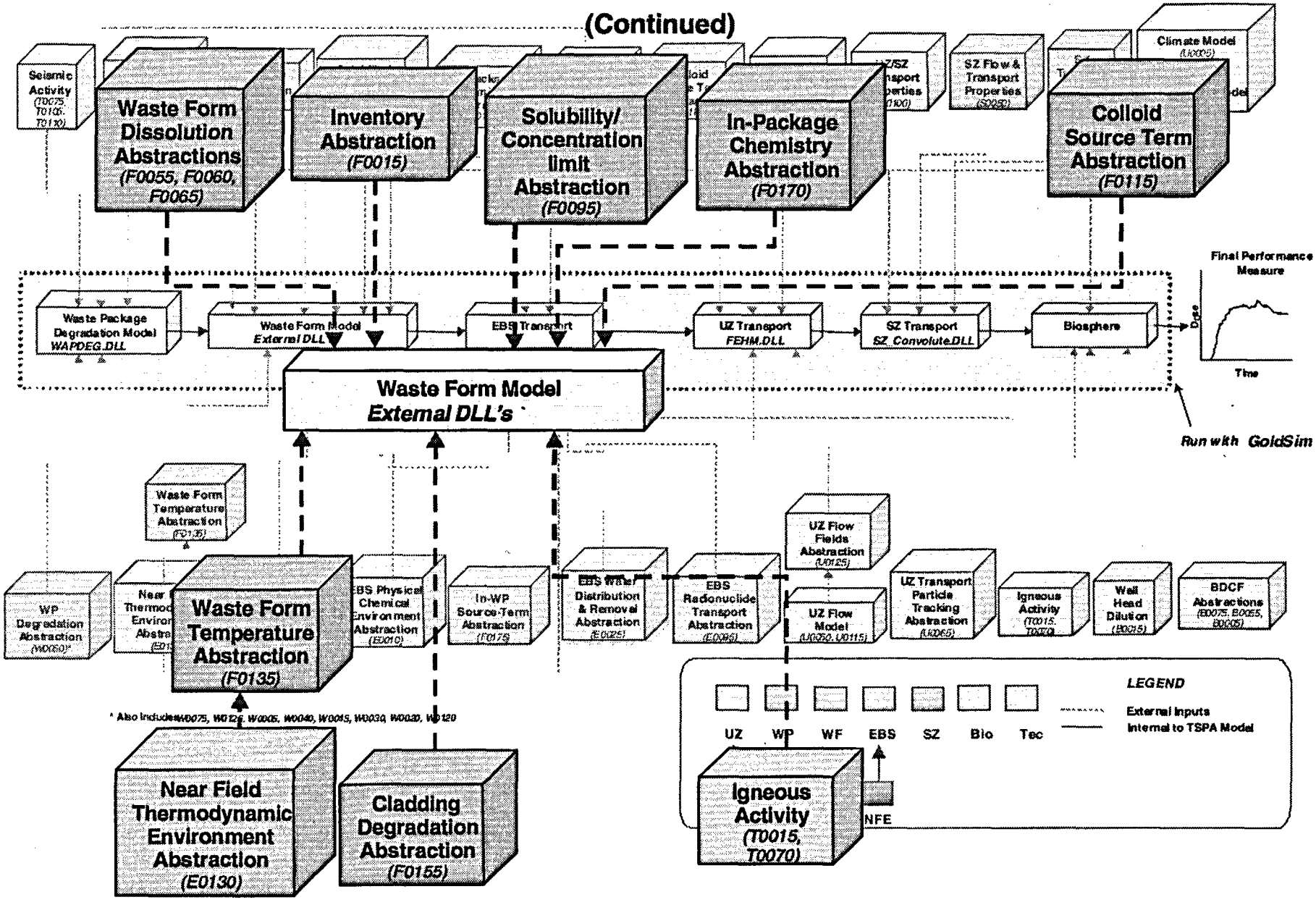
Integration of Component Models in TSPA-SR

(Continued)



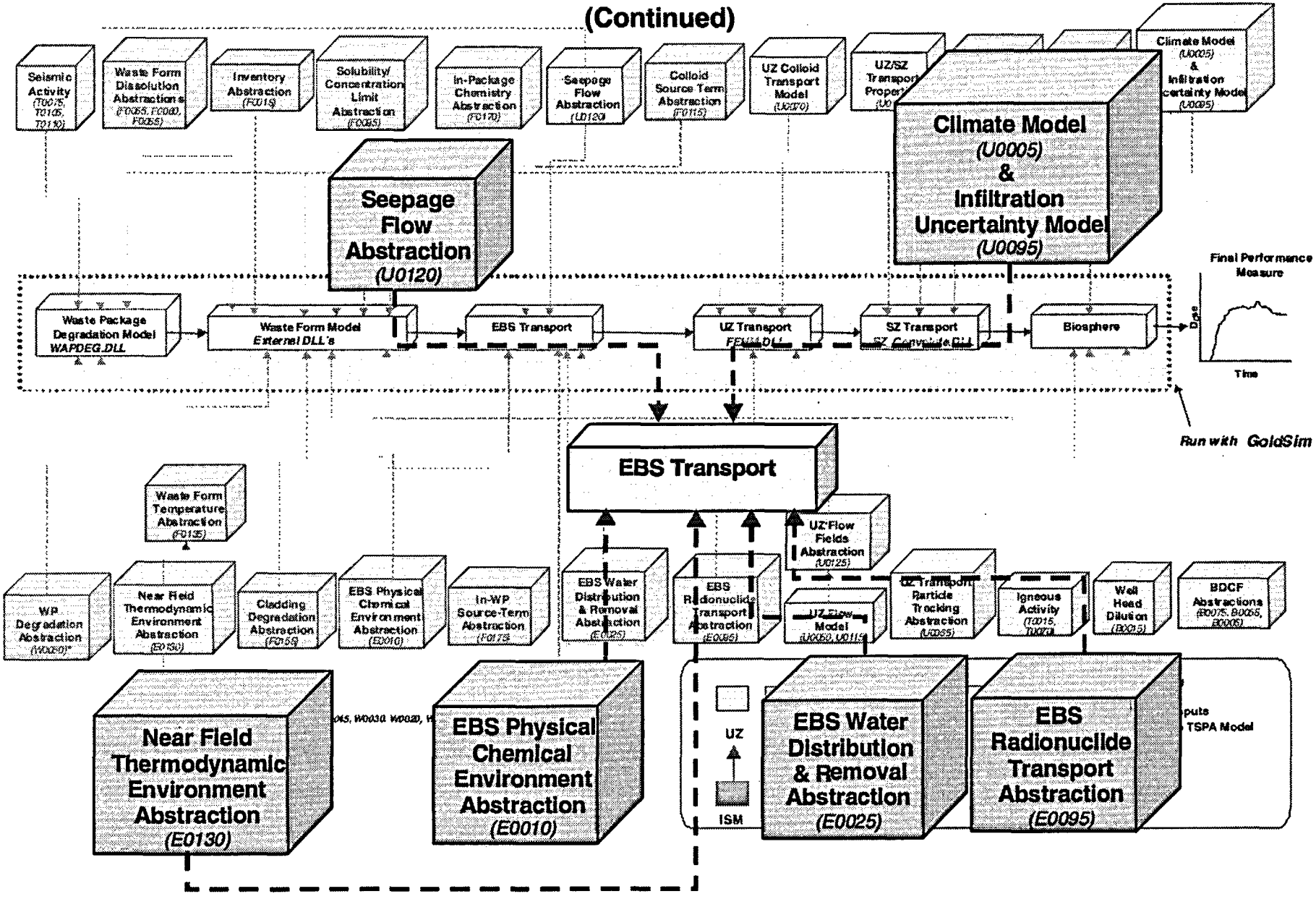
Integration of Component Models in TSPA-SR

(Continued)



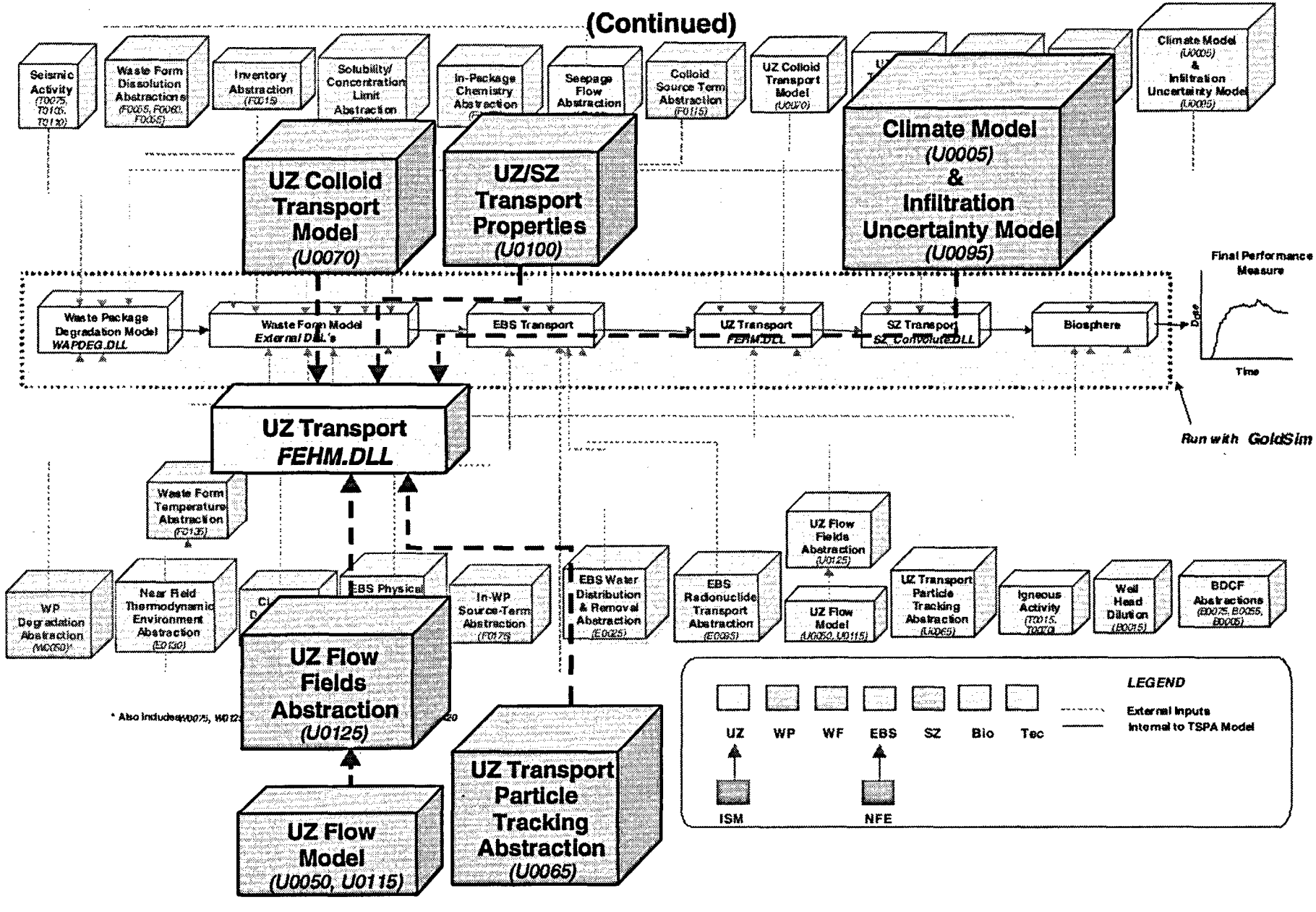
Integration of Component Models in TSPA-SR

(Continued)



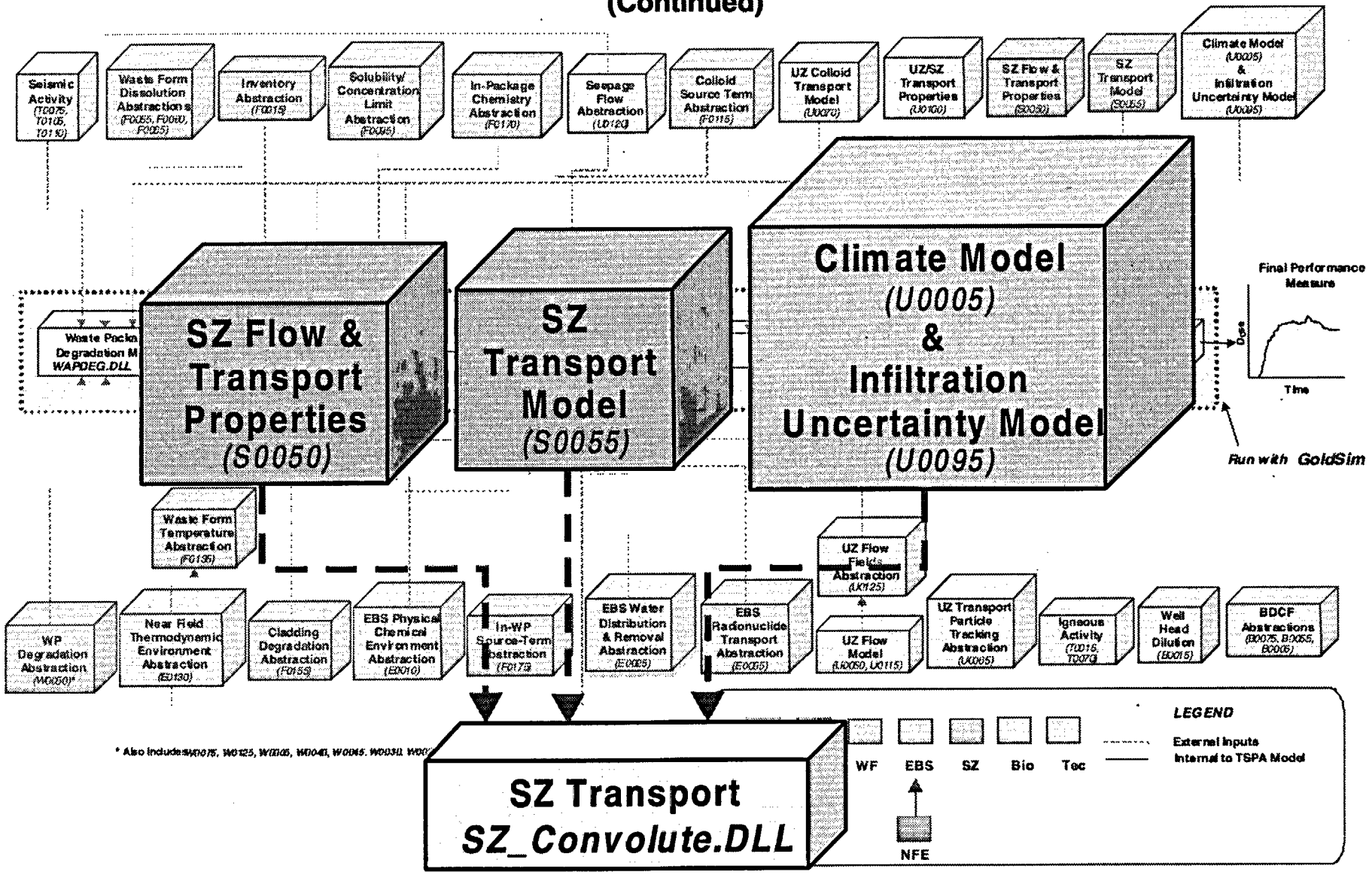
Integration of Component Models in TSPA-SR

(Continued)



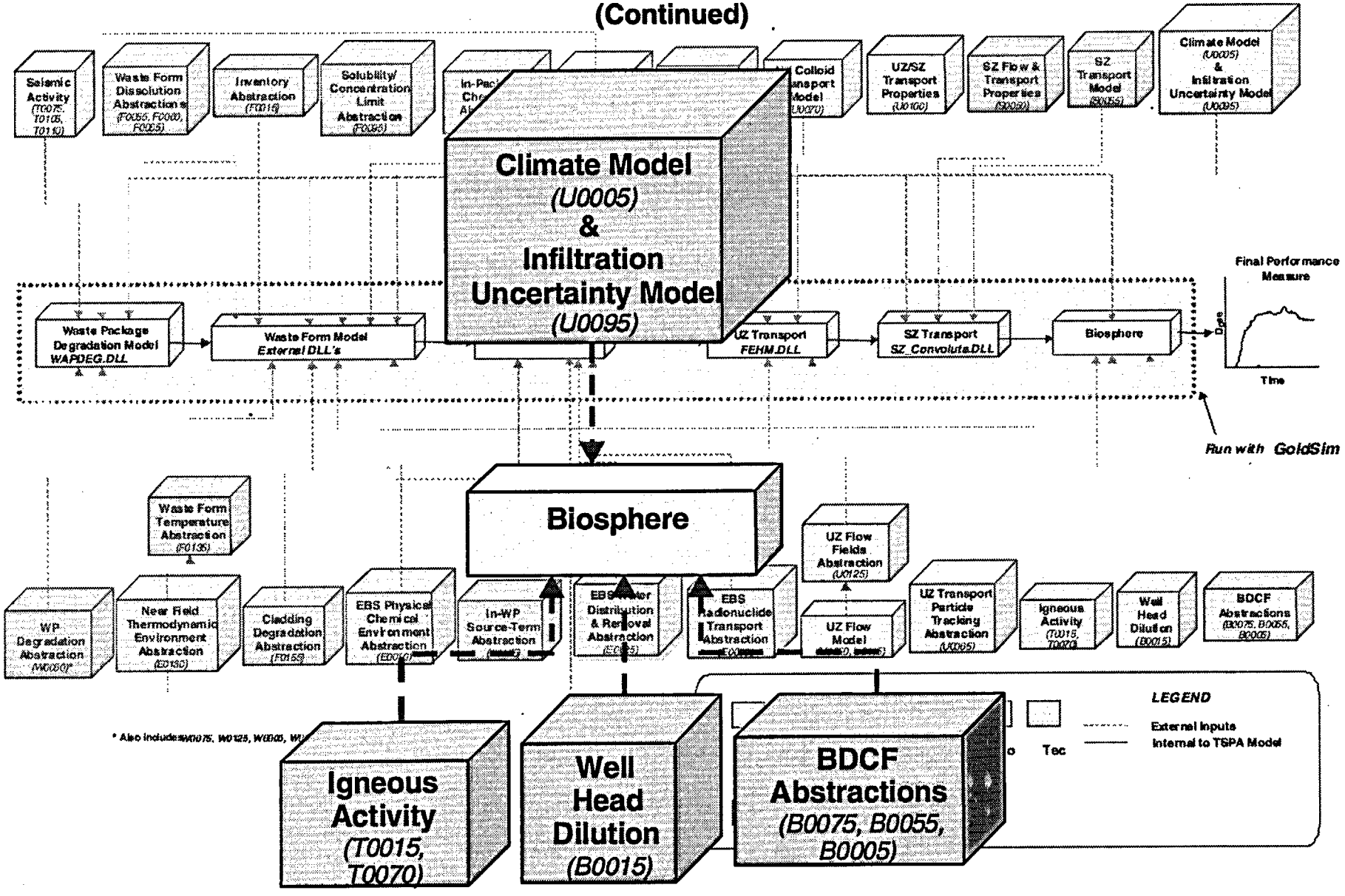
Integration of Component Models in TSPA-SR

(Continued)



Integration of Component Models in TSPA-SR

(Continued)



Summary

- DOE continues to make significant progress to address the issues related to the TSPAI KTI
- TSPAI Issue Resolution Status Report Revision 2 is currently being reviewed
- Comments on the current revision will be forwarded to NRC upon completion of review