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

TSPA-SR: Overview of Model Development

Presented to:
NRC/DOE Technical Exchange on Total System Performance Assessment (TSPA) for Yucca Mountain
San Antonio, Texas

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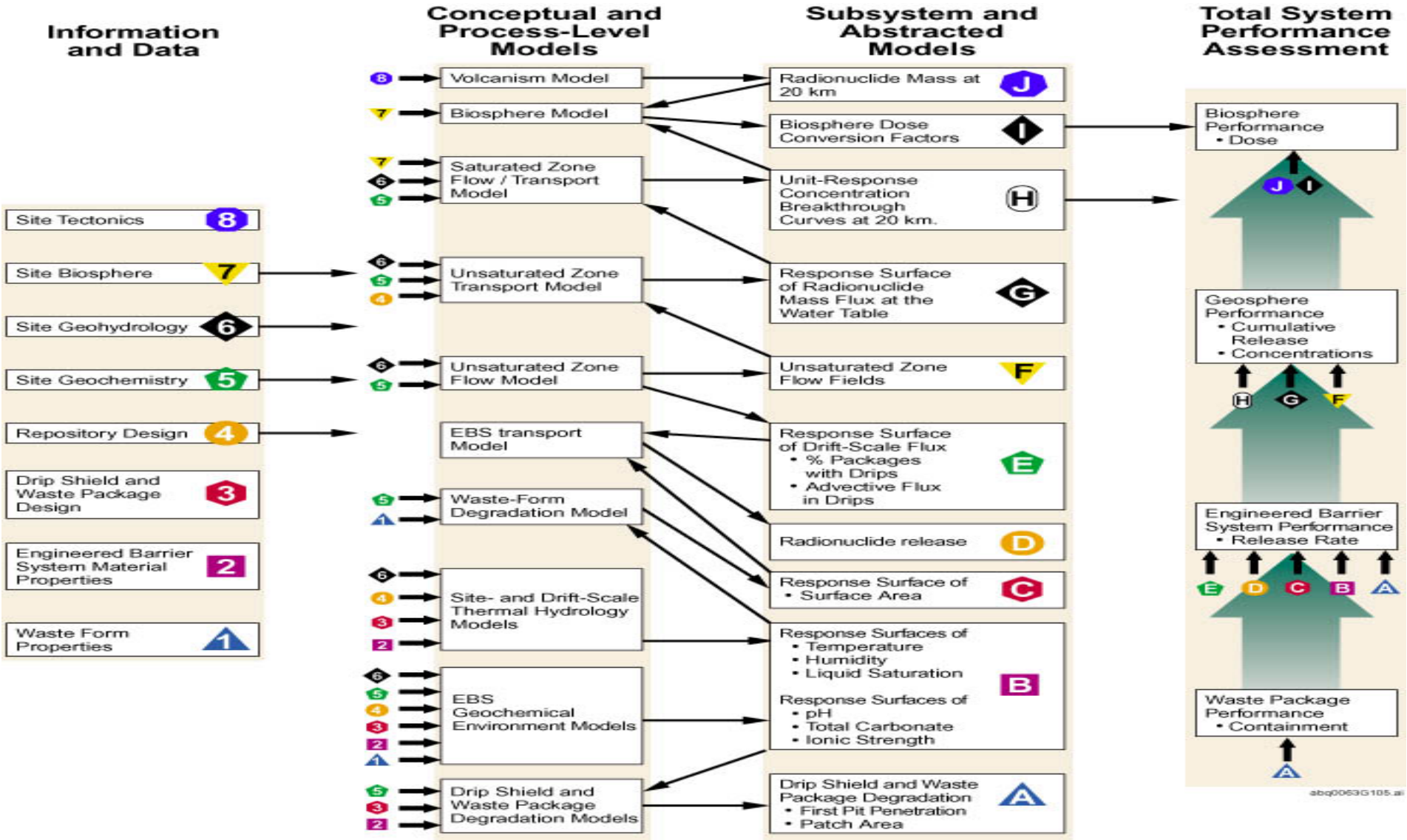
YUCCA MOUNTAIN PROJECT

TSPAI IRSR REV. 2 ACCEPTANCE CRITERIA	PRESENTATION/ DOCUMENTATION	SELF-ASSESSMENT	PATH FORWARD TO CLOSURE
SUBISSUE 1 - System Description and Demonstration of Multiple Barriers			
Transparency and Traceability of the Analysis			
Assessment Results			
T1) PA results (i.e., the peak expected annual dose within the compliance period) can be traced back to applicable analyses that identify the FEPs, assumptions, input parameters, and models in the PA.	All PMRs, TSPA-SR Section 4	Partially Resolved	The TSPA-SR is currently being performed. For this acceptance criteria to be closed, the TSPA-SR Technical Report and supporting PMRs and AMRs will need to be reviewed by the NRC.
T2) The PA results include a presentation of intermediate results that provide insight into the assessment (e.g., results of intermediate calculations of the behavior of individual barriers).	All PMRs, TSPA-SR Section 4	Partially Resolved	The TSPA-SR is currently being performed. For this acceptance criteria to be closed, the TSPA-SR Technical Report and supporting PMRs and AMRs will need to be reviewed by the NRC.
Code Design and Data Flow			
T1) The flow of information (input and output) between the various modules is clearly described.	TSPA-SR Section 2.2	Largely Resolved	The TSPA-SR is currently being performed. For this acceptance criteria to be closed, the TSPA-SR Technical Report will need to be reviewed by the NRC.
T2) Supporting documentation (e.g., user's manuals, design documents) clearly describes code structure and relationships between modules.	TSPA-SR	Partially Resolved	The TSPA-SR is currently being performed. For this acceptance criteria to be closed, the TSPA-SR Technical Report and supporting documentation will need to be reviewed by the NRC.

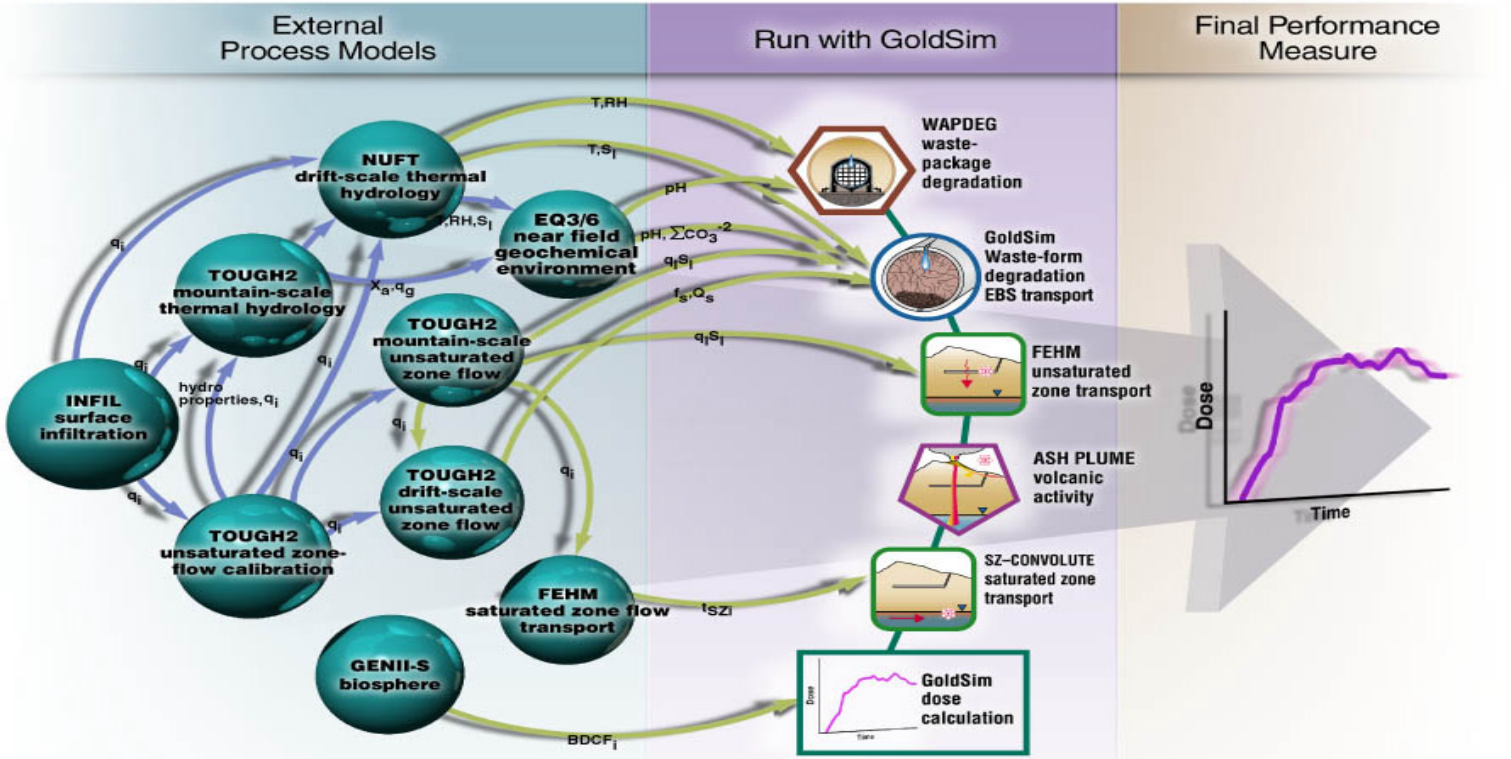
Overview of Presentation

- Information Flow
- Model Architecture
- Control of Information
- Verification of Model
- Transparency of TSPA-SR Analyses
- Summary

Information Flow for TSPA-SR



TSPA-SR Model Architecture



Output Parameters

M_i	Radionuclide Mass Flux	T	Temperature	I	Ionic Strength
C_i	Radionuclide Concentration	RH	Relative Humidity	t_{pit}	Initial-pit-penetration time
f_S	Fraction of WPs with Seeps	S_l	Liquid Saturation	t_{patch}	Initial-patch-penetration time
EBS	Engineered Barrier System	X_a	Air Mass Fraction	A_{perf}	Perforated Container Area
Q_S	Seep Flow Rate	q_g	Gas Flux	A_{fuel}	Exposed Fuel Area
pH	pH	q_l	Liquid Flux	t_{SZi}	Saturated Zone Transport Time
ΣCO_3^{-2}	Carbonate Concentration	q_i	Infiltration Flux	$BDCF_i$	Biosphere Dose Conversion Factor

Legend

Response Surface Between Process Models

Response Surface from Process Model to GOLDSIM

Control and Traceability of TSPA-SR Analyses

- **Control of information from sources**
  - **Analysis/Model Reports (AMRs)**
  - **Preliminary inputs**
  - **Other**
- **Software verification/qualification**
  - **Version control**

Sources of Information for TSPA-SR

- **TSPA-SR is based on individual models, data and analyses developed for each engineered and natural barrier component of the system**
- **Scientific basis for models and analyses documented in 122 "Analysis/Model Reports" and summarized in 9 "Process Model Reports" (analogous to compliance criteria in 10 CFR Part 963 and NRC's "Key Technical Issues")**

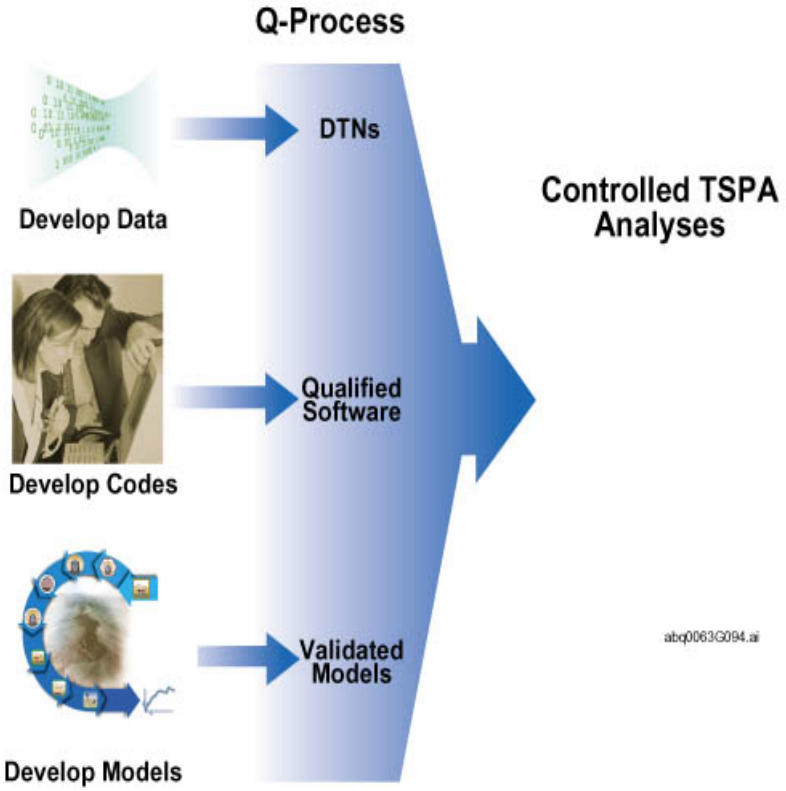
Sources of Information for TSPA-SR

(continued)

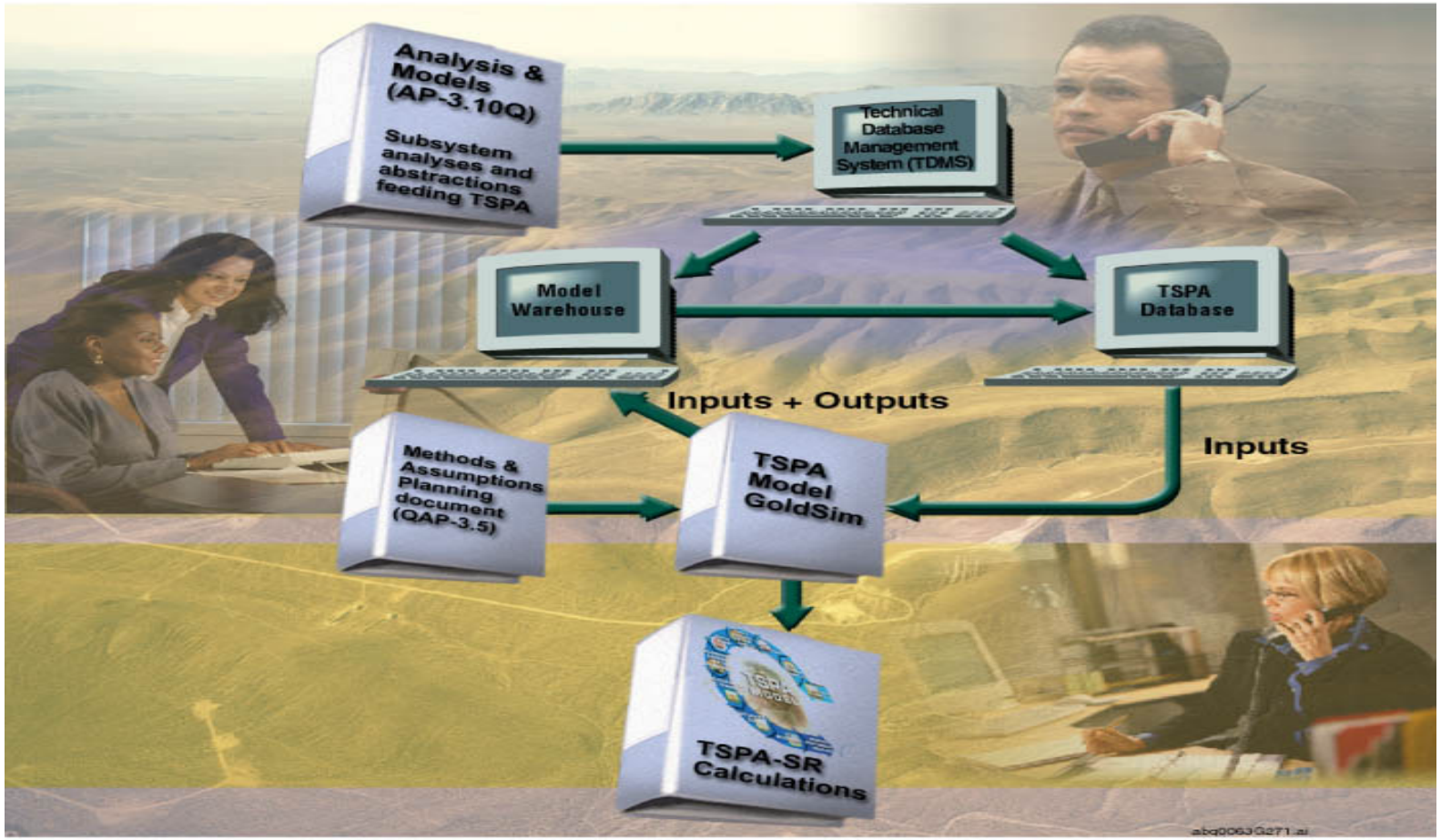
- **Scientific bases includes range of laboratory, in-situ and field tests, including**
  - **Niche tests and cross-drift tests (for seepage model)**
  - **Drift-scale test and single-heater test (for coupled thermal-hydro-chemical models)**
  - **Busted Butte transport test (for unsaturated zone transport model)**
  - **Long-term corrosion test (for waste package degradation models)**
  - **Engineered barrier test (for EBS thermal-hydro-chemical models)**
  - **C-Wells tracer test (for saturated zone transport model)**

Control of Information for TSPA-SR

- Data is submitted to Technical Data Management System and data tracking number is obtained.
- Software is developed under controlled environment and procedurally qualified.
- Models are developed using controlled software and controlled data inputs.



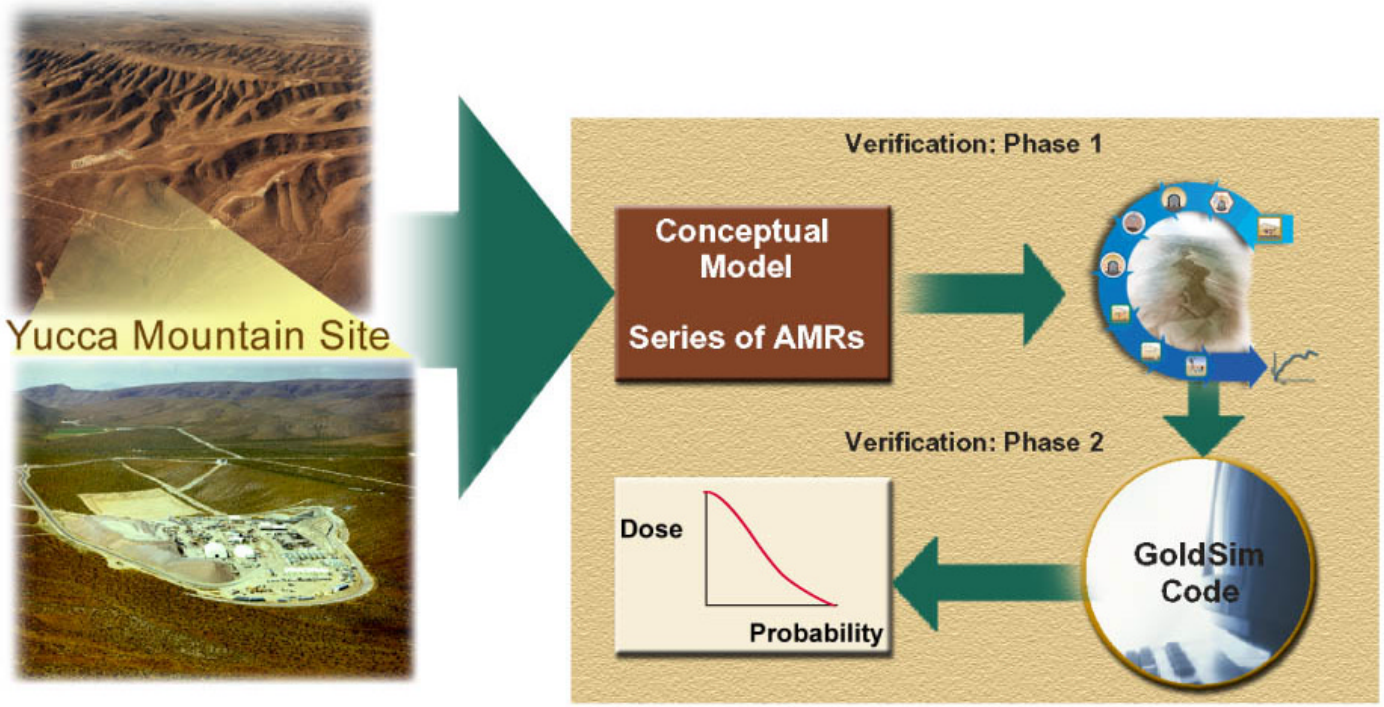
TSPA-SR Database Information Flow



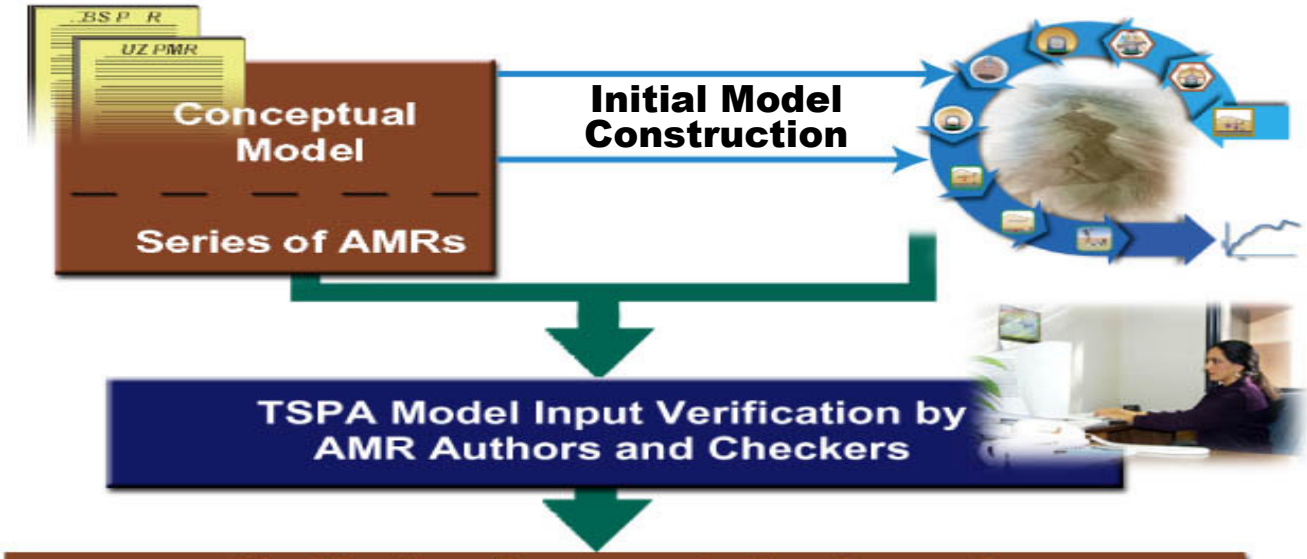
Testing of TSPA-SR Model

- To ensure the model adequately and reasonably represents the processes intended
- Use of controlled data inputs
- Check to ensure that the information is being used as intended in TSPA-SR
- Check intermediate results to ensure subsystem linkages are performing properly
- Check expected value case results to ensure overall system model is performing properly
- Electronic transfer of files checked for electronic signature

Testing of TSPA-SR Model



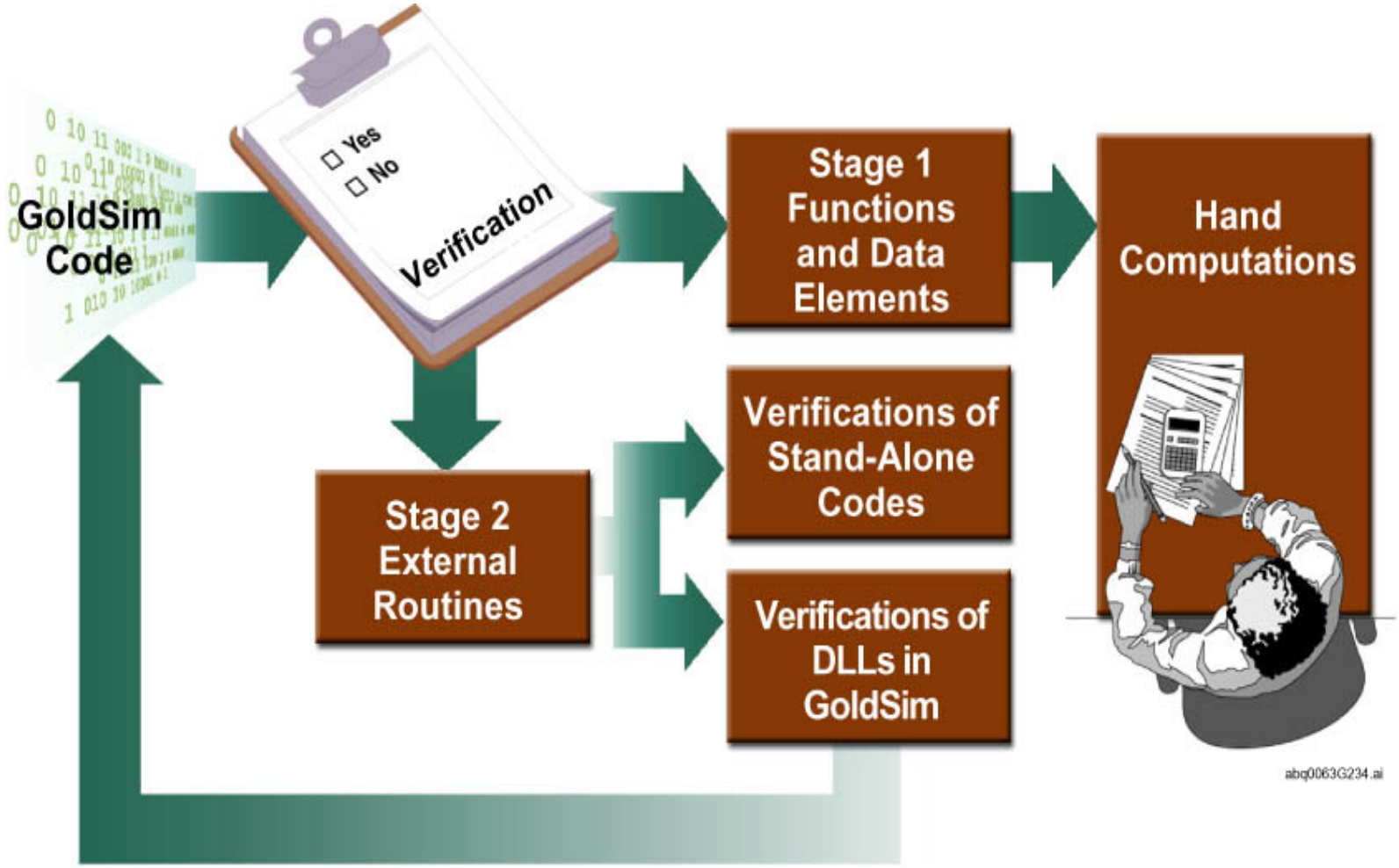
Testing of TSPA-SR Model (continued)



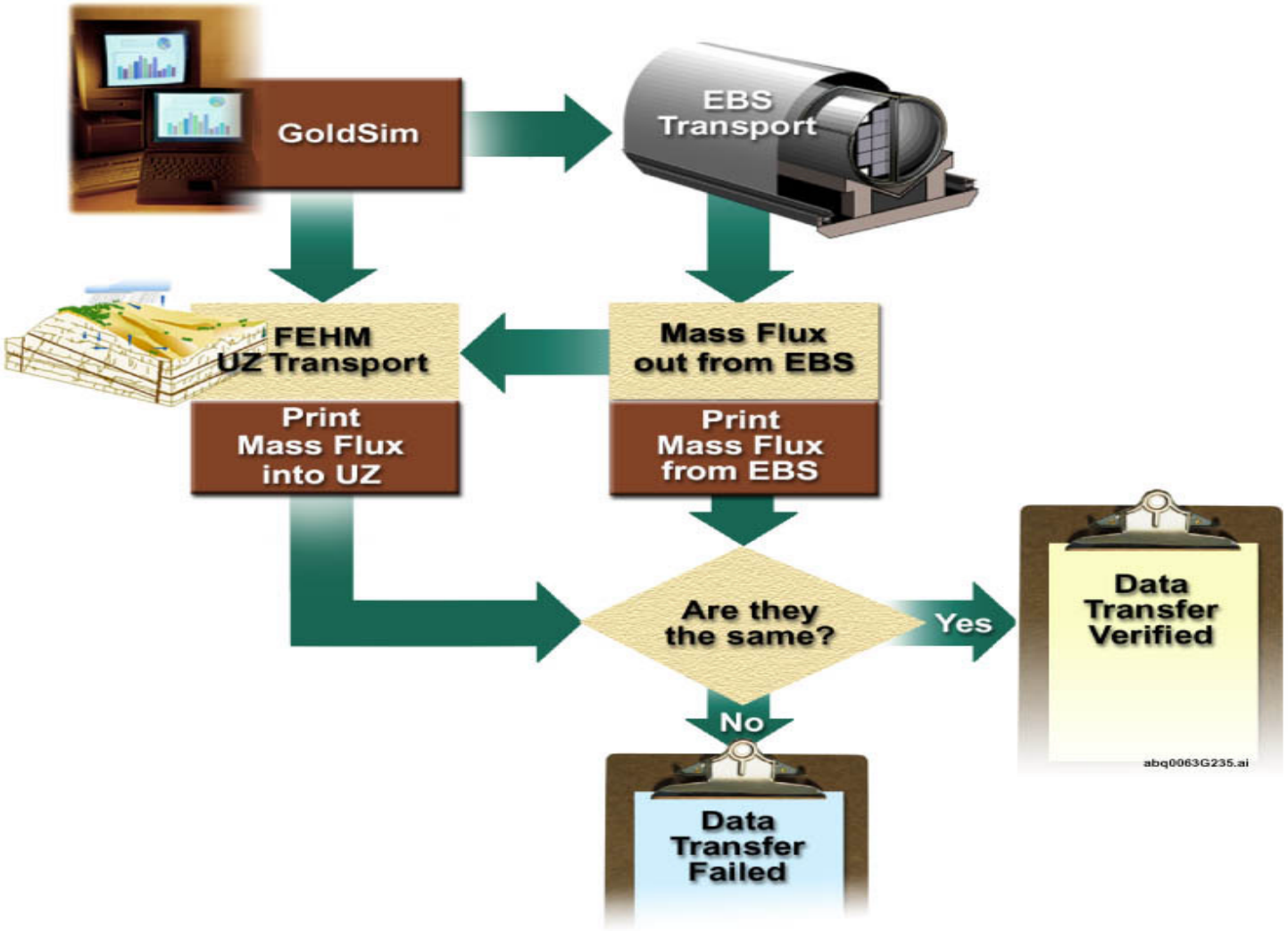
Verification Documentation Record

Conceptual Model Components	Included in Input?		Relevant Data Verified		Reference	Remark
	Yes	No	Yes	No		

Testing of TSPA-SR Software (GoldSim)



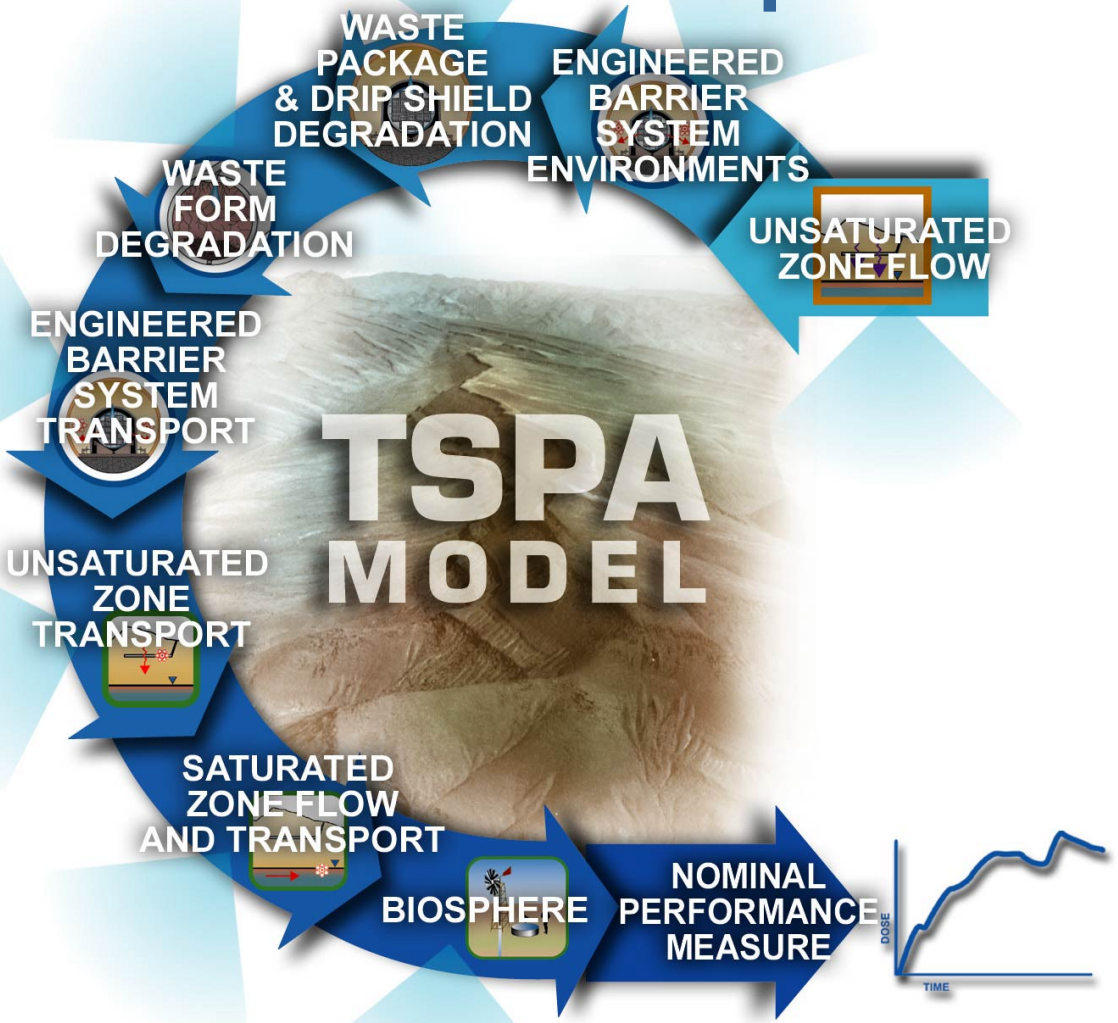
Example Verification Check for TSPA-SR Model Components



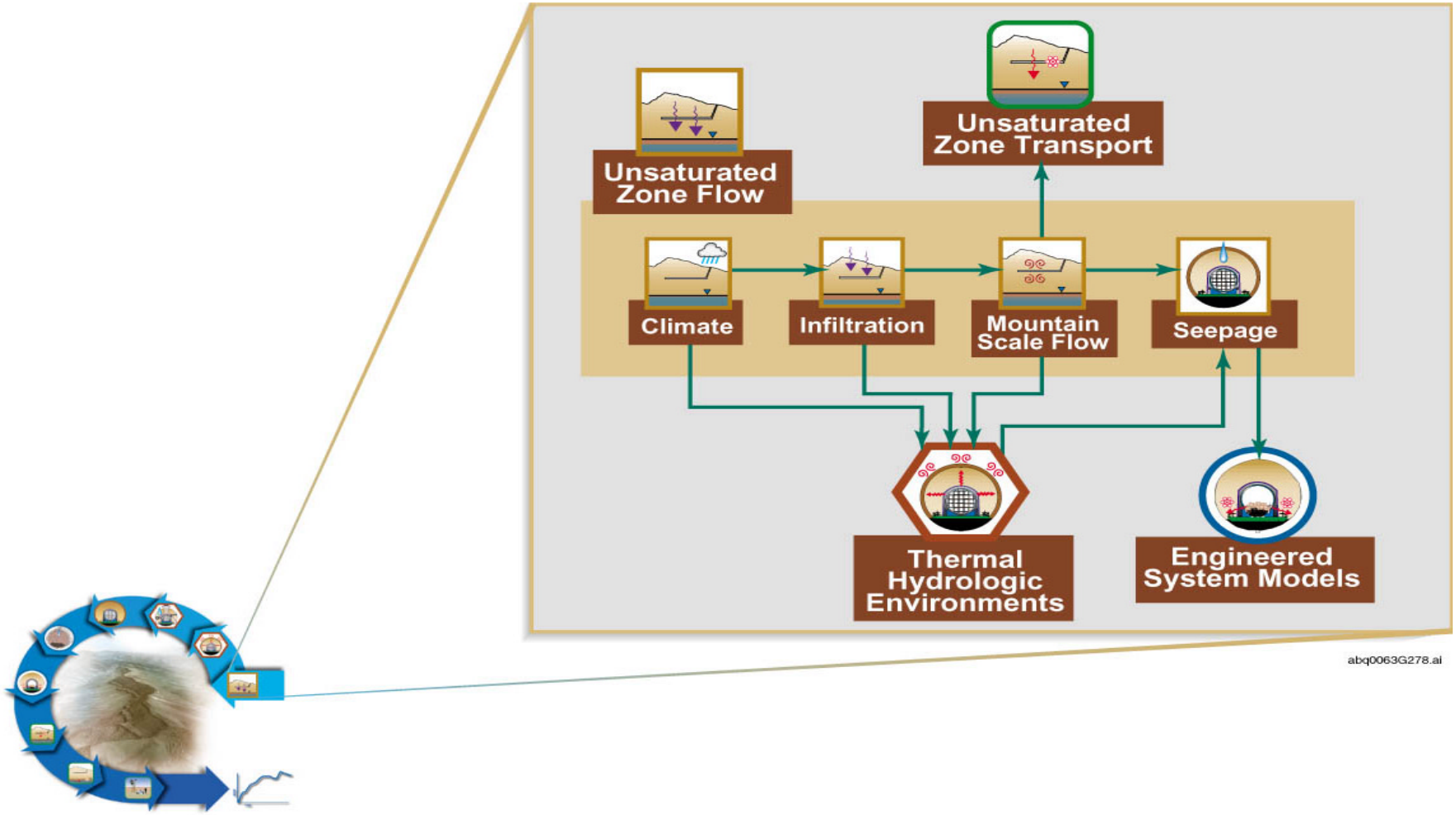
Transparency of TSPA-SR Analyses

- Sequence of information flow diagrams
  - TSPA-SR overall components
  - Detail of component
  - Inputs/outputs/basis for component model
- Conceptual figures
- Animation of results
- Technical edit of documentation
- Reviews of documentation

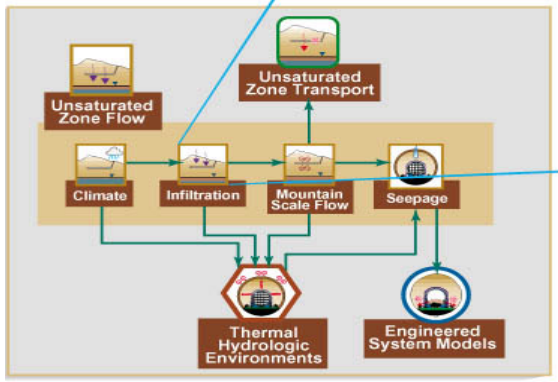
Sequence of information flow diagrams: TSPA-SR overall components

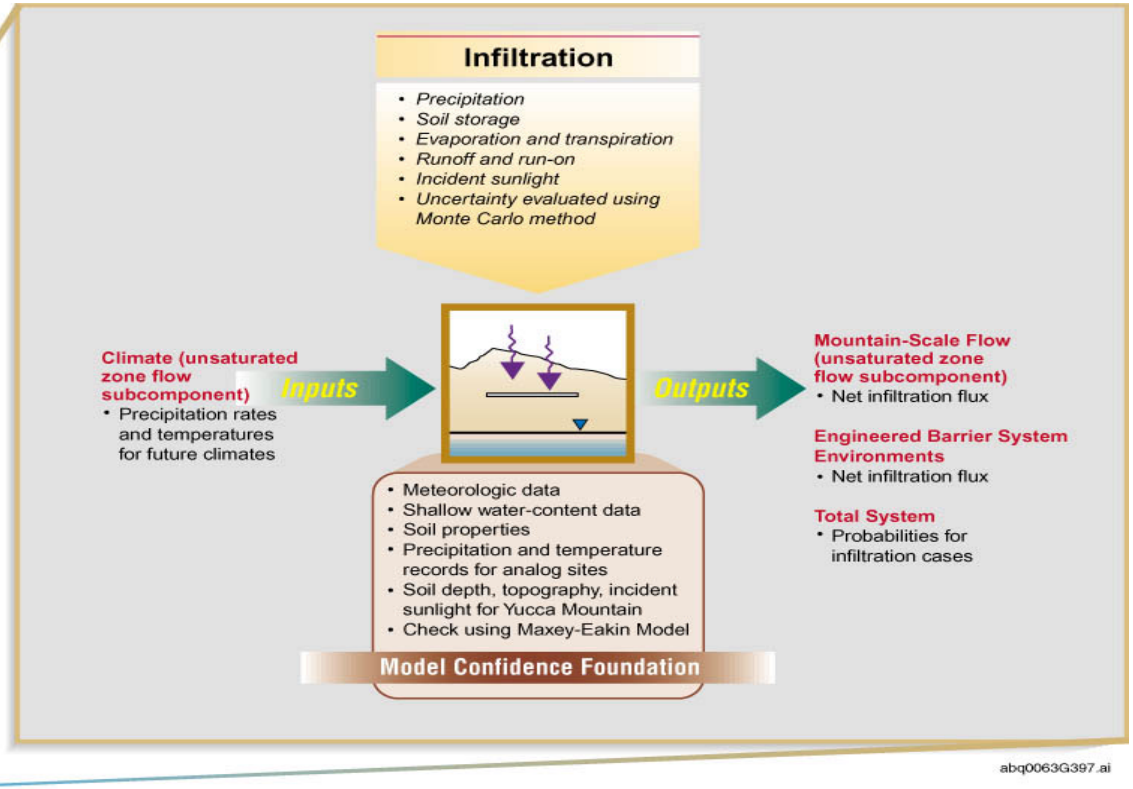


Sequence of information flow diagrams: Detail of Component



Sequence of information flow diagrams: Inputs/outputs/basis for component model





Introduction to TSPA-SR Model Presentation

- TSPA-SR model built of multiple component models
- Integrated model utilizes a variety of external files (table lookups, software routines)
- Data inputs are derived directly from over 30 abstraction AMR's, that are integrated with the remainder of the AMR's
- Majority of software is verified according to APSI-1Q procedure, remainder in process of being verified

Summary

- **TSPA-SR model brings together information from a complex variety of sources**
- **Integration of component models is achieved in TSPA-SR**
- **Information feeds to TSPA-SR model are controlled**
- **TSPA-SR model is systematically tested and confirmed that the model represents the processes as intended**