

**An Overview of the
WIPP Performance Assessment**

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**Presentation to the
Nuclear Waste Technical Review Board**

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Outline of the Presentation

- 1) The Regulations 40CFR191 and 40CFR268.6**
- 2) PA Methodology**
- 3) Present Status of the WIPP PA**
- 4) Lessons Learned from WIPP PA**

1985 RULETITLE 40, CODE OF FEDERAL REGULATIONS
SUBCHAPTER F--RADIATION PROTECTION
PROGRAMSPART 191--ENVIRONMENTAL RADIATION
PROTECTION STANDARDS FOR
MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR
FUEL, HIGH-LEVEL AND
TRANSURANIC RADIOACTIVE WASTESSubpart A--Environmental Standards for Management and
Storage

Sec.

- 191.01 Applicability.
- 191.02 Definitions.
- 191.03 Standards.
- 191.04 Alternative standards.
- 191.05 Effective date.

Subpart B--Environmental Standards for Disposal

- 191.11 Applicability.
- 191.12 Definitions.
- 191.13 Containment requirements.
- 191.14 Assurance requirements.
- 191.15 Individual protection requirements.
- 191.16 Ground water protection requirements.
- 191.17 Alternative provisions for disposal.
- 191.18 Effective date.

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- ~~191.16 Groundwater protection requirements.~~
- 191.17 Alternative provisions for disposal.
- ~~191.18~~ Effective date.

KEY

Strike-through = deletions

Boldface = additions

Vertical bar = rearrangement of sequence

Subpart C—Environmental Standards for Ground-Water Protection

- 191.21 Applicability.**
- 191.22 Definitions.**
- 191.23 General provisions.**
- 191.24 Disposal standards.**
- 191.25 Compliance with other Federal regulations.**
- 191.26 Effective date.**

Appendix A Table for Subpart B

Appendix B Guidance for Implementation of Subpart B

Authority: The Atomic Energy Act of 1954, as amended; Reorganization Plan No. 3 of 1970; and the Nuclear Waste Policy Act of 1982.

Appendix A Table for Subpart B

Appendix B—Calculation of Annual Committed Effective Dose

Appendix BC Guidance for Implementation of Subpart B

Authority: The Atomic Energy Act of 1954, as amended, **42 U.S.C. §§ 2011-2296**; Reorganization Plan No. 3 of 1970, **5 U.S.C. App. 1**; and the Nuclear Waste Policy Act of 1982, as amended, **42 U.S.C. §§ 10101-10270**; and the Waste Isolation Pilot Plant Land Withdrawal Act, Pub. L. 102-579.

191.15 Individual protection requirements.

Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system shall not cause the annual dose equivalent from the disposal system to any member of the public in the accessible environment to exceed 25 millirems to the whole body or 75 millirems to any critical organ. All potential pathways (associated with undisturbed performance) from the disposal system to people shall be considered, including the assumption that individuals consume 2 liters per day of drinking water from any significant source of ground water outside of the controlled area.

191.15 Individual protection requirements.

(a) Disposal systems for ~~spent nuclear fuel or high-level or transuranic radioactive wastes~~ and any associated radioactive material shall be designed to provide a reasonable expectation that, for ~~1,000~~ **10,000** years after disposal, undisturbed performance of the disposal system shall not cause the annual **committed effective dose equivalent, received through all potential pathways** from the disposal system, to any member of the public in the accessible environment, to exceed **25 15 millirems (150 microsieverts)**. ~~to the whole body or 75 millirems to any critical organ. All potential pathways (associated with undisturbed performance) from the disposal system to people shall be considered, including the assumption that individuals consume 2 liters per day of drinking water from any significant source of ground water outside of the controlled area.~~

(b) Annual committed effective doses shall be calculated in accordance with Appendix B of this part.

(c) Compliance assessments need not provide complete assurance that the requirements of § 191.15 (a) of this subpart will be met. Because of the long time period involved and the nature of the processes and events of interest, there will inevitably be substantial uncertainties in projecting disposal system performance. Proof of the future performance of a disposal system is not to be had in the ordinary sense of the word in situations that deal with much shorter time frames. Instead, what is required is a reasonable expectation, on the basis of the record before the implementing agency, that compliance with §191.15(a) will be achieved.

(d) Compliance with the provisions in this section does not negate the necessity to comply with any other applicable Federal regulations or requirements.

191.17 Alternative provisions for disposal.

The Administrator may, by rule, substitute for any of the provisions of Subpart B alternative provisions chosen after:

(a) The alternative provisions have been proposed for public comment in the Federal Register together with information describing the costs, risks, and benefits of disposal in accordance with the alternative provisions and the reasons why compliance with the existing provisions of Subpart B appears inappropriate;

(b) A public comment period of at least 90 days has been completed, during which an opportunity for public hearings in affected areas of the country has been provided; and

(c) The public comments received have been fully considered in developing the final version of such alternative provisions.

191.18 Effective date.

The standards in this Subpart shall be effective on November 18, 1985.

~~191.17~~ 16 Alternative provisions for disposal.

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(b) A public comment period of at least 90 days has been completed, during which an opportunity for public hearings in affected areas of the country has been provided; and

(c) The public comments received have been fully considered in developing the final version of such alternative provisions.

~~191.18 Effective date:~~

~~The standards in this Subpart shall be effective on November 18, 1985.~~

Subpart C-Environmental Standards for Ground-Water Protection

191.21 Applicability.

(a) This Subpart applies to:

(1) Radiation doses received by members of the public as a result of activities subject to subpart B of this part; and

(2) Radioactive contamination of underground sources of drinking water in the accessible environment as a result of such activities.

(b) This Subpart does not apply to:

(1) Disposal directly into the oceans or ocean sediments;

(2) Wastes disposed of before the effective date of this subpart; and

(3) The characterization, licensing, construction, operation, or closure of any site required to be characterized under § 113(a) of Public Law 97-425.

191.22 Definitions.

Unless otherwise indicated in this subpart, all terms have the same meaning as in subparts A and B of this part.

Public water system means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals. Such term includes

(1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system; and

(2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

Total dissolved solids means the total dissolved (filterable) solids in water as determined by use of the method specified in 40 CFR Part 136.

Underground source of drinking water means an aquifer or its portion which:

(1) supplies any public water system; or

(2) contains a sufficient quantity of ground water to supply a public water system; and

(i) currently supplies drinking water for human consumption; or

(ii) contains fewer than 10,000 milligrams of total dissolved solids per liter.

191.23 General provision

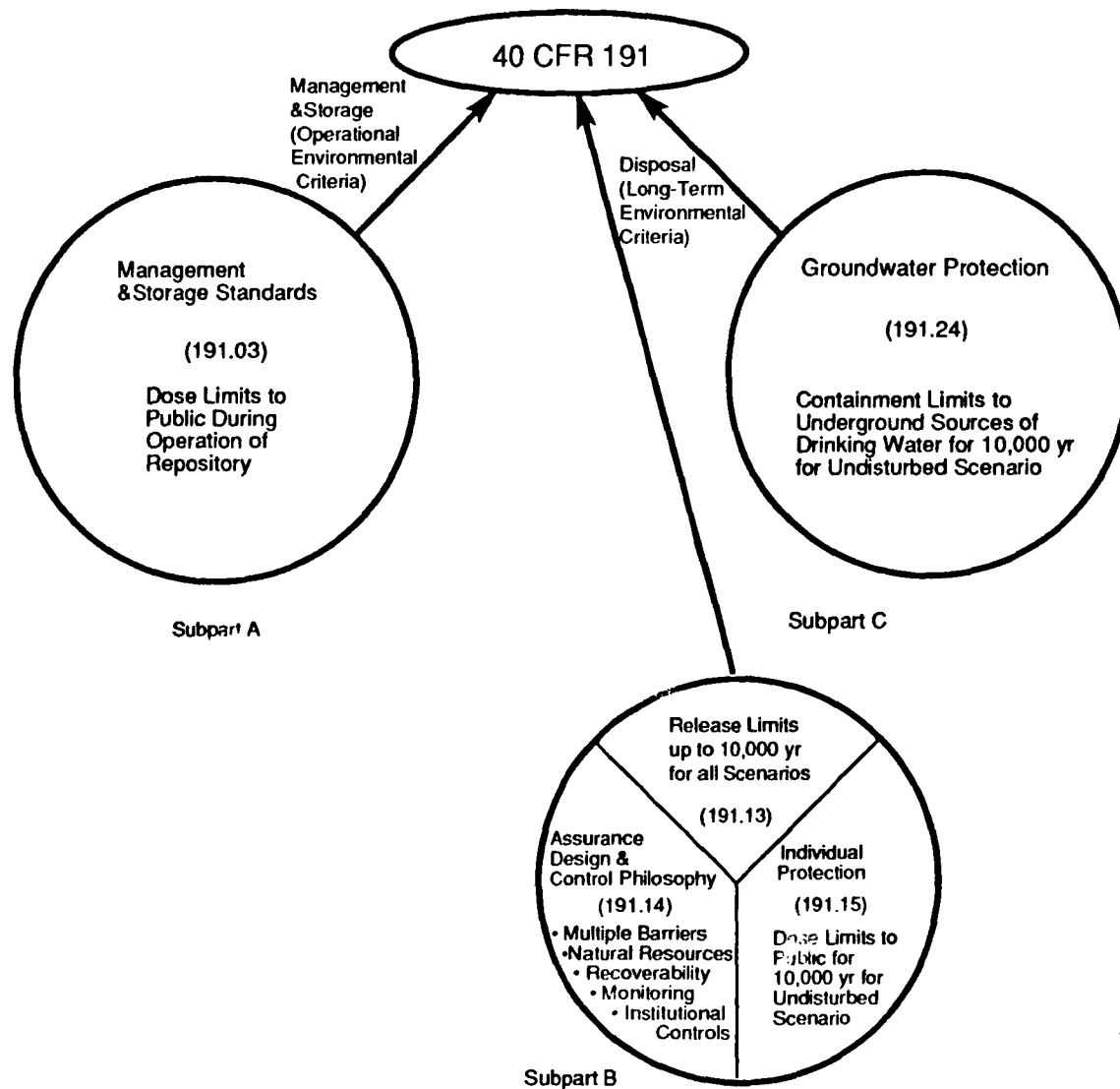
(a) Determination of compliance with this subpart shall be based upon underground sources of drinking water which have been identified on the date the implementing agency determines compliance with subpart C of this part.

191.24 Disposal standards

(a) Disposal systems.

(1) *General.* Disposal systems for waste and any associated radioactive material shall be designed to provide a reasonable expectation that 10,000 years of undisturbed performance after disposal shall not cause the levels of radioactivity in any underground source of drinking water, in the accessible environment, to exceed the limits specified in 40 CFR 141 as they exist on the effective date of this subpart.

Environmental Standards for Management And Disposal (40 CFR 191)



As Defined by 40 CFR 191, Performance Assessment Is...

"An analysis that:

- 1. Identifies the processes and events that might affect the disposal system;**
- 2. Examines the effects of these processes and events on the performance of the disposal system, and**
- 3. Estimates the cumulative releases of radionuclides, considering the associated uncertainties, caused by all significant processes and events.**

These estimates shall be incorporated into an overall probability distribution of cumulative releases to the extent practicable."

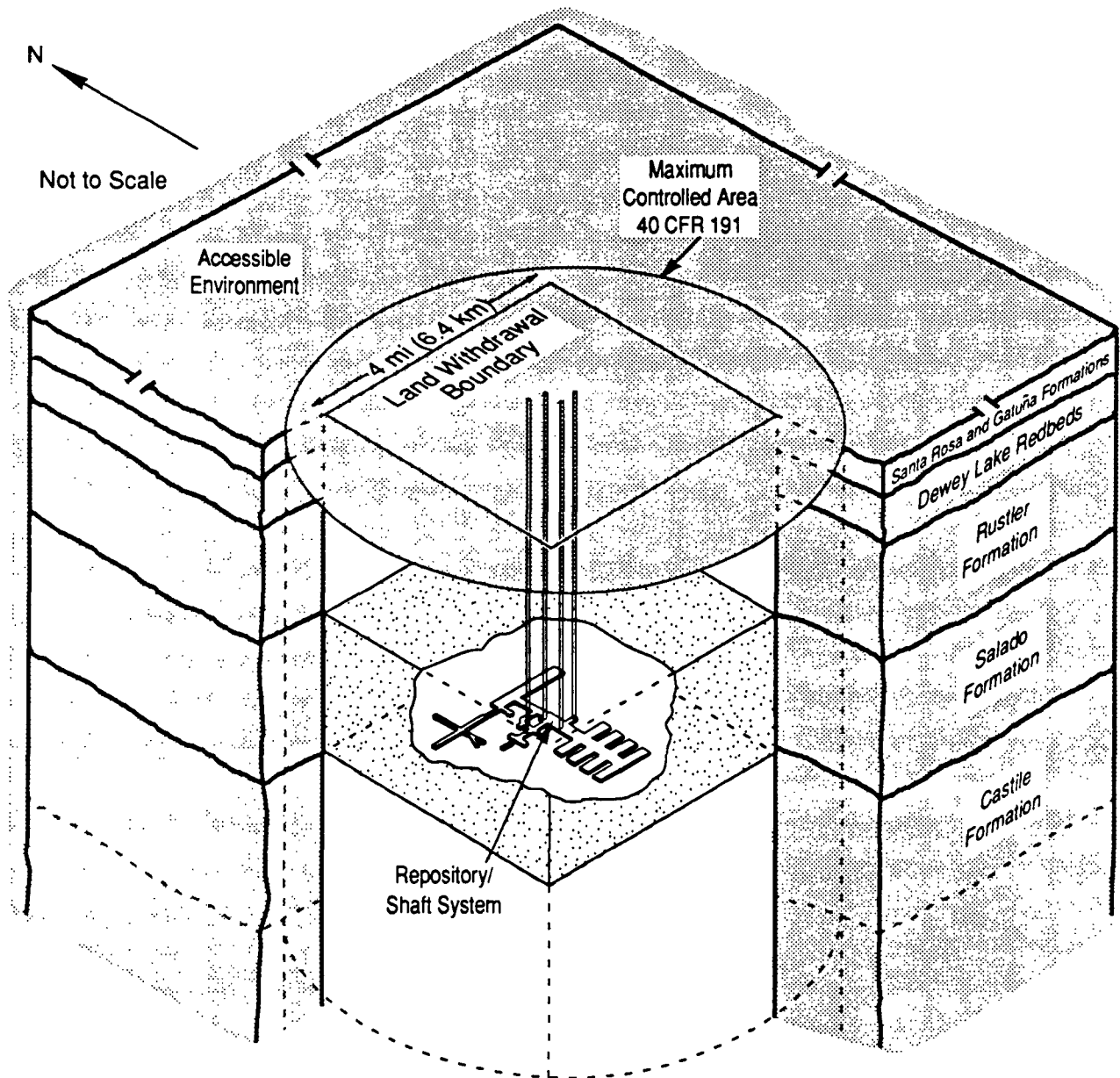
Long-Term Performance Assessment Is also Applicable to 40 CFR 268.6



**Regulatory performance measure is concentrations
of specific hazardous materials at the unit
boundary**

- **Volatile Organic Compounds (VOCs)**
- **Heavy Metals (HMs)**

**Regulatory boundary is different for 40 CFR 268.6
and 40 CFR 191**

Accessible Environment and Disposal unit Boundaries



-  40 CFR 191 Accessible Environment
-  40 CFR 268 Disposal Unit

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6342-106-0

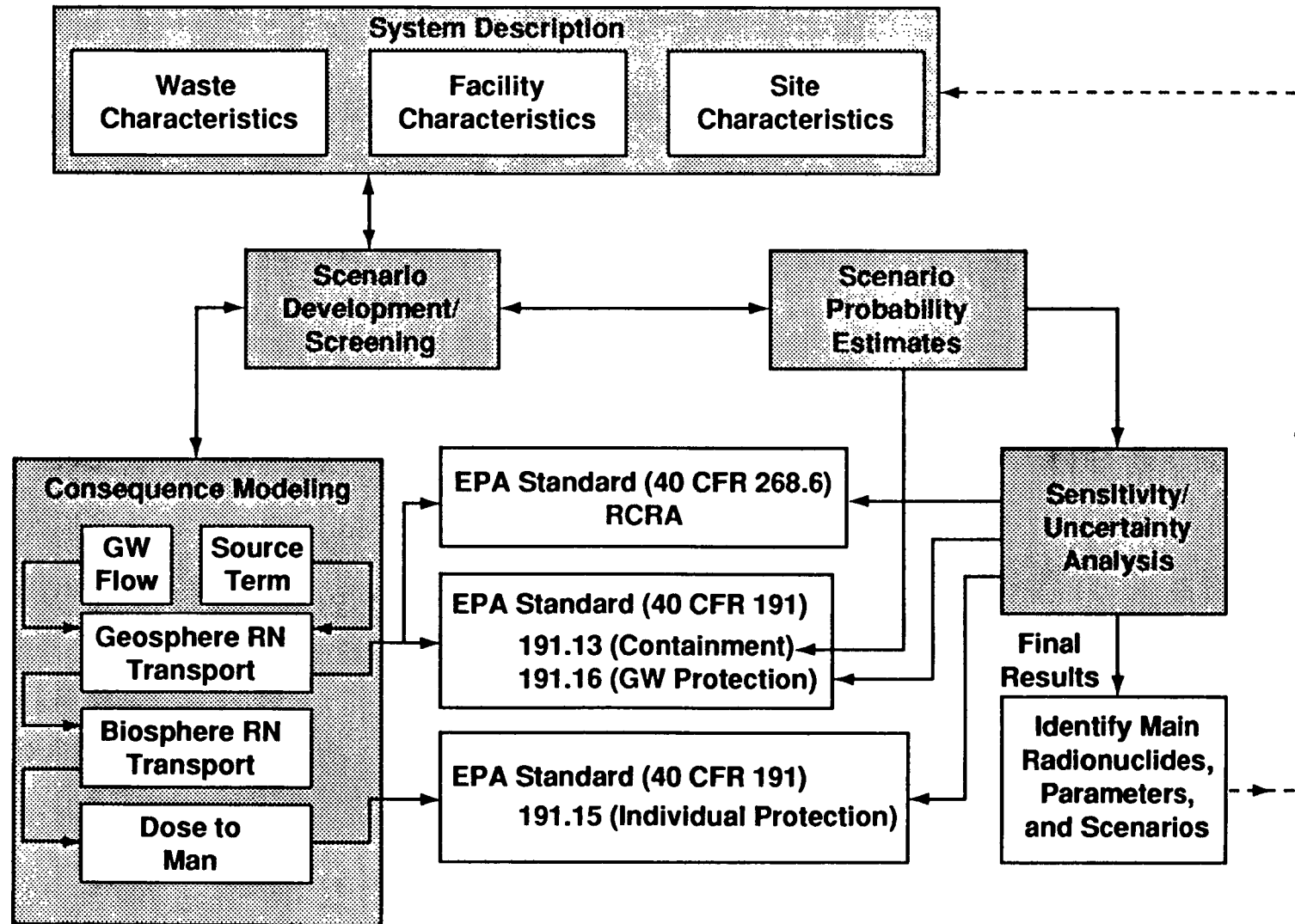
PAs for Long-Term Requirements of 40 CFR 268.6 and 40 CFR 191 Will:

Cover the same time period (10,000 years)

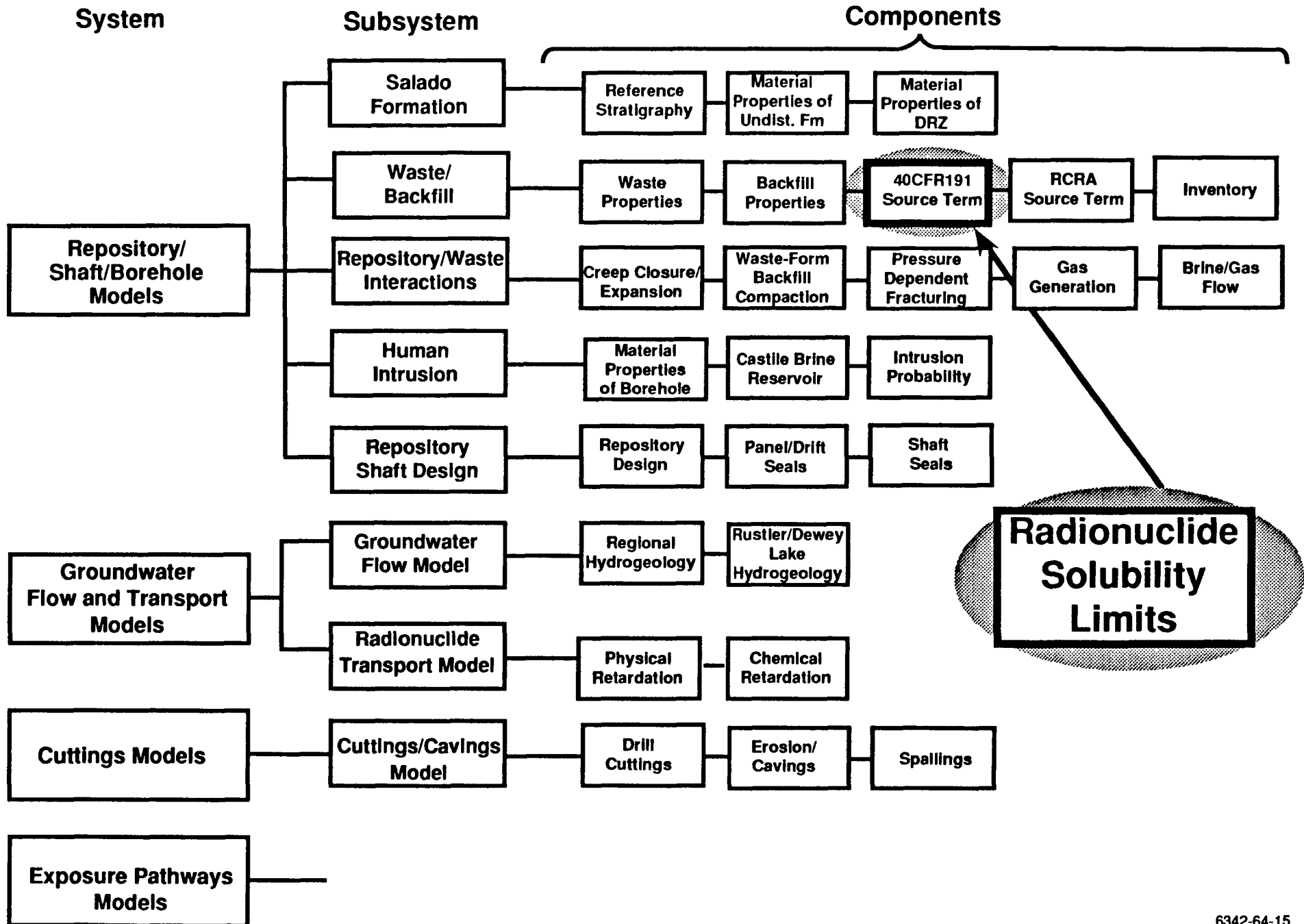
Use the same data and conceptual models to describe the disposal system

Use comparable computational models to simulate performance

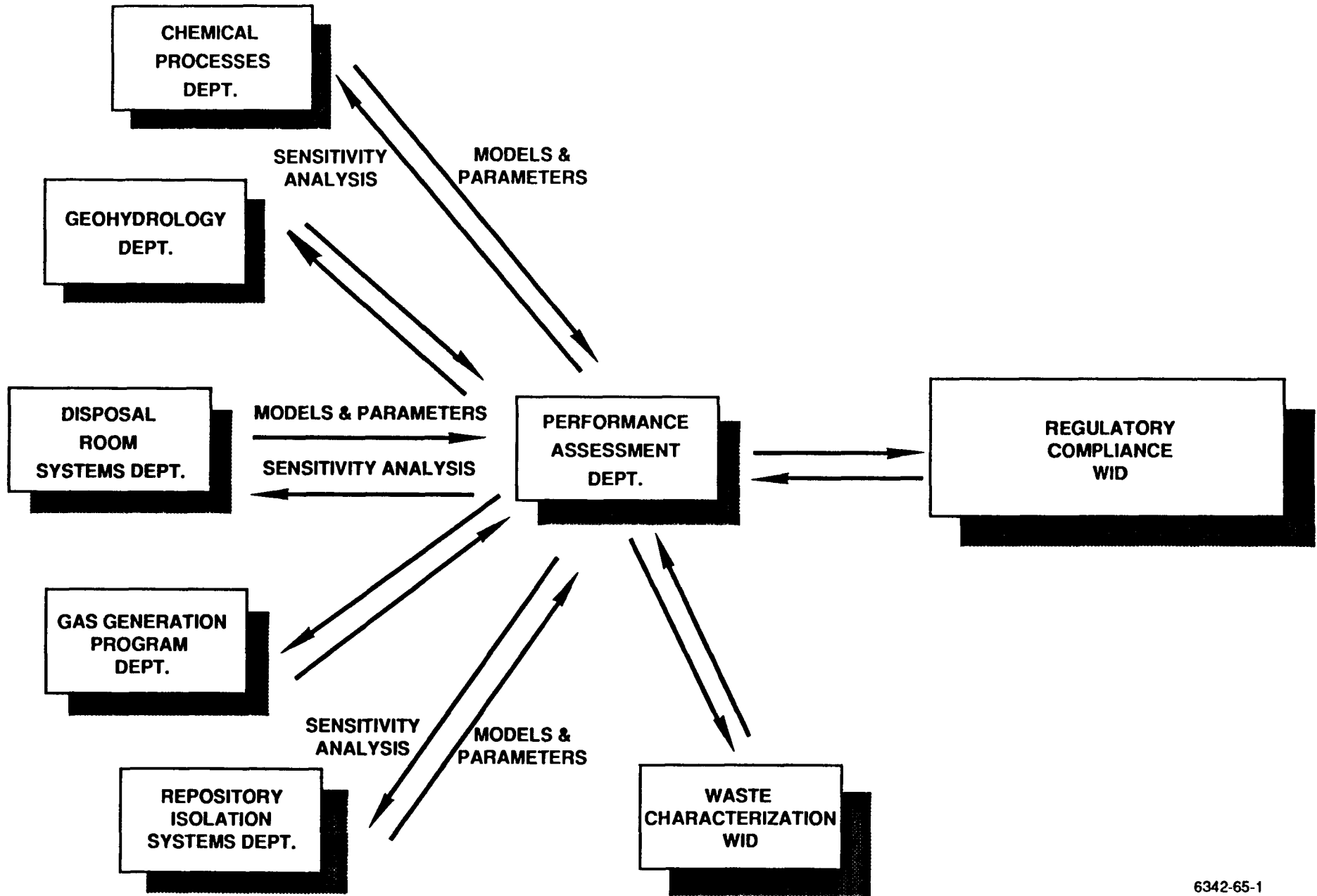
Methodology for Performance Assessment of TRU Repositories



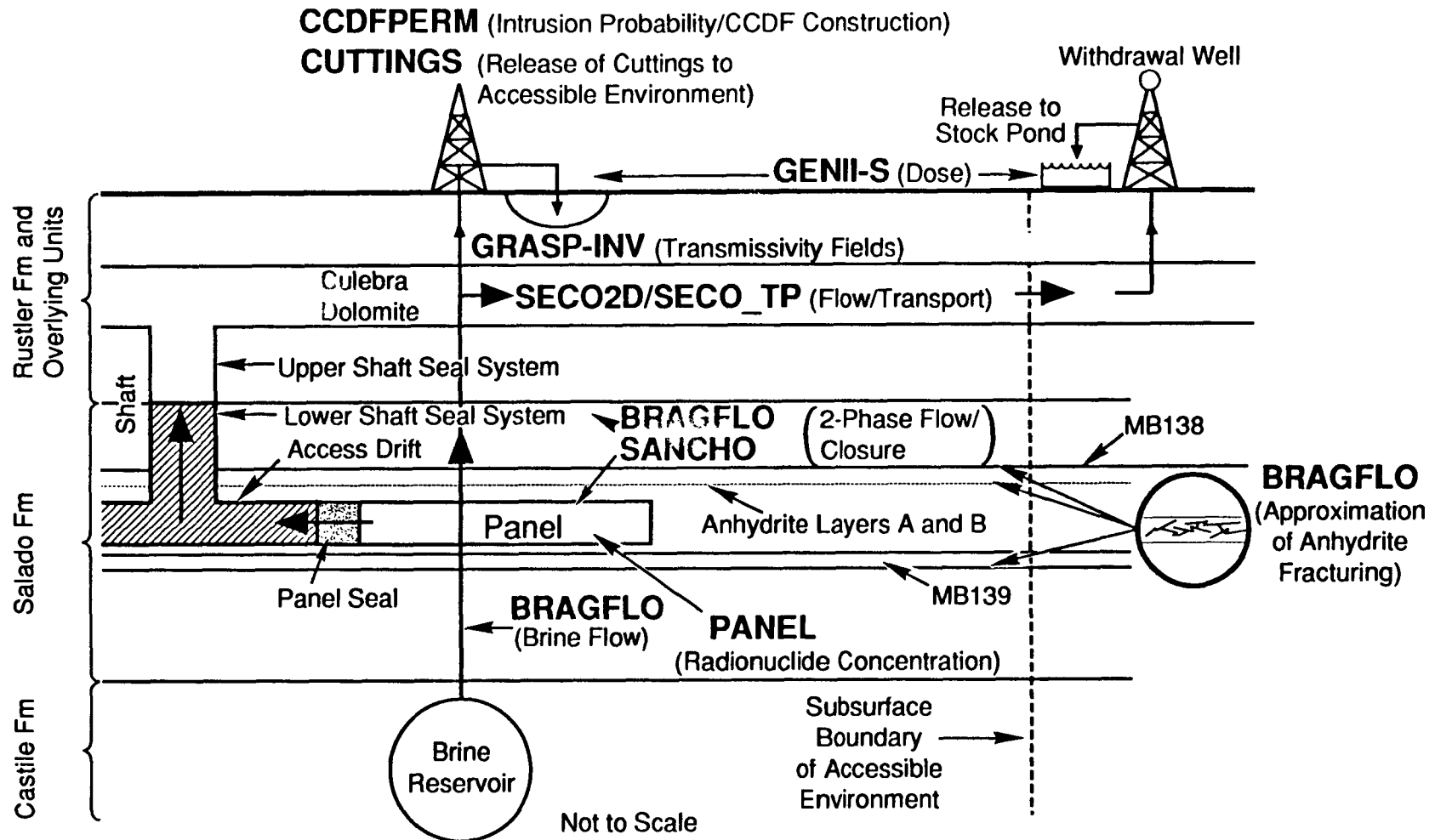
Performance Assessment Information Flow

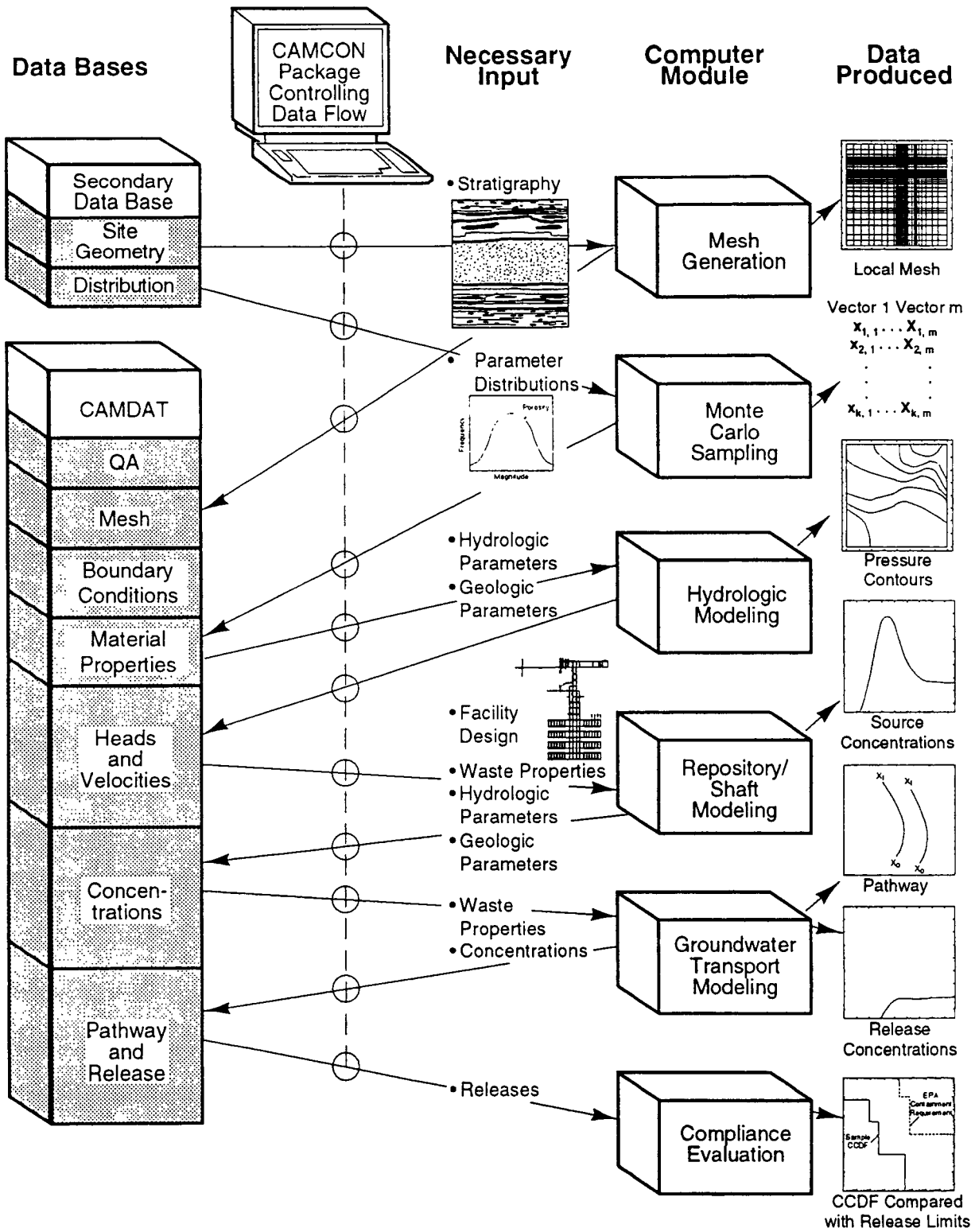


WIPP Performance Assessment Interfaces



1994 Modeling System (Codes)





WIPP PA Uses Iterative Monte Carlo Methodology

**Iterations of Preliminary PAs in 1989, 1990, 1991,
1992, and planned for 1994**

- **Provide interim guidance to project**
- **Allows early peer review**

Monte Carlo Technique

- **Multiple deterministic simulations using sampled values**
- **Facilitates parameter sensitivity analyses at full system scale**
- **40 CFR 191.13 requires consideration of uncertainty in performance measure**

Deterministic Analyses Are Part of the Monte Carlo Methodology

Multiple deterministic analyses are the basis for uncertainty and sensitivity analyses

Single deterministic analyses in WIPP PA

- **Valuable for benchmarking and code verification with test problems**
- **Can be used for rapid turn-around for specific parametric variation studies, but multiple simulations are preferable**

**Present Status of the
WIPP PA**

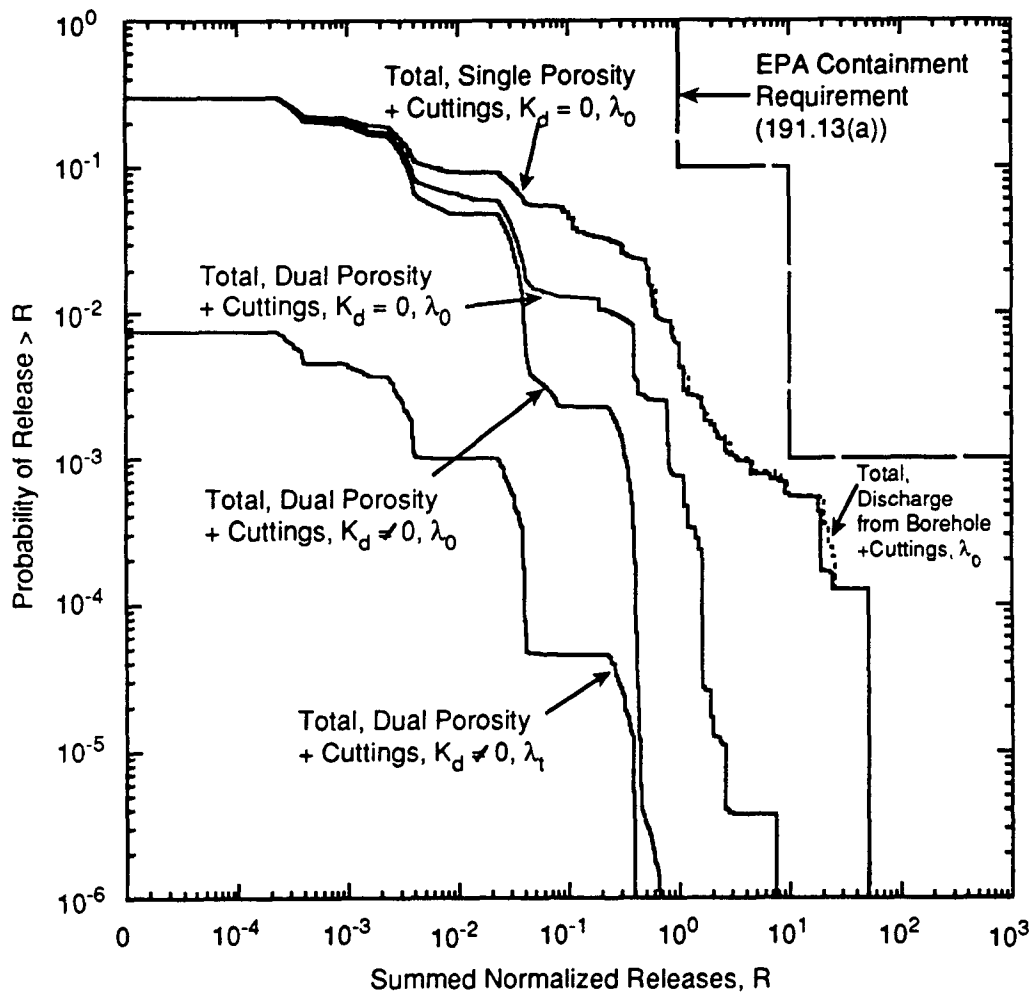
Sources of Uncertainty in System Performance Assessments

Future states of the system

Models used to assess consequences

Model parameters and data

Barrier Effect Display, 1992 PA Showing Effects of Physical and Chemical Retardation and Markers



TRI-6342-2399-0
TRI-6342-2397-0
TRI-6342-2410-0
TRI-6342-2411-0
TRI-6342-2414-0

6342-117-0

Summary of Importance of Sampled Parameters in the 1992 WIPP PA (Conditional on Assumptions of 1992 PA)

1991 Rank 191.13 268.6

Critically Important Parameters

1. Drilling Intensity	1	Y*	na
2. Borehole Fill Permeability	2	Y	na
3. Shaft Seal Permeability (Long-Term)	3	N	Y

Very Important Parameters

4. Permeability of Intact Anhydrites	5	Y	Y
5. Permeability of Intact Halite	4	Y	Y
6. Initial Water Content of Waste/Backfill	8	N	Y
7. Radionuclide Solubility Limits	6	Y	na
8. Fracture Spacing in Culebra	14	Y	na
9. Sorption in Culebra Matrix (K_d s)	7	Y	na

Important Parameters (order of listing is not significant)

Gas Generation Model Parameters (6)	N	Y
Two-Phase Relative Permeability Model	N	Y
Porosity of Intact Anhydrite	N	Y
Shaft Seal Permeability (Short-Term)	N	Y
Disturbed Rock Zone Porosity	N	Y
Metal (and Glass) Content of Waste	N	Y
Combustible (Cellulosic) Content of Waste	Y	N
Culebra Transmissivity Fields	Y	na
Culebra Matrix Porosity	Y	na

Less Important Parameters

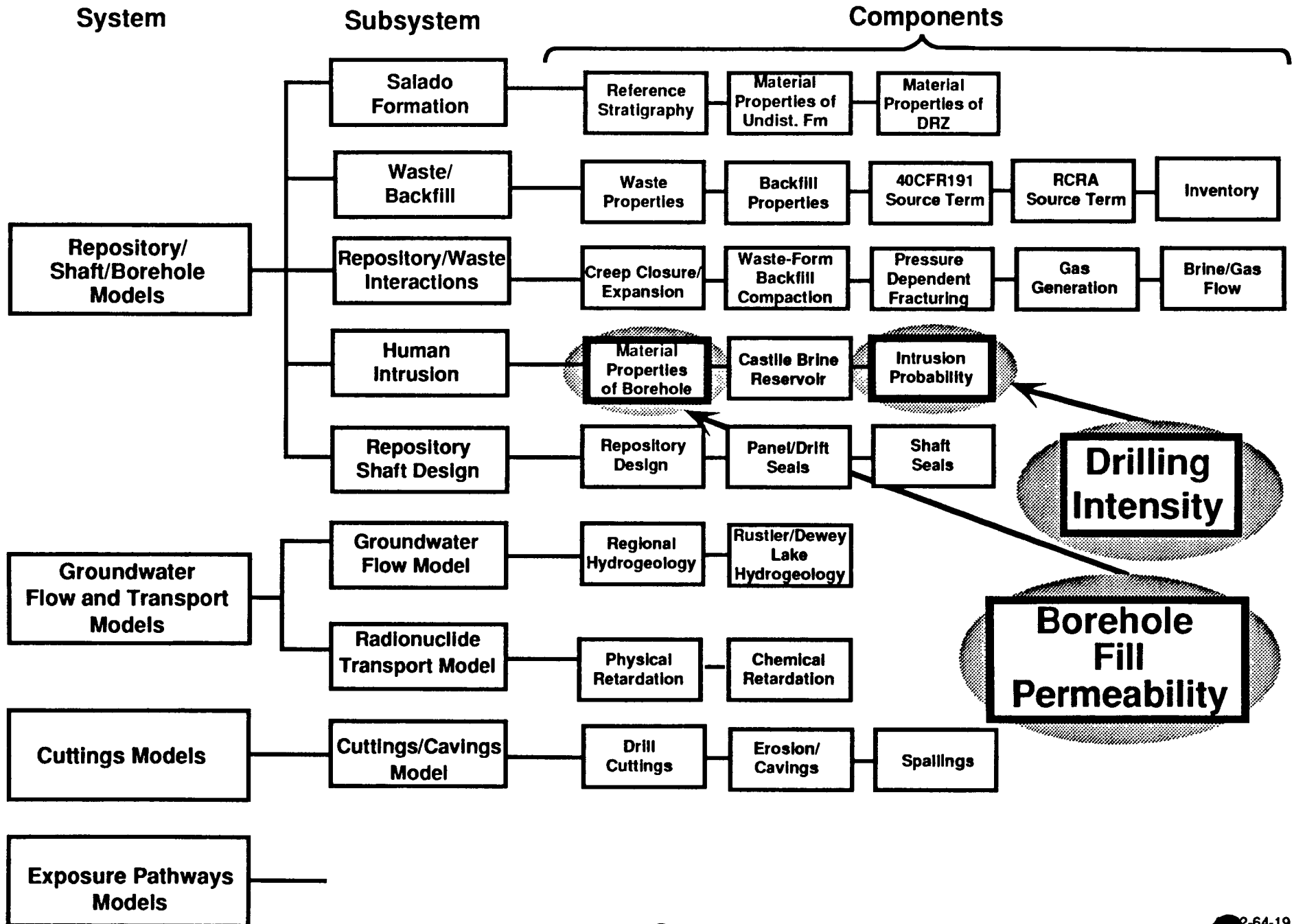
Remaining 21 Sampled Parameters

* Y (yes) indicates a parameter is important with respect to the listed regulation. N (no) indicates that sensitivity with regard to the regulation is the primary reason for the ranking. NA (not applicable)

**"Less Important" Parameters
Sampled in the 1992 PA
(Conditional on Assumptions of 1992 PA)**

Climatically-Varying Recharge Factor
Fracture Porosity in Culebra
Porosity of Clay Lining Fractures in Culebra
Radionuclide Sorption in Clay Fracture-Linings in Culebra (6 elements)
Residual Brine Saturation in Halite
Residual Brine Saturation in Anhydrite
Residual Gas Saturation in Halite
Residual Gas Saturation in Anhydrite
Two-Phase Flow Model Exponent
Castile Brine Reservoir Pressure
Castile Brine Reservoir Area
Castile Brine Reservoir Storativity
Porosity of Backfill in Drifts, Experimental Regions, and Shafts Below Seal
Drift and Panel Seal Permeability
Far-Field Pressure in Salado Formation
Shaft Seal Vertical Thickness

Performance Assessment Information Flow

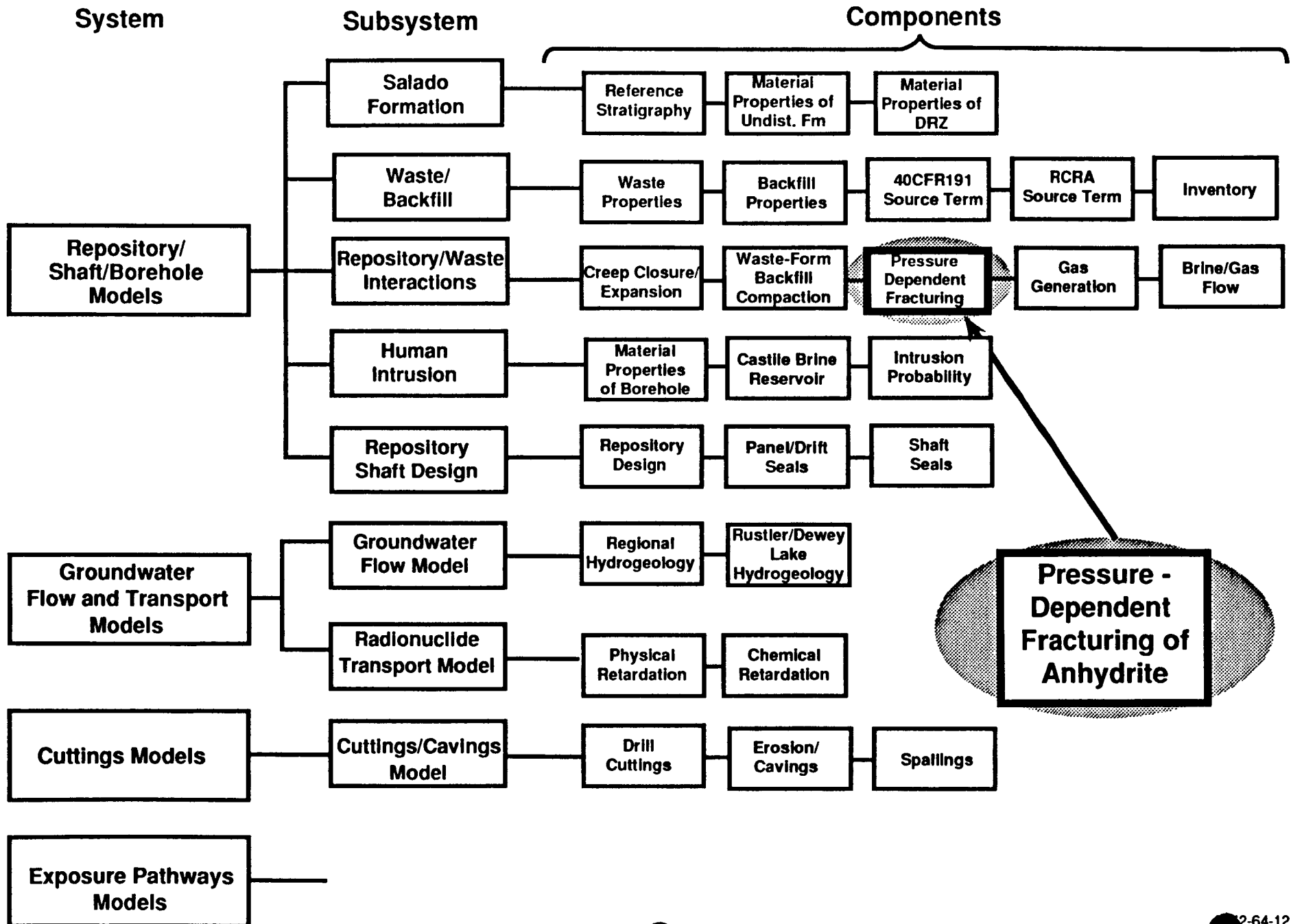


Examples of Important Sources of Conceptual Model Uncertainty in the 1992 PA

<u>Conceptual Model</u>	<u>191.13</u>	<u>268.6</u>
VOC Source Term and Transport	na*	Y
Spalling	Y	na
Pressure-Dependent Fracturing of Anhydrite	N	Y
Darcy Flow in Low Permeability Mediums (e.g., Halite)	Y	Y
Dual-Porosity Transport in Culebra	Y	na
Sorption in Culebra Matrix	Y	na
Gas-Generation Model	Y	Y
Actinide Source Term Model	Y	na
Confined Aquifer Model for Flow in the Culebra	Y	na
Others...		

* NA (not applicable) indicates a conceptual model does not apply to the listed regulation. Y (yes) and N (no) indicate whether or not conceptual model uncertainty is important with respect to the listed regulation.

Performance Assessment Information Flow



For 268.6, PA Does Not yet Calculate a Regulatory Performance Measure

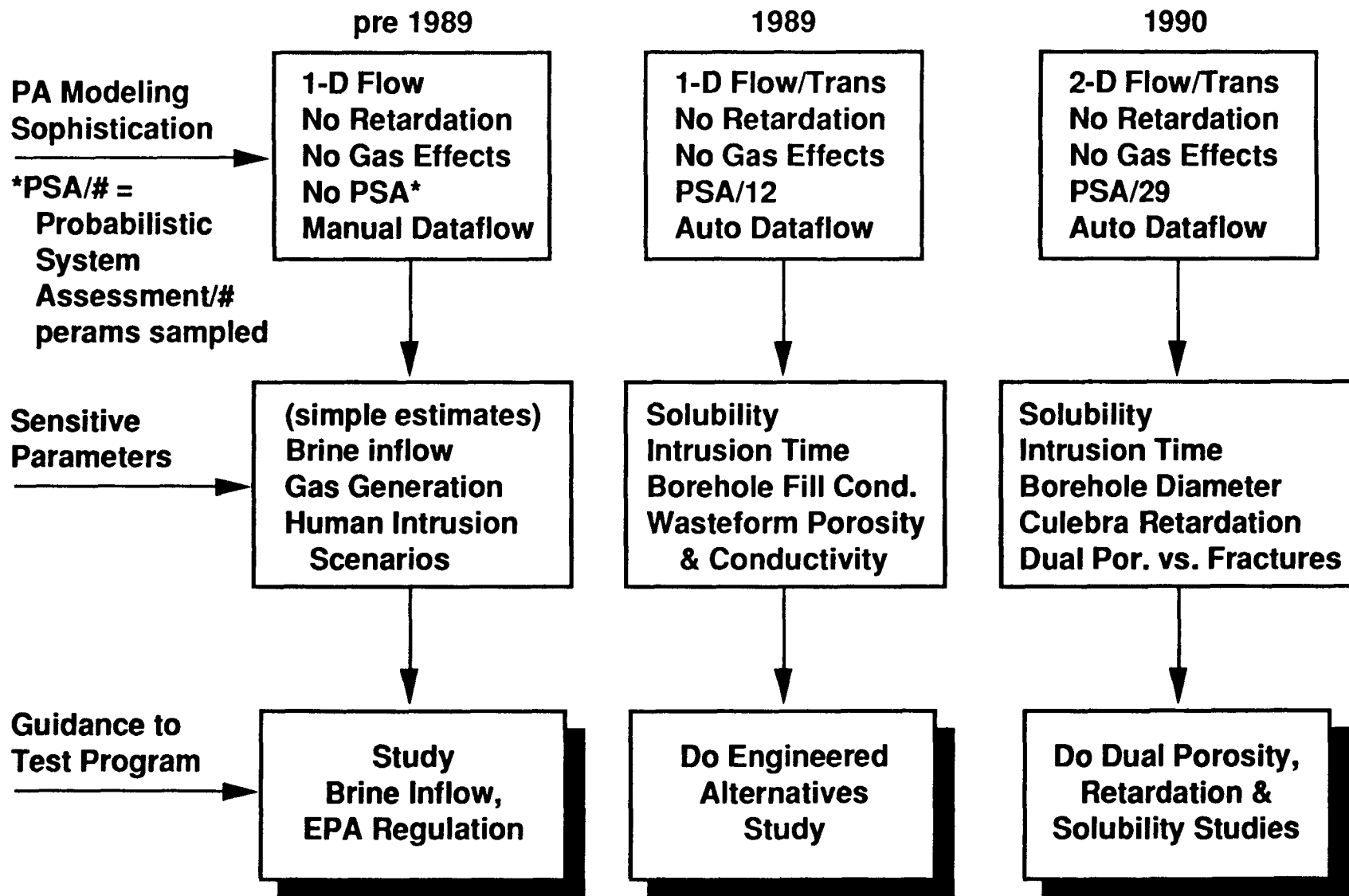
**Regulatory measure is VOC (and HM)
concentration at unit boundary**

**VOC source term and transport not modeled in
1992 PA or in 1994 preliminary runs**

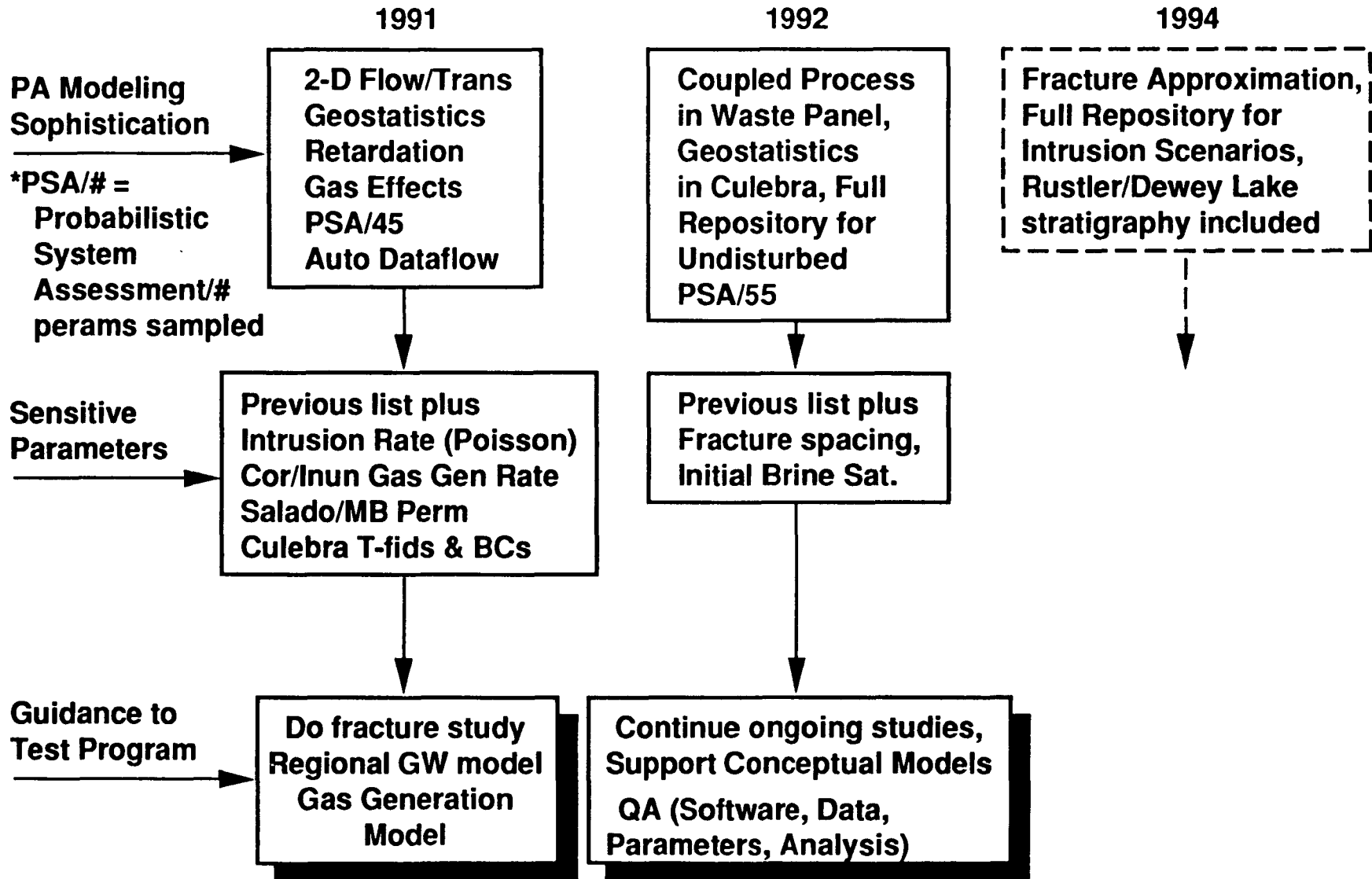
**Gas migration is reported as a nonregulatory
performance measure**

- **Potentially a conservative bounding calculation**
- **Migration past unit boundary has no regulatory significance**
- **Preliminary 1994 undisturbed calculations show all gas
remaining within unit boundary in 46 of 50 realizations**

Maturation of PA Process



Maturation of PA Process (Continued)



Rip's Lessons Learned From WIPP PA

- **Iterative PA analyses must be used to guide R & D needs**
- **Human Intrusion is dominant (only) release pathway for 40CFR191**
- **Calculational complexity is both good and bad**
- **Methods are available to treat data uncertainty**
- **For data spacial variability is still a problem**
- **Conceptual model uncertainty is the largest remaining problem**
- **A definition of future states for Human Intrusion are needed**
- **A figure of merit for 40CFR268.6 (RCRA) is needed**
- **The international community is at approximately the same level of development for PA**