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Interactions and Integration Between Site Characterization and Performance Assessment

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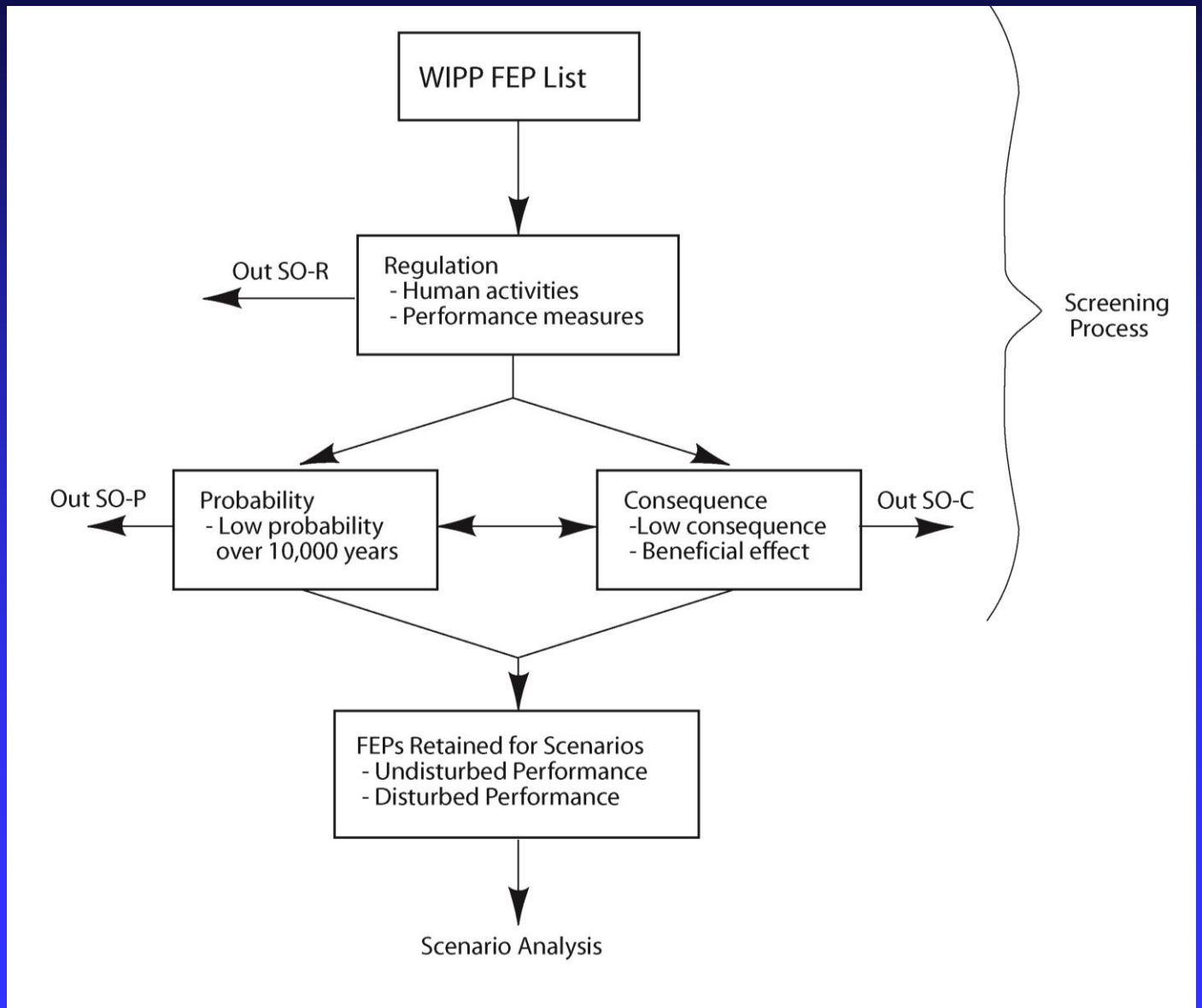
Site Characterization and Performance Assessment

- Projects begin with a broad-based approach to site characterization (SC) to identify site features relevant to performance
- Once initial site characterization has been completed, a FEPs (Features, Events, and Processes) analysis can be performed
- FEPs analysis can focus future work on the features of the repository environment and the physical/chemical processes of greatest importance to PA

FEPs

- Natural FEPs: geological, hydrological, geochemical, geomorphological, climatic, marine, and ecological features, events, and processes that might affect repository performance
- Waste- and Repository-Induced FEPs: caused by waste properties, repository construction, etc.
- Human-Initiated EPs: events and processes that might be initiated by humans and affect repository performance

FEP Screening



FEPs Analysis

- FEPs analysis can show that waste- or repository-induced FEPs, or human-initiated EPs, can lead to increased importance of parts of the natural system
- For example, repository- or waste-induced fracturing can cause a low-permeability unit with little transport potential to have high transport potential, and therefore require greater characterization

Conversely …

- Early PA and FEPs results should not be used to terminate experimental programs on the grounds that safety can be adequately demonstrated without invoking the process or mechanism to be studied
- Early understandings of the relative importance of different processes sometimes change as a project progresses, and no real barrier to radionuclide migration should be ignored simply because it “isn’t needed” nor should less likely pathways be ignored because a dominant pathway can be “conservatively” assumed

WIPP Experience

- The first groundwater flow models developed showed that a high-transmissivity region in the Culebra dolomite, thought to be bounded on all sides, actually continued off-site and would be the dominant flow pathway
- Additional field work was performed to refine our knowledge of the extent and hydraulic properties of this zone

WIPP Experience (2)

- Preliminary PA modeling then showed that matrix diffusion could be an important retardation mechanism in this zone, motivating field tracer tests
- Sorption was, at one time, thought to be unnecessary to compliance and experimental sorption studies were cancelled. Later evaluations showed that sorption could be important for some scenarios, and was always valuable in providing confidence in compliance, and experimental studies were resumed.

PA Guidance for SC

- A sensitivity analysis is performed for every PA that is completed to identify the uncertain (sampled) parameters having the largest effects on calculated releases
- If additional experimentation could reduce the range of uncertainty of the sensitive parameters, more tests may be performed
- SC and PA continue in an iterative fashion

Limitations of PA

- PA can only show the relative importance of parameters in the context of the models it is employing – if the models are inadequate or inappropriate, unsound guidance may be provided to SC
- Additional SC may identify the need for alternative models

Lesson #1

- SC and PA should evolve together through an iterative process, with neither activity completely dominating the other
- For experimental guidance, PA should use reasonable estimates of parameter and conceptual uncertainty, and not conservative assumptions that may bias results towards preconceived notions
- SC should be cautious about focusing attention too much on assumed dominant processes or pathways before PA modeling is performed

Defensibility and Credibility

- Models must always be appropriate to the scale of test or investigation
- Using more detailed models for test interpretation than can/will be used in PA:
  - allows a detailed understanding of a process to be developed and demonstrated
  - provides a defensible basis for model simplification as the scale of interest increases

WIPP Experience #1

- Double-porosity models with multirate diffusion have been used to model tracer-test results from the Culebra to demonstrate understanding of the important processes, even though a model using a single rate of diffusion may be suitable for PA
- Use of a simplified model in PA has not been challenged because of the underlying detailed understanding

WIPP Experience #2

- Experiments designed to measure fracture dilation *in situ* as a function of induced pore pressure were terminated when the information to be obtained was judged unnecessary to demonstrate compliance
- The simplified model used to represent fracture dilation in PA has since been criticized as unrealistic and unconvincing, with insufficient experimental support

Safety Case

- "A Safety Case is the synthesis of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe after closure and beyond the time when active control of the facility can be relied on." (OECD NEA, 2004)
- Safety cases involve both quantitative (e.g., PA) and qualitative (e.g., reasoned arguments) elements

SC Support of the Safety Case

- SC provides hard data to be used in PA calculations as well as the conceptual understanding of the site that is needed to develop a safety case
- SC must provide a convincing description of parts of the overall system not explicitly included in PA models

Lesson #2

- Defensibility and credibility require a much greater depth of understanding than can be represented in PA models
  ➔ SC must go beyond the needs of PA to support the overall Safety Case

Model/Parameter Abstraction

- SC and PA typically occur simultaneously, with the result that different people are responsible for each
- Model simplification, however, requires an understanding of how processes operate at both the experimental and PA scales
- At WIPP, experimentalists were not willing to defend PA models and parameters until they were directly involved in developing the models and selecting parameter values

Lesson #3

- Experimentalists should be directly involved in model and parameter abstraction and simplification for PA

Team Integration

Integration methods at WIPP have evolved over time

- Early years: monthly meetings of PI's and managers ⇒ effective (small group)
- After site "validation": separate departments established for surface-based and underground-based investigations, then for PA ⇒ less than optimal
- License submittal preparation: formal procedures established to ensure traceability ⇒ effective
- Operational/recertification phase: integrated hierarchy of Analysis Plans and Test Plans ⇒ highly effective

Co-Signed Data Sheets

WASTE ISOLATION PILOT PLANT
Sandia National Laboratories

WIPP Data Entry Form

WPO: 31612

Form Number: 464 Effective: 11/28/95

Procedure: 9-2 Revision: 1 Page 1 of 1

☒ Major Modification ☐ Error Correction ☐ New ☐ Deactivation

Parameter: Initial Pressure Id: 66

Material: Castile Brine Reservoir **INFORMATION ONLY** Matname: CASTILER

Model: BRAGFLO Idpram: PRESSURE

Category: 1 Units: Pa

Distribution:

Type: CUMULATIVE (WPO: 35368) (Attach. # 1)

Mean: 1.361 E+07 ✓

Median: 1.268 E+07 ✓

Values: (see attached table)

max. = 2.0 E+07
min. = 1.07 E+07

Std Dev: 1.710 E+06 ✓ ~~1.7051E+06~~ mam 3/19/96 Value checks: round off above to 3 sig. fig. MAT 7/26/96

Attachment: ☒ Yes ☐ No

Source:
SWCF-A: 1.2.07.1: PDD: QA: NONSALADD: PKG #19: Castile Brine Reservoir Pressure (WPO: 31072) REQUEST MEMO, 3/25/97 (WPO 35597)

Interpretation: see attached sheets:
1. Original interpretation by M. Tierney 1/12/96 (Attach. # 2)
2. Suggested changes by Geoff Freeze 1/24/96 (Attach. # 3)

Qualified Parameter: ☐ Yes ☒ No Attachment: ☒ Yes ☐ No

Parameter Entry Approved by:

Martin Tierney — Parameters Task Leader (Print) | Martin Tierney — Parameters Task Leader (Sign) | 1/26/96 — Date

Requester:

Martin Tierney — Requester (Print) | Martin Tierney — Requester (Sign) | 1/26/96 — Date

Concurrence: *(Required for Category 1 Parameters Only)*

Geoff Freeze — Scientific Investigator (Print) | Geoff Freeze — Scientific Investigator (Sign) | 2/7/96 — Date

Palmer Vaughn — Performance Assessment Analyst (Print) | Palmer Vaughn — Performance Assessment Analyst (Sign) | 2/7/96 — Date

Entered by:

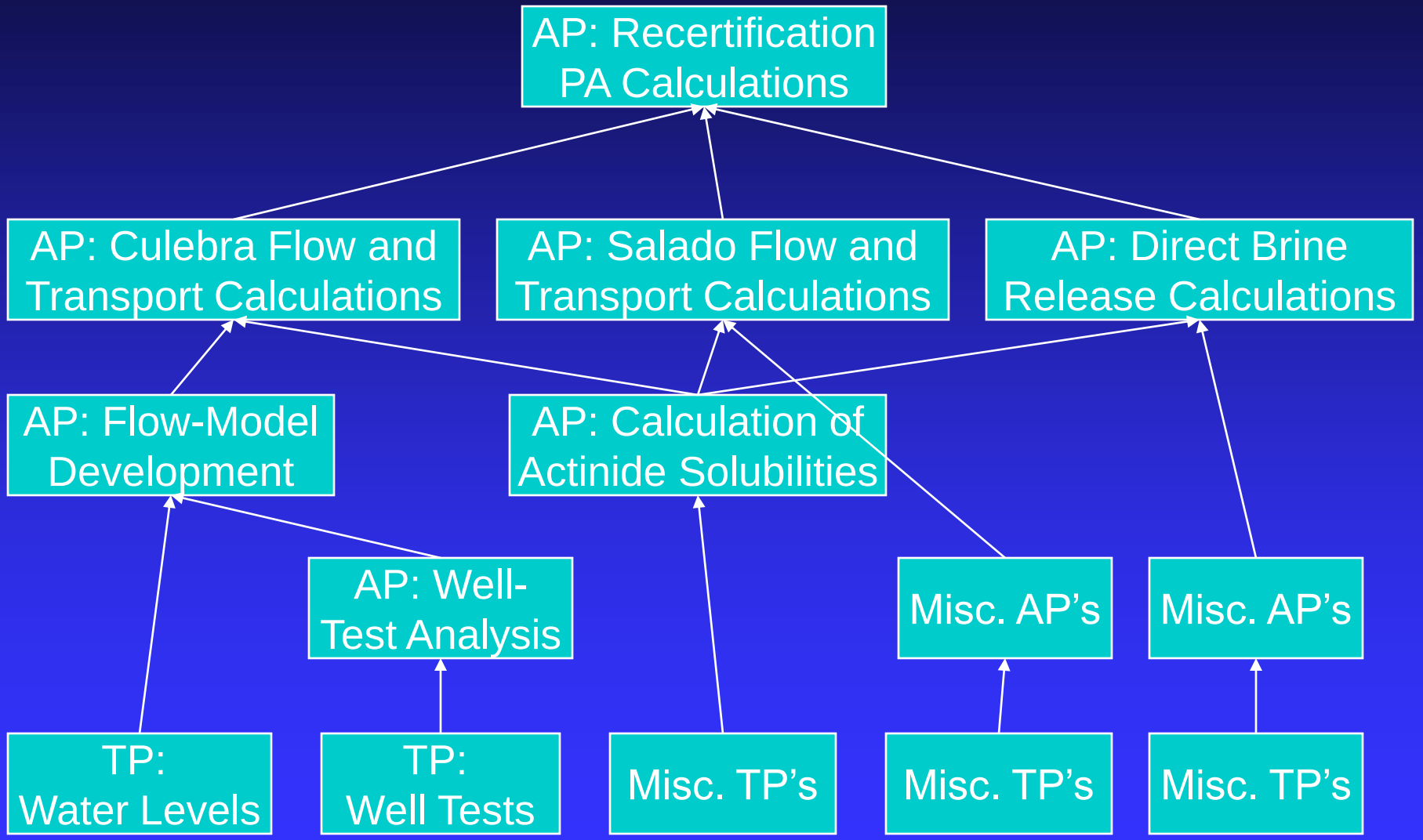
Kelly Rost (Print) | Charlene Lattier for K. Rost — Sign | JTS 2/16/96 2/16/96 — Date

Entry Checked by:

Robert Carter (Print) | Robert E. Carter — Sign | 2/15/96 — Date

SWCF File Code:

Hierarchy of Integrated Plans



Prioritization of Information

Prioritization has evolved as WIPP has progressed

- **Site characterization:**
  - **Initial priority given to information that would confirm expected beneficial features of the site, and to assess processes and features that might threaten waste isolation**
  - **Later priority given to FEPs with the most potential to affect performance adversely, and to providing information to address scenarios of concern**

Prioritization of Information (2)

- Preparation of license application:
  - Priority given to data needed for PA modeling
  - Difficulty in assigning priority to information needed to defend conceptual models--all WIPP conceptual models must, by regulation, be peer reviewed

Prioritization of Information (3)

- Operational/Recertification Phase:
  - Priority given to monitoring requirements specified in regulations
  - When monitoring shows unexpected conditions, data needs and priorities are established through iterative discussions with the regulator

Summary

- Site characterization and PA should evolve together through an iterative process, with neither activity completely dominating the other
- Early PA and FEPs results should not be used to terminate experimental programs on the grounds that safety can be adequately demonstrated without invoking the process or mechanism to be studied

Summary (2)

- Defensibility, credibility, and the overall safety case require a much greater depth of understanding from SC than can be represented in PA models
- Experimentalists should be directly involved in model and parameter abstraction and simplification for PA

Summary (3)

- Team integration may evolve from an early *ad hoc* arrangement to a fully structured state as a repository program matures
- Prioritization of efforts changes as a repository program goes through different stages