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

Update on Development of the Repository Safety Strategy

Presented to:
Nuclear Waste Technical Review Board (NWTRB)

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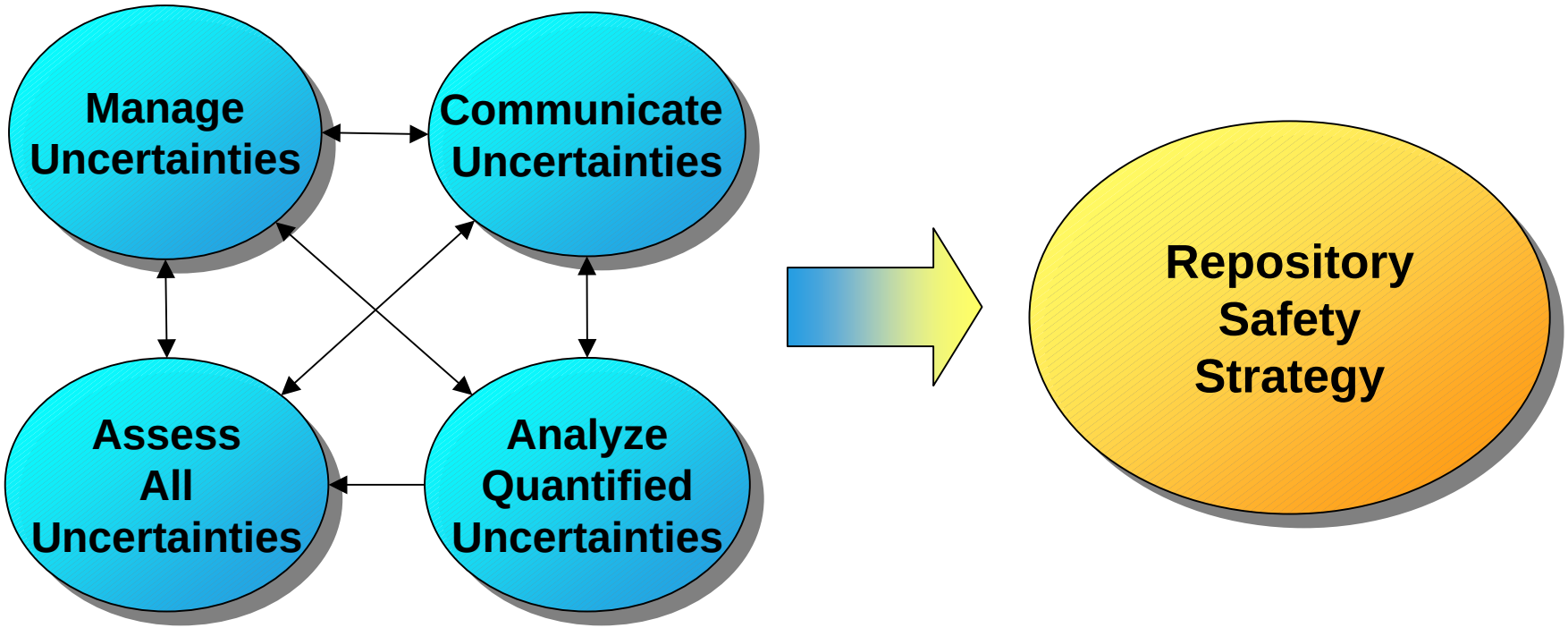
YUCCA MOUNTAIN PROJECT

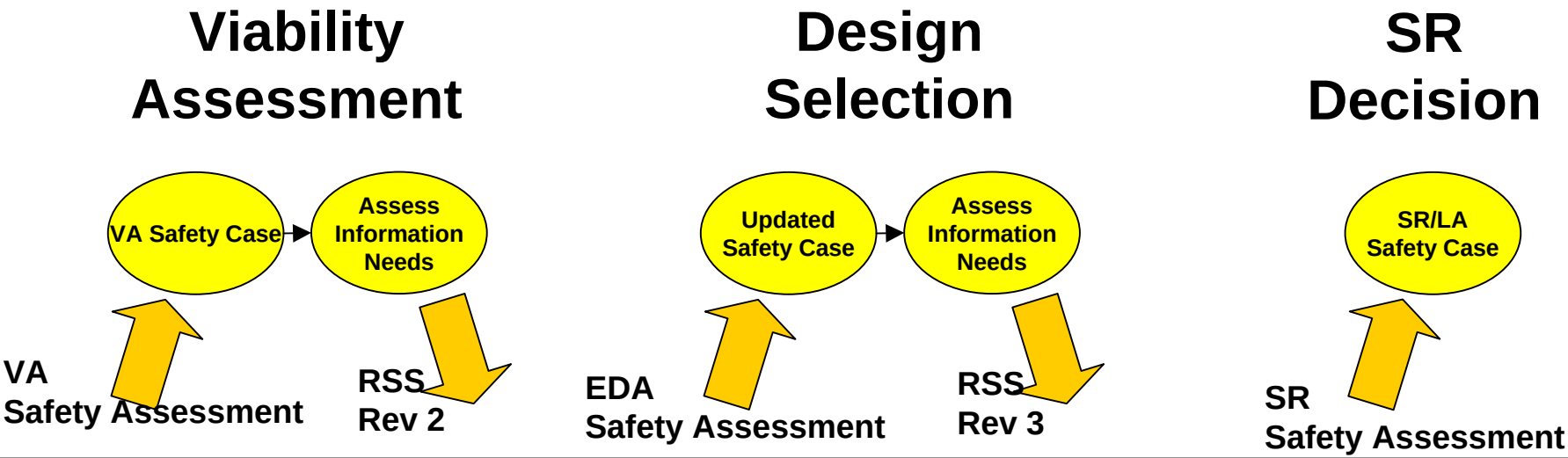
Repository Safety Strategy (RSS) Documents DOE's Plans to Address Uncertainties Important to Postclosure Safety



General Elements of the Repository Safety Strategy

- **Summarize status of postclosure safety case**
- **Identify principal factors**
- **Describe the strategy for the updated postclosure safety case**
  - **Performance assessment**
  - **Safety margin and defense-in-depth**
  - **Treatment of potentially disruptive processes and events**
  - **Natural analogues**
  - **Performance confirmation**
- **Provide plans to update technical basis to support that updated safety case**

Revisions to the Repository Safety Strategy



Evolving Technical Basis

- **Because of the iterative nature of strategy development, the RSS is periodically revised**
- **Here we will discuss Revision 3 of the RSS**

Status of Postclosure Safety Case in Revision 3 of the RSS

- **Safety case updated from VA because of**
  - **Increased site and materials knowledge**
  - **Changed regulatory framework**
  - **Enhanced repository design**
    - **Modified thermal management approach**
    - **More robust waste package**
    - **Drip shield for defense-in-depth**
    - **Backfill**
  - **Conducted preliminary TSPA and Barriers Importance Analyses for the enhanced design**

Status of Postclosure Safety Case in Revision 3 of the RSS

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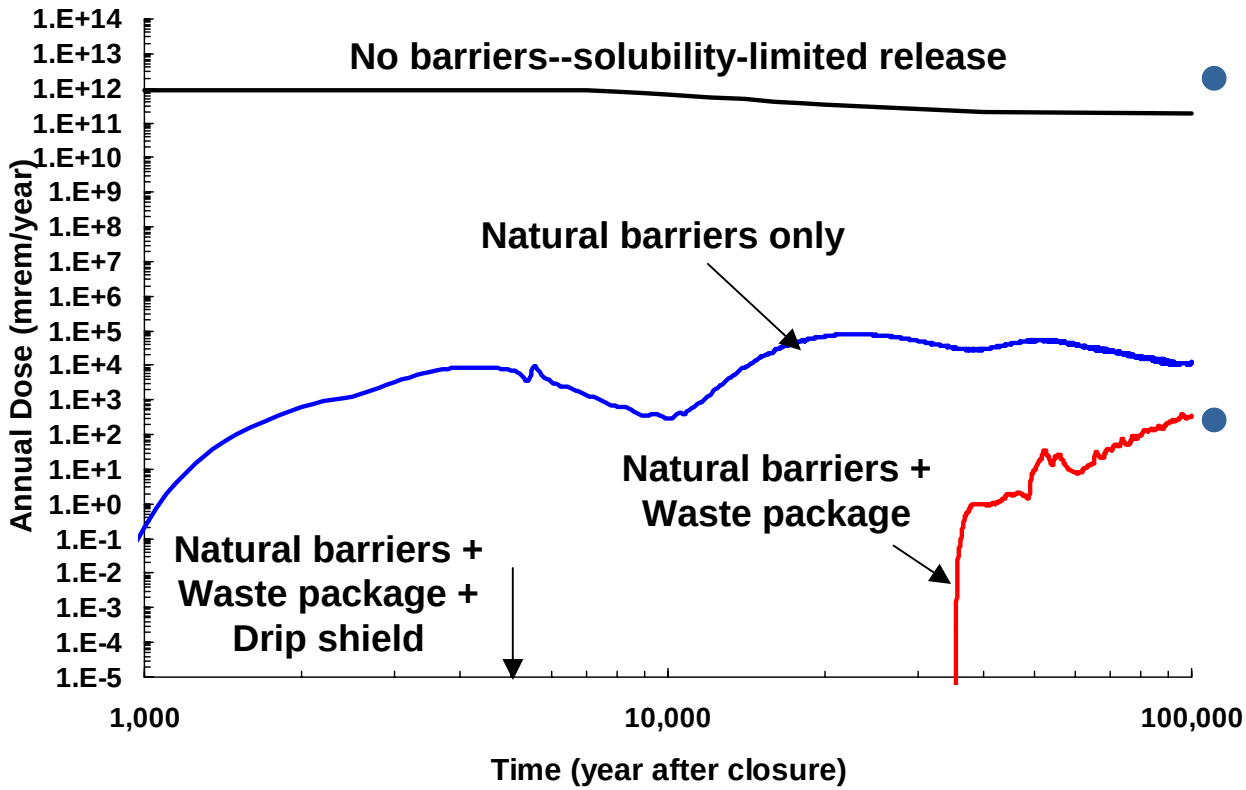


- **Calculations using preliminary models**
- **Deterministic, only mean values of parameters**

Status of Postclosure Safety Case in Revision 3 of the RSS

(Continued)

- Natural barriers effective--reduce estimated dose rate by orders of magnitude
- Remaining dose rate due to small number of relatively mobile radionuclides
- Effective waste package and drip shield are utilized to address this residual
  - Base case gives zero release for at least 10,000 years
  - Neutralization of all barriers except waste package and drip shield also give zero release--other barriers unimportant or are backed up by remaining barriers
- System utilizes multiple natural and engineered barriers to ensure postclosure safety

Principal Factors in Revision 3 of RSS

- **Quantitative analyses--Preliminary Barriers Importance Analyses for two scenarios**
  - **Nominal scenario--barriers perform as expected**
  - **Early waste package failure scenario to examine importance of factors for unanticipated conditions**
- **Broad review by Principal Investigators and Performance Assessment personnel to ensure consideration of:**
  - **General review of uncertainties and limitations of preliminary analyses**
  - **Assessment of current confidence in representation of the factors**
  - **Information needed to address current issues and possible appropriate simplifications of the safety case**

Principal Factors in Revision 3 of RSS

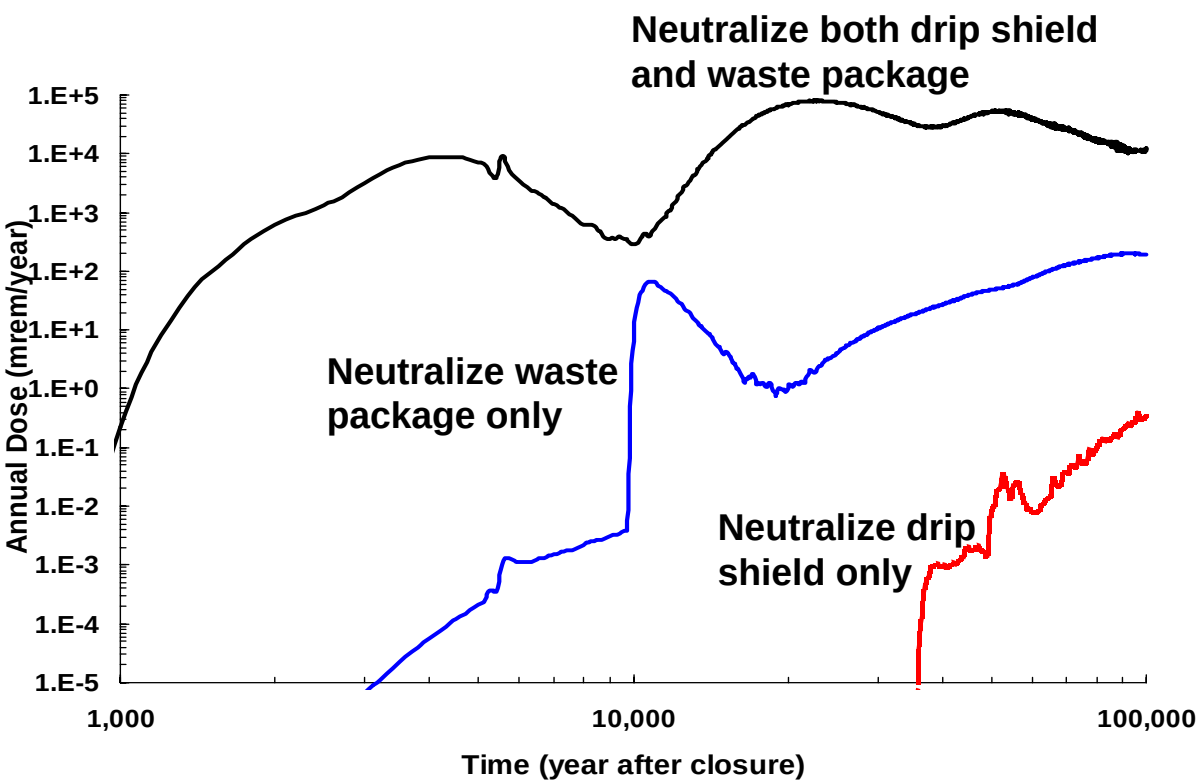
(Continued)

Key Attributes	Factors for Enhanced System Design
Water Contacting Waste Package	Climate
	Net infiltration into the mountain
	UZ flow above repository
	Seepage into drifts
	Coupled processes - effects on UZ flow
	Coupled processes - effects on seepage
	Environments on drip shield
	Performance of drip shield
Waste Package Lifetime	Environments on waste package
	Performance of waste package barriers
Radionuclide Mobilization and Release from the Engineered Barrier System	Environments within waste package
	CSNF waste form performance performance
	DSNF, Navy fuel, Pu disposition waste form performance
	DHLW glass waste form performance
	Solubility limits of dissolved radionuclide
	Colloid-associated radionuclide concentrations
	In-package radionuclide transport
	Transport through the drift invert
Transport Away from the Engineered Barrier System	Advective pathways in the UZ
	Retardation of radionuclide migration in UZ
	Colloid-facilitated transport in the UZ
	Coupled processes--effects on UZ transport
	Advective pathways in SZ
	Retardation of radionuclide migration in SZ
	Colloid-facilitated transport in SZ
	Dilution of radionuclide concentration in UZ and SZ
	Biosphere transport and uptake

Principal Factors

- Seepage into Emplacement Drifts
- Performance of the Drip Shield
- Performance of Waste Package Barriers
- Solubility Limits of Dissolved Radionuclides
- Retardation of Radionuclide Migration in UZ
- Retardation of Radionuclide Migration in SZ
- Dilution of Radionuclide Concentrations in UZ and SZ

Example of Principal Factor in Revision 3: Drip Shield Performance



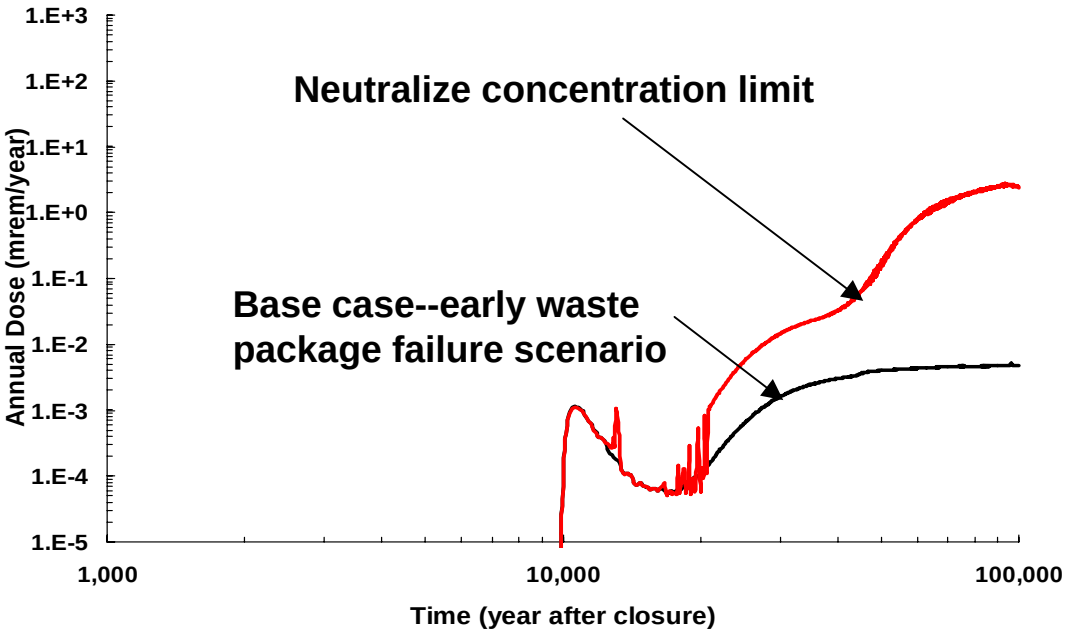
- **Neutralization analyses do not estimate expected performance, but only indicate reliance on barriers**
- **Drip shield appears to be important in preventing undue reliance on waste package alone**

Example of Principal Factor in Revision 3: Drip Shield Performance

(Continued)

- **Under expected conditions, the waste package lasts more than 100,000 years**
- **However, the drip shield provides defense-in-depth to prevent undue reliance on the waste package**
- **A drip shield design appears to be feasible--a number of corrosion resistant materials and concepts are available**
- **Drip shield concept appears to be testable demonstrable through prototype testing**

Example of Principal Factor in Revision 3: Seepage into Drifts



- **Concentration limits are potentially important after waste package failure**
- **Concentration limits depend on seepage, radionuclide solubility limits, dilution**
- **These factors are especially important for the case of early failure of waste package**

Example of Principal Factor in Revision 3: Seepage into Drifts

(Continued)

- **Under expected conditions, waste package lasts more than 100,000 years - - life time estimates show little dependence on the amount of seepage**
- **However, in the event of an early failure of waste packages, seepage can enter, dissolve waste, and transport radionuclides away from the waste package**
- **Current estimates of this scenario do not show dose rates exceeding proposed standards**
- **Never the less, seepage is still important because there are uncertainties in these estimates**

Expected Approach for SR Safety Case in Revision 3 of RSS

- **Performance Assessment**
  - **Will give estimates of expected performance and variances for nominal, igneous activity, and human intrusion scenarios**
  - **TSPA sensitivity and importance analysis will be conducted**
  - **Principal factors will be finalized for SR**
- **Safety Margin and Defense-in-Depth**
  - **Expect substantial margin and defense-in-depth in SR design**
  - **Will have considered additional design enhancements**
    - **Possible changes to thermal management strategy**
    - **Backfill strategy**
    - **Drip shield design (material, thickness, configuration)**
    - **Drip shield concept (Richards barrier, other measures)**
  - **Will have evaluated benefits of seepage threshold, SZ retardation**

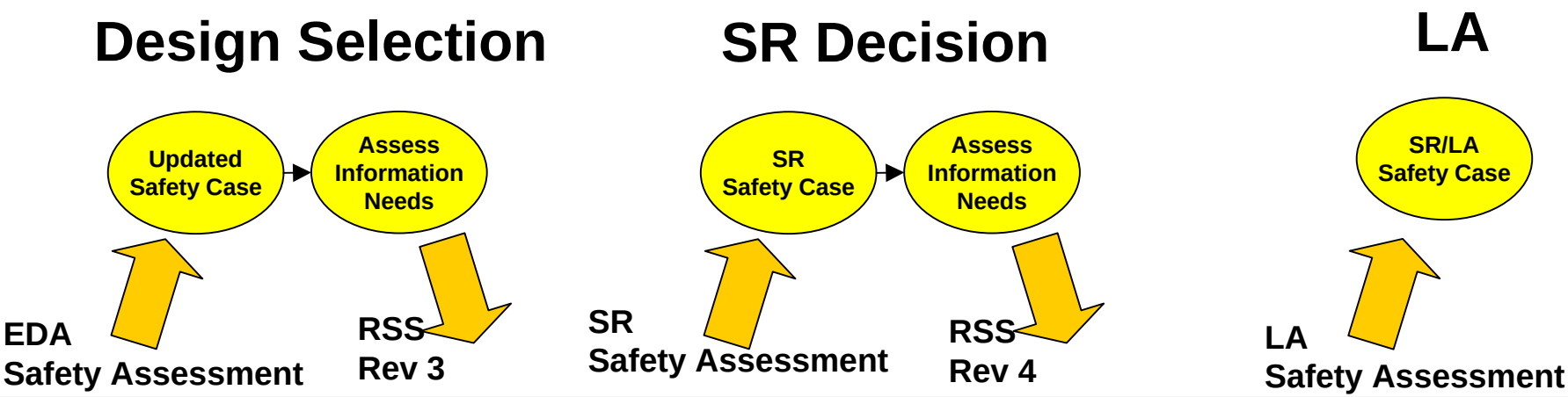
Expected Approach for SR Safety Case in Revision 3 of RSS

(Continued)

- **Potentially Disruptive Processes and Events**
  - **TSPA will explicitly address unanticipated early failure of EBS, igneous activity, and human intrusion**
  - **Other FEPs will be discussed**
    - **Water table rise**
    - **Seismic activity**
    - **Waste-generated changes (including criticality)**
    - **Drift collapse**
- **Natural Analogues**
  - **Existing information will be compiled**
  - **Areas for future examination will be identified**
- **Performance Confirmation Plan**
  - **Summary plan for principal factors will be completed**

Evolution in the Repository Safety Strategy

- **In the event the site is recommended, modification of the RSS would be considered**
- **The update would consider the results of TSPA-SR and appropriate simplifications in the safety case**



Evolving Technical Basis