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Albuquerque, New Mexico 87185

July 30, 1987

Dr. Daniel Galson
Repository Projects Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Dear Dr. Galson:

Accompanying this letter is a copy of the interim report for the licensing assesment methodology (LAM). The first part of this report represents a first attempt at approaching the LAM from the direction of breaking-down the components of a performance assessment into elements and subelements with the intent of tracking their status. No attempt was made to standardize the format of the tables.

The second part of this report contains a listing of the computer codes incorporated into or being considered for the LAM. A scheme for tracking the codes is included.

A third part lists the statements of work (SOWs) currently on file here. Most of the active SOWs need to be updated, especially for program manager, principal investigators, and work period.

I would appreciate receiving any suggestions for additions, deletions, or other changes that your or other NRC personnel recommend.

Sincerely,

Robert V. Guzowski

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Waste Management Systems
Division 6416

Enclosure

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At a future date, the NRC will receive from the DOE an application for a license to construct a repository for the disposal of high-level radioactive waste (HLW). The content of the application is designated in the NRC regulation 10 CFR Part 60. An examination of the required application content indicates either explicitly or implicitly that a complete performance assessment (PA) of the site must be done. A license-assessment methodology (LAM) is being developed to make certain that the tools and techniques necessary to evaluate the license application are available to the NRC when needed.

The LAM should have the tools and techniques to fulfill the following regulatory needs:
1. the capability to evaluate DOE's Safety Analysis Reports (SARs) in order to assess compliance with 10 CFR Part 60 and 40 CFR Part 191 (release to the accessible environment),
2. the capability to assess DOE's demonstration that HLW packages will comply with long-term radionuclide containment requirements as defirned in 10 CFR Part 60,
3. the capability to assess DOE's demonstration that the engineered facility and waste package will comply with release-rate criteria of 10 CFR Part 60,
4. the capability to identify and assess uncertainties pertaining to the performance and assessment of performance of a geologic repository,
5. the capability to assess the rik from preclosure operations as a HLW repository,
6. the capability to develop and screen scenarios for candidate repository sites,
7. the capability of assessing probabilities of potentially disruptive events and processes, and
8. the capability of determining the ground-water travel time from the engineered facility to the accessible environment.

The LAM requires the capability of assessing all the components of a PA. To accomplish this, a scheme for tracking the status of each component of a PA and for determining whether the finished products are suitable and compatible is necessary. The following scheme is recommended:
a. determination of the components of a PA,
b. NRC to decide which components of a PA will be handled independently from DOE and which will consist of a review of DOE work,
c. review each component to determine all of the elements for all candidate media that constitute each component [overlap of elements between two or more components will occur],
d. NRC to determine which elements will be handled independently of the DOE and which will consist of a review of DOE work [independent includes experimentation and/or code development],
e. develop a means of tracking the status, accountability, and quality of the work done on the elements of each component,
f. identify where computer codes need to be used,

g. develop a means of tracking the status, accountability, and documentation of each code [both NRC developed and those adopted from other sources],
h. for codes in sequence, determine if the output and format of the output from one code are appropriate for the inupt into the next code,
i. review all documents and reports for adequate treatment of the topics, data, assumptions, etc. [earlier work may not be adequate in light of more recent developments], and
j. summarize existing documents and reports [many are out of print and summaries will provide an overview of previous work to new personnel].

Figure 1 illustrates the components of a PA and their assumed interrelationship for this part of the project. A dot in the upper right-hand corner of a component box indicates that the component has been broken-down into elements and subelements. Tables 1 through 11 are a break-down of the individual components. The reasoning used for this step of the LAM is that in order to determine what is important in a process, all of the details must be recognized before any simplifying assumptions can be made.

The data needed will depend on how the data will be used. By listing what data are required for the various components, a check can be made to determine whether the appropriate data are being collected by the DOE. This consideration is particularly important because the computer codes to be used by the NRC are not necessarily going to be the same as those used by the DOE. As a result, the data needs may be different.

Once the components are broken down, a scheme to track the status of each element and subelement is needed. A scheme for the components is listed in Table 12. This scheme keeps track of who made what decisions when and hopefully why, and who is or will be working in what areas and when completion of particular products is expected.

A tracking scheme (Table 13) was developed to note where computer codes need to be used and to monitor how this need has been, is being, or will be addressed. In addition, the scheme keeps track of the compatability of codes in a series. Table 14 is a preliminary list of computer codes associated with several components of the PA. Some of the codes are established parts of the methodology, whereas others have been identified as dealing with a certain aspect of PA and need to be evaluated as to their usefulness.

To determine what work has been completed and what work is in progress so that the tracking schemes can be implemented, statements of work (SOWs) primarily from the NRC, were collected. Table 15 lists the SOWs by FIN and indicates as much of the preliminary information as was obtainable from the available copies. The tasks that were or are to be completed under each SOW have not been determined and summarized at this time.

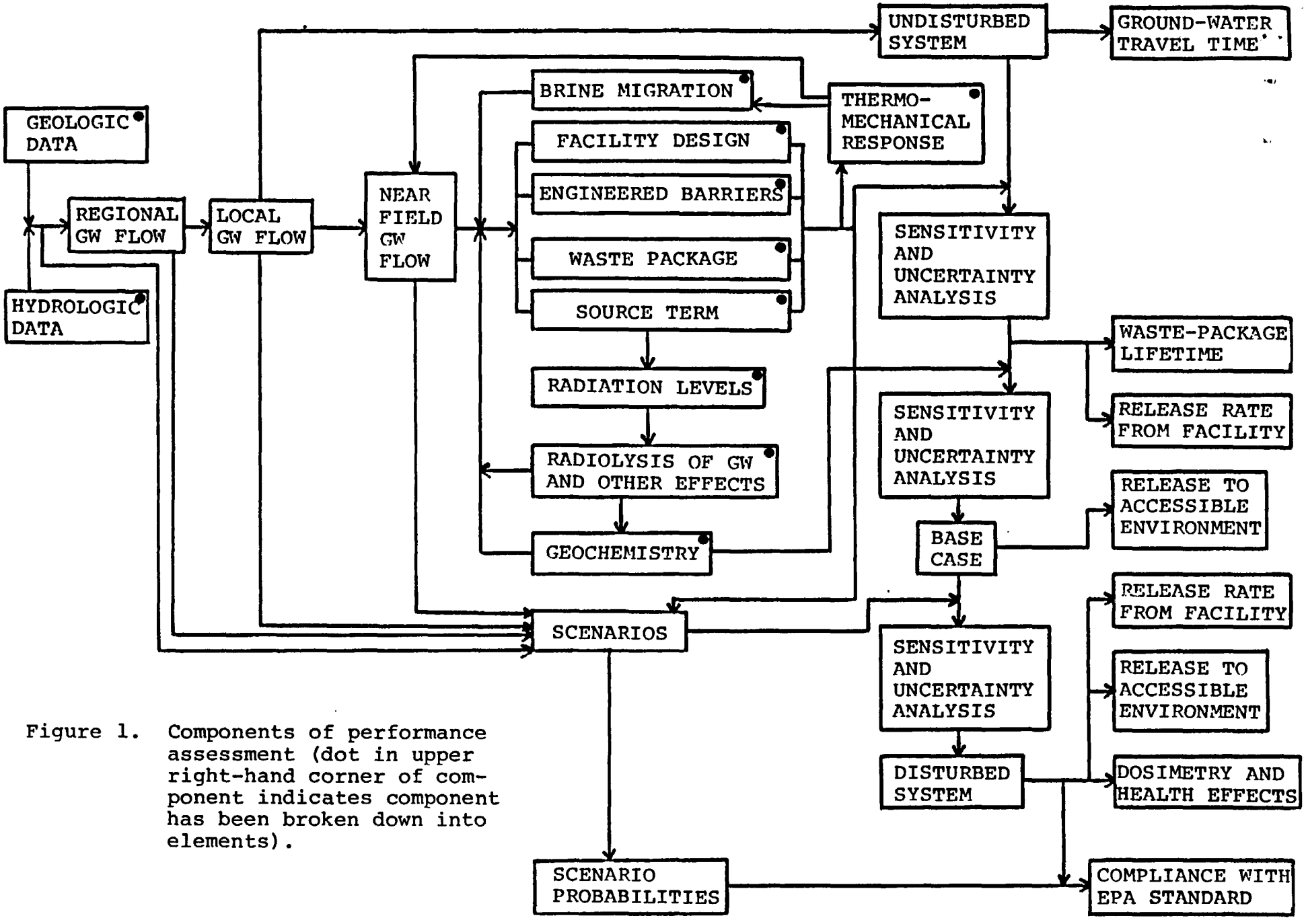

Figure 1. Components of performance assessment (dot in upper right-hand corner of component indicates component has been broken down into elements).

Table 1. Elements of Geologic Data component.

GEOLOGIC DATA

- Stratigraphy
  - Regional scale
    - thickness of each unit and lateral variations
    - depth to contacts
  - Local scale
    - thickness of each unit and lateral variations
    - depth to contacts of units
    - depth to contacts of subdivisions of units
    - thickness of subdivisions of units
  - Mineralogy of each unit
    - lateral variations
    - vertical variations
  - Rock properties of each unit and subunit
    - density
    - porosity
      - total matrix
      - effective matrix
      - total fracture
      - effective fracture
    - fracture characteristics
      - density
      - orientation
      - aperture
      - composition of fracture-fill material
    - mechanical characteristics
      - thermal conductivity
      - specific heat
      - thermal diffusivity
      - thermal expansion
    - mechanical characteristics
      - compressive strength
      - tensile strength
      - elastic constants
      - values as function of temperature and pressure
    - variations of properties as function of:
      - temperature
      - pressure
      - combined pressure and temperature
      - mineralogy
      - location within unit
  - Structure
    - folds
      - location
      - orientation
      - type
      - amplitude
      - history (age(s) of deformation)
      - associated fractures
        - density
        - orientation

- aperture
- Faults
  - location
  - orientation
  - type
  - amount of displacement
  - width of fault zone
  - porosity of fault zone
  - history (age(s) of movement on fault)
  - associated fractures
    - density
    - orientation
    - aperture
    - composition of fracture-fill material
- Regional stability
  - type of movement (uplift or subsidence or both)
  - amount of movement
  - history (age(s) of movement)
- Geomorphic processes (each process could be listed separately)
  - type of process
  - rate of change
  - history of process
  - variations with time
- Seismicity
  - locations of epicenters
    - regional scale
    - local scale
  - frequencey of occurrence
  - magnitude
  - amount of displacement
  - displacement as function of magnitude
- Volcanism
  - location of volcanic centers and features
  - dimensions of volcanic centers and features
  - type of volcanic activity
  - volumes of material erupted from each center
  - history of each center
  - history of each type of volcanic activity
  - relationship of centers and features to other structures
- Natural resources
  - type (metallic, nonmetallic, energy, water)
  - locations of each type
  - origin/age of each location or type of resource
  - history of exploitation
  - potential resources

Table 2. Elements of hydrologic-data component.

- Meteorology
  - amount and type of precipitation
  - distribution of types throughout the year
  - amount of runoff
  - amount of evapotranspiration
  - soil/rock type at surface
  - types of vegetation at site and recharge areas
  - paleoclimate, especially pluvial conditions or glacial maximum
  - recharge, both annual and distributed through year
- Pumping/irrigation
  - location of wells
  - amount of water
  - amount distributed through time
- River/stream elevations
- Rock types/units along streams and rivers
- Location of drill holes
- Head data for hydrologic units in each drill hole
- Potentiometric maps for each hydrologic unit
- Porosity of rock types/hydrologic units
- Hydraulic conductivity
  - for matrix of each unit and subunit
  - for fractures in each unit and subunit
  - horizontal and vertical
  - lateral variations
  - vertical variations
  - parallel to faults
  - across faults
  - vertical through folds
  - across folds
  - along folds
- Degree of saturation
  - by hydrologic units
    - lateral variations
    - vertical variations
  - by rock type
    - lateral variations
    - vertical variations

Table 3. Elements of source-term component (radioactive waste assumed to be spent fuel).

Composition of fuel initially used in reactors
History of fuel in reactors
to include types of reactors, power level, burn-up, flux
Age of fuel removed from reactors (by percent or fraction of total inventory to be placed in repository)
Age of fuel placed into canisters
Initial composition of waste in canisters
Change in composition with time (curies and/or grams)
Thermal history of waste after emplacement
Intensity of various types of radiation as function of time

Table 4. Elements of radiation component.

Composition of waste
Intensities of types of radiation for intact canister (based on time since emplacement)
- as a function of distance from source
  - in canister
  - in overpack
  - in host rock
- canister composition
- overpack composition
- water content of overpack
- composition of water in overpack
- rock properties of host rock
- water content of host rock
- composition of water in host rock

Intensities of types of radiation for ruptured canister (based on time since emplacement)
- time of rupture after emplacement
- extent of rupture
- distance from source
  - in canister
  - in overpack
  - in host rock
- canister composition
- overpack composition and density
- water content of overpack
- composition of water in overpack
- rock properties of host rock
- water content of host rock
- composition of water in host rock

Effect of radiation on:
- integrity of pellets
- internal frame
- overpack
- host rock
- water in overpack
- water in host rock

Additional inventory because of irradiation of above

Table 5. Elements of facility-design component.

Depth to facility
Aerial extent of facility
Shafts (including ramps)
- number of shafts
- location of each shaft
- diameter of each shaft
- depth of each shaft
- technique used to emplace shafts
- drilling fluid composition (if used)
- size of casing (section length, thickness)
- composition of casing
- composition of welds
- location of cement emplacement to secure casing
- composition of cement
- thickness of cement
- thermomechanical properties of cement

Drill Holes
- number of holes
- location of each hole
- diameter of each hole (includes change with drilling depth)
- depth of each hole
- drilling technique
- drilling fluid composition
- location of cased interval
- size of casing (section length, thickness)
- composition of casing
- composition of welds
- location of cement used to secure casing
- composition of cement
- thermomechanical properties of cement

Rooms
- number of rooms
- dimensions of rooms
- shape of rooms
- direction of long axis
- mining technique(s)
- types and distribution of roof supports
- distance between rooms
- extraction ratio

Access Drifts
- location relative to rooms, shafts, and drill holes
- shape
- dirction of long axis
- mining technique
- types and distribution of roof supports
- extraction ratio when included with rooms

Emplacement Holes
- orientation (horizontal or vertical)
- diameter
- depth
- spacing between centers of holes
- number of canisters per room

drilling technique
composition of drilling fluid

Table 6. Elements of waste-package component

Composition of: waste
frame supporting fuel rods
canister
overpack
host rock

Composition and Chemistry of: water in overpack
water in host rock

Radiation and thermal history of waste

Effect of radiation on: integrity of pellets
internal frame
overpack
host rock
water in overpack
water in host rock

Additional inventory because of irradiation

Effect of temperature on: fuel pellets
internal frame
canister
overpack
host rock
water chemistry in overpack
water chemistry in host rock
movement of water near canister
physical state of water near canister
movement of gaseous phases near canister

Construction criteria for canister

In-situ stresses

In-site temperature

In-situ pore pressure

Strsses resulting from swelling of and/or chemical changes in overpack

Effect of overpack swelling and/or chemical changes on surrounding rock and canister

Behavior of overpack to water

Hydrologic properties of overpack (fuction of temperature, pressure, saturation, chemistry)

Hydrologic properties of rock (function of temperature, pressure, saturation, chemistry)

Reactivity of: pellets and frame
pellets and canister
canister and overpack
overpack and host rock
pellets and water
frame and water
canister and water
overpack and water

(each of the above as a funtion of temperature and water chemistry)

Effect of clay coating in protecting canisters

Table 7. Elements of engineered-barriers component.

<u>Drill Holes And Shafts</u>
Diameter of hole
Drilling technique
Composition of drilling fluid
Casing: composition
thickness
composition of cement
location of cement
composition of rock that cement in contact with
reactivity of cement and rock
reactivity of cement and casing
reactivity of cement and ground water
reactivity of casing and ground water
Seal: location in hole
length
composition
hydraulic conductivity
porosity
wetting history
composition of rock in contact with
hydraulic conductivity of rock
porosity of rock
fracure density of rock
fracture aperture
hydraulic conductivity of fractures
fracture porosity
Reactivity of seal and rock
Reactivity of seal and ground water
Quality of contact between seal and rock
Quality of contact between seal and casing
Quality of set-up of seal
Reactivity of seal with casing
Shear strength of seal
Compressive strength of seal

<u>Drifts</u>
Design
Composition of components
Dimensions
Type of rock each component in contact with
Reactivity of components with rock
Reactivity of components with ground water
Hydrologic properties of components
Hydrologic properties of surrounding rock
Expected thermal history of drifts
Effect of temperature on thermomechanical properties
Effect of wetting on thermomechanical properties
Effect of wetting on hydraulic properties
Effect of resaturation on stress field
Effect of backfill on water composition
Effect of backfill on ground-water flow

Table 8. Elements of thermomechanical-response components.

- Depth to repository
- Subsurface facility
  - dimensions of rooms
  - spacing of rooms
  - extraction ratio
  - shape of rooms
  - type of excavation techniques
  - type and distribution of roof supports
- Host unit and adjacent units
  - mineral composition with horizontal and vertical variations
  - matrix porosity
    - total
    - effective
  - fractures
    - density
    - orientations
    - apertures
    - amount of fracture fill/porosity
  - mechanical properties (function of pressure, temperature, composition, and saturation)
    - compressive strength
    - shear strength
    - tensile strength
  - thermal properties (fuction of pressure, temperature, composition, and saturation)
    - coefficient of thermal expansion
    - thermal conductivity
    - rock creep
    - effect of temperature on pore pressure
- In-situ conditions
  - stress field as function of depth
  - pore pressure as function of depth
  - geothermal gradient
- Inventory
  - initial composition
  - age at emplacement
  - thermal history
- Backfill
  - composition-initial and as function of temperature and pressure
  - amount of room back filled
  - initial porosity
  - compactability (fuction temperature, pressure, and saturation)
  - hydraulic conductivity (function of temperature and compactability)
  - effect of temperature on pore pressure
  - time to resaturation
  - thermal conductivity
  - coefficient of thermal expansion
- Extent of chimney formation
- Surface uplift because of heat generation
- Effect of openings on stress field (function of temperature, swelling upon resaturation and/or heating of backfill)

Table 9. Elements of brine-migration component.

- Thickness and lateral extent of lothologic units at site
- In-situ temperature field prior to waste emplacement
- Thermal history of waste after emplacement
- Temperature field round repository after waste emplaced (function of time)
- For inclusions
  - range and distribution of diameters
  - volume of inclusions/volume of salt
  - distribution of inclusions in salt
  - shapes of inclusions (relative to size and distribution)
  - composition of fluid in inclusions
  - composition of gas in inclusions
  - volume percent of gas
  - grain size of salt
  - nature of grain boundaries
  - rate of movement and direction
    - function of:
      - thermal gradient
      - actual temperature
      - size of inclusion
      - shape of inclusion
      - volume percent of gas
      - composition of liquid and gas
      - composition of unit [nonsalt grains as obstructions]
  - potential volume of liquid brought into contact with canisters
- For brine pockets
  - range and distribution of pocket volumes
  - shape of pockets
  - spatial distribution of pockets
  - volume percent of gas in pockets
  - rate of movement and direction
    - function of:
      - temperature gradient
      - actual temperature
      - size of pocket
      - shape of pocket
      - volume percent of gas
      - fluid pressure
      - composition of unit [residuals]
  - potential volume of brine brought into contact with canisters

Table 10. Elements of radiolysis component.

Type of waste
Composition of waste
Age of waste when placed into canisters
Age of waste when emplaced in repository
Thermal history of waste, overpack, and host rock
Flux history of waste
Composition of canister
Thickness of canister
Composition of overpack
Thickness of overpack
Composition of host rock
Composition of water in overpack (function of Eh, pH, organic acids, dissolved gases)
Composition of water in host rock (function of Eh, pH, organic acids, dissolved gases)
Expected life of canister
Mode of canister failure
Amount and types of radiation as function of time
For gaseous species (function of temperature, water chemistry, level of irradiation, duration of irradiation, presence or absence of other components, composition of other components)
- production of hydrogen, oxygen, hydrocarbons
- break down of nitrogen
- formation of nitric acid

For aqueous species
- change in inorganic content [differentiate radiolysis from hydrothermal effects]
- change in Eh and pH (function of temperature and water chemistry, esp. methane)

For solids
- formation of organic and inorganic solids
- relationship between polymer formation and amount and duration of irradiation
  - also with presence and composition of components

Reactivity of products of radiolysis with each other and other materials present
Effect of trace metals on the system
- reactivity with radialytic products
- effect on Eh and pH
- effect on hydrogen production
- effect on pydrogen peroxide composition

Sorptivity of polymers [high molecular-weight polymers are not mobile, may sorb]
Effect of radiolytic products on solubility and transport of waste
Effect of irradiation on host rock
- composition of pore water
- gas phase in water
- strength of rock [especially salt]

Effect of irradiation on strength of canister and/or internal supports of fuel rods [brittleness]
Effect of irradiation on the sorptivity of material in overpack [account for mineralogical changes from waste heat]

Table 11. Elements in geochemisty component.

Ground-Water Composition

Water chemistry of each hydrostratigraphic unit
- composition and concentration of dissolved solids
- composition and concentration of dissolved solutions
- Eh
- pH
- presence of humic, fulvic, and other organic acids
- mineral saturation index

Changes in ground-water chemistry because of construction
- Eh
- pH
- composition of host rock
- reactivity of altered ground water with host rock
- composition of backfill
- reactivity of altered ground water with back fill
- composition of overpack
- reactivity of altered ground water with overpack
- composition of water in backfill
- composition of water in overpack

Transport

Time to resaturation
Mechanism of canister failure
Volume of water in contact with spent fuel/time
Degredation of spent fuel/time [surface area available for dissolution]
Reactivity of water with waste
Formation of colloids
Formation of complexes
Migration of gaseous radionuclides
Kd or Rd of overpack (function of pH, Eh,temperature, water chemistry)
Hydraulic properties of badkfill
If upward flow gradient
- hydraulic properties of backfill
- Kd or Rd of backfill (function of pH, Eh, temperature, water chemistry)
- formation of complexes

For each rock type along flow path
- composition
- hydraulic properties of matrix
- fracture density
- composition of fracture fill
- hydraulic properties of fractures
- Kd or Rd of each rock type (function of pH, Eh, temperature, water chemistry)
- Kd or Rd of fracture filling (function of Eh, pH, temperature, water chemistry)
- constrictivity/tortuosity
- matrix diffusion
- effective diffusion coefficient
- exchange capacity

For drill hole and shaft seals
- composition of components
- hydraulic properties-intact and failed (function of age)
- quality of seal
- mode of failure
- Kd or Rd (function of pH, Eh, temperature, water chemistry)

Effect of organic acids
Effect of introduced bacteria

<u>Clay Coating</u>

<u>Humic, Fulvic, And Other Acids</u>

Table 12. Tracking scheme for elements of components of PA.

COMPONENT/SITE

Topic

Subtopic

Status:

1. Not to be considered/not relevant
   a. authorized by/date
   b. documentation

2. To be considered in future
   a. by whom
   b. starting date
   c. NRC program manager

3. Work in progress
   a. by whom
   b. statement of work
   c. completion date
   d. NRC program manager

4. Work completed
   a. by whom
   b. reference
   c. critique of reference/critiquer
   d. recommendations for additional work
   e. summary of reference
   f. NRC program manager during work
   g. current NRC program manager

5. In-progress non-NRC-sponsored work to be used
   a. by whom
   b. statement of work
   c. comments on SOW
   d. completion date
   e. program manager/organization

6. Completed non-NRC-sponsored work to be used
   a. by whom
   b. reference
   c. critique of reference/critiquer
   d. recommendations for additional work
   e. summary of reference
   f. program manager/organization
   g. authorizer to use non-NRC work
   h. documentation for decision
   i. NRC program manager

Table 13. Scheme to track the status of computer codes.

<u>Data</u>

Aspect of component being modeled
Code to be used
    required input parameters/format
    units of input parameters
Previous code in series
    output parameters/format
    units of output parameters
Output/input parameter compatibility
    output parameters satisfy input needs
        documentation
    output parameters do not satisfy input needs
        what input needs are not met
        how are the differences to be resolved
        by whom
        project title/number
        estimated starting date
        estimated completion date
        NRC program manager
        documentation, if any, to date
    format of output parameters same as input format
        documentation
    format of output not same as input format
        differences in format
        how are differences to be resolved
        by whom
        project title/number
        estimated starting date
        estimated completion date
        NRC program manager
        documentation to date
    units of output same as units of input
        documentation
    units of output not same as input units
        parameters that are different
        how are differences to be resolved
        if conversion factors added to either code, what factors
        verification of conversion factors
        by whom
        program title/number
        estimated starting date
        estimated completion date
        NRC program manager
        documentation to date

<u>Code Documentation</u>

Use of code in methodology
Code to be developed
    by whom

- starting date
- completion date
- NRC program manager

Development in progress

- by whom
- statement of work
- completion date
- NRC program manager

Work completed

- by whom
- name of code
- documentation
  - QA for code
    - reference
    - critique of reference
    - summary of document
  - verification of code
    - reference
    - critique of reference
    - recommendations for additional work
    - summary of document
  - validation of code
    - reference
    - critique of reference
    - recommendations for additional work
    - summary of document
  - user's manual
    - reference
    - critique of reference
    - recommendations for additional work
    - summary of document
  - sample problems
    - reference
    - critique of reference
    - recommendations for additional work
    - summary of document

Non-NRC-developed code to be used

- name of code
- developed by whom
- documentation
  - QA for code
    - reference
    - critique of reference
    - recommendations for additional work
    - summary of document
  - verification of code
    - reference
    - critique of reference
    - recommendations for additional work
    - summary of document
  - validation of code
    - reference
    - critique of reference
    - recommendations for additional work

- summary of document
- user's manual
  - reference
  - critique of reference
  - recommendations for additional work
  - summary of document
- sample problems
  - reference
  - critique of reference
  - recommendations for additional work
  - summary of document

Table 14. Computer coded developed or considered for LAM.

REGIONAL SCALE

SWIFT-2D and 3D ground-water flow, porous media, heat transfer, brine transport, radionuclide transport
SWIFT II-same as SWIFT, but also for fractured media
NEFTRAN-1D flow, porous media, radionuclide transport
USGS 3D-3D ground-water flow, porous media

LOCAL SCALE

<u>saturated zone</u>
SWIFT
SWIFT II
NEFTRAN
USGS 3D
DNET-salt dissolution

<u>unsaturated zone</u> (all codes for porous media; liquid flow both saturated and unsaturated)
TOUGH-1D, 2D, and 3D, liquid and gas flow, heat transfer
NORIAH-1D and 2D, liquid and gas flow, heat transfer
PETROS-1D, liquid and gas flow, heat transfer
WAFE-2D, liquid and gas flow, heat transfer
TRUST-3D, liquid flow
FLUMP-2D, liquid flow
UNFLOW-2D, liquid flow
VERGE-3D, liquid flow
SEGOL-3D,liquid flow, solute transport
TRANSTWO-2D,liquid flow, solute transport
FECTRA-2D, solute transport
UNSAT2-2D, liquid flow
WHC-3D, liquid flow, heat transfer, solute transport
VS2D-2D, liquid flow
SUPERMOCK-2D,liquid flow
MLTRAN-2D, solute transport
TRACR3D-3D, liquid flow, air flow, solute transport
FECWATER-2D, liquid flow
FECWASTE-2D, solute transport
SHAFT 79-3D, liquid flow, water vapor, heat transfer
SAGUARO-2D, liquid flow, heat transfer

NEAR FIELD

not addressed at this time

FACILITY

ORIGIN-radionuclide inventory
BARIER-waste package containment time
NUTRAN-estimated peak, integrated, and cumulative releases at points in engineered and geologic systems

WASTE PACKAGE

TRANSL-linear transport through packing
TRANSO-cylindrical transport through packing
TEMP3D-develops response surface for waste package temperature history
BWIP-canister corrosion
BROOKHAVEN-canister corrosion
PC-statistical model of pitting corrosion
ORIGIN
HEATING5-heat conduction
ADINA-general structural and rock mechanics stress analysis
ADINAT-thermal analysis with ADINA
NIKE-static and dynamic response of 2D solids to deformation
ANISN-W-radionuclide transport
PHREEQE-chemical reactions
EQ3/EQ6-equilibrium models of aqueous geochemical systems
RADIOL-amounts of radiation-produced species in brine solution
PORFLO-flow through porous media
MAGNUM 2D-transient ground-water flow and heat transfer in fractured porous rock
CHAINT-multicomponent radionuclide transport in fractured porous rock
MAKSIMA-CHEMIST-mass action kinetics

THERMOMECHANICAL RESPONSE

Independent

DNET, STEALTH, SWIFT, SWIFT II

Family of Codes

SANCHO, COYOTE, MERLIN, QMESH

Small PC CODES

Thermal Composite-VSRC3D, NTRAN, NTPLT
Stress-BOYLEM, HEFF
Stress Due To Cavity-THERST, THCYLB1

DATA SAMPLING AND ESTIMATION

LHS-sampling from range of data
AKRIP-kriging

Table 15. Preliminary listing of statements of work on hand at SNLA for integration project.

Note: PM=NRC program manager
PI=contractor prinicpal investigator

FIN A0294
TITLE Technical assistance in seismo-tectonic impacts on repositories
PM Michael Blackford (NMSS)
PI _____
CONTRACTOR _____
WORK PERIOD to September 30, 1986

FIN A0367
TITLE Geotechnical, environmental, and radiation field measurement system evaluation: HLW
PM _____
PI _____
CONTRACTOR Lawrence Livermore National Laboratory
WORK PERIOD March 8, 1982 through FY 82 and 83

FIN A1158
TITLE Repository site definition and technology transfer
PM Peter Ornstein (NMSS)
PI _____
CONTRACTOR Sandia National Laboratories
WORK PERIOD FY 85 and 86

FIN A1165
TITLE Technical assistance for performance assessment
PM Leslie Peters (NMSS)
PI _____
CONTRACTOR Sandia National Laboratories
WORK PERIOD FY 85 through 87

FIN A1166
TITLE Maintainance of computer codes
PM Richard Codell (NMSS)
PI _____
CONTRACTOR Sandia National Laboratories
WORK PERIOD through September 30, 1985

FIN A1266
TITLE Development of a methodology for risk assessment of nuclear waste isolation in alternative geologic media
PM Robert Shepard (research)
PI _____
CONTRACTOR Sandia National Laboratories
WORK PERIOD FY 83 through 85

FIN A1755
TITLE Technical assistance for review of coupled thermal-hydrological-mechanical assessment and site characterization activities as proposed sites
PM M. Nataraja (NMSS)
PI N. Ortiz and K. Wahi
CONTRACTOR Sandia National Laboratories
WORK PERIOD October 1, 1983 through September 30, 1986

FIN A1756
TITLE Geochemistry sensitivity analysis
PM Walton Kelley
PI Malcolm Siegel
CONTRACTOR Sandia National Laboratories
WORK PERIOD May 1, 1984 through September 30, 1987

FIN A1757
TITLE Technical assistance in numerical modeling assessment of high-level waste repositories
PM Neil Coleman (NMSS)
PI _____
CONTRACTOR Sandia National Laboratories
WORK PERIOD September 20, 1984 through September 30, 1986

FIN A2254
TITLE A study of natural glass analogues as applied to nuclear waste glass alteration
PM Kyo Kim
PI C. Byers and R. Ewing
CONTRACTOR Argonne National Laboratory
WORK PERIOD July 1, 1984 through June 30, 1987

FIN A 3167
TITLE Review of waste package verification tests
PM (NMSS)
PI _____
CONTRACTOR _____
WORK PERIOD October 1, 1984 through September 30, 1985

FIN A3237
TITLE Container assessment
PM M. McNeil
PI T. Ahn
CONTRACTOR Battelle National Laboratory
WORK PERIOD October 1, 1981 through September 30, 1985

FIN A4167
TITLE Programmatic system studies and analyses
PM Philip Altomare (NMSS)
PI _____
CONTRACTOR Aerospace Corporation
WORK PERIOD 3 years from acceptance; PA signed May 30, 1984, through April 30, 1987(?)

FIN B0289
TITLE Survey of metabolic data appropriate for HLW dosimetry (ICRP-30)
PM Daniel Fehringer (NMSS)
PI _____
CONTRACTOR Oak Ridge National Laboratory
WORK PERIOD effective date until September 30, 1984

FIN B0290
TITLE Laboratory evaluation of DOE radionuclide solubility data and selected retardation parameters, experimental strategies, laboratory techniques and procedures
PM J. W. Bradbury (NMSS)
PI _____
CONTRACTOR _____
WORK PERIOD effective date until October 30, 1986

FIN B0462
TITLE Valence effects on adsorption
PM G. Birchard
PI R. Meyer
CONTRACTOR Oak Ridge National Laboratory
WORK PERIOD June 1 1981 through September 30, 1982; follow on for FY 83?

FIN B1380
TITLE High-level waste preclosure safely systems analysis
PM Norman Eisenberg
PI _____
CONTRACTOR _____
WORK PERIOD FY 83

FIN B3046
TITLE Investigation of coupled interactions in geothermal and hydrothermal systems for the assessment of HLW isolation
PM D. Alexander
PI C. Tsang and P. Witherspoon
CONTRACTOR Lawrence Berkeley National Laboratory
WORK PERIOD August 1, 1983 through July 31, 1986

FIN B4119
TITLE Publication of proceeding for 1984 symposium on "The Scientific Basis For Nuclear Waste Management"
PM Everett Wick (NMSS)
PI _____
CONTRACTOR Materials Research Society
WORK PERIOD effective date of SOW through September 30, 1985

FIN B6627
TITLE Rock mass sealing
PM Jacob Philip
PI Jaak Daemen
CONTRACTOR University of Arizona
WORK PERIOD to May 31, 1985 (or FY 85?)

FIN B6661
TITLE Radionuclide migration around uranium ore bodies: Analogue of radioactive waste repositories
PM G. Birchard
PI P. Airey
CONTRACTOR Australian Atomic Energy Commission
WORK PERIOD (FY 81 through 86) July 1, 1984 through September 30, 1986

FIN B6932
TITLE Support for contiuing activities of the US National Committee For Rock Mechanics
PM Dinesh Gupta
PI _____
CONTRACTOR USNC/RM
WORK PERIOD to September 30, 1986

FIN B6934-0
TITLE Technical assistance for assessment of repository siting and design
PM Peter Hart
PI George Niewiadomski
CONTRACTOR US Bureau of Mines
WORK PERIOD effective date of SOW to October 1, 1981

FIN B6935
TITLE Technical support on siting activities
PM _____
PI _____
CONTRACTOR US Army Corps of Engineers
WORK PERIOD effective date of SOW through September 30, 1982; also FY 83 and 84?

FIN B6985
TITLE Fuel cycle project review
PM _____
PI _____
CONTRACTOR Science Applications, Inc.
WORK PERIOD _____

FIN B7121
TITLE Climates of the Holocene: Methodology for paleoclimate reconstruction
PM Robert Kornasiewicz (research)
PI _____
CONTRACTOR Division of Atmospheric Sciences, National Science Foundation
WORK PERIOD FY 84

FIN B7278
TITLE Effect of manufacturing processes on failure of high-level waste containers
PM M. McNeil (research)
PI _____
CONTRACTOR _____
WORK PERIOD July 1983 through July 1986

FIN B7291
TITLE Unsaturated flow and transport through fractured rock related to high-level waste repositories-phase II
PM T. Nicholson
PI Daniel Evans
CONTRACTOR University of Arizona
WORK PERIOD October 1, 1982 through September 30, 1985

FIN B7328-2
TITLE Technical assistance for design reviews
PM _____
PI _____
CONTRACTOR _____
WORK PERIOD effective date or SOW plus 24 months
WMRG approved March 18,1984

FIN B7330
TITLE Technical assistance in hydrogeology
PM _____
PI _____
CONTRACTOR _____
WORK PERIOD effective date of SOW plus 12 months, option for additional 12 months; WMRG approved March 8, 1984

FIN B8944
TITLE Laboratory studies of thermoconvective phenomena in high-level waste disposal and development of empirical heat transfer correlations for repository licensing
PM John Randall (research)
PI Francis Kulacki
CONTRACTOR University of Delaware
WORK PERIOD December 1, 1983 through November 30, 1986

FIN D1003
TITLE Technical assistance in geophysical methods for site characterization
PM Paul Prestholt
PI _____
CONTRACTOR _____
WORK PERIOD sometime in 1982 through September 30, 1984

FIN D1004
TITLE Technical assistance for in-situ testing
PM _____
PI _____
CONTRACTOR _____
WORK PERIOD WMRG approved March 9, 1984

FIN D1010
TITLE Proposal for support of the continuing activities of the US National Committee on Tunneling Activity
PM _____
PI _____
CONTRACTOR National Academy of Sciences to the US Bureau of Mines
WORK PERIOD January 1 through December 31, 1984

FIN D1014
TITLE Analysis and development of recommendations regarding quality assurance, safety, and reliability
PM _____
PI _____
CONTRACTOR _____
WORK PERIOD about August 8, 1984 through October 31, 1985

FIN D1016
TITLE Technical assistance for design review
PM _____
PI _____
CONTRACTOR David Tiktinsky
WORK PERIOD October 1, 1984 through September 30, 1987

FIN D1018
TITLE Technical assistance in natural resuources assessment
PM Richard Lee
PI _____
CONTRACTOR US Bureau of Mines
WORK PERIOD effective date of SOW through September 30, 1986; WMRG approved June 4, 1984

FIN D1019
TITLE Co-sponsorship financial support of the 17th international congress on "Hydrogeology Of Rock Of Low Permeability"
PM Atef Elzeftawy
PI _____
CONTRACTOR University of Arizona
WORK PERIOD WMRG approved September 21, 1984

FIN D1020
TITLE (review of site data)
PM _____
PI _____
CONTRACTOR _____
WORK PERIOD WMRG approved October 23, 1984

FIN D1021
TITLE (review of site documents, etc.)
PM _____
PI _____
CONTRACTOR _____
WORK PERIOD WMRG approved October 23, 1984

FIN D1146
TITLE Statistics of waste package failure by pitting
PM M. McNeil
PI U. Bertocci
CONTRACTOR National Bureau of Standards
WORK PERIOD July 1, 1984 through August 1, 1986

FIN D1163
TITLE Flow of ground water and transport of contaminants through saturated fractured geologic media from high-level radioactive waste
PM John Randall and F. Doyle (research)
PI _____
CONTRACTOR _____
WORK PERIOD FY 85 through 88

A-1165, Task I
1183.010
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.1	3.3
II. Direct Loaded Labor Costs	1	35
Materials and Services	0	9
ADP Support (computer)	0	0
Subcontracts	5	32
Travel	0	2
G&A	1	8
Other (computer roundoff)	1	1
TOTAL COSTS	8	87

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
$4K*	$125K	$125K	-0-

* Carryover to be used for uncertainty task.

A-1165, Task II
1183.020
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.0	0.8
II. Direct Loaded Labor Costs	1	12
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	1	18
Travel	0	4
G&A	0	3
Other (computer roundoff)	-1	0
TOTAL COSTS	1	37

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
$51K*	$50K	$50K	-0-

* Carry over to be used for uncertainty task.

A-1165, Task III
1183.030
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.5	3.4*
II. Direct Loaded Labor Costs	6	36
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	-4	-31
Travel	0	1
G&A	0	0
Other (computer roundoff)	0	1
TOTAL COSTS	2	7

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
-0-	$150K	$150K	-0-

* Corrected for year

A-1165, Task IV
1183.040
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year -to- Date
I.	Direct Manpower (man-months of charged effort)	0.0	0.0
II.	Direct Loaded Labor Costs	0	0
	Materials and Services	0	0
	ADP Support (computer)	0	0
	Subcontracts	0	0
	Travel	0	0
	G&A	0	0
	Other (computer roundoff)	0	0
	TOTAL COSTS	0	0

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
-0-*	-0-	$138K**	-0-

* funding is carryover from all tasks for FY86
** $138K carryover from FY86 will fund project in FY88

A-1165, Task V
1183.050
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year -to- Date
I.	Direct Manpower (man-months of charged effort)	0.0	0.0
II.	Direct Loaded Labor Costs	0	0
	Materials and Services	0	0
	ADP Support (computer)	0	0
	Subcontracts	0	0
	Travel	0	0
	G&A	0	0
	Other (computer roundoff)	0	0
	TOTAL COSTS	0	0

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
-0-	-0-	-0-	-0-

A-1165, Task VI
1183.060
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.3	1.4
II. Direct Loaded Labor Costs	5	18
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	0
Travel	1	2
G&A	1	2
Other (computer roundoff)	0	2
TOTAL COSTS	7	24

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
$8K*	$50K	$50K	-0-

* Carryover to be used for uncertainty task.

A-1165
Total for 1183.010, 1183.020, 1183.030, 1183.040, 1183.050 and 1183.060.
July 1987

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.4	8.9**
II. Direct Loaded Labor Costs	13	101
Materials and Services	0	9
ADP Support (computer)	0	0
Subcontracts	2	19
Travel	1	9
G&A	2	13
Other (computer roundoff)	0	4
TOTAL COSTS	18	155

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
$138K	$513K*	$375	-0-

* Includes $138K for uncertainty task.
** Corrected for year