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8.5 MILESTONES, DECISION POINTS, AND SCHEDULE

This section presents the major milestones, decision points, and summary schedule information established for the site characterization program for the Yucca Mountain site through the submittal of the license application to the Nuclear Regulatory Commission (NRC). The overall schedule information presented in this section is consistent with the Draft Mission Plan Amendment (DOE, 1988a). This information represents a summary of the schedule information provided in Section 8.3, which includes the sequencing, interrelationships, and durations of the studies and activities described in each site investigation and performance assessment or design information need. Schedule information is presented in calendar years.

Section 8.5.1 presents summary schedule information related to the site programs described in Section 8.3.1. An exploratory shaft schedule showing the durations and sequencing of construction- and testing-related activities is included, as well as a schedule for surface-based drilling and testing. Section 8.5.2 presents summary schedule, information for preclosure and postclosure performance assessment issues. Summary schedule information for both preclosure and postclosure repository design issues and for the seal design issue are presented in Section 8.5.3. Section 8.5.4 presents summary schedule information associated with waste package design issues while Section 8.5.5 provides a list of the major decision points and presents a simplified flow diagram showing the interfaces among these decision points. Section 8.5.6 presents a summary schedule for the program elements covered in Sections 8.5.1 through 8.5.4.

The points shown on the summary schedules presented in Sections 8.5.1 through 8.5.4 represent major events or important summary milestones associated with the investigations or information needs presented in Section 8.3. The summary schedule in Section 8.5.6 presents major integration products from the activities presented in Sections 8.5.1 through 8.5.4. Regulatory and institutional milestones have been added, as appropriate, to augment the schedule.

The information provided in this section should be viewed as a snapshot in time with regard to planned site characterization activities and the schedule for those activities. Schedules will be reevaluated and updated as the site characterization program proceeds. Schedule changes will be reported, as appropriate, in semiannual progress reports.

8.5.1 SITE CHARACTERIZATION ACTIVITIES AND MILESTONES

The site programs described in Section 8.3.1 do not directly tie to regulatory requirements in the same manner as do the performance and design issues. Instead, site programs have been structured to address acquisition of data on present and expected site characteristics, processes, and events needed to develop site descriptions and to support the resolution of design and performance issues. The performance and design issues were derived from the regulations, thus providing an indirect tie from the site programs to the regulations. The issue resolution strategies discussed in Sections 8.3.2 through 8.3.5 identified the site data required to support the resolution of

the design and performance issues that are tied directly to the NRC (10 CFR Part 60) and other regulatory requirements. This includes data required to support an evaluation of the DOE general siting guidelines (10 CFR Part 960). On the basis of these strategies, the site testing program has been designed to obtain sufficient data to satisfy these requirements.

The following section, 8.5.1.1, provides summary schedule information associated with the site program. A schedule showing the durations and sequencing of major exploratory shaft construction- and testing-related activities is provided in Section 8.5.1.2. Section 8.5.1.3 presents the surface-based drilling and testing schedule. Site characterization study plans are listed in Section 8.5.1.4. Study plans will contain schedule information to supplement that presented in the SCP.

8.5.1.1 Site programs

Summary schedule information for those site programs containing one or more investigations described in Section 8.3.1 is provided in this section. The schedule information presented in the figures that follow has been grouped by site program as follows:

- 1. Geohydrology (8.3.1.2).
- 2. Geochemistry (8.3.1.3).
- 3. Rock characteristics (8.3.1.4).
- 4. Climate (8.3.1.5).
- 5. Erosion (8.3.1.6).
- 6. Postclosure tectonics (8.3.1.8).
- 7. Human interference (8.3.1.9).
- 8. Meteorology (8.3.1.12).
- 9. Offsite installations and operations (8.3.1.13).
- 10. Surface characteristics (8.3.1.14).
- 11. Thermal and mechanical rock properties (8.3.1.15).
- 12. Preclosure hydrology (8.3.1.16).
- 13. Preclosure tectonics (8.3.1.17).

Each investigation within the site program is represented on the summary schedule. The investigation number and brief description are shown as well as major events associated with each investigation. A major event for purposes of these schedules may represent the initiation or completion of an activity, completion or submittal of a report to the DOE, an important data feed, or a decision point. It should be noted that preliminary data meeting applicable quality assurance requirements (Section 8.6) will be available before report availability. Solid lines on the schedules represent investigation durations and dashed lines show interfaces among investigations, as well as data transferred into or out of the site program. The schedules assume continuous integration among activities with only major ties shown. It should also be noted that final reporting may continue into the confirmatory test phase. Candidates for confirmatory testing that have already been identified are shown on the schedules. The rationale for tests continuing as performance confirmation is provided in Section 8.3.5.16.

Geohydrology program (Section 8.3.1.2)

Summary schedule information for the geohydrology program is presented in Figure 8.5-1. The results of studies in this program will be used in the resolution of Issues 1.1 and 1.6 (total system performance and pre-wasteemplacement ground-water travel time, respectively). The activities in this investigation will proceed in parallel with the activities necessary to resolve performance and design issues.

The major events shown on the schedule in Figure 8.5-1 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
А	Draft report available to DOE on the conceptual model of the saturated zone at Yucca Mountain	8/90
В	Draft report available to DOE on the evaluation of steep hydraulic gradients near Yucca Mountain	8/92
С	Draft report available to DOE on regional potentiometric level	3/93
D	Draft report available to DOE on ground-water discharge in the Amargosa Desert	6/93
E	Report available to DOE on the estimate of ground-water recharge at Fortymile Wash	2/94
F	Complete three-dimensional porous equivalent flow model of the saturated zone at Yucca Mountain	10/94
G	Draft report available to DOE on the preliminary evaluation of unsaturated-zone modeling	5/90
Н	Draft of preliminary report on gaseous-phase flow through the unsaturated zone at Yucca Mountain available to DOE	10/91
I	Draft report available to DOE on the summary of unsaturated-zone hydrologic modeling	2/92



Figure 8.5-1. Summary schedule information for the geohydrology program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Major event	Event description	Date
J	Draft report available to DOE on the preliminary evaluation of unsaturated-zone hydrology	1/93
ĸ	Draft report available to DOE on the preliminary evaluation of unsaturated-zone hydrochemistry	4/93
L	Draft report available to DOE on the hydrochemical characterization of the upper part of the saturated zone within the site area	10/93
М	Report available to DOE on the preliminary description of the saturated zone	11/93
N	Report available to DOE on application of fracture network models for the saturated zone to UE25c tests	9/94
0	Complete conceptual model of the saturated zone	1/95

Geochemistry program (Section 8.3.1.3)

Summary schedule information for the geochemistry program is presented in Figure 8.5-2. The results of studies in this program will be used in the resolution of Issue 1.1 (total system performance). The geochemical retardation that can be relied upon in the rock units between the repository and the accessible environment is one component of the strategy for meeting the release limits specified in the regulations. The activities in this investigation will proceed in parallel with activities supporting resolution of the performance and design issues.

The major events shown on the schedule in Figure 8.5-2 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
A	Interim report on modeling of water chemistry of the saturated zone available to DOE	12/91
В	Report available to DOE on modeling of unsaturated-zone water chemistry	7/94



Figure 8.5-2. Summary schedule information for the geochemistry program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 1 of 2)

1988 1989 1990 1991 1992 1993 1994 1995 DE IS START ES-1 CONSTRUCTION INVESTIGATION (CONTINUED) data on Hater BEGIN Chemistry (8.3, 1.3, 1) DRILLING 8.3.1.3.5 RADIONUCL.IDE H U.W X.Y Z PRECIPITATION Updated FU2/5 Final Code Requirements E03/6 Code 8.3.1.3.6 RADIONUCLIDE AA' 88 EE FF DISPERSION. to Total System DIFFUSION AND Performance (Issue 1.1) ADVECTION 8.3.1.3.7 RADIONUCLIDE GG II JJ KK HH. LL MM RETARDATION to Cation Scrption INVESTIGATIONS Models (8.3.1.3.4.3.1) 8.3.1.3.8 GASEOUS NN 00 RADIONUCLIDE RETARDATION

Figure 8.5-2. Summary schedule information for the geochemistry program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 2 of 2)

Major <u>event</u>	Event description	Date	
С	Report on modeling of ground-water geochemistry available to DOE; report feeds final ground- water chemistry model	12/94	
D	Complete analysis of alteration history of surface fracture deposits; draft report available to DOE on alteration and fracture mineralogy	9/90	
Е	Draft report available to DOE on the petrographic stratigraphy and lateral variation within the Topopah Spring Member	4/93	
F	Complete fracture mineralogy model develop- ment	11/93	
G	Final report on the history of chemical alteration at Yucca Mountain available to DOE	4/94	
Н	Complete three-dimensional pathways model	4/94	
I	Final report on the rating of alternative models for three-dimensional mineralogy available to DOE	12/94	
J	Complete model for analcime thermodynamics	8/89	
K	Draft report available to DOE on natural analogs	8/90	
L	Draft report available to DOE on the kinetics of cristobalite/quartz transition as a function of pH	2/92	
М	Report available to DOE on the conceptual model of mineral evolution	8/94	
N	Draft report available to DOE on sorption measurements with known oxidation states of plutonium	8/89	
0	Draft of final report on microbiological activity and its influence on sorption available to DOE; report feeds final sorption report	4/92	
P	Draft of final report on actinide batch sorption available to DOE	6/92	

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Major event	Event description	Date
Q	Draft of final report on sorption modeling available to DOE; report feeds final sorption report	1/93
R	Final report on the effects of ground-water composition on sorption available to DOE; report feeds final sorption report	2/94
S	Final report on sorption isotherms (deconvo- lution) available to DOE; report feeds final sorption report	10/94
Т	Draft of final report on measured solubilities of Pu, Am, and Np in typical ground-water at Yucca Mountain available to DOE	8/89
ט	Final report on Pu(IV) colloid available to DOE	9/92
v	Draft report on EQ3/6 database of solubil- ity measurements available to DOE	7/93
W	Draft report on solubility measurements available to DOE; begin final report on solubility	7/93
x	Report on the results of speciation meas- urements available to DOE; report feeds final report on solubility	9/94
Y	Complete solubility calculations for elements on the EPA critical list; data feeds final report on solubility	9/94
Z	Final report on colloid formation and sta- bility of Np, Pu, and Am available to DOE; input to final report on solubility	9/94
AA	Preliminary report on retardation by diffu- sion in saturated tuff slab available to DOE	9/89
BB	Draft report on the transport of radio- nuclides by fracture flow under satu- rated conditions available to DOE	9/90

Major event	Event description	Date
сс	Draft of summary report on the kinetics of sorption available to DOE; report feeds summary report on retardation by diffusion, dispersion, and advective processes	4/93
DD	Draft reports available to DOE on the results of fractured tuff column experiments and on unsaturated flow column experiments; reports feeds summary report on retardation by diffusion, dispersion, and advective processes	6/93
EE	Summary report on filtration of radionuclides available to DOE; report feeds summary report on retardation by diffusion, dispersion, and advective processes	6/94
FF	Final report on retardation by diffusion available to DOE; report feeds summary report on retardation by diffusion, dispersion, and advective processes	9/94
GG	Draft report available to DOE on the evaluation and recommendation for field tests, laboratory block tests, Caisson tests, natural analog work, and Nevada Test Site nuclide migration work	9/89
НН	Draft report available to DOE on the results of the retardation sensitivity analysis	10/90
II	Final field test results available to DOE	6/92
JJ	Draft of final report on coupled phenomena available to DOE	9/92
KK	Draft of final report on the geochemical transport code available to DOE	11/92
LL	Complete revised integrated transport calculations; begin final validation of transport models	6/93

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Major <u>event</u>	Event description	Date
MM	Final report on the results of retardation sensitivity analysis available to DOE; report feeds final geochemical/geophysical model and report on effectiveness of geochemical barrier	4/94
NN	Draft report on results of the calculated gas transport rate assessment available to DOE	9/90
00	Draft report available to DOE on the results of experimental measurements of gaseous transport rates and retardation rates	3/92

Rock characteristics program (Section 8.3.1.4)

Summary schedule information for the rock characteristics program is presented in Figure 8.5-3. The results of studies in this program will be used to develop an integrated drilling program for the Yucca Mountain site, to better define the geologic framework of the site, and to produce a three-dimensional rock characteristics model for the site. This information will be useful in the resolution of a number of performance and design issues, including Issues 1.1 (total system performance), 1.6 (pre-wasteemplacement ground-water travel time), and 1.11 (configuration of underground facilities).

The major events shown on the schedule in Figure 8.5-3 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
А	Draft report available to DOE on the preliminary site geologic description	8/92
В	Complete compilation of structural and stratigraphic information from geologic drillholes	12/92
с	Draft of report on preliminary geophysics available to DOE; continue surface-based and borehole geophysical surveys and petrophysical properties testing	7/93



Figure 8.5-3. Summary schedule information for the rock characteristics program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available

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Major <u>event</u>	Event description	Date
D	Complete collection of test data for characterization of structural features	4/94
Е	Begin preparation of the final report on borehole evaluation of faults and fractures	1/95
F	Complete performance assessment-based systematic drilling program	7/92
G	Reference model for three-dimensional rock characteristics available to DOE; model feeds final three-dimensional model	7/93

Climate program (Section 8.3.1.5)

Summary schedule information for the climate program is presented in Figure 8.5-4. The results of studies in this program will be used to support the resolution of Issue 1.1 (total system performance). Potential changes in climatic conditions will be considered in the evaluation of the cumulative radionuclide release over the next 10,000 yr.

The major events shown on the schedule in Figure 8.5-4 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Final surface deposits map of the Yucca Mountain region available to DOE	5/91
В	Draft of final report on the eolian history of Yucca Mountain available to DOE	5/91
С	Draft report on the simulation of future climates available to DOE	11/92
D	Draft report available to DOE on characterization of the present regional climate and environment	3/93



Figure 8.5-4. Summary schedule information for the climate program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Major event	Event description	Date
E .	Report on the Quaternary climate of Yucca Mountain available to DOE	12/94
F	Draft report summarizing modern flooding events available to DOE; report feeds to report on prediction of future flooding and debris movement	8/91
G	Final report on the evaluation of past discharge areas available to DOE	2/94

Erosion program (Section 8.3.1.6)

Summary schedule information for the erosion program is presented in Figure 8.5-5. Studies in this program will document the predicted impacts of erosion on the performance of a repository at Yucca Mountain. A series of topical reports are planned to demonstrate that the overall impacts of erosion at the Yucca Mountain site are likely to be insignificant.

The major events shown on the schedule in Figure 8.5-5 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Draft report/map available to DOE on the geomorphology of Yucca Mountain	8/92
В	Draft report available to DOE on the analysis of hillslope erosion	8/92
С	Begin studies to evaluate the impacts of future climate on rates of erosion	7/93
D	Complete evaluation of the impact of future climatic conditions on locations and rates of erosion	1/95
Ε	Draft report available to DOE on the impact of future uplift/subsidence and faulting on erosion at Yucca Mountain and vicinity	8/92



Figure 8.5-5. Summary schedule information for the erosion program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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event	Event description	Date
F	Information on the evaluation of the impact on future climatic conditions	1/95
	on erosion available for studies on	

the effects of erosion

Postclosure tectonics program (Section 8.3.1.8)

Summary schedule information for the postclosure tectonics program is presented in Figure 8.5-6. The results of studies in this program will be used to support the resolution of a number of performance and design issues, including Issues 1.1 (total system performance), 1.8 (NRC siting criteria), 1.11 (configuration of underground facilities), and 4.4 (preclosure design and technical feasibility). Scenarios resulting from tectonic processes and events will be considered in the evaluation of the cumulative radionuclide releases over 10,000 yr in Issue 1.1.

The major events shown on the schedule in Figure 8.5-6 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Draft reports available to DOE on consequences of hydrovolcanic and strombolian eruptions	9/92
В	Complete preliminary probability estimate of volcanism	6/93
С	Final report on the probability of future volcanic activity available to DOE	10/94
D	Complete calculations on the number of waste packages intersected by a fault	9/90
E	Report on the assessment of waste package rupture due to faulting available to DOE	12/93
F	Report on faulting, recurrence intervals, and probable cumulative offset in 10,000 yr available to DOE	6/93





8.5-18

DECEMBER 1988

Major		
event	Event description	Date
G	Report available to DOE on annual probability of volcanic or igneous events in controlled area	9/93
Н	Reports available to DOE on the effects of igneous activity, folding, uplift, subsidence, faulting, and strain changes on average percolation flux, water-table elevation, and hydrologic properties of the rock mass	11/94
I	Reports available to DOE on the effects of tectonic processes on geochemical changes along faults, mineralogic change due to tectonically induced water-table changes, and fault offset effects on travel pathways	10/94
J	Report available to DOE on the depth of curie isotherm	1/89
К	Report available to DOE on the evaluation of heat flow from existing data	10/90
L	Report available to DOE on age dating of Lathrop Wells, Crater Flats, and Sleeping Butte volcanics	3/92
М	Report available to DOE on the geology and geochemistry of V-series holes	2/94
N	Report available to DOE on age dating of V-series holes	9/94

Human interference program (Section 8.3.1.9)

Summary schedule information for the human interference program is presented in Figure 8.5-7. The results of studies in this program will be used to establish that markers and monuments will remain effective for the time specified in the regulations. The likelihood of human interference related to natural resources will be considered in the calculation of total releases to the accessible environment over 10,000 yr as required for the resolution of Issue 1.1 (total system performance).



Figure 8.5-7. Summary schedule information for the human interference program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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The major events shown on the schedule in Figure 8.5-7 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
А	Report available to DOE synthesizing data on the natural processes that could affect marker survivability	3/94
В	Initiate assessment of geothermal energy potential	5/90
С	Initiate geophysical/geological assess- ment of mineral resources	2/91
D	Draft report available to DOE on the assessment of water resources at Yucca Mountain	4/91
E	Draft report available to DOE on the mineral and energy potential of the site	2/92
F	Draft of final report on the evaluation of natural resource potential at the site available to DOE	8/92
G	Initiate work on the determination of factors contributing to the likelihood of human interference and intrusion at Yucca Mountain	8/92
H	Draft report available to DOE on the potential effects of exploiting ground-water resources proximal to the Yucca Mountain site	12/92
I	Draft report available to DOE on factors contributing to the likelihood of human interference and intrusion at Yucca Mountain	2/93
J	Complete assessment of noncredible human interference	6/93

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Meteorology program (Section 8.3.1.12)

Summary schedule information for the meteorology program is presented in Figure 8.5-8. The results of studies and monitoring performed in this program will be used to support issue resolution of a number of preclosure issues concerned with radiological safety, including Issues 2.1 (public radiological exposures--normal conditions), 2.2 (worker radiological safety--normal conditions), 2.3 (accidental radiological releases), and 2.7 (repository design criteria for radiological safety). The activities in this program will proceed in parallel with the performance and design activities.

The major events shown on the schedule in Figure 8.5-8 and their planned dates of completion are provided in the following table:

event	Event description	Date
A	Draft report available to DOE on regional meteorological conditions	1/90
В	Annual meteorological monitoring data reports available to DOE	6/89 8/89 4/90 4/91 4/92
С	Draft of five-year summary report on meteorological conditions available to DOE	2/93
D	Complete compilation of data on wind flow patterns for use in estimating doses to the public (Issues 2.1 and 2.3)	2/93
E	Draft report available to DOE on extreme weather phenomena and expected recurrence intervals	3/91



Figure 8.5-8. Summary schedule information for the meteorology program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Offsite installations and operations program (Section 8.3.1.13)

Summary schedule information for the offsite installations and operations program is presented in Figure 8.5-9. The results of the activities of this program will be used to support the resolution of a number of preclosure issues concerned with radiological safety requirements, including Issues 2.1 (public radiological exposures--normal conditions), 2.2 (worker radiological safety--normal conditions), 2.3 (accidental radiological releases), 2.5 (higher-level findings--preclosure radiological safety), and 2.7 (repository design criteria for radiological safety). The activities in this program will proceed in parallel with the performance and design activities.

The major events shown on the schedule in Figure 8.5-9 and their planned dates of completion are provided in the following table:

Major		
event	Event description	Date
A	Draft of environment monitoring report 1988 available to DOE	5/89
В	Complete survey and evaluation of nuclear fuel cycle activities	10/89
С	Complete identification of near-site activities (non-nuclear related)	6/90
D	Complete analysis of overflight hazards due to USAF activities	9/89
Έ	Environmental monitoring data summaries available to DOE; environmental monitoring will continue beyond 1995	5/90 5/91 5/92 5/93 5/94
F	Draft of final report on USAF overflight impacts available to DOE	3/91
G	Summary report available to DOE documenting environmental and radiological data	9/92



Figure 8.5-9. Summary schedule information for the offsite installations and operations program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available

Surface characteristics program (Section 8.3.1.14)

Summary schedule information for the surface characteristics program is presented in Figure 8.5-10. The results of the activities completed for this investigation and the studies in Investigation 8.3.1.14.2 will be used in the design and siting of surface repository facilities at the Yucca Mountain site. The principal issue concerned with surface-facility design is Issue 4.4 (preclosure design and technical feasibility). This program will proceed in parallel with the activities supporting resolution of the performance and design issues.

The major events shown on the schedule in Figure 8.5-10 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
Α	Draft report available to DOE on the results of site reconnaissance; begin preliminary exploration	5/91
В	Draft of updated reports on physical properties and index laboratory testing and mechanical and dynamic laboratory properties testing available to DOE	8/91
С	Draft of updated reports on the results of physical and mechanical property field tests and geophysical field measurements available to DOE	8/91
D	Draft report available to DOE on the results of detailed exploration	6/93



Figure 8.5-10. Summary schedule information for the surface characteristics program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Thermal and mechanical rock properties program (Section 8.3.1.15)

Summary schedule information for the thermal and mechanical rock properties program is presented in Figure 8.5-11. The results of studies in this program will be used in the design of the underground repository facilities. Issue 1.11 (configuration of underground facilities) will use the stratigraphic data, the information on geologic structure, and information on thermal and mechanical rock properties to develop appropriate layouts for the underground repository facilities.

The major events shown on the schedule in Figure 8.5-11 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Draft of final report on thermal, mechanical, thermomechanical, and mechanical properties available to DOE	9/91
В	Draft report available to DOE on the effects of variable environmental conditions on the mechanical properties of fractures	7/92
С	Draft of final report on the analysis of spatial variation of thermal and mechanical properties of intact rock available to DOE	5/93
D	Complete rock mechanics data summary	10/93
E	Draft report available to DOE on site ambient thermal conditions	1/92
F	Draft of final report on anelastic strain recovery testing available to DOE	7/92
G	Draft report available to DOE on the results of in situ stress testing	5/93



Figure 8.5-11. Summary schedule information for the thermal and mechanical rock properties program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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Preclosure hydrology program (Section 8.3.1.16)

Summary schedule information for the preclosure hydrology program is presented in Figure 8.5-12. The results of studies in this program will be used to support resolution of Issue 4.4 (preclosure design and technical feasibility). Potential flooding hazards will be considered in the design and placement of surface facilities. This program will provide input to the plans being developed for obtaining the water necessary to support repository-related activities.

The major events shown on the schedule in Figure 8.5-12 and their planned dates of completion are provided in the following table:

event	Event description	Date
A	Draft of summary report on prehistoric flooding available to DOE (report associated with Study 8.3.1.5.2.1.1.)	2/91
В	Compile current information on future flooding and debris transport and begin preparation of final report	12/94
С	Draft report available to DOE on the assessment of wells J-12 and J-13 for repository water supply	6/90
D	Draft report available to DOE on repository-related water supply alternatives	12/91
Е	Draft report available to DOE on the effects of water withdrawals on local flow system	6/92
F	Draft report available to DOE on ground- water conditions within and above potential host rock	11/92



Figure 8.5-12. Summary schedule information for the preclosure hydrology program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Preclosure tectonics program (Section 8.3.1.17)

Summary schedule information for the preclosure tectonics program is presented in Figure 8.5-13. The results of studies in this program will be used to support the resolution of Issue 4.4 (preclosure design and technical feasibility). Designs of the surface and underground facilities will account for all aspects of the seismic hazards recognized at the Yucca Mountain site. Hazards due to volcanic activity and to both vibratory ground motion and surface faulting will be identified through activities in this program. Repository design activities will proceed in parallel with the studies in this program.

The major events shown on the schedule in Figure 8.5-13 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
Α	Draft reports available on potential ash flow thickness and preclosure hazards of volcanism at the site	3/90
В	Draft final report on the potential for faulting at the surface facilities available to DOE	8/92
С	Draft report available to DOE on the potential for displacement on faults that intersect underground facilities	8/92
D	Draft preliminary report on the probabilistic seismic hazards assess- ment available to DOE	8/90
Е	Final ground motion and calibrated site effects model selected	3/92
F	Preliminary deterministic design values available	8/92
G	Relevant earthquake sources identified and earthquake magnitude estimates completed	9/92
Н	Draft report available to DOE on final ground motion design basis and time histories	6/93
I	Surface facilities trench logging completed	12/89



Figure 8.5-13. Summary schedule information for the preclosure tectonics program. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Major event	Event description	Date	``
J	Complete fault studies on north-trending faults (Bow Ridge, Windy Wash, Fatigue Wash, Paintbrush Canyon, Ghost Dance, Solitario Canyon faults) in the site area	6/91	
K	Report available to DOE on contemporary seismicity studies and strong motion recordings at the site	12/91	
L	Complete evaluation of northeast-trending faults (Mine Mountain, Rock Valley, Stagecoach Road, Cane Springs faults)	9/92	
М	Complete intermediate depth seismic reflections surveys at the site	12/92	
N	Final annual report on seismic data available to DOE; continue seismic network monitoring and Yucca Mountain base station network monitoring (geodetic leveling) as performance conformation	12/94	

8.5.1.2 Exploratory shaft

The following table presents a list of major milestones related to the construction of, and testing in, the exploratory shaft (ES). A schedule for these activities is presented in Figure 8.5-14. As with the schedules in the site programs, the information provided in this section should be viewed as a snapshot in time with regard to planned ES activities and the schedule for those activities. The schedule has been included to illustrate the sequence of activities planned and the relationships of the various activities to the construction schedule and to each other. It should be recognized that certain in situ tests will be continued for confirmatory purposes after the license application has been submitted.

Milestone number	Related SCP section	Milestone description	Date
	CONSTRUCT	TION-RELATED ACTIVITIES AND MILESTONES	
M645	8.4.2.3.4	Start exploratory shaft (ES) site preparation	12/88
R013	8.4.2.3.4.2	Start construction of surface facilities	1/89





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Milestone number	Related SCP section	Milestone description	Date
	CONSTRUCTION-RE	LATED ACTIVITIES AND MILESTONES (continued)	
M642	NAa	Issue revised surface Title II design	6/89
M652	8.4.2.3.4.3	Start ES-1 shaft construction	6/89
M647	8.4.2.3.4.3	Start ES-2 shaft construction	6/89
M646	8.4.2.3.4.2	Complete surface facility construction	8/89
M089	8.4.2.3.4.4	Complete ES-1 upper break-out room	4/90
M093	8.4.2.3.4.4	Complete ES-2 main test level breakout room	4/90
M643	8.4.2.3.4.4	Complete ES-2 shaft construction	8/90
T153	8.4.2.3.4.4	Complete ES-1 excavation to main test level	11/90
R569	8.4.2.3.4.4	Complete connection of ES-1 to ES-2	12/90
M654	8.4.2.3.4.4	Complete ES-1 shaft liner and internals	9/91
M655	8.4.2.3.4.4	Complete ES-2 main test level excavation	9/91
R572	NA	Test bed cables terminated	3/92
P750	NA	Complete exploratory shaft facility Title III design	7/92
M656	8.4.2.3.4.4	Complete geologic drifting	12/92
	TESTIN	G-RELATED ACTIVITIES AND MILESTONES	
M612	NA	Start ES construction phase testing	6/89
M675	8.3.1.4.2.2.4	Begin shaft wall mapping	6/89
M693	8.3.1.2.2.2.1	Begin chlorine-36 dating pore water test	6/89
M604	8.3.1.2.2.4.7	Begin perched-water test	8/89
M680	8.3.1.2.2.4.8	Begin hydrochemistry tests	8/89
M681	8.3.1.2.2.4.4	Begin radial borehole tests	8/89

8.5-36

Mileston number	Related e SCP section	Milestone description	Date
	TEST-RELATED	ACTIVITIES AND MILESTONES (continued)	
M686	8.3.1.15.1.5.1	Begin shaft convergence test	3/90
M688	8.3.1.15.1.5.2	Begin demonstration breakout room testing	6/90
M882	8.3.1.2.2.4.5	Begin excavation effects test	6/90
M678	8.3.1.4.2.2.4	Begin drift wall mapping	8/90
P751	NA	Complete construction phase testing	12/90
R570	NA	Start in situ phase testing	12/90
6040	8.3.1.15.1.6.4	Begin thermal stress test	12/90
M602	8.3.1.15.2.1.2	Begin overcore stress experiments	11/91
M689	8.3.1.15.1.5.3	Begin sequential drift mining evaluations	11/91
N601	8.3.1.15.1.6.1	Begin heater experiment in unit TSwl	11/91
M690	8.3.1.15.1.6.3	Begin Yucca Mountain heated block experiment	12/91
M603	8.3.1.15.1.6.2	Begin canister-scale heater experiments	12/91
6044	8.3.1.15.1.6.5	Begin heated room test	12/91
M619	8.3.1.4.2.2.4	Complete shaft wall mapping report	1/92
M696	8.3.1.2.2.5.1	Begin diffusion test	3/92
M620	8.3.1.15.1.5.1	Complete shaft convergence testing data report	4/92
M674	8.3.1.15.1.7.1	Begin plate loading tests	4/92
M698	8.3.1.15.1.7.2	Begin rock mass response experiment	4/92
M624	8.3.1.4.2.2.4	Complete report on drift wall mapping	5/92
M682	8.3.1.2.2.4.1	Begin intact-fracture tests	5/92
M683	8.3.1.2.2.4.3	Begin bulk-permeability tests	5/92

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Milestone number	Related SCP section	Milestone description	Date
	TEST-RELATED	ACTIVITIES AND MILESTONES (continued)	
M699	8.3.4.2.4.4	Begin waste package system test	5/92
M684	8.3.1.2.2.4.2	Begin percolation test	5/92
6042	8.3.1.15.1.6.4	Complete report on thermal stress test	7/92
N602	8.3.1.15.1.6.1	Complete final report on heater exper- iment in unit TSw1	8/92
M609	8.3.1.15.1.5.2	Complete report on demonstration breakout room testing	11/92
M617	8.3.1.2.2.4.8	Complete final report on the results of hydrochemistry tests	11/92
M694	8.3.1.2.2.4.7	Complete report on the results of the perched-water test	2/93
M627	8.3.1.15.1.5.3	Complete sequential drift mining evaluations report	3/93
N600	8.3.1.15.1.7.2	Complete final report on rock mass response experiment	3/93
M648	NA	Provide in situ test data for the draft environmental impact statement (DEIS)	4/93
M687	8.3.1.15.2.1.2	Complete report on overcore stress experiments	5/93
M623	8.3.1.2.2.2.1	Complete chlorine-36 analysis report	7/93
M697	8.3.1.15.1.7.1	Complete final report on plate loading tests	7/93
M631	8.3.1.15.1.6.3	Complete report on the results of the Yucca Mountain heated block experiment	8/93
T081	8.3.1.2.2.4.5	Complete report on the results of the excavations effects test	11/93

Mileston number	Related e SCP section	Milestone description	Date
	TEST-RELATED	ACTIVITIES AND MILESTONES (continued)	
6046	8.3.1.15.1.6.5	Complete report on the results of the heated room test	11/93
M633	8.3.1.2.2.5.1	Complete final report on the results of diffusion tests	11/93
M640	8.3.1.2.2.4.4	Complete report on the results of the radial borehole tests	2/94
T384	NA	Provide in situ test data for the license application (LA)	4/94
M691	8.3.1.15.1.6.2	Complete report on the results of canister-scale heater experiments	6/94

^aNA = not applicable

8.5.1.3 Surface-based drilling and testing

The schedule for planned surface-based drilling and testing, upon which the site program schedules are based, is summarized in Figure 8.5-15. This figure includes a brief description of planned drilling and testing activities as well as major events associated with each activity. The related SCP section numbers under which these activities are discussed in greater detail are also provided on the figure. Solid lines on the schedule represent activity durations and dashed lines show constraints among drilling and testing activities. The events shown on the schedule and their planned dates of completion are provided in Table 8.5-1.

8.5.1.4 Site characterization study plans

Table 8.5-2 provides a list of site characterization study plans that will present details of site-related studies, tests, and analyses and the schedule for those activities as a supplement to the information in this document. Preparation and review of study plans will be staggered depending on when the studies are to commence. The availability of new or updated study plans will be reported in semiannual site characterization progress reports.



Figure 8.5-15. Summary schedule for the surface-based drilling and testing. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 1 of 3)



Figure 8.5-15. Summary schedule for the surface based drilling and testing. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 2 of 3)



Figure 8.5-15. Summary schedule for the surface-based drilling and testing. This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 3 of 3)

Dativitu	Related SCP	Event	Event description	Dato
ACCIVICY	Section	numer	avent description	Date
Unsaturated zone (UZ) drilling and	8.3.1.2.2.3	A	Begin drilling deep unsturated zone (UZ) holes ^a	2/89
Cesting	8.3.1.2.2.3	В	Complete drilling of deep UZ holes	10/90
	8.3.1.2.2.3	С	Instrument drillholes and initiate monitoring	11/90
	8.3.1.2.2.3	D	UZ boreholes testing and monitoring complete ^b	1/95
	8.3.1.2.2.3	Е	Begin drilling new UZ holes and pre- paring existing UZ holes for percola- tion testing and monitoring	8/89
	8.3.1.2.2.3	F	Complete drilling new UZ holes and pre- paring existing UZ holes for percola- tion testing and monitoring	10/90
C-hole complex testing	8.3.1.2.3.1	A	Begin C-hole complex testing	3/89
•	8.3.1.2.3.1	в	Complete C-hole complex testing ^c	3/90
Southern Tracer Complex drilling	8.3.1.2.3.1.6	A	Begin drilling Southern Tracer complex holes	12/90
and testing	8.3.1.2.3.1.6	В	Complete drilling Southern Tracer Complex holes	5/91
	8.3.1.2.3.1.6	С	Complete testing of Southern Tracer Complex holes	3/93

Table 8.5-1. Summary schedule for surface-based drilling and testing (page 1 of 5)

Activity	Related SCP section	Event number	Event description	Date
Solitario Canyon horizontal hole	8.3.1.2.2.3.3	A	Begin drilling Solitario Canyon hole	7/91
drilling	8.3.1.2.2.3.3	. B	Complete drilling Solitario Canyon hole	8/91
Hydrologic drilling and monitoring	8.3.1.2.3.1.1	A	Begin drilling hydrologic test hole for Solitario Canyon fault study	11/90
	8.3.1.2.3.1.1	В	Complete drilling hydrologic test hole	12/90
	8.3.1.2.3.1.1	С	Estimated completion of tests in the hydrologic test hole ^d ; water table monitoring will continue ^e	6/91
Water table drilling	8.3.1.2.3.1.2	A	Begin drilling water table holes	5/89
and testing	8.3.1.2.3.1.2	В	Complete drilling of water table holes	11/89
	8.3.1.2.3.1.2	С	Complete potentiometric measurements in water table holes; potentiometric-level monitoring will continue®	10/92
	8.3.1.2.3.1.2	D	Begin testing existing water table holes	10/89
	8.3.1.2.3.1.2	Е	Complete testing existing water table holes	2/90
Large plot rainfall	8.3.1.2.2.1.1	A	Begin drilling LPRS holes	2/89
simulation (LPRS) study	8.3.1.2.2.1.1	В	Complete drilling LPRS holes	5/89

Table 8.5-1. Summary schedule for surface-based drilling and testing (page 2 of 5)

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Activity	Related SCP section	Event number	Event description	Date
	8.3.1.2.2.1.1	с	Complete testing LPRS holes	9/92
Small plot rainfall	8.3.1.2.2.1.1	A	Begin drilling SPRS holes	5/89
simulation (SPRS) study	8.3.1.2.2.1.1	В	Complete drilling SPRS holes	5/89 ^f
	8.3.1.2.2.1.1	с	Complete testing of SPRS holes	9/92
Neutron moisture logging for Fortymile Wash	8.3.1.2.1.3.3	A	Begin drilling FMN series for neutron moisture logging	5/89
recharge study	8.3.1.2.1.3.3	В	Complete drilling FMN series for neutron moisture logging	6/89
	8.3.1.2.1.3.3	с	Complete Fortymile Wash neutron logging	8/93
Unsaturated zone neutron	8.3.1.2.2.1.2	A	. Begin drilling neutron holes	6/89
moisture logging for infiltration study	8.3.1.2.2.1.2	В	Complete drilling neutron holes	7/89
	8.3.1.2.2.1.2	с	Complete UZ infiltration logging	8/93
Fortymile Wash recharge study	8.3.1.2.1.3.3	A	Begin drilling Fortymile Wash recharge study holes	7/89
	8.3.1.2.1.3.3	В	Complete drilling of Fortymile Wash recharge study holes	9/89
	8.3.1.2.1.3.3	С	Complete testing of Fortymile Wash recharge study holes	9/93

Table 8.5-1. Summary schedule for surface-based drilling and testing (page 3 of 5)

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Activity	Related SCP section	Event number	Event description ,	Date
Geologic hole drilling	8.3.1.4.2.1	A	Begin drilling geologic holes	12/89
and testing	8.3.1.4.2.1	В	Complete drilling geologic holes	10/90
	8.3.1.4.2.1	с	Complete testing of geologic holes	7/94
Systematic drilling program	8.3.1.4.3.1	A	Begin performance assessment-based systematic drilling program	11/90
	8.3.1.4.3.1	В	Complete drilling boreholes of the systematic drilling program	7/92
	8.3.1.4.3.1	С	Complete testing and evaluation of systematic drilling program boreholes	9/93
Volcanic K-Ar drilling	8.3.1.8.5.1.1	A	Begin drilling volcanic holes	11/90
	8.3.1.8.5.1.1	В	Complete drilling volcanic holes	1/91
In situ stress hole	8.3.1.17.4.8.2	A	Begin drilling in situ stress hole	5/91
drilling	8.3.1.17.4.8.2	в	Complete drilling in situ stress hole	5/919
	8.3.1.17.4.8.2	С	Estimated completion of in situ stress hole testing ^d	12/93
Calcite-silica drilling	8.3.1.5.2.1.5	А	Begin Ca-Si drilling	6/89
	8.3.1.5.2.1.5	В	Complete Ca-Si drilling	7/89

Table 8.5-1. Summary schedule for surface-based drilling and testing (page 4 of 5)

Activity	Related SCP section	Event number	Event description	Date
Engineered drilling for repository surface facilities construction	8.3.1.14.2.1	A	Begin drilling exploratory shaft facility (ESF) series of test holes for engineering design assessment	7/89
	8.3.1.14.2.1	В	Complete drilling ESF series of test holes	8/89

*Deep holes are >1500 ft in depth.

^bSite vertical boreholes/UZ boreholes monitoring will be continued beyond January 1995 as performance confirmation.

^cResults of C-hole complex testing will determine whether Southern Tracer Complex test holes are drilled.

^dIn situ stress testing may also be done in the geologic and hydrologic boreholes.

^eSite potentiometric-level monitoring will continue beyond January 1995 as performance confirmation. ^fTotal drilling time for SPRS wells expected to be about three weeks. ^gTotal drilling time for in situ stress hole approximately two weeks.

Study plan number ^a	Study plan title ^b
<u></u>	GEOHYDROLOGY PROGRAM
8.3.1.2.1.1	Characterization of the Meteorology for Regional Hydrology
8.3.1.2.1.2	Characterization of Runoff and Streamflow
8.3.1.2.1.3	Characterization of the Regional Ground-Water Flow System
8.3.1.2.1.4	Regional Hydrologic System Synthesis and Modeling
8.3.1.2.2.1	Characterization of Unsaturated-Zone Infiltration
8.3.1.2.2.2	Water Movement Tracer Tests Using Chloride and Chlorine-36 Measurements of Percolation at Yucca Mountain
8.3.1.2.2.3	Characterization of Percolation in the Unsaturated Zone - Surface-Based Study
8.3.1.2.2.4	Characterization of Yucca Mountain Percolation in the Unsaturated ZoneExploratory Shaft Facility Study
8.3.1.2.2.5	Diffusion Tests in the Exploratory Shaft Facility
8.3.1.2.2.6	Characterization of Gaseous-Phase Movement in the Unsaturated Zone
8.3.1.2.2.7	Hydrochemical Characterization of the Unsaturated Zone
8.3.1.2.2.8	Fluid Flow in Unsaturated, Fractured Rock
8.3.1.2.2.9	Site Unsaturated-Zone Modeling and Synthesis
8.3.1.2.3.1	Characterization of the Site Saturated-Zone Ground-Water Flow System
8.3.1.2.3.2	Characterization of the Saturated-Zone Hydrochemistry
8.3.1.2.3.3	Saturated-Zone Hydrologic System Synthesis and Modeling
	GEOCHEMISTRY PROGRAM
8.3.1.3.1.1	Ground-Water Chemistry Model
8.3.1.3.2.1	Mineralogy, Petrology, and Chemistry of Transport Pathways

Table 8.5-2. Site characterization study plans

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Study plan number ^a	Study plan title ^b
<u></u>	GEOCHEMISTRY PROGRAM (continued)
8.3.1.3.2.2	History of Mineralogic and Geochemical Alteration of Yucca Mountain
8.3.1.3.3.1	Natural Analog of Hydrothermal Systems in Tuff
8.3.1.3.3.2	Kinetics and Thermodynamics of Mineral Evolution
8.3.1.3.3.3	Conceptual Model of Mineral Evolution
8.3.1.3.4.1	Batch Sorption Studies
8.3.1.3.4.2	Biological Sorption and Transport
8.3.1.3.4.3	Development of Sorption Models
8.3.1.3.5.1	Dissolved Species Concentration Limits
8.3.1.3.5.2	Colloid Behavior
8.3.1.3.6.1	Dynamic Transport Column Experiments
8.3.1.3.6.2	Diffusion
8.3.1.3.7.1	Retardation Sensitivity Analysis
8.3.1.3.7.2	Demonstration of Applicability of Laboratory Data to Repository Transport Calculations
8.3.1.3.8.1	Gaseous Radionuclide Transport Calculations and Measurements
	ROCK CHARACTERISTICS PROGRAM (POSTCLOSURE)
8.3.1.4.2.1	Characterization of the Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area
8.3.1.4.2.2	Characterization of the Structural Features Within the Site Area
8.3.1.4.2.3	Three-Dimensional Geologic Model

Study plan number ^a	Study plan title ^b
ROCK	C CHARACTERISTICS PROGRAM (POSTCLOSURE) (continued)
8.3.1.4.3.1	Systematic Acquisition of Site-Specific Subsurface Information
8.3.1.4.3.2	Three-Dimensional Rock Characteristics Models
	CLIMATE PROGRAM
8.3.1.5.1.1	Characterization of Modern Regional Climate
8.3.1.5.1.2	Paleoclimate Study: Lake, Playa, Marsh Deposits
8.3.1.5.1.3	Climatic Implications of Terrestrial Paleoecology
8.3.1.5.1.4	Analysis of the Paleoenvironmental History of the Yucca Mountain Region
8.3.1.5.1.5	Paleoclimate-Paleoenvironmental Synthesis
8.3.1.5.1.6	Characterization of the Future Regional Climate and Environments
8.3.1.5.2.1	Characterization of the Quaternary Regional Hydrology
8.3.1.5.2.2	Characterization of the Future Regional Hydrology due to Climate Changes
	EROSION PROGRAM
8.3.1.6.1.1	Distribution and Characteristics of Present and Past Erosion
8.3.1.6.2.1	Influence of Future Climatic Conditions on Locations and Rates of Erosion
8.3.1.6.3.1	Evaluation of the Effects of Future Tectonic Activity on Erosion at Yucca Mountain
8.3.1.6.4.1	Development of a Topical Report to Address the Effects of Erosion on the Hydrologic, Geochemical, and Rock Characteristics at Yucca Mountain

Study plan number ^a	Study plan title ^b
	TECTONICS PROGRAM (POSTCLOSURE)
8.3.1.8.1.1	Probability of a Volcanic Eruption Penetrating the Repository
8.3.1.8.1.2	Effects of Volcanic Eruption Penetrating the Repository
8.3.1.8.2.1	Analysis of Waste Package Rupture due to Tectonic Processes and Events
8.3.1.8.3.1	Analysis of the Effects of Tectonic Processes and Events on Average Percolation Flux Rates Over the Repository
8.3.1.8.3.2	Analysis of the Effects of Tectonic Processes and Events on Changes in Water-Table Elevation
8.3.1.8.3.3	Analysis of the Effects of Tectonic Processes and Events on Local Fracture Permeability and Effective Porosity
8.3.1.8.4.1	Analysis of the Effects of Tectonic Processes and Events on Rock Geochemical Properties
8.3.1.8.5.1	Characterization of Volcanic Features
8.3.1.8.5.2	Characterization of Igneous Intrusive Features
8.3.1.8.5.3	Investigation of Folds in Miocene and Younger Rocks of the Region
	HUMAN INTERFERENCE PROGRAM
8.3.1.9.1.1	An Evaluation of Natural Processes That Could Affect the Long-Term Survivability of the Surface Marker System at Yucca Mountain
8.3.1.9.2.1	Natural Resource Assessment of Yucca Mountain, Nye County, Nevada
8.3.1.9.2.2	Water Resource Assessment of Yucca Mountain, Nevada
8.3.1.9.3.1	Evaluation of Data Needed to Support an Assessment of the Likelihood of Future Inadvertent Human Intrusion at Yucca Mountain as a Result of Exploration and/or Extraction of Natural Resources

Study plan number ^a	Study plan title ^b
	HUMAN INTERFERENCE PROGRAM (continued)
8.3.1.9.3.2	An Evaluation of the Potential Effects of Exploration for or Extraction of Natural Resources on the Hydrologic Characteristics at Yucca Mountain
	METEOROLOGICAL PROGRAM
8.3.1.12.2.1	Meteorological Data Collection at the Yucca Mountain Site
	SURFACE CHARACTERISTICS PROGRAM
8.3.1.14.2.1	Exploration Program
8.3.1.14.2.2	Laboratory Tests and Material Property Measurements
8.3.1.14.2.3	Field Tests and Characterization Measurements
	ROCK CHARACTERISTICS PROGRAM (PRECLOSURE)
8.3.1.15.1.1	Laboratory Thermal Properties
8.3.1.15.1.2	Laboratory Thermal Expansion Testing
8.3.1.15.1.3	Laboratory Determination of Mechanical Properties of Intact Rock
8.3.1.15.1.4	Laboratory Determination of the Mechanical Properties of Fractures
8.3.1.15.1.5	Excavation Investigations
8.3.1.15.1.6	In Situ Thermomechanical Properties
8.3.1.15.1.7	In Situ Mechanical Properties
8.3.1.15.1.8	In Situ Design Verification
8.3.1.15.2.1	Characterization of the Site Ambient Stress Conditions
8.3.1.15.2.2	Characterization of the Site Ambient Thermal Conditions

Study plan numbera Study plan title^b PRECLOSURE HYDROLOGY PROGRAM 8.3.1.16.1.1 Characterization of Flood Potential of the Yucca Mountain Site 8.3.1.16.2.1 Location of Adequate Water Supply for Construction, Operation, Closure, and Decommissioning of a Mined Geologic Disposal System at Yucca Mountain, Nevada 8.3.1.16.3.1 Determination of Preclosure Hydrologic Conditions of the Unsaturated Zone at Yucca Mountain, Nevada TECTONICS PROGRAM (PRECLOSURE) 8.3.1.17.1.1 Potential for Ash Fall at the Site 8.3.1.17.2.1 Faulting Potential at the Repository 8.3.1.17.3.1 Relevant Earthquake Sources 8.3.1.17.3.2 Underground Nuclear Explosion Sources 8.3.1.17.3.3 Ground Motion from Regional Earthquakes and Underground Nuclear Explosions 8.3.1.17.3.4 Effects of Local Site Geology on Surface and Subsurface Motions 8.3.1.17.3.5 Ground Motion at the Site from Controlling Seismic Events 8.3.1.17.3.6 Probabilistic Seismic Hazards Analyses 8.3.1.17.4.1 Historical and Current Seismicity Location and Recency of Faulting Near Prospective Surface 8.3.1.17.4.2 Facilities 8.3.1.17.4.3 Quaternary Faulting Within 100 km of Yucca Mountain, Including the Walker Lane 8.3.1.17.4.4 Quaternary Faulting Proximal to the Site Within Northeast-Trending Fault Zones 8.3.1.17.4.5 Detachment Faults at or Proximal to Yucca Mountain 8.3.1.17.4.6 Quaternary Faulting Within the Site Area

Table 8.5-2. Site characterization study plans (continued)

8.5-53

Table 8.5-2. Site characterization study plans (continued)

Study plan number ^a	Study plan title ^b	
	TECTONICS PROGRAM (PRECLOSURE) (continued)	
8.3.1.17.4.7	Subsurface Geometry and Concealed Extensions of Quaternary Faults at Yucca Mountain	
8.3.1.17.4.8	Stress Field Within and Proximal to the Site Area	
8.3.1.17.4.9	Tectonic Geomorphology of the Yucca Mountain Region	
8.3.1.17.4.10	Geodetic Leveling	
8.3.1.17.4.11	Characterization of Regional Lateral Crustal Movement	
8.3.1.17.4.12	Tectonic Models and Synthesis	
	SHAFT AND BOREHOLE SEAL CHARACTERISTICS	
8.3.3.2.2.1	Seal Material Properties Development	
	WASTE PACKAGE CHARACTERISTICS	
8.3.4.2.4.1	Characterize Chemical and Mineralogical Changes in the Postemplacement Environment	
8.3.4.2.4.2	Hydrologic Properties of Waste Package Environment	
8.3.4.2.4.3	Mechanical Attributes of the Waste	
8.3.4.2.4.4	Engineered Barrier System Field Tests	

^aStudy plan number corresponds to the SCP section number under which a discussion of the study is provided. ^bStudy plan title corresponds to the appropriate SCP section title.

Study plans are being prepared to be consistent with agreements between the DOE and the NRC. Detailed technical and compliance reviews will be completed by the DOE. Following these reviews, study plans will then be submitted to the NRC for review and to the State for information.

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8.5.2 PERFORMANCE ASSESSMENT ACTIVITIES AND MILESTONES

The elements of performance assessment for a high-level radioactive waste repository can be categorized into calculations covering two distinctly different time periods. The first time period, referred to as the preclosure period, covers the period during repository operation, closure and decommissioning. Calculations must demonstrate compliance with the radiation exposure and radioactive material release limits for the unrestricted area and the exposure limits for repository workers during the period of waste emplacement and until final closure and decommissioning of the repository. The preclosure radiological safety requirements are discussed in Sections 8.3.5.3, 8.3.5.4, and 8.3.5.5. In addition, as required by 10 CFR 60.111, the repository must be designed, constructed, operated, closed, and decommissioned so that the retrieval option will be maintained. This requirement is discussed in Section 8.3.5.2.

The second time period covered by performance assessment calculations is termed the postclosure period, which represents the time following permanent closure of the repository. Calculated releases from the repository must meet the limits specified by the NRC in 10 CFR Part 60. The postclosure performance requirements are summarized in Section 8.3.5.8. Performance requirements apply to the overall geologic repository, the engineered barrier system, the geologic setting (natural barriers), and the waste package.

The following sections provide summary schedule information associated with the performance assessment issues presented in Section 8.3.5. Schedule information for preclosure and postclosure performance assessment is treated separately in Sections 8.5.2.1 and 8.5.2.2, respectively.

8.5.2.1 <u>Preclosure performance assessment</u>

Preclosure performance assessment activities address the requirements for controlling occupational and public radiation exposures specified in 10 CFR Part 20, 10 CFR Part 60, and 40 CFR 191, Subpart A, and the requirement for maintenance of the option to retrieve.

Summary schedules for each preclosure performance assessment issue described in Sections 8.3.5.2 through 8.3.5.5 are provided in this section. Information needs within an issue are represented as appropriate. The information need number and brief description are shown on the schedules, as well as major events associated with each information need. A major event, for purposes of these schedules, may represent the initiation or completion of an activity, completion or submittal of a report to the DOE, an important data feed, or a decision point. It should be noted that preliminary data meeting applicable quality assurance requirements (Section 8.6) will be available prior to report availability. Solid lines on the schedules represent information need durations and dashed lines show interfaces among information needs, as well as data transferred into or out of the issue. The schedules assume continuous integration among activities with only major ties shown.

Waste retrievability (Issue 2.4, Section 8.3.5.2)

Summary schedule information for Issue 2.4 is presented in Figure 8.5-16. The activities described in this issue are those addressing the requirement that the repository design, construction, operation, and maintenance must ensure that any or all of the emplaced waste can be retrieved starting at any time up to 50 yr after waste emplacement operations have begun. Activities planned to support resolution of this issue include design analyses and documentation of retrieval conditions for access to waste emplacement boreholes, access to waste containers, borehole access for waste removal, and for transport of retrieved waste to the surface facilities. Issue 4.4 (preclosure design and technical feasibility) integrates the requirements for maintaining the retrieval option from Issue 2.4 with other constraints on repository design addressed in other issues to produce reference designs.

The major events shown on the schedule in Figure 8.5-16 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Complete compilation of site and design requirements to support retrieval	8/89
В	Complete analysis of site and design data requests	11/89
С	Complete compilation of retrieval conditions	8/90
D	Complete report on site and design and design requirements to support retrieval	8/90
E	Complete compilation of retrieval strategy data required for compliance analysis	6/89
F	Complete retrieval compliance analysis required for advanced conceptual design (ACD)	1/92
G	Complete retrieval compliance analysis required for license application design (LAD)	5/94



Figure 8.5-16. Summary schedule information for the Issue 2.4 (waste retrievability). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Public radiological exposures--normal conditions (Issue 2.1, Section 8.3.5.3)

Summary schedule information for Issue 2.1 is presented in Figure 8.5-17. The activities planned to support resolution of this issue address the requirements that radiation exposure to the general public associated with normal conditions during operation, closure, and decommissioning of the repository meet the requirements in 10 CFR Part 20 and 40 CFR 191, Subpart A. The activities performed under this issue involve repetitive examination of an evolving design to ensure that the final design meets the established criteria.

The major events shown on the schedule in Figure 8.5-17 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
A	Complete development of performance assessment activities for advanced conceptual design (ACD) preclosure radiological safety through the preclosure risk assessment methodol- ogy (PRAM) program; initiate devel- opment of assessment activities for license application design (LAD) pre- closure radiological safety	7/89
B .	Complete assessment of PRAM program for ACD assessment of public safety	2/91
C	Complete ACD assessment of public radio- logical safety using PRAM program method	1/92
D	Complete development of performance assessment activities for LAD preclosure radiological safety through the PRAM program	3/93
E	Start LAD assessment of public radio- logical safety using final PRAM program methods developed	11/93
F	Final site data feed	5/94
G	Complete LAD assessment of public radiological safety using final PRAM program methods developed	8/94



Figure 8.5-17. Summary schedule information for the Issue 2.1 (public radiological exposures normal conditions). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Worker radiological safety--normal conditions (Issue 2,2, Section 8.3.5.4)

Summary schedule information for Issue 2.2 is presented in Figure 8.5-18. The activities performed under this issue will address the requirement that the radiation doses to workers under normal conditions during construction, operation, closure, and decommissioning of the repository will meet the requirements specified in 10 CFR Part 20.

The major events shown on the schedule in Figure 8.5-18 and their planned dates of completion are provided in the following table:

Major	Event description	Data
event	Event description	Date
A	Start advanced conceptual design (ACD) assessment of worker radiological safety during normal operations	12/90
В	Complete ACD assessment of worker radiological safety during normal operations	7/92
С	Start license application design (LAD) assessment of worker radiological safety during normal operations	11/93
D	Final site data feed	6/94
E	Complete LAD assessment of worker radiological safety during normal operations	8/94
F	Complete development of performance assessment activities for worker radiological safety during normal operations through the preclosure risk assessment methodology (PRAM) program	5/91
G	PRAM procedure guide available for LAD assessment of worker radiological safety during normal operations	7/92
Н	Final PRAM procedures available to	9/93



Figure 8.5-18. Summary schedule information for the Issue 2.2 (worker radiological safety normal conditions). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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Accidental radiological releases (Issue 2.3, Section 8.3.5.5)

Summary schedule information for Issue 2.3 is presented in Figure 8.5-19. The activities planned to support resolution of this issue include those necessary to address the requirement that radiation exposure to the general public and repository workers under credible accident conditions during construction, operation, closure and decommissioning must remain at safe levels. The activities to be conducted will demonstrate the adequacy of the structures, systems, and components of the repository to provide for prevention of accidents and mitigation of their consequences. The approach that will be used to protect the health and safety of the general public and repository workers is to provide locations that assist in limiting potential radiation exposure from accidents and provide prevention, containment, and mitigation of accident consequences.

The major events shown on the schedule in Figure 8.5-19 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
A	Complete development of list of credible accident sequences	11/90
В	Complete development of list of credible design-basis accidents	3/91
С	Complete assessment of the development methodologies for credible accident sequences	7/92
D .	Complete assessment of the development methodologies for design-basis accidents	7/92
Е	Complete report on credible accident sequences and their respective frequencies	5/94
F	Complete report on design-basis accidents	8/94
G	Complete credible accident consequence analysis for advanced conceptual design (ACD)	6/91
Н	Complete credible accident sensitivity analysis	6/91
I	Complete documentation of the results of safety analyses for ACD	1/92
J	Initiate documentation of updated credible accident sensitivity analysis	5/93



Figure 8,5-19. Summary schedule information for the Issue 2.3 (accidental radiological releases). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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event	Event description	Date
ĸ	Final report available to DOE on the consequence analysis of credible accidents for license application design (LAD)	7/94
L	Complete documentation of safety analyses for LAD	9/94

8.5.2.2 Postclosure performance assessment

This section presents summary schedule information for each postclosure performance assessment issue described in Sections 8.3.5.9 through 8.3.5.15. The information presented has been grouped by the principal elements of postclosure performance assessment: overall system performance of the geologic repository, performance of the engineered barrier system and the waste packages, and performance of the geologic setting (natural barriers). These elements represent the primary barriers for which the NRC established performance objectives in 10 CFR 60.112 and 60.113.

Overall geologic repository system performance

The requirement for performance of the overall geologic repository system after permanent closure is established in 10 CFR 60.112. This requirement states that the geologic setting shall be selected and the engineered barrier system and the shafts, boreholes, and their seals shall be designed to ensure that releases of radioactive materials to the accessible environment conform to environmental standards for radioactive material release established by the U.S. Environmental Protection Agency (EPA). The EPA has specified limits in 40 CFR 191.13 for total cumulative release of radionuclides over 10,000 yr. Performance assessment calculations will be used to show that releases resulting from both expected conditions and processes and from disturbed conditions and processes will be within the allowable limits.

Engineered barrier system and waste package performance

The engineered barrier system (EBS) is to be designed so that assuming anticipated processes and events releases of radionuclides are gradual, resulting in small fractional releases to the geologic setting over long periods of time. The release rate is specified to be not greater than one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 yr after permanent closure of the repository. The EBS is also to be designed so that containment of high level waste will be substantially complete during the period when radiation and thermal conditions are dominated by fission product decay. The waste package is to be designed to provide substantially complete containment of the high level waste for 300 to 1,000 yr after permanent closure of the geologic repository. The major events associated with the waste package and EBS performance issues

(Sections 8.3.5.9 and 8.3.5.10) represent the results of evaluations of releases from various components of the EBS, and reports that document the performance of the waste package in compliance with the requirements previously specified.

Performance of the geologic setting

The performance requirements specified by the NRC in 10 CFR 60.113(a)(ii)(B)(2) for the geologic setting state that the geologic repository should be located so that pre-waste-emplacement ground-water travel time (GWTT) along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment will be at least 1,000 yr. Although this regulation addresses the pre-waste-emplacement ground-water travel time, the calculations for ground-water flow (Section 8.3.5.12) are the same ones used to predict radionuclide migration in the total system performance assessment (Section 8.3.5.13). Therefore, the activities and milestones completed for this component of the performance assessment program serve a dual role although they are more focused toward the assessment of ground-water travel times.

Summary schedules for the issues associated with the principal elements of postclosure performance assessment are provided in this section. Information needs within an issue are represented as appropriate. The information need number and brief description are shown on the schedule, as well as major events associated with each information need. A major event, for purposes of these schedules, may represent the initiation or completion of an activity, completion or submittal of a report to the DOE, an important data feed, or a decision point. It should be noted that preliminary data meeting applicable quality assurance requirements (Section 8.6) will be available prior to report availability. Solid lines on the schedules represent information need durations and dashed lines show interfaces among information needs, as well as data transferred into or out of the issue. The schedules assume continuous integration among activities with only major ties shown.

Containment by waste package (Issue 1.4, Section 8.3.5.9)

Summary schedule information for Issue 1.4 is presented in Figure 8.5-20. The activities planned to support resolution of this issue include those necessary to determine if the set of waste packages will meet the NRC requirement for substantially complete containment for 300 to 1,000 yr. These activities will produce information that allows prediction of both the degree of containment and the duration of containment. The results derived from activities in this issue provide important input to Issue 1.5 (engineered barrier system release rates) and Issue 1.1 (total system performance).

The major events shown on the schedule in Figure 8.5-20 and their planned dates of completion are provided in the following table:



Figure 8.5-20. Summary schedule information for the Issue 1.4 (containment by waste package). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

	Major event	Event description	Date
	A	Information on waste packages material selected feeds to waste package advanced conceptual design (ACD); information on alternative barriers recommended for further testing feeds to waste package ACD	10/89
	В	Final selection of waste package material and design concept feeds to waste package license application design (LAD)	1/92
	с	Metal barrier material selected	10/89
	D	Initiate license application testing of metal barriers	5/90
	E	Complete testing of alternative barriers; results of testing feed to development and testing of materials models	9/91
	F	Complete metal barrier data acquisition to support draft environmental impact statement (DEIS) performance calculations	9/92
)	G	Complete corrosion modes model studies	11/89
	Н	Complete preliminary metal barrier models	7/91
	I	Provide results of metal barriers testing to waste package performance assessment	10/92
	J	Final report on oxidation and corrosion performance of selected container materials available to DOE	1/94
	K	Begin ensemble and uncertainty analysis for conceptual design following development of uncertainty codes and process models	2/89
	L	Complete performance assessment of waste package ACD	1/92
	М	Complete performance assessment of waste package LAD	1/94
	N	Complete report on LAD ensemble performance for defining source term from waste package	1/95

Engineered barrier system release rates (Issue 1.5, Section 8.3.5.10)

Summary schedule information for Issue 1.5 is presented in Figure 8.5-21. The activities conducted under this issue will support an evaluation of compliance with the requirements of the NRC that the engineered barrier system should limit the release rate of any radionuclide after the containment period so that no greater than one part in 100,000 of the 1,000 yr inventory of that nuclide shall be released per year. The activities that will be performed under this issue include waste form testing, waste package performance assessment, and scenario analysis to provide near-field radionuclide source terms to Issue 1.1 (total system performance).

The major events shown on the schedule in Figure 8.5-21 and their planned dates of completion are provided in the following table:

Major		` .	
event	Event description	Date	
A	Draft report available to DOE on West Valley glass waste form qualification; begin accumulation of spent fuel and glass waste form data	3/89	
В	Compile current spent fuel, glass waste form, and waste package and repository design information for use in modeling activities	5/93 8/93	
С	Initiate dissolution testing of oxidized spent fuel	10/88	
D	Complete spent fuel waste form testing for advanced conceptual design (ACD)	6/90	
E	Complete West Valley glass waste form testing for design	8/91	
F	Draft of final report on oxidation rates and and mechanisms for spent fuel available to DOE	11/91	
G	Complete long-term confirmation dissolution tests on glass waste forms	8/93	
Н	Complete documentation of spent fuel waste form testing	12/93	
I	EQ3/6 code release	3/90	
J	Final EQ3/6 code release to DOE	7/92	
K	Finalize deterministic waste package code for license application design (LAD)	10/93	,



Figure 8.5-21. Summary schedule information for the Issue 1.5 (engineered barrier system release rates). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

8.5-69

DECEMBER 1988

Major <u>event</u>	Event description	Date
L	Complete integration of scenarios	8/93
М	Complete modeling of long-term expected performance of spent fuel waste forms under repository conditions	8/93
N	Complete modeling of long-term performance of glass waste forms under repository conditions	9/93
0	Complete documentation of waste package assessment codes	8/94
P	Complete documentation of the verification and validation of waste package assessment codes	1/95
Q	Complete performance assessment of waste package ACD	1/92
R	Complete assessment of ACD ensemble performance against regulatory criteria using uncertainty models	10/92
S	Complete performance assessment of waste package LAD	1/94
T	Complete analysis of LAD ensemble performance using uncertainty models and analysis of LAD ensemble performance for defining source term from the waste package	10/94
U	Complete report on LAD ensemble performance for defining source term from the waste package	1/95
v	Complete investigation of materials inter- actions among engineered barrier system (EBS) components	1/92
W	Complete model for integrated testing of waste forms with ground water and container materials	12/92
x	Complete documentation of radionuclide transport models and results of integrated testing	1/94

Ground-water travel time (Issue 1.6, Section 8.3.5.12)

Summary schedule information for Issue 1.6 is presented in Figure 8.5-22. The activities planned to support resolution of this issue are those required to determine if the pre-waste-emplacement ground-water travel time from the disturbed zone to the accessible environment will be at least 1,000 yr. Because a repository at the Yucca Mountain site would be situated in the unsaturated zone, many of the activities are focused on understanding the dynamics and mechanisms of flow under unsaturated conditions. The NRC regulation responsible for this issue requires that the travel time be calculated along the fastest path of likely radionuclide travel, resulting in some activities to identify the fastest path. This issue also requires a definition of the starting point for the travel-time calculation, i.e., the disturbed zone. Activities necessary to identify the disturbed zone are also included under this issue.

The major events shown on the schedule in Figure 8.5-22 and their planned dates of completion are provided in the following table:

Major <u>Event</u>	Event Description	Date
A	Draft report available to DOE on COVE 3 benchmarking	12/88
В	Draft report available to DOE on the results of preliminary lab studies for validation of the unsaturated zone flow model	2/89
С	Begin final update/validation of non- isothermal flow models	1/93
D	Complete certification of computer codes for the calculation of ground-water travel time (GWTT)	7/93
Ε	Complete code development	8/93
F	Final information on the validation and verification of models available for final update of GWTT calculations	1/94
G	Information on initial analysis of flow paths available for GWTT calculations	2/89
H	Update of flow path analysis available for updating GWTT calculations	5/91
I	Final results of flow path analysis available for final update of GWTT calculations	1/94


Figure 8.5-22. Summary schedule information for the Issue 1.6 (ground-water travel time). This network is consistent with the Draft Mission Plan Amendment (DOE. 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

1	Major		
	Event	Event Description	Date
	J	Draft report available to DOE on the ranges of potential GWTT based on current data	1/90
	K	Draft report available to DOE on the ranges of GWTT based on interim site characterization data	7/91
	L	Draft report available to DOE on preliminary calculations of pre-waste-emplacement GWTT to support the draft environmental impact statement	7/92
	M	Complete updating calculations of pre-waste- emplacement GWTT for final environmental impact statement and license application	9/93
	N	Final report on GWTT calculations available to DOE	7/94
	0	Preliminary definition of disturbed zone available for GWTT calculations	11/89
	P	Complete calculation of post-emplacement GWTT using available site data	2/91
	Q	Updated definition of disturbed zone available for GWTT calculations	5/91
	R	Complete update of post-emplacement GWTT calculations	2/92
	S	Draft report available to DOE on the effects of near-field changes on the disturbed zone definition	5/92
	T	Final report on post-emplacement GWTT and definition of the disturbed zone available to DOE	3/94

Total system performance (Issue 1.1, Section 8.3.5.13)

Summary schedule information for Issue 1.1 is presented in Figure 8.5-23. The activities planned to support resolution of this issue are those necessary to address the requirement that total repository system releases over 10,000 yr must comply with the cumulative release limits specified in 40 CFR Part 191. The contribution of radionuclide releases to the accessible environment for the nominal case, as well as for disturbed scenarios, will be determined. This issue relies on Issue 1.6 (pre-wasteemplacement ground-water travel time) for transport models, and Issue 1.5



Figure 8.5-23. Summary schedule information for the Issue 1.1 (total system performance). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

(engineered barrier system releases) for radionuclide source terms. It also draws information from a variety of site programs, such as the climate program (Section 8.3.1.5) and the postclosure tectonics program (Section 8.3.1.8) to establish conditions and processes over the next 10,000 yr at the Yucca Mountain site.

The major events shown on the schedule in Figure 8.5-23 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
A	Description of preliminary scenario classes to be screened against consequences	10/88
В	Complete refinement of potential release- scenario classes based on screening against models; begin refinement based on available site data	3/89
С	Complete refinement of release-scenario classes	11/91
D	Draft report available to DOE on final release-scenario classes for input to the DEIS	12/92
Е	Draft report available to DOE on preliminary system models of gas-phase releases	6/89
F	Draft report available to DOE on preliminary system models of release through water	7/90
G	Updated water- and gas-release models available	12/91
н	Complete final water-release model reflecting site characterization input	3/93
I	Draft report available to DOE on interim screening of release scenario classes	1/91
J	Begin development of simplified, computation- ally efficient models of the final scenario classes	1/91
K	Complete screening to identify final release scenario classes	1/92

Major event	Event description	Date
L	Draft report available to DOE on efficient models to be used in the total system simulations	3/92
М	Complete development/validation of perform- ance assessment codes	12/93
N	Draft report available to DOE on the refined source term model	6/92
0	Complete interim probabilistic analysis of performance of the total system	7/93
P	Updated total system performance assessment calculations available	5/94

Individual protection (Issue 1.2, Section 8.3.5.14)

Summary schedule information for Issue 1.2 is presented in Figure 8.5-24. The activities planned to support resolution of this issue address the EPA requirements limiting the annual dose equivalent from the repository system to any member of the public in the accessible environment following permanent closure. Two transport mechanisms must be considered at the Yucca Mountain site: ground-water transport and gas-phase transport. The activities planned under this issue will determine if any exposure to the public during the 1,000-yr period following permanent closure will meet the limits imposed by the EPA.

The major events shown on the schedule in Figure 8.5-24 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Draft of preliminary report on the evaluation of radionuclide releases and public doses via water and gas pathways available to DOE	8/90
В	Update available to DOE on the evaluation of radionuclide releases and public doses via water and gas pathways	1/93
С	Draft of final report on the evaluation of radionuclide releases and public doses via water and gas pathways available to DOE	10/93



Figure 8.5-24. Summary schedule information for the Issue 1.2 (individual protection). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

8.5-77

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Major event	Event description	Date
D	Report available to DOE on the evaluation of doses to the public through water releases	7/94
E	Report available to DOE on the evaluation of doses to the public through gas-phase releases	7/94

Ground-water protection (Issue 1.3, Section 8.3.5.15)

Summary schedule information for Issue 1.3 is presented in Figure 8.5-25. The activities planned to support resolution of this issue are those necessary to determine if the concentrations of radioactive waste products in special sources of ground-water will meet the limits specified in 40 CFR 191.16. To comply with this requirement, the DOE will determine if special sources of ground water exist in the vicinity of the site. If special sources of ground water are found to be present, the DOE will then determine if the concentrations of radionuclides in any ground-water sources during the first 1,000 yr after disposal will meet the limits.

The major events shown on the schedule in Figure 8.5-25 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
A	Draft report available to DOE on the evaluation of the potential for special sources of ground-water at Yucca Mountain	1/91
В	Complete evaluation of the potential for special sources of ground-water at Yucca Mountain	6/91
С	Interim report available to DOE on the concentration of waste products in special sources of ground-water at Yucca Mountain	4/93
D	Final report on the concentration of waste products in special sources of ground-water at Yucca Mountain available to DOE	3/94





8.5.3 REPOSITORY DESIGN ACTIVITIES AND MILESTONES

The repository design must address regulatory requirements for both the preclosure and postclosure periods. The design must ensure radiological safety, as described in Section 8.5.2.1. For the preclosure period, 10 CFR 60.131-133 specify general design criteria for the geologic repository operations area and additional design criteria for the surface and underground facilities. A DOE requirement (10 CFR Part 960) also specifies that the designs should be feasible on the basis of reasonably available technology. For postclosure, a general criterion for the underground facility requires that the orientation, geometry, layout and depth of the facility, and the design of engineered barriers should contribute to the containment and isolation of radionuclides (10 CFR 60.133(a)(1)). The engineered barriers are also to be designed to assist the geologic setting in meeting the performance objectives. Other postclosure requirements on the repository design specify that it must allow the performance objectives to be met under the predicted postclosure conditions (10 CFR 60.133(h)). Another postclosure requirement placed on the geologic repository operations area, and combined with the repository design schedules for purposes of this section, is the requirement for the development of seals for shafts and boreholes (10 CFR 60.134).

Summary schedules for each preclosure and postclosure repository design issue presented in Sections 8.3.2.2 through 8.3.2.5 and the seal design issue presented in Section 8.3.3.2 are provided in this section. Information needs are represented as appropriate. The information need number and brief description are shown as well as major events associated with each information need. A major event, for purposes of these schedules, may represent the initiation or completion of an activity, completion or submittal of a report to the DOE, an important data feed, or a decision point. It should be noted that preliminary data meeting applicable quality assurance requirements (Section 8.6) will be available prior to report availability. Solid lines on the schedules represent information need durations and dashed lines show interfaces among information needs, as well as data transferred into or out of the issue. The schedules assume continuous integration among activities with only major ties shown.

Configuration of underground facilities (postclosure) (Issue 1.11, Section 8.3.2.2)

Summary schedule information for Issue 1.11 is presented in Figure 8.5-26. The activities planned to support resolution of this issue are those related to aspects of the underground facility design that have implications for the postclosure behavior of the repository. The requirements addressed by the issue state that the underground facility and the engineered barrier system shall contribute to the containment and isolation of radionuclides, incorporate sufficient flexibility to accommodate site specific conditions, and assist the geologic setting in meeting the postclosure performance objectives. Major considerations in addressing the requirements covered by this issue include the potential excavation effects on performance, the rock response to the thermal loads induced by the emplaced waste, and the availability of adequate usable host rock for the underground facility. Data from site programs are required for resolution of this issue,



Figure 8.5-26. Summary schedule information for the Issue 1.11 (configuration of underground facilities - postclosure). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 1 of 3)



Figure 8.5-26. Summary schedule information for the Issue 1.11 (configuration of underground facilities - postclosure). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 2 of 3)



Figure 8.5-26. Summary schedule information for the Issue 1.11 (configuration of underground facilities - postclosure). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 3 of 3)

including information on stratigraphy and structure and on the thermal and mechanical properties of the host rock.

The major events shown on the schedule in Figure 8.5-26 and their planned dates of completion are provided in the following table:

Major event	Event description	Date	
A	Draft report available to the DOE on the reference thermal/mechanical stratigraphy for advanced conceptual design (ACD)	4/89	
В	Draft report available to DOE describing the reference thermal/mechanical stratigraphy of Yucca Mountain for license application design (LAD)	9/91	
С	Draft report available to DOE documenting updated reference thermal/mechanical properties for LAD	9/91	
D	Draft of final report on thermal/mechanical stratigraphy available to DOE	12/93	
E	Complete determination and compilation of waste package information required for underground facility design	1/92	-
F	Updated information on waste package characteristics available for the reference information base	5/93	
G	Final report on compilation of waste package information available to DOE	3/94	
н	Complete preliminary performance comparison of vertical and horizontal emplacement of the waste packages	10/88	
I	Underground facility moisture control plan available to DOE	8/89	
J	Select waste-package emplacement orientation	9/89	
K	Underground facility contingency plan available to DOE	8/90	
L	Complete determination of area needed	12/91	

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)	Major event	Event description	Date
	M	Complete evaluation of usable area and flexibility for LAD	12/91
	N	Draft of final report on the underground facility moisture control plan available to DOE	12/93
	0	Draft of final report on the underground facility contingency plan available to DOE	12/93
	P	Draft report available to DOE on water usage criteria	9/90
	Q	Complete development of preliminary underground facility material inventory criteria	12/90
	R	Draft report available to DOE on expected chemical changes resulting from the use of construction materials	11/91
)	S	Draft of final report on chemical changes from construction materials available to DOE	12/93
	T	Draft of final report on water management criteria available to DOE	12/93
	U	Final report on material inventory criteria available to DOE	1/94
	v	Preliminary subsidence control strategy available	8/90
	W	Draft of final report on excavation methods criteria available to DOE	12/93
	x	Final report on long-term subsidence control strategy available to DOE	4/94
	Y	Draft report available to DOE on the borehole spacing strategy for ACD	7/89
	Z	Complete strategy for underground facility design considerations to enhance containment	7/89
	AA	Complete determination of allowable far-field areal power density for ACD	8/89

Major <u>event</u>	Event description	Date	
BB	Draft report available to DOE on equivalent energy density concept for ACD	9/89	
сс	Complete repository ACD near-field and thermomechanical analysis sensitivity studies	12/90	
DD	Complete determination of allowable far-field areal power density for LAD	2/91	
EE	Complete ACD near-field and far-field reference design analysis calculations	7/91	
FF	Draft reports available to DOE on updated equivalent energy density concept and borehole spacing strategy for LAD	2/92	
GG	Final report on equivalent energy concept available to DOE	1/94	
НН	Complete LAD near-field and far-field thermomechanical analysis sensitivity study	1/94	
II	Complete update of strategy and begin final report on underground facility design considerations to enhance containment	1/94	
JJ	Complete LAD reference design calculations	5/94	
KK	Complete reference postclosure design for ACD	11/90	
LL	Complete reference ACD postclosure design confirmation	7/91	
MM	Draft design analysis report available to DOE on performance assessment of LAD	6/93	
NN	Design analysis report to support the license application available to DOE	8/94	
00	Complete reference LAD postclosure design confirmation	9/94	

Repository design criteria for radiological safety (Issue 2.7, Section 8.3.2.3)

Summary schedule information for Issue 2.7 is presented in Figure 8.5-27. The activities performed under this issue will provide radiological safety design analyses to support resolution of Issue 4.4



Figure 8.5-27. Summary schedule information for the Issue 2.7 (repository design criteria for radiological safety). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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(preclosure design and technical feasibility). Data from a variety of site programs, such as meteorology (Section 8.3.1.12) and preclosure tectonics (8.3.1.17) will be used to determine the site-specific conditions that must be considered in designing a repository facility that will protect the health and safety of repository workers and the public.

The major events shown on the schedule in Figure 8.5-27 and their planned dates of completion are provided in the following table:

Major <u>event</u>	Event description	Date
A	Continue generation of radiological safety requirements	10/88
B	Radiological requirements identified feed to advanced conceptual design (ACD) repository design requirements; continue to generate radiological requirements	11/89
С	Initiate preclosure risk assessment methodology (PRAM) analysis of ACD	12/90
D	Draft report available to the DOE on the results of PRAM analysis of ACD	1/93
E	Start preparation of report on PRAM analysis of license application design (LAD)	12/93
F	Report available to DOE on the results of PRAM analysis of LAD	7/94

Nonradiological health and safety (Issue 4.2, Section 8.3.2.4)

Summary schedule information for Issue 4.2 is presented in Figure 8.5-28. The activities planned to support resolution of this issue are those necessary to demonstrate that repository designs and operating procedures will protect the nonradiological health and safety of repository workers. General areas of concern for nonradiological health and safety include stability of drifts and boreholes, adequate ventilation, and temperatures in the underground facility.

The major events shown on the schedule in Figure 8.5-28 and their planned dates of completion are provided in the following table:



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Figure 8.5-28. Summary schedule information for the Issue 4.2 (nonradiological health and safety). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

Major <u>event</u>	Event description	Date
A	Data on air quality and ventilation activities output to license application design (LAD)	1/90
В	Data on air quality and ventilation activities output to surface facility LAD	4/91
С	Data on access and drift usability studies output to LAD	12/91
D	Data on access and drift usability output to surface facility LAD	3/93
E	Complete design of activities to verify air quality and design	7/93
F	Complete studies to verify access and drift usability	7/94

Preclosure design and technical feasibility (Issue 4.4, Section 8.3.2.5)

Summary schedule information for Issue 4.4 is presented in Figure 8.5-29. The activities supporting resolution of this issue are those necessary to demonstrate that the repository can be designed, constructed, operated, and closed using reasonably available or proven technology. This issue is also the focus for repository design requirements addressed under other issues. Because of this role, the activities performed under this issue must address a variety of design requirements, such as the ability to retrieve the waste, the quantities and types of waste to be emplaced, the waste package designs, the waste handling and emplacement systems, the stability of boreholes, the seismic design of surface facilities, and the mine ventilation systems. Activities under this issue will provide updated designs that meet design criteria, taking into account the various requirements placed on the preclosure repository facilities.

The major events shown on the schedule in Figure 8.5-29 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Complete updating repository design parameters (site data) for advanced conceptual design (ACD) freeze	12/90



Figure 8.5-29. Summary schedule information for the Issue 4.4 (preclosure design and technical feasibility). This network is consistent with the Draft Mission Plan Amendment (DOE. 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 1 of 3)

8.5-91



Figure 8.5-29. Summary schedule information for the Issue 4.4 (preclosure design and technical feasibility) This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 2 of 3)



Figure 8.5-29. Summary schedule information for the Issue 4.4 (preclosure design and technical feasibility). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available. (page 3 of 3)

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Major event	Event description	Date
В	Complete updating of repository design parameters (site data) for start of license application design (LAD)	1/92
С	Complete updating of repository design parameters (site data) for LAD	10/93
D	Waste package/repository design interface at ACD freeze	12/90
E	Waste package/repository interface at LAD freeze	11/93
F	Complete waste package/repository design interface documents for LA	6/94
G	Repository operations plan for ACD available for ACD report	3/92
Н	Repository operations plan for LAD available for LAD report	6/94
I	Complete repository design requirements for ACD	5/90
J	Update repository design requirements for LAD freeze	9/93
К	Repository ACD freeze	12/90
L	Complete repository ACD report	1/93
М	Repository LAD freeze	11/93
N	Complete detailed design of emplacement/ retrieval system hardware and emplacement/ retrieval equipment demonstration plan	2/91
0	Start conducting emplacement/retrieval equipment demonstrations	12/91
P	Complete documentation of emplacement/ retrieval equipment demonstration results for LA	11/93
Q	Complete design analyses of surface facilities for ACD	8/91
R	Draft reports available to DOE on repository access, opening, and borehole analyses for ACD and the design analysis of underground mine ventilation	11/91

event <u>Event description</u>		Event description	Date
	S	Complete surface facility design analysis for LAD	11/93
	T	Complete updated design analysis	6/94
	σ	Complete evaluation of reasonably available technology for repository surface facilities for ACD	6/91
	v	Report available to DOE on technology require- ments for surface facilities for LAD	8/94
	W	Complete evaluation of reasonably available technology for underground facilities for ACD	12/91
	X	Report available to DOE on technology require- ments for underground facilities for LAD	8/94
	Y	Complete evaluation of reasonably available technology requirements for postclosure sealing design for ACD	10/91
J.	Z	Report available to DOE on technology requirements for sealing design for LAD	8/94

Seal characteristics (Issue 1.12, Section 8.3.3.2)

Summary schedule information for Issue 1.12 is presented in Figure 8.5-30. The activities planned to support resolution of this issue include those necessary to develop designs and evaluate performance of seals to be placed in the shafts, ramps, and boreholes associated with the development and closure of the repository. Data from a number of site programs, such as geohydrology (Section 8.3.1.2) and rock properties (Section 8.3.1.15), will be used to ensure that shafts and boreholes are adequately sealed so that after closure, they do not become pathways that compromise the ability of the geologic repository to meet the postclosure performance objectives. It should be noted that work under Information Need 1.12.2 (seal materials) will continue as confirmatory testing. The rationale for tests continuing as performance confirmation tests is provided in Section 8.3.5.6.

The major events shown on the schedule in Figure 8.5-30 and their planned dates of completion are provided in the following table:



Figure 8.5-30. Summary schedule information for the Issue 1.12 (seal characteristics). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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	Major <u>event</u>	Event_description	Date
	A	Complete compilation of preliminary list of information needed for seal design for advanced conceptual design (ACD); continue to compile information needed for seal design	9/89
	В	Complete compilation of updated list of information needed for seal design for license application design (LAD)	7/91
	С	Complete compilation of information used for seal design for license application	1/94
	D	Complete Phase I material testing	3/91
	E	Complete Phase II testing of seal material properties	6/91
	F	Complete updates to degradation models for cementitious sealing materials	8/91
	G	Draft report available to DOE on the results of Phase I testing	1/92
لر	H	Draft report available to DOE on the results of Phase II testing of seal material properties	6/92
	I	Draft report available to DOE on results of the crushed tuff properties test	6/92
	J	Preliminary long-term test data available for last input to seal subsystem performance assessment; long-term testing continues	5/93
	K	Complete update of sealing design requirements for ACD	8/89
	L	Recommend final sealing materials for LAD	9/91
	М	Complete seal design report for LAD	9/91
	N	Complete ACD for sealing	1/92
	0	Begin evaluation of reasonably available technology for sealing components	1/92

Major event	Event_description	
P	Report available to DOE on seal subsystem performance assessment	1/94
Q	Incorporate results of the evaluation of reasonably available technology of sealing components into the LAD report	8/94

8.5.4 WASTE PACKAGE DESIGN ACTIVITIES AND MILESTONES

The waste package design requirements address the preclosure and postclosure time periods in a manner similar to the repository design requirements covered by the milestones presented in Section 8.5.3. Detailed discussions of the waste package preclosure and postclosure design requirements are provided in Section 8.3.4. The primary requirements placed on the waste package for the preclosure time period cover such concerns as control of criticality, limits on reactive materials and free liquids, and the availability of production technologies for fabrication, closure, and inspection of the waste package.

For the postclosure time period, the waste package requirements address the need for considerations of potential interactions between the waste package and its environment that could compromise the function of the packages or the performance of the underground facility or the geologic setting.

Summary schedules for design-oriented waste package issues presented in Sections 8.3.4.2 through 8.3.4.4 are provided in this section. Summary schedule information related to waste package performance assessment issues was presented in Section 8.5.2. Information needs are represented as appropriate. The information need number and brief description are shown on the schedules , as well as major events associated with each information need. A major event, for purposes of these schedules, may represent the initiation or completion of an activity, completion or submittal of a report to the DOE, an important data feed, or a decision point. It should be noted that data meeting applicable quality assurance requirements (Section 8.6) will be available prior to report availability. Solid lines on the schedules represent information need durations and dashed lines show interfaces among information needs, as well as data transferred into or out of the issue. The schedules assume continuous integration among activities with only major ties shown.

Waste package characteristics (postclosure) (Issue 1.10, Section 8.3.4.2)

Summary schedule information for Issue 1.10 is presented in Figure 8.5-31. The activities planned to support resolution of this issue are those required to demonstrate that interactions of the waste package with the emplacement environment do not compromise the function of the package or the



Figure 8.5-31. Summary schedule information for the Issue 1.10 (waste package characteristics - postclosure). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

8.5-99

performance of the underground facility or the geologic setting. The principal characteristics of high-level waste that must be considered are the high levels of radiation and the heat generated within the waste form. To understand the effects of the waste package on the emplacement environment, it is necessary, first, to understand ambient conditions at the repository horizon and the way those conditions will be altered by repository construction and operation. The activities displayed in this section are those necessary to show that the waste package design will meet the requirements addressed by this issue. It should be noted that some activities under Information Need 1.10.4 (near-field environment) will continue as confirmatory testing. The rationale for tests continuing as performance confirmation tests is provided in Section 8.3.5.16.

The major events shown on the schedule in Figure 8.5-31 and their planned dates of completion are provided in the following table:

Major		
event	Event description	Date
A	Continue development of test plans for long- term confirmation testing considering postclosure criteria	10/88
В	Complete development of test plans for long- term confirmation testing	2/93
С	Waste package advanced conceptual design (ACD) freeze	9/91
D	Complete waste package ACD; initiate waste package license application design (LAD)	1/92
Е	Make final selection of material for barrier	2/92
F	Complete waste package LAD drawings and specifications	1/94
G	Continue waste-package emplacement- configuration studies	10/88
H	Information on waste package emplacement configurations available to Design Activity 1.11.3.3 (vertical and horizontal emplacement orientation decision)	6/89
I	Complete studies on reference waste- package emplacement configurations	9/89
J	Draft of final report on fracture flow studies available to DOE	9/91

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	Major <u>event</u>	Event description	Date
	ĸ	Begin waste-package environment test installation in the exploratory shaft	5/92
	L	Final results of rock-water interactions using candidate repository horizon material available to DOE	7/92
	M	Draft of final report on laboratory testing of waste-package environment hydrologic properties available to DOE	12/92
	N	Draft of final report on the effects of grout, concrete, and other materials on waste package environment available to DOE; initiate document revisions to support the license application	9/93
	0	Final report on waste package environment available to DOE	9/93
	P	Final report on radionuclide source term available to DOE	1/94
J	Q	Complete evaluation of thermal stress on mechanical properties	1/94

Waste package characteristics (preclosure) (Issue 2.6, Section 8.3.4.3)

Summary schedule information for Issue 2.6 is presented in Figure 8.5-32. The activities planned to support resolution of this issue are related to development of the waste package designs and the integration of the designs into the repository system. Requirements and constraints are placed on the waste form, the container, and the waste package assembly during the preclosure period. It is also important that the waste form and container are not subjected to conditions that could impact their performance during the postclosure period. The requirements derived through this issue are combined with those from the postclosure waste-package design issue (Issue 1.10, Section 8.3.4.2) to develop a consolidated design.

The major events shown on the schedule in Figure 8.5-32 and their planned dates of completion are provided in the following table:



Figure 8.5-32. Summary schedule information for the Issue 2.6 (waste package characteristics - preclosure). This network is consistent with the Draft Mission Plan Amendment (DOE. 1988a) schedule. Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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Major <u>event</u>	Event description	iption Date	
A	Initiate development of preclosure waste package design requirements for ACD	11/89	
В	Final report available to DOE on the development of preclosure waste package design requirements for LAD	1/94	

Waste package production technologies (Issue 4.3, Section 8.3.4.4)

Summary schedule information for Issue 4.3 is presented in Figure 8.5-33. The activities planned to support resolution of this issue are those related to the DOE requirements that the repository operations shall be demonstrated to be feasible on the basis of reasonably available technology. Rather than differentiate among various aspects of the production process, all production-related requirements are addressed in this issue. Activities to be performed under this issue include process criteria definition, process identifications, process testing and evaluation, and prototype fabrication and testing.

The major events shown on the schedule in Figure 8.5-33 and their planned dates of completion are provided in the following table:

Major event	Event description	Date
A	Complete report on container closure process development	11/90
В	Complete report on waste-package closure inspection development	11/90
с	Complete report on container fabrication process development	11/91
D	Complete preparation of plans and procedures for waste-package closure inspection process for inclusion in report on waste-package prototype fabrication process	6/92
E	Begin preparation of reports, plans, and procedures for waste-package prototype fabrication process	2/93
F	Complete fabrication of waste package prototype; initiate demonstration tests of waste package prototype	11/93



Figure 8.5-33. Summary schedule information for Issue 4.3 (waste package production technologies). This network is consistent with the Draft Mission Plan Amendment (DOE, 1988a) schedule Revisions will be published in semiannual site characterization progress reports as new information becomes available.

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event	Event description	
G	Complete engineering tests of advanced	1/95
	conceptual design (ACD) prototype waste	

8.5.5 MAJOR DECISION POINTS FOR THE YUCCA MOUNTAIN PROJECT

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This section presents the major decision points currently recognized by the Yucca Mountain Project. A logic diagram, shown in Figure 8.5-34, illustrates the interfaces among the major program elements affected by the decisions.

The timing of the highest level decision points is closely tied to milestones in the Mission Plan (DOE, 1985b). Decision points for the Yucca Mountain Project are generally related to the provision of site information required by the performance and design elements to address licensing and other regulatory requirements. This information consists of the technical data bases and supporting information that will allow an evaluation of compliance with regulatory requirements. Preliminary design and performance assessment analyses and calculations, such as those presented in the environmental assessment (DOE, 1986b), were completed on the basis of limited site information. If new site information collected during site characterization raises questions about earlier models and hypotheses, then certain design or performance strategies and approaches may require revision. Revised design or performance strategies may also result in the need for additional site information.

Some of the major decision points covered in this section do not rely on site information. Decision points may be determined by the activities of other Federal agencies, such as the publication of the site characterization analyses by the NRC. Other decision points will be reached by the systematic progress of design activities from preliminary conceptual to advanced conceptual design, and ultimately to the final design suitable for inclusion in the license application.

Table 8.5-3 lists major decision points in the site characterization program and describes their likely outcome. These deal with topics such as the need to extend the exploratory shaft (ES) into the Calico Hills unit (including the determination of impacts on waste isolation), and the need to expand ES drifting into the southern part of the repository block. Additionally, a range of geophysical testing techniques will be evaluated during site characterization and new tests planned as appropriate.



Figure 8.5-34. General logic diagram for major decision points in site characterization program.

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Table 8.5-3. Major decision points in the site characterization program

Decision point	Likely outcome
Is the SCP acceptable for public release?	Release SCP for NRC, State, and public review
Can the decision be made on hori- zontal versus vertical waste emplacement?	Stop all design and analyses of emplacement mode not selected
Have all prerequisites been met to start advanced conceptual design (ACD)? ^a	Conduct waste package and reposi- tory ACD
Is Project prepared to initiate surface-based activities? ^b	Complete readiness review and begin surface-based activities
Is the Project ready for exploratory shaft (ES) construction and ES construction-phase testing? ^c	Complete readiness review and start ES construction and ES construction-phase testing
Can the metal barrier be selected for the waste package?	Primary emphasis placed on selected materials
Can the decision be made to use or not use a ceramic liner for waste packages?	Continue or terminate liner design and production
Can the repository horizon be selected?	Stop consideration of alternative horizons and continue ACD
Is the ACD adequate and complete?	Conduct final design review for ACD; complete all required design documents; start license applica- tion design (LAD)
Is the Project prepared to conduct ES in situ testing? ^d	Complete readiness review and start in situ testing
Can the decision on final areal power density be made?	Incorporate final areal power density into LAD
Is the lateral extent sufficient and are the characteristics of repository horizon acceptable?	Stop consideration of extension areas; continue LAD
Can the reference sealing material for LAD be selected?	Stop consideration of alternative materials; continue LAD
(continued)	
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Decision point	Likely outcome
Is the Project prepared to conduct the demonstration of waste emplace- ment and retrieval technologies?	Demonstrate the technologies and incorporate into LAD
Are site information and the tech- nical data base sufficient for waste package and repository design?	Freeze input to ACD; continue data collection for LAD or Freeze input to LAD
Is the Project ready to hold the final LAD design review for waste package?	Conduct the final LAD design review and activities for waste package design
Is the Project ready to hold the final LAD design review for repository?	Conduct the final LAD design review and terminate LAD activities for repository design
Are performance assessment model development and code validation and verification complete?	Complete performance assessment calculations for draft environ- mental impact statement (DEIS), final environmental impact state- ment (FEIS) or license application (LA)
Are site information and the tech- nical data base sufficient for performance assessment calculations?	Complete performance assessment calculations for DEIS, FEIS, or LA
Is all technical information adequate to issue DEIS?	Issue DEIS
Is all technical information suffi- cient to support higher level findings on DOE siting guidelines?	DOE/HQ begins site suitability report
Is all technical information suffi- cient for LA?	Issue final SCP progress report supporting LA; complete LA; start NRC licensing process

Table 8.5-3. Major decision points in the site characterization program (continued)

^aPrerequisites for ACD:

- waste emplacement mode selection
- systems requirements document published
- repository design requirements document published
- waste package design requirements document published
- reference information base data available

Table 8.5-3. Major decision points in the site characterization program (continued)

Footnotes (continued)

- waste package postclosure compliance strategy developed ^bRequirements for readiness review prior to initiation of surface-based activities:

- land access agreements in place

- applicable environmental permits obtained
- appropriate study plans provided to NRC
- test procedures and quality assurance (QA) level assignments completed and approved

°Requirements for ES construction and ES construction-phase testing readiness review:

- applicable environmental permits obtained
- construction-phase study plans provided to NRC

- test procedures and QA level assignments completed and approved ^dRequirements for ES in situ testing readiness review:

- in situ phase study plans provided to NRC
 test procedures and QA level assignments completed and approved

8.5.6 SUMMARY SCHEDULE

The following sections provide information useful for developing an overall understanding of the structure of the site characterization program, together with the repository and waste package design and the performance assessment programs. The summary schedule presented in Section 8.5.6.1 portrays the evolution of the major elements of the program from the present time through the license application to the Nuclear Regulatory Commission (NRC). The major Draft Mission Plan Amendment (DOE, 1988) milestones and the scheduled completion date for each milestone are listed in Section 8.5.6.1. A schematic figure, presented in Section 8.5.6.2, and the text describing preliminary plans for regulatory and institutional activities and milestones provide an overview of the general approach that will be used to document the results of site characterization and important design and performance assessment products.

8.5.6.1 Presentation of summary schedule for the Yucca Mountain site

Figure 8.5-35 provides a summary schedule for the site characterization program planned at the Yucca Mountain site. The schedule should be viewed as an aid to understanding the overall structure of the site characterization program. A list of the major Draft Mission Plan Amendment milestones (DOE, 1988) and the scheduled completion date for these milestones is provided in the following table. These milestones are a subset of the major events shown on the summary schedule.

Milestone	Current schedule	
Start of exploratory shaft construction Start of in situ test phase Draft environmental impact statement (DEIS) Final environmental impact statement (FEIS) Submittal of the site recommendation report (SRR) to the President Submittal of the license application (LA) to the Nuclear Regulatory Commission	Second quarter 1989 Fourth quarter 1990 1993 1994 1994 1995	

Other milestones shown on the summary schedule in Figure 8.5-35 are listed in the following table. The major program elements represented include regulatory and institutional (see Section 8.5.6.2), performance assessment, repository and waste package design, site investigations, and exploratory shaft.



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	Related		
Major event	SCP section	Event description	Date
	REGU	LATORY AND INSTITUTIONAL MILESTONES	
A	NAª	DOE/HQ issues SCP to public	12/88
В	. NA	Conduct public hearings on SCP	3/89
С	NA	Issue draft environmental impact statement (DEIS)	10/93
D	NA	Issue final environmental impact statement (FEIS)	10/94
E	NA	Submit site recommendation report (SRR) to the President	11/94
F	NA	Submit license application (LA) to the NRC	1/95
•		PERFORMANCE ASSESSMENT	
A	8.3.5.9.2.1	Metal barrier material selected	10/89
В	8.3.5.2.6	Complete retrieval compliance analysis required for advanced conceptual design (ACD)	1/92
С	8.3.5.4.1 and 8.3.5.4.2	Complete ACD assessment of radiological safety during normal operations	7/92
D	8.3.5.12.4	Preliminary calculations of pre-waste- emplacement ground-water travel time (GWTT) available for DEIS	7/92
E	8.3.5.9.4 and 8.3.5.9.5	Complete performance assessment of waste package ACD	10/92
F	8.3.5.13.5	Total system performance assessment calculations available for DEIS	8/93
G	8.3.5.12.4	Complete updating calculations of pre-waste- emplacement GWTT for FEIS and LA	9/93
H	8.3.5.13.4	Complete development/validation of per- formance assessment codes	12/93
I	8.3.5.9.4 8.3.5.9.5	Complete performance assessment of waste- package license application design (LAD)	1/94

8.5-112

Major event	Related SCP section	Event description	Date
		PERFORMANCE ASSESSMENT (continued)	
J	8.3.5.13.5	Updated total system performance assessment calculations available	5/94
ĸ	8.3.5.4.1 8.3.5.4.2	Complete LAD assessment of radiological safety during normal operations	8/94
L	8.3.5.16	Complete baseline phase and begin confirma- tion phase of performance confirmation	1/95
M	8.3.5.10.3	Complete documentation of the verification and validation of waste-package assessment codes	1/95
		REPOSITORY AND WASTE PACKAGE DESIGN	
A	8.3.4.2.2	Start waste package ACD	10/89
В	8.3.2.5.5	Start repository ACD	10/89
С	8.3.4.2.2	Complete waste package ACD	1/92
D	8.3.4.2.2	Start waste package LAD	1/92
Е	8.3.2.5.5	Complete repository ACD	1/92
F	8.3.2.5.5	Start repository LAD	1/92
G	8.3.4.2.2	Complete waste package LAD	1/94
H	8.3.2.5.5	Complete repository LAD	7/94
SITE			
A	8.3.1.4.2.2	Final report on geologic mapping of the Paintbrush Tuff available to DOE	7/90
В	8.3.1.2.1.4	Draft report available to DOE on the conceptual model of the saturated zone at Yucca Mountain	8/90
С	8.3.1.3.7.1	Update of geochemical/geophysical model available to DOE	1/91

8.5-113

Major event	Related SCP section	Event description	Date
D	8.3.1.12.4.1	Draft report available to DOE on extreme weather phenomena and expected recurrence intervals	3/91
E	8.3.1.5.2.2	Draft report summarizing modern flooding events available to DOE; report feeds report on predictions of future flooding and debris movement	8/91
F	8.3.1.17.3.6	Complete earthquake source evaluation	11/91
G	8.3.1.16.2.1	Draft report available to DOE on the effects of water withdrawals on the local flow system	6/92
Н	8.3.1.17.2.1	Final reports on the potential for faulting at the surface facilities and for displacement on faults that intersect underground facilities	8/92
I	8.3.1.4.2.3	Draft report available to DOE on the preliminary site geologic description; report feeds development of three- dimensional geologic model	8/92
J	8.3.1.9.2.1	Final report on evaluation of natural resource potential at the site available to DOE	8/92
K	8.3.1.17.4.12	Preliminary regional tectonic model available to DOE	9/92
L	8.3.1.2.2.9	Draft report available to DOE on the preliminary evaluation of unsaturated zone hydrology	1/93
М	8.3.1.12.2.1	Draft of five-year summary report on meteorological conditions available to DOE	2/93
N	8.3.1.2.2.3	Preliminary report on the hydrologic properties of tuff matrix available to DOE	3/93

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Major event	Related SCP section	Event description	Date
		SITE (continued)	
0	8.3.1.3.5.1	Draft report available to DOE on solubility measurements	7/93
P	8.3.1.2.3.3	Report available to DOE on the prelim- inary description of the saturated zone	11/93
Q	8.3.1.8.3.1	Report available to DOE on the assessment of the effects of faulting on flux rates	3/94
R	8.3.1.3.7.1	Final report on the results of retardation sensitivity analysis available to DOE; report feeds final geochemical/geo- physical model	4/94
S	8.3.1.3.1.1	Report available to DOE on modeling of of unsaturated zone water chemistry	7/94
Т	8.3.1.8.1.1	Final report on the probability of future volcanic activity available to DOE	10/94
		EXPLORATORY SHAFT ^b	
A	8.4.2.3.4	Start exploratory shaft (ES) site preparation	12/88
В	8.4.2.3.4.3	Start ES-1 shaft construction	6/89
с	NA	Start ES construction phase testing	6/89
D	8.4.2.3.4.4	Complete connection of ES-1 to ES-2	12/90
Е	NA	Start in situ phase testing	12/90
F	8.4.2.3.4.4	Complete ES-2 main test level excavation	9/91
G	NA	Complete exploratory shaft facility Title III activities	7/92

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Major event	Related SCP section	Event description	Date
		EXPLORATORY SHAFT (continued)	
Н	NA	Provide available in situ test data for the DEIS	4/93
I	NA	Provide available in situ test data for the LA	4/94
		SURFACE-BASED DRILLING	
A	8.3.1.2.2.3	Begin drilling deep unsaturated zone holes	2/89
В	8.3.1.5.2.1.5	Complete Ca-Si drilling	7/89
С	8.3.1.2.2.3	Complete drilling of deep unsaturated zone holes	10/90
D	8.3.1.4.3.1	Complete drilling boreholes of the drilling program	7/92

^aNot applicable. ^bSee Section 8.5.1.2.

8.5.6.2 Regulatory and institutional activities and milestones

As shown in Figure 8.5-35, the principal milestones for regulatory and institutional activities include issuance of the SCP and the semiannual progress reports, issuance of the environmental impact statement, and submittal of the license application and other supporting regulatory documents. Because regulatory and institutional milestones were not included in Sections 8.5.1 through 8.5.4, a brief discussion of the preliminary planning basis for regulatory and institutional activities is provided here. The manner in which site information will be utilized in performance and design activities and, finally, in the preparation of regulatory documents is schematically displayed in Figure 8.5-36.

Throughout site characterization, a number of reports, currently called position papers, will be prepared, documenting the DOE's technical and regulatory positions. Position papers will be developed by assimilation of data and information from published reports documenting the results of site program activities and analyses, performance assessment activities, and the design of the waste package and repository. The schedules presented in



Figure 8.5-36. Schematic diagram showing utilization of site data by performance assessment and design, and for preparation of regulatory documents. (ACD - advanced conceptual design; DEIS - draft environmental impact statement; FEIS - final EIS; HLF - higher-level findings; LA - license application; LAD - LA design; NEPA - National Environmental Policy Act; SCA - site characterization analysis; SCP - site characterization plan; SRR - site recommendation report)

Sections 8.5.1 through 8.5.4, as well as the schedule sections of Section 8.3, include some reports that will serve as input to the position papers. Other documents currently called issue resolution reports, will be prepared to formally document the implementation of the issue resolution strategies defined for performance and design issues in Sections 8.3.2 through 8.3.5. These reports may also be used to document positions on other technical issues of concern to the NRC, State, or public, such as an assessment of the seismic hazards at the Yucca Mountain site or the significance of calcite-silica deposits in faults near the site.

Throughout the issue resolution process, the DOE will be soliciting the views of and interacting with outside organizations, such as the NRC, on selected key topics. Additional information on issue resolution documentation can be found in Section 8.1.2.4. Potential topics to be covered in issue resolution reports are presented in Section 8.2.2.