3.0 Underground Test Area

A total of 908 historical nuclear detonations occurred in shafts or tunnels at the NTS. They are categorized into 878 CASs assigned to the UGTA. These CASs are grouped into five CAUs. CASs in each CAU are located near each other, and CAUs are geographically distinct. CAUs have distinctly different contaminant source, geologic, and hydrogeologic characteristics related to their location.

3.1 Corrective Action Units

The CAUs, shown in Figure 3-1, are listed below:

- Frenchman Flat CAU consists of 10 CASs located in the northern part of Area 5 and the southern part of Area 11. These events were conducted in both vertical emplacement holes and mine shafts. The events in Frenchman Flat were located in alluvium of great depth. The deeper geology is not well known. Lateral transport in the alluvium is very slow due to the low lateral gradient.

- Western Pahute Mesa CAU consists of 18 CASs along the western edge of Area 20. These events were all conducted in vertical emplacement holes. This CAU is separated from Central Pahute Mesa by the Boxcar Fault and is distinguished by the relative abundance of tritium. Transport of contaminants on and from Western Pahute Mesa involves groundwater flow in both welded and vitric tuffs, both in the rock matrix and in the fracture system.

- Central Pahute Mesa CAU consists of 64 CASs in Areas 19 and 20 on Pahute Mesa. These events were all conducted in vertical emplacement holes. Transport of contaminants on and from Central Pahute Mesa involves groundwater flow in fractures and the rock matrix, in welded and vitric tuffs, and lava flow aquifers. The influence of the large-scale block faulting is not well known.

- Yucca Flat/Climax Mine CAU consists of 717 CASs located in Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and 3 CASs located in Area 15. These events were conducted in vertical emplacement holes and tunnels. Contaminant transport in Yucca Flat/Climax Mine may involve alluvium, both welded and vitric tuffs, fractured granite, and carbonate rocks.

- Rainier Mesa/Shoshone Mountain CAU consists of 60 CASs on Rainier Mesa and 6 CASs on Shoshone Mountain, located in Areas 12 and 16. These events were all conducted above the water table in tunnels constructed in bedded and non-welded vitric and zeolitized volcanic tuffs.

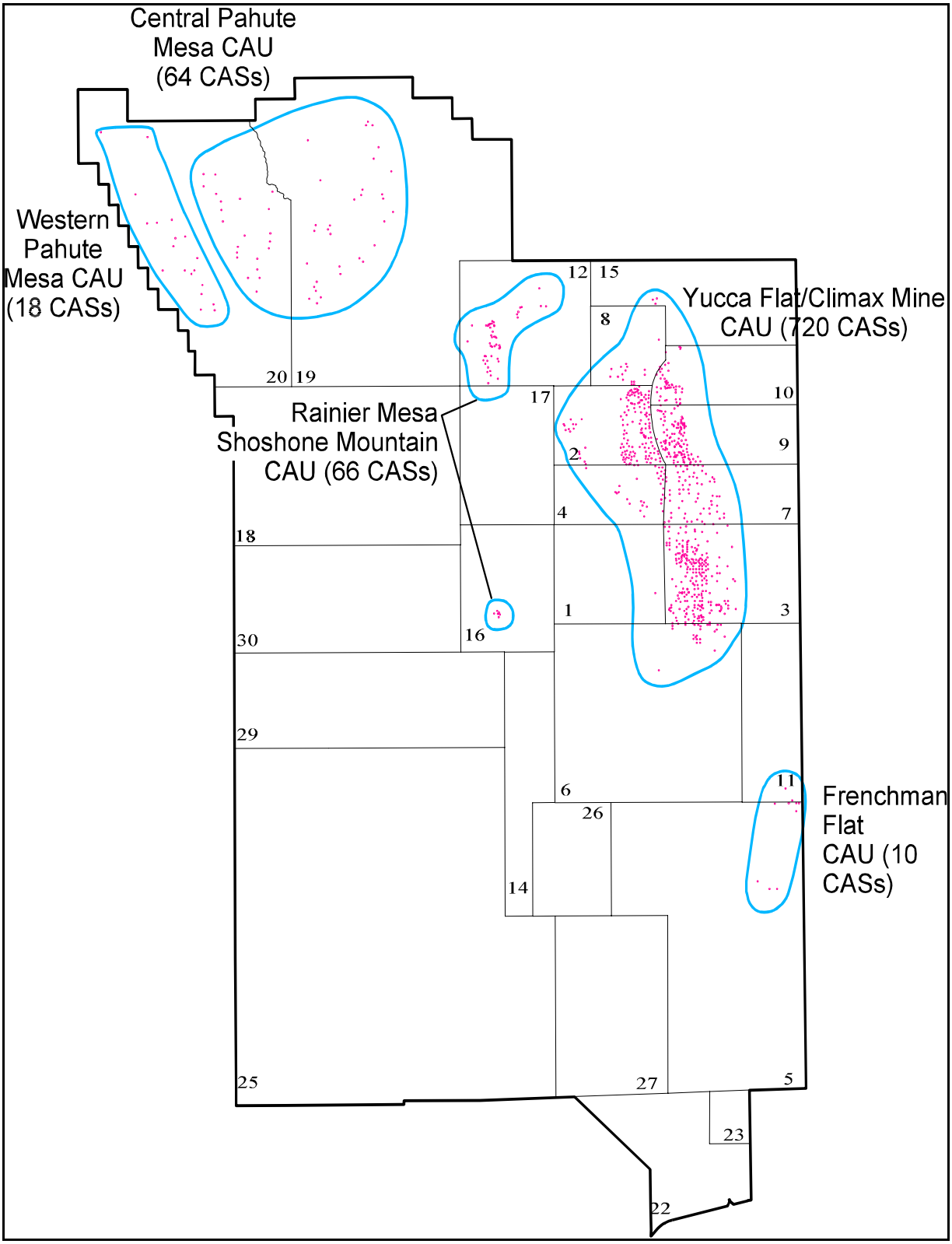

Figure 3-1
Underground Test Area Corrective Action Units

The process outlined in Section 1.3 was used for the initial prioritization of UGTA CAUs. The first three CAUs are in priority order, but the priority of the remaining CAUs may change as they become specifically addressed in the planning process.

3.2 Corrective Action Strategy

The corrective action strategy for UGTA is based on the complex corrective action process. The objective of the CAI process is to define boundaries around each UGTA CAU to establish areas that contain water that may be unsafe for domestic and municipal use. Any ambiguity resulting from different language used in this subpart of Appendix VI versus the body of the FFACO Agreement shall be resolved in favor of terms and conditions found in the body of the FFACO Agreement.

The UGTA Corrective Action Strategy was developed to address the contamination created by the testing of nuclear devices in shafts and tunnels at the Nevada Test Site. The objective of the strategy is to analyze and evaluate each UGTA CAU through a combination of data and information collection and evaluation, and modeling groundwater flow and contaminant transport. This analysis will estimate the vertical and horizontal extent of contaminant migration for each CAU in order to predict contaminant boundaries. A contaminant boundary is the model-predicted perimeter which defines the extent of radionuclide-contaminated groundwater from underground testing above background conditions exceeding the *Safe Drinking Water Act* (SDWA) standards. The contaminant boundary will be composed of both a perimeter boundary and a lower hydrostratigraphic unit boundary. The computer model predicts the location of this boundary within 1,000 years and must do so at a 95% level of confidence. Additional results showing contaminant concentrations and the location of the contaminant boundary at selected times will also be presented. These times may include the verification period, the end of the five-year proof of concept period, as well as other times that are of specific interest.

From the contaminant boundary predicted by the computer model, a compliance boundary will be negotiated between NDEP and DOE. The compliance boundary will define the area within which the radiological contaminants above the SDWA standards relative to background are to remain. DOE will be responsible for ensuring compliance with this boundary. The compliance boundary may or may not coincide with the contaminant boundary. If the predicted location of the contaminant boundary cannot be accepted as the compliance boundary, an alternate compliance boundary will be negotiated by both parties.

An initial assumption is that contaminant control will not be required. After establishing a compliance boundary for each CAU, an evaluation of remedial alternatives and a monitoring Corrective Action Plan will be developed. A 5-year proof of concept period will follow using groundwater wells in a monitoring network to determine if the monitoring network design will provide adequate CAU surveillance. If the monitoring network is found acceptable, a closure plan will then be developed, followed by implementation of a long-term closure monitoring program.

The long-term closure monitoring program will address any contamination left in place in a closed CAU. This program consists of all activities necessary to ensure protection of human health and the environment following the completion of corrective actions at a CAU. These activities will include periodic analysis of monitoring results, determining optimum performance indicators, evaluation of monitoring performance criteria, locating new monitoring wells and replacing existing monitoring wells to support performance criteria evaluation at timed intervals of interest within the 1,000-year time period.

A model of regional flow encompassing the NTS and the groundwater flow systems extending to downgradient discharge has been completed. Regional modeling is a cross-cutting activity, supporting the entire UGTA program, which provides the initial basis for assessing flowpaths from CAUs, determining potential receptors, evaluating isolation or interaction of CAUs, and creating a consistent hydrogeologic framework across all the CAUs. Regional transport modeling provides the initial basis for determining the magnitude of risk from the source to potential receptors and for scaling individual CAU work.

The second phase of the CAI process will focus on refining CAU boundaries through CAU-specific models that include CAU-specific data. The CAU-specific modeling objectives are to estimate movement of contaminants utilizing the acquisition and evaluation of CAU-specific hydrogeologic data and define boundaries that encompass the extent of contamination. If CAU-specific modeling is not successful in achieving CAU objectives, this strategy will be evaluated to determine whether it will allow the objectives to be reached. If it is not possible or feasible to achieve the objectives, it may be necessary to reevaluate and consider alternative approaches.

Figure 3-2 is a diagram of the generalized decision process leading to the closure of CAUs. The process contains five major decision points where data and/or data analysis are reviewed and consensus reached before proceeding with the next phase of corrective action activities. The first of these major decisions is the determination of data adequacy prior to developing the CAU flow and contaminant transport model. If the data are not adequate, alternatives will be evaluated, and the second major decision point, a decision on whether the UGTA strategy can be achieved, will be reached. If the strategy can be achieved, an addendum to the CAIP will then be developed. If the strategy cannot be achieved, a new strategy will then be proposed. If the data are adequate, the CAU flow and transport model will be developed.

The third major decision concerns the acceptability of the CAU flow and transport model. If the CAU flow and transport model is not acceptable, the alternatives will be evaluated and, again, the second major decision point, a decision on whether the UGTA strategy can be achieved, will be reached. If the strategy can be achieved, an addendum to the CAIP will then be developed. If the strategy cannot be achieved, a new strategy will then be proposed. If the CAU model is acceptable, the CAU boundaries will be defined.

The model results, along with the results of the CAI, will be utilized for an evaluation of remedial alternatives and a proposed remedial action. The fourth major decision is whether contaminant control is required. If contaminant control is required, then a corrective action plan will be developed and implemented. If contaminant control is not required, then a monitoring corrective action plan will be developed and a five-year proof of concept monitoring program will be initiated. The fifth and final major decision occurs after a review of the monitoring results. If DOE and NDEP are confident of the results, the closure process will begin. If the results at any of these decision points are not acceptable, then contingency activities will be initiated and evaluated, as appropriate, to correct the deficiencies.

For saturated conditions, a flow model of each CAU will be constructed to provide local three-dimensional flow, to evaluate the range of flow conditions in the CAU that may be important in determining maximum extent of transport, and to provide boundary conditions for modeling transport. Saturated conditions are planned to be modeled for Frenchman Flat, Yucca Flat/Climax Mine, Western Pahute Mesa, and Central Pahute Mesa CAUs.

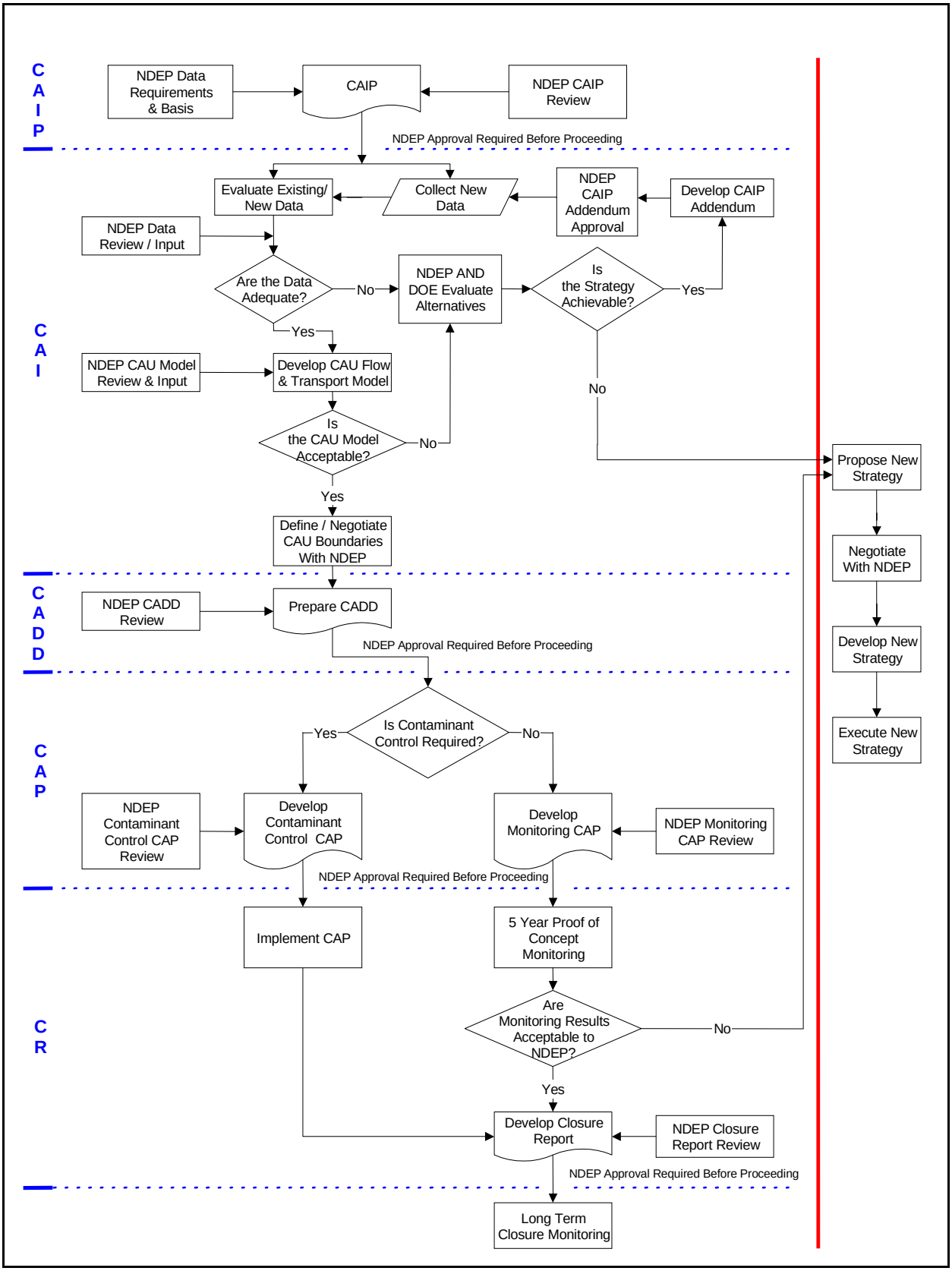

Figure 3-2
Process Flow Diagram for the Underground Test Area
Corrective Action Units

For CAUs where unsaturated groundwater conditions prevail (Rainier Mesa/Shoshone Mountain CAU), saturated zone flow and transport modeling results, based on field data, will be evaluated to determine if the saturated zone has been impacted. If the saturated zone has been impacted, then the need for further examination of the unsaturated zone will be evaluated.

CAU models utilizing tritium as the source term will be used to establish the contaminant boundary for each CAU. The boundary will be composed of a perimeter boundary and a lower hydrostratigraphic unit boundary. The perimeter boundary will define the aggregate maximum extent of contamination transport at or above the concentration of concern for the CAU. The lower hydrostratigraphic unit boundary will define the lowest aquifer unit affected by the contamination. Long-lived radionuclides, besides tritium, will be included to evaluate the relative extent of migration of different radionuclides in the future. If it is predicted that another radionuclide will migrate farther than tritium at concentrations of concern, the contaminant boundary will include that prediction.

Figure 3-3 illustrates how modeling uncertainty can be expressed as confidence levels. Each contour reflects an increased level of confidence that no contaminants exceeding a given regulatory concentration will ever cross that boundary. As confidence increases, the distance from the CAU increases. The confidence levels could lead to the development of different contaminant boundaries, depending on the degree of certainty decision makers need to select appropriate controls.

Monitoring compliance with the CAU boundaries will be accomplished through measurement of appropriate physical and chemical parameters in wells within the modeled region. Appropriate physical and chemical parameters remaining within the range of measurements used in the flow model will be an indication that the conditions have not significantly changed. Sensitivity analysis of parameters relevant to the groundwater will indicate the extent that appropriate physical and chemical parameters can vary before the acceptable confidence limit for the model is exceeded.

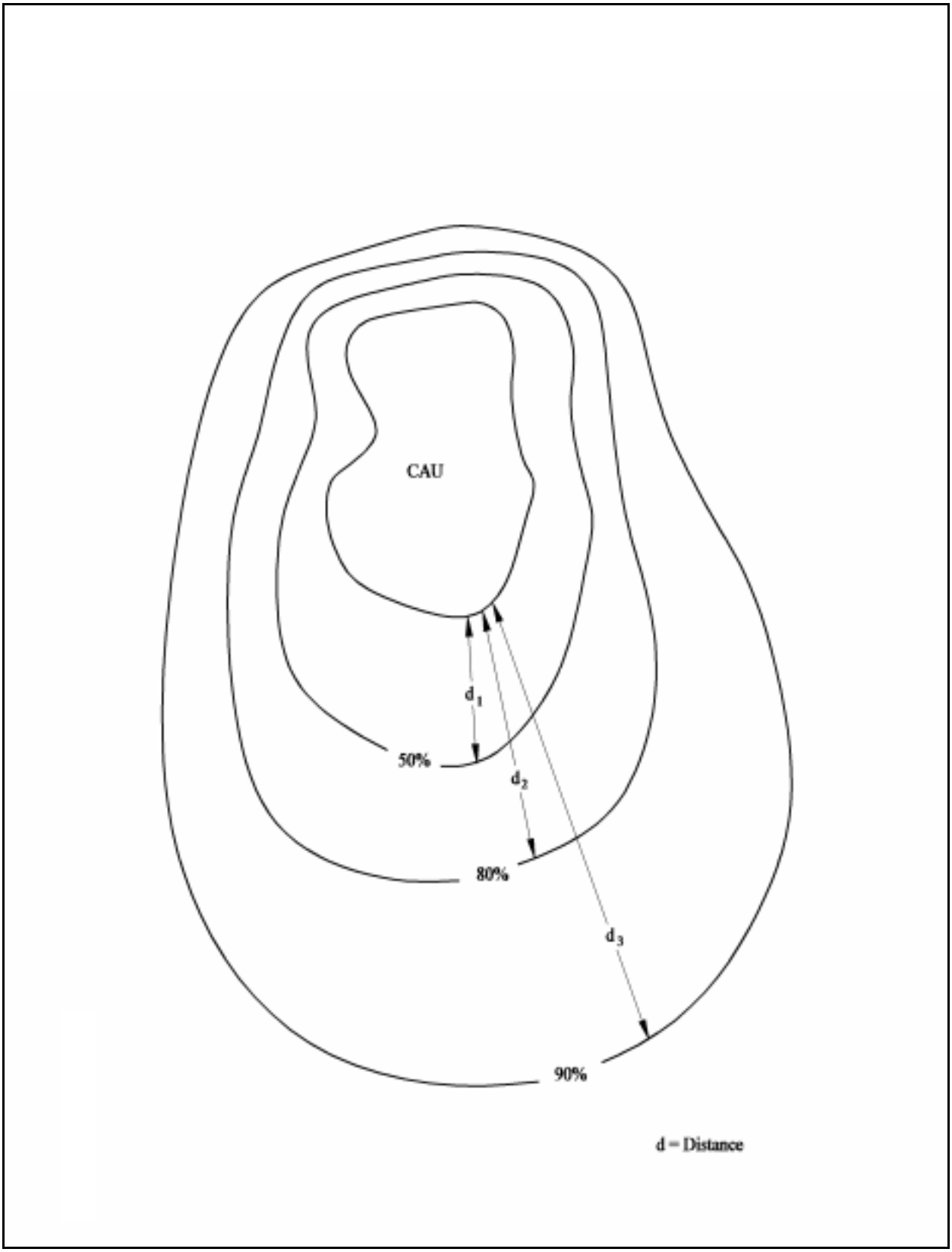

Figure 3-3
Example of Contaminant Boundary Confidence Levels

3.3 Implementing Corrective Action Investigations and Corrective Actions

Work elements expected to be required to conduct the CAI and corrective action process for each of the UGTA CAUs are identified in the Process Flow Diagram for the Underground Test Area Corrective Action Units (see Figure 3-2), and are described below. These descriptions form the basis for establishing due dates for milestones and deadlines for these CAUs. If activities other than those described herein are determined to be necessary to achieve closure of the CAUs, the milestones and schedule will be reevaluated in accordance with the terms and conditions defined in the Agreement. As of the effective date of this Agreement, no specific, proven cost-effective technologies, as known by the parties individually, have been previously demonstrated to either remove radioactive contaminants from the groundwater, stabilize them, or remove the source of the contaminants at the CASs that are subject to that Agreement. Such technologies may be perfected in the future, which may perhaps alter the choice of corrective action at that time.

The following dictionary sets forth the meaning of each block/step of the Process Flow Diagram for Underground Test Area Corrective Action Units (see Figure 3-2) for achieving the UGTA Corrective Action Strategy. The dictionary is presented in tabular form identifying each of the steps developed to achieve the Strategy. The table presents the process section that each block/step is in, the descriptor, or name, of each block/step, and a definition of the block/step.

PROCESS SECTION	***BLOCK DESCRIPTOR***	***DEFINITION OF THE PROCESS STEP***
CAIP	**CAIP**	DOE will develop and prepare the Corrective Action Investigation Plan (CAIP). The CAIP will be prepared in accordance with the FFACO and Data Quality Objective (DQO) Process. The CAIP will meet the informational requirements of the "Annotated Outline for UGTA Corrective Action Investigation Plan," which includes a description of the CAU, a summary of the DQO process results, the proposed Corrective Action Investigation (CAI), and a description of and rationale for any planned field investigations. The description of the CAU will include the investigative background which contains a summary of historical data and previous studies, operational history, physical setting, contaminants of concern, and a conceptual model of the CAU that will be proved or disproved by the CAI. The DQO process results provide problem identification, relate the conceptual model with contaminant migration scenarios, and the investigations aimed at satisfying the DQOs. The proposed CAI provides the plans for the conduct of the investigation that will be carried out, and the details of field investigations and data collection and data analysis activities identified as necessary to better model the physical system. The CAU-scale flow and contaminant transport modeling will also be planned and developed in the CAI, including the modeling steps, flow and transport code selection, and flow model calibration and verification. During the development of the CAIP, DOE will meet with and update NDEP. NDEP will then be given the opportunity to review the draft version of the CAIP and identify any deficiencies. Field investigations, data collections, and analyses identified during the development of the CAIP as part of the Corrective Action Investigation will not be initiated without NDEP approval.
	NDEP Data Requirements & Basis	During the development and preparation of the CAIP, NDEP will identify the specific data requirements and the basis for those data requirements which will be required for NDEP acceptance of the CAIP. These data requirements will be presented to DOE during the development of the CAIP.
	NDEP CAIP Review	NDEP reviews the draft version, along with the CAIP, and prepares comments if appropriate. Review criteria are based on the informational requirements specified in the "Annotated Outline for UGTA Corrective Action Investigation Plan". NDEP approval is required prior to initiating any Corrective Action Investigation-related activities.

PROCESS SECTION	*BLOCK DESCRIPTOR*	*DEFINITION OF THE PROCESS STEP*
CAI	**Collect New Data**	DOE will collect new data to address deficiencies in existing data, or to improve the assimilation and utilization of existing data. The data collection activities undertaken will be those specific tasks detailed in the CAIP or an addendum to the CAIP.
	Evaluate Existing/New Data	DOE will evaluate new and existing data to determine if this current data set will allow for the development of an acceptable flow and contaminant transport model, and provide the data evaluation results to NDEP.
	NDEP Data Review/Input	NDEP reviews interim/final work products, supplemental materials, and attends presentations on the status of the investigation. NDEP then provides comments to DOE specifically aimed at data adequacy issues and the data evaluation process. NDEP input can take the form of identifying to DOE additional data collection activities that NDEP believes will be necessary to create an acceptable flow and contaminant transport model. After DOE completes its evaluation of existing and new data, and after NDEP has reviewed the information that was provided by DOE, NDEP will develop its determination concerning data adequacy.
	Are Data Adequate?	If both DOE and NDEP agree that the data are adequate, the answer to this question is yes. If either party determines that the data are not adequate, the answer is no.
	NDEP/DOE Evaluate Alternatives	If both parties cannot agree that data are adequate to develop a flow and contaminant transport model to meet the conditions of the strategy, or that the flow and contaminant transport model has not produced acceptable results, then NDEP and DOE will conduct an evaluation of the alternatives.
	Is The Strategy Achievable?	After NDEP and DOE have completed the evaluation of alternatives, the question “Is the Strategy Achievable?” can be answered.
	Develop CAIP Addendum	If it is determined that the strategy is achievable, then DOE will develop and prepare an addendum to the CAIP. The CAIP addendum will address the identified needs, how these needs are translated to requirements, and what additional work activities will be conducted that are expected to address and/or satisfy these requirements. The CAIP Addendum will be structured as mutually agreed to by DOE & NDEP prior to document preparation. During the development and preparation of the CAIP addendum, DOE will keep NDEP informed and updated in order to expedite NDEP’s review and approval.
	NDEP CAIP Addendum Approval	NDEP reviews the draft version along with the CAIP addendum, and provides comments if appropriate. NDEP approval of the CAIP Addendum is required prior to initiating Corrective Action Investigation-related activities.

PROCESS SECTION	***BLOCK DESCRIPTOR***	***DEFINITION OF THE PROCESS STEP***
CAI	**Develop CAU Flow & Transport Model**	DOE will develop a flow and contaminant transport model for each CAU. The CAU-scale flow and contaminant transport model is a three-dimensional, mathematical representation of the important physical and chemical features of the flow system, and simulates the movement of a variety of radiological contaminants through the water-bearing units. First, a geologic model is constructed from surface and subsurface geologic and geophysical data. This geologic model is then used in conjunction with boundary fluxes, recharge & discharge data, hydraulic head data, and hydraulic conductivity data to develop a flow model. After completion of the flow model, the contaminant transport model is developed. The contaminant transport model will estimate the extent to which the migration of radionuclides exceeds the SDWA standards above background within 1,000 years, which will comprise the contaminant boundary. The contaminant boundary will be composed of a perimeter boundary and a lower hydrostratigraphic unit boundary. As part of the contaminant transport modeling process, sensitivity and uncertainty analyses will be performed which will include estimating the impacts of alternative models on flow and contaminant transport.
	NDEP Model Review & Input	The flow and contaminant transport model will be reviewed by DOE and presented to NDEP for review and evaluation. Both DOE and NDEP will evaluate the flow and contaminant transport model to determine if it is acceptable for defining the contaminant boundary. Acceptance will only be granted for a fully calibrated and verified model. Calibration and verification are steps in the model validation process. Calibration refers to the process of refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to achieve a desired degree of correspondence between the model simulation and observations of the ground-water flow system. Verification is using the set of parameter values and boundary conditions from a calibrated model to approximate acceptably a second set of data measured under similar hydrologic conditions.
	Is the CAU Model Acceptable?	If both DOE and NDEP determine that the model is acceptable, the answer to this question is yes. If either party determines that the model is not acceptable, the answer is no.
	Define/Negotiate CAU Boundaries with NDEP	A CAU flow and contaminant transport model utilizing Tritium and radionuclides with half-lives greater than Tritium (12.32 years) as the source term will be used to estimate a contaminant boundary for each CAU. The boundary will be composed of a perimeter boundary and a lower hydrostratigraphic unit boundary. The accepted contaminant boundary and other considerations will form the basis for a negotiated compliance boundary.

PROCESS SECTION	*BLOCK DESCRIPTOR*	*DEFINITION OF THE PROCESS STEP*
CADD	**Prepare CADD**	The Corrective Action Decision Document (CADD) will present the results of the CAI along with an evaluation of the remedial alternatives being considered, and also provides the basis for recommending the proposed remedial alternative. The results of this evaluation will be presented with the CADD. The initial assumption is that long-term monitoring will be the accepted remedial action. The structure of the CADD is based on requirements specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation.
	NDEP CADD Review	NDEP reviews the preliminary draft along with the Corrective Action Decision Document and prepares comments, if appropriate. Review criteria are based on guidelines specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation. NDEP approval of the CADD is required prior to initiating any Corrective Action Plan-related activities.
CAP	**Is Contaminant Control Required?**	During the development of the CADD, a determination is made either that contaminant control will be required, or long-term monitoring will provide sufficient CAU surveillance. One of two separate courses of action will follow this juncture, as indicated on the process flow diagram.
	Develop Contaminant Control CAP	DOE prepares the Contaminant Control Corrective Action Plan, which specifies the corrective measures required to achieve contaminant control. The structure of the plan is based on requirements specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation. The tasks to be implemented for contaminant control, and the engineering design and specifications for each corrective measure, are the focus of the document.
CAP	**NDEP Contaminant Control CAP Review**	NDEP reviews the preliminary draft along with the Contaminant Control Corrective Action Plan and prepares comments, if appropriate. Review criteria are based on guidelines specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation. NDEP approval of the Contaminant Control CAP is required prior to initiating any elements of the CAP implementation or related activities.
	Implement CAP	Elements of the Contaminant Control Corrective Action Plan are carried out by DOE. This involves the implementation of each corrective measure task specified in the CAP. DOE develops the schedule and keeps NDEP informed of progress as the work continues. NDEP may inspect or review completed elements of the work at intervals deemed appropriate throughout the implementation of the CAP.

PROCESS SECTION	*BLOCK DESCRIPTOR*	*DEFINITION OF THE PROCESS STEP*
	Develop Monitoring CAP	DOE prepares the Monitoring Corrective Action Plan which specifies the monitoring required. The structure of the plan is based on requirements specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation. The plan outlines the monitoring strategy and its basis, the engineering design and specifications for the monitoring well network, the post-closure plan, and a 5-year proof of concept phase. Additionally, the planned monitoring and reporting procedures are specified including: sampling frequency; analytes to be sampled for; the data reporting, data validation, and analysis of results to be periodically performed.
	NDEP Monitoring CAP Review	NDEP reviews the preliminary draft along with the Monitoring Corrective Action Plan and prepares comments, if appropriate. Review criteria are based on guidelines specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation. NDEP approval of the Monitoring CAP is required prior to initiating any elements of the Monitoring CAP implementation or related activities.
CAP	**5-Year Proof of Concept Monitoring**	A 5-year proof of concept monitoring network will be developed in accordance with the CAP. This phase of monitoring will use groundwater wells in a monitoring network to determine if the monitoring network design will provide adequate CAU surveillance. Measurements of field parameters will be used to demonstrate that the model is capable of making reasonable predictions that fall within an acceptable level of confidence. Model validation, to ensure fidelity of the model to the physical system, will utilize a ten-step protocol to demonstrate that a model has been developed which meets user needs. These ten steps are: 1) Establishment of model purpose, 2) Development of conceptual model, 3) Selection of a computer code and verification of code, 4) Model design, 5) Model calibration, 6) Sensitivity and uncertainty analyses, 7) Model verification, 8) Predictive simulations, 9) Presentation of model results, and 10) Postaudit. The validation postaudit step tests whether the model can predict future system behavior. The five-year proof of concept is the model postaudit to establish, within a longer time frame, that the model is capable of producing meaningful results with an acceptable degree of uncertainty. Model validation is substantiated once all ten steps are shown to have been acceptably completed.
	Are Monitoring Results Acceptable to NDEP?	NDEP reviews the results of the 5-year proof of concept monitoring and determines if they are acceptable.

PROCESS SECTION	***BLOCK DESCRIPTOR***	***DEFINITION OF THE PROCESS STEP***
CR	**Develop Closure Report**	If the results of the pre-closure monitoring fall within limits previously defined in the Monitoring CAP, a Closure Report will be prepared to propose that the CAU be designated a closed site. The closure report will describe the results of closure, establish long-term monitoring requirements for the CAU, develop technical and administrative contingency plans for actions to be taken if long-term monitoring results are not acceptable, and define future land-use restrictions. The structure of the report is based on requirements specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation.
	NDEP Closure Report Review	NDEP reviews the preliminary draft along with the Closure Report and prepares comments, if appropriate. Review criteria are based on guidelines specified in the most recent document outline agreed to by DOE and NDEP prior to document preparation. NDEP approval of the Closure Report is required prior to initiating any Long-Term Closure Monitoring-related activities.
	Long-Term Closure Monitoring	DOE performs long-term monitoring in accordance with the specific monitoring requirements stated in the Closure Report. NDEP reviews periodic monitoring results and ensures that the monitoring provisions in the Closure Report are followed.
	Propose New Strategy	If the current strategy is found not to be achievable, a new strategy will be proposed by DOE.
	Negotiate With NDEP	Following the proposal of a new strategy, NDEP will review the new strategy. NDEP and DOE will negotiate the overall approach and general conditions of the strategy.
	Develop New Strategy	Once a consensus regarding the general conditions of the strategy has been reached between DOE and NDEP, DOE will fully develop the details of the new strategy.
	Execute New Strategy	DOE and NDEP implement their respective tasks, as outlined in the new strategy.