U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
OFFICE OF QUALITY ASSURANCE

AUDIT REPORT

OF

CIVILIAN RADIOACTIVE WASTE MANAGEMENT SYSTEM
MANAGEMENT AND OPERATING CONTRACTOR

LAS VEGAS, NEVADA

AUDIT M&O-ARP-98-02

NOVEMBER 17 through NOVEMBER 21, 1997

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1.0 EXECUTIVE SUMMARY

As a result of Quality Assurance (QA) Performance Based Audit M&O-ARP-98-02, the audit team determined that the Civilian Radioactive Waste Management System Management and Operating Contractor (CRWMS M&O) is satisfactorily implementing an effective QA program and process controls for repository design, and is producing quality design products.

The audit was performed based on reviews of the pertinent documentation relative to selected repository design deliverables, interviews with management and design personnel responsible for the process and products, followup to the past Mined Geologic Disposal System (MGDS) Design Control Audit (YM-94-01) and direct observations of the design process. The audit team analyzed and evaluated information gained throughout this process in order to make a determination whether or not the performance was satisfactory.

The audit team identified three deficiencies during the audit requiring the issuance of two Deficiency Reports (DRs) relative to design processes. One additional deficiency was found to be adequately addressed in the open DR YM-97-D-080. These conditions are described in Section 5.5.1 and 5.5.3 respectively. Additionally, there were eight recommendations resulting from the audit, which are detailed in Section 6.0 of this report.

The audit team found the problems identified in the previous audit to have been adequately resolved and that the current deficiencies do not impact the quality or integrity of the resultant end products. The design program now in place is effective and satisfactorily implemented.

2.0 SCOPE

This performance based audit of the CRWMS M&O contractor was a limited scope audit of Repository Design in Las Vegas, Nevada conducted by a team of auditors from the Office of Quality Assurance (OQA) and a Technical Specialist from the Yucca Mountain Site Characterization Office. While some design activities are being performed by the CRWMS M&O outside of Las Vegas, the activities have been surveilled by OQA independent of this audit. The audit team evaluated the effectiveness of selected design processes, and the quality of the resultant end products (detailed below) through an assessment of the design to the critical process steps developed by the audit team and the CRWMS M&O management organization. The audit was intended to determine the degree to which repository design results meet program requirements, e.g., Quality Assurance Requirements and Description (QARD) document (Department of Energy (DOE)/RW-0333P, Revision 7), Section 3.0, and management

commitments and expectations.
The processes/end-products for the repository design were evaluated during the audit, in accordance with the audit plan.

PROCESS/ACTIVITY/END-PRODUCT

The following deliverables were evaluated during the audit:

- Repository Thermal Loading Management Analyses
  B00000000-01717-0200-00135 R00
- Repository Subsurface Layout Configuration Analysis
  BCA000000-01717-0200-00008 R00
- Overall Development and Emplacement Ventilation Systems
  BCA000000-01717-0200-00015 R00
- Repository Surface Design Site Layout Analysis
  BCB000000-01717-0200-00007 R00
- Drift Ground Support Design Guide
  BCAA00000-01717-02500-00001 R00
- Q-Repository Drawings associated with the above analyses

The performance-based evaluation of process effectiveness and product acceptability was based on:

1. Satisfactory implementation of the critical process steps.
2. Demonstrated adherence to management and performance objectives.
3. Use of trained and qualified personnel working effectively.
4. Documentation that substantiates the quality of the products.
5. Acceptable results and adequate end products.

TECHNICAL AREAS

The audit included a technical evaluation of process effectiveness and product acceptability. Details of the technical evaluation are included in Section 5.4.

3.0 AUDIT TEAM AND OBSERVERS

The following is a list of audit team members, their assigned areas of responsibility, and observers:

Individual	QA Program Element/ Products or Processes
Kenneth O. Gilkerson, OQA/QATSS, Las Vegas, NV, ATL	3.0/ Selected Design Analyses/Guide
Dan Tunney, OQA/QATSS, Las Vegas, NV, Auditor	3.0/Selected Design Analyses/Drawings
John F. Pelletier, OQA/QATSS, Livermore, CA, Auditor	3.0/Selected Design Analyses/Drawings
Emily Reiter, OQA/QATSS, Las Vegas, NV, Auditor	3.0/Selected Design Analyses/Drawings
Jim Gardiner, DOE, YMSCO, Las Vegas, NV, Technical Specialist	3.0/Selected Design Analyses/Drawings

William Belke, Observer, U.S. Nuclear Regulatory Commission (NRC)
Chad Glenn, Observer, NRC
Susan Zimmerman, Observer, State of Nevada
James Grubb, Observer, State of Nevada

4.0 AUDIT MEETINGS

The preaudit meeting was held at CRWMS M&O facilities at Summerlin in Las Vegas, Nevada, on 11/17/97. A daily debriefing and coordination meeting was held with CRWMS M&O management and staff, and daily audit team meetings were held to discuss issues and potential deficiencies. The audit was concluded with a postaudit meeting held at the CRWMS M&O facilities in Las Vegas, Nevada on 11/21/97. Personnel contacted during the audit are listed in Attachment 1 of this report. This list includes an indication of those who attended the preaudit and postaudit meetings.

5.0 SUMMARY OF AUDIT RESULTS

5.1 Program Effectiveness

The audit team concluded that the CRWMS M&O, with the

exception of the areas identified in three deficiencies, is satisfactorily implementing an effective QA program and process controls for repository design and produces a quality design product. The audit team found the problems identified in the previous audit (YM-94-01) to have been adequately resolved, and that the current deficiencies do not impact the quality or integrity of the resultant end products. This conclusion was supported by the determination that the design organization's critical process steps were appropriately implemented; management and performance objectives were accomplished using trained and qualified personnel working effectively; documentation was provided that substantiated quality of the product; and, the results and quality of the end products were acceptable.

5.2 Stop Work or Immediate Corrective Actions or Additional Actions

None

5.3 QA Program Audit Activities

A summary table of audit results is provided in Attachment 2. The details of the audit evaluation, along with the objective evidence reviewed, are contained within the audit checklists. The checklists are kept and maintained as QA Records.

5.4 Technical Activities

The Repository Design Analyses selected for evaluation were found in general to be satisfactory, with the exception of the deficiencies identified in the following paragraphs (5.5.1 and 5.5.3). While there were no specific conditions which directly impacted the results of the analyses, improvements in the processes can be made. These are identified in Section 6.0 as process recommendations. It was recognized during the audit that CRWMS M&O design personnel were adhering to the design processes depicted in the MGDS Design Guidelines Manual (DGM) although recommendations are made in Section 6.0 to clarify the processes.

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Several generic observations for all of the repository analyses reviewed were discussed with the audit team and design personnel. The analyses output data and drawings were not considered qualified because most of the data and design inputs used were To Be Verified (TBV) or To Be Determined (TBD). Consequently, the analyses and output drawings prohibited their use in construction, procurement, fabrication, or release as design inputs. (See process recommendation number two in Section 6.0). Similarly, the extensive use of unqualified data throughout these analyses may have an adverse impact on the

CRWMS M&O ability to identify what data is necessary for qualification, know where it is used, and qualify the data in a timely manner. (See recommendation number three in Section 6.0). The process of updating Q-List classifications are not being performed until at this stage of design until completion of the System Design Documents and the actual preparation of the final analysis. Also, it was noted that presently there is no active effort to assign a Configuration Item (CI) program to any of the repository items. CIs are primarily only assigned to items ready for baselining. Given the nature and stage of these analyses, the CRWMS M&O is not applying this program at this time, although the Technical Specialist considers that the CI system should be worked continuously with all the analyses with an active interface.

Specific comments relative to the assessments of the selected analyses are as follows:

REPOSITORY THERMAL LOADING MANAGEMENT ANALYSIS, Revision 00
The purpose of this analysis was to 1) select a thermal loading value for the Viability Assessment repository subsurface design with the mass loading range (80 to 100 metric tons of uranium (MTU)/acre) recommended by the Controlled Design Assumptions Document and 2) to evaluate emplacement drift and waste package spacings to provide an efficient waste emplacement strategy. The overall objective was to develop a plan and strategy to emplace the statutory 70,000 MTU at an areal loading that meets defined thermal goals and to integrate the emplacement plan with the overall repository design.

Technical Summary
Design inputs for the analysis included a design parameter, criteria, and assumptions. Design inputs obtained from external sources included a physical constant, engineered barrier and repository design requirements, High-Level Waste and Spent Nuclear Fuel waste stream data, Waste Package dimensions, mass loading range, repository horizon, site geology and thermal/mechanical stratigraphy, properties of steel, and thermal goals. The analysis also identified assumptions generated by the originator. The audit team checked a sample of the external design inputs and found these to be traceable to and consistent with the sources. The analysis originator maintained a copy of the pertinent pages from reference material in a binder. This was deemed to be a good practice because it made it easy to check design inputs against the source. As a result of evaluating the source material, the audit team generated a process recommendation regarding qualification of data, identification of data qualification status, currency of data in the Reference Information Base, and establishing a point of contact and interfaces for data obtained from non-Office of Civilian Radioactive Waste Management (OCRWM) DOE sources. (See process recommendation number three for details).

The use of inputs in the analyses was evaluated and found to be satisfactory. This

included checking that the calculations incorporated the design input and the results of previous calculations. The following calculations were checked: Waste Package Spacing, Comparison of Annual High-Level Waste Arrival and Spaces Available, Minimum Number of Waste Packages, Waste Package Emplacement Schedule and Required Drift Lengths, High-Level Waste - Savannah River Site Heat Output, Waste Package Average Mass Content, Waste Package Average Initial Heat Output, Average Thermal Decay for all Waste Packages, Heat Flux for Large-21-Pressurized Water Reactor Waste Package, Heat Flux for Large-44-Boiling Water Reactor Waste Package, Heat Flux for Small-12-Pressurized Water Reactor Waste Package, Heat Flux for High-Level Waste Package.

ANSYS Version 5.2 software was used in the analysis to develop two-dimensional models and three-dimensional models for various emplacement scenarios to determine temperature maximums. The use of these models was within the range of validation provided in the software qualification report. The software was obtained from Software Configuration Management in accordance with appropriate procedures. However, a statement attesting to this was not included in the analysis. A Deficiency Report was generated by the audit team. (See DR LVMO-98-D-014 for details). This deficiency did not appear to have impact on the analysis or its conclusions.

This analysis was used as output in two drawings (Emplacement Plan for 70,000 MTU of Waste and Waste Package Emplacement Arrangements). The details of these drawings were consistent with the analysis.

Prior to approval, the analysis and drawings were checked, reviewed, and final checked. Checklists where used to facilitate the checking process and this was deemed to be a good practice. Although not required by procedure, calculations which developed data used as input to the computer models were checked prior to running the applications. This was deemed to be a good practice, and it is recommended that this type of checking be incorporated in the DGM. (See process recommendation number eight for details).

A summary of some important conclusions in this analysis is as follows:

a. Waste stream data were acquired, thermal goals were identified, average spent fuel and waste characteristics were identified.

b. An Areal Mass Loading of 85 MTU/acre was recommended.

c. The maximum practical drift spacing was identified as 28 meters.

d. Average waste package spacings and desirable arrangements were identified. Restrictions on arrangements were identified.

e. Emplacement strategies were evaluated and compared. The analysis recommended that the Equivalent Energy Distribution approach be considered in future thermal management studies.

f. The length of useable emplacement drift needed was identified as approximately 107,150 meters. The analysis recommended the use of multiple active emplacement drifts available all the time during waste emplacement.

Overall, the Repository Thermal Loading Management analysis and the associated drawings were found to be of excellent quality.

REPOSITORY SUBSURFACE LAYOUT CONFIGURATION ANALYSIS, Revision 00

The purpose of the Repository Subsurface Layout configuration Analysis was to develop a repository layout for the statutory capacity of 70,000 MTU, or equivalent, with a degree of flexibility to accommodate potential changes in site conditions or programmatic requirements. The objective of the analysis is to provide a repository subsurface layout for the Viability Assessment (VA) design in accordance with the current waste isolation strategy.

Technical Summary

In general, this analysis was found to be satisfactory, except for the deficiency identified in Section 5.5.1 relating to design inputs. Additionally, there were several areas where improvements to the current design process could be made. These improvements are discussed as process recommendations in Section 6.0.

A sample of design inputs (design parameter, criteria or assumption) were taken from this analysis and traced back to their source. This included a sample of inputs taken from design and regulatory sources, as well as engineering assumptions. The audit team identified a deficiency that the Repository Subsurface Layout Configuration Analysis does not identify the source of coordinates of where boreholes intersect the repository level. In addition, borehole locations are not shown on Figure 7-1 as indicated by this analysis. Although a violation of CRWMS M&O procedures, the audit team concluded that since the design inputs were found to be traceable and consistent to their source, there was no adverse impact on the analysis. A Deficiency Report was generated for this and other issues. (See DR LVMO-98-D-014 in Section 5.5.1). Specific examples of other design inputs checked, as well as the objective evidence reviewed, are contained within the audit checklists. As a result of evaluating the design inputs and the vast number of TBVs and TBDs, the audit team generated process recommendations regarding the qualification of data, identification of the data status (“Q” versus “Non Q”), and to develop a method to track and control the TBVs and TBDs. (See process recommendations two and three in Section

6.0).

The use of design inputs in the analyses were also evaluated and found to be satisfactory. This included spot checking calculations used throughout the analyses and verifying the results against previous calculations. Specific examples of the calculations checked, as well as the objective evidence reviewed, are contained within the audit checklists.

The use of computer software in this analysis (LYNX Version 3.06) was also evaluated and determined to be satisfactory. A sample of software used in the analysis was identified and verified to be in the software configuration management system and in the associated software qualification packages reviewed. Additionally, a process recommendation was made relative to the current configuration management process. (See process recommendation number five in Section 6.0 for details).

This analysis was used to generate several output drawings; however, due to the vast number of TBVs and TBDs, all the drawings were identified as preliminary and not intended for construction, procurement or fabrication. A number of drawing inputs were checked against the drawings inputs list and found that the drawing inputs as well as the details of the drawings to be consistent with their associated analysis. A complete listing of the drawings associated with the analysis can be obtained from the drawings input list. Specific examples of the drawings checked as well as the objective evidence reviewed are contained within the audit checklists.

The Technical Specialist raised specific concerns in this analysis that were addressed during the audit. Discussions were held relative to the test niche floor. The test niche floor had a 0% slope (page 10 figure 4.2). Most other floors of the tunnel and niches are sloped for water control. The designers indicated that the test niches coincide with future tunnel turnouts and will be drilled out at some later date. As for temporary water control, the designers indicated that an evaluation was previously performed for the overall test that was to be conducted within the niche, and, the impact of potential water was taken into account in that evaluation. The use of TBVs for the ESF opening dimensions was also questioned. An explanation was provided that there have been no approved “as-builts” made of the ESF, and that the data they now have cannot be considered as “qualified.” It seems that this data could be verified such that TBVs would not be necessary. (See Section 6.0 process recommendation numbers two and three relative to the extensive use of TBVs and unqualified data throughout these analyses). Other concerns addressed included differences in verbiage between “maximum possible flood” and “probable maximum flood,” and the rationale identifying emplacement drift size as TBD (page 20, sect. 4.3.10), while later in this section giving a size of 5.5 meters. These issues were adequately addressed by design personnel in subsequent discussions.

Overall, the technical adequacy for the development of the design analysis for the Repository Subsurface Layout Configuration Analysis was determined to be satisfactory.

REPOSITORY SURFACE DESIGN SITE LAYOUT ANALYSIS, Rev 00
The purpose of the Repository Surface Design Site Layout Analysis was to establish the arrangement of the Repository surface facilities and features near the North Portal, and to provide a suitable level of design for the Viability Assessment. The analysis updates and expands the North Portal area site layout concept presented in the Advanced Conceptual Design.
Technical Summary
In general, this analysis was found to be satisfactory. There were several areas where improvements to the current design process could be made. These improvements are discussed as process recommendations in Section 6.0.

A sample of design inputs (design parameter, criteria or assumption) were taken from this analysis and traced back to their source. This included a sample of inputs taken from design and regulatory sources, as well as engineering assumptions. The design inputs checked, as well as the objective evidence reviewed, are contained within the audit checklists. As previously identified, the audit team generated process recommendations (numbers two and three) regarding the qualification of data, identification of the data status, and to develop a method to track and control the TBVs and TBDs.

The use of design inputs used in the analysis was also evaluated and found to be satisfactory. For example, the quantity for the Probable Maximum Flood precipitation rate of 28 inches per hour and the rainfall intensities of 2.1, 2.3, and 2.6 (reference 5.13 Storm Water Drainage) were tracked back to its source. These values were found to be accurate per the source but were from unqualified sources (i.e., TBV/TBD). (See process recommendations two and three in Section 6.0). This evaluation also included spot checking calculations used throughout the analyses and verifying the results against previous calculations. Specific examples of the calculations checked, as well as the objective evidence reviewed, are contained within the audit checklists.

This analysis was used to generate several output drawings; however, due to the vast number of TBVs and TBDs, all the drawings were identified as preliminary and not intended for construction, procurement or fabrication. A number of drawing inputs were checked against the drawings inputs list and found the drawing inputs, as well as the details of the drawings, to be consistent with their associated analysis. A complete listing of the drawings associated with the analysis can be obtained from the drawings input list. Specific examples of the drawings checked, as well as the objective evidence reviewed, are contained within the audit checklists.

An evaluation of the reviews of the analysis determined that not all comments were addressed as required by CRWMS M&O procedures. Three specific conditions were found while verifying comment resolution incorporation (e.g., incorrect reference listed as 5.7 instead of 5.6, section 4.1; comment not incorporated in section 4.2.8; application of what a TBV applied to, section 4.1.6). These anomalies were identified during a review of thirteen of the thirty-nine total pages in this analysis. The audit team addressed these deficient conditions by adding them to the specific conditions cited in the existing deficiency document YM-97-D-080. In addition, there were other questionable conditions found for which resolution could not be readily determined without recourse to the reviewer and originator. For example, based on a comment questioning a value with respect to the number of acres needed for dry storage (220 acres in revision 00b), a new value was provided (350 acres in revision 00c) without calculations in the analysis to support this change or other justification. It was demonstrated through conversation with the designers that the 350 figure was correct. Without direct contact with the designers this could not have been resolved. Most of the questionable comments were nonmandatory and editorial in nature. While there were no specific conditions which were shown to have a direct impact on the analysis that would invalidate or change it, the quality of the work and attention to detail could be improved. (See also process recommendation number six in Section 6.0).

Other issues addressed during the evaluation of this analysis included the application of DOE orders, such as 6430.1A. The analysis made specific reference to 6430.1A (i.e., Repository Design Requirements Document flow down), and determined it to be adequate. It is unclear as to how recent revisions of DOE orders are to become effective. Another issue that was discussed addresses the railroad rail curvatures listed in Section 4.3.3.4. Two railroad rail curvatures listed appeared to conflict with each other. These radii were 20 meters and 360 feet. Clarification by the designers indicated the 360 feet radii was for tracks entering the Waste Handling Building (WHB) from the offsite boundary side, the 20 meter radii was for the exit of the WHB where a different set of criteria/requirements applied.

Overall, the technical adequacy for the development of the design analysis for the Repository Surface Design Site Layout Analysis was determined to be satisfactory.

OVERALL DEVELOPMENT AND EMPLACEMENT VENTILATION SYSTEMS, Rev 00

The purpose of the Overall Development and Emplacement Ventilation Systems analysis was to develop an overall ventilation system for the repository subsurface Repository Surface Design Site Layout Analysis emplacement operations and development activities. The scope covers emplacement and development side

ventilation systems and separation of these systems. Conditions includes normal and abnormal situations and phases of repository construction and operations.

Technical Summary

In general, this analysis was found to be satisfactory, although two deficiency documents were identified relative to this analysis. One dealt with the absence of a statement attesting to obtaining software from Software Configuration Management, and the other addressed the appropriate qualification and selection of software prior to use. These deficiencies are described in Section 5.5.1. There were several areas where improvements to the current design process could be made. These improvements are discussed as process recommendations in Section 6.0.

The analyses output data and drawings were not considered qualified because most of the data and design inputs used were TBV or TBD. It also was noted during the audit that Table 4.1.6 (page 13) was not indicated as being TBV data. The data presented in Table 4.1.6 of the analysis was traced back to its source reference 5.17, *Thermal Loading Study for FY96*, Vol II of II which is a QA/L report. The data from this reference was accurately duplicated in this analysis. The data is considered TBV, although it was not indicated as such in the analysis. The CRWMS M&O will be asked correct this as part of their response to LVMO-98-D-014. (See also process recommendations two and three in Section 6.0).

A sample of design inputs (design parameter, criteria or assumption) was taken from this analysis and traced back to their source. This included a sample of inputs taken from design and regulatory sources, as well as engineering assumptions. References 5.9 (*Evaluation of Waste Package Transport and Emplacement Equipment*) and 5.29 (*Non-Gassy Mine Classification Analysis*) were checked. Reference 5.9 was a qualified report, but based on numerous TBV/TBDs, use of old data and reports need to be given additional consideration. For example, reference 5.29, *Non-Gassy Mine Classification Analysis*, is a report developed in 1993 under a previous Contractor QA program. The use of the analysis as a qualified input was evaluated, in light of the fact that it was developed in 1993 under CRWMS M&O design processes determined to be unsatisfactory in the CRWMS M&O Audit YM-94-01. This analysis (reference 5.29) had never been re-evaluated or reviewed under the revised CRWMS M&O Design Control program, to assure that the design process problems associated with Design Package 2C were not present in this analysis. A process recommendation (number seven) was made relative to this issue and is described in Section 6.0. The design inputs checked, as well as the objective evidence reviewed, are contained within the audit checklists. As previously identified, the audit team generated process recommendations (numbers two and three) regarding the qualification of data, identification of the data status, and to develop a method to track and control the TBVs and TBDs.

The repository layout in the analysis was from a “figure 7.1." Figures are not controlled on the project except as may be done within the revision of the analysis itself. CRWMS M&O design personnel identified that this figure came from reference 5.5, *Repository Subsurface Layout Configuration Analysis*. Figures may be converted into drawings later as required, and are then under drawing control. Impact analyses are to be done when drawings or analysis are revised (per NLP 3-26); but, it is generally not known in how many places a drawing or figure is used, which makes it difficult to determine all the affected locations.
The audit team as part of followup to the Design Control Audit YM-94-01 examined the analysis in respect to “lessons learned.” The issues relative to insufficient air flow, dust control and use of water experienced in the Exploratory Studies Facility (ESF) Tunnel design and construction influenced the selection and type of ventilation system for repository design (e.g. Flexible Bag Type). Another observation relative to this analysis is that while this analysis is primarily a scoping analysis developed in conjunction with broad based risk analyses (e.g., release of radiation issues); fire protection, repository flooding and other unusual occurrences will be addressed in other analyses as part of License Application (LA), not VA.

Additionally, the analysis does not take the impact of organic contaminants into consideration (e.g., use of diesel) for repository design. There is an assumption that all equipment would be mechanical or electrical. At such time an introduction of organics becomes a consideration, there would be an impact to the duct size and a new analysis would be necessary. The audit team agreed with the designers that this is a Performance Assessment issue at this stage (scoping), and there is no impact on this analysis for VA.

This analysis review package was examined to ensure that review comments were appropriately addressed or incorporated. It was noted that in two instances, comments identified as nonmandatory were not addressed or incorporated. A comment on figure 7.1 VA Layout of the Subsurface Repository and a comment in paragraph 7.7.1 were not addressed. The CRWMS M&O program requires that they address all comments regardless of mandatory versus nonmandatory. The audit team determined that this issue along with the comment issues identified in the Repository Surface Design Site Layout Analysis would be addressed in the existing deficiency document YM-97-D-080.

The use of computer software used in this analysis was also evaluated resulting in the identification of two deficient areas. A sample of software used in the analysis was identified and verified to be in the software configuration management system and in the associated software qualification packages reviewed. Based on the review of the qualification package for the VNETPC Version 3.1, software which was qualified relative to the ESF design was used in the Overall Development and Emplacement Ventilation Systems analysis without performing an impact review of the software qualification. DR LVMO-98-D-015 was

generated (detailed in Section 5.5.1). DR LVMO-98-D-014 (also detailed in Section 5.5.1) identifies this analysis failed to include a statement that the software was obtained from Software Configuration Management. Additionally, a process recommendation was made relative to the current configuration management process. (See process recommendation number five in Section 6.0 for details).

Overall, the technical adequacy for the development of the design analysis for the Overall Development and Emplacement Ventilation Systems Analysis was determined to be satisfactory with the exception of deficiencies denoted in the two DRs previously cited.

DRIFT GROUND SUPPORT DESIGN GUIDE R00
The purpose of this design document is to provide a consistent format and methodology for the development of design products (drawings, specifications and analyses). This particular "guide" is a design-topic-specific document for ground support. The Drift Ground Support Design Guide was provided as a deliverable for Repository Design.

An examination of this guide raised question as to just what is its scope and role in design. It is not defined nor described in any CRWMS M&O design procedure; it is not identified in any design process flow charts; it is not defined nor described in the CRWMS M&O MGDS DGM which was provided by the CRWMS M&O as the key to evaluating their design process.

A review disclosed that this guide addresses scope, applicability, quality assurance, design inputs, methodology, performance verification, and references similar to analyses and specification design documents. The review of this document disclosed that it was developed in a consistent and uniform manner and provided design methodology and design detail consistent with what one might expect to find in a "design specification." In some areas it provided "general" design guidance; in other areas it provided specific guidance (i.e., qualitative and quantitative criteria).

Interviews of CRWMS M&O design personnel disclosed that this document is considered a preliminary document to present alternative approaches to design. There appeared to be differences of opinion as to what this document actually is (a guide, a design specification, a design standard, input to design analyses, a requirements versus a guidance document, etc.). It was agreed that it was not a final product and needed to be clearly defined in the CRWMS M&O design program.

Discussions were held with the originator of this Design Guide with respect to specific issues. The document states that it will be a basis for design for LA. The CRWMS M&O perceives that this document at this stage is in early development

and as it is revised and becomes a final document, it will be used in LA not VA. The adherence to this document is currently by management direction. Since this is a "Q" product, adherence needs to be by program (i.e., procedures) rather than management direction. Specifics provided in this guide do not always provide a basis or justification; e.g., a 4% value given for inside diameter liner deformation actually was obtained from the Thermo-Mechanical Analysis, but this is not

referenced. In other cases thermal analysis parameters are shown without providing any absolute values. Performance Verification (Section 6 of the guide) identifies what performance verification consists of but does not identify the criteria that the performance is verified to. These issues were all agreed to by the originator and need to be resolved by revision to the guide. A process recommendation was made relative to the Drift Ground Support Design Guide, specifically, and to topic-specific design guides generically.

Currently, these documents are developed under a Technical Document Preparation Plan (TDPP) for Design-Topic-Specific Design Guides used by the Repository Design Department dated February 28, 1997 (BC000000-01717-4600-00005 R00). TDPPs are developed in accordance with CRWMS M&O procedure QAP-3-5. A process recommendation (number one) was made relative to clarifying the use and definition of these documents.

5.5 Summary of Deficiencies

The audit team identified three deficiencies during the audit requiring the issuance of two DRs relative to design processes. One additional deficiency was found to be adequately addressed in the open DR YM-97-D-080. A synopsis of the deficiencies documented are detailed below. The DRs generated during this audit have been transmitted under separate cover to CRWMS M&O.

5.5.1 DR

As a result of the audit, the following DRs were issued:

LVMO-98-D-014
Per QAP-3-9, (1) the originator must determine that any software used was obtained from Software Configuration Management in accordance with appropriate procedures, and a statement must be provided to attest to this determination; and, (2) Design Inputs and their sources shall be identified and documented. (1) Statements attesting that software was obtained from Software Configuration management in accordance with appropriate

procedures were not provided for two design analyses. (2) The "Repository Subsurface Layout Configuration Analysis" does not identify the source of coordinates of where boreholes intersect the repository level and borehole locations are not shown on Figure 7-1, as indicated by this analysis. Additionally, Table 4.1.6 in the "Overall Development and Emplacement Ventilation Systems" analysis is not flagged as TBV/TBD as required.

LVMO-98-D-015
The QARD Supplement I requires that the use of software be independently reviewed and approved to ensure that the software selected is suitable to the problem being solved. The VNETPC software used in "Overall Development and Emplacement Ventilation Systems" analysis (1997) was verified and validated (1993) relative to ESF Design. It was subsequently used in this analysis to support Subsurface Repository Design, without performing an impact review of the existing qualification to the changes in the QARD/SI Procedures to identify any impacts. Additionally, the software was not qualified in accordance with current software procedures as required.

5.5.2 Deficiencies Corrected During the Audit

None

5.5.3 Follow-up of Previously Identified CARs

A total of twenty-one deficiencies were reviewed during the audit. The review included both CRWMS M&O and OQA initiated deficiencies. Seven CRMWS M&O initiated DRs, five CRMWS M&O initiated Performance Reports (PR), three OQA initiated Corrective Action Requests, five OQA initiated DRs reports, and one OQA initiated PR were reviewed. With the exception of one DR initiated originally by the CRWMS M&O, and rolled over into an OQA generated DR, the review of deficiencies revealed that appropriate and effective remedial corrective action and action to preclude recurrence was implemented by the CRWMS M&O. The audit team has recommended to the OQA, QA Representative that YM-97-D-080 remain open, and new remedial/corrective actions be obtained, due to the additional concerns identified in the review of the comment resolution process. The audit team determined that no significant adverse trends were identified during the audit. Overall, the CRWMS M&O is satisfactorily and effectively implementing an adequate corrective action process relative to Repository Design. The deficiency documents reviewed are as follows:

YM-95-C-007	LVMO-95-D-003	LVMO-96-P-022
YM-95-C-033	LVMO-96-D-005	LVMO-96-P-023

YM-95-C-039	LVMO-95-D-007	LVMO-97-D-013
YM-96-D-036	LVMO-95-P-001	LVMO-95-D-005
YM-95-D-013	LVMO-96-D-055	
YM-96-D-072	LVMO-96-D-056	
YM-96-D-092	LVMO-96-P-018	
YM-97-D-080	LVMO-96-P-020	
YM-97-P-019		

6.0 RECOMMENDATIONS

The following recommendations resulted from the audit and are presented for consideration by CRWMS M&O management.

1) A process recommendation relative to clarification to the definition and use Topic Specific Design Guides is suggested for clarification and improving the program. Reviews of the Drift Ground Support Design Guide suggest that the document provides more than an approach to design, i.e., it provides specific design methodology with quantitative and qualitative criteria. This raises questions as to whether it is a guidance or a requirements document. This document is not addressed in the DGM, design flowcharts or in any procedures. If this document is to be used for repository design it needs to be clearly defined, described and controlled. Additionally, specific recommendations for improvement of the specific product reviewed (Drift Ground Support Design Guide) follows.

   Since this is a “Q” product, adherence needs to be by program (i.e., procedures) rather than management direction. Specifics provided in this guide do not always provide a basis or justification; e.g., a 4% value given for inside diameter liner deformation came from the Thermo-Mechanical Analysis, but is not referenced. In other cases, thermal analysis parameters are shown without providing any absolute values. Performance Verification (Section 6 of the guide) identifies what performance verification consists of, but does not identify the criteria that the performance is verified to. These issues were all agreed to by the originator and need to be addressed by revision of the design guide.

2) A process recommendation relative to the control of TBVs is provided as follows: A number of Design Inputs (TBVs) relating to Design Parameters & Design Assumptions have been identified throughout the “Overall Development and Emplacement Ventilation Systems” & “Repository Subsurface Layout Configuration Analysis” & “Repository Thermal Management Analysis,” without a consistent methodology for identifying and controlling these TBVs. It is recommended that CRWMS M&O management develop a process to track and control the TBVs to ensure that they are incorporated into the final analysis.

3) The following Process Recommendation addresses concerns relative to the identification and use of data to include:

a. Develop strategy for qualification of unqualified data to support design effort.

The Repository Thermal Loading Management Analysis uses unqualified data from the Reference Information Base including values for upper and lower contacts, in situ bulk density, thermal conductivity, and thermal capacitance. Unqualified data directly relied upon to address safety and waste isolation issues are required to be qualified at appropriate times during the scientific investigation and design process and before: OCRWM acceptance of DOE-owned high-level waste or spent nuclear fuel, submittal of the LA, relying on the item, for which data were used as design input, to perform its function, or data is relied upon to resolve safety or waste isolation issues. A Repository Design Data Needs document has been developed to identify what and when data are needed. It is recommended that an evaluation be performed to determine which unqualified data used in design of the Repository will require qualification, when these will be qualified, how these will be qualified, and who will qualify these.

b. Method for identification of data qualification status not consistent.

The level of detail and method for identification of unqualified data are not consistent throughout design documents. Some analyses use only "TBV" to identify unqualified data" (e.g., Section 4.3.21 of analysis BCA000000-01717-0200-00008, Rev. 00, "Repository Subsurface Layout Configuration Analysis"), others use "Q" and "Non-Q" designators to distinguish qualified from unqualified for each subset of a data set (e.g., Attachment I of BCA000000-01717-0200-00007, Rev. 00, Determination of Available Volume for Repository Siting). It is recommended that guidelines be developed on how to designate the qualification status of data.

c. Maintain current data in reference information base

Reference Information Base data for Site Geology (Section 1.1326) and Thermal/Mechanical Stratigraphy (Section 1.12b.) were used as input in the Repository Thermal Loading Management Analysis. These sections were last updated in 1992. There appears to be a concern that the Reference Information Base may not reflect the current available data. It is recommended that management take actions necessary to ensure that data in the Reference Information Base are maintained current.

d. Establish control point and interfaces for data obtained from non-OCRWM DOE organizations

Highest heat output for High Level Waste canisters data, obtained from DOE/RW-0184, "Characteristics of Potential Wastes," were used as input in the Repository Thermal Loading Management Analysis. This document was generated by a DOE organization outside of OCRWM and controlled versions were unavailable. Although DOE/RW-0184 identified these data as qualified, it was not possible to determine whether these had been superseded. It is recommended that the CRWMS M&O establish a control point for document/data generated by non-OCRWM DOE organizations. This control point should establish interfaces with organizations generating data and notify data users of changes so that impacts can be evaluated.

4) The team was asked to assess CRWMS M&O compliance to the MGDS DGM. During the audit, selected areas of this manual were examined. Recommendations to clarify the manual include:

a) clarifying the use and development of the data base that was to provide traceability for each specification/drawing. During the audit, the CRWMS M&O indicated that one had been started for ESF design only, but was not complete. Later it was determined that input from Repository design was going into this database, but the consistency of this was unknown. The DGM needs to be clarified relative to the development and use of this database.

b) updating the DGM since references to organizations, etc are not current.

c) design "guides" not identified as part of design process (see recommendation number one)

It is further recommended that some type of assigned reading (training) be considered for all design personnel expected to follow the DGM.

5) QAP-SI-3, Revision 1, identifies that the Responsible Manager is responsible for establishing new baselines, baseline changes, retirement, ... and defect reports without requiring a list of approved users of the software. It is recommended that CRWMS M&O management develop a centralized software baseline list that identifies the software applications to the individual users of the software, to ensure that changes to any software applications are identified to the users.

6) A process recommendation relative to enhancing the review process for comment resolution/incorporation is provided. A signature/initial log needs to be established such that one can determine the originator of the comments. The documenting of comment resolutions do not always occur, are incomplete, not clear or otherwise confusing. It is often difficult to understand how a comment was resolved without talking to the reviewer and originator. Recommend that

when such resolutions as “Don’t Agree” are used, a basis or justification should be provided. Incorporation of comments should be more concise and reviewers should assure their comments were appropriately incorporated prior to sign-off.

7) A recommendation is suggested relative to the use of earlier design produced under earlier program requirements. Design products (e.g., 1993 Non Gassy Mine Classification Analysis) that were produced prior to the 1994 Design Control Audit, and not re-evaluated as part of the design process fix and procedural changes as a result of that audit, need to be re-evaluated under current program controls. Recommend developing an impact review methodology for assessing design inputs that were developed under the early CRWMS M&O design program, and are to be used without revision in current 1997 design.

8) A process recommendation was made based on the recognition of a good checking practice. Due to the 21-day run time of the ANSYS software applications for the Repository Thermal Loading Management Analysis, an informal check of the development of input was conducted prior to running the software. This check was in addition to the check required by procedure to be performed after the draft of the analysis was completed. This was deemed to be a good practice because it precluded a rerun of the applications due to data input error. It is recommended that the MGDS DGM endorse this practice for software applications with long run times.

7.0 LIST OF ATTACHMENTS

Attachment 1: Personnel Contacted During the Audit
Attachment 2: Summary Table of Audit Results

ATTACHMENT 1

Personnel Contacted During The Audit

Name	Organization/Title	Preaudit Meeting	Contacted During Audit	Postaudit Meeting
Fred Arth	M&O MGDS Staff Support	X	X	X
Jack Bailey	M&O Acting Deputy General Manager		X	X
Craig Barnes	OQA/QATSS QA Specialist	X	X	X
Robert Barton	DOE/YMP Deputy Assistant Manager Licensing			X
Hugh Benton	M&O Waste Package Manager			X
Ron Berlien	M&O Engineering Assurance	X	X	X
K.K. Bhattacharyya	M&O Repository Design Manager	X	X	X
Frank Bierich	M&O MGDS Repository Design Lead Mechanical Engineer	X		X
James Blaylock	OQA Verification Lead/Engineer			X
Steve Bodner	M&O Technical Data Manager		X	
Saeed Bonabian	M&O ESF Geotechnical Design Engineer		X	
Gary Bowman	M&O Configuration Management Specialist		X	
David Calloway	M&O Configuration Management-Supervisor	X		
Greg Carlise	M&O Configuration Management Specialist		X	
Bob Cikanek	M&O Repository Subsurface Geoengineer		X	
Robert Clark	OQA, Deputy Director	X		
John J. Clark	M&O Development Staff	X	X	X
Betty Cruz	M&O Senior Systems Engineer	X		X
Steve Dana	OQA/QATSS Quality Engineering	X		X
Thomas W. Doering	M&O Waste Package Design . Manager	X		
Robert Dulin	M&O EBS performance Manager	X		
Bob Elayer	M&O MGDS Repository Design Geologist		X	
Douglas Franks	M&O Licensing	X		
Matt Gomez	M&O Subsurface Design Engineer	X	X	X
Jaime Gonzalez	DOE/YMP Engineer	X		
Christine Gorrell	M&O MGDS Repository Design Engineer/Scientist		X	X

Hank Greene	QATSS QA Manager-Verification	X		X
Paul Harrington	DOE/YMP Licensing Team Leader	X	X	
Robert P. Hasson	OQA/QATSS QA Specialist			X
Robert Howard	M&O Product Integrity Group		X	
Bonnie Howe	M&O Engineering Document Control Coordinator		X	
Woody Hudson	OQA/QATSS Program Manager		X	
Romeo Jurani	M&O MGDS Repository Design Lead Mining Engineer		X	
Gene Kimura	M&O MGDS ESF Design	X		
Daniel A. Klimas	OQA/QATSS QA Specialist			X
Larry McGrath	OQA/QATSS QA Specialist			X
Dan McKenzie	M&O MGDS Repository Subsurface Design Supervisor	X	X	X
Steven Meyers	M&O MGDS Repository Surface Design- Lead	X	X	X
Ed Miller	M&O Configuration Management Specialist		X	
Hector Montalvo	M&O MGDS Repository Design Lead Civil Engineer		X	X
Robert A. Morgan	M&O Engineering Assurance		X	X
Richard M. Nolting	M&O MGDS Repository Design Lead Geo-Technical	X	X	X
John W. Peters	M&O Engineering Services-Product Checking Group		X	
John H. Pye	M&O MGDS ESF Lead Geotechnical Engineer		X	
Sam Rindskopf	M&O Requirements, Integration & Configuration Management	X		
Jim Salchak	M&O Engineering Services Manager	X	X	X
Robert S. Saunders	M&O MGDS Repository Design Lead Mining Engineer		X	X
Alden M. Segrest	M&O MGDS Development Manager	X	X	X
Richard D. Snell	M&O Operations Manager/ Engineer & Integration	X	X	X
Roberta Stambaugh	M&O Engineering Standards & Compliance Manager		X	
Yiming Sun	M&O MGDS Repository Design Geotechnical Engineer		X	
David Tang	M&O MGDS Repository Design		X	X

	Geotechnical Engineer			
Malcolm Taylor	M&O MGDS Repository Design LDE- Civil	X		
Gary Teraoka	M&O Project Operations/ Requirements		X	
Frank Van Der Laan	M&O Systems Engineering			X
Bernard J. Verna	DOE/YMP Viability Assessment	X		X
Charles C. Warren	OQA/QATSS Lead- Internal Audit	X		X
Richard Weeks	OQA/QATSS QA Specialist			X
Mary Woods	M&O Engineering Document Control Supervisor		X	X
Hang Yang	M&O MGDS Repository Engineer	X	X	

LEGEND:
ESF- Exploratory Studies Facility
M&O- CRWMS Maintenance and Operating Contractor
OQA- Office of Quality Assurance
QATSS- Quality Assurance Technical Support Services
MGDS- Mined Geologic Disposal System
YMP- Yucca Mountain Project

ATTACHMENT 2

SUMMARY TABLE OF AUDIT RESULTS

QA ELEMENT/ ACTIVITIES	PROCESS STEPS/ MGMT OBJECTIVES	DETAILS (Checklist)	DEFICIENCIES	REC	PROCESS EFF.	PRODUCT ADEQUACY	OVERALL
3.0/ Repository Design - General	Appropriate Personnel assigned. (M/O/CPS)	I-1, I-2, p.2	N	N	SAT	SAT	SAT
	Training/qualification (M/O)	I-1, I-2, p.2	N	N	SAT	SAT	
	Value Added practices: Compliance to Design Guidelines Manual/Resource management (M/O)	I-3, p.3	N	Yes, See process recommend-ation #4	SAT	SAT	
	M&O Management criteria, reviews, schedules	I-4, I-5, I-6 pp.3,4	N	N	SAT	SAT	
	Effectiveness of corrective actions from previous audits/ findings (MO)	I-7, I-8, p.5	YM-97-D080	Yes, See process recomm	UNSAT	SAT	

				end-ation#6			
	Flowchart of Design Processes Design Guidelines Manual Design guides/ SSDs, Design Flowdown (Requirements Documents)(MO/CPS)	I-9, I-11, I-12, I-13 to I-17 pp.6-8 II-3, p.9	N	Yes, See process recommend-ations # 1,4	SAT	SAT	
	M&O Interfaces for work at remote locations (MO)	I-10, p.6	N	N	SAT	SAT	

QA ELEMENT/ ACTIVITIES	PROCESS STEPS/ MGMT OBJECTIVES	DETAILS (Check list)	DEFICIENCIES	REC	PROCESS EFF.	PRODUCT ADEQUACY	OVERALL
3.0/ Repository Design Critical Process Steps	Scope and Applicability	II-1,II-3, p.9	N	Yes, See process recommend-ations # 1, 4	SAT	SAT	
Drift Ground	Design Input	II-5,II-6, P.10	N	Yes, See	SAT	SAT	

Support Design Guide				process recommend-ations # 1, 4			
	Design Methodology	II-1, II-2,II-5,II-6 PP.9-10	N	Yes, See process recommend-ations # 1, 4	SAT	SAT	SAT
	Performance Verification	II-7, P.10	N	Yes, See process recommend-ation#1	SAT	SAT	
	Reviews	II-4, p.10	N	See recom-mendation #6	SAT	SAT	

QA ELEMENT/ ACTIVITIES	PROCESS STEPS/ MGMT OBJECTIVES	DETAILS (Cklst)	DEFICIENCIES	REC	PROCESS EFF.	PRODUCT ADEQUACY	OVERALL
3.0/ Repository Design -	Control of *design inputs*: Inputs identified and documented; selected; approved/ Identification and control of "assumption based inputs"(CPS)	III-1 to III-5, III-7, pp.11-14	N	See recommendation #3	SAT	SAT	
Repository Thermal Loading Management Analysis	Control of *design process*: level of detail necessary to permit the design process to be carried out/adequacy of design documents to support design/standards identified and documented, and their selection reviewed and approved/design methods, materials, parts, equipment, and processes selected and reviewed/use of information derived from documented	III-1 to III-20 pp.11-19	N	N	SAT	SAT	SAT

	experiences; e.g. lessons learned from ESF/ ability to evaluate design without recourse to originator						
	Design analyses planned, documented: legibility, calculation computer software qualified, objectives, inputs, assumptions (CPS)	III-6, III-8, III-9, pp.13-15.	See LVMO-98-D-014	See recom-mendation #3, #5, #8	SAT	SAT	
	Design Reviews (CPS)	III-10/11 III-14 to III-17 pp 15-18	N	See recom-mendation #6	SAT	SAT	
	Design Interfaces/Change Control (CPS)	III-18/19 pp.18 to 19	N	N	SAT	SAT	

QA ELEMENT/ ACTIVITIES	See recommendation #3 **PROCESS STEPS/ MGMT OBJECTIVES**	**DETAILS (Ck lst)**	**DEFICIENCIES**	**REC**	**PROCESS EFF.**	**PRODUCT ADEQUACY**	**OVERALL**

3.0/ Repository Design -	Control of *design inputs*: Inputs identified and docu-mented; selected; approved/ Identifi- cation and control of *assumption based inputs* (CPS)	IV-1 to IV-4 and IV-9 pp. 20, 21, 23.	LVMO-98-D-014	See recom-mendation #2&#3	UNSAT	SAT	
Overall Development & Emplacement Ventilation Systems	Control of *design process*: level of detail necessary to permit the design process to be carried out/adequacy of design documents to support design/ standards identified and documented,& their selection reviewed and approved/design methods, materials, parts, equipment, and processes selected and reviewed/use of	IV-1 thru IV-12 pp.20-25	N	See recom-mendation #2,3,4, 6	SAT	SAT	SAT

	information derived from documented experiences; e.g. lessons learned from ESF/ ability to evaluate design without recourse to originator.						
	Design analyses planned, documented: legibility, calculations computer software qualified, objectives, inputs assumptions (CPS)	IV-7, IV-8, IV-10 to IV-12 pp.22-23.	LVMO-98-D-015	See recom-mendation #5,#7	UNSAT	SAT	
	Design Reviews (CPS)	IV-5, IV-6, pp. 21,22.	YM-97-D080	See recom-mendation#6, 7	UNSAT	SAT	

QA ELEMENT/ ACTIVITIES	PROCESS STEPS/ MGMT OBJECTIVES	DETAILS (Cklst)	DEFICIENCIES	REC	PROCESS EFF.	PRODUCT ADEQUACY	OVERALL
3.0/ Repository	Control of *design inputs*: Inputs	V-2 thru V-	LVMO-98-D-014	See recom-	UNSAT	SAT	

Design -	identified and documented; selected; approved/ Identi-fication and control of *assumption based inputs* (CPS)	8, V-16 pp.25-29, 32		mendation #2 & #3			
Repository Subsurface Layout Configuration Analysis	Control of *design process*: level of detail necessary to permit the design process to be carried out/adequacy of design documents to support design/ standards identified and docu- mented, and their selection reviewed and approved/design methods, materials, parts, equipment, and processes selected and reviewed/use of information derived from documented experiences; e.g. lessons learned from ESF/ ability	V-1 thru V-20, pp.25-33	N	See recom-mendation #2, #3, #4 #6	SAT	SAT	SAT

	to evaluate design without recourse to originator						
	Design analyses planned, documented: legibility, calculations, computer software qualified, objectives, inputs assumptions (CPS)	V-9 thru V-12, pp.29-30	N	See recommendation #5	SAT	SAT	
	Design Reviews (CPS)	V-13 to V-15	N	See recommendation #6	SAT	SAT	
	Design Interfaces/Change Control (CPS)	V-17, V-20, p.33	N	N	SAT	SAT	

QA ELEMENT/ ACTIVITIES	PROCESS STEPS/ MGMT OBJECTIVES	DETAILS (Cklst)	DEFICIENCIES	REC	PROCESS EFF.	PRODUCT ADEQUACY	OVERALL
3.0/ Repository Design -	Control of *design inputs*: Inputs identified and documented; selected; approved/ Identification and control of "assumption based inputs" (CPS)	VI-2 thru VI-4 VI-6 thru VI-9, & VI-11, pp.34-37	N	See recommendation #2, #3,	SAT	SAT	
Repository Surface	Control of *design process*:	VI-1 thru VI-14	N	See recom-	SAT	SAT	SAT

Design Site Layout Analysis	level of detail necessary to permit the design process to be carried out/adequacy of design documents to support design/standards identified and documented, and their selection reviewed and approved/design methods, materials, parts, equipment, and processes selected and reviewed/use of information derived from documented experiences; e.g. lessons learned from ESF/ability to evaluate design without recourse to the originator	pp.34-38.		mendation #2, #3, #4, #6		
	Design analyses planned, and documented: legibility, calculations, computer soft-ware qualified,	VI-1, VI-2, VI-5, VI-12, VI-13	N	N	SAT	SAT

	objectives, inputs assumptions (CPS)						
	Design Reviews (CPS)	VI-14	YM-97-D080	See recom-mendation #6	UNSAT	SAT	
	Design Interfaces/Change Control (CPS)	VI-11	N	N	SAT	SAT	