CHPRC-04466
Revision 0

Radiological Design Review Process (PRC-PRO-RP-1622)

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
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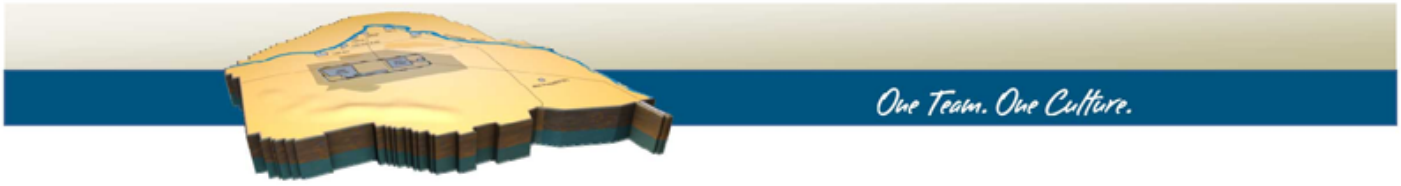

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CR-2020-0661: Revise procedure from a multi-facility (Level 2) to a sitewide (Level 1). Added language in step 3.4.5.2 to manage final report in accordance with PRC PRO-CMT-40118, Plateau Remediation Contract Correspondence. Updated records.

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1.0 INTRODUCTION

1.1 Purpose

This procedure provides the requirements and process for the radiological as low as reasonably achievable (ALARA) design reviews for facilities and projects under the control of CH2M HILL Plateau Remediation Company (CHPRC). The purpose of the radiological design review process is to ensure that design of equipment and facilities considers ALARA principles so that the facility or equipment can be installed, operated, and maintained in a manner that minimizes radiological exposure to personnel. (6.1.2.m) In addition, this procedure implements Title 10 *Code of Federal Regulations*, Part 835, *Occupational Radiation Protection* (10 CFR 835), Subpart K, *Design and Control* requirements.

1.2 Scope

This procedure applies to CHPRC personnel who perform radiological design reviews that meet the Radiological Control ALARA Review or ALARA Design Team Review trigger points identified in Table 1 of this procedure. CHPRC-00073, *CH2M HILL Plateau Remediation Company Radiological Control Manual*, further defines the functions of ALARA in the design review process in Article 125.

1.3 Applicability

PRC-PRO-RP-40109, *Radiological Work Planning*, applies to the normal work planning process.

Radiological design reviews are applicable to the design of new facilities as specified in PRC-PRO-EN-40271, *Engineering Design Process,* as well as to modifications of existing facilities as specified in PRC-PRO-EN-2001, *Facility Modification Package Process,* if the potential for exposure to ionizing radiation exists in the facility.

1.4 Implementation

This procedure is effective upon publication.

2.0 OVERVIEW

Modifications of existing facilities and design of new facilities are managed through the engineering design process (PRC-PRO-EN-40271) or the facility modification package process (PRC-PRO-EN-2001). Both engineering processes require the Engineering Design Lead to screen the work to identify known hazards or safety requirements. If a radiological hazard is identified, the Engineering Lead will contact the Radiological Control Organization to request support in determining the need for radiological controls support for the design, and will complete the Functional Requirements and design criteria checklist for the project.

From early in the design phase and throughout the project, Radiological Control Technical Staff (RCTS) is assigned to the design review team from the Radiological Control Organization if dose trigger levels are exceeded. This individual should ensure that reasonable radiological considerations are integrated into the design and all other related documents such as construction procedures, proposed operating procedures, and plans for decommissioning.

As the design matures from design initiation through the definitive or final design, the RCTS is responsible for ensuring that ALARA measures minimize dose for workers, members of the public, and the environment, at a reasonable cost to the project. This is accomplished by ensuring that the core radiological controls (i.e., direct dose control, contamination control, and controls to minimize airborne radioactivity) are considered during the design process. For a statement of roles and responsibilities, see Section 2.2.

There is considerable value to the design process in performing a radiological design review:

- It will add assurance that the design will implement ALARA principles.
- It will add assurance that the design will meet regulatory and other requirements related to radiological design.
- It will demonstrate to stakeholders that the design is being developed to meet radiological requirements.
- It will help avoid costly post-construction mitigation efforts.
- It will result in documentation that will justify that the design is ALARA program compliant.

Measures taken to maintain radiation exposures ALARA shall include the use of engineered controls and administrative controls. (6.1.2.h)

The primary ALARA control methods to be used shall be engineered controls. Examples of engineered controls are:

- Containment
- Confinement
- Shielding
- Ventilation
- Remote handling
- Specialized tools

Administrative controls are used only as supplemental methods to maintain exposures ALARA unless the use of engineered controls have been demonstrated and documented to be insufficient to fully control the hazard. Examples of administrative controls are:

- Cost-benefit analysis
- Dose budget
- Source term report
- Radiological Work Permits (RWP)
- Work procedures
- Training (including the use of mock-ups)
- Alarms

2.1 Precautions and Limitations

As described in PRC-PRO-EN-40264, *Formal Design Review*, the Engineering Lead may elect to perform a Formal Design Review at the conceptual, preliminary, or definitive design phases. If it is determined that a Formal Design Review will be performed, a person other than the individual assigned to perform the radiological design work should be assigned to perform the formal design review.

The RCTS assigned to the design team should ensure that ALARA measures considered for the design are well documented in the *CHPRC ALARA Review Checklist* (Site Form A-6004-606) and the project ALARA plan.

A graded approach based on radiological risk should be used when selecting ALARA measures to be integrated into the design.

Radiological Design Criteria are based on Total Effective Dose. Consideration must be given to both external dose and internal dose when determining ALARA measures to be applied in the design.

Specific deliverables for the RCTS may change as the design matures from design initiation to final design. These changes should be captured in the project ALARA plan and the related ALARA review checklist.

The RCTS assigned to perform ALARA reviews must be trained in accordance with Section 3.4.4 of this procedure.

When assigned to a Design Review Team, discuss the method to be used to document calculations and dose estimates with the Engineering Design Lead. The ALARA Design Review is a living document, and should be revised and updated as the review process completes.

2.2 Roles and Responsibilities

NOTE: *This is a summary of responsibilities for each role. Additional detail is located in the body of this procedure.*

ALARA COMPANY TECHNICAL AUTHORITY (CTA)

- Establishes and maintains the CHPRC radiological design review process.

RADIOLOGICAL CONTROL TECHNICAL STAFF (RCTS) EVALUATES THE PROPOSED DESIGN TO DETERMINE THE RIGOR OF RADIOLOGICAL REVIEW REQUIRED

- Provides input to the Functional Design Criteria and Functional Design Requirements documents
- Ensures ALARA design reviews are planned and performed consistent with this process.
- Ensures ALARA design review documentation is generated and updated consistent with this process.
- Serves as an integral part of the design team.
- Provides input for post-construction ALARA effectiveness and ensures the documentation is consistent with this process.

ENGINEERING DESIGN LEAD (PROJECT MANAGER) FOR RADIOLOGICAL DESIGN

- Assembles a Design Team based on the scope of the requested facility or system modification
- Ensures radiological control resources are requested and coordinates with facility management to ensure resources are allocated in a timely manner to support implementation of this process.
- Grades the overall design review process along with the RCTS to determine the level of review.
- Ensures that the budget provides sufficient funds specifically allocated for ALARA, including ALARA design reviews, the use of ALARA decision-making methods, needed physical controls, and funding for a RCTS on the design team when required.
- Develops a detailed design review process and schedule.
- Solicits Project/Activity Radiological Control Manager's (RCM) input concerning potential radiological consequences of proposed modification or new facility.
- Schedules design review meetings.
- Ensures adequate documentation of all aspects of the design review.
- Ensures distribution of reports of design reviews.
- Makes any required decision that the team cannot reach consensus on.
- Applicable reports and or documents generated in accordance with Appendix D will have the signed approval of the Engineering Design Lead and Project/Activity RCM.

DESIGN REVIEW TEAM FOR RADIOLOGICAL DESIGNS

- Conducts the design review as scheduled by the team leader.
- Determines by consensus the level of effort and detail necessary to review the design at each step of the engineering design process.
- Develops specific findings and recommendations for each step of the design process.
- Determines by consensus the extent and detail of the documentation required to adequately record the team's findings and recommendations.
- Assists the Engineering Design Lead in preparation of documentation.
- The Project/Activity Engineering Organization will be the custodian of all original documents, and will file and maintain copies in accordance with PRC-PRO-IRM-10588.

3.0 PROCESS

The radiological design review process uses a graded approach for reviewing designs based on the radiological risk associated with the design. Table 1 provides the type of review required based on the estimated dose trigger levels for the project. These dose trigger levels are not to be used for radiological work planning, which is currently addressed in PRC-PRO-RP-40109. When the dose for the design/project has been documented to be <0.1 person-rem/yr, refer to PRC-PRO-RP-40109 for guidance to perform and document the review and controls selected to maintain exposures ALARA. (6.1.2.m)

During the design initiation phase, the assigned Engineering Design Lead will review the scope of the design and identify the functional disciplines required to perform the design. If the design involves a new facility or modification of a facility that will handle radioactive materials, the Engineering Design Lead will identify the need for RCTS to evaluate the proposed design for radiological risk. This initiates radiological controls involvement in the design process.

The RCTS assigned to perform the initial evaluation will determine the radiological hazards associated with the proposed design. During the design initiation phase, the design concept is often not detailed enough to perform an accurate dose estimate. If this is the case, the RCTS should use professional judgment to evaluate the best available information on the proposed work and the radioactive materials source term to estimate the internal and external dose risks associated with the design.

Compare the results to the dose trigger levels listed in Table 1. The results of the evaluation will be communicated to the Engineering Design Lead. If the evaluation determines that estimated dose will exceed one person-rem/yr Total Effective Dose (TED), a RCTS will be assigned to participate on the design team. Estimated dose rates less than one person-rem/yr will trigger a graded approach to the ALARA review, as specified in Table 1.

The Engineering Design Team will determine if the design is considered to be a major or minor facility modification, or if it is subject to the requirements of DOE-STD-1189, *Integration of Safety in the Design Process,* or DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Both Engineering processes used to perform designs (i.e., Facility Modification Process and the Engineering Design Process) include five distinct design phases to direct the design. For more complex designs, all five phases will normally be included, but a graded approach combining one or more of the design phases may be used for simpler designs. The Engineering Design Lead will determine the design phases that will be followed for the design.

The five phases of a design are:

- The Design Initiation phase triggers the design.
    - The functional requirements for the design are determined in this phase.
    - The need for radiological controls input to the design is evaluated based on trigger levels in Table 1.

- The Conceptual Design phase develops the design outputs by performance of a design analysis by the design team.
    - Completion of the Conceptual design phase signifies 30% completion of the design.
    - ALARA requirements are established during this phase.
    - A *CHPRC ALARA Design Review Checklist* (Site Form A-6004-606) should be completed to document the ALARA measures discussed and initially incorporated into the design.
    - If required (see Table 1), a Project ALARA Plan is also drafted to provide additional details on the incorporation of ALARA in the design.
- The Preliminary Design phase is a more detailed analysis of the design that may include verification of the design through testing.
    - Completion of the Preliminary Design phase signifies 60% completion of the design.
    - The *CHPRC ALARA Design Review Checklist* (Site Form A-6004-606) and the Project ALARA Plan as applicable should be updated to document changes or additions to the ALARA measures incorporated in the design.
- The Definitive Design Phase continues the analysis of the design, and incorporates any test results and resultant modifications to the systems into the design.
    - Completion of the Definitive Design phase signifies 90% completion of the design.
    - The design is considered ready for release for construction.
    - The *CHPRC ALARA Design Review Checklist* (Site Form A-6004-606) and the Project ALARA Plan as applicable should be updated to document the final status of ALARA measures incorporated in the design.
- The Construction phase of the design implements the planned design.
    - Changes to the design during the construction phase are controlled using the Design Change Notification (DCN) system.
    - DCNs should be reviewed by the RCTS to determine if there is any impact to the ALARA measures, assumptions, or controls included in the design. If the DCNs impact the ALARA measures, assumptions, or controls included in the design; document the changes in a revision to the Project ALARA Plan and update accordingly.
    - A Post-Construction ALARA Review should be conducted to validate the accuracy of assumptions made for the ALARA measures and to identify areas of improvement for future designs once construction has been completed and the facility has been placed in operation.
    - The *CHPRC ALARA Design Review Checklist* (Site Form A-6004-606) and Project ALARA Plan (if applicable) should be updated to include the results of the Post-Construction ALARA review.

3.1 Trigger Levels for Radiological Review of Designs

Projected radiation exposures for the design that trigger a RCTS ALARA Review or Radiological Controls staff member participation on the Design Team are listed in Table 1.

Table 1. Dose Trigger Levels and associated Radiological Design Review Criteria

Dose Trigger Levels	Review Type	Required ALARA Documents
< 0.1 person-rem/yr	Radiological Control staff member ALARA review of the Facility Modification Package (FMP) using the Normal work planning process	
< 1 person rem/yr Total Effective Dose (TED), **OR** <10 person rem/yr CED (Committed Equivalent Dose), **OR** <3 rem/year equivalent dose to the lens of the eye, **OR** <10 rem/year committed equivalent dose to the skin, **AND** >0.1 person-rem/yr	Radiological Control staff member ALARA Review of the Facility Modification Package (FMP)	ALARA Design Review Checklist
>1 person-rem/yr TED **OR** >10 person-rem/yr CED (Committed Equivalent Dose) **OR** Project Life cycle total whole body dose is expected to exceed 5 person-rem, **OR** Project life cycle extremity dose is expected to exceed 50 person-rem	Radiological Controls staff member participation on the Design Team	ALARA Design Review Checklist AND Project ALARA Plan

3.2 Initial Evaluation of a Design and Radiological Review of Facility Modification Packages

Actionee	*Step*	*Action*
Project/ Activity RCM	1.	ASSIGN the RCTS to perform an initial evaluation of the design.
	2.	ENSURE the RCTS assigned to perform the ALARA review is trained in accordance with Section 3.4.4 of this procedure.
RCTS	3.	EVALUATE all available information for the proposed design AND USE professional judgment to estimate the worker dose that will result from the proposed design scope and anticipated radiological source term.
	4.	DETERMINE the level of ALARA review required for the design based on dose trigger levels in Table 1.
		a. COMMUNICATE the results of the evaluation to the Engineering Design Lead for the design project.
	5.	IF the worker dose estimate indicates that an RCTS ALARA review of the FMP is appropriate, THEN COMPLETE the *ALARA Management Worksheet (AMW)* (Site Form A-6004-634) and/or *CHPRC ALARA Review Checklist* (Site Form A-6004-606) as applicable based on guidance in Table 1.
	6.	IF the worker dose estimate indicates radiological control participation on the Design Team, THEN PROCEED TO Section 3.3 of this procedure.
	7.	PROVIDE radiological control input if requested in developing budget and schedule for the design through final construction.

Actionee	Step	Action
RCTS	8.	CONSIDER the following in the radiological design review process as applicable: • CHPRC and DOE requirements for radiological design • Existing site project design reviews of similar scope • Applicable State of Washington environmental requirements affecting design for occupational ALARA elements • Use of ALARA decision-making methods • Radiation exposure during installation • Contamination control during installation • Airborne radioactive material control during installation • Radioactive waste minimization • Provisions for decommissioning
	9.	UPDATE the *CHPRC ALARA Review Checklist* (Site Form A-6004-606) and the ALARA plan at the Conceptual Design phase, the Preliminary Design phase, and the Definitive Design Phase as applicable.
	10.	REPORT the status of the design review to the Project/Activity RCM at least once per month if it is an extended design review.
	11.	PROVIDE completed documents and reports to the Engineering Design Lead and provide a copy to Project/Activity RCM.
	12.	After release of the design for construction, REVIEW DCNs to determine if there is an impact to radiological controls integrated into the design. a. IF the DCNs have altered a fundamental assumption or had an impact on the radiological controls of the Project ALARA Plan, THEN REVISE the plan accordingly.

3.3 Radiological Control Participation on the Design Team

The following section lists activities to be performed if a Table 1 Dose Trigger level requiring the RCTS's participation on the Design Team.

Actionee	*Step*	*Action*
Project/Activity RCM	1.	APPROVE OR APPOINT the RCTS who will serve on the Design Team.
	2.	PROVIDE input to the Engineering Design Lead concerning the budget and schedule by estimating the cost of potential radiological and ALARA controls as the design matures.
RCTS	3.	PROVIDE radiological controls input for the Functional Design Criteria document during the Design Initiation phase. If applicable, include discussions of likely radiological consequences of potential alternatives including decontamination and decommissioning (D&D), collective dose, and likelihood of radiological releases, as appropriate. (6.1.1.c)
	4.	PROVIDE radiological control input to the Design Team effort to develop a budget and schedule for the design process during the Design Initiation Phase.
	5.	INITIATE a *CHPRC ALARA Review Checklist* (Site Form A-6004-606) for the design (see Appendix A for guidance) during the Conceptual Design phase.
		a. PERFORM calculations required to support the development of the *CHPRC ALARA Review Checklist*.
	6.	INITIATE a Project ALARA Plan (see Appendix D) during the Conceptual Design phase of the project.
		a. INCLUDE calculations as appendices to the ALARA Plan.
	7.	ENSURE any environmental assessments or safety analysis reports developed or being developed for facilities under review are evaluated for conflicts to the radiological requirements.
	8.	CONDUCT the design review as scheduled by the Engineering Design Lead.
	9.	REPORT the status of the design review to the Project/Activity RCM at least once per month if it is an extended design review, and at the end of each design phase.

Actionee	*Step*	*Action*
RCTS	10.	DETERMINE by consensus of the Design Team the level of effort and detail necessary to review the design at each phase of the design.
	11.	DEVELOP specific findings and recommendations for each phase of the design. a. SUBMIT findings and recommendations to the Engineering Design Lead on a *CHPRC - Review Comment Record (RCR)* (Site Form A-6004-835).
	12.	EXAMINE the design at defined steps during the developmental stages, particularly at major design review points (6.1.1.d) referenced in Section 3.0 of this procedure.
	13.	REVIEW design frequently enough so that the design cannot progress past the point where it cannot be changed without excessive costs or schedule delays.
Engineering Design Lead	14.	ASSIGN members who will serve on the design review team, of which he/she will act as team leader. (6.1.1.c, 6.1.1.d)
	15.	ENSURE radiological requirements (including ALARA design reviews, the use of ALARA decision-making methods, and physical controls), and the RCTS are accounted for in the budgeting process by providing sufficient funds specifically allocated for these purposes.
	16.	ENSURE ALARA decision-making methods are used when required and that their use is documented. (6.1.2.k, 6.1.2.l)
	17.	VERIFY RCTS has been assigned to the design team in the initial stages AND SOLICIT input throughout the Design Process.
	18.	ENSURE all radiological design requirements are met during the design, including the regulatory requirements of 10 CFR 835, Subpart K.
	19.	KEEP the Design Team informed of all aspects of the design.
	20.	PROVIDE input for the post-construction review of radiological design effectiveness (Appendix B).
	21.	ENSURE there is a post-construction review of the radiological design's effectiveness for each approved design reviewed.

3.4 Design Objectives for the Radiological Design Review

Radiological design criteria should be identified to ensure regulatory and procedural compliance. Criteria triggering ALARA reviews of designs are given in Section 3.0 Table 1. During the design review process, the ALARA review will evaluate the proposed design based on radiation exposure design objectives that reflect occupancy levels in the facility work areas.

Regulatory requirements for designs are based on worker Total Effective Dose (TED), which includes both external and internal dose to an individual. The risk of uptake of radioactive material must be controlled as well as external exposure risks. ALARA review of a design must be based on design criteria for the three core principles of radiation protection—control of external exposure, control of contamination, and control of airborne radioactive material.

Design features shall ensure that the individual worker's Total Effective Dose (TED) is ALARA and that external exposure risk is less than an average of 0.5 mrem per hour in areas that are continuously occupied. Worker dose in areas that are not continuously occupied shall also be ALARA and shall not exceed 20% of CHPRC-00073 Table 2-1 limits (6.1.2.c) (see Table 2 below). A total of 2000 hours shall be used as worker stay times for areas of continuous occupancy. (6.1.2.b) In areas that are not continuously occupied, an occupancy factor should be determined based on the length of worker stay times in the area. The occupancy factor can be used to increase the external exposure criteria as long as the design objective for Whole Body TED listed in Table 2 is not exceeded (see Table 3 for examples).

A summary of the design objectives for exposure limits in areas that are continuously occupied are included in Table 2. The objectives are based on 20% of CHPRC-00073, Table 2-1 limits (6.1.2.c), CHPRC-00073, Article 223 airborne limits, and CHPRC-00073, Table 2-2 contamination limits for uncontrolled areas.

Table 2. Radiation Exposure Design Objectives

Exposure Type	Design Objective
Whole body TED (internal + external)	1.0 Person-rem
Lens of Eye Equivalent Dose	3.0 Person-rem
Extremity Equivalent Dose	10 Person-rem
Organ (other than eye) or Tissue	10 Person-rem
Airborne Radioactive Material	<0.2 DAC
Unconfined Contamination	<1000 dpm/100 cm^2 B-G AND <20 dpm/100 cm^2 Alpha

NOTE: *The dose to any member of the public or a minor exposed to radiation at a DOE facility shall not exceed 0.1 rem total effective dose in a year.*

Control of exposure to radiation requires the use of engineered controls that are part of the design of a new system or facility. If it is not possible to engineer a control that meets the design objectives, justification for using an administrative control rather than an engineered control must be provided. The justification should be documented in the *CHPRC ALARA Review Checklist* (Site Form A-6004-606) and the project ALARA plan. The justification should include an estimate of the expected increase in worker dose.

Table 3. Acceptable External Dose Rates Based on Occupancy Factors

Zone Classification	Access Time Allowed (max anticipated occupancy = 1 person)	Dose Rate = mrem/hr @ 30 cm
Uncontrolled Area	Continuous Occupancy	≤0.05
Controlled Area 1	Continuous Occupancy	≤0.5
Controlled Area 2	<2 hours per day	2
Controlled Area 3	<2 hours per week	10
Controlled Area 4	<20 hours per year	50
Controlled Area 5	Isolation Area	Normally not accessed

3.4.1 Incorporate and Document Radiological Design Features in the Design Package

Design features incorporated into the design that maintain occupational exposures ALARA must be documented in the *CHPRC ALARA Review Checklist* (Site Form A-6004-606) and the Project ALARA Plan, if applicable. The following steps should be completed to ensure that documentation is adequate:

1. COMPILE pertinent data at each phase of the design review.

2. ENSURE that all of the ALARA measures considered during the review process are documented, including those that were not accepted by the design team.

3. ENSURE that ALARA measures accepted by the design team are verified to be effective through peer review.

4. DEVELOP the dose estimates and update as the design matures. Follow guidance in Appendixes A and D.

Prior to beginning construction, finalize the dose estimate, taking into account all radiological risks. Finalizing the ALARA estimate involves the following:

1. USE the latest dose rate and contamination level estimates for the construction area(s).

2. ESTIMATE the volume, dose, and contamination levels expected for all radioactive waste that the construction might generate.

3. ENSURE that the project provides an accurate estimate of the craft resource requirements and estimated times to perform tasks related to operation of the newly designed facility or system.

4. ENSURE that the estimates for source term to be handled in the new facility or system are up to date.

5. REVIEW the project design to ensure that the design and material specifications include all reasonable engineered control measures to reduce worker dose and radioactive waste generation.

6. REVIEW project implementation planning to ensure that all reasonable time, distance, and shielding measures are included to reduce worker dose.

3.4.2 Dose Optimization through Cost Benefit Analysis

ALARA measures should be optimized where feasible to ensure that the adopted measure represents the most effective dose reduction for the cost. Examples of ALARA measures that can be optimized are shielding thickness, decontamination processes (e.g., spray system operation times) and use of ventilation to reduce airborne contamination levels.

Dose optimization requires establishing an unmitigated dose for an activity that includes no dose reduction due to ALARA measures. This becomes the benchmark for determining the effectiveness of ALARA measures in reducing worker dose.

A selected ALARA measure (e.g., shielding thickness) is then included in the dose estimate, and a sensitivity study is performed to determine the resulting dose reduction. Once the dose savings are computed for each sensitivity case, the cost for each sensitivity case should be estimated, taking into consideration the cost of the material, installation costs (i.e., worker time, cost of installation equipment), and maintenance costs, if applicable.

A cost benefit analysis in $/rem avoided is then determined for each of the sensitivity cases. The recommended cost benefit factor value used for the analysis is $10,000 per person-rem saved. The analysis would include the following processes:

1. DETERMINE the net benefit for the available options. This step will be completed for all viable options. The expression for net benefit is given as:

   $$B = V – (P+ X + Y)$$

   Where:
   - B = net benefit;
   - V = gross benefit;
   - P = construction cost (excluding production);
   - X = cost of protection; and
   - Y = cost of health effects associated with the construction.

2. CHOOSE the options that only have a positive net benefit. A negative net benefit deems the option unjustifiable. A positive net benefit will ensure that the sum of all costs associated with an option is less than the gross benefit.

3. CHOOSE the options that have a person-rem dose, determined from the dose assessment for each option, less than regulatory and procedural limitations.

3.4.3 Required Documentation

Actions taken to maintain occupational exposure as low as reasonably achievable must be documented. (6.1.2.k, 6.1.2.l) Appendix A provides a checklist of items from which applicable items incorporated in the design must be documented and submitted to Engineering for retention.

3.4.4 Required Training

Individuals functioning as radiological design reviewers and RCTS on design review teams shall be trained on this procedure and complete training course 020934, *ALARA Design Review (CBT)*. Those performing second technical reviews must also be members of the RCTS and have completed course 020934. (6.1.2.l)

3.4.5 Post-Construction Review of Radiological Control Features and Effectiveness

The following steps should be completed by the RCTS who performed the design review within 1 year of the completion of construction and startup activities. If this is not possible, any member of the RadCon organization may fulfil this function if they have fulfilled the requirements in Section 3.4.4 of this procedure. The goal of the review is to evaluate the effectiveness of the ALARA measures incorporated in the design and to capture any improvements or lessons learned that will aid in future design efforts.

Actionee	*Step*	*Action*
RCTS	1.	ASSESS the effectiveness of the radiological design measures incorporated into the design. Use Appendix B for guidance.
		a. PREPARE a report detailing the effectiveness of the radiological design measures.
	2.	ENSURE a copy of the report is transmitted in accordance with PRC-PRO-CMT-40118, *Plateau Remediation Contract Correspondence*, to the engineering design organization for use in future design efforts.
	3.	ENSURE the report includes a discussion of radiological design measures that were effective as well as design measures that could be improved in future designs.
	4.	ENSURE specific recommendations for future designs are made and entered into the radiological lessons learned system.

4.0 FORMS

CHPRC ALARA Design Review Checklist, A-6004-606
CHPRC - Review Comment Record (RCR) A-6004-835
ALARA Management Worksheet (AMW), A-6004-634

5.0 RECORD IDENTIFICATION

All records are generated, processed, and maintained in accordance with PRC-PRO-IRM-10588, *Records Management Processes*.

Records Capture Table

Name of Record	Submittal Responsibility	Retention Responsibility
ALARA Design Documents	Project/Activity Engineering Organization	IRM Service Provider
CHPRC ALARA Design Review Checklist(s), A-6004-606	Project/Activity Engineering Organization	IRM Service Provider
Radiological ALARA Plans	Project/Activity Engineering Organization	IRM Service Provider

6.0 SOURCES

6.1 Requirements

1. CHPRC-00073, *CH2M HILL Plateau Remediation Company Radiological Control Manual*

    a. Article 125.1.f
    b. Article 125.1.g
    c. Article 312.1
    d. Article 312.2

2. CHPRC-00072, *CH2M HILL Plateau Remediation Company Radiation Protection Program*

    a. Requirement 205, 835.1002(a)
    b. Requirement 206, 835.1002(b).1
    c. Requirement 208, 835.1002(b).3
    d. Requirement 209, 835.1002(c).1
    e. Requirement 210, 835.1002(c).2
    f. Requirement 211, 835.1002(d)
    g. Requirement 201, 835.1001(a).1
    h. Requirement 202, 835.1001(a).2
    i. Requirement 203, 835.1001(a).3
    j. Requirement 204, 835.1001(b)
    k. Requirement 170, 835.704(b)
    l. Requirement 30, 835.103
    m. Requirement 213, 835.1003(b)

6.2 References

10 CFR 835, *Occupational Radiation Protection*
DOE 5480.23, *Nuclear Safety Analysis Reports*
DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*
DOE-STD-1189, *Integration of Safety into the Design Process*
PRC-PRO-CMT-40118, *Plateau Remediation Contract Correspondence*
PRC-PRO-EN-2001, *Facility Modification Package Process*
PRC-PRO-EN-40264, *Formal Design Review*
PRC-PRO-EN-40271, *Engineering Design Process*
PRC-PRO-IRM-10588, *Records Management Processes*
PRC-PRO-RP-40109, *Radiological Work Planning*
WAC 246-247, *Radiation Protection – Air Emissions*

6.3 Basis Documents

DOE-STD-1098-2008, *Radiological Control*
PRC-1007-CDMP-0058, *ALARA CDMP*

Appendix A - Basic Radiological Design Review Checklist

This appendix contains guidance on points to consider when preparing a *CHPRC ALARA Review Checklist* (Site Form A-6004-606). Areas or systems that are not included in the specific design being reviewed are not required to be addressed in detail, but for completeness, the design review checklist should indicate that they are not applicable.

1. Design Process Regulatory Requirements (10 CFR 835, Subpart K-*Design and Control*, 835.1001 – 835.1003)
2. Facility Layout
3. Installation Considerations
4. Maintenance and Operations
5. Shielding
6. Contamination Control
7. Liquid Systems -- Tanks, Pumps, and Sumps
8. Liquid Systems – Valves
9. Piping
10. Slurry Systems
11. Instrumentation
12. Ventilation
13. Filters and Demineralizers
14. Implementation Requirements
15. Breathing Air and Cooling Systems
16. Waste Minimization
17. Post Construction Review of Effectiveness
18. Decommissioning Considerations
19. DOE Regulations, Orders and Notices
20. State of Washington Environmental Requirements Affecting Design for Occupational ALARA
21. Environmental Assessments
22. Safety Analysis Report
23. Design Documentation

This checklist is not intended to be a checklist for any specific sub-contractor or facility. It is intended as a general list out of which site-specific checklists can be developed. Many of the items listed may not apply to specific facilities. On the other hand, particular facilities may need to add items specific to their facility.

1.0 DESIGN PROCESS REGULATORY REQUIREMENTS

1. What plan do the designers have or what actions have they already taken to ensure that doses will be ALARA through the combined use of facility and equipment design and administrative control? (6.1.2.h)

2. How are designers implementing the requirement that physical design features be the primary methods used to maintain exposures ALARA (e.g., confinements, ventilation, remote handling, and shielding)? (6.1.2.h)

3. For cases where administrative controls are to be used, how were design features demonstrated to be impractical so that administrative controls are justified? (6.1.2.i, 6.1.2.j)

Appendix A - (Cont.)

4. How are the designers ensuring that administrative controls can be practically implemented in cases where design features are demonstrated to be impractical? (6.1.2.i, 6.1.2.j)

5. For design of new facilities and modifications of old facilities, how do the designers plan to use or how are they using optimization methods (ALARA decision-making methods) to assure that occupational exposure is maintained ALARA in developing and justifying the facility design and physical controls? (6.1.2.a)

6. For design of new facilities and modifications of old facilities, how do the designers plan to meet or how are they meeting the design objective to maintain exposure levels ALARA and below an average of 0.5 mrem/h in continuously occupied areas (2000 hours/year)? (6.1.2.b)

7. For design of new facilities and modifications of old facilities, how do the designers plan to meet or how are they meeting the design objective to maintain exposure levels ALARA and below 20% of the applicable standard in 835.202 in areas not continuously occupied (less than 2000 hours/year)? (6.1.2.c)

8. For design of new facilities and modifications of old facilities, how do the designers plan to meet or how are they meeting the design objective to avoid, under normal conditions, releases of airborne radioactive material to the workplace atmosphere? (6.1.2.d)

9. For design of new facilities and modifications of old facilities, how do the designers plan to meet or how are they meeting the design objective to control, in any situation, the inhalation of radioactive material by workers to levels that are ALARA? (6.1.2.e)

10. How do the designers plan to meet or how are they meeting the objective that the design or modification of the facility and the selection of materials include features that facilitate operations? (6.1.2.f)

11. How do the designers plan to meet or how are they meeting the objective that the design or modification of the facility and the selection of materials include features that facilitate maintenance? (6.1.2.f)

12. How do the designers plan to meet or how are they meeting the objective that the design or modification of the facility and the selection of materials include features that facilitate decontamination? (6.1.2.f)

13. How do the designers plan to meet or how are they meeting the objective that the design or modification of the facility and the selection of materials include features that facilitate decommissioning? (6.1.2.f)

14. What is the plan to use monitoring, during routine operations, to demonstrate that exposure levels are as low as reasonably achievable?

Appendix A - (Cont.)

2.0 FACILITY LAYOUT

1. Review the general configuration of the facility, considering traffic patterns, location of the radiation areas, location and size of the changing rooms, adequacy of personnel decontamination facilities, location of the fixed survey equipment, and adequacy of space for anticipated operations, maintenance, production, research, and decommissioning. Facility design and selection of materials shall include features that facilitate operation and maintenance, decontamination, and decommissioning. (6.1.2.f)

2. Verify that the design shall be able to maintain personnel entry control for each radiological area, commensurate with existing or potential radiological hazards within the area, by using one or more of the methods listed in CHPRC-00073, Article 330.

3. Verify that the entrance of each access point to high and very high radiation areas shall have the control features required by CHPRC-00073, Appendix 3A.

4. Equipment and controls are located for accessibility and to minimize radiological exposure to personnel during normal operations, shutdown, maintenance, anticipated operational transients, and postulated accident conditions.

5. Verify facility layouts and personnel traffic routes are developed to minimize radiological exposures to personnel.

6. Verify accessibility requirements for the maintenance, inspection, removal, or replacement of equipment consider potential radiological exposure to personnel.

7. Verify doorways and labyrinths are wide enough to permit personnel, component, and equipment passage.

8. Evaluate and confirm the adequacy of specific control devices for reducing occupational exposures, including shielding, hoods, glove boxes, containments, interlocks, barricades, shielded cells, decontamination features, and remote operations.

9. Are areas of the facility which exhibit high occupancy, or are presently uncontrolled, adequately protected from new or increased radiation sources?

10. Is maximum distance provided between serviceable components and any substantial radiation sources in the area?

11. Does the design change protect the public and facility personnel from hazards associated with the use of radioactive and other hazardous materials as a result of normal operations, anticipated operational occurrences, and Design Basis Accidents (DBA) conditions, including the effects of natural phenomena pertinent to the site, and maintains these effects ALARA?

12. Does the project protect government property and essential operations from the effects of potential accidents?

Appendix A - (Cont.)

3.0 INSTALLATION CONSIDERATIONS

1. Modular components or other design considerations are utilized to reduce the duration of construction or installation activities in the area.

2. Bolted rather than welded flanges are used for quick removal where appropriate.

3. Build-in rigging provided for ease of installation.

4. Is the equipment ready for service as received?

5. Does the equipment require modification prior to installation? If so, is the modification reflected in applicable documents, and can the modification be performed in a non-radiological controlled area?

6. Have the radiological conditions in areas not routinely accessed been adequately characterized? Are any assumptions made about them valid?

7. For tasks that have historical dose data, has this data been reviewed?

4.0 MAINTENANCE AND OPERATIONS

1. Permanent platforms, walkways, stairs, or ladders are provided to permit accessibility.

2. Serviceable components are capable of being isolated and drained.

3. Flange components are provided for quick removal of high maintenance components.

4. Installation design provides for rapid removal.

5. Surveillance can be performed from outside a high radiation area through the use of TV camera, viewing port, or remote readout.

6. Built-in rigging is provided to facilitate component handling.

7. Components are designed to facilitate flushing and decontamination. (6.1.2.f)

8. Components are designed and selected with consideration for long service life, ease of removal, and frequency of maintenance.

9. Components should be selected to minimize the buildup of radioactivity and include ALARA considerations for maintenance, repair, and decommissioning. (6.1.1.b)

10. Serviceable components are easily accessible with adequate workspace, lay down areas, and lighting.

11. Design features prevent personnel from inadvertently entering high radiation areas. Using the electronic dosimetry with an internal set-point of 100 mrem/hr will greatly reduce inadvertent high radiation area entries.

12. Special provisions are made for ease of maintenance and operation of equipment.

Appendix A - (Cont.)

13. Equipment cover plates are hinged or captive quick-opening fasteners are used to facilitate routine personnel access or maintenance access.

14. Life expectancy and reliability of the chosen equipment for their selection and location are considered to minimize personnel access in the area.

15. Electrical, mechanical, or hydraulic quick release mechanisms are used where possible for insulation, sample bombs, electrical connections, and even entire skids.

16. Remote operations or robotics are considered for use in high radiation areas.

17. Equipment has been selected to ensure their functionality in the radiological environment as required for normal, upset, and accident conditions.

5.0 SHIELDING

1. Shielding analysis has been performed.

2. Entrances to high radiation areas are adequately shielded (e.g., labyrinth).

3. Radioactive equipment is separated by shielding from non-radioactive equipment (to minimize exposure to personnel in adjacent areas).

4. Shield penetrations are minimized in size and number.

5. Shield penetrations are located high on the wall and in a corner to avoid line-of-sight streaming.

6. If the answer to 5.5 is "No," are the penetrations adequately shielded or sealed (e.g., use of high-density sealant or equivalent)?

7. Permanent shielding is employed, to the degree feasible, to avoid the need for temporary shielding.

8. If permanent shielding is not feasible, provisions are made to allow temporary shielding during maintenance activities.

9. Is shielding placed between serviceable components and any substantial radiation source in the area?

10. Is an adequate safety margin applied to seismic load analysis to accommodate the additional load from temporary shielding?

11. Are shields employed to prevent streaming of radiation through doors, pipes, and duct penetrations (e.g., labyrinths or shadow shields)?

12. Has shielding calculations and design been verified to meet ALARA requirements?

13. Have the shielding calculations, including the basic assumptions, been reviewed by an independent, competent reviewer?

Appendix A - (Cont.)

6.0 CONTAMINATION CONTROL (6.1.1.A)

1. Corrosion-resistant material is used for piping and equipment.
2. Curbs are provided to control spread of liquid spills. Can containments be established to reduce the spread of contamination, i.e., cribs, catch pans, drip pans, or cofferdams?
3. Radioactive floor drains are inside the curbs.
4. Floors slope toward the drains.
5. Coatings have been specified that can be easily decontaminated.
6. Ventilation is provided to control airborne radioactivity.
7. Drain lines are sloped continuously and back-flooding is prevented.
8. Surfaces that could be contaminated are made non-porous or sealed for ease of decontamination. Are rough surfaces and features such as crevices, holes, notches, recesses, socket-head cap screws, and knurled finishes avoided?
9. Consider design measures to minimize potential releases of solids, liquids, or gases to reduce contamination when the design requires the breaching of a system that may contain radioactive material.
10. Where material might become activated, materials with low activation potential and corrosion-resistant materials are used as much as possible.
11. Where material might become activated, proper chemical and flow control is used to minimize erosion and corrosion.
12. Preclude by design cross-connections of radioactive drains with non-radioactive drains.
13. Does the design incorporate features that will reduce the likelihood of cross contamination of clean systems and unmonitored release pathways?

7.0 LIQUID SYSTEMS – TANKS, PUMPS, AND SUMPS

1. Pumps are located apart from tanks they serve (so exposure rates from tanks do not increase maintenance exposures).
2. Pumps are fitted with catch basins that are properly drained.
3. Pump casings are provided with equipment drains.
4. Pump seals are covered to prevent contaminated liquids from being projected from the pump.
5. Vents are provided.

Appendix A - (Cont.)

6. Pumps requiring frequent maintenance are equipped with flanged connections for easy removal.

7. Canned pumps or mechanical seals are employed instead of standard packing glands.

8. Tanks and sumps are provided with a mechanism for flushing and decontamination.

9. Vents and relief tail pipes are routed to drains.

10. Components are designed to facilitate draining, flushing, and cleaning by chemical or mechanical means. (6.1.2.f)

11. Agitators or other devices are provided in tanks or other vessels to ensure adequate mixing and to minimize localized radioactivity buildup.

12. Tanks and other vessels are designed with conical or dished bottoms with a central drain and spargers to remove radioactive sediment.

8.0 LIQUID SYSTEMS – VALVES

1. Valves are located away from tanks, filters, demineralizers, etc., where practical.

2. Process valves are remotely operated where needed.

3. Valves are mounted with the stem facing up where practical.

4. Platforms are provided for valve maintenance.

5. There is sufficient space around the valve for efficient maintenance.

6. Valve designs minimize cavities and crevices.

7. The design eliminates the use of cobalt-containing materials for parts or components (e.g., valve trim, seats, pins, etc.) that could be in a flow path leading to a reactor core.

8. The design maximizes the removal of cobalt particulates from systems that can interface with reactor coolant systems.

9. Valves can be installed or removed without cutting or welding.

10. Manual valve operators are used only for infrequently operated valves.

9.0 PIPING

1. Crud traps are minimized and stagnant legs avoided.

2. Socket welds are avoided.

3. All sections of piping can be adequately drained.

4. Vents are provided and piping can be flushed or hyrdolased.

Appendix A - (Cont.)

5. Piping run is in a shielded pipe case where needed.

6. Piping run lengths and horizontal runs are minimized.

7. Field joins are minimized.

8. Piping that potentially contains radioactive contaminants is physically separated from non-radioactive piping.

9. Use of field-run piping is avoided.

10. System piping is designed to eliminate or minimize dead legs, standpipes, or low points.

11. Drains are provided at unavoidable low points and dead legs to flush out radioactive residues.

12. All piping or tubing connections for tritium processes are inside a ventilated hood or glove box and positive sealing connections are use.

10.0 SLURRY SYSTEMS

In addition to considerations for liquid systems, systems containing slurries should meet the criteria below:

1. Sharp bends in pipes are avoided (5 x diameter or greater bends are acceptable).

2. Check valves or strainers are provided at interfaces with liquid systems.

3. Back-flush connections and/or hydro lasing ports are provided.

4. Spent resin or slurry piping are designed with full-ported valves and without screwed connections and orifices.

5. Spent resin or slurry piping are sloped downward and designed to maintain turbulent flow and to minimize pipe connections and fittings.

6. Piping tees in resin or slurry piping are designed to ensure that the normal flow is through the straight portion and the branch line is located above the run.

11.0 INSTRUMENTATION

1. Instrument readouts are located in the lowest radiation area feasible.

2. Instrument taps on liquid systems are located above the piping midplane.

3. Existing radiation monitors are appropriate in terms of types and locations. (If "No," indicate how existing radiation monitoring systems should be modified or new systems that will be required.)

4. Instruments and controls are grouped functionally to minimize time spent in the area.

Appendix A - (Cont.)

5. Instruments are selected and specified for long service life and low maintenance requirements.

6. Provisions are made for remote calibration.

7. Instruments can be flushed to reduce crud accumulation.

8. Assess the adequacy of planned radiation monitoring and nuclear criticality safety instrumentation, including whether the proposed instrumentation is appropriate for the expected types and intensities of radiation, and whether it has sufficient redundancy and capability for operation under normal operating conditions and in emergencies.

9. Readouts or control points for instruments and controllers are located outside of radiation areas.

10. Radiation monitoring systems (RMSs) channels have both local and remote readouts and alarms, with a read out in a central location if appropriate.

11. RMSs have circuitry indicating component failure and built with fail-safe capabilities.

12. Instruments using radioactive or contaminated working fluid contain a minimum quantity of working fluid.

13. Effluent airborne, and off-line process monitor lines and sampler lines are as short as possible and heat-traced and insulated, as necessary, to minimize line loss, water condensation, and radioactivity build-up.

12.0 VENTILATION

1. Provisions are made for ventilating the area.

2. The flow of air is from areas of lesser contamination to areas of greater contamination.

3. Filter banks are readily accessible for maintenance.

4. Filter banks are separated or shielded from each other to permit working on one with the other operating.

5. The ventilation system (exclusive of filters) is designed to minimize radioactivity buildup.

6. Ventilation ducts have cleanout ports for decontamination.

7. Verify that the design of the confinement and ventilation systems provide the required level of protection from airborne contamination, giving particular attention to patterns of air flow and to the locations of air inlets, penetrations, and exhausts. Releases of radioactive material to the workplace atmosphere shall be avoided under normal operating conditions (6.1.2.d) and inhalation of such materials by workers shall be controlled to the extent reasonably achievable. (6.1.2.e)

Appendix A - (Cont.)

8. Direction of ventilation flow is maintained from areas of lower potential airborne radioactivity to areas of higher potential airborne radioactivity.

9. Ducts carrying clean air are located to eliminate, where possible, their passing through radiological controlled areas and are at positive pressure where they pass through areas of potential airborne radioactivity.

10. All process fittings, valves, and equipment for tritium processes are inside a ventilated hood or glove box.

11. Ducts containing potentially contaminated air are at negative pressure if they pass through clean areas.

12. The number of direction changes in ductwork containing potentially contaminated air is minimized.

13. Fans or blowers in ventilation systems containing potentially contaminated air are located downstream of filters.

14. Air hoods or glove box openings have sufficient linear air velocity for their service conditions.

13.0 FILTERS AND DEMINERALIZERS

1. Vents and relief valve tail pipes are routed to drains.

2. Filters and demineralizers have been assessed as radiation sources.

3. Multiple filters or demineralizers are housed in separate cubicles to permit maintenance with the system operating.

4. Filter cartridge sizes are common to other filters already in use at the plant.

5. Filters are designed to minimize servicing frequency.

6. Filters are designed for efficient removal.

7. Filters are located in low occupancy and low traffic areas.

8. Filters are provided for remote or shielded methods of filter removal.

9. Submicron filters are employed as applicable.

10. System filters are provided upstream of heat exchangers or demineralizers.

Appendix A - (Cont.)

14.0 ADDITIONAL IMPLEMENTATION REQUIREMENT CONSIDERATIONS

1. Temporary shielding.
2. Additional or temporary ventilation.
3. Temporary containments.
4. Decontamination of systems, components, and/or work areas.
5. System flushing.
6. Tool list.
7. Special installation.
8. Quality Assurance (QA)/Quality Control (QC) inspection/hold points.
9. Support work (scaffolding, etc.).
10. Special training (mock-up, classroom).
11. Safety.

15.0 BREATHING AIR &COOLING SYSTEMS

1. Are breathing air and cooling systems being planned if needed?
2. Are the system specifications adequate?

16.0 WASTE MINIMIZATION

1. The volume of radioactive waste generated is minimized by operation of the system or equipment (e.g., minimize the quantity or volume of consumables, use high capacity filter elements, use mechanical seals rather than packing on rotating equipment).
2. Non-radioactive waste (e.g., oil, refrigerant) is segregated from potential contamination to preclude the generation of mixed waste.

17.0 POST CONSTRUCTION REVIEW OF EFFECTIVENESS

1. Are there plans for a post-construction review of effectiveness of engineered features to reduce dose and the spread of radioactive materials to provide feedback to the design engineers and help refine the design process?

Appendix A - (Cont.)

18.0 DECOMMISSIONING CONSIDERATIONS

1. Use modular, separable confinements for radioactive materials to preclude contamination of fixed portions of the structure.

2. Long runs of buried contaminated piping will be avoided and provisions will be included in the design to ensure the integrity of joints in buried pipelines.

3. Designs that ease cut-up, dismantlement, removal, and packaging of contaminated equipment from the facility (e.g., glove boxes, filtration equipment, ductwork, etc.).

4. Use of modular shielding, in lieu of monolith shielding walls.

5. Use of lifting lugs on equipment.

6. Fully drainable piping systems that carry contaminated products.

19.0 DOE REGULATIONS, ORDERS & NOTICES

1. Verify that radiological design criteria are consistent with applicable federal/state regulations, recognized standards and guides, and with DOE directives relating to radiological safety in design.

20.0 STATE OF WASHINGTON ENVIRONMENTAL REQUIREMENTS AFFECTING DESIGN FOR OCCUPATIONAL ALARA

The following standards should be reviewed to ensure that there are no conflicts with occupational radiation protection requirements:

1. WAC 246-247, Section 060 describes the information requirements for approval to construct, modify, and operate an emission unit. These permits should be reviewed to ensure that there are no conflicts with occupational radiation protection.

2. WAC 246-247, Section 040 identifies standards for radioactive air emissions in the state of Washington; differing standards apply based on the potential release from the unit and whether it is a new construction or modification. All new construction must meet BARCT (Best Available Radionuclide Control Technology) standards, Appendix B. All existing emission units and non-significant modifications shall utilize ALARACT (As Low as Reasonably Achievable Control Technology), Appendix C.

21.0 ENVIRONMENTAL ASSESSMENTS

1. Review any associated environmental assessments to ensure that there are no conflicts with occupational radiological protection requirements.

22.0 SAFETY ANALYSIS REPORTS

1. Review any associated safety analysis reports to ensure that there are no conflicts with occupational radiological protection requirements.

Appendix A - (Cont.)

23.0 DESIGN DOCUMENTATION (6.1.2.k, 6.1.2.l)

1. Statement of purpose of the design.
2. Statement of scope of the design.
3. Radiological input to the budget for the design.
4. Copies of radiological surveys used as reference in the design.
5. Process flow diagram or other record of the system operational methodology.
6. Records of all ALARA decision-making methods used.
7. Review Comment Records (Form A-6004-835) documenting:
    a. Radiological review and input into functions and requirements documents.
    b. Radiological review and input into procurement documents.
    c. Radiological review and input into design specifications.
8. Descriptions of the design concepts considered including a description of the advantages and disadvantages of each.
9. ALARA review meeting minutes.
10. Dose estimates made at various phases of the design.
11. Failure analysis of critical components affecting ALARA and mitigating plans.
12. Summary of the ALARA features of the design.
13. Description of how the various regulations concerning radiological design are met.
14. ALARA initiatives to aid in decommissioning.
15. Records of any shielding calculations done and the verification of the shielding calculations.
16. Radiological reviews of mockups.
17. Radiological reviews of fabrication and testing.
18. Records of the post-construction review of ALARA design effectiveness.

Applicable reports and or documents generated in accordance with Appendix A will have the signed approval of the Design Decision Authority and Project/Activity Radiological Control Manager. The Project/Activity Engineering Organization will be the custodian of all original documents, and will file and maintain copies in accordance PRC-PRO-IRM-10588.

Appendix B - Post-Construction Review of Radiological Control Design Features and Effectiveness

After the facility and/or equipment, for which a design review has been performed, has been constructed and reached full operation for some period of time, a post-construction review of the effectiveness of the radiological aspects of the design is required to be done. The following are areas that will need to be addressed:

REVIEW RADIOLOGICAL CONDITIONS

In order to determine if a radiological design and design review effort has been successful, it is necessary to compare the actual radiological conditions with the expected and explain any significant differences.

1. PERFORM confirmatory surveys of actual dose rates, contamination levels, and airborne contamination levels.

2. COMPARE actual to expected dose rates, contamination levels, and airborne contamination levels.

3. EXPLAIN any significant differences between the expected and actual dose rates, contamination levels, and airborne contamination levels.

4. DISCUSS any unexpected facility and/or equipment layout problems.

5. DISCUSS any unexpected construction, maintenance, or operational problems with radiological consequences.

Recommendations – Clear recommendations should be prepared for two cases:

1. Good practices from design or design review activities that went well and should be duplicated in future designs.

2. Design or design review practices that need to be improved in future designs.

3. Documentation of recommendations shall be maintained. (6.1.2.k, 6.1.2.l)

Appendix C - Definitions and Abbreviations

Term	*Definition*
ALARA	The "approach" to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to levels as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. "ALARA is not a dose limit but a process" which has the objective of attaining (and maintaining, if achieved) doses as far below the applicable limits of CHPRC-00073, Table 2-1 as is reasonably achievable.
Engineering Design Lead	The person empowered by the design organization or the originating organization to make final decisions concerning aspects of the design or design process. The Engineering Design Lead manages the Design Team members during the design process.
Early Stage of Design (6.1.1.c)	The Initiation Phase of the design process where the functions and requirements required for a design task are considered. This is the point when an Engineering Design Lead is appointed, and the need for the design is established.
Facility Modification Package	An engineering process used for modifications made to Configuration Managed Structures, Systems, and Components (CM SSCs). A modification is defined as any permanent change, addition, or alteration to a CM SSC and/or its baseline documentation.
New Facility	A structure (or set of structures), being designed and built to handle radioactive material in any way; or that intrudes (including excavation) into areas containing radioactive material; or is attached to a structure(s) that contains or processes radioactive material; or that contains a non-medical radiation generating machine. A facility includes the equipment within the structure(s). This definition includes those facilities classified as non-reactor nuclear facilities, reactors, and nuclear facilities in accordance with DOE 5480.23, *Nuclear Safety Analysis Reports*.
Project/Activity Radiological Control Manager	The Radiological Control Manager for the entire project under the ultimate oversight of the Project Manager or Design Decision Authority.

Appendix C – (Cont.)

Term	*Definition*
ALARA Design Review Process	A process beginning at the earliest stage of the engineering design and ending with a post-construction review of effectiveness. The process is performed by competent radiological controls personnel who review the design of equipment or facilities during the engineering design process. The review ensures that appropriate dose reduction methods and other radiological considerations are included in the design so that the radiation exposure to install, operate, and maintain the facility or system will be ALARA. Other considerations included in the review is minimization of radioactive waste, decommissioning, and demolition of the facility.
ALARA Design Review Screening Criteria	The ALARA design review screening criteria are used to determine the rigor of radiological review required for engineering designs.
Design Team	A group of individuals selected by the Engineering Design Lead to perform the engineering design for a new radiological facility or system. Radiological Controls participation is required on the Design Team if the design exceeds worker dose criteria listed in Table 1.
RCTS for a Design Team	An appointed member of the design team who by education, training, and experience is capable of guiding the radiological design or modification of a facility to ensure that the design supports the ALARA principle and meets regulatory commitments. He or she should have a strong grasp of the overall design needs and regulatory requirements from a radiological perspective, and will be appointed from the Radiological Control Organization.
Second Technical Review/Peer Review	A member of the Radiological Control Technical Staff who has completed training course 020934, and performs a second technical review of documents developed in accordance with this procedure.

Appendix D - ALARA Plan for Designated Projects

A project ALARA Plan is required if the estimated dose for the planned use of the facility or system to be designed exceeds dose trigger levels specified in Table 1 of this procedure. The ALARA Plan is used to capture the radiological review criteria established for the design, and with the aid of the Radiological Review Checklist (see Appendix A), documents the ALARA measures incorporated into the design.

This appendix provides guidance on elements that should be included in the ALARA Plan. Since every design is unique, the points included here may or may not be applicable on a project specific basis. The ALARA plan should be started during the Conceptual Design Phase of the engineering process, and revised at the end of each subsequent phase of the design as directed by the Engineering Design Lead. The final revision of the ALARA Plan should capture the results of the Post-Construction Radiological Review that is performed once the facility or system is operating.

Project being reviewed:

Dose Evaluation

- Document the justification for project's dose trigger level based on Table 1 (Section 3.0 of this procedure). Use checklist of Appendix A as supporting document.
- Based on the estimated person-hours and radiological dose rates projected for specific areas.
- Contingency plans to be implemented based on work scope increase, elevated dose rates, and or increase in person-hours.
- Dose before recommended mitigating techniques have been applied to the design.

Example of Controls that may be Applicable

- Shielding analysis and calculations.
- Review of benchmarking if applicable.
- ALARA decision-making methods used.
- Contamination control methods proposed during installation and demobilization.
- Radiation exposure controls during installation and demobilization stages.
- Airborne radioactive material control during installation and demobilization periods.
- Mock-up training of personnel for specific tasks.

Additional Administrative or Engineered Controls to be Considered (6.1.2.g)

- Post decontamination review and evaluation.
- Provisions for decommissioning.
- Applicable State of Washington environmental requirements affecting design.
- New technology available.

Appendix D – (Cont.)

- Briefing of applicable personnel.
- Engineered controls, walls, ventilation paths, and temporary shielding.

Implementation Process

- The ALARA Plan will contain specific actions and or plans to control areas of radiological concern such as airborne activity, contamination, and exposure to personnel.
- Determine which work group will complete the control measures mentioned above.
- Committee or specific disciplines to be assigned.
- Date to start and date projected for completion.
- Oversight involvement such as CHPRC ALARA CTA, Project/Facility ALARA Coordinators, and/or Radiological Managers.
- Feedback and review of final radiological mitigation efforts.
- Applicable reports and or documents generated in accordance with Appendix E will have the signed approval of the Design Decision Authority, Project/Activity Radiological Control Manager, and the RCTS assigned for the ALARA project review on the Design Team. Peer reviews will be performed by members of the Radiological Control Technical Staff who are trained in accordance with
  Section 3.4.4. The Project/Activity Engineering Organization will be the custodian of all original documents, and will file and maintain copies in accordance with
  PRC-PRO-IRM-10588.

Monitoring and Evaluation Radiological Mitigation Controls

- Periodic assessment of exposure.
- Post ALARA Review of the Project/Program.

Appendix E - Dose Optimization using Cost Basis Methodology

The cost-benefit analysis process is a method of calculating the net benefit of a radiological control practice. It is adopted from ICRP Publication 37 *Cost-Benefit Analysis in the Optimization of Radiation Protection (ICRP 1983)*. Cost-benefit analysis is a tool used to identify the best way to allocate resources. ICRP 37 recommends this method to justify radiation exposure practices, in keeping with the As Low as Reasonably Achievable (ALARA) philosophy, taking into account all economic and social considerations associated with the radiation exposure.

The analysis involves assigning a monetary value to all terms so that a net benefit can be determined for a radiation protection practice. The terms included in the evaluation are associated with the procurement, installation, and operation costs for the selected practice. To optimize a given practice, a sensitivity analysis is performed on one variable associated with the practice (e.g., shielding thickness) to determine the net benefit for the collective dose (S) that results. The analysis requires that a monetary value be assigned to the dose detriment for the practice being evaluated.

The cost-benefit analysis process is expressed in ICRP Publication 37 as:

$$\boldsymbol{B} = \boldsymbol{V} - (\boldsymbol{P} + \boldsymbol{X} + \boldsymbol{Y}) \qquad \text{Equation 1}$$

Where:

B = the net benefit of the practice

V = the gross benefit of the practice

P = the basic production cost of the practice, excluding the cost of radiation protection

X = the cost of achieving a selected level of radiation protection

Y = the total cost (both objective and subjective) assigned to the dose detriment resulting from the practice at the selected level of radiation protection (ICRP 1983). CHPRC establishes the $ to dose conversion factor to be $10,000/Person-Rem.

To determine Y, the estimated dose savings (in Person-Rem) should be multiplied by the $ to dose conversion factor ($10,000/Person-Rem)

In this process, the net benefit is the gross benefit less the production costs, the radiation protection costs, and the health detriment costs. In such a simplified model, the optimum radiation protection practice minimizes the total cost, which is the sum of the basic production costs for the practice, the radiation protection costs, and the health detriment costs (ICRP, 1983). The radiation protection costs are costs associated with the design, procurement, construction, and or installation of materials/equipment necessary for the practice, and periodic monitoring after installation. The health detriment costs are expressed as costs associated with both health and non-health risks to workers and/or the public from exposure to ionizing radiation.

Appendix E – (Cont.)

Theoretically, the costs for the radiation protection practice include all costs associated with social or economic impacts related to the systems. These include the cost of mining materials, forging steel, forestry, etc. In practice however, it is appropriate to assume that these costs are already factored into the estimated costs for procurement, fabrication, and installation of the system materials.

Net Benefit of the Practice (B)

A positive net benefit B for the expression determines that the option should be considered during the optimization evaluation, but only if the resulting dose rates/worker effective doses meet regulatory and/or contractual limits. If B is a negative result, the option should be removed from consideration as this signifies that the option is not justified.

A net benefit (B) of zero signifies the point at which an individual exposure (E_i) equals the maximum applicable dose limit, i.e., 5 person-rem. Early in the cost benefit analysis process, costs should be determined for the highest total effective dose allowed by regulation, i.e., 2000 mrem total effective dose. By assuming that this results in a net benefit B of zero, the value of the gross benefit V for the practice can be determined, since V then equals (P + X + Y). This baseline value of V is then used in ensuing calculations to determine the net benefit for each incremental change of the variable applicable to the particular radiation protection practice being evaluated.

Gross Benefit of the Practice (V)

Based on guidance from ICRP Publication 37, the gross benefit V of the radiation protection practice represents the sum of all benefits accruing to society, not just the benefits to a particular project, local group, or individuals. As such, it is comprised of both objective (defined) costs and subjective (value judgment) costs for the proposed practice such as:

- Capital costs for procurement, design, installation of structures needed to support the radiation protection practice (does not include the cost of the radiation protection practice), as well as Operations and Maintenance costs for the practice (P)
- Costs for procurement, design, fabrication and installation of the radiation protection practice, as well as monitoring/surveillance costs for the practice (X)
- Costs including energy costs, mining costs, forging costs, or any other costs that could be associated with risks created because the radiation protection practice is being put into place (affects both P and X)
- Cost of health detriment related to the total effective dose for the practice (objective part of Y)
- Cost of non-health detriment related to the individual dose risk associated with the practice, including social considerations for nearing or exceeding a dose limit (subjective part of Y)

The last two bullets represent the difficult components to quantify when determining the total gross benefit, due to the esoteric nature of the terms. See below for more detail.

Appendix E – (Cont.)

Basic Production Costs (P)

This term addresses the straightforward costs of designing, procuring, fabricating, and installing support systems required to support the radiation protection practice, but does not include the costs for the radiation protection practice itself. For instance, installation and operation of air monitoring equipment in a ventilation system would be considered a radiation protection practice, but the construction of the stack and the room required to house the monitoring equipment, as well as the cost for maintenance and repair of the equipment would be considered basic production costs.

Theoretically, the basic production costs include all costs associated with social or economic impacts related to the systems. These include the cost of mining materials, forging steel, forestry, etc. In practice however, it is appropriate to assume that these costs are already factored into the estimated costs for procurement, fabrication, and installation of the system.

Cost of Achieving a Selected Level of Radiation Protection (X)

This term represents the costs of designing, procuring, fabricating and installing the equipment/material necessary for the radiation protection practice. For instance, the radiation protection practice of installing shielding would require that the shielding be designed, shielding material procured, then installed and periodically monitored to ensure effectiveness. Costs for providing engineered supports for the shielding would not be included in this factor; those costs would be included in the basic production costs P.

The reason for separating this cost from the basic production costs is that this term, along with the cost of the dose detriment (Y) are the portions of the equation that are related solely to radiation protection functions. Separation of these terms allows the impacts of modifying the risk factors associated with a radiation protection practice to be evaluated to determine the most cost effective measure to implement.

Cost assigned to Dose Detriment (Y)

The total dose detriment conversion factor for CHPRC is $10,000/Person-Rem. This value should be used when evaluating an ALARA measures to determine the most cost effective measure to implement.

Appendix F - Cost Benefit Analysis Methodology

The following is a recommended method to perform the cost-benefit analysis for a radiological control practice.

- Determine the radiological control practice to be analyzed
- Determine the cost of facility/system modifications required to support the radiological control practice (e.g., shielding supports, ventilation duct additions, collection systems for decontamination solutions, etc.)
- Determine the cost of the radiological control practice (e.g., cost for shielding material, including installation and maintenance costs, cost of a containment hood to create capture velocity (including materials, installation and maintenance costs)
- Determine the anticipated source term contributing to dose rates for the practice
- Determine historical exposure rate information, or create dose models to determine unmitigated exposure rates
- Determine the anticipated work to be performed and prepare an exposure estimate for the work based on stay times, number of personnel required.
- Create a dose model for a maximally exposed individual (e.g., 5000 mrem total effective dose) (required to determine the value of the gross benefit V)
- Calculate net benefit B for each option
- Eliminate options with negative Net Benefit values
- Eliminate options that exceed applicable dose limits
- Evaluate the remaining options to determine the option with lowest positive net benefit

References

ICRP Publication 37, *Cost-Benefit Analysis in the Optimization of Radiation Protection (ICRP 1983)*

IAEA Bulletin Volume 22, No. 5/6, *Cost-Benefit Analysis and Radiation Protection* (Ahmed et al)

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