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—COMMITTED TO PROTECTION OF THE ENVIRONMENT—

Record of Decision for the On-Post Operable Unit

Volume 1
Sections 1–11

Version 3.1

June 1996

Contract No. DAAA 05-92-D-0002

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TECHNICAL SUPPORT FOR
ROCKY MOUNTAIN ARSENAL

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Prepared by:

Foster Wheeler Environmental Corporation

Prepared for:

U.S. Army Program Manager's Office for the
Rocky Mountain Arsenal

This document is intended to comply with the National Environmental Policy Act of 1969.

The information and conclusions presented in this report represent the official position of the Department of the Army unless expressly modified by a subsequent document. This report constitutes the relevant portion of the administrative record for this CERCLA operable unit.

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6.0 Summary of Site Risks

A risk assessment is a scientific procedure used to estimate the potential adverse effects on human health and the environment from exposure to chemicals. At a CERCLA site, a baseline risk assessment is prepared and serves as the basis for evaluating risks posed from contamination if no remedial actions are taken. The resulting level of risk is called the baseline risk, i.e., an estimate of risk that might exist if no remediation or institutional controls were applied at a site. At RMA, a risk assessment called the Integrated Endangerment Assessment/Risk Characterization (IEA/RC) was performed and used as the baseline risk assessment. In this instance, the IEA/RC defined baseline to include the completion of the soil-related IRAs (e.g., Basin F, Lime Basins) and enforcement of the FFA's use restrictions. The FFA prohibits residential development; potable use of groundwater and surface water; agricultural activities for the purpose of raising livestock, crops, or vegetables; and the consumption of fish and game taken from RMA. Therefore, these uses were not considered during the IEA/RC. The relevant IRAs (Table 2.4-1) were implemented in accordance with the FFA to prioritize the selection of some of the more highly contaminated sites for remedial action and reduce or eliminate the risk for exposure to contaminated soil prior to the selection of the final remedial action. The risk assessment methodology used during the IEA/RC was initiated prior to the publication of EPA risk assessment guidance (OERR-EPA 1989). However, this methodology does incorporate the exposure assumptions and toxicity assessment methods specified in EPA guidance and fulfills EPA's requirement of estimating risk based on a reasonable maximum exposure (RME).

The IEA/RC was the result of a progressive series of endangerment assessment analyses initiated by the Biota RI (ESE 1989), the Human Health Exposure Assessment (HHEA), and the HHEA Addendum. These initial evaluations served as screening assessments for the protection of human health and preliminary estimations of biota risk, and provided the basic building blocks of the IEA/RC report, which is divided into two evaluations, the Human Health Risk Characterization (HHRC) and the Ecological Risk Characterization (ERC). Both of these evaluations are summarized in the final report.

The general methodology of the risk assessment process involves the following steps: identify the COCs, perform the exposure and toxicity assessments, and perform the risk characterization. The more than 50,000 groundwater, surface water, sediment, soil, air, and biota samples collected during the past decade were used to evaluate which chemicals were of concern to human health and the environment and to develop the risk assessment.

6.1 Human Health Risk Characterization

Soil at RMA is the primary medium by which humans can be exposed to contamination on post, due to land-use restrictions and/or limitations on the uses of other environmental media specified in the FFA and the Rocky

Figures 6.1-13 and 6.1-14 show the composite of carcinogenic and noncarcinogenic chronic risk exceedances, as well as acute risk exceedances.

For all receptors evaluated in the HHRC, the major contaminants contributing to potential cancer risks were aldrin, DBCP, arsenic, and dieldrin. For noncancer risk endpoints, DBCP, aldrin, and arsenic account for the majority of the total estimated HIs.

Acute and Subchronic Risk Evaluation

In the probabilistic evaluation, PPLVs were calculated to be protective of chronic (long-term) exposures. However, it is possible that exposures to COCs at RMA could be short term, such as exposures occurring only on a single day (acute), or exposures lasting more than 1 day but less than 7 years (subchronic). These PPLVs, originally calculated for the HHEA Addendum, are summarized in Tables 6.1-19 and 6.1-20. The cumulative direct acute and subchronic PPLVs are protective of exposure via three pathways, soil ingestion, particulate inhalation, and dermal contact with soil. The PPLVs presented in these tables are the same as those originally calculated, with two exceptions: PPLVs for aldrin and dieldrin were recalculated during the HHRC to reflect updated toxicity criteria and the dermal relative absorption factor (all receptor scenarios) and soil covering factor (visitor populations only) were revised.

In general, and particularly for the biological and industrial worker populations, the acute and subchronic PPLVs shown in Tables 6.1-19 and 6.1-20 are higher than the corresponding chronic noncarcinogenic 5th percentile PPLVs (Tables 6.1-13 through 6.1-17). This finding is expected because the body can generally tolerate a higher contaminant dose over a short (e.g., acute) duration than over a long (chronic) duration for a given dose rate. However, for the recreational and regulated/casual visitor exposure settings, acute/subchronic PPLVs for some chemicals are lower than corresponding chronic noncarcinogenic 5th percentile PPLVs. Figure 6.1-15 shows sample locations exceeding an HI of 1.0 for all COCs having acute PPLV values.

6.2 Ecological Risk Characterization

Ecological risk characterization focuses on chemicals that, because of their toxicity, may adversely affect biota populations, individuals of threatened or endangered species, or the species diversity in a community. For these effects to occur, toxic chemicals must be present in the environment, potential biota receptors must be present and they must be engaged in activities that would expose them to chemicals that are not only present, but bioavailable (Figure 6.2-1). The sections below summarize the steps of the ERC at RMA, which are similar to the HHRC steps.

6.2.1 Identification of Contaminants of Concern

Fourteen chemicals detected on RMA were selected as of concern to biota: aldrin, dieldrin, chlordane, endrin, DDT, dichlorodiphenyldichloroethene (DDE), mercury, arsenic, cadmium, chlorophenylmethylsulfide (CPMS), chlorophenylmethylsulfone ($CPMSO_2$), copper, DBCP, and DCPD. The biota COCs were selected on the basis of criteria (toxicity, persistence, amount used or produced at RMA, and areal extent of contamination) developed collectively by the Army, EPA, USFWS, and Shell to focus on the potential main risk drivers.

Of the 14 biota COCs considered in the ERC, six (aldrin, dieldrin, endrin, DDT, DDE, and mercury) are known to biomagnify substantially, and seven do not biomagnify substantially or at all (arsenic, cadmium, CPMS, $CPMSO_2$, copper, DBCP, and DCPD). Chlordane can biomagnify (usually in the form of its metabolites), but was not treated quantitatively as such because no tissue sample data were available for this chemical. Biomagnification means that each successive organism in the food chain (e.g., from plant to insect, mouse, and hawk) will have a higher concentration of the chemical in its body tissue.

6.2.2 Exposure Assessment

Numerous ecological studies have been performed at RMA, particularly by USFWS in the 1960s, the Army in the 1970s to mid-1980s, and by Shell, USFWS, and the Army in the late 1980s and 1990s to identify the ecological receptors that may be exposed to the biota COCs and to determine the effects of this exposure. Using the data from these studies, several food webs were constructed to represent the biota food chains present at RMA. For the purposes of the IEA/RC, a food web is a collection of food chains that all culminate in a single top predator. Five such food webs were evaluated for RMA, each headed by different predators:

- Bald eagle
- American kestrel
- Great horned owl
- Great blue heron
- Shorebird

The following types of biota were selected to represent the various feeding levels (trophic boxes) in these RMA food webs and were evaluated from past varied studies where tissues were collected for analysis of COC concentrations:

- Earthworms
- Insects (represented by grasshoppers and ground beetles)
- Small birds (represented by vesper sparrows, western meadowlarks, and mourning doves)
- Small mammals (represented by deer mice and 13-lined ground squirrels)
- Medium mammals (represented by desert cottontails and black-tailed prairie dogs)
- Water birds (represented by mallards, blue-winged teal, and American coots)

- Shorebirds (represented by killdeer)
- Large fish (represented by northern pike and largemouth bass)
- Small fish (represented by channel catfish, black/brown bullheads, and bluegills)
- Aquatic invertebrates
- Plankton
- Terrestrial and aquatic plants

The data on tissue concentrations of contaminants were used to both document the nature and extent of contamination in biota and to provide tissue data that could be used in the ERC process described in Section 6.2.4. The exposure assessment included the estimation of exposure area soil concentrations; the estimation of species- and chemical-specific biomagnification factors (BMFs) based on bioaccumulation factors (BAFs) that describe the amount of COC transfer from food to consumers; and the identification of dietary items, fraction of items consumed, and feed rates. Exposure area soil concentrations were calculated based on an area-wide average (i.e., an arithmetic mean) concentration, an "area" being defined as an organism's estimated foraging or exposure area. The area-averaged concentration was computed from spatially interpolated soil concentrations in the 0-ft to 1-ft depth interval (except for the prairie dog's exposure area, which incorporated a vertical average for the 0-ft to 20-ft depth interval). The interpolated soil concentrations were calculated on a square grid with 100-ft spacing using surrounding actual soil sample concentration data and the inverse distance-squared algorithm. Before the soil data were interpolated, values that were below certified reporting limits (BCRL) were replaced with estimated values based on nearby detections when the surrounding data were sufficient using the inverse distance-squared algorithm. Because the spatial interpolation of BCRL data proceeded iteratively, a previously estimated BCRL value may have been included with nearby detections to estimate a replacement value for a BCRL at a different location (see Appendix C of the IEA/RC report for a detailed description of the spatial interpolation of BCRL data). Specifically, exposure area soil concentrations were estimated in three steps: spatial interpolation of BCRL data, interpolation of soil concentrations onto an RMA-wide grid, and averaging of interpolated data within an exposure area to compute exposure area soil concentrations. A best estimate of the exposure range of each receptor was obtained from the literature and represented by a circle (to facilitate the modeling of average risk) within which an individual receptor was assumed to be exposed. By centering the exposure range circle for a given receptor on a grid block and averaging the soil values within grid blocks that fell half or more within the circle, an average exposure concentration was estimated. This process was repeated for each grid block over the entire RMA area.

The BMF used at RMA represents a ratio between the concentration of a chemical in biota tissue (generally represented as the "whole-body concentration," which includes the whole animal for small mammals, such as deer mice, and the skinned/eviscerated carcass for medium mammals, such as prairie dogs) and that in soil. Three different methods of calculating the BMF were used in evaluating potential risk at RMA, which yielded

differing BMF values for four COC categories (Table 6.2-1). The differences reflect the uncertainties associated with the data as well as the alternate methods used to derive the BMFs. Because the BMFs resulted in varying risk estimations, the SFS (see Section 6.2.4.3) will attempt to resolve uncertainties about the spatial extent of potential excess exposure and resulting subpopulation risk to biota compared to the three ranges of risk derived from the three BMFs.

Once a BMF was developed for a particular chemical/receptor combination, it was multiplied by the estimated exposure soil concentration in each block to obtain an estimated tissue concentration for the ecological receptor centered on that grid block. Data on dietary fractions and feed rates were obtained from the literature and from studies conducted at RMA. Where appropriate, the RMA-specific dietary data were used instead of literature values; however, if RMA data were not available, preference was given to literature dietary information from geographic and habitat types most similar to those at RMA. The exposure assessment parameters (Table 6.2-2) were based on best estimates of averages and were used to calculate potential tissue concentrations and dosages based on ingestion of contaminated soil and prey.

6.2.3 Toxicity Assessment

Literature data on chemical toxicity that include biota COC concentrations associated with some type of adverse health effect were used as numerical thresholds against which risk was evaluated. Reported effects on reproduction were preferred because these have the most obvious connection with detrimental population impacts; however, nonreproductive effects, such as behavioral toxicity, may also be important, but these effects are more difficult to evaluate and quantify. Other such toxicological endpoints were considered from a qualitative perspective. For all of the receptors evaluated, both tissue-based (i.e., maximum allowable tissue concentrations, or MATCs) and dose-based (i.e., toxicity-reference values, or TRVs) threshold values were sought in the literature. Each of the values found in the literature was evaluated as to its appropriateness for use as a threshold value (NOAELs and no observed effects levels, or NOELs, were the preferred endpoints). UFs were applied to the final literature-based pre-UF MATCs and pre-UF TRVs to help ensure adequate protection of biota populations. UFs were developed for the MATC and the TRV (Table 6.2-3) approaches in parallel (i.e., it was decided to apply the same rationale and values for each derivation process).

UFs were developed for four categories as follows:

- Intertaxon variability in toxicological responses to contaminants when extrapolating from the species used in an experimental study to a target species at RMA
- Extrapolation from the duration of an experimental study to the chronic exposure being assessed at RMA

- Extrapolation from a toxicity endpoint in an experimental study to the desired no adverse effects endpoint for the ecological risk assessment at RMA
- Modifying factors to account for additional sources of uncertainty

The final UF, the product of the results of these four categories, is divided into the pre-UF MATC or pre-UF TRV critical value to determine a final MATC or TRV (Table 6.2-4). The total uncertainty (final UF) applied for the derivation of TRVs ranged from 4 to 7,500 and the total uncertainty for MATCs ranged from 1.5 to 375. However, if the final UF exceeded 400, a final UF of 400 was used. The total uncertainty ranges for the main risk driver, aldrin/dieldrin, was much tighter: 4 to 30 for the aldrin/dieldrin TRVs (Table 6.2-5) and 1.5 to 30 for the aldrin/dieldrin MATCs (Table 6.2-6).

The MATCs represent maximum whole-body concentrations of bioaccumulative chemicals that are unlikely to cause harmful effects to specific receptors. The MATCs, expressed as the weight of contaminant per unit of body weight (mg/kg-bw), were derived from literature data on tissue concentrations associated with the presence or absence of observed toxicological effects in biological test species (to produce pre-UF MATCs), and then adjusted with the COC/receptor-specific UF to produce final MATCs.

The final TRVs represent estimates of a daily dose (mg/kg-bw-day) that are likely to be without an appreciable risk of harmful effects to target receptors. The TRVs computed for the IEA/RC follow an approach that is different from that described in the Off-Post Operable Unit Endangerment Assessment/FS for RMA (Harding Lawson Associates 1992); however, both RMA approaches are similar to the methodology used by EPA to compute RfDs for assessing risks to human health.

The final toxicological threshold values, MATCs and TRVs, are compared to the site-specific exposure measurements (i.e., population mean contaminant tissue concentrations and doses) to estimate potential risk to biota populations (Section 6.2.4.1). The toxicological threshold values are intended to be protective of biota populations and individual bald eagles at RMA.

The final tissue- and dose-based threshold values selected for the characterization of risk are shown in Table 6.2-4. When both tissue-based and dose-based threshold values were available, the value with the lower UF was selected. When the uncertainty was equal, the TRV was selected because it avoided the use of a BMF, which introduced uncertainty of its own. Where two values were calculated, the value that is shown in bold face was used to estimate risk.

6.2.4 Risk Characterization

6.2.4.1 Methods

The characterization of potential risk from the biota COCs to terrestrial receptors was performed by integrating the exposure assessment and the toxicity assessment with a Geographic Information System (GIS) to produce a series of maps that display areas of potential risk (i.e., HQs or HIs greater than 1.0).

For the tissue-based approach, estimated tissue concentrations were compared directly with a tissue-based toxicity threshold value to calculate an HQ, which represented an estimate of potential risk in a grid block for the chemical/receptor combination being investigated. This approach is represented by the following equation:

$$HQ = \frac{Tissue\ Concentration}{MATC}$$

Alternatively, if the dose-based approach was used, the dose to the receptor being investigated was estimated and compared to a dose-based toxicity threshold value to calculate an HQ. The dose-based approach is represented by the following equation:

$$HQ = \frac{Dose}{TRV}$$

The HQ equations presented above are a generalized representation of those actually used in the ERC. Appendix C of the IEA/RC report contains a detailed description of the equations used. The risk characterization processes were repeated for all grid blocks and for all chemical/receptor combinations for which biomagnification factors were calculated. There were variations from these approaches for chemicals having no tissue data, for predators that were not sampled for nonbioaccumulative COCs, and for aquatic food chains. These variations are also described in Appendix C of the IEA/RC report.

An HQ greater than 1.0 indicated a potential risk from a particular chemical. The sum of all HQs for a single receptor resulted in an HI, which indicates the potential risk from all biota COCs to that receptor. HQs and HIs were mapped using GIS to show the geographic extent of areas having potential risk (Figures 6.2-2 through 6.2-5).

The degree to which the results of the risk characterization were consistent with the ecological measurement endpoints on observable field effects identified within the ecological database available for RMA was also evaluated. Ecological measurement endpoints were selected at the community, population, and individual levels of ecosystem organization. The community-level measurement endpoints considered were species richness and trophic diversity; these provide information on the assessment endpoint of biological structural

diversity of the RMA and regional ecosystem. Population-level measurement endpoints were relative abundance, reproductive success, and morbidity; these provide information on the assessment endpoint of population robustness. Selected biomarkers (i.e., acetylcholinesterase inhibition and eggshell thinning) were examined at the individual level, but evaluated as measurement endpoints for extrapolation to population effects. Endpoints at the individual level are appropriate for evaluating adverse effects on individuals of threatened or endangered species (e.g., bald eagle), which by definition have populations reduced to the level where individuals are important.

6.2.4.2 Results

Quantitative results were calculated for all five of the predators (bald eagle, American kestrel, great horned owl, great blue heron, and shorebird) heading the food webs developed for RMA and for four of the trophic boxes in their food webs (small bird, small mammal, medium mammal, and water bird). Other trophic boxes, including all strictly aquatic organisms in the RMA lakes, were not evaluated quantitatively because toxicity threshold values for these biota COCs/trophic box combinations were not available in the literature. The results of the terrestrial risk characterization are presented primarily in maps, which best show the spatial variability of the estimated potential risk. Figures 6.2-2 and 6.2-3, which illustrate the number of receptors having potential risk, are based on the Shell BMF because Shell BMF results were intermediate between the Army and EPA BMF results. Many other such maps are available in the IEA/RC report (Section 4 and Appendix C.3). In viewing these maps, it should be remembered that a small hot spot (identified by only a few borings) or a large relatively clean area can affect the soil concentrations interpolated for several surrounding grid blocks. These grid blocks in turn can affect the estimated exposure soil concentrations for many grid blocks, particularly for receptors with large exposure ranges such as raptors. Such species are likely to have sizable areas of potential risk because very high contaminant concentrations in hot spots around the manufacturing plants and basins were averaged over large exposure ranges. If the high contaminant concentrations in just these hot spots were reduced, then the areal extent of potential risk, as well as the magnitude of HQs and HIs, would be reduced. Conversely, if large relatively clean areas are included in the estimation of exposure soil concentrations, the effect could be a dilution of concentration attributed to hot spots.

Potential risk varied depending on the BMF used, the chemical or chemical group being considered, and receptor (trophic box) being evaluated. Differences in risk among receptors for a given chemical were partly due to differences in the toxicity threshold values, and especially due to differences in the exposure range size. Figure 6.2-2 shows the number of representative trophic boxes that have HIs greater than 1.0 in various parts of RMA. This figure shows that the areas of potential risk to the greatest number of species tend to be smaller and located toward the center of RMA, even though the specific receptors subject to potential risk in one area may be different from those subject to potential risk elsewhere. Terrestrial areas where all trophic boxes are expected to be at potential risk (based on cumulative risk from all of the COCs combined) are most of the

central sections of RMA, including South Plants; Basins A, B, C, D, and F; and the northernmost upland areas adjacent to the South Lakes area. Pesticides (especially aldrin/dieldrin) are the primary biota COCs contributing to biota risk at RMA, as shown in Figure 6.2-3. This figure shows the number of trophic boxes having an HI greater than 1.0 for aldrin/dieldrin, DDT/DDE, and endrin based on soil exposure and the Shell BMF approach. Metals are also significant contributors to biota risk.

The degree to which potential risk predicted by the EPA, Shell, and Army BMFs differed for a single COC/receptor combination based on the TRV (dose-based) approach is shown for aldrin/dieldrin in Figure 6.2-4 for the great horned owl and in Figure 6.2-5 for the small mammal. The effect of the small mammal's much smaller exposure range can be seen by comparing Figure 6.2-4 with Figure 6.2-5. Receptors with larger exposure ranges generally show greater areas of potential risk, and receptors with smaller exposure areas tend to show smaller areas of potential risk that more directly reflect specific areas of higher soil contamination. The areas depicted in the maps do not necessarily denote the extent of magnitude or severity of potential risks to biota, nor do they depict the ecological relevance of the potential risks to local populations. The ecological relevance of the potential risks will be addressed as part of remedial design and incorporate the ongoing USFWS biomonitoring program, as well as the SFS and other evaluations being performed by the BAS (see Section 6.2.4.3). EPA defines ecological relevance generally in terms of "population sustainability and community integrity" for both current and future exposure and risk.

The potential risk to predators at the top of food webs having aquatic food chains is shown in Table 6.2-7. These risks are tabulated because a single risk value was calculated for all the lakes combined. In combining measured tissue concentrations from the various lakes, feeding was assumed to be proportional to the size of the lake. Table 6.2-7 shows that potential risk from aquatic food chains is greatest to the great blue heron.

The results of the quantitative ERC were also compared with the results of evaluating potential ecological effects such as impacts on reproduction, species abundance, and species diversity. No strong trends in any of these data indicated populational effects. However, because sampling was concentrated in contamination areas, average tissue concentrations exceeded the MATC (which represents the tissue-based toxicity threshold value) for dieldrin, mercury (for this COC, the **detection limit** also exceeded the MATC), and DDE. Likely adverse effects of RMA contamination have been observed in individual animals collected at RMA, but these effects were not apparent in the available data collected for wildlife populations as a whole at RMA. The available data were obtained from studies that had varying purposes and degrees of ability to discern contaminant effects on local populations. It should be noted that the state and EPA disagreed with the ability to draw conclusions on wildlife populations or on the effects of RMA contaminants to individual animals from the available data. In accordance with the Conceptual Remedy, all Parties, through their representatives on the BAS, will continue

to evaluate the SFS and USFWS biomonitoring studies and provide information to risk managers on the status and health of biota at RMA in terms of the need to refine design boundaries to include additional locations where biota risks were deemed to be excessive. This process will continue during the remedial design after the ROD is signed (see Section 6.2.4.3).

The potential risk from all COCs combined covered most of RMA for at least one species. However, a number of considerations should be taken into account when evaluating this risk. For example, the risk from mercury is overestimated for RMA because all mercury was assumed to be in its most toxic and bioavailable form, methyl mercury, although this is not the most prevalent form at RMA. Conversely, because chlordane was not quantitatively modeled as a bioaccumulative COC, its risks to biota may be underestimated. For terrestrial and aquatic receptors, there are uncertainties inherent in the toxicity threshold values used and in the estimated tissue concentrations that were compared to these threshold values. The uncertainties in threshold values are mostly reflected in the magnitude of UFs used to derive each TRV or MATC. For terrestrial receptors, uncertainties in estimated tissue concentrations result primarily from uncertainties in the estimates of the exposure soil concentration and the BMF.

The available ecological data used to evaluate ecological effects were also subject to uncertainty resulting from the short-term nature of many of the studies, lack of sufficient precision of the results, and study designs that were not always oriented toward correlating ecological parameters with contaminant concentrations. As noted previously, not all the Parties agreed with the appropriateness of the ecological data used in this comparison.

6.2.4.3 Continuing Biological Studies

Generally, the results of the ERC showed that the areas of highest potential risk are located in the central portions of RMA and are associated with major chemical manufacturing processes or a disposal area that contains the greatest concentration of contaminants. Although the Army, Shell, and EPA approaches all agree regarding excessive risk (i.e., HQ or HI greater than 1.0) to wildlife in the central areas of RMA, they differ in their estimates of areas and magnitudes of potential ecological risk in other parts of RMA. The major variation is due to the use of different BMFs (as calculated by the Army, EPA, and Shell) to estimate exposure. Because of the scientific differences of opinion concerning the best approach to determine field BMFs at RMA, the SFS was established. Phase I of the SFS is designed to determine whether unacceptable levels of exposure (i.e., risk) exist within the Area of Dispute (Figure 6.2-6). The Area of Dispute is defined as the difference in the areas of potential aldrin/dieldrin risk (HQ greater than 1.0, based on MATC) to small mammals based on the Army and EPA approaches and was delineated for the primary purpose of sample collection in Phase I of the SFS. It may or may not reflect the area of uncertainty in terms of excessive risk to biota, although this is also coincidentally the ROD Area of Contamination (AOC) boundary. If Phase I of the SFS indicates that unacceptable risks to biota are likely,

the SFS may proceed with Phase II under RMA Council direction to collect additional tissue and soil data to estimate field BMFs for selected species.

The goal of biota remediation is to achieve appropriate remediation such that it is protective of biota health (i.e., sustainability of local subpopulations and individuals of threatened or endangered species). HIs were used in the IEA/RC to provide a semiquantitative characterization of predicted risks to biota at RMA. In general, HIs less than 1.0 denote the absence of excessive risk to biota populations. HIs greater than 1.0 may indicate potential adverse risks to biota populations; the greater the HI, the greater the potential risk.

To demonstrate spatial representation of biota risk, a series of additional risk maps (pre- and post-remediation) are presented for the American kestrel and great horned owl using the Army and EPA BMF approaches (Figures 6.2-7 through 6.2-14). These residual risk maps show locations and relative magnitudes of estimated biota risks due to exposure to the bioaccumulative COCs (excluding mercury) following proposed remediation. Residual risk areas will be evaluated by the BAS as potential locations for additional ecotoxicological studies.

Mean HIs for the American kestrel and great horned owl were estimated within the pre-remediation areas identified as having an HI greater than 1.0 using the Army and EPA BMF approaches based on a semiquantitative analysis of the pre- and post-remediation risk maps (Figure 6.2-7 through 6.2-14). Several general conclusions about the pre- and post-remediation risks to biota and associated uncertainty can be made from this semiquantitative analysis as follows:

- EPA mean HI estimates were an average of about 3 times higher than the Army mean HI estimates based on differences in the BMFs (ranging from about 2 to 4 times higher; American kestrel had the highest difference).
- Pre-remediation mean HIs ranged from about 2 to 120 using Army BMFs and about 7 to 270 using EPA BMFs (bald eagle was the highest in both cases).
- Post-remediation mean HIs ranged from 1 to 7 using Army BMFs and about 4 to 16 using EPA BMFs (bald eagle was the highest in both cases). The residual risk maps show that in general residual risks remain adjacent to the ROD's biota remediation areas (shown as the shaded areas in Figure 6.2-6) and that the highest ranges of residual risk are located adjacent to the southwest section of the green-shaded areas.
- In general, both the Army and EPA methods show at least a 10-fold reduction in risk for all species of concern following remediation of the shaded areas shown in Figure 6.2-6.

While the SFS is being conducted, certain areas of more highly contaminated surficial soil, which represent the areas in which all three BMF approaches yielded HQs greater than 1.0 (using the MATC approach) for aldrin/dieldrin for small mammals, as well as some additional areas north of Former Basin F and areas identified by USFWS as priority areas (i.e., known areas of high contamination and posing a threat to wildlife based on field observations), have been identified as candidates for initial focused remediation and are identified as the green-

shaded areas in Figure 6.2-6. The process outlined in the Conceptual Remedy and summarized below permits the further investigation of other identified areas of potential residual risk outside the green-shaded areas in order to more accurately characterize actual biota risk and impacts and to refine design boundaries if warranted. This process includes the following:

- The BAS of technical experts (e.g., ecotoxicologists, biologists, range/reclamation specialists) from the Parties will focus on the planning and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The BAS will provide interpretation of results and recommendations to the Parties' decision makers.
- The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to refine design boundaries for surficial soil and aquatic contamination to be remediated.
  - Phase I and the potential Phase II of the SFS will be used to refine the general areas of surficial soil contamination concern. The field BMFs from Phase II will be used to quantify ecological risks in the Area of Dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of excess risks (Figure 6.2-6).
  - Pursuant to the FFA process, USFWS will conduct detailed site-specific exposure studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC report as appropriate). These studies will address both the aquatic resources and at least the surficial soil in and around the Area of Dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.
  - Results from both the SFS/risk assessment process and the site-specific studies will be considered in risk-management decisions, which may further refine the areas of surficial soil and aquatic contamination to be remediated. (In the event of a conflict between management of RMA as a wildlife refuge and performance of remedial response actions, the Rocky Mountain Arsenal National Wildlife Refuge Act indicates that response actions will take priority.)
- The BAS will serve as a technical resource to the Parties' decision makers by using technical expertise in analyzing, and potentially collecting, data sufficient to support design refinement for surficial soil areas and aquatic resources that will break unacceptable exposure pathways in consideration of minimizing habitat disturbance. Further, it will assess through monitoring the efficacy of remedies in breaking unacceptable pathways to biota. If any additional sites are identified, the remedy will be implemented as follows:
  - It will be staged to allow habitat recovery.
  - It will be performed first on locations selected through a balance of factors such as:
    - The Parties agree an area has a negative impact on or excessive risk to fish or wildlife.
    - The effort will not be negated by recontamination from other remediation activities.
    - The existing fish and wildlife resource value.
  - It will include revegetation of a type specified by USFWS; if the initial revegetation is not successful, the appropriate adjustments will be made and revegetation again implemented.
  - It will provide that the locations and timing of remediation are to be determined with consideration of and in coordination with USFWS refuge management plans and activities.

6.3 Uncertainty Analysis

Several sources of uncertainty must be considered in the evaluation of the HHRC and ERC results. Model parameter distributions were developed based on empirical data, and in instances where empirical data were

lacking, best professional judgment was incorporated. In addition, when uncertainty in the empirical data for a given parameter warranted conservative assumptions, these assumptions were incorporated into the exposure and risk estimations.

6.3.1 Human Health Risk Characterization

6.3.1.1 Chemical Database

Contributing to the chemical database uncertainty are the different analytical techniques used by the RI Phase I and Phase II programs for some of the organic chemicals. Phase I employed **gas chromatography/mass spectrometry (GC/MS)**, and Phase II employed more precise GC methods. The Phase I techniques made use of higher detection limits; thus, chemicals present at lower levels may not have been detected. In a few cases, Phase I samples required dilution to facilitate analysis, and the dilution may have masked the presence of some compounds by raising the effective detection level. When necessary, an expanded suite of Phase II analyses and/or additional GC/MS analyses were used to ensure that all target analytes were evaluated. Some other limitations associated with the chemical database are soil sample collection, tentatively identified compounds, unidentified compounds, and Army agent contamination. Uncertainties associated with soil sample collection can under- or overestimate risk. Tentatively identified and unidentified compounds were not considered in the risk characterization and the detections of Army chemical agent reported in the chemical database were not quantitatively evaluated. Potential risk may have been underestimated based on the exclusion of agent and tentatively identified compounds from the evaluations.

6.3.1.2 Exposure Point Concentration

Uncertainties associated with the exposure point concentrations include the estimation method used to approximate site concentration values used to calculate risk. In accordance with EPA guidance, representative soil concentrations were estimated using the arithmetic mean ($C_{rep,mean}$). The uncertainty in these estimates was characterized by reporting the 95 percent upper and lower confidence limits (95% UCL and 95% LCL, respectively) on the mean. The 95% UCL ($C_{rep,upper}$) was used to estimate the RME risks. Conservative assumptions were also employed to address potential dilution effects when soil boring samples were composited and to calculate the boring-by-boring risk estimates; the highest detected concentration of the COC was used regardless of the depth of the sample.

6.3.1.3 Land-Use and Exposure Scenarios

Uncertainty exists regarding the likelihood that the land uses evaluated will in fact occur under a future development scenario at RMA. Land use at RMA is currently limited to commercial, industrial, recreational, and open space (i.e., nature preserve/wildlife refuge) uses. The land-use designations were based on information obtained from several governmental agencies overseeing and directing land use within their respective jurisdictions surrounding RMA. The FFA restricts the ownership, use, and transfer of property at

however, this simplifying step may not have introduced large degrees of uncertainty because most of the noncancer effects were attributed to a single COC (dieldrin).

6.3.2 Ecological Risk Characterization

6.3.2.1 Chemical Database

The same uncertainties associated with the chemical database that were identified for the HHRC apply to the ERC. However, the database used for the ERC also included results associated with biota sample collection and analysis. Despite the relative abundance of site-specific field data to characterize ecological risk at RMA, the need to work with data from sampling programs designed for other purposes (e.g., to establish nature and extent of contamination) may have been less than ideal for the estimation of exposure soil concentrations and BMFs. It is difficult to know if the use of these data resulted in an over- or underestimation of potential risks to biota. The biota species sampled on RMA were chosen from species that best represented the uptake of contaminants from environmental media and the subsequent transfer, via food consumption, through food chains to top predators. Uncertainty is associated with the use of these biota samples to derive RMA-specific BMFs. Some uncertainty is also associated with the more scattered peripheral abiotic sampling where heterogeneous soil contamination occurs, and where detection limits, in some cases, exceeded the risk-based concentrations. These factors, along with lesser sampling density and little collocation of tissue and soil samples, added to the uncertainties associated with the chemical database.

6.3.2.2 Exposure Pathways

Exposure pathways were selected to include the predominant pathways of exposure believed to exist at RMA. Those selected for the food-web model included food consumption, dermal exposure to surface water by organisms, ingestion of water by some terrestrial organisms, and sediment and soil ingestion by some aquatic and terrestrial organisms. Exposure pathways excluded from the food-web model included inhalation of contaminant vapors and particulates and dermal exposure to contaminants from soil contact. These exposure pathways are implicitly contained in the BMF because measured tissue concentrations (from sampled biota species) are the result of cumulative exposure by all pathways. Additional uncertainties related to the exposure pathways are presented in Section 6.3.2.4.

6.3.2.3 Exposure Concentrations

Most of the uncertainty regarding exposure concentrations centers on the estimated exposure area concentrations used to calculate terrestrial risk. Aquatic risk was estimated directly from measured tissue concentrations and therefore was not based on quantitative exposure concentrations in aquatic media. Terrestrial tissue concentrations, dose, and risk are theoretically dependent on exposure soil concentrations (ESCs), i.e., the concentration in soil that is bioavailable and accessed by an individual during exposure activity. The ESC is, for all practical purposes, unverifiable in the field; therefore, it is represented by

estimated exposure area soil concentration, i.e., the average soil concentration in a specified depth profile within a circular species-specific exposure area. Two types of uncertainty occur when applying ESC to estimate risk. "Representation uncertainty" refers to the uncertainty in adequately representing spatial and temporal scales of the ESC by exposure area soil concentration, and "estimation uncertainty" refers to the uncertainty in analytically estimating the exposure area soil concentration based on available data. Representation uncertainty explains the difference between true exposure concentration for an individual and the exposure area concentration for a typical (mean) individual. Unfortunately, representation uncertainty is for all practical purposes unquantifiable and irreducible, because the detailed information on individual organisms (and their prey) required for its calculation cannot be practically obtained. Estimation uncertainty explains the differences between the true exposure area soil concentration in a given area or for a given individual, and the estimated exposure area soil concentration based on available sampling and analytical data.

The empirical mathematical constant used to relate exposure area soil concentration to tissue concentration is the BMF. BMF is therefore defined as a correlation based on the variable exposure area soil concentration and not on actual exposure soil concentration. The BMF values determined purely from literature data, rather than site-specific data from RMA, will describe the relationship between tissue concentration and a different dose-based quantity than ESC, and therefore may create more or less bias if used with ESC to predict risk at RMA. Uncertainty is also associated with the BMF based on the use of site-specific information (e.g., RMA-soil and biota data collected at different times and locations and for various purposes). The uncertainty associated with the exposure concentration, including the estimation of BMFs, will be further ascertained by review of the findings gathered from the SFS and the ongoing USFWS biomonitoring studies.

6.3.2.4 Ecological Toxicity Estimates

MATC and TRV uncertainty was incorporated quantitatively by use of UFs as discussed in Section 6.2.3. The UFs were applied to add a margin of safety to the extrapolated toxicity measures. The UF protocol included factors to account for four categories of uncertainty: intertaxon variability, study duration, toxicity effect levels (study endpoints), and other modifying factors (including nine subcategories) that were multiplied to arrive at the total estimated uncertainty.

In addition to the uncertainty incorporated in the UFs are potentially unrecognized or unquantifiable sources of uncertainty. These include the following:

- Representativeness of toxicity endpoint tissue concentration data from one species relative to other species in the trophic box
- Differences in metabolic rate, body size, and physiology between test and target species
- Differences in feeding habits and behavioral patterns in test v. target species
- Differences in the life stage of the organisms tested v. those exposed

- Seasonal differences in response to toxicants (e.g., "fat" versus "lean" times)
- Difficulty in adequately estimating exposure concentrations (including environmental variability in time and space)
- The possibility that exposed organisms may avoid, or be attracted to, contaminated media (e.g., pesticide-debilitated prey) and so may not show effects seen in laboratory tests (Suter 1993)
- Inability to quantify the other stresses that biota may face (e.g., climate, food supplies, background levels of toxicants, habitat disturbance, and other manmade causes)
- The possibility that exposure pathways, in addition to ingestion, are significant
- The fact that there are no standard measures of effect, patterns of dosing, durations of exposure, etc., so comparison across studies/ecosystems is obscured or confounded

6.3.2.5 Risk Estimates

Toxicological effects from multiple chemicals were assumed to be additive, consistent with the risk assessment procedures used for human health. This assumes independence of action, i.e., no net synergistic or antagonistic effects, since these effects are poorly understood with the limited toxicological data available. This practice of additivity without a toxicological basis (i.e., common mechanism of action or target organ effect) is protective but scientifically questionable; however, some means of evaluating the potential cumulative effects of exposure was required and EPA guidance requires such an approach in the absence of site-specific data on additivity. Hence, the individual HQs for each COC were summed to estimate the total risk (HI) for each trophic box. It is difficult to determine whether this procedure over- or underestimated risks to biota. As noted in the IEA/RC report, a range of potential risk was presented for the bioaccumulative COC because three different BMFs were employed. Because of the overall uncertainty associated with each of the parameters incorporated in the food-web model and the toxicity threshold values, it is difficult to state with certainty at this time which of the three BMF approaches best estimated risk to biota at RMA. Additionally, it is possible that actual residual risk to biota of an excessive nature may occur in some cases following remediation based on the uncertainty associated with the food-web risk modeling process and its application to delineated areas proposed for remediation. Again, the uncertainty associated with the risk estimates will be further ascertained by review of the findings gathered from the SFS and the ongoing USFWS biomonitoring studies.

6.3.2.6 Ecological Measurement Endpoints

The presence of potential ecological risk was given further perspective by considering it together with available field data on ecological endpoints. The available data on ecological status and health used to evaluate ecological endpoints are also subject to uncertainty. In this context, uncertainty results from the following:

- The short-term nature of many of the studies relative to the cycles of natural variability
- Estimation of quantitative ecological parameters at levels of precision that may not be biologically and/or statistically significant and/or use of endpoints that may not have been sensitive enough to discern the various potential human health risks to biota

- Study designs that did not precisely and quantitatively correlate ecological parameters with parameters related to contaminant concentrations
- Study designs that did not precisely quantify all parameters that might have positively or negatively affected the ecological data

Appendix E of the IEA/RC report presents a detailed discussion on the assumptions, limitations, and uncertainties associated with each of the uncertainty categories listed above.

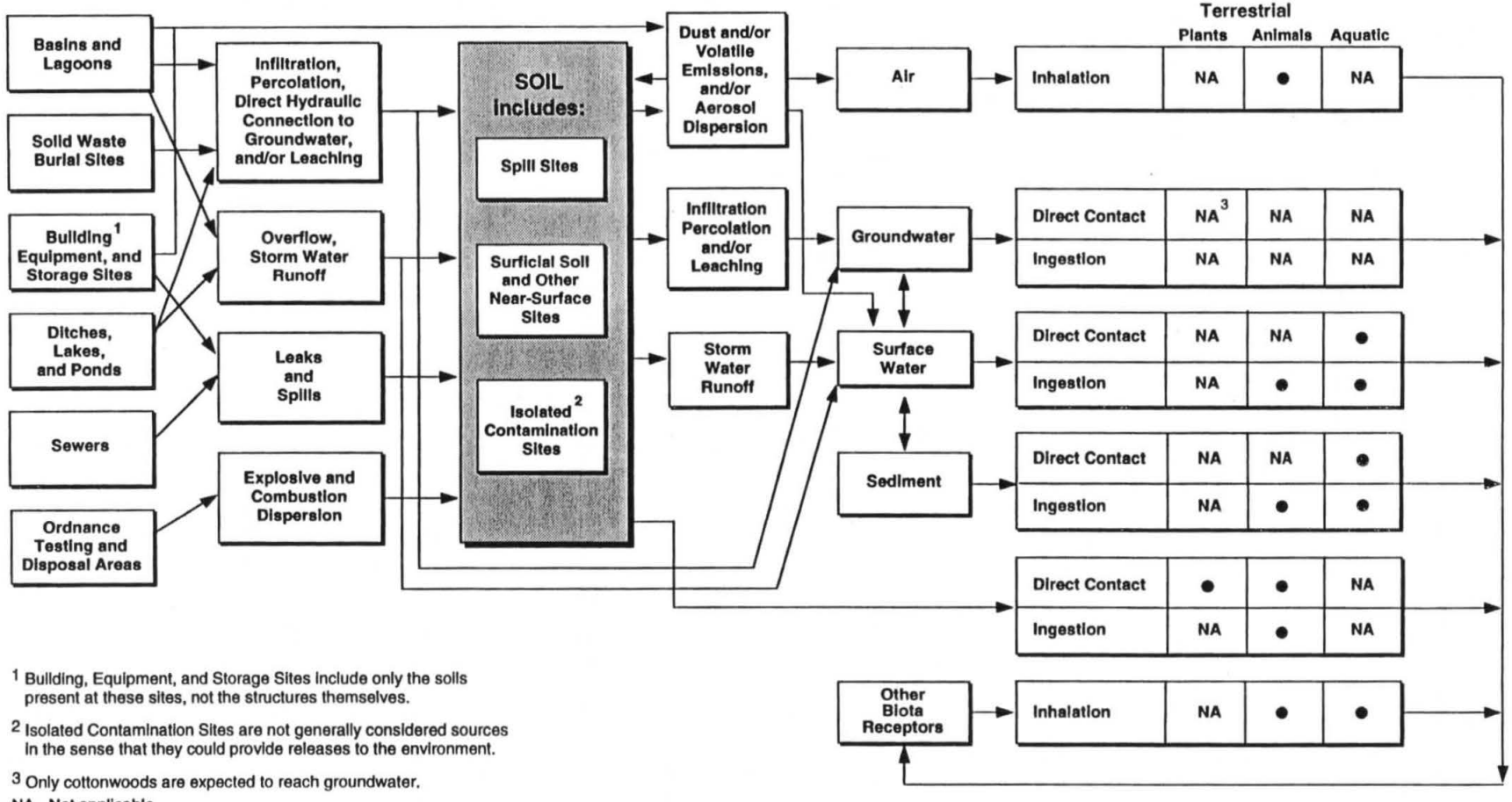
6.4 Conclusions

Both the human health and the ecological risk assessment results are based on probabilistic methodologies. The probabilistic methods account for the variability in literature and field data for the various parameters used to quantify exposure and risk and at least partially reflect the uncertainty associated with these parameters. The use of this methodology and the discussions of uncertainty increases the understanding the risk characterization by clarifying the uncertainties associated with the input values and their implications on estimated risks.

The results of the risk assessment, as presented in the IEA/RC report, indicate that potential risks exist for both human and ecological receptors. The contaminants that are the major contributors to overall potential risks are similar for both receptor groups, i.e., the OCPs. Likewise, the areas that pose the greatest potential risks to both receptor groups are in the central core region of RMA. It is very important to remember that the potential risks presented in this report are based on current and historical contamination evaluated under present or future land-use scenarios. However, data from some of the areas at RMA that have undergone interim remediation (e.g., capping to eliminate possible exposure pathways for receptors) were not revised to reflect the remediation; the actual risks are, therefore, likely to be lower than the risks presented in the IEA/RC report.

Areal extents of biota remediation that are needed to reduce or prevent excessive risks to ecological health are not completely known at present, but will be further refined as part of remedial design and incorporate ongoing ecotoxicological evaluations by the BAS. Recommendations regarding the nature and extent of excessive risks to biota will be presented by the BAS to RMA risk managers for inclusion in soil remedial actions to reduce risks to acceptably healthy levels in accordance with EPA Superfund guidance, the Rocky Mountain Arsenal National Wildlife Refuge Act, and the selected remedy.

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.



[1] Building, Equipment, and Storage Sites include only the soils present at these sites, not the structures themselves.

[2] Isolated Contamination Sites are not generally considered sources in the sense that they could provide releases to the environment.

[3] Only cottonwoods are expected to reach groundwater.

NA - Not applicable.

Figure 6.2-1
RMA Site Conceptual Model for Ecological Receptors

Rocky Mountain Arsenal
Prepared by: Foster Wheeler Environmental Corporation

Table 6.2-1 Mean BMF Calculated by Alternate Methods[1]

Trophic Box	BMF by the Army Calibration Procedure	BMF_{obs} by the Shell Collocated Distributions Approach	BMF_{obs} by the (EPA) Modified Paired Data Approach
	Mean BMF	Mean BMF	Mean BMF
Aldrin/Dieldrin			
Soil	1	1	1
Terrestrial Plant	1.6E-02	6.0E-02	1.8E-01
Worm	2.3E-01	1.0E+00	2.5E+00
Insect	7.4E-02	9.7E-02	4.2E-01
Small Bird	2.1E-01	2.7E-01	6.8E-01
Small Mammal	2.7E-01	5.9E-01	3.0E+00
Medium Mammal	3.8E-01	2.7E-01	1.9E+00
Herptile	2.4E+00	2.4E+00	7.7E+00
Kestrel	2.6E+00	4.9E+00	2.3E+01
Owl	8.0E+00	6.9E+00	4.1E+01
Shorebird	3.6E+00	2.3E+00	6.2E+00
Heron	2.9E+00	3.0E+00	8.6E+00
Eagle	6.1E+00	4.4E+00	2.8E+01
DDE/DDT			
Soil	1	1	1
Terrestrial Plant	6.6E-01	9.2E-01	5.2E+00
Worm	1.4E+00	1.1E+00	7.8E+00
Insect	7.5E-01	9.9E-01	3.9E+01
Small Bird	5.4E-01	8.1E-01	3.3E+00
Small Mammal	4.6E-01	6.5E-01	2.8E+00
Medium Mammal	4.9E-01	3.1E+00	6.0E+00
Herptile	1.3E+00	2.5E+00	6.3E+00
Kestrel	9.9E+00	1.4E+01	5.5E+01
Owl	3.2E+01	1.7E+02	3.4E+02
Shorebird	4.8E+01	6.0E+01	1.5E+02
Heron	1.1E+01	1.8E+01	4.2E+01
Eagle	1.9E+01	1.2E+02	2.2E+02

Trophic Box	BMF by the Army Calibration Procedure	BMF_{obs} by the Shell Collocated Distributions Approach	BMF_{obs} by the (EPA) Modified Paired Data Approach
	Mean BMF	Mean BMF	Mean BMF
Endrin			
Soil	1	1	1
Terrestrial Plant	1.4E-01	2.1E-01	1.3E+00
Worm	4.0E-01	2.4E-01	1.1E+00
Insect	1.0E-01	5.3E-02	3.6E-01
Small Bird	1.1E-01	1.3E-01	9.1E-01
Small Mammal	1.7E-01	2.7E-01	1.5E+00
Medium Mammal	3.3E-02	3.6E-01	1.2E+00
Herptile	1.0E+00	9.0E-01	1.5E+00
Kestrel	1.9E-01	2.6E-01	1.3E+00
Owl	8.8E-02	4.0E-01	1.4E+00
Shorebird	9.9E-01	6.0E-01	1.1E+00
Heron	1.1E-01	1.0E-01	1.6E-01
Eagle	6.7E-02	4.0E-01	1.3E+00
Mercury			
Soil	1	1	1
Terrestrial Plant	3.5E-02	1.6E-01	3.1E-01
Worm	6.2E-01	4.0E-01	8.1E-00
Insect	1.1E-02	1.3E-01	2.7E-01
Small Bird	1.1E-01	1.9E-01	3.4E-01
Small Mammal	5.5E-01	1.5E-02	1.7E-01
Medium Mammal	2.8E-01	3.3E-01	7.3E+00
Herptile	6.0E-01	7.8E-01	8.2E-01
Kestrel	3.2E-01	6.8E-02	1.8E-01
Owl	2.6E-01	2.4E-01	4.8E+00
Shorebird	1.2E+0	1.6E-01	1.8E-02
Heron	6.8E-01	7.2E-01	7.6E-01
Eagle	2.3E-01	2.6E-01	5.4E+00

[1] For the three BMF_{obs} methods, kestrel, owl, heron, and eagle BMFs were calculated with the food-web model because there are no available field data. For these four trophic boxes:

$$BMF_{obs(k)} = BAF_{lit(k)} * SUM_{(j)FR(k,j)} * BMF_{obs(j)}$$

where:

$BMF_{obs(k)}$ is the BMF for predator trophic box k
$BAF_{lit(k)}$ is the literature-derived BAF distribution for trophic box k
$SUM_{(j)}$ is the summation function over the argument j
$FR_{(k,j)}$ is the mass fraction of predator k's food from prey trophic box j
$BMF_{obs(j)}$ is the BMF for prey trophic box j

Biota	Chemical	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.	End Point
Parameter = Bioaccumulation Factor (BAF)							
Small Bird	Aldrin/Dieldrin	Normal	6.6	1.8			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Small Mammal	Aldrin/Dieldrin	Uniform	NA	NA			0.64, 1.6
	Endrin	Lognormal	0.08	1.0	-2.526	0.001	
	DDE/DDT	Uniform	NA	NA			0.44, 0.98
	Arsenic	Lognormal	0.19	4.7	-1.684	1.543	
	Mercury	Triangular	22.5	NA			0.001, 50
Medium Mammal	Aldrin/Dieldrin	Uniform	NA	NA			0.64, 3.2
	Endrin	Lognormal	0.16	1.1	-1.833	0.095	
	DDE/DDT	Uniform	NA	NA			0.44, 0.98
	Arsenic	Lognormal	0.19	4.7	-1.684	1.543	
	Mercury	Triangular	22.5	NA			0.001, 50
Water Bird	Aldrin/Dieldrin	Normal	16	5.1			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Normal	96	26.2			
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Lognormal	4.1	3.4	1.411	1.224	
Kestrel	Aldrin/Dieldrin	Normal	10.5	1.2			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Owl	Aldrin/Dieldrin	Normal	21.1	3.4			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Lognormal	43.7	2.4	3.777	0.875	
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Shorebird	Aldrin/Dieldrin	Normal	13.3	4.2			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Uniform	NA	NA			7.7, 29
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2
Heron	Aldrin/Dieldrin	Normal	16	5.1			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Normal	93.5	20			
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Lognormal	4.1	3.4	1.411	1.224	

Biota	Chemical	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.	End Point
Parameter = Bioaccumulation Factor (BAF)							
Bald Eagle	Aldrin/Dieldrin	Normal	15.9	3.9			
	Endrin	Lognormal	1.0	1.6	0.000	0.470	
	DDE/DDT	Lognormal	27.1	2.4	3.300	0.875	
	Arsenic	Uniform	NA	NA			0.3, 3
	Mercury	Triangular	0.33	NA			0.001, 2

* Mean = arithmetic mean for normal distribution, geometric mean for lognormal distribution, and apex for triangular distribribution

Predator	Prey Item	Biomass Fraction*
Parameter = Dietary Fractions (FR)		
Terrestrial Food Chain		
Small Birds	Soil	0.057
	Terrestrial Plants	0.113
	Earthworm	0.116
	Insect	0.714
Small Mammals	Soil	0.020
	Terrestrial Plants	0.866
	Earthworm	0.008
	Insect	0.106
Medium Mammal	Soil	0.074
	Terrestrial Plants	0.926
	Insect	0.000
Kestrel	Soil	0.029
	Insect	0.184
	Small Mammal	0.665
	Small Bird	0.122
Owl	Soil	0.029
	Small Mammal	0.121
	Medium Mammal	0.830
	Small Bird	0.020
Heron	Soil	0.036
	Reptile	0.060
	Small Mammal	0.013
	Water	0.071
	Aquatic Plant	0.000
	Aquatic Invertebrates	0.024
	Small Fish	0.186
	Large Fish	0.604
	Amphibian	0.006
Bald Eagle	Soil	0.029
	Small Mammal	0.000
	Medium Mammal	0.936
	Small Bird	0.003
	Waterbird	0.030
	Large Fish	0.002
Aquatic Food Chain		
Water bird	Water	0.019
	Sediment	0.038
	Aquatic Plant	0.942
	Aquatic Invertebrates	0.001

Predator	Prey Item	Biomass Fraction*
Shorebird	Terrestrial Plants	0.007
	Insect	0.728
	Sediment	0.160
	Aquatic Invertebrates	0.105

* Fractions reported as zero are pathways considered to be relatively inconsequential to model output due to their small values.

Biota	Distribution	Mean*	Std. Dev.	LOG Mean	LOG Std Dev.
Parameter = Feed Rate (R)	kg/kg body weight/day				
Water Bird	Normal	0.07602	0.0245		
Small Bird	Fixed	0.0879			
Small Mammal	Fixed	0.12			
Medium Mammal	Fixed	0.096			
Shorebird	Lognormal	0.0879	1.652	-2.4315	0.50189
Kestrel	Normal	0.08913	0.02689		
Owl	Normal	0.08913	0.02689		
Heron	Normal	0.08913	0.02689		
Bald Eagle	Normal	0.08913	0.02689		

* Mean = Arithmetic mean for normal distribution, geometric mean for lognormal distribution, and apex for triangular distribribution.

Biota	Chemical	Distribution	Value
Parameter = Maximum Allowable Tissue Concentration (MATC)			
Small Bird	Aldrin/Dieldrin	Fixed	0.15
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	0.14
	Mercury	Fixed	0.017
Small Mammal	Aldrin/Dieldrin	Fixed	0.19
	Endrin	Fixed	NA
	DDE/DDT	Fixed	0.22
	Mercury	Fixed	NA
Medium Mammal	Aldrin/Dieldrin	Fixed	0.19
	Endrin	Fixed	NA
	DDE/DDT	Fixed	0.22
	Mercury	Fixed	NA
Reptile	Aldrin/Dieldrin	Fixed	NA
	Endrin	Fixed	NA
	DDE/DDT	Fixed	NA
	Mercury	Fixed	NA
Kestrel	Aldrin/Dieldrin	Fixed	0.73
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	4.3
	Mercury	Fixed	0.017
Owl	Aldrin/Dieldrin	Fixed	0.76
	Endrin	Fixed	0.087
	DDE/DDT	Fixed	0.53
	Mercury	Fixed	0.017
Water bird	Aldrin/Dieldrin	Fixed	0.24
	Endrin	Fixed	0.09
	DDE/DDT	Fixed	0.18
	Mercury	Fixed	0.01
Shorebird	Aldrin/Dieldrin	Fixed	0.15
	Endrin	Fixed	0.052
	DDE/DDT	Fixed	1.4
	Mercury	Fixed	0.011
Heron	Aldrin/Dieldrin	Fixed	0.87
	Endrin	Fixed	0.043
	DDE/DDT	Fixed	15
	Mercury	Fixed	0.011
Bald Eagle	Aldrin/Dieldrin	Fixed	0.41
	Endrin	Fixed	0.031
	DDE/DDT	Fixed	2.2
	Mercury	Fixed	0.0083

Biota	Chemical	Distribution	Value
Parameter = Toxicity Reference Values (TRV)			
Terrestrial Plant	Arsenic	Fixed	1.9
Small Bird	Aldrin/Dieldrin	Fixed	0.028
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.003
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Small Mammal	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.010
	DDE/DDT	Fixed	0.029
	Mercury	Fixed	0.0014
	Arsenic	Fixed	0.038
	Copper	Fixed	0.75
	Cadmium	Fixed	0.045
	DCPD	Fixed	2.8
	Chlordane	Fixed	0.10
	CPMS	Fixed	0.24
	$CPMSO_2$	Fixed	0.27
	DBCP	Fixed	0.05
Medium Mammal	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.010
	DDE/DDT	Fixed	0.029
	Mercury	Fixed	0.0014
	Arsenic	Fixed	0.038
	Copper	Fixed	0.75
	Cadmium	Fixed	0.045
	DCPD	Fixed	2.8
	Chlordane	Fixed	0.10
	CPMS	Fixed	0.24
	$CPMSO_2$	Fixed	0.27
	DBCP	Fixed	0.05

NA Data not available to calculate a TRV.

Biota	Chemical	Distribution	Value
Kestrel	Aldrin/Dieldrin	Fixed	0.01
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.04
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Owl	Aldrin/Dieldrin	Fixed	0.004
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.008
	Mercury	Fixed	0.0019
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Water brid	Aldrin/Dieldrin	Fixed	0.027
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.004
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	3.2
	Chlordane	Fixed	3.1
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Shorebird	Aldrin/Dieldrin	Fixed	0.022
	Endrin	Fixed	0.002
	DDE/DDT	Fixed	0.008
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA

Biota	Chemical	Distribution	Value
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Heron	Aldrin/Dieldrin	Fixed	0.03
	Endrin	Fixed	0.003
	DDE/DDT	Fixed	0.004
	Mercury	Fixed	0.00094
	Arsenic	Fixed	0.38
	Copper	Fixed	0.96
	Cadmium	Fixed	0.24
	DCPD	Fixed	8.9
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17
Bald Eagle	Aldrin/Dieldrin	Fixed	0.002
	Endrin	Fixed	0.001
	DDE/DDT	Fixed	0.005
	Mercury	Fixed	0.00063
	Arsenic	Fixed	0.19
	Copper	Fixed	0.48
	Cadmium	Fixed	0.10
	DCPD	Fixed	5.3
	Chlordane	Fixed	0.035
	CPMS	Fixed	NA
	$CPMSO_2$	Fixed	NA
	DBCP	Fixed	0.17

NA Data not available to calculate a TRV.

[redacted]

Table 6.2-4 Toxicity Threshold Values Selected for Representative Receptors (Trophic Boxes)[1, 2, 3]

	American Kestrel		Bald Eagle		Great Horned Owl		Great Blue Heron		Shorebird		Water Bird		Small Bird		Small Mammal		Medium Mammal		Reptile	Terrestrial Plant
Chemical	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV	MATC	TRV
Aldrin/ Dieldrin	0.73	**0.01**	0.41	**0.002**	0.76	**0.004**	**0.87**	0.027	0.15	**0.022**	**0.24**	0.027	0.15	**0.028**	0.19	**0.004**	0.19	**0.004**	NA	
DDT/DDE	**4.27**	0.04	**2.17**	0.005	**0.53**	0.008	**15**	0.004	**1.38**	0.008	**0.18**	0.004	0.14	**0.003**	0.22	**0.029**	0.22	**0.029**	NA	
Endrin	**0.05**	0.002	**0.03**	0.001	**0.09**	0.003	**0.09**	0.003	**0.05**	0.002	0.09	**0.003**	**0.05**	0.002	NA	**0.01**	NA	**0.01**	NA	
Mercury	0.02	**0.002**	0.01	**0.001**	0.02	**0.002**	0.01	**0.001**	0.01	**0.001**	**0.01**	0.001	0.02	**0.002**	NA	**0.001**		**0.001**	NA	
Arsenic		0.378		0.189		0.378		0.378		0.378		0.378		0.378		0.038		0.038	NA	1.9
Copper		0.96		0.48		0.96		0.96		0.96		0.96		0.96		0.75		0.75	NA	
Cadmium		0.24		0.103		0.24		0.24		0.24		0.24		0.24		0.045		0.045	NA	
DCPD		8.889		5.333		8.889		8.889		8.889		3.2		8.889		2.833		2.833	NA	
Chlordane		0.035		0.035		0.035		0.035		0.035		3.125		0.035		0.1		0.1	NA	
CPMS		ND		ND		ND		ND		ND		ND		ND		0.235		0.235	NA	
$CPMSO_2$		ND		ND		ND		ND		ND		ND		ND		0.272		0.272	NA	
DBCP		0.167		0.167		0.167		0.167		0.167		0.167		0.167		0.05		0.05	NA	

[1] Values shown in bold face were selected for use in the estimation of potential risk based on their total uncertainty and whether or not use of a BAF was necessary.

[2] Tissue-based approach was used for calculation of risk from mercury to shorebird from aquatic food chains; other trophic boxes with mixed food chains (bald eagle and great blue heron) used the same approach for aquatic and terrestrial food chains.

[3] MATC values are presented in mg/kg, and TRVs are presented in mg/kg-bw-day.

EPA = 0.63 mg dieldrin/kg BW-d
without UFs!

Table 6.2-5 Toxicity Reference Value (Post-UF)[1]

Aldrin/Dieldrin	Critical Value	Intertaxon (I)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor[2] (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Intraspecific Variability
American Kestrel	0.04	1	1	1	4			1		2		1
Bald Eagle	0.05	5	1	1	6	2		1	0	2		1
Great Horned Owl	0.06	4	1	1	4			1	0	2		1
Great Blue Heron	0.4	5	1	3	1		-1	1				1
Shorebird	0.22	5	1	1	2			1				1
Waterbird	0.4	5	1	3	1		-1	1				1
Small Bird	0.28	5	1	1	2			1				1
Sm. Mammal	0.06	4	1	1	4			2		1		1
Med. Mammal	0.06	4	1	1	4			2		1		1
Reptile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Trophic Box	Total UF	Final TRV
American Kestrel	4	0.010
Bald Eagle	30	0.002
Great Horned Owl	16	0.004
Great Blue Heron	15	0.027
Shorebird	10	0.022
Waterbird	15	0.027
Small Bird	10	0.028
Sm. Mammal	16	0.004
Med. Mammal	16	0.004
Reptile	NA	NA

[1] Values reported as mg/kg bw.

[2] If $0 \leq U < 1$, it was replaced with 1; if $U < 0$, it was replaced with 0.5.

Final TRV Critical value/total UF

NA Not Available

Total UF 1*Q2*Q3*U

TRV Toxicity Reference Value

U Sum of factors to right

UF Uncertainty Factor

Table 6.2-6 Post-Uncertainty MATC[1]

Aldrin/Dieldrin	Critical Value	Intertaxon (I)	Study Duration (Q2)	Study Endpoints (Q3)	Modifying Factor[2] (U)	T&E	Endpoint Relevance	Lab to Field	Co-Contam.	Unclear Endpoint	ID. Sensitive Species	Tissue to Whole-Body Ratio	Intraspecific Variability
American Kestrel	2.9	1	1	1	4			1		2			1
Bald Eagle	12.2	5	1	1	6	2		1		2			1
Great Horned Owl	12.2	4	1	1	4			1		2			1
Great Blue Heron	1.3	1	1	3	0.5			0	-1				0
Shorebird	2.9	5	1	1	4			1		2			1
Waterbird	7.1	5	1	3	2		-1	1				1	1
Small Bird	2.9	5	1	1	4			1		2			1
Mammal	4.5	4	1	1	6			2		2		1	1

Trophic Box	Total UF	Final MATC
American Kestrel	4	0.73
Bald Eagle	30	0.41
Great Horned Owl	16	0.76
Great Blue Heron	1.5	0.87
Shorebird	20	0.15
Waterbird	30	0.24
Small Bird	20	0.15
Mammal	24	0.19

1 Values reported as mg/kg bw.

2 If $0 \leq U < 1$, it was replaced with 1; if $U < 0$, it was replaced with 0.5.

Total UF 1*Q2*Q3*U

U Sum of factors to right

Final TRV Critical value/total UF

Table 6.2-7 HQs and HIs for Exposure through Aquatic Food Chains

Trophic Box	Hazard Quotients for Aldrin/Dieldrin	Hazard Quotients for DDT/DDE	Hazard Quotients for Endrin	Hazard Quotients for Mercury	Hazard Index
Water bird	2.87	1.66	0.63	6.75	11.91
Shorebird	0.19	2.60	1.17	8.30	12.26
Great Blue Heron	2.28	1.06	0.63	15.63	19.60
Bald Eagle	0.93	0.17	0.03	0.21	1.34

out of the Basin A area towards the First Creek drainage. Alternative 4 is accomplished in conjunction with the soil remedy, which includes caps or soil covers over the Basin A and South Plants areas, and caps and slurry walls associated with the Shell Trenches and the Army Complex Trenches.

Groundwater-quality and water-level data are collected and used to evaluate the effectiveness and operation of the Bedrock Ridge and Basin A Neck systems. It is assumed that there are sufficient existing wells in both areas to be used for performance monitoring, so no new wells are installed. Wells closed during the implementation of the soil remedy will be replaced if required to maintain adequate performance monitoring. Further evaluation of the hydraulic control provided by the entire system (wells, caps, and slurry walls) will be performed during the remedial design.

confined flow system

Alternative 4 also includes groundwater monitoring of the CFS. Monitoring of the CFS is to be conducted in the South Plants area, the Basin A area, and close to Basin F. Data from these wells are assessed to determine whether contaminant levels within the CFS are increasing or migrating significantly with time. Due to poor construction or documentation of well-installation techniques, screened intervals, and bentonite-seal locations, approximately 30 to 40 CFS wells are closed and abandoned. Both groundwater and system monitoring continues.

Water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems. The biological health of the ecosystems will continue to be monitored. Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance.

? Freq ? point of discharge ? duration?

The components of this alternative are summarized in Table 7.2-1. The total estimated cost for this alternative is $146 million (present worth cost of $104 million). A breakdown of capital and O&M costs is presented in Table 7.2-2. Operations under this alternative are assumed to continue for at least 30 years.

7.3 Description of Sitewide Remedial Alternatives for Structures

7.3.1 Description of Medium

As described in Section 5 and detailed in the structures inventory tables (Tables 5.4-6 through 5.4-9), approximately 94 percent of the remaining 798 structures at RMA were identified as potentially contaminated based on previous use or location in manufacturing areas. To date, 525 structures at RMA have been demolished. The debris has been disposed off post or is awaiting disposal.

9.0 Identification of the Selected Remedy

The selection of the preferred remedy for remediation of groundwater, structures, and soil for the On-Post Operable Unit was based on the NCP evaluation criteria, which are described in Figure 8.0-1 and discussed with respect to each of the alternatives evaluated in Sections 8.1 through 8.3. As a result of these evaluations, the selected remedy for the On-Post Operable Unit consists of implementing Groundwater Alternative 4, Structures Alternative 2, and Soil Alternative 4. These selected alternatives are described in detail in Section 7. Remediation goals for the selected remedy satisfies the evaluation of statutory requirements under CERCLA as described in Section 10.

9.1 Groundwater Alternative 4 – Boundary Systems/IRAs/Intercept Systems

The selected groundwater alternative is Alternative 4. This alternative includes operation of all existing boundary systems and on-post groundwater IRA systems, installation of a new extraction and piping system, and development of an extended monitoring program. The specific components of the alternative are as follows:

- Operation of the three boundary systems, the NBCS, NWBCS, and ICS, continues. These systems include extraction and recharge systems, slurry walls (NBCS and NWBCS) for hydraulic controls, and carbon adsorption for removal of organics. The systems will be operated until shut-off criteria, as described below, are met.
- Operation of existing on-post groundwater IRA systems continues. The Motor Pool and Rail Yard IRA systems, which pipe water to ICS for treatment, will be shut down when shut-off criteria, as described below, are met. The Basin F extraction system continues to extract water that is treated at the Basin A Neck system and the Basin A Neck system continues to extract and treat water from Basin A until shut-off criteria are met.
- A new extraction system will be installed in the Section 36 Bedrock Ridge area. Extracted water will be piped to the Basin A Neck system for treatment (e.g., by air stripping or carbon adsorption).
- Water levels in Lake Ladora, Lake Mary, and Lower Derby Lake will be maintained to support aquatic ecosystems. The biological health of the ecosystems will continue to be monitored. Lake-level maintenance or other means of hydraulic containment or plume control will be used to prevent South Plants plumes from migrating into the lakes at concentrations exceeding CBSGs in groundwater at the point of discharge. Groundwater monitoring will be used to demonstrate compliance.
- Confined aquifer wells are monitored in the South Plants, Basin A, and Basin F areas. Specific monitoring wells will be selected during remedial design.
- Those monitoring wells installed in the confined aquifer that may represent pathways for migration from the unconfined aquifer (approximately 30–40 wells) are closed and sealed; replacement wells will be installed if the Parties jointly determine that specific wells to be closed are necessary for future monitoring.
- Chloride and sulfate are expected to attenuate naturally to the CSRGs.
- Monitoring and assessment of NDMA contamination will be performed in support of design refinement/design characterization to achieve remediation goals specified for the boundary groundwater treatment systems.

CSRGs were established for each containment/treatment system on the basis of ARARs and health-based criteria. The ARAR-based values were either Colorado Basic Standards for Groundwater (CBSGs), federal maximum contaminant levels (MCLs), or non-zero maximum contaminant level goals (MCLGs). The health-based values are to-be-considered criteria (TBCs) and were based on EPA health advisories and/or EPA Integrated Risk Information System database criteria. All of the boundary CSRGs are consistent with those derived for the ROD for the Off-Post Operable Unit (Harding Lawson Associates 1995). CSRGs were developed for each of the existing boundary and IRA systems, depending on the specific contaminants found upgradient of each system and whether the systems were on post or at the boundary. Tables 9.1-1, 9.1-2, 9.1-3, and 9.1-4 present the CSRGs for the three boundary systems, and the Basin A Neck system. Where the CSRG is below the detection limit, the detection limit is listed next to the CSRG. Except where technically impractical, the detection limit is less than the CSRG.

Criteria for shutting down boundary systems and internal systems have also been developed and are provided as follows:

- Existing wells within the boundary and off-post containment systems can be removed from production when concentrations of constituents detected in the well are less than the ARARs listed in Appendix A and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the remediation goals described above and the CSRGs listed in Tables 9.1-1, 9.1-2, and 9.1-3. Wells removed from production and monitoring wells upgradient and downgradient of the boundary and off-post containment systems will be monitored quarterly for a period of 5 years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Boundary and off-post containment system extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.
- Existing wells within the internal containment systems can be removed from production when concentrations of constituents detected in the wells are less than ARARs listed in Appendix A and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems as identified by the CSRGs listed in Table 9.1-4. Wells removed from production and monitoring wells upgradient and downgradient of the internal containment systems will be monitored quarterly for a period of 5 years to determine whether contaminants have reappeared; however, those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. Internal containment system extraction wells removed from production for water-quality reasons will be placed back into production if contaminant concentrations exceed ARARs. Wells with concentrations less than ARARs can remain in production if additional hydraulic control is required.
- Shell and the Army will operate the ICS for 2 years or until the Rail Yard/Motor Pool plumes no longer require containment at the ICS.

Figure 9.1-1 illustrates the selected alternative. Additional detail on this alternative is provided in the Detailed Analysis of Alternatives report.

9.2 Structures Alternative 2 – Landfill/Consolidate

Structures Alternative 2 is the selected alternative for the structures medium. This alternative applies to all No Future Use structures, i.e., structures in the Other Contamination History, Significant Contamination History, and Agent History Groups. Under this alternative, the following activities will occur:

- All No Future Use structures will be demolished.
- Agent History structures will be monitored for the presence of Army chemical agent, and treated by caustic washing as necessary prior to disposal.
- Both Agent History and Significant Contamination History Group structural debris will be disposed in the on-site hazardous waste landfill.
- Other Contamination History Group structural debris will be used as grade fill in Basin A, which will subsequently be covered as part of the soil remediation.
- Structural assessments and review of ACM and PCB contamination status and disposition of ACM or PCB-contaminated materials will be performed as described in Section 7.3.3.
- Process-related equipment not remediated as part of the Chemical Process-Related Activities IRA will be disposed in the on-post hazardous waste landfill.

An inventory of structures in each medium group is presented in Tables 5.4-6, 5.4-7, 5.4-8, and 5.4-9. Refinement of the Future Use structures inventory will be completed during remedial design. Most of the demolition at RMA will consist of dismantling with standard dust-suppression measures Remediation goals and standards have been identified for each medium group (see Table 9.5-1). The Other Contamination History Group structural debris is disposed by consolidation in Basin A. This procedure includes transporting the debris to the consolidation area and using it as a portion of the gradefill required by the soil remediation. When the consolidation area has been regraded, it will be covered as part of the soil remediation. Significant Contamination History Group and Agent Contamination History Group structural debris is disposed in the on-post hazardous waste landfill. The slabs and foundations of structures located in the South Plants Central Processing Area within principal threat or human health soil exceedance excavation areas are removed to a depth of 5 ft. In most cases, floor slabs and foundations for the Other Contamination History and Significant Contamination History Groups are left behind after demolition (unless contaminated soil is to be excavated from beneath the slabs or foundations). Floor slabs are broken to prevent water ponding. Additional detail on this alternative is provided in the Detailed Analysis of Alternatives Report.

9.3 Soil Alternative 4 – Consolidation/Caps/Treatment/Landfill

The selected soil alternative is Alternative 4. This alternative includes consolidation of 1.5 million BCY of soil with low levels of contamination into Basins A and F and the South Plants Central Processing Area; capping or soil cover of contaminated soil in the Basins, South Plants, North Plants, and Section 36 sites (including Shell and Complex Trenches); treatment (primarily by in situ solidification/stabilization) of 207,000 BCY of

principal threat soil; and on-post landfilling of 1.7 million cubic yards of soil and debris, including the Basin F Wastepile. The specific components of this alternative are listed below and are summarized in Table 9.3-1:

- On-Post Hazardous Waste Landfill – Construction of a RCRA- and TSCA-compliant hazardous waste landfill on post.
- Former Basin F – Treatment of approximately 180,000 BCY of principal threat soil in the Former Basin F to a depth of 10 ft (measured from below the base of the overburden) using in situ solidification/stabilization to reduce the mobility of the contaminants and minimize further contamination of groundwater. The mixture of solidification agents will be determined during remedial design by treatability testing. This treatability testing will be used to verify the effectiveness of the treatment process and establish operating parameters for the design of the full-scale operation. The entire site is capped (including the Basin F Wastepile footprint) with a RCRA-equivalent cap that includes a biota barrier.
- Basin F Wastepile – Excavation of approximately 600,000 BCY of principal threat soil and liner materials from the wastepile and containment in dedicated triple-lined landfill cells at the on-post hazardous waste landfill facility. Excavation is conducted using vapor- and odor-suppression measures as necessary. If the wastepile soil fails EPA's paint filter test, the moisture content of the soil will be reduced to acceptable levels by using a dryer in an enclosed structure. Any volatile organics (and possibly some semivolatile organics) released from the soil during the drying process are captured and treated; however, the main objective of this process is drying. Prior to excavation of the wastepile, overburden from the existing cover is removed and set aside. The excavation area is backfilled with on-post borrow material and stockpiled overburden.
- Basin A – Construction of a soil cover consisting of a 6-inch-thick layer of concrete and a 4-ft-thick soil/vegetation layer over the principal threat and human health exceedance soil and soil posing a potential risk to biota, and consolidation of debris and soil posing a potential risk to biota and structural debris from other sites. No RCRA-listed or RCRA-characteristic waste from outside the AOC will be placed in Basin A. Any UXO encountered will be removed and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.
- South Plants Central Processing Area – Excavation and landfill of principal threat and human health exceedance soil to a depth of 5 ft and caustic washing and landfill of any agent-contaminated soil found during monitoring. Backfill excavation and placement of a soil cover consisting of a 1-ft-thick biota barrier and a 4-ft-thick soil/vegetation layer over the entire site to contain the remaining human health exceedance soil and soil posing a potential risk to biota. Soil posing a potential risk to biota from other portions of South Plants may be used as backfill and/or gradefill prior to placement of the soil cover.
- South Plants Ditches – Excavation and landfill of principal threat and human health exceedance soil. Excavation of soil posing a potential risk to biota and consolidation under the South Plants Central Processing Area soil cover. Backfill excavated area with on-post borrow material. These sites are contained under the South Plants Balance of Areas soil cover.
- South Plants Balance of Areas – Excavation (maximum depth of 10 ft) and landfill of principal threat and human health exceedance soil and caustic washing and landfill of any agent-contaminated soil found during monitoring. Any UXO encountered will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Excavation of soil posing a potential risk to biota and consolidation as backfill and/or gradefill under the South Plants Central Processing Area soil cover and/or for use as backfill for excavated areas within this medium group. The former human health exceedance area is covered with a 3-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover. Prior to placing this cover, two composite samples per acre will be collected to verify that the soil under the 1-ft-thick soil cover does not exceed human health or principal threat criteria. If the residual soil is found to exceed these levels, the 3-ft-thick cover will be extended over these areas or the

exceedance soil will be excavated and landfilled. The top 1 ft of the entire soil cover area will be constructed using soil from the on-post borrow areas.

- Section 36 Balance of Areas – Excavation and landfill of human health exceedance soil and UXO debris and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover and the human health excavation area is backfilled with on-post borrow material. Prior to excavation, a geophysical survey is conducted to locate potential UXO. Any UXO encountered will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The former human health exceedance area is covered with a 2-ft-thick soil cover and the former potential risk to biota area is covered with a 1-ft-thick soil cover.

- Secondary Basins – Excavation and landfill of human health exceedance soil. The excavated area is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over the entire area of Basins B, C, and D, including the potential biota risk area.

- Complex Trenches – Construction of a RCRA-equivalent cap, including a 6-inch-thick layer of concrete, over the entire site. Installation of a slurry wall into competent bedrock around the disposal trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be reevaluated during remedial design. Soil excavated for the slurry wall trench is graded over the surface of the site and is contained under the cap. Prior to installing the slurry wall and cap, a geophysical survey is conducted to locate potential UXO within construction areas. Any UXO encountered will be removed and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.

- Shell Trenches – Modification of the existing soil cover to be a RCRA-equivalent cap with a biota barrier. Expansion of the existing slurry wall around the trenches. Dewatering within the slurry wall is assumed for purposes of conceptual design and will be re-evaluated during remedial design. Soil excavated for the slurry wall trench is graded over the surface of the site and is contained under the cap.

- Hex Pit – Treatment of approximately 1,000 BCY of principal threat material using an innovative thermal technology. The remaining 2,300 BCY are excavated and disposed in the on-post hazardous waste landfill. Remediation activities are conducted using vapor- and odor-suppression measures as required. Treatability testing will be performed during remedial design to verify the effectiveness of the innovative thermal process and establish operating parameters for the design of the full-scale operation. The innovative thermal technology must meet the treatability study technology evaluation criteria described in the dispute resolution agreement (PMRMA 1996). Solidification/stabilization will become the selected remedy if all evaluation criteria for the innovative thermal technology are not met. Treatability testing for solidification will be performed to verify the effectiveness of the solidification process and determine appropriate solidification/stabilization agents. Treatability testing and technology evaluation will be conducted in accordance with EPA guidance (OSWER-EPA 1989a) and EPA's "Guide for Conducting Treatability Studies under CERCLA" (1992).

- Section 36 Lime Basins – Excavation and containment of principal threat and human health exceedance soil in a triple-lined landfill cell at the on-post hazardous waste landfill facility. Prior to excavation of exceedance soil, overburden from the existing cover is removed and set aside. The excavated area is backfilled with clean borrow and the soil cover is repaired. Caustic washing and landfill of any agent-contaminated soil found during monitoring.

- Buried M-1 Pits – Approximately 26,000 BCY of principal threat and human health exceedance soil is treated by solidification/stabilization and then landfilled. The mixture of solidification/stabilization agents will be determined during remedial design by treatability testing. This treatability testing will be used to verify the effectiveness of the treatment process and establish operating parameters for the design of the full-scale operation. Excavation is conducted using vapor- and odor-suppression

measures. Caustic washing and landfill of any agent-contaminated soil found during monitoring. The excavated area is backfilled with clean borrow.

- Burial Trenches – UXO in these sites is located using a geophysical survey, excavated, and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Excavation and landfill of human health exceedance soil and backfill with on-post borrow material. Caustic washing and landfill of any agent-contaminated soil found during monitoring. Removal and landfill of munitions debris and nearby soil in excess of TCLP.
- Chemical Sewers – For sewers located within the South Plants Central Processing Area and Complex Trenches area, the sewer void space is plugged with a concrete mixture to prohibit access to these lines and eliminate them as a potential migration pathway for contaminated groundwater. The plugged sewers are contained beneath the soil cover or cap in their respective sites. For sewers located outside the South Plants Central Processing Area and Complex Trenches areas, sewer lines and principal threat and human health exceedance soil are excavated and landfilled. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. Prior to excavation of exceedance soil, overburden is removed and set aside. The excavated area is backfilled with on-post borrow material and the overburden replaced.
- Sanitary/Process Water Sewers – Void space inside sewer manholes is plugged with a concrete mixture to prohibit access and eliminate the manholes as a potential migration pathway for contaminated groundwater. Aboveground warning signs are posted every 1,000 ft along the sewer lines to indicate their location underground.
- North Plants – Excavation and landfill of human health exceedance soil. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. The excavated area is backfilled with on-post borrow material. A 2-ft-thick soil cover is placed over the soil posing a potential risk to biota and the footprint of the North Plants processing area.
- Toxic Storage Yards – Excavation and landfill of human health exceedance soil. Any agent-contaminated soil found during monitoring is caustic washed and landfilled. The excavated area is backfilled with on-post borrow material. The New Toxic Storage Yards are used as a borrow area for both low-permeability soil and structural fill.
- Munitions Testing – UXO in these sites is located using a geophysical survey, excavated, and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process. Removal and landfill of munitions debris and nearby soil in excess of TCLP.
- Lake Sediments – Excavation and landfill of human health exceedance soil and excavation and consolidation of soil posing risk to biota from Upper Derby Lake to Basin A. The excavated human health exceedance area is backfilled with on-post borrow material and the consolidated material is contained under the Basin A cover. Aquatic sediments are left in place and the area is monitored to ensure that the sediments continue to pose no unacceptable risk to aquatic biota.
- Ditches/Drainage Areas – Excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.
- Sanitary Landfills – Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of landfill debris and soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.
- Buried Sediments – Excavation and landfill of human health exceedance soil. The excavated area is backfilled with on-post borrow material.

- Sand Creek Lateral – Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A of soil posing a potential risk to biota. The consolidated material is contained under the Basin A cover. The excavated area is backfilled with on-post borrow material.
- Surficial Soil – Excavation and landfill of human health exceedance soil and excavation and consolidation to Basin A or Former Basin F of soil posing a potential risk to biota from this medium group and excavation and landfill of soil from the pistol and rifle ranges. The consolidated material is contained under the Basin A cover or Basin F cap, and the human health exceedance area is backfilled.
- Excavation and disposal in the on-post TSCA-compliant landfill of PCB-contaminated soil (three areas identified by the PCB IRA with concentrations of 250 ppm or greater). Soil identified with concentrations ranging from 50 to 250 ppm will be covered with at least 3 ft of soil (five areas identified by the PCB IRA).
- Contingent Volume – Excavation and landfill of up to 150,000 BCY of additional volume to be identified based on visual field observations. An additional 14 samples from North Plants, Toxic Storage Yards, Lake Sediments, Sand Creek Lateral, and Burial Trenches and up to 1,000 additional confirmatory samples may be used to identify the contingent soil volume requiring excavation.
- Remedy components for all sites include reconditioning the surface soil and revegetating areas disturbed during remediation with locally adapted perennial vegetation.

Exceedance volumes for all medium groups are listed in Table 7.1-5. For sites with excavation as part of the selected remedy, the exceedance volume is considered the volume to be excavated and no confirmatory sampling will occur during implementation, other than to identify contingent volume.

Additional detail on this alternative is provided in the Detailed Analysis of Alternatives report. Figure 9.3-1 shows the selected sitewide soil remedy; Figures 9.3-2, 9.3-3, and 9.3-4 show the major excavation areas and cap or cover components of the selected soil remedy; and Figure 9.3-5 shows the areas where exceedance volumes are left in place and the type of containment systems used in those areas following implementation of the selected remedy. Tables 9.3-2 and 9.3-3 show the disposition of exceedance volumes and Table 9.3-4 details the capped/covered areas for the selected soil remedy. A process will be presented in future implementation documents that will allow for independent confirmation that volumes (defined spatially) are removed. The process will allow for verification by the state or EPA during remedial action.

9.4 Additional Components of the Selected Remedy

The Army, Shell, EPA, USFWS, and state of Colorado have agreed to several additional components that will be included in the overall on-post remedy. These components have been considered in the selection of the preferred alternatives and are as follows:

- Provision of $48.8 million held in trust to provide for the acquisition and delivery of 4,000 acre-feet of potable water to SACWSD and the extension of the water-distribution lines from an appropriate water supply distribution system to all existing well owners within the DIMP plume footprint north of RMA as defined by the detection limit for DIMP of 0.392 parts per billion (ppb). In the future, owners of any domestic wells, new or existing, found to have DIMP concentrations of 8 ppb (or other relevant CBSG at the time) or greater will be connected to a water-distribution system or provided a deep well

or other permanent solution. The Army and Shell have reached an Agreement in Principle with SACWSD, enclosed as Appendix B of this ROD, regarding this matter.

- In compliance with NEPA, PMRMA will separately evaluate the potential impacts to the environment of both the acquisition of a water supply for SACWSD and for extension of water-distribution lines.
- The Army and Shell will fund ATSDR to conduct an RMA Medical Monitoring Program in coordination with CDPHE. The program's nature and scope will include baseline health assessments and be determined by the on-post monitoring of remedial activities to identify exposure pathways, if any, to any off-post community.

  A Medical Monitoring Advisory Group (MMAG) has been formed to evaluate information concerning exposure pathways and identify and recommend appropriate public health actions to CDPHE and ATSDR and to communicate this information to the community. CDPHE and ATSDR will use the recommendations of the MMAG to jointly develop an appropriate medical monitoring plan and jointly define the trigger for when such a plan will take effect. Any human health assessment completed by CDPHE and ATSDR will be formally reviewed by the Parties and the MMAG prior to issuance to the public. The MMAG includes representatives from the affected communities, regulatory agencies, local governments, Army, Shell, USFWS, and independent technical advisors. Any necessary technical advisors will be identified in coordination with CDPHE and funded through ATSDR.

  The primary goals of the Medical Monitoring Program are to monitor any off-post impact on human health due to the remediation and provide mechanisms for evaluation of human health on an individual and community basis, until such time as the soil remedy is completed. On behalf of the communities surrounding RMA, the MMAG will develop and submit to CDPHE and ATSDR specific recommendations defining goals, objectives, and the methodology of a program designed to respond effectively to RMA-related health concerns of the community.

  Elements of the program could include medical monitoring, environmental monitoring, health/community education or other tools. The program design will be determined through an analysis of community needs, feasibility, and effectiveness.

- Trust Fund – During the formulation and selection of the remedy, members of the public and some local governmental organizations expressed keen interest in the creation of a Trust Fund to help ensure the long-term operation and maintenance of the remedy once the remedial structures and systems are installed. In response to this interest, the Parties have committed to good-faith best efforts to establish a Trust Fund for the operation and maintenance of the remedy, including habitat and surficial soil. Such operation and maintenance activities will include those related to the new hazardous waste landfill; the slurry walls, caps, and soil and concrete covers; all existing groundwater pump-and-treat systems; the groundwater pump-and-treat system to intercept the Section 36 Bedrock Ridge Plume; the maintenance of lake levels or other means of hydraulic containment; all monitoring activities required for the remedy; design refinement for on-post surficial soil as described in Section 9.4; and any revegetation and habitat restoration required as a result of remediation.

  These activities are estimated to cost approximately $5 million per year (in 1995 dollars). The principal and interest from the Trust Fund would be used to cover these costs throughout the lifetime of remedial program.

  The Parties recognize that establishment of such a Trust Fund may require special legislation and that there are restrictions on the actions federal agencies can take with respect to proposing legislation and supporting proposed legislation. In addition to the legislative approach, the Parties are also examining possible options that may be adapted from trust funds involving federal funds that exist at other remediation sites. Because of the uncertainty of possible legislative requirements and other options, the precise terms of the Trust Fund cannot now be stated.

  A trust fund group will be formed to develop a strategy to establish the Trust Fund. The strategy group may include representatives of the Parties (subject to restrictions on federal agency

participation), local governments, affected communities, and other interested stakeholders, and will be convened within 90 days of the signing of the ROD.

Notwithstanding these uncertainties, it is the intent of the Parties that if the Trust Fund is created it will include the following:

- A clear statement that will contain the reasons for the creation of the Trust Fund and the purposes to be served by it.
- A definite time for establishing and funding the Trust Fund, which the Parties believe could occur as early as 2008, when the remedial structures and systems may have been installed.
- An appropriate means for competent and reliable management of the Trust Fund, including appropriate criteria for disbursements from the Trust Fund to ensure that the money will be properly used for the required purposes.

- Continued operation of the CERCLA Wastewater Treatment Plant to support the remediation activities.
- Stored, drummed waste identified in the waste management element of the CERCLA Hazardous Waste IRA may be disposed in the on-post hazardous waste landfill in accordance with the CDD (Harding Lawson Associates 1996).
- Continued monitoring, as part of design refinement, for areas that may pose a potential risk to biota as outlined in the following process:
  - The BAS of technical experts (such as ecotoxicologists, biologists, and range/reclamation specialists) from the Parties will focus on the planning and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The BAS will provide interpretation of results and recommendations for design refinements to the Parties' decision makers.
  - The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to refine design boundaries for surficial soil and aquatic contamination to be remediated.
    - Phase I and the potential Phase II of the SFS will be used to refine the general areas of surficial soil contamination concern. The field BMFs will be used to quantify ecological risks in the Area of Dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of excess risks (Figure 6.2-6).
    - Pursuant to the FFA process, USFWS will conduct detailed site-specific exposure studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC report as appropriate). These studies will address both the aquatic resources and at least the surficial soil in and around the Area of Dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.
    - Results from both the SFS/risk assessment process and the site-specific studies will be considered in risk-management decisions, which may further refine the areas of surficial soil and aquatic contamination to be remediated. (In the event of a conflict between management of RMA as a wildlife refuge and performance of remedial response actions, the Rocky Mountain Arsenal National Wildlife Refuge Act indicates that response actions will take priority.)
  - The BAS will serve as a technical resource to the Parties' decision makers by using technical expertise in analyzing, and potentially collecting, data sufficient to support design refinement for surficial soil areas and aquatic resources that will break unacceptable exposure pathways in consideration of minimizing habitat disturbance. Further, it will assess through monitoring the efficacy of remedies in breaking unacceptable pathways to biota. If any additional sites are identified, the remedy will be implemented as follows:

  - It will be staged to allow habitat recovery.
  - It will be performed first on locations selected through a balance of factors such as:
    - The Parties agree an area has a negative impact on or excessive risk to fish or wildlife.
    - The effort will not be negated by recontamination from other remediation activities.
    - The existing fish and wildlife resource value.
  - It will include revegetation of a type specified by USFWS; if the initial revegetation is not successful, the appropriate adjustments will be made and revegetation again implemented.
  - It will provide that the locations and timing of remediation are to be determined with consideration of and in coordination with USFWS refuge management plans and activities.
  - The SFS, biomonitoring programs, and recommendations of the BAS will be used to refine the areas of remediation during remedial design.

- Any UXO encountered during remediation will be excavated and transported off post for detonation (unless the UXO is unstable and must be detonated on post) or other demilitarization process.
- Within 180 days after issuance of the Notice of Availability for the ROD, the Army will append to the ROD a complete, detailed schedule for completion of activities associated with the selected remedy. The schedule will identify the enforceable project milestone dates for design activities. Future design documents will detail milestone dates for implementation activities. Revisions to this schedule will be initiated prior to the start of each fiscal year to allow adequate time for review and concurrence by the Parties.

9.5 Remediation Goals and Standards

The treatment components of the selected groundwater remedy will meet the CSRGs presented in Tables 9.1-1 through 9.1-4, and the components of the selected soil and structures remedy will meet the remediation goals and standards presented in Table 9.5-1. The selected remedies will comply with the performance standards as provided in Appendix A (ARARs).

9.6 Cost of the Selected Remedy

The total estimated cost (in 1995 dollars) for the selected remedy is $2.2 billion (present worth $1.8 billion). Table 9.6-1 presents the capital and O&M costs for the selected alternatives. The time required for implementation is approximately 17 years, with groundwater system operations continuing for at least 30 years. The implementation of the remedy could be accelerated if funding is available that exceeds $100 million/year.

9.7 Long-Term Operations

Long-term operations are those ongoing activities that will be performed after the initial remediation work is completed and that will continue after EPA releases the site to USFWS as a wildlife refuge. These include monitoring and maintaining containment systems, such as the caps and the landfill, and continuing the operation of groundwater treatment systems.

Soil sites where covers or caps are constructed will be inspected on a regular basis, and damage to the vegetative cover or any eroded soil will be repaired. Long-term management also includes access restrictions to capped and covered areas to ensure the integrity of the containment systems. Where human health exceedances are left in place at soil sites, groundwater will be monitored, as necessary, to evaluate the effectiveness of the remedy. The on-site hazardous waste landfill will be closed and monitored according to RCRA and TSCA requirements. Long-term activities at this facility will include leachate collection and disposal, regular cover inspections with repair of vegetative cover damage or erosion, and sampling of upgradient and downgradient wells to monitor for migration of landfill contaminants into the groundwater. Monitoring activities for biota will continue by USFWS in support of evaluating the effectiveness of the selected remedy.

Long-term activities for the water medium include continued operation of the NWBCS, NBCS, ICS, the Basin A Neck and North of Basin F Groundwater IRA systems, and the new Section 36 Bedrock Ridge groundwater Extraction System. Operation of wells within these systems may be discontinued according to the shutdown criteria listed in Section 9.1. Maintenance of lake levels and groundwater monitoring will be continued as described in Section 9.1.

A network of monitoring wells will be sampled to evaluate the effectiveness of the remedy. A select number of deep wells will also be sampled to monitor any contamination in the confined aquifer. Surface water will be monitored and managed in a manner consistent with the selected remedy.

There are no long-term activities directly associated with the structures medium groups as all potentially contaminated structures will be demolished and the structural debris placed into the on-post hazardous waste landfill or used as fill under the Basin A cover. These sites will be monitored and maintained as described above.

Technical working groups or subcommittees will combine their efforts to evaluate the effectiveness of the remedy and make recommendations to the Parties' decision makers. In addition, site reviews will be conducted at least every 5 years (following the signing of the ROD) for all sites where contaminants that exceed remediation goals are left in place. The effectiveness of containment remedies will be evaluated to determine what additional remedial actions may be required if containment is found to be inadequate. In the event other contaminants not included as COCs are identified as a concern (e.g., dioxin) during or after design or implementation, an evaluation will be conducted as required by EPA guidance (OSWER-EPA 1989a) to ensure that the remedial action is protective of human health and the environment. At a minimum, evaluations will be part of the 5-year site review.

Table 9.1-4 CSRGs for the Basin A Neck IRA Treatment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)
Arsenic	50[1,2]
Mercury	2[1,2]

1 Colorado Basic Standards for Groundwater. The Basic Standards for Groundwater, 5 CCR 1002.8, Section 3.11.
2 Federal maximum contaminant levels, 40 CFR 141.
3 Health-based value from the ROD for the Off-Post Operable Unit (Harding Lawson Associates 1995).
4 Current practical quantitation limit or certified reporting limit.

Table 9.1-4 CSRGs for the Basin A Neck IRA Treatment System

Chemical Group/Compound	Containment System Remediation Goals (µg/l)	
VHOs (Volatile Halogenated Organics)		
1,2-Dichloroethane	0.4[1]	(1.1)[4]
1,1,1-Trichloroethane	200[1,2]	
1,1-Dichloroethylene	7[1,2]	
Carbon tetrachloride	0.3[1]	(1.0)[4]
Chlorobenzene	100[1,2]	
Chloroform	6[1]	
Tetrachloroethylene	5[1,2]	
Trichloroethylene	5[1,2]	
VHCs (Volatile Hydrocarbon Compounds)		
Dicyclopentadiene	46[3]	
VAOs (Volatile Aromatic Organics)		
Benzene	5[1,2]	
OPHPs (Organophosphorus Compounds; Pesticide Related)		
Atrazine	3[1,2]	
SHOs (Semivolatile Halogenated Organics)		
Hexachlorocyclopentadiene	50[1]	
OCPs (Organochlorine Pesticides)		
DDT (Dichlorodiphenyltrichloroethane	0.1[1]	
Dieldrin	0.002[1]	(0.1)[4]
Endrin	0.2[1]	
OSCHs (Organosulfur Compounds; Herbicide Related)		
Chlorophenylmethylsulfide	30[3]	
Chlorophenylmethylsulfone	36[3]	
Chlorophenylmethylsulfoxide	36[3]	
Dicyclopentadiene	46[3]	
OSCMs (Organosulfur Compounds; Mustard Agent Related)		
1,4-Oxathiane	160[3]	
Dithiane	18[3]	

AGREEMENT FOR A CONCEPTUAL REMEDY
FOR THE CLEANUP OF THE
ROCKY MOUNTAIN ARSENAL

Introduction

This document represents a conceptual remedy for the cleanup of the U.S. Army's Rocky Mountain Arsenal (RMA).

The U.S. Army, Shell Oil Company, the state of Colorado, the U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service (the Parties), agree to the conceptual remedy described herein, believe it to be protective of human health and the environment, and believe it to be representative of the best balance of competing considerations among the remedial alternatives considered.

A. CERCLA, Public Participation, and the Proposed Plan

The Parties understand that the conceptual remedy must be put back into the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) remedy selection process. The Parties agree that the conceptual remedy will be incorporated into the Detailed Analysis of Alternatives (DAA), will be presented as the preferred alternative in the DAA, and will be placed in the Proposed Plan. Each Party agrees to support the conceptual remedy as the preferred remedial alternative and to support the Proposed Plan based on the elements of the conceptual remedy.

The Parties recognize that CERCLA requires a public comment period and evaluation of the Proposed Plan in light of public comment received during the public comment period. In accordance with CERCLA, public comment may necessitate modification of the Proposed Plan. The Parties also recognize, however, that substantial public comment on the remedy for RMA already exists and was considered by the Parties in developing the conceptual remedy as the preferred remedial alternative. The Parties understand that the Proposed Plan, in its original form or as modified based on public comment, will be ultimately incorporated in the Final Record of Decision (ROD). The Parties will continue the ongoing dialogue with stakeholders to ensure their meaningful participation.

B. Colorado Hazardous Waste Management Act

The portions of the conceptual remedy relating to those areas covered by the Consent Decree, filed June 30, 1994, in Civil Action No. 89-C-1646, will be integrated into the Colorado Hazardous Waste Management Act (CHWMA) closure process and will be incorporated into the Closure Plan. The U.S. Army and the state of Colorado agree that the draft Closure Plan will be issued at the same time as the Proposed Plan and there will be a concurrent public comment period on both documents.

C. Timing, Funding and Implementation

The Parties commit to good faith best efforts to assist in implementing the conceptual remedy and to cooperate with the U.S. Army in finalizing the DAA and the Proposed Plan within six months. The signatories below (or successor or other official with equal authority) shall meet or confer and take all necessary steps to ensure timely incorporation of the conceptual remedy into the Final DAA and Proposed Plan. Although the Parties recognize that many of the disputed issues may have been addressed by the conceptual remedy, any issue now in the formal dispute process will be resolved consistent with the Federal Facility Agreement (FFA). The Parties agree that the state of Colorado will become a full participant in the FFA Dispute Resolution process.

The Parties commit to use good faith best efforts to seek funding for the implementation of the ROD recognizing, however, that federal expenditures are subject to appropriations from Congress and other requirements of the Anti-Deficiency Act, 30 U.S.C. 1341, et seq. The U.S. Army shall request, through the normal U.S. Army and U.S. Department of Defense budgetary processes, all funds and authorizations necessary to meet the conditions of, and to implement, the final remedy. The Parties also commit to good faith best efforts to ensure timely implementation of the ROD and the full transition to a National Wildlife Refuge.

D. Reservation of Rights

The conceptual remedy document is not intended to affect or determine individual Parties' legal authorities. Nothing in the conceptual remedy affects the rights of the state of Colorado with respect to natural resource damages, past response costs and future oversight costs, and the state of Colorado reserves all rights and claims related thereto. Nothing in the conceptual remedy affects the rights of the federal trustees with respect to natural resource damages, and the federal trustees reserve all rights and claims related thereto.

Conceptual Remedy Components

The following items represent the specific components of the conceptual remedy that will be presented as the preferred alternative in the DAA and will be placed in the Proposed Plan.

1. Future Hazardous Waste Landfill (RCRA)

   - o A new on-site, state-of-the-art hazardous waste landfill (hazardous waste landfill) will be constructed in an agreed-upon location between Former Basin F and North Plants. One or more cells (approximately 750,000 cubic yards) of this landfill will have an enhanced design with an additional liner and leachate detection system and will contain contaminated soil from the Basin F Waste Pile and Lime Basins.

- o The hazardous waste landfill will be state-of-the-art because it will meet or exceed federal, state and local regulations for hazardous waste landfills. At a minimum, the design will include a double liner system, leachate detection and collection, and groundwater monitoring.

- o Since the Basin F waste pile represents the largest portion of principal threat exceedence soil volume being excavated, it will be placed into one or more enhanced cells as an added measure of protection. The Lime Basins are another significant source of principal threat exceedence soil which will be placed in one or more enhanced cells at the hazardous waste landfill.

- o The ROD will specify that this landfill will accept material only from RMA.

- o Approximately 1.5 million cubic yards of soil and debris will be placed into this landfill. The surface footprint of the landfill will be approximately 40-50 acres. The landfill cells will be constructed partially below grade while the final site surface will be gently sloping and revegetated.

- o Technologies to control emissions and odors for material handling operations will be determined during remedial design and implemented as necessary throughout the remediation phase.

2. Former Basin F

- o Principal threat soil will be treated in-place using solidification to a depth of 10 feet. Solidification will reduce mobility of volatile organic compounds (VOCs) and pesticides. Further treatability work will be necessary to select the specific solidification process and to establish treatment goals.

- o A RCRA-equivalent cap with biota barrier will be constructed over the entire former basin to prevent contact with remaining human health exceedence soil (and in-situ treated principal threat areas). The RCRA cap and the current groundwater treatment and controls will minimize further groundwater contamination.

3. Basin F Waste Pile

- o Waste pile soil, including the bottom liners, will be excavated and placed at one or more enhanced cells at the hazardous waste landfill designed for approximately 750,000 cubic yards of contaminated soil (to include Basin F Waste Pile and Lime Basin soil).

- o Where the waste pile soil exceeds EPA's paint filter test, moisture content will be reduced to acceptable levels by using a dryer in an enclosed structure. Any VOCs (and possibly some semi-volatile organics) released from the soil during drying will be captured and treated; however, the main objective of this process is drying.

- o Odor controls for all stages of the excavation, drying and disposal process will be employed as necessary and will be selected during remedial design.

4. Basin A

- o To reduce the amount of clean soil used for fill from other portions of RMA, some excavated biota exceedence soil from other sites at RMA will be placed in Basin A as fill material under the cap.

- o Structural debris on RMA, except agent-contaminated building material and pesticide-contaminated building material (unless pesticide-contaminated building material is washed), may be placed in Basin A as fill material. Specifics of the washing process will be addressed during the design phase.

- o Basin A contaminated soil (both principal threat and human health exceedence soil), structural debris on RMA, RMA biota exceedence soil, and portions of the Sanitary Landfills as specified in paragraph #26 will be entombed under six inches of concrete and a four foot soil cover. The concrete layer is meant to serve as both a biota barrier and a barrier to digging.

- o Further groundwater contamination will be minimized through two means: continued operation of the Basin A Neck system, and natural dewatering of the basin area.

5. South Plants Central Processing Area

- o Principal threat and human health exceedence soil will be excavated to a depth of five feet and placed in the hazardous waste landfill. In the South Plants Central Processing Area, a depth limit of five feet was selected due to the unique nature of this area. Biota exceedence soil from the Balance of South Plants Areas may be placed in this excavation.

- o A four foot soil cover with a biota barrier will be constructed over the entire site to isolate remaining contamination.

6. Balance of South Plants Areas

- One foot of biota exceedence soil will be excavated from the entire South Plants Balance of Areas and used as fill in the principal threat and human health exceedence soil excavations and may be used as the lower two feet of cover in the South Plants Central Processing Area and the South Plants Balance of Areas.

- Principal threat and human health exceedence soil will be excavated up to ten feet and placed in the hazardous waste landfill.

- Three feet of cover in addition to the fill described above will be placed over a specified area of the South Plants Balance of Areas depicted on a map that will be incorporated into the Final DAA. The remaining area will have a minimum of one foot of cover.

- The top one foot of cover placed over the entire South Plants Balance of Areas will be constructed of uncontaminated soil.

- The U.S. Army and Shell Oil Company will sample the periphery of Balance of South Plants Areas (two composite samples per acre methodology, the methodology to be determined) to determine if soil exceeds principal threat and human health levels. If after sampling, soil exceeds principal threat and human health levels, the U.S. Army and Shell Oil Company agree to extend the three foot cover over these areas or to excavate and landfill the materials under the soil volume contingency provisions.

7. Section 36 Balance of Areas

- Human health exceedence soil will be excavated up to 10 feet and placed in the hazardous waste landfill.

- Biota exceedence soil from the entire area will be excavated to a depth of one foot and placed in Basin A.

- A two foot cover will be placed over the west two-thirds portion of the Section 36 Balance of Areas and a one foot cover will be placed on the eastern one-third portion.

- The areas to be covered will be depicted on a map to be incorporated into the Final DAA.

8. Secondary Basins

- o Human health exceedence soil will be excavated and placed in the hazardous waste landfill and backfilled. A two foot cover will be placed over the entire area of Basins B, C, and D.

9. North Plants

- o Human health exceedence soil will be excavated and placed in the hazardous waste landfill.
- o Two feet of soil cover will be placed over the North Plants Processing Area as depicted on a map that will be incorporated into the Final DAA.

10. Pits and Trenches

A. Complex (Army) Trenches

- o Construction of a slurry wall around the Trenches and a RCRA-equivalent cap with biota barrier which will be six inches of concrete at this area will prevent contact with contaminated soil and will minimize further groundwater contamination.

B. Shell Trenches

- o Expansion of the current slurry wall around the Trenches and a RCRA-equivalent cap with biota barrier will prevent contact with contaminated soil and will minimize further groundwater contamination.

C. M-1 Pits

- o Principal threat and human health exceedence soil will be excavated and treated via a solidification technology. Treated soil will be placed in the hazardous waste landfill. Site will be backfilled to grade.

D. Hex Pits

- o Principal threat soils will be treated with a yet-to-be-agreed-upon technology.

E. Lime Basin

- o Principal threat and human health exceedence soil will be excavated and placed in an enhanced designed cell(s) at the hazardous waste landfill. Site will be backfilled to grade.

F. Burial Trenches

- o Human health exceedence soil will be excavated and placed in the hazardous waste landfill. Site will be backfilled to grade.

11. Ditches, etc.

A. Sand Creek Lateral

- o Human health exceedence soil will be excavated and placed in the hazardous waste landfill; biota exceedence soil will be excavated and used as fill material in Basin A.

B. Buried lake sediments

- o Human health exceedence soil will be excavated and placed in the hazardous waste landfill.

C. South Plants Ditches

- o Principal threat and human health exceedence soil will be excavated and placed in the hazardous waste landfill.
- o Biota exceedence soil will be used as specified in the Balance of South Plants Areas.

D. Upper Derby Lake

- o Excavate up to 3,000 cubic yards of additional human health exceedence soil and place in the hazardous waste landfill.

12. Chemical Sewers

- o Chemical sewer lines (typically buried deeper than six feet) and manholes located in the South Plants Central Processing Area will be plugged with concrete. A soil

cover with a biota barrier will be placed at the surface. These actions will eliminate access to the lines and minimize further groundwater contamination.

- o In areas outside the South Plants Central Processing Area, human health exceedence soil associated with the sewers will be excavated and placed in the hazardous waste landfill.

13. Structures

- o Demolish all contaminated structures. Buildings have been categorized according to their manufacturing history.

- o In order to minimize use of uncontaminated soil for fill material in Basin A, building debris could be placed into Basin A for fill. Pesticide-contaminated building material will not be placed in Basin A for fill unless contaminated building material is washed.

- o Agent-contaminated building material will undergo a caustic wash process prior to being placed in the hazardous waste landfill. The resulting liquids will be treated.

14. Munitions

- o Munitions and munitions debris in formerly used testing sites will be located (using geophysical techniques) and excavated. Excavated munitions debris and nearby soil in excess of TCLP will be placed in the hazardous waste landfill. If explosives-containing munitions are found, they are to be taken to the closest on-post site for detonation. If not considered safe for removal and transport, they are to be detonated in place.

15. Groundwater and Point of Compliance

- o Operation of all existing groundwater pump and treat systems will continue, including the three boundary systems (Irondale, Northwest Boundary and North Boundary Control Systems) and interim response action systems (Motor Pool and Rail Classification Yard Extraction System, Basin F Groundwater IRA, Basin A Neck IRA and Off-post System).

- o Natural lowering of the water table in Basin A and South Plants Central Processing Area will be allowed to continue.

- o A groundwater pump and treat system will be installed and operated to intercept the Section 36 Bedrock Ridge Plume until the plume is hydrologically controlled.

- o Lake levels will be maintained at or greater than one foot above aquifer level or use of other means of hydraulic containment will be used to prevent South Plants plumes from migrating into the lakes. Demonstration that these measures are adequate or necessary to protect lakes will occur at the five year site review.

- o Western Tier Plume

  - Shell Oil Company and the U.S. Army will operate the Irondale System for two years or until the Railyard/Motorpool Plumes no longer require containment at the Irondale System.

  - Shell Oil Company and the U.S. Army agree to operate the Irondale System for two additional years contingent upon the state of Colorado and/or the U.S. EPA taking actions at other sources of groundwater contaminants contributing to that plume to prevent on-post migration of contaminants. If the state of Colorado and U.S. EPA desire continued operation of the Irondale System after Shell Oil Company and the U.S. Army's obligation is satisfied, Shell Oil Company and the U.S. Army will make the Irondale System available for operation by other parties. However, costs for additional operations beyond the two year contingency period will not be borne by Shell Oil Company and the U.S. Army unless otherwise finally determined through an appropriate legal process.

- o DIMP Standard for Internal Treatment Systems

  - The Basin A Neck Treatment System will treat DIMP to a level necessary to enable influent to the Northwest Boundary Treatment System to meet the eight parts per billion (ppb) Colorado Basic Standards for Groundwater (CBSG) (or other relevant CBSG at the time).

16. South Adams County Water and Sanitation District (SACWSD) Replacement Water

- o The U.S. Army and Shell Oil Company agree to pay for, and provide or arrange for the provision of 4,000 acre feet of water, the details of which will be worked out between the U.S. Army, Shell Oil Company, and SACWSD. If such water is not available, the U.S. Army and Shell Oil Company will provide payment of an agreed upon amount of money in lieu of water. This obligation will be part of the final remedy and will be incorporated into the On-post ROD.

17. Extension of Water Distribution Lines

- As of the date of the On-post ROD, and based on a .392 parts per billion (ppb) detection limit, the U.S. Army will use the last available quarterly monitoring results to determine the DIMP plume footprint.

- The U.S. Army and Shell Oil Company will pay for the extension of, and hook-up to, the current distribution system for all existing well owners within the DIMP plume footprint referenced above.

- The U.S. Army will continue monitoring of the DIMP plume.

- Existing domestic well owners outside of the DIMP plume footprint as of the date of the On-post ROD where it is later determined that levels of DIMP are eight ppb or greater (or other relevant CBSG at the time) will be hooked up at the U.S. Army and Shell Oil Company's expense to the SACWSD distribution system or provided a deep well or other permanent solution.

- For new domestic wells with levels of eight ppb or greater (or other relevant CBSG at the time), the Off-post ROD institutional controls will provide that the U.S. Army and Shell Oil Company will pay for hook-up to the distribution system or provided a deep well or other permanent solution.

18. Medical Monitoring Program

- The U.S. Army and Shell Oil Company will fund the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct an RMA Medical Monitoring Program in coordination with the Colorado Department of Public Health and Environment (CDPHE). The program's nature and scope will include base line health assessments and be determined by the on-post monitoring of remedial activities to identify exposure pathways, if any, to any off-post community.

- A Medical Monitoring Advisory Group will be formed to provide information concerning exposure pathways and to recommend to the CDPHE and ATSDR any appropriate medical monitoring plan and to provide community members with advice to understand the Medical Monitoring Program. CDPHE and ATSDR will jointly develop any appropriate medical monitoring plan and jointly define the trigger for when such a plan will take effect. The members of the Medical Advisory Group will include representatives from the affected communities, regulatory agencies, local governments, the U.S. Army, Shell Oil Company, and independent technical advisors. Any necessary independent technical advisors will be identified in coordination with CDPHE and funded through ATSDR. This

advisory group will be convened within the next 180 days. Any health assessments completed by CDPHE and ATSDR will be formally reviewed by the Parties prior to issuance to the Medical Monitoring Advisory Group or the public.

- o The primary goals of the Medical Monitoring Plan are to monitor any off-post impact on human health due to the remediation and provide mechanisms for evaluation of health status on an individual and community basis, until such time as the soil remedy is completed.

19. Trust Fund

- o The Parties commit to good faith best efforts to establish a trust fund for the operations and maintenance of the remedy, including habitat and surficial soils. The Parties recognize, however, that establishment of such a trust fund requires special legislation and there are restrictions on the actions federal agencies can take with respect to proposing legislation and supporting proposed legislation. The funding amount will be determined in the Final DAA and would be funded by the U.S. Army and Shell Oil Company.

20. Criteria for Shutting Down Groundwater Boundary and Off-post Containment Systems

- o Existing wells within the boundary and off-post containment systems (BCS) can be removed from production when concentrations of constituents detected in the well are less than applicable or relevant and appropriate requirements (ARARs) established in the ROD and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the systems. The containment objective of the systems will be outlined in the ROD. Wells removed from production and monitoring wells up-gradient and down-gradient of the BCS will be monitored quarterly for a period of five years to determine if contaminants reappear, except those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. BCS extraction wells removed from production for water quality reasons will be placed back into production if contaminant concentrations exceed ARARs established in the ROD. Wells with concentrations less than ARARs established in the ROD can remain in production if additional hydraulic control is required.

21. Criteria for Shutting Down Internal Containment Systems (ICS)

- o Existing wells within the internal containment systems (ICS) can be removed from production when concentrations of constituents detected in the wells are less than

ARARs established in the ROD and/or it can be demonstrated that discontinuing operation of a well would not jeopardize the containment objective of the system. The containment objective of the system will be outlined in the ROD. Wells removed from production and monitoring wells up-gradient and down-gradient of the ICS will be monitored quarterly for a period of five years to determine if contaminants reappear, except those wells turned off for hydraulic purposes will not be subject to the quarterly monitoring requirements. ICS extraction wells removed from production for water quality reasons will be placed back into production if contaminant concentrations exceed ARARs established in the ROD. Wells with concentrations less than ARARs established in the ROD can remain in production if additional hydraulic control is required.

22. Off-post Surficial Soils

- Shell Oil Company and the U.S. Army agree to revegetate the approximately 160-acres located in the southeast portion of Section 14 and the southwest portion of Section 13 as depicted in the U.S. Army's Dieldrin Contour Data which will be presented in the Final Off-post ROD.

- Revegetation will involve tilling and seeding. No sampling will be conducted before or after revegetation.

- Shell Oil Company and the U.S. Army believe that existing soil risk in the revegetated area falls within EPA's established acceptable risk range and that remediation is not necessary. However, Shell Oil Company and the U.S. Army agree to the above revegetation as part of the settlement.

23. Off-post Institutional Controls

- Institutional controls will be utilized to prevent domestic use of off-post contaminated water. These institutional controls incorporate a variety of existing regulatory controls, and controls to be put in-place, that serve to discourage or prevent the development of future domestic wells in areas where the aquifer exceeds groundwater cleanup standards. Cleanup standards will include the Colorado Basic Standards for Groundwater and Surface Water. The dispute resolution agreement between the Parties on this issue is reflected in the June 7th letter (P. Tourangeau to J. Potter) which identifies relevant portions of the off-post ROD.

- To eliminate potential exposure to contaminated groundwater under the Shell Oil Company properties, Shell Oil Company commits to execute and record proper

documentation (e.g., covenant/negative easement) for its properties to: (i) preclude drilling of all groundwater wells into any alluvial aquifer water under Shell's property for future use until such groundwater no longer contains contamination in exceedence of ground water cleanup standards in the Off-post ROD, and (ii) preclude any use of any deeper aquifer water (e.g., Denver Basin) containing contamination in exceedence of ground water cleanup standards in the Final Off-post ROD. The recorded documents shall be enforceable by U.S. EPA, the U.S. Army, and the state of Colorado, and shall touch upon and run with the land. This commitment shall also be part of the Final ROD.

24. Soil Volume

- o The soil volumes will be those identified by the U.S. Army during the settlement discussions and detailed in the table to be incorporated in the Final DAA (Appendix 1).

- o Contingent Confirmatory Sampling and Contingent Soil Volume. Additional sampling and excavation may be necessary based on visual field observations such as soil stains, barrels or newly discovered evidence of contamination. Contingent confirmatory samples will be limited to 1,000. Contingent soil volume will not exceed 150,000 cubic yards. The location of samples and volume of contingent soil to be excavated will be based on mutual agreement of all Parties.

- o Excavation will be to no greater depth than five feet at the South Plants Central Processing Area. Excavation of principal threat and human health exceedence soil at other sites will be to no greater depth than 10 feet.

- o Fourteen additional samples will be taken at North Plants, Toxic Storage Yard, lake sediments, Sand Creek Lateral, and Burial Trenches. Any additional excavation will be within the soil volume contingency provision.

25. NDMA

- o Agreement was reached to use a PRG of 7.0 parts per trillion (ppt) or a certified level readily available from a certified commercial lab (now 33 ppt) at the boundary and off-post systems.

- o The U.S. Army and Shell Oil Company agree to continue monitoring and to perform an assessment of the NDMA plume within one year using a 20 ppt method detection limit.

- o The U.S. Army and Shell Oil Company agree to prepare a feasibility study of

potential actions, both on-post and at the boundary, or adjacent to the boundary in order to achieve PRGs at the RMA boundary.

26. Sanitary Landfills

- The U.S. Army will revise the maps in the DAA to more accurately show the human health exceedence soil areas that occur in the Sanitary Landfills. The human health exceedence soil will be landfilled and the biota exceedence volume and remaining refuse in these areas will be placed into Basin A.

27. Surficial Soils

- Several disputes relate to the biota risk assessment and the associated remediation of surficial soils and aquatic resources which have solely biota-exceedence levels of contaminants. A list of those disputes, by party and number, will be included in the Dispute Resolution Agreement on those matters. That Dispute Resolution Agreement will contain the following language:

  "1. The parties acknowledge the U.S. Fish & Wildlife Service's expertise and principal role in assessments of the scope of residual contaminant impacts on fish and wildlife and in forwarding appropriate response recommendations. The parties acknowledge EPA's expertise and principal role in the CERCLA risk assessment process and remedy selection.

  2. The parties agree that the disputes listed in Attachment #___ are resolved by agreement to the following items.

  REGARDING REMEDY SELECTION:

  3. The Proposed Plan will reflect a preferred remedy consistent with the following.

  4. The On-post ROD will select a remedy to adequately break exposure pathways to surficial soils and aquatic resources. The remedy will include options of soil tilling, soil removal, soil covering, lake sediment dredging, and other appropriate techniques to reduce the concentrations of contaminants that the biota are exposed to. Site-specific engineering and/or biological considerations will be used to define which option is implemented.

  5. The On-post ROD will specify a process to determine the locations where the remedy will be applied. That process will consist of the following components:

a. A FFA Subcommittee of technical experts from the Parties (such as ecotoxicologists, biologists, and range/reclamation specialists) will focus on the plans for and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The Subcommittee will provide interpretation of results and recommendations to the parties' decision-makers.

b. The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to delineate areas of surficial soil and aquatic contamination to be remediated.

i) Phase I and the potential Phase II of the Supplemental Field Study (SFS) will be used to refine the general areas of surficial soil contamination concern called the "area of dispute." The field Bio-Magnification Factors will be used to quantify ecological risks in the area of dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of concern.

ii) Pursuant to the FFA process, USFWS will conduct detailed site-specific studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC). These studies will address both the aquatic resources and at least the surficial soil area of dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.

iii) Results from both the SFS/risk-assessment-process and the site-specific studies will be considered in risk management decisions which may further refine the areas of surficial soil and aquatic contamination to be remediated.

c. The Subcommittee will analyze site-specific resource values, levels of contamination impact on biota, long-term/short-term impacts and benefits to biota, and/or engineering considerations to identify the most appropriate of the selected remedial options to implement, and to evaluate the potential for site-specific exclusions from the remediation. The Subcommittee will make recommendations to the Parties' decision-makers.

6. The ROD language on schedules will be consistent with the concepts below regarding implementation of the remediation.

7. The ROD will define a sufficient funding level to fully support the identified

remediation projects and residual area contamination assessments, including full analytical support.

REGARDING REMEDY IMPLEMENTATION:

8. The On-post ROD will specify that the remedy implementation will:

a. be staged, to allow habitat recovery;

b. be performed FIRST on locations selected through a balance of factors such as:

i) the parties agree an area has an impact on fish or wildlife;

ii) the effort will not be negated by recontamination from other remediation activities; and

iii) the existing fish and wildlife resource value;

c. include revegetation, of a type specified by USFWS; if initial revegetation is not successful, make appropriate adjustments then again revegetate; and

d. provide that the locations and timing of remediation are to be determined with consideration of and coordination with USFWS Refuge management plans and activities."

28. Colorado Basic Standards for Groundwater (CBSGs)

- The Colorado Basic Standards for Groundwater (CBSG), Section 3.11.0 et seq., 5 CCR 1002-8 (CBSG), and the Colorado Basic Standards and Methodologies for Surface Water, Section 3.11.0 et seq., 5 CCR 1002-8 (CBSM), including the water quality standards therein, are ARARs for both the on-post and off-post operable units at RMA.

- To comply with the CBSG and CBSM, the U.S. Army will treat any contaminated extracted groundwater so that it meets these standards prior to discharge or reinjection. The U.S. Army will continue to operate the RMA groundwater intercept and treatment systems pursuant to paragraphs #15, #20 and #21 of this document.

Glossary of Terms

Principal threat soil - Soil on RMA exhibiting the highest estimated risks. Exceeding 1 in 1,000 excess cancer risk for humans and/or non-cancer hazard index of 1,000.

Human health exceedence soil - Soil exhibiting less estimated risk than principal threat soils. This soil poses less of a cancer risk that the principal threat soil (less than 1 in 1,000) but is above the Army's site evaluation criteria (more than 1 in 10,000 excess cancer risk and/or a hazard index of 1).

Biota exceedence soil - Low-level contaminated soil that does not pose an unacceptable risk to humans yet may be harmful for animals.

Biota barrier - A layer of crushed concrete or cobbles designed to prevent burrowing of animals and contact with contaminated soil. This layer will be part of any RCRA-equivalent cap or specified soil cover design at RMA.

Future on-site hazardous waste landfill - An engineered, state-of-the-art containment system providing a physical barrier above and below contaminated material. A low-permeability cover will prevent humans and animals from coming in contact with the waste and will minimize moisture infiltration into the landfill. A low-permeability bottom liner will protect underlying soil and groundwater from contamination. The RMA landfill will meet or exceed state hazardous waste (RCRA) standards.

Slurry wall - An underground, vertical barrier that impedes the lateral flow of contaminated groundwater. This barrier is typically constructed by creating a low-permeability clay wall in an open trench.

RCRA-equivalent cap - A multi-layered cap that prevents exposure of contamination to humans and animals and that minimizes the potential for migration of the contamination from infiltration of surface water. EPA specifies design requirements but may allow alternative designs when they can be demonstrated to provide equivalent protection.

Cover - A vegetated soil cover that prevents direct contact with contaminated soils

and minimizes infiltration of surface water.

Solidification - A treatment process for immobilizing contaminates by adding a binder (such as Portland cement, fly ash, lime, etc.) to the waste. The process can be performed on soils either in-place or ex-situ. It is most commonly used to immobilize inorganic contaminants such as arsenic and mercury but can also be applied effectively to some organic contaminants. Solidification does not destroy contaminants but minimizes leaching from the treated material.

Paint Filter Test - A simple test to determine whether a waste contains free liquids. If so, the waste must be dried sufficiently before it can be disposed of in a landfill.

Dryer - Some of the waste in the lower portion of the Basin F Waste Pile is expected to be saturated. A dryer system has been agreed upon to reduce the moisture content to an acceptable level before placement into the hazardous waste landfill. The design elements have not yet been developed, however, it could incorporate passing warm air over soils in a rotating drum. Any volatile contaminants released from the soil during this process would be treated.

Odor controls - Odor and vapor control for each medium group will be addressed during remedial design. Potential controls could include a variety of measures including enclosures, foams, tarps, wind fences, specific work practices, etc. Air monitoring will be an integral part of the remedial action.

RMA Conceptual Agreement

Site	Principal Threat Cancer risk=10-3 HI=1000 volume (yd3)*	Human Health Cancer risk=10-4 HI=1 volume (yd3)*	Biota 0-1 ft owl-based volume (yd3)*
Basin F Wastepile	600,000	0	0
Former Basin F	180,000	500,000	0
S.P. Central Processing	38,000	72,000	170,000
Basin A	34,000	146,000	120,000
Section 36 Lime Basins	9,700	44,300	0
Buried M-1 Pits	22,000	4,000	0
Complex Trenches	440,000	5,000	90,000
Shell Trenches	100,000	0	0
Hex Pits	3,300	0	0
S.P. Ditches	3,400	30,600	23,000
S.P. Balance of Areas	17,000	117,000	530,000
Chemical Sewers	47,000	35,000	0
Munitions Testing	0	90,000	0
North Plants	0	220	16,000
Toxic Storage Yards	0	2,700	18,000
Lake Sediments	0	19,000	23,000
Surficial Soils	0	90,000	0**
Ditches/Drainage Areas	0	0	52,000
Secondary Basins	0	32,000	170,000
Sanitary/Process Sewers	0	0	0
Sanitary Landfills	0	14,000	406,000***
Buried Sediments	0	16,000	16,000
Sand Creek Lateral	0	15,000	90,000
Section 36 Balance	0	79,000	190,000
Burial Trenches	0	107,000	0
Total Volume	1,494,400	1,418,820	1,914,000

Total Landfill Volume = 1,456,220 CY

* HH volumes do not include PT, potential UXO or agent volumes; biota volumes do not include PT or HH volumes.
** Area to be determined per dispute resolution agreement
*** Includes 383,000 CY of refuse

Signed this 13th day of June, 1995

Gail Schoettler
Lt. Governor

Lewis D. Walker
Deputy Assistant Secretary of the Army
(Environment, Safety and Occupational Health)

William P. Yellowtail
Regional Administrator, Region VIII
United States Environmental Protection Agency

Ralph O. Morgenweck
Regional Director
United States Fish and Wildlife Service

Larry Smith
Vice President
Shell Oil Company

ON-POST OPERABLE UNIT DETAILED ANALYSIS OF ALTERNATIVES
DISPUTE RESOLUTION AGREEMENT
October 11, 1995

Consistent with the dispute resolution process under the Federal Facility Agreement (FFA), the Organizations and the State hereby agree that the following listed disputes raised by the U.S. Environmental Protection Agency, the State of Colorado, the U.S. Fish and Wildlife Service and Shell Oil Company have been resolved either as a result of the execution of the Agreement for a Conceptual Remedy for the Cleanup of the Rocky Mountain Arsenal dated June 13, 1995, ("Agreement") or as described in this dispute resolution agreement.

The U.S. Army, Shell Oil Company, the State of Colorado, the U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service (the Parties) agree to the conceptual remedy, believe it to be protective of human health and the environment, and believe it to be representative of the best balance of competing considerations among the remedial alternatives considered.

The Parties understand that the conceptual remedy must be put back into the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedy selection process. The Parties agree that the conceptual remedy will be incorporated into the Detailed Analysis of Alternatives (DAA), will be presented as the preferred alternative in the DAA and will be placed in the Proposed Plan.

EPA Dispute 1 - Cost Estimating Uncertainties

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The last paragraph on page 29 of Volume I, DAA Executive Summary, will be removed and replaced with language stating that estimates for all alternatives in the DAA are within the range of +50% to -30%. References to uncertainty factor percentages in Volume III, pages 20-20 and 20-21, will be deleted. The last paragraph on page 20-21 and the 1st and 2nd paragraphs on page 20-22 will be deleted.

EPA Dispute 2 - Omission of PCB Remediation

RESOLUTION: This dispute issue is resolved pursuant to the incorporation in the DAA of the following: The DAA will fully address any Army or Shell PCB contamination that is not specifically addressed in the PCB IRA by defining methodology of identification, inventory and treatment or disposal of PCB-contaminated equipment, spills, structures and foundations prior to completion of remedial action. Any PCB IRA remediation not completed before the ROD will be addressed in the ROD. The DAA will include TSCA requirements as ARARs for remediation of any PCB contamination. Specific text, that the parties have agreed upon,

Pursuant to Paragraph 27 of the Agreement, the following language is set forth in this Dispute Resolution Agreement:

"1. The parties acknowledge the U.S. Fish & Wildlife Service's expertise and principal role in assessments of the scope of residual contaminant impacts on fish and wildlife and in forwarding appropriate response recommendations. The parties acknowledge EPA's expertise and principal role in the CERCLA risk assessment process and remedy selection.

2. The parties agree that the disputes noted above which refer to this language are resolved by agreement to the following items, as described above:

REGARDING REMEDY SELECTION:

3. The Proposed Plan will reflect a preferred remedy consistent with the following.

4. "The On-post ROD will select a remedy to adequately break exposure pathways to surficial soils and aquatic resources. The remedy will include options of soil tilling, soil removal, soil covering, lake sediment dredging, and other appropriate techniques to reduce the concentrations of contaminants that the biota are exposed to. Site-specific engineering and/or biological considerations will be used to define which option is implemented.

5. The On-post ROD will specify a process to determine the <u>locations</u> where the remedy will be applied. That process will consist of the following components:

a. A FFA Subcommittee of technical experts from the Parties (such as ecotoxicologists, biologists, and range/reclamation specialists) will focus on the plans for and conduct of both the USFWS biomonitoring programs and the SFS/risk assessment process. The Subcommittee will provide interpretation of results and recommendations to the parties' decision-makers.

b. The ongoing USFWS biomonitoring programs and the SFS/risk assessment process will be used to delineate areas of surficial soil and aquatic contamination to be remediated.

i) Phase I and the potential Phase II of the Supplemental Field Study (SFS) will be used to refine the general areas of surficial soil contamination concern called the "area of dispute." The field BioMagnification Factors will be used to quantify ecological risks in the area of dispute, identify risk-based soil concentrations considered safe for biota, and thus refine the area of concern.

ii) Pursuant to the FFA process, USFWS will conduct detailed site-specific studies of contaminant effects and exposure (tissue levels and Army-provided abiotic sampling) on sentinel or indicator species of biota (including the six key species identified in the IEA/RC). These studies will address both the aquatic resources and at least the surficial soil area of dispute. These site-specific studies will be used in refining contamination impact areas in need of further remediation.

iii) Results from both the SFS/risk-assessment-process and the site-specific studies will be considered in risk management decisions which may further refine the areas of surficial soil and aquatic contamination to be remediated.

c. The Subcommittee will analyze site-specific resource values, levels of contamination impact on biota, long-term/short-term impacts and benefits to biota, and/or engineering considerations to identify the most appropriate of the selected remedial options to implement, and to evaluate the potential for site-specific exclusions from the remediation. The Subcommittee will make recommendations to the Parties' decision-makers.

6. The ROD language on schedules will be consistent with the concepts below regarding implementation of the remediation.
7. The ROD will define a sufficient funding level to fully support the identified remediation projects and residual area contamination assessments, including full analytical support.

REGARDING REMEDY IMPLEMENTATION:

8. The On-Post ROD will specify that the remedy implementation will:

a. be staged, to allow habitat recovery;

b. be performed FIRST on locations selected through a balance of factors such as:

i) the parties agree an area has an impact on fish or wildlife;

ii) the effort will not be negated by recontamination from other remediation activities; and

iii) the existing fish and wildlife resource value;

c. include revegetation, of a type specified by USFWS; if initial revegetation is not successful, make appropriate adjustments then again revegetate; and

d. provide that the locations and timing of remediation are to be determined with consideration of and coordination with USFWS Refuge management plans and activities."

Signed this 16th day of October, 1995

Charles T. Scharmann
U.S. Army

Laura Williams
U.S. EPA

William Adcock
Shell Oil

Ronel Finley
USF&WS

for Barbara Nalvern
Jeff Edson
State of Colorado

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Rocky Mountain Arsenal National Wildlife Refuge
Building 111
Commerce City, Colorado 80022-1748
Telephone (303) 289-0232
Fax (303) 289-0579

IN REPLY REFER TO:

January 13, 1998

MEMORANDUM

To: Lorri Harper
Environmental Engineer

From: Mark Sattelberg
Biological Advisory Subcommittee Chairperson

Subject: Remediation of lake sediments

This is in response to your request that the Biological Advisory Subcommittee (BAS) make recommendations to the design team concerning the remediation of lake sediments due to biota concerns. The Service had Colorado State University (CSU) study the effects of contaminants on aquatic species (fish species in particular) over the last few years. CSU's study concluded that there are no adverse effects, due to contamination, to the aquatic species that they studied in any of the Rocky Mountain Arsenal's lakes. The BAS has decided that no remediation of lake sediments, other than the previously planned removal of human health criteria-based sediments, is needed at this time. This decision includes all sediments, including the Priority 1 sediments in Lake Ladora. There will be continued biomonitoring of the lakes as proposed in the Biomonitoring Plan.

There is, however, concern amoung the BAS that the "aquatic to terrestrial" pathway (emerging insects eaten by birds and fish eating birds) has not been analyzed fully. The BAS is planning on working towards this matter later using refined risk assessments. The BAS needs to know if additional remediation of sediments needs to be incorporated into remedial designs now or can it be added at a later date. If it needs to be incorporated now, what is the "drop dead" date that the decision has to be made. The BAS may need to change the priorities of the issues we have been working on so that the aquatic to terrestrial pathway can be scrutinized thoroughly. Secondly, if the BAS decides after the "drop dead"date that additional sediments need to be excavated due to biota concerns, how would the delayed decision effect the cost of remediation of sediments (e.g., remobilization, etc.).

If you have any questions, please contact me at 5232 ext.123

Biological Advisory Subcommittee Meeting Minutes

April 8, 1998

Attendees: Mark Sattelberg, Fred Applehans, Doug Reagan, Gerry Henningsen, Karen Prochnow (pm), Mark Kadnuck, Ira Star, Carl Mackey, Michael Macrander, Laura DiNorcia, and Cindy Fornstrom (am)

General: Mark announced that his office will be moving the week of April 20, he therefore will not have a desk, phone, or computer that week.

Previous Minutes: Mark asked if there were any more changes to the March BAS Meeting Minutes. Dates of the second day of meeting and the day of the next BAS meeting were changed. It was decided that all correspondence going out to all BAS members should be in both WordPerfect and MS Word. Mark said that he would resend the March minutes out.

IEA/RC Review: Fred reported that Steve had pulled out the assumption used in the Aquatic portion of the IEA/RC. After looking at them, Fred felt that the risk numbers would not change much. He emphasized that EPA would be doing a risk assessment after current remedial action is complete, and if risk remained, that additional remediation may have to take place. It was agreed that revising the IEA/RC would take longer than the design team proposed. It was brought up that a lot was going to happen to the lakes in the next 5 to 7 years and to revise the risk assessment at this point would be like "hitting a moving target". Everyone agreed that the terrestrial risk assessment is pretty solid, but the aquatic risk assessment has quite a bit of uncertainty. The state expressed a fear that if risk to aquatic related biota remains after the current remedial action, that the responsible parties would not be willing to spend additional money to remobilize contractors. Other parties stated that the ROD would not let that occur without the BAS's concurrence. Shell representatives and Army representatives stated that their parties are willing to take that risk. Everyone agreed that we don't know what the effect the current remedy will have on the current excessive risk. The BAS decided to place a statement in the minutes stating their position, and that the risk managers need to make a decision on that basis.

Statement of Position: The BAS has been working on the question of whether additional lake sediment should be remediated when the human health exceedance sediments are removed. At this time, the BAS has no basis to change the recommended remedy. It is assumed that the RVO will proceed with the excavation of soils (in ditches leading to the lake and in vicinity of the lakes) and sediments in the lake that exceed Human Health criteria as well as soils that exceed biota criteria in the ditches leading to the lake and in the vicinity of the lakes. Once that lakes have equilibrated, monitoring of the lakes will determine if there is continued exposure to COCs due to pathways established in the IEA/RC. If there is unacceptable risk shown during and/or after the monitoring, the BAS may recommend that further remedial action needs to take place for the protection of biota. The BAS cannot, at this time, give a criteria for cleanup objectives or goals, but an alternative for the risk managers to consider is to go ahead and remove additional sediments. Removal of additional sediment during human health sediment remediation

could provide cost minimization by decreasing the possibility that additional sediments would need to be removed if biomonitoring shows that there is unacceptable exposure of biota to contaminants.

It was decided that the Residual Risk Subcommittee should take on the role of looking at the assumptions used, the receptors, as well as other information that needs to be updated in the IEA/RC. Fred said that he would add the aquatic information into Gerry's strawman.

Colorado State University Aquatic Data: Mark reported that he was still working on getting onto the environmental database to pull the CSU data off. There were ~600 samples submitted. It was decided that even though we would not be addressing the IEA/RC now, the data would be important to distribute. Mark will continue to try to get the data.

Residual Risk Subcommittee strawman: No one had submitted written comments to Gerry, so we went over some of the general comments. Assessment end points need to be spelled out. More focus is needed. LOAEL as preferred endpoint, but use range of LOAEL to NOAEL. It was decided to use language from the ROD when discussing constituents of concern, in particular dioxin/furans. There is a need to add management goals section, from the FWS plans. Any more comments are due before the May meeting. The residual risk subcommittee will meet May 5, 1998 at 9 am in the ARF Assembly Room to go over comments. Fred will add work on the aquatic risk, and Doug will work on an overall outline.

GIS/Database Update: Bonnie had to cut back workload due to medical conditions (twins), so her work was passed on to Josh. He has been able to complete the 100 ft. concentration maps. Laura passed out a status of the Biota Database that Debbie is working on. She asked that everyone review it and add any additional data that should be incorporated into it as well. Submit any additions to Laura by the May meeting.

Sample Update: Mark reported that the owl livers and carp eggs had been split and the congener potion had been sent to MRI. Mark will be calling MRI for preliminary data before the May meeting. Mark had a brief history of the Kestrel eggs, but it was decided that a comprehensive history of the eggs is needed, including any correspondence concerning egg volumes, and audit results and responses. Mark will work on this for the May meeting. Mark will also get estimated weights for the remaining eggs.

Michigan State University/Woodward-Clyde Contract: Laura reported that WCC is waiting to hear from MSU on what they cannot live with in the contract. She also reported that they are working on a letter of intent to award the contract so the students and QAPP started. She also reported that John may be doing a study for the State of Michigan, which may postpone or negate our project with him.

Chlorine Plant: Since Carl had passed out the sheet of information during the last meeting, Laura said that she would answer questions. There were no questions.

MATC document: A new version was handed out. However, Ian was trying to contact Elliot for

further information and it was requested that the document reference Dick and John's documents as internal peer review. One final revision will be out by the May meeting.

Egg Acceptance/Rejection Document: A new version was handed out. Please review and submit comments ASAP. A revised document will be handed out at the May meeting.

Decision Document: The eggs collected in 1998 will utilize the original decision document; using H4IIe analysis first, then Congener analysis.

Sampling and Analysis Plan: Fred stated that after everything that has happened within the last year, that we should look at the SAP to see if we need to start "anew" for the '98 samples. The old SAP is fine for the owl livers and carp eggs. Everyone needs to review the SAP for the May meeting.

ELISA test kits: Mark reported that he contacted the company that produced the test kits. They no longer produce the Cyclodiene kits, unless you order 600. They do produce a Chlordane and a Toxaphene kit, both which will detect the 'drins. It was then discussed that the fisherman's parking lot was a Priority 1 site, not a remediation site, and therefore, additional samples were not necessarily needed. BAS then decided that the trees could be saved. The use of ELISA kits was put on hold until the time that they are needed.

Priority 1 Soil Boundary Subcommittee: Carl presented the results of the P1 Subcommittee. Only a few boundaries changed, and language equivalent to "Thou shalt not cut trees" will be added into the design packages. A summary of the changes are as follows.

1. Borrow area #8 should be avoided entirely. As a replacement, it is recommended that the eastern portion of the north plants area be used as replacement. This area is bounded by the eastern fence line and the interior perimeter road.

2. The eastern boundary of borrow site 9B should be slightly adjusted to retain existing habitat and trees.

3. The southern boundary of borrow site #11B should be adjusted to protect existing trees and wetland site.

4. In addition, the central portion of borrow area 3 has an intersect with the water treatment facility in Section 35. It is assumed that the borrow area will follow the fence line and terminate at the access road on the eastern edge of the facility.

5. Also, it is recommended that language be incorporated into specific borrow area operation documents that instructs contractors to protect trees by maintaining a protected area of a minimum of 25 feet or outside the drip line around individual or groves of trees as occur in borrow area #3 south, #4 and #9A for example. There are trees that FWS may want to remove as part of borrow area operations, but these will be identified by the Service.

These recommended changes in borrow area configuration were agreed to by BAS members with the understanding that the potential reduction in risk to biota achieved by the previous alignment will not be substantially altered. Biomonitoring will continue to be utilized as one of the methods to assess residual risk to biota in areas adjacent to the central remediation area, but not included in the borrow or remediation activity.

In addition to the borrow source sites, the BAS concurred on the realignment of the boundaries at the fisherman's parking lot. The realignment will bring the boundary inside of the tree line on the east side and around the existing trees in the center of the site.

ACTION ITEMS:

ALL:	Review and comment on Minutes, Biota Database sheet, MATC document, Egg Acceptance/Rejection document, Residual Risk Strawman, and SAP
SHELL:	None
ARMY:	Work on contracting mechanism for working with John's Lab
	Add Aquatic portion to Residual Risk Strawman
FWS:	Get est. weights of remaining eggs
	Put together and copy CSU database.
	Find out preliminary results of QA/QC eggs
	Look into spiking additional quail eggs.
	Put together a comprehensive history of the kestrel egg samples.
USEPA:	Revise decision documents

May Extended BAS Meeting:
We will meet in the ARF Assembly Room from 11:00 am to 4:00 pm on May 5, 1998, and 8:30 am to 4:00 pm on May 6, 1998 (Assembly room is large room on right side of hall from Board Room).

Residual Risk Subcommittee will meet from 9 am to 11 am in the ARF Assembly Room on May 5, 1998.

Agenda Items (in no particular order)

CSU data
Residual Risk Strawman
GIS update
Sample update
Sample history
MSU/WCC contract
MATC document
Egg acceptance/rejection document
Decision document