Draft

Green Paper
Ravenna Army Ammunition Plant (RVAAP)
Facility-Wide Risk-Based Ecological Cleanup Goal Development

Ravenna Army Ammunition Plant
Ravenna, Ohio

March 2008

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SAIC®
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Science Applications International Corporation
151 Lafayette Drive
Oak Ridge, Tennessee 37831

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U.S. Army Corps of Engineers, Louisville District
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The draft concept paper (aka "green" paper) describes the planned technical approach for developing facility-wide, risk-based cleanup goals for environmental media and ecological receptors at the Ravenna Army Ammunition Plant.

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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Science Applications International Corporation (SAIC) has completed the Preliminary Draft Green Paper for Facility-Wide Risk Based Ecological Cleanup Goal Development at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures, and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy.

Barney W. Cornaby — February 14, 2008

Barney Cornaby
Study/Design Team Leader

Date

Angela Johnson — February 14, 2008

Angela Johnson
Independent Technical Review Team Leader

Date

Significant concerns and the explanation of the resolution are as follows:

Internal SAIC Independent Technical Review comments are recorded on a Document Review Record per SAIC quality assurance procedure QAAP 3.1. This Document Review Record is maintained in the project file. Changes to the report addressing the comments have been verified by the Study/Design Team Leader. As noted above, all concerns resulting from independent technical review of the project have been considered.

W. Kevin Jago — 2-14-08

Principal w/ A-E firm

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DOCUMENT DISTRIBUTION

Name/Organization	Number of Printed Copies	Number of Electronic Copies
Mark Krivansky, USAEC	0	1
Katie Elgin, RTLS-ENV	1	1
Mark Patterson, RVAAP Facility Manager	2	2
Cindy Ries, USACE	2	1
Eileen Mohr, Ohio EPA-NEDO	1	1
Todd Fisher, Ohio EPA-NEDO	1	1
Bonnie Buthker, Ohio EPA-OFFO	1	1
Kevin Jago, SAIC Project Manager	3	2

RTLS-ENV = Ravenna Training and Logistics Site Environmental Specialists.
RVAAP = Ravenna Army Ammunition Plant.
SAIC = Science Applications International Corporation.
USACE = U. S. Army Corps of Engineers.
USAEC = U. S. Army Environmental Center.
Ohio EPA-NEDO = Ohio Environmental Protection Agency – Northeast District Office.
Ohio EPA-OFFO = Ohio Environmental Protection Agency – Office of Federal Facilities Oversight.

DISCLAIMER STATEMENT

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

ACRONYMS

AOC	area of concern
AUF	area use factor
AWQC	ambient water quality criteria
BAF	bioaccumulation factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPEC	contaminant of potential ecological concern
EPA	U. S. Environmental Protection Agency
ERA	ecological risk assessment
ESV	ecological screening value
HQ	hazard quotient
INRMP	Integrated Natural Resource Management Plan
LD_{50}	lethal dose fifty
LOAEL	lowest observed adverse effect level
MKM	MKM Engineers, Inc.
NACA	National Advisory Committee for Aeronautics
NOAEL	no observed adverse effect level
ODA	Open Demolition Area
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
RFWERWP	Ravenna Facility-Wide Ecological Risk Work Plan
RI	remedial investigation
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
TRV	toxicity reference value
UDD	unit daily dose
USACE	U. S. Army Corps of Engineers
WBG	Winklepeck Burning Grounds

GREEN PAPER
RAVENNA ARMY AMMUNITION PLANT (RVAPP)
FACILITY-WIDE RISK-BASED ECOLOGICAL CLEANUP GOAL DEVELOPMENT

FORWARD

The Ravenna Army Ammunition Plant (RVAAP) Facility-Wide Ecological Risk Work Plan (RFWERWP; USACE 2005) requires that, prior to commencing any risk assessment activities at RVAAP, a paper (hereafter called a Green Paper) be developed to ensure stakeholders understand and agree with the proposed process. This Green Paper has been developed to comply with this requirement as the U. S. Army Corps of Engineers (USACE), Louisville District prepares to develop facility-wide risk-based cleanup goals for ecological resources at RVAAP. A concurrent effort covers the development of human health cleanup goals. The goals would be applied to areas of concern (AOCs) during the Remedial Investigation (RI)/Feasibility Study process and where ecological significance deems such application appropriate.

Following RVAAP stakeholder input, this Green Paper will be incorporated into a subsequent report that presents the final assumptions, methods, and calculated facility-wide cleanup goals.

INTRODUCTION

The U.S. Army is conducting cleanup at a number of AOCs at RVAAP under the Installation Restoration Program. To support programmatic decision-making efforts, consistent, quantitative ecological cleanup goals are needed. This Green Paper outlines the proposed assumptions, rationales, and calculation methods used to develop ecological cleanup goals.

The cleanup goals will be based on a different set of assumptions than if an ecological risk assessment (ERA) was being performed. ERA is typically done at the RI stage and includes conservative assumptions in the estimation of quantitative risk. The present work – development of ecological cleanup goals – accommodates a more realistic approach based on characteristics of habitats and ecosystems at RVAAP.

The focus of this Green Paper is the development of facility-wide goals. The application of these facility-wide goals to specific AOCs constitutes a separate activity. When the application process is completed, it is envisioned that modifying factors will be determined on an AOC-by-AOC basis. For example, background concentrations may be considered during application to AOCs. An area use factor (AUF) regarding the area of the AOC relative to the area of the home range of an ecological receptor and a time use factor may be applied. Furthermore, ecological significance and importance of the AOC and other AOC-specific characteristics will be considered and will influence the application of the facility-wide cleanup goals. The development of ecological cleanup goals at RVAAP is being modeled after similar work at other Department of Defense installations. For example, the U.S. Army has conducted similar work at Joliet Army Ammunition Plant and Savannah Army Depot Activity, as discussed in the *Plant Area (Sites 16, 36, 47, and 84) Baseline Ecological Risk Assessment*, *Savanna Army Depot Activity* (USACE 2008).

OBJECTIVES

The first objective of this work is to provide a rational procedure to develop facility-wide ecological cleanup goals. The second objective is to compute the cleanup goals for various exposure media and ecological receptors. Selection of media, ecological receptors, and data will be compatible with media, receptors, and guidance issued by the Ohio Environmental Protection Agency (Ohio EPA) (Ohio EPA 2003) and the RFWERWP (USACE 2005).

PRIORITIES FOR REALISTIC ASSUMPTIONS

The development of the ecological cleanup goals includes consensus building through discussions with RVAAP stakeholders and development of this Green Paper. A key part of this consensus uses data and assumptions considered realistic as opposed to conservative. For example, the observations and information gathered during the Winklepeck Burning Grounds (WBG) Biological Field Truthing Study (USACE 2006) can be utilized to highlight the weaknesses inherent to the conservative data and assumptions in a mathematical risk assessment.

The strengths of the realistic approach are cleanup goals associated with actual risk based on measurable, albeit small, biological effects. This approach avoids expensive remediation that does not offer any reduction of actual risk. Because cleanup goals will be based on realistic assumptions, it is unlikely that the Ohio Army National Guard (OHARNG) training regimen will be affected or limited. In addition, the cleanup goals will compliment and incorporate management goals from the Integrated Natural Resource Management Plan (INRMP) and established land quality evaluation. Because valuable site-specific ecological information was obtained during the WBG Biological Field Truthing Study and numerous historical Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigations, it is possible to develop ecological cleanup goals that are based on realistic data and assumptions rather than the conservative data and assumptions typically adopted during early phases of the CERCLA remedial action process. Thus, the intent is that USACE, Ohio EPA, and OHARNG have cleanup goals based on realistic assumptions and data.

IDENTIFICATION OF MEDIA

There are five potential exposure media at the facility: air, soil, surface water, wet sediment, and groundwater. The air medium for ecological receptors has not been investigated as an ecological exposure pathway at RVAAP; the majority of site-related chemicals have low volatility, especially after being in place for decades, and inhaling contaminants has not been a viable exposure route. Likewise, the groundwater pathway has not been an ecological exposure medium. Groundwater typically discharges to surface water where the ecological receptors would be exposed so it is adequately evaluated through surface water exposure. Thus, the remaining media are soil, surface water, and wet sediment.

Soil consists of porous media of varying depths and is the dominant exposure medium for consideration at RVAAP. Usual depths for ecological resource purposes are 0 to 1 ft (surface) and 1 + ft (subsurface). Soil includes dry sediment within ponds, intermittent streams, and storm water ditches that have water on their surface less than 50% of the time. Surface water includes water in ponds and permanently flowing streams and ditches. Wet sediment is defined as porous media with saturated pore water and is under water in such locations as ponds and flowing streams.

IDENTIFICATION OF CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN

Previously completed RIs at RVAAP will be systematically searched for previously identified chemicals of potential ecological concern (COPECs). Re-screening of raw analytical data against the latest ecological screening values (ESVs) will not be performed. Previously completed RIs have been approved and are in the public domain. Data were screened and COPECs were identified based on the methods and ESVs that were available and acceptable at the time of approval. Rather than attempt to re-create data screening processes (performed by multiple contractors over time), the most straight-forward approach is to accept the historical work and to extract all the lists of COPECs from these RIs. The COPECs will be evaluated using criteria described in the latter part of this section. The RIs addressed 30 AOCs. A listing of historical RIs, cited by contractor and AOC, is provided below:

- Winklepeck Burning Grounds (WBG) by Science Applications International Corporation (SAIC) – one RI;
- Load Line 1 through Load Line 4 by SAIC – four RIs;
- Central Burning Pit, Erie Burning Grounds, Fuze and Booster Quarry, Load Line 12, Open Demolition Area (ODA) 2, and Ramsdell Quarry Landfill by SAIC – six RIs;
- National Advisory Committee for Aeronautics (NACA) Test Area and ODA 1 by SAIC – two RIs;
- 14 AOCs by MKM Engineers, Inc. (MKM) – one large RI; and
- Load Line 6, Load Line 9, and Load Line 11 by MKM – three RIs.

Source documents are provided in Table 1.

Table 1. Source Documents for COPECs

AOC	Title	Date Issued	Author
RVAAP-49 Central Burn Pits	Final RI Report for RVAAP-49 Central Burn Pits	09/01/05	SAIC
RVAAP-02 Erie Burning Grounds	Final Phase II RI Report for RVAAP-02 Erie Burning Grounds	09/26/05	SAIC
RVAAP-02 Erie Burning Grounds	Final Addendum to the Phase II RI Report for RVAAP-02 Erie Burning Grounds	09/25/06	SAIC
RVAAP-16 Fuze and Booster Quarry Landfill/Pond	Final Report Phase I/II RI of RVAAP-16 Fuze and Booster Quarry Landfill/Ponds	11/18/05	SAIC
RVAAP-08 Load Line 1	Final Phase II RI Report for RVAAP-08 Load Line 1	06/06/03	SAIC
RVAAP-09 Load Line 2	Final Phase II RI Report for RVAAP-09 Load Line 2	07/01/04	SAIC
RVAAP-10 Load Line 3	Final Phase II RI Report for RVAAP-10 Load Line 3	07/23/04	SAIC
RVAAP-11 Load Line 4	Final Phase II RI Report for RVAAP-11 Load Line 4	09/03/04	SAIC
RVAAP-33 Load Line 6	Final Report for the Phase I RI of RVAAP-33 Load Line 6	08/21/07	MKM
RVAAP-42 Load Line 9	Final Report for the Phase I RI at RVAAP-42 Load Line 9	10/17/07	MKM
RVAAP-44 Load Line 11	Final Report for the RI at Load Line 11	09/09/05	MKM
RVAAP-12 Load Line 12	Final Phase II RI Report for RVAAP-12 Load Line 12	03/02/04	SAIC
RVAAP-12 Load Line 12	Final Phase II RI Supplemental Report for RVAAP-12 Load Line 12	11/02/05	SAIC
RVAAP-38 NACA Test Area	Final Phase I RI Report for RVAAP-38 NACA Test Area	12/01/01	SAIC
RVAAP-03 Open Demolition Area #1	Final Phase I RI Report for RVAAP-03 Demolition Area 1	12/10/01	SAIC

Table 1. Source Documents for COPECs (continued)

AOC	Title	Date Issued	Author
RVAAP-04 Open Demolition Area #2	Final Phase II RI Report for RVAAP-04 Open Demolition Area #2	09/29/05	SAIC
RVAAP-04 Open Demolition Area #2	Final Addendum to the Phase II RI Report for RVAAP-04 Open Demolition Area #2	09/12/06	SAIC
RVAAP-01 Ramsdell Quarry Landfill	Final Phase I RI Report for RVAAP-01 Ramsdell Quarry Landfill	09/16/05	SpecPro, Inc.
RVAAP-05 Winklepeck Burning Grounds	Final Phase II RI Report for RVAAP-05 Winklepeck Burning Grounds, Volumes 1 through 3	04/04/01	SAIC
RVAAP-05 Winklepeck Burning Grounds	Final Phase III RI Report for RVAAP-05 Winklepeck Burning Grounds	03/01/05	SAIC
RVAAP-06 C Block Quarry RVAAP-12 Load Line 12 RVAAP-13 Building 1200 RVAAP-19 Landfill North of Winklepeck Burning Grounds RVAAP-36 Pistol Range RVAAP-38 NACA Test Area RVAAP-39 Load Line 5 RVAAP-40 Load Line 7 RVAAP-41 Load Line 8 RVAAP-43 Load Line 10 RVAAP-45 Wet Storage Area RVAAP-46 Building F-15 and F-16 RVAAP-48 Anchor Test Area RVAAP-50 Atlas Scrap Yard	Final Report of the Characterization of 14 AOCs, Volume 1	03/29/07	MKM

AOC = Area of concern.
COPEC = Contaminant of potential ecological concern.
MKM = MKM Engineers, Inc.
NACA = National Advisory Committee for Aeronautics.
RI = Remedial Investigation.
RVAAP = Ravenna Army Ammunition Plant.
SAIC = Science Applications International Corporation.

Each RI or database for the RI compared the concentrations of chemicals in the three media (and often soil depths at 0 to 1 and 1 + ft) to an ESV. The chemicals that exceeded an ESV were listed as COPECs. These chemicals will be compiled to show the complete COPEC list. Note that the same chemical names and concentrations used for the human health cleanup goal development will be used for the ecological cleanup goal development.

The analytes for each AOC are extensive and usually include inorganics and organics, including metals, volatile organic compounds, semivolatile organic compounds, pesticides, and explosives. The lists of COPECs are expected to be extensive, too. Following compilation of COPECs, four evaluation steps will be applied:

1. **Background evaluation:** COPECs detected at concentrations less than the available RVAAP background values for respective surface and subsurface soil horizons will be eliminated from the facility-wide COPEC list.

2. **Frequency of COPEC occurrence evaluation:** COPECs having been identified only once across all 30 data sets from the 30 AOCs may be eliminated from the facility-wide COPEC list following evaluation.

3. **Major geochemical elements and nutrients evaluation:** widely distributed major geochemical elements and nutrients (calcium, iron, magnesium, manganese, nitrogen, phosphorus, potassium, sodium, and zinc) will be eliminated from the facility-wide COPEC list. These elements will be eliminated from soil and wet sediment, but not in surface water.

4. **Weight-of evidence evaluation:** selected COPECs may be candidates for elimination based on scientific weight-of-evidence and RVAAP team consensus [aluminum, for example, is often removed in this way because of the high pH in RVAAP soil relative to the U. S. Environmental Protection Agency (EPA) threshold of a soil pH of 5 (EPA 2000)].

The evaluation steps are meant to identify those chemicals that are site-related and have the potential to harm ecological receptors. Evaluation step 1 will be the same as for human health cleanup goal development because the same data will be assembled for human health purposes as for ecological resource purposes. Evaluation step 3 is similar to the human health essential nutrient screen. Evaluation steps 2 and 4 are unique to ecological purposes.

IDENTIFICATION OF ECOLOGICAL RECEPTORS

Numerous ecological receptors have been documented by a number of natural resource studies (e.g., INRMP) lead by OHARNG. Each selected receptor is representative because they occur at RVAAP and occupy a trophic position in a typical food web. In addition, considerable data are available about their life history and toxicological responses to COPECs and this will allow more robust calculation of representative ecological cleanup goals. For example, in soil/dry sediment, shrews and voles have different food preferences. Shrews primarily eat animals and voles primarily eat plants. Thus, two different food pathways would be represented. The candidate receptors for cleanup goals are:

- Soil/dry sediment – plants, soil invertebrates, vole*, shrew*, robin*, hawk*, owl*, and fox*;
- Wet sediment – benthic invertebrates, mallard duck, wood duck, and raccoon; and
- Surface water – fish, heron*, kingfisher*, and mink*.

where * = receptor profile present in RFWERWP (USACE 2005).

Each of the 16 candidate receptors has been compared to four evaluation points developed by the RVAAP team. These evaluation points are:

A. Feeding guilds with the highest score for good representatives of a particular trophic level:

   1. Back-up choice to a good representative.
   2. Representativeness is not apparent.
   3. Good representative of any guild.

B. Directness of connection to exposure medium with the highest score for living directly in the medium:

   1. Low contact with the exposure medium.
   2. Some contact with the exposure medium.
   3. Lives in the medium so exposure is maximal.

C. Food chain multiplier, indicative of trophic level with the highest score for top carnivores:

   1. Biomagnification is not likely; trophic role at the start of the food chain.
   2. Biomagnification could/could not occur.
   3. Biomagnification is likely; trophic role at the end of the food chain.

D. Home range exposure with the highest scores for small home ranges relative to likely sizes of the AOCs:

   1. Home range size is likely large compared to the AOC size (exposure likely low).
   2. Home range size varies and is not clear.
   3. Home range size is likely small compared to the AOC size (exposure likely higher).
   4. Not applicable.

A matrix (Table 2) has been developed that shows each candidate receptor and each evaluation point. Scores in each cell are 3 for a strong (high) relationship between the receptor and evaluation point, 2 for a lesser (medium) relationship, and 1 for a weak (low) relationship. The receptors with the most points became the proposed receptors.

Based on the evaluation, the proposed media/receptor combinations are:

- Soil (surface at 0 to 1 ft) and (subsurface at 1+ ft)/dry sediment – soil invertebrates, voles, and hawks.

- Wet sediment – benthic invertebrates and raccoons.

- Surface water – aquatic life (includes bottom- and water column-dwellers and some birds/mammals) fits the Ambient Water Quality Criteria (AWQC) (US EPA 2006). Thus, the facility-wide cleanup level for fish and fish-eating receptors will be the general receptor of aquatic life related to the AWQC.

In summary, soil has three receptors because it is the dominant or most frequently encountered medium. Wet sediment has two receptors. By contrast, only one receptor – aquatic life – will be used for surface water because of the low amount of standing and running water systems in the AOCs at RVAAP (e.g., Cobbs Pond, a small pond at Load Line 6, and Sand Creek or related creeks near some of the AOCs).

Table 2. Selection of Ecological Receptors at RVAAP

	Evaluation Points				
Candidates	Feeding Guilds [a]	Media Exposure [b]	Food Chain Multiplier [c]	Home Range Exposure [d]	Total and Highest Score
Soil/Dry Sediment					
Plants	3	3	1	NA	7
Soil Invertebrates	3	3	2	NA	8[e]
Vole	3	2	2	3	10[e]
Shrew	1	1	2	3	7
Robin	1	1	2	3	7
Hawk	3	1	3	1	8[e]
Owl	1	1	3	1	5
Fox	1	1	3	1	5
Wet Sediment					
Benthic Invertebrates	3	3	2	NA	8[e]
Mallard Duck	2	2	1	1	7
Wood Duck	2	2	1	1	5
Raccoon	3	2	2	1	8[e]
Surface Water					
Aquatic Life	3	3	2	NA	9[e]

[a] Representative of a range of feeding guilds (e.g., food chain base and omnivores).
[b] Directness of connection to medium of exposure (i.e., lives in the medium and/or has high exposure to the medium during ingestion).
[c] Food chain multiplier; indicative of trophic level.
[d] Likelihood of exposure based on likely home range size.
[e] Highest scores.
NA = Not applicable.
3 = High relationship to the evaluation point.
2 = Medium relationship to the evaluation point.
1 = Low relationship to the evaluation point.

THE DEVELOPMENT OF CLEANUP GOALS

Exposure Assessment Considerations – Media, Pathways, and Receptor Ingestion Rates

Facility-wide cleanup goals will be developed for soil, surface water, and wet sediment. Each of these media may have layers where chemical concentrations may vary. For example, water near the top of a pond may have concentrations different from water several feet lower and near the wet sediment. Likewise, soil and wet sediment may have different concentrations depending on a given layer. However, only one goal is needed for each medium because the same toxicity information is used regardless of layer and the formula uses a unit daily dose to accommodate any horizontal or vertical location in the facility-wide cleanup goal development.

Exposure assumptions include acceptable bioaccumulation factors (BAFs), ingestion rates of principal media and food, and any AUFs or other factors applied to exposure pathways.

Receptors need to be truly exposed to the media they represent. Each receptor will have a profile of its weight, food ingestion rate, ratio of plant and animal food, medium (e.g., soil) ingestion amount, and water ingestion rate. Such tables are found in the RFWERWP (see asterisked receptors above). In anticipation of the red-tailed hawk being one of the approved ecological receptors, a representative exposure profile is provided (Table 3) from the RFWERWP (USACE 2005). The ecological cleanup goals report will show all the receptor exposure profiles, once the list of receptors has been finalized.

Table 3. Receptor Parameters for the Red-tailed Hawk (USACE 2005)

		Receptor:	**Red-Tailed Hawk** *(Buteo jamaicensis)*
Parameter	**Definition**	**Value**	**Reference/Notes**
BW	Body weight (kg)	1.13	Arithmetic mean, female and male, Michigan (EPA 1993b)
HR	Home range (ha)	697	Mean, adults, both sexes, winter, Michigan (EPA 1993b)
TUF	Temporal use factor	1	Will be 1 unless a specific value exists for a receptor
IR_F	Food ingestion rate (g/g-d = kg/kgBW/d)	0.11	Adult female, winter, Michigan, captive outdoors (EPA 1993b)
PF	Plant fraction of diet	0	Not stated in EPA (1993b); assumed to be negligible
AF	Animal fraction of diet	1	Prey brought to nests (EPA 1993b)
SF	Soil fraction of diet	0	Not stated in EPA (1993b) and Beyer, Conner, and Gerould (1994); assumed to be negligible
IR_w	Water ingestion rate (g/g-d = L/kgBW/d)	0.057	Arithmetic mean, both sexes, estimated (EPA 1993b)

Acceptable BAFs, ingestion rates, and other information that are published in the receptor profiles of the RFWERWP and various documents associated with RVAAP CERCLA work will be defined and applied. The sources of the bioaccumulation data are previously completed and approved RIs at RVAAP. The types of bioaccumulation found in the formulae (e.g., SPv and BSAF) and the data for many COPECs are found in the appendices to the RIs. These values have received the endorsement of Ohio EPA in the past and are, therefore, acceptable values. Adjustment for AUFs is an AOC-specific activity, and, thus, would be made during the application of the facility-wide cleanup goals. In preparation for this and other modifying considerations, realistic exposure assumptions will be developed and lowest observed adverse effect level (LOAEL) toxicity reference values (TRVs) will be used for the development of the facility-wide cleanup goals.

Ecological Effects Considerations – Field Studies and Laboratory-Based Metrics

For soil, the standard types of biological effects data are laboratory-based tests with a variety of endpoints (EPA 2005a and 2005b). For wet sediment, field studies are often used (MacDonald et al, 2000). Whenever field studies are readily available, they will be used to provide the ecological effects numbers (e.g., concentration in soil or other media that is associated with no to very low ecological effects). For example, the WBG Biological Field Truthing Study (USACE 2006) was completed on plants and small mammals. Most of the plant metrics had no differences between the contaminated burn pits and the uncontaminated reference areas. Several plant protection levels were identified. If plants are selected as a receptor for facility-wide ecological cleanup goals, these plant protection levels will be used in this cleanup goal development. If the vole is selected as a receptor, then laboratory-based TRVs will be used and the WBG Biological Field Truthing Study with the reproduction endpoints will be considered.

For laboratory metrics, there are a number of choices, as specified in the Ohio EPA Ecological Risk Assessment Guidance Document (Ohio EPA 2003) and the RFWERWP (USACE 2005). In addition, these toxicological metrics have been used in the development of ERAs in the RIs (see the list in the "Identification of COPECs" section). These laboratory metrics range from general effects with loosely defined endpoints on various life forms (ESVs) to exacting tests on particular mammal and bird species (many types of metrics). For example, a no observed adverse effect level (NOAEL) means “a no observed adverse effect level to a particular test species” and often the dose concentration is considerably lower than a dose concentration associated with an actual measurable biological effect. Thus, use of a NOAEL is too conservative for cleanup goal development because funds for remediation can be spent without any reduction of actual risk. Furthermore, remediation usually does damage to the habitat. The use of a LOAEL means that there is a small measurable effect and; therefore, a small amount of risk may be removed (unless the damage to the habitat outweighs the benefit). By contrast, other metrics [lethal dose 50 (LD_{50})] refer to dose concentrations associated with death. The ESV and NOAEL are often used for risk assessments where higher levels of conservatism are warranted. By contrast, LOAELs represent a level of potential low ecological effect, but not impairment, that better suits the realistic assumptions that the cleanup goals require. The following definitions further explain and document these points.

Ecological Screening Value (ESV) – *most conservative of the various options (NOAEL, LOAEL, and LD_{50}); a typical ESV represents, for a given chemical, a variety of toxicological endpoints from a variety of life forms (e.g., plants, animals, microorganisms) and, therefore, is used in conservative screens to identify chemicals of potential concern. Typically, the ESV is used in the first step of formal ERAs. Conservative assumptions are typically made in the first step of ERA because site-specific ecological observations and information are generally not available.*

Chronic no observed adverse effect level (NOAEL) – *relatively conservative toxicological measurement for a given chemical and specific to a given endpoint and given test organism. The NOAEL is frequently used in the second step of formal ERAs. The NOAEL is not recommended for use in the development of ecological cleanup goals because it is a metric representing no adverse effects and, thus, is too conservative for cleanup goal development.*

Chronic lowest observed adverse effect level (LOAEL) – *also conservative because it is the lowest concentration in a laboratory test setting that is associated with any type of effect, including cellular and organ as opposed to whole organism. The LOAEL is for a given chemical and a given test organism. The LOAEL is often used in ERAs to narrow the list of chemicals to those that truly need further work to document the possible presence of a real risk. The LOAEL is recommended as the best toxicological metric for use in the development of the RVAAP ecological cleanup goals.*

Acute lethal dose-fifty (LD_{50}) – *not a conservative number because it represents the dose that kills 50% of a small test population. The LD_{50} is for a given chemical and given receptor. This and related metrics are not often used in ERA nor in the development of cleanup goals because they are so non-conservative. The LD_{50} is not recommended in the RVAAP work.*

LOAELs are available for various endpoints and the preferred one is reproduction (usual assumption by ecological risk assessors). In cases where a reproduction endpoint is not available, a physiological endpoint, like growth, will be used. LOAELs based on behavior may be used if there are no others available in this hierarchy. The endpoint for each LOAEL chosen will be documented in the report. Furthermore, the preferred exposure is chronic and the preferred route of administration is oral. When the chronic LOAEL is not available, conversions may be made for one test length to another test length (subchronic LOAEL divided by 10 to chronic LOAEL) using US EPA procedures (US EPA 1993a) and Ohio EPA procedures (Ohio EPA 2003, Attachment C). Another possible conversion will be done from one endpoint to another; for example, if a NOAEL is present, but no LOAEL is present, then the NOAEL will be adjusted by multiplying by a factor (e.g., 10) to predict a LOAEL, per EPA and per tri-services procedures (Wentsel et al. 1996). Other conversions will be selected from those published by EPA or the military. No phylogenetic conversions (bird to mammal or mammal to bird) will be made.

For wet sediment macro-invertebrate receptors, other population and community effects metrics (e.g., benthic community indices that fit benthic invertebrate communities) will be used.

AWQCs are protective, readily available, and will be used as cleanup goals when deemed the most applicable water quality standard. However, AWQCs may not necessarily be the most appropriate goal for all surface water at RVAAP and AOC-specific goals may be warranted.

Equations for Development of Cleanup Goals – Quantification

The general equation for computation of an ecological cleanup goal is:

$$\frac{\text{TRV – any adjustments/direct concentration and/or}}{\text{daily dose} \times \text{hazard quotient (HQ)}}$$

For soil and dry sediment, the equation for the cleanup goal or the concentration in soil is:

$$C_{soil} = \text{TRV/unit daily dose (UDD)} \times \text{HQ}$$

(HQ assumed to be the standard of 1 and also 3),

where

C_{soil} is the cleanup goal or concentration in soil for species 1, 2, … n for a COPEC;
1, 2, … n (mg/kg);
HQ = 1 (and other scenarios when applicable, e.g., HQ = 3);
TRV = LOAEL endpoint for chronic reproduction or other (mg/kg/d);
UDD (kg/kg/d) = unit daily dose (dose of various types of food) (($SP_v \times IR_f \times 0.2 \times PF$) + ($BAF \times IR_f \times AF$) + ($IR_f \times SF$)) $\times$ F;

where

Sp_v = BAF for plant food (unitless),
IR_f = food (e.g., plant, animal, or sediment) ingestion rate (kg/kgBW/d),
0.2 = dry to wet weight conversion (plants only),
PF = plant fraction of ingested food (unitless),
BAF = bioaccumulation factor for animal food (unitless),
AF = animal fraction of ingested food (unitless),
SF = soil fraction of ingested food (unitless),
F = any other factor (e.g., AUF or bioavailability factor) applied to all pathways.

For wet sediment, the equation for the cleanup goal or the concentration in wet sediment is:

$$C_{sed} = \text{TRV / UDD} \times \text{HQ}$$

(HQ assumed to be the standard of 1 and also 3),

where

C_{sed} is the cleanup goal or concentration in wet sediment for species 1, 2, … n for a COPEC;
1, 2, … n (mg/kg);
HQ = 1 (and other scenarios when applicable, e.g., HQ = 3);

TRV = LOAEL endpoint for chronic reproduction or other (mg/kg/d);

UDD (kg/kg/d) = unit daily dose (dose of various types of food) $((SP_v \times IR_f \times 0.2 \times PF) + (BASF \times IR_f \times AF) + (IR_f \times SF)) \times F$;

where

Sp_v = BAF for plant food (unitless),
IR_f = food (e.g., plant, animal, or sediment) ingestion rate (kg/kgBW/d),
0.2 = dry to wet weight conversion (plants only),
PF = plant fraction of ingested food (unitless),
BASF = bioaccumulation factor for animal food (unitless),
AF = animal fraction of ingested food (unitless),
SF = sediment fraction of ingested food (unitless),
F = any other factor (e.g., AUF or bioavailability factor) applied to all pathways.

The above equations are based on those found in the RFWERWP and have been modified by SAIC to allow computation backwards once the HQ is set.

Note that for surface water, the equations are already published by EPA as part of the development of the AWQC. No new equations are needed in the RVAAP effort. The AWQC serve as the C_{sw}.

It is likely that some key exposure and toxicity data are not available for some of the COPECs, especially organic chemicals. In this case, no risk-based cleanup goals can be computed.

REPORTING OF ECOLOGICAL CLEANUP GOALS

After the rationale and methods in this Green Paper have reached a consensus, implementation will follow. Lists of ecological cleanup levels for the chosen COPECs will be calculated and published for each medium/receptor combination. This will likely result in a variety of cleanup goals because of the variety of ecological receptors; thus, managers and trustees should have options to select.

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