Targeted Health Assessment for Wastes Contained at the Niagara Falls Storage Site to Guide Planning for Remedial Action Alternatives – 13428

John Busse, Karen Keil, Jane Staten, Neil Miller, and Michelle Barker*;
Margaret MacDonell, John Peterson, Young-Soo Chang, and Lisa Durham**
* U.S. Army Corps of Engineers, Buffalo District, 1776 Niagara Street, Buffalo, NY 14207, fusrap@usace.army.mil;
** Argonne National Laboratory, Environmental Science Division, 9700 S. Cass Ave., Argonne, IL 60439, macdonell@anl.gov

ABSTRACT

The U.S. Army Corps of Engineers (USACE) is evaluating potential remedial alternatives at the 191-acre Niagara Falls Storage Site (NFSS) in Lewiston, New York, under the Formerly Utilized Sites Remedial Action Program (FUSRAP). The Manhattan Engineer District (MED) and Atomic Energy Commission (AEC) brought radioactive wastes to the site during the 1940s and 1950s, and the U.S. Department of Energy (USDOE) consolidated these wastes into a 10-acre interim waste containment structure (IWCS) in the southwest portion of the site during the 1980s. The USACE is evaluating remedial alternatives for radioactive waste contained within the IWCS at the NFSS under the Feasibility Study phase of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. A preliminary evaluation of the IWCS has been conducted to assess potential airborne releases associated with uncovered wastes, particularly during waste excavation, as well as direct exposures to uncovered wastes. Key technical issues for this assessment include: (1) limitations in waste characterization data; (2) representative receptors and exposure routes; (3) estimates of contaminant emissions at an early stage of the evaluation process; (4) consideration of candidate meteorological data and air dispersion modeling approaches; and (5) estimates of health effects from potential exposures to both radionuclides and chemicals that account for recent updates of exposure and toxicity factors. Results of this preliminary health risk assessment indicate if the wastes were uncovered and someone stayed at the IWCS for a number of days to weeks, substantial doses and serious health effects could be incurred. Current controls prevent such exposures, and the controls that would be applied to protect onsite workers during remedial action at the IWCS would also effectively protect the public nearby. This evaluation provides framing context for the upcoming development and detailed evaluation of remedial alternatives for the IWCS.

INTRODUCTION

USACE is evaluating potential remedial alternatives at the 191-acre Niagara Falls Storage Site (NFSS) in Lewiston, New York (Figure 1), under FUSRAP. The MED and AEC brought radioactive wastes to the site during the 1940s and 1950s, and in the 1980s the USDOE consolidated these wastes into the 10-acre IWCS in the southwest portion of the site. Wastes in the IWCS include the K-65 residues, which contain high concentrations of radium-226.

The USACE is evaluating the final disposition of the NFSS under the CERCLA process. The IWCS is the first of three operable units (OUs) being addressed at the NFSS, and the preliminary suite of remedial alternatives being considered for this OU range from no action to excavation of all IWCS contents. To help guide planning for the upcoming development and evaluation of such alternatives, a preliminary assessment of potential health effects was conducted to evaluate both airborne releases associated with waste excavation and direct exposures to uncovered wastes [1].

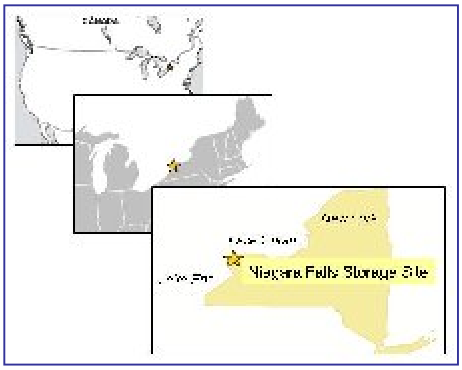

Figure 1. Site Location

ASSESSMENT APPROACH

Standard guidance for assessing health risks at contaminated sites that was established by the U.S. Environmental Protection Agency (EPA) [2] provides the basic framework for the preliminary assessment conducted for the IWCS. Technical issues encountered in developing this assessment are common to many cleanup projects. These issues include: (1) addressing limitations in characterization data; (2) determining representative receptors and exposure routes; (3) developing illustrative estimates of emissions at an early stage of the evaluation process; (4) assessing candidate meteorological data and air dispersion modeling approaches for site-specific application; and (5) evaluating health effects from potential exposures to both radionuclides and chemicals, including incorporating recent updates of exposure and toxicity factors. The approaches applied to address each of these issues in the targeted assessment for the IWCS wastes [1] are highlighted below.

Waste Characterization Data

This preliminary risk assessment reflects information already available for wastes in the IWCS. No new waste characterization activities were conducted for three reasons. First, it was determined that sufficient information already exists from historical records and related technical evaluations to support a decision for the IWCS under the CERCLA process. Second, such sampling could put those workers at risk from unwarranted exposures. Third, such characterization activities could potentially compromise the integrity of the IWCS cover. Thus, historical documentation for the IWCS and NFSS was selected as the information basis for this health risk assessment. Key contaminants of interest for the IWCS include radium-226 and its progeny radon-222 (gas), notably associated with the K-65 residues that were generated by uranium ore processing activities more than 60 years ago. While these residues account for only

1.5% of the total IWCS waste volume, they account for 95% of the total radioactivity in the IWCS.

Representative Receptors

Previous health risk evaluations prepared for the NFSS, including in the 1980s and 1990s, consider a variety of hypothetical future exposures that include an IWCS resident. Thus, it was determined that the current risk assessment would complement rather than duplicate existing analyses. The illustrative receptors evaluated in this targeted assessment include a remedial action worker, maintenance worker, and trespasser onsite. Nearby offsite receptors are represented by an outdoor worker and both an adult and a child resident. The key hypothetical exposures assessed for these six receptors are: (1) inhalation of radon gas and its decay products as well as particulate emissions, including indoor air for the residential exposures; (2) incidental ingestion of surface soil contaminated by deposition of airborne particulates, and inadvertent ingestion of uncovered waste; and (3) external gamma irradiation, from both contaminated surface soil and uncovered waste.

Emissions

Contaminant releases that could result from potentially uncovered wastes were a main focus of this preliminary risk assessment. To support upcoming feasibility study evaluations for the IWCS under the CERCLA process, this assessment considered both hypothetical inadvertent intrusion into the IWCS and intentional excavation alternatives. A number of square area sources were evaluated to accommodate different extents of uncovered waste per various hypothetical breach events, both natural (e.g., burrowing animal for the in-place configuration) and intentional (e.g., for waste excavation). The objective was to provide estimates that can assist in evaluating potential remedial alternatives for the IWCS, including emission controls and worker protection measures.

For the hypothetical inadvertent intrusion evaluations, small source areas were modeled to estimate doses and risks from radon-222 progeny and external gamma irradiation for several breach events of the IWCS. For the excavation case, larger source areas were modeled that reflect preliminary assumptions for excavation zones.

Estimates of radon-222 flux from the radium-226-bearing residues were developed earlier for the project [3]. Subsequently, potential airborne releases of radon from the IWCS were evaluated using the air modeling described below to estimate dispersion of the gas and decay products to the onsite and offsite receptor locations evaluated and to estimate radiological doses and cancer risks for those receptors associated with inhaling radon gas and its particulate decay products.

While estimated concentrations of airborne and deposited particulates from IWCS releases would not be expected to vary substantially within the receptor areas evaluated for nearby offsite locations, they would be expected to vary close to the IWCS. Therefore, the three onsite receptors are conservatively assumed to move around the uncovered waste within a limited distance from that source. As an example, the remedial action worker was conservatively assumed to be 1 m (3 ft) from the illustrative excavation area at all times (during the time per year spent onsite), and 36 locations spaced 10 degrees apart were evaluated for this receptor. A similar number of locations ringing the area of uncovered waste were evaluated for the other two receptors at distances ranging from 1 to 100 m (3 to 330 ft).

Releases were estimated two different ways to support the evaluation of excavation alternatives: one assuming engineering controls would be used and another assuming no controls; the latter was included to help bound potential impacts and inform planning for future control measures.

Meteorological Data and Air Dispersion Modeling

The air dispersion analyses in the targeted health risk assessment for the IWCS [1] incorporate information presented in a companion technical report for the site on meteorological data and dispersion analyses [4]. That technical report includes measurements from meteorological stations on two commercial landfill properties adjacent to NFSS. The USACE installed a meteorological station on the NFSS in spring 2011, and data collection began soon after. Data from this onsite station may be used in future dispersion modeling for the site. Meanwhile, the evaluation in the technical report indicates that data from the adjacent landfill just north of the site are well-suited for use in NFSS dispersion analyses [4].

Contaminant concentrations in outdoor air were estimated from the representative source concentrations for the IWCS wastes scaled to the estimated unit emissions and associated dispersion based on the meteorological data and modeling analyses described in the USACE technical report [4]. As the current standard EPA dispersion model jointly developed with the American Meteorological Society, the AERMOD system was used to evaluate the dispersion of airborne releases from the IWCS.

To support the inhalation calculations, AERMOD was applied to the estimated IWCS releases assuming practical particulate and radon emission controls to estimate airborne radon concentrations and particulate matter (PM) concentrations at the representative receptor locations. These concentrations were then multiplied by the source concentrations of radionuclides and chemicals (volume weighted per delineated waste groups in the IWCS) to estimate the airborne contaminant concentrations at each receptor location.

Radiation doses associated with radon releases were evaluated using an algorithm developed by the EPA which establishes working-level ratios (WLRs) for radon decay products as a function of distance from the point of release, using a specified wind speed [5].

To estimate indoor air concentrations for the hypothetical offsite residential adult and child scenarios, a filtration factor of 0.5 was assumed [6]. For radon-222 progeny, the WLR estimated for the representative residential location offsite was used to calculate the exposure point concentration.

Contaminant concentrations in surface soil resulting from airborne releases at the IWCS were also considered. Particulate deposition was addressed as part of the dispersion modeling with the AERMOD system, using the fine particle fraction and mass median diameter. To estimate deposition of PM_{10} (PM with an aerodynamic diameter of a nominal 10 microns [µm] or less), a fine particle fraction of 10% was used (for $PM_{2.5}$, PM with an aerodynamic diameter of a nominal 2.5 µm or less) [7], and a mass median diameter of 4.6 µm was assumed based on values identified for various hazardous air pollutants [8]. To estimate $PM_{2.5}$ deposition as a further supporting evaluation, values of 100% and 0.5 µm were used for these two input parameters, respectively.

Particulate deposition at each receptor location (in $\mu g/m^2$) was assumed to be uniformly distributed in the top 1 cm (0.4 in.) to estimate a surface soil concentration in $\mu g/m^3$. Using an estimated density of 1.8 g/cm^3, this particulate concentration in surface soil was then multiplied by representative source concentrations of radionuclides and chemicals in the IWCS wastes to estimate the deposited concentrations of contaminants in µg/g at each receptor location. Those contaminant concentrations were then used to calculate exposures via incidental ingestion (for both radionuclides and chemicals) and external gamma irradiation.

For particle deposition on surface soil, estimated concentrations decrease with distance from the IWCS. Modeling indicates that about 20 to 30% of the PM_{10} mass is deposited up to 10 km (6.2 mi) from a source. In contrast, $PM_{2.5}$ acts as a gas due to its small particle size and thus only a small fraction (about 4 to 5%) is predicted to deposit up to this distance. Because the receptors evaluated are located within 10 km (6.2 mi) from the IWCS, the estimated deposition of airborne particulates onto surface soil focuses on PM_{10}, because the contribution from $PM_{2.5}$ to overall estimates was considered to be negligible.

Radiological and Chemical Exposures and Effects

The preliminary USACE health risk assessment for the IWCS incorporates recent updates of the EPA exposure factors handbook, including child-specific exposure factors [9,10,11]. It also reflects an evaluation of recent toxicity values and radiological dose conversion factors, including standard chemical values available via EPA's Integrated Risk Information System [12] and updated dosimetry context to support the estimates of chemical and radiological doses and risks.

The radiological and chemical risks are calculated separately in this assessment because of differences in the quality of the characterization data and approaches applied to identify the contaminants of potential concern and fill data gaps, as well as differences in the methods used to estimate cancer risks. The most significant difference in the assessment approaches is the basis for the risk estimators. For radionuclides, the risk coefficients are best estimate, average values; for chemicals, the risk estimators generally represent the upper bound or upper 95% confidence limit of the slope of the dose-response curve. Furthermore, the radiological risk coefficients are derived from human epidemiological data, while the estimators for chemicals are commonly derived from experiments with laboratory animals. Hence, the uncertainties associated with the risk estimates for radionuclides and chemicals differ.

RESULTS

Results of this targeted USACE health risk assessment for the IWCS are being used to help frame the development and detailed evaluation of remedial alternatives to be presented in the feasibility study for this OU. These results indicate that if the wastes were uncovered and someone stayed at the IWCS for a number of days to weeks, substantial doses and serious health effects could result from both external gamma irradiation and inhalation of radon-222 gas (the decay product of radium-226) and its short-lived progeny. Radionuclides dominate the risk estimates for the uncovered IWCS wastes, and the K-65 residues are shown to warrant the most rigorous controls because of their high radium-226 concentrations.

If the wastes were uncovered, the main concerns for onsite personnel at and near the IWCS would be inhalation and direct (inadvertent) ingestion of wastes, particularly the high-activity residues; this information will be useful when evaluating potential remedial alternatives involving excavation. The controls applied to protect onsite workers from such exposures – notably those that limit radon releases and particulate emissions – would also effectively protect the nearby public. The estimates in this preliminary assessment suggest little offsite impact from waste excavation.

Inhalation is generally the main exposure pathway for both radionuclides and chemicals, with radon-222 being the main contributor to the radiological (and total) doses and risks. Incidental ingestion and external gamma radiation associated with contaminants deposited on soil are lesser contributors to overall risk estimates. Other than potential issues associated with lead (to be evaluated as part of the feasibility study process for the IWCS), chemicals do not appear to pose a concern, with those assessed contributing less than 1% to overall risk estimates.

Because this targeted assessment preceded the development of conceptual planning information for waste excavation alternatives (which will be reflected in the upcoming feasibility study for the IWCS OU), related assumptions are conservative. For example, waste excavation is represented by ground-level releases from an area source, so modeled ground-level concentrations are used in the calculations underlying the estimated health risks. This approach results in a conservative estimate of exposure point concentrations close to the IWCS (by roughly a factor of 3 within 1 m [3 ft]), while at distances of 50 m (160 ft) and beyond, the air concentrations estimated at the ground level and breathing height (1.5 m or 5 ft) are essentially the same. Such conservative assumptions are expected to be modified or replaced as more project-specific information becomes available for the upcoming evaluations.

Scientific knowledge underlying the exposure factors and toxicity or risk estimators (including dosimetry) continues to evolve. Current exposure factors and chemical toxicity values were incorporated into the current IWCS health risk assessment, and evolving values were also noted. The approach used to calculate radiation doses and cancer risks in this assessment promotes general consistency with more recent knowledge and reflects dosimetry context from the 1996 publication of the International Commission on Radiological Protection [13], which updated information from nearly 20 years earlier [14].

In summary, this targeted assessment for the IWCS illustrates that whether the future scenario involves the wastes being excavated or simply uncovered, control measures will be important to protect against external gamma irradiation and limit radon gas releases, and also to prevent any access that could result in inadvertent ingestion.

REFERENCES

1. USACE. 2012. *Preliminary Evaluation of Health Effects for Hypothetical Exposures to Contaminants from the Interim Waste Containment Structure*, Technical Memorandum for the Niagara Falls Storage Site, Lewiston, New York, ANL/EVS/R-11-11 (Feb.). Prepared for U.S. Army Corps of Engineers, Buffalo District, Buffalo, NY, by Environmental Science Division, Argonne National Laboratory, Argonne, IL; http://www.lrb.usace.army.mil/fusrap/nfss/index.htm#Documents.

2. USEPA (U.S. Environmental Protection Agency). 1989. *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A), Interim Final,* EPA/540/1-89/002 (Dec.). Office of Emergency and Remedial Response, Washington, DC; http://www.epa.gov/oswer/riskassessment/ragsa/index.htm.

3. USACE, 2012, *Radon Assessment Technical Memorandum for the Niagara Falls Storage Site, Lewiston, New York* (Jan.). Prepared by Science Applications International Corporation, Dublin, OH, for USACE Buffalo District, Buffalo, NY; http://www.lrb.usace.army.mil/fusrap/nfss/#Documents.

4. USACE (U.S. Army Corps of Engineers). 2011. *Evaluation of Meteorological Data and Modeling Approaches to Assess the Dispersion of Airborne Releases from the Niagara Falls Storage Site*, Technical Report for the Niagara Falls Storage Site, Lewiston, New York, ANL/EVS/R-11/3 (Dec.). Prepared for U.S. Army Corps of Engineers, Buffalo District, Buffalo, NY, by Environmental Science Division, Argonne National Laboratory, Argonne, IL; http://www.lrb.usace.army.mil/fusrap/nfss/index.htm#Documents.

5. USEPA. 2007. *CAP88-PC Version 3.0 User Guide* (Dec.). Prepared by Trinity Engineering Associates, Inc., Cincinnati, OH, for R. Rosnick, EPA Office of Radiation and Indoor Air, Washington, DC; http://www.epa.gov/radiation/docs/cap88/userguide_120907.pdf ; http://www.epa.gov/radiation/assessment/CAP88/#version3.

6. Godish, T. 2004. *Air Quality*, 4th Edition. CRC Press LLC, Boca Raton, FL.

7. Countess Environmental. 2006. *WRAP Fugitive Dust Handbook* (Sept. 7). Prepared for Western Governors' Association, Denver, CO; http://www.wrapair.org/forums/dejf/fdh/content/FDHandbook_Rev_06.pdf.

8. Wesely, M.L, P.V. Doskey, and J.D. Shannon. 2002. *Deposition Parameterizations for the Industrial Source Complex (ISC3) Model*, ANL/ER/TR-01/003 (June). Argonne National Laboratory, Argonne, IL.

9. USEPA. 2008. *Child-Specific Exposure Factors Handbook,* EPA/600/R-06/096F (Sept.); http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243.

10. USEPA. 2011. *Exposure Factors Handbook 2011 Edition*, EPA/600/R-09/052F (dated Sept., released Oct. 3). National Center for Environmental Assessment, Washington, DC; http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.

11. USEPA. 2011. *Highlights of the Exposure Factors Handbook*, EPA/600/R-10/030 (Oct.), National Center for Environmental Assessment, Washington, DC; http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=221023.

12. USEPA. 2012. *Integrated Risk Information System*. National Center for Environmental Assessment, Washington, DC; http://www.epa.gov/iris.

13. ICRP 1996. *Age-Dependent Doses to the Members of the Public from Intake of Radionuclides, Part 5, Compilation of Ingestion and Inhalation Coefficients.* ICRP Publication 72, Annals of the ICRP, 26(1), Pergamon Press, New York, NY.

14. ICRP (International Commission on Radiological Protection). 1977. *Recommendations of the International Commission on Radiological Protection.* ICRP Publication 26, Annals of the ICRP, 1(3), Pergamon Press, New York, NY.