

INEEL/CON-02-00159
PREPRINT

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August 4, 2002 – August 8, 2002

Spectrum 2002

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Source Release Modeling for the Idaho National Engineering and Environmental Laboratory's Subsurface Disposal Area

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ABSTRACT

A source release model was developed to determine the release of contaminants into the shallow subsurface, as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation at the Idaho National Engineering and Environmental Laboratory's (INEEL) Subsurface Disposal Area (SDA). The output of the source release model is used as input to the subsurface transport and biotic uptake models. The model allowed separating the waste into areas that match the actual disposal units. This allows quantitative evaluation of the relative contribution to the total risk and allows evaluation of selective remediation of the disposal units within the SDA.

INTRODUCTION

The migration of contaminants buried in the SDA was simulated as part of the ongoing CERCLA evaluation. The first step in the modeling process is the source release simulation. This paper describes the implementation of the source term model used in the evaluation.

BACKGROUND

The SDA is the disposal portion of the Radioactive Waste Management Complex at the INEEL. The SDA started receiving waste in 1952. LLW, mixed, and TRU waste was disposed of until 1970, when the TRU waste was segregated and put on storage pads in the Transuranic Storage Area. Hazardous waste may have been disposed of until 1984, when only LLW was allowed to be disposed. Waste from on-site reactor operations and from off site generators was disposed. The most notable offsite generator was the Rocky Flats Plant (RFP), which sent

actinide contaminated waste for disposal.

Waste was disposed of in pits trenches, and soil vault rows. Pits are large excavations. Most pits are roughly rectangular and approximately an acre in size. The bulk of the RFP waste went into pits. Other large and bulk items were disposed in the pits. Trenches are long narrow excavations that typically received onsite generated waste. Some remote handled waste did go into the trenches. Soil vaults are holes up to 5 foot in diameter augured into the soil. Remote handled waste was lowered into the hole and covered. The waste in the soil vaults is from INEEL reactor operations.

The SDA represents a heterogeneous waste repository. Not only is the waste put in pits, trenches and soil vaults, but a multitude of different waste types were disposed of. Some of the waste was loose and dumped into the pits or trenches. Other waste was in cardboard or wooden boxes that would degrade rapidly and offer little barrier to contaminant transport. The rest of the waste was in drums or welded metal canisters or stabilized in concrete that would act as a barrier to transport for some period of time. However, even the period of time a drum would act as a barrier to transport is variable as disposal

practices changed and some drums were neatly stacked and some were dumped and compacted with heavy equipment.

Inventory evaluations^{1,2,3} identified 80 chemical contaminants and 100 radionuclides disposed in the SDA. Previous evaluations screened the total inventory to 25 radionuclides (and associated decay chain products) and 4 chemicals as contaminants of potential concern (COPCs). Of the chemicals, 3 are volatile organic compounds, whose inventory is being re-evaluated. The volatile organic compounds were not part of this study but will be addressed when the inventory evaluation is complete.

MODEL DEVELOPMENT

The source release model had to handle a variety of waste forms and container types. Previous work⁴ identified Disposal Unit Source Term – Multiple Species (DUST-MS)^{5,6} as the code to use. DUST-MS allows simulation of container failure and has three release mechanisms: surface wash off, diffusion, and dissolution. Enhancements were made to the code for this application. The first allowed simulation of waste emplacement over time. This allows simulating the 50 years of operational history and projecting LLW disposals in the future. The second enhancement allowed simulating container failure distributed in time. This mimics data on drum failure collected from previous retrieval operations at the SDA⁷.

Previous work⁴ had simulated average concentrations across the entire 96 acre SDA. While this is appropriate for screening contaminants, it does not help in defining areas that are the main contributors to the risk. The major waste streams for the COPCs were used with knowledge of where those major waste streams were disposed to subdivide the SDA into 12 physical areas for simulations. A 13th area was used in the uncertainty evaluation to address future disposals in the active LLW pits. Figure 1 is a map of the SDA with the subsurface model grid superimposed on it. The 13 waste areas are shown in color. The pits containing RFP waste are modeled because they are major contributors to the total actinide inventory. Soil vaults and trenches are lumped together and contain the fission and

activation waste, which generally comes from onsite operations at the INEEL.

DUST-MS is a 1 dimensional model, so in order to simulate the 13 separate regions, 13 separate simulations were performed for each case evaluated. The output from the 13 simulations was input into the appropriate grid blocks in the subsurface model. The physical dimensions of the disposal areas were used as input for each of the simulation areas. Area-specific infiltration rates were developed and are shown in Figure 2.

To develop the contaminant-specific input for the 13 simulations, the yearly disposed inventory was proportioned between the 13 disposal areas for each contaminant. To do this, a tool called the WasteOScope⁸ was used, which is a linked GIS database application that contains the shipping records for the SDA. As an example, most of the Am-241 came from RFP sludge. The inventory in a year was divided between the disposal areas by computing the fraction of sludge drums that went to each disposal area that year.

The release rate inputs were developed by looking at the individual waste streams disposed of in an individual year and selecting appropriate values. For example, in any given year C-14 could have been disposed of in beryllium reflector blocks, in activated metal, or as surface contamination on combustible trash. The inventory in the beryllium blocks would be in the soil vault rows and would be released via corrosion. The input to the model for the soil vault area would be to select the dissolution release model and the corrosion rate for the beryllium. Similarly, the activated metal would be in different disposal areas, and the input would again be dissolution of the metal and the appropriate corrosion rate for the metal. The corrosion rates used in the simulations are based on coupon tests performed with SDA backfill soils.⁹ The contamination on trash would be released via the surface wash off mechanism, and the input would be the appropriate partition coefficient between the contaminant and the waste.

Also input was the container failure rate for the waste stream. It is assumed that cardboard and wooden boxes offer no barrier to contaminant movement. Drums have a failure rate that depends on whether they were stacked or dumped, which is based on data from retrieval.

SIMULATION RESULTS

Dividing the inventory into the separate source areas reveals the relative contributions from the individual disposal units. Figure 3 shows the total Np-237 release as a function of time for the source areas. The NP-237 disposals are primarily in Area 11. Large amounts of Am-241 was disposed of, the decay of which produces Np-237. Figure 3, shows that the release from Area 11 occurs more rapidly than the other areas. This is because there is an initial inventory to release in Area 11. The other areas show an increase in release until 1,000 years in the future. This shape reflects the ingrowth from Am-241. Also, looking at the relative magnitude of the peak release, it appears that the majority of the Np237 comes from the decay of the disposed Am-241 not the initial disposed Np-237.

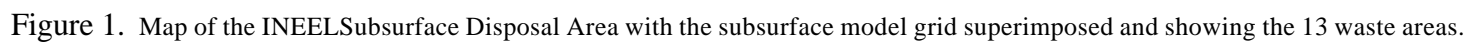
Figure 4 shows the initial effort to address potential remedial options. It shows the total release for several possible remedies. For CERCLA, the base case is the *no action* alternative. The other options addressed are capping, in situ grouting, in situ vitrification, and a combination

case that grouts some areas, vitrifies some areas, and caps the entire facility. The release is then input into the groundwater simulations to ultimately give risks from groundwater ingestion at the site.

The source release model, in conjunction with the subsurface transport model, can be used to develop remedial goals. A series of cases can be modeled to develop what combinations of inventory remaining and release rate would be protective of human health and the environment. This would be used in the feasibility study with the cost information to determine the most cost-effective remedial strategy.

SUMMARY AND CONCLUSIONS

A source release model was developed to support the CERCLA evaluations at the INEEL. It is integrated with other tools to develop a complete set of fate and transport simulations to assess the potential risks from waste at the SDA. As developed, the model is flexible to evaluate selective remediation within the SDA.



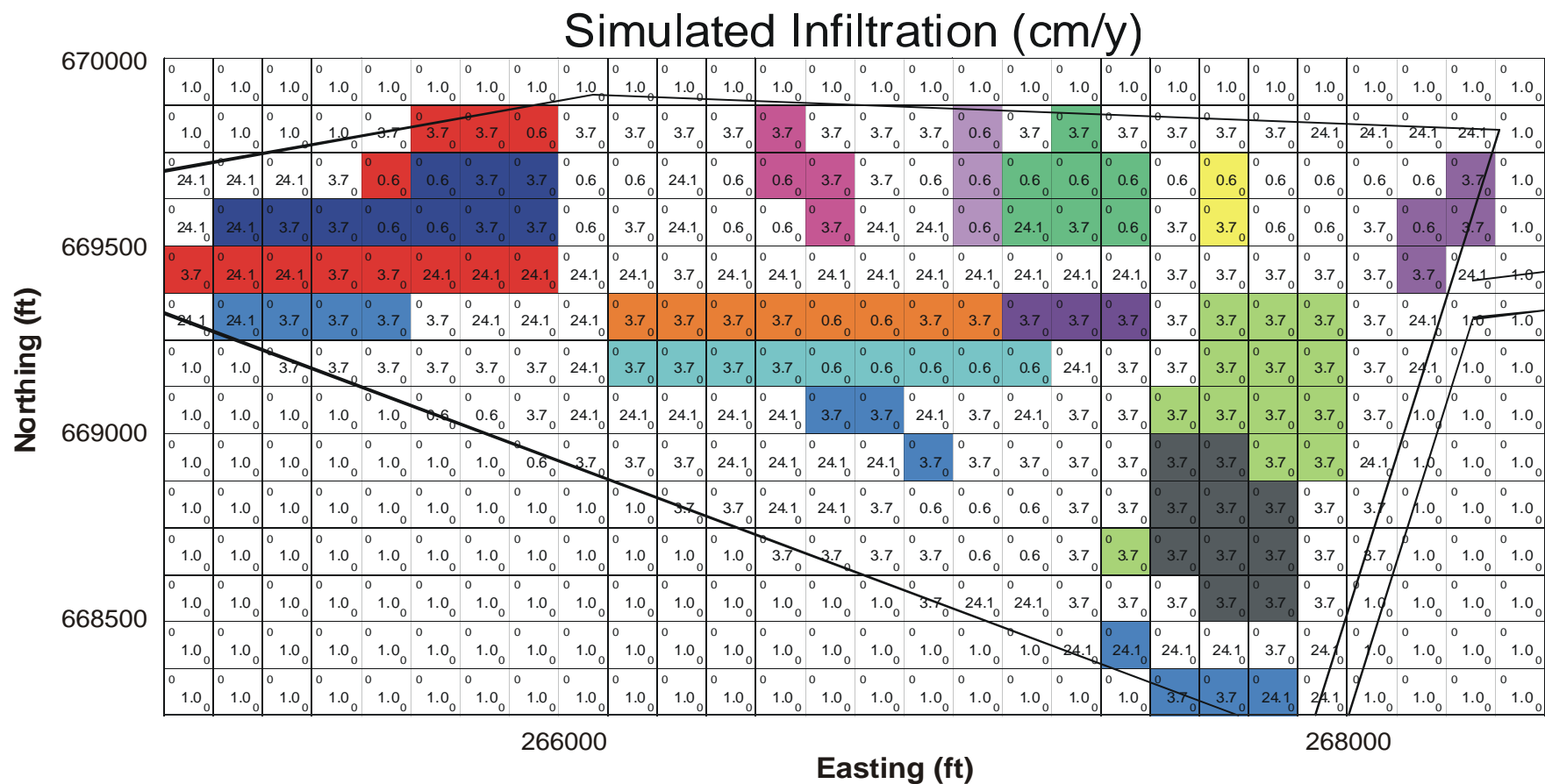


Figure 2. Infiltration rates used in the simulation areas.

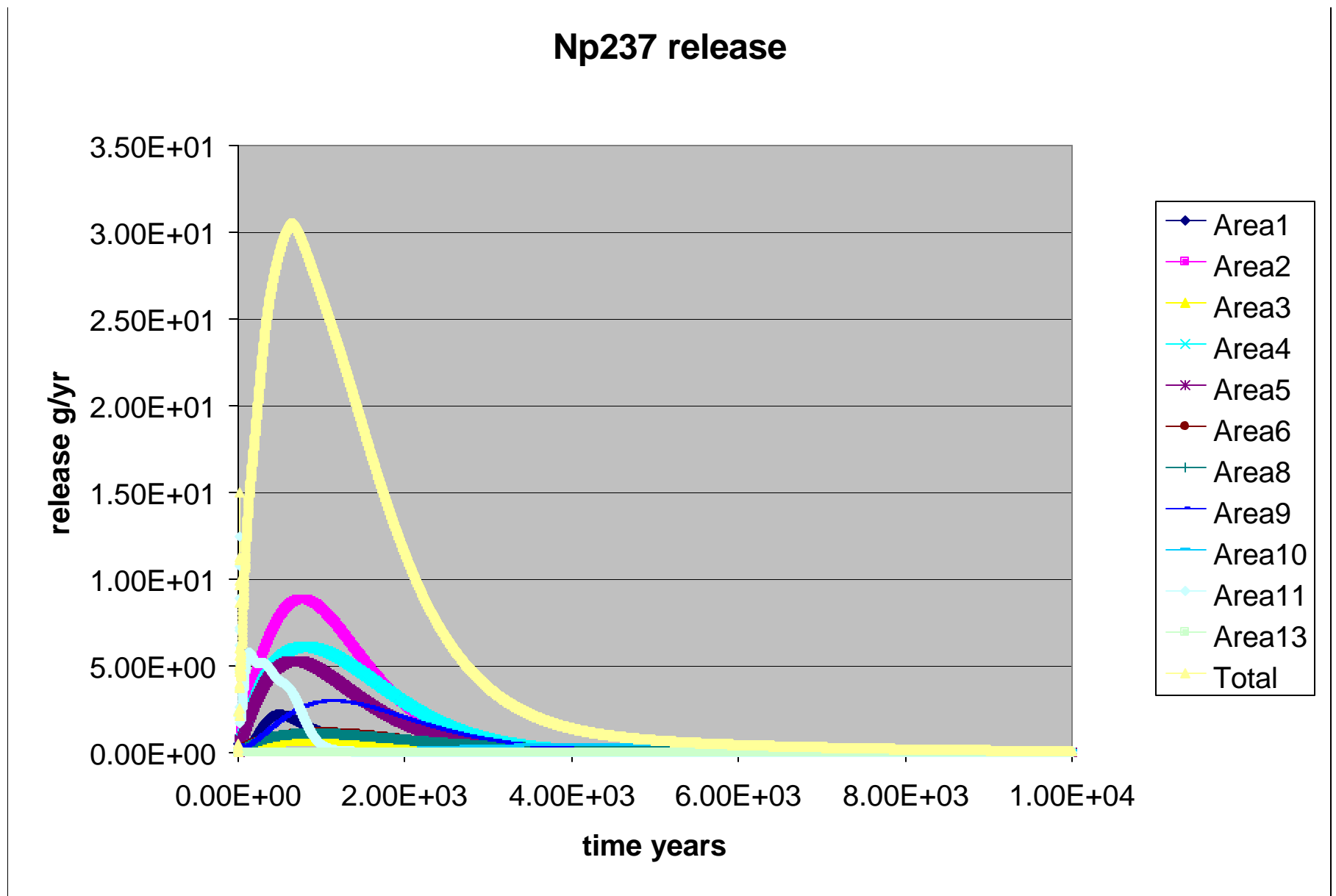


Figure 3 The relative contributions to the Total Np-237 Release from the individual source areas

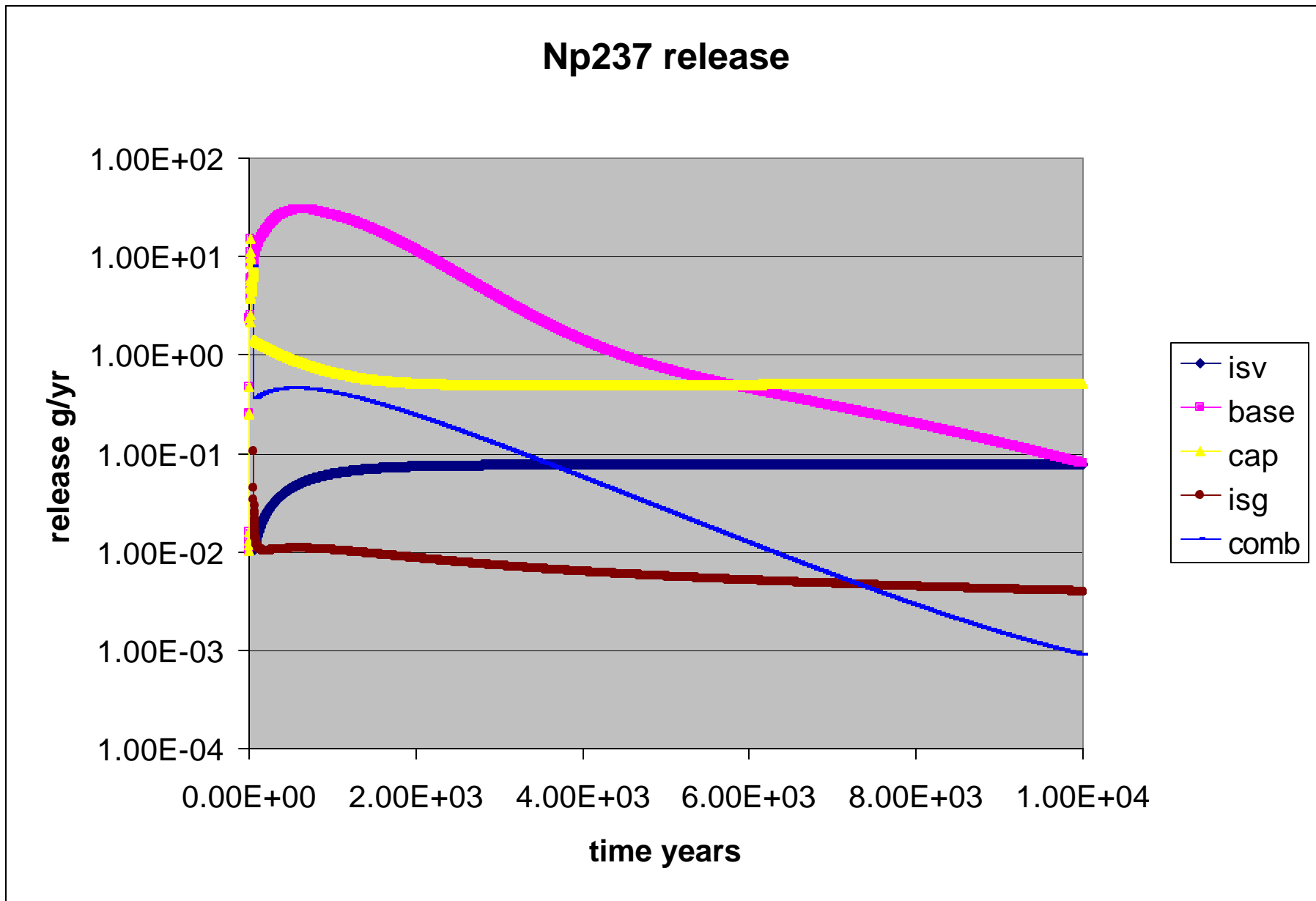


Figure 4 Comparison of the release rate for different remedial options.

ACKNOWLEDGEMENTS

Work supported by the U.S. Department of Energy, Assistant Secretary for Environmental Management, under DOE Idaho Operations Office Contract DE-AC07-99ID13727.

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