COMPARISON OF FOOTPRINT QUANTIFICATION TOOLS RELATIVE TO EACH OTHER AND THE EPA FOOTPRINT METHODOLOGY

ALAMEDA POINT OU-2B, CALIFORNIA

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NOTICE

Work described herein was performed by Tetra Tech for the U.S. Environmental Protection Agency (EPA). Work conducted by Tetra Tech, including preparation of this report, was performed under Work Assignment #2-73 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a collaborative effort between the U.S. Navy, EPA Region 9, and the EPA Office of Superfund Remediation and Technology Innovation (OSRTI). This report is available for download from www.cluin.org/greenremediation.

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LIST OF ACRONYMS

CAMX	eGRID subregion representing the California area
CO2e	carbon dioxide equivalents of global warming potential
EPA	U.S. Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
GAC	granular activated carbon
GHGs	greenhouse gases
GSR	Green and Sustainable Remediation
HAP	Hazardous air pollutant as defined by the Clean Air Act
ISCO	*in situ* chemical oxidation
ISO	International Standards Organization
lbs	pounds
LCA	life-cycle assessment
LCI	life-cycle inventory
MNA	monitored natural attenuation
MMBtus	millions of British Thermal Units
MWh	megawatt-hour
NOx	nitrogen oxides (for example, nitrogen dioxide)
PM10	particulate matter (particles 10 microns or less in diameter)
PRB	permeable reactive barrier
PVC	polyvinyl chloride
SOx	sulfur oxides (for example, sulfur dioxide)
USLCI	U.S. Life-Cycle Inventory
UV/OX	ultraviolet oxidation
WAPA	Western Area Power Authority

1.0 INTRODUCTION

1.1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) defines green remediation as the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprint of cleanup actions. When appropriate, green remediation involves quantifying the environmental effects or environmental footprint of a remedy. The EPA's *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 542-R-12-002), February 2012 ("Methodology") defines the metrics that comprise the environmental footprint and the process for quantifying those metrics. Metrics are calculated for the following categories:

- Materials and Waste
- Water
- Energy
- Air

Several tools have been developed to assist with quantifying the environmental footprints of remedies. In addition, life-cycle assessment (LCA) tools developed for and used in the manufacturing sector can be applied to remedies to help quantify an environmental footprint.

1.2 PURPOSE

This study evaluates the environmental footprint of a remedy using multiple footprint quantification tools to evaluate consistency among the tools and consistency with the EPA Methodology. Various remedial alternatives are considered as part of this evaluation, but the tools are not applied to compare various competing alternatives with each other. The tools used in this study are as follows:

- SiteWise™ was developed by the Battelle Memorial Institute on behalf of the U.S. Army and U.S. Navy as a screening tool to quantify the energy, emissions, and other metrics associated with environmental cleanup projects. Version 2.0 of the SiteWise™ (released in June 2011) is used for this project.
- Spreadsheets for Environmental Footprint Analysis (SEFA) was released in April 2012 by the EPA to assist with applying the Methodology.
- SimaPro™ was developed and marked by Pré Consultants in the Netherlands, to facilitate LCA studies in accordance with International Standards Organization (ISO) Standards.

Input parameters and results for SiteWise™ and SimaPro™ were obtained from a currently underway Environmental Security Technology Certification Program (ESTCP) project titled Quantifying Life-Cycle Environmental Footprints of Soil and Groundwater Remedies (ESTCP Project # ER-201127). Input parameters and results for SEFA were developed and calculated as part of this analysis and reporting effort under contract to the EPA.

The ESTCP project has produced a new version of SiteWise ™ (version 3) that incorporates modifications recommended from the analysis conducted for the ESTCP project. The revised version includes several changes to improve footprint calculations, ease of use, and formatting.

1.3 DESCRIPTION OF TOOLS

Each of the tools is described below. Familiarity with environmental cleanups and green remediation are generally needed to use the tools effectively and interpret the output generated by the tools.

1.3.1 SITEWISE™

SiteWise™ is a publicly-available tool built on the Microsoft Excel® platform that can be applied to multiple remedial alternatives or technologies based on site-specific information. Information on SiteWise™, including spreadsheet files are expected to be available in near future from the following Navy web site.

http://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/er/erb.html

A GSR assessment in SiteWise™ is carried out using a building block approach where the remedial alternatives are first broken down into modules that mimic the phases of a remedy (remedial investigation, remedial action construction, remedial action operation, and long-term monitoring). The tool structure is flexible enough to allow consideration of virtually any remedy type. The user enters information regarding material use for remedial activities, remedial system's utility (water and electric) consumption, vehicles and distances for transportation related to remedial activities, and on-site equipment use in the tool. The information is entered into tables on an "input sheet" by typing values and choosing elements of dropdown menus. The tool calculates certain sustainability metrics based on the information entered by the user. The following sustainability metrics are calculated by SiteWise™ using conversions factors that are provided in a lookup table:

- Total energy use (million metric British Thermal Units, MMBTU)
- Greenhouse gas (GHG) emissions (metric tons of CO2e)
- Nitrogen oxide emissions (metric tons of NOx)
- Sulfur oxide emissions (metric tons of SOx)
- Particulate matter (less than 10 microns) emissions (metric tons of PM10)
- Accident/safety risk
- Resource Consumption (tons of top soil used, gallons of groundwater lost, cubic yard of landfill space)
- Water use (gallons)

In SiteWise™, conversion factors for GHG emissions and energy used for materials, fuel, and electricity are life cycle based. The boundary condition that is drawn for calculating these life cycle emission factors is around the entire life cycle or 'cradle-to-grave' of the material used, fuel or electricity consumed. This means that complete life cycle emissions for material production are taken into account. The analysis includes all energy used and GHG emissions due to production and transportation of raw materials, manufacturing of consumable materials, fabrication of installed equipment (e.g., pumps, PVC piping) production of the electricity, and on site operation, maintenance, and monitoring of remediation systems. NOx and SOx emissions are calculated for electricity generation, transportation , and heavy equipment use. PM10 is calculated for transportation and heavy equipment use. SiteWise™ does not conduct an

impact assessment (a component of the LCA process) to convert the sustainability metrics into environmental impacts such as acidification and ecotoxicity.

The SiteWise™ spreadsheets allow for full transparency of all calculations and provide referenced conversion factors for activities and materials. Fuel usage rates are provided for various forms of transportation and various types of equipment. Electricity usage can be entered using one of three methods, including actual lump-sum usage, usage based on fluid head and flow rate, and usage based on motor size. Region specific emission factors are provided for calculating emissions from electricity generation, to account for different types of electrical generation in different parts of the country.

SiteWise™ generally requires less than a full day of training or independent use to learn how to apply the tool to a variety of remediation projects.

1.3.2 SEFA

SEFA is a collection of Microsoft Excel® spreadsheets designed to apply the EPA Methodology. The spreadsheets are publicly available at the following website:

http://www.cluin.org/greenremediation/methodology

The spreadsheets allow information to be organized in up to six different components that can be defined by the user. Input includes materials use, water use, waste disposal, transportation, equipment use, and other items. Output is provided for all metrics defined in the Methodology (see Table 1.)

In SEFA, conversion factors for all energy and emission metrics are life-cycle based. The boundary condition that is drawn for calculating the energy and emission factors is around the entire life cycle or 'cradle-to-grave' of the material used or fuel or electricity consumed. By contrast, water and waste footprints consider only the water used on site or the waste generated on site. Consistent with the Methodology, SEFA does not conduct an impact assessment (a component of the LCA process) to convert the sustainability metrics into environmental impacts such as acidification and ecotoxicity.

SEFA allows for full transparency of all calculations and provides referenced conversion factors for activities and materials consistent with the Methodology.

SEFA generally requires less than a full day of training or independent use to learn how to apply the tool to a variety of remediation projects.

1.3.3 SIMAPRO™

The SimaPro™ LCA software developed by PRé (www.pre-sustainability.com) provides a user interface and tools to facilitate the use of life-cycle inventory (LCI) databases in LCA studies that are consistent with governing ISO Standards 14040:2006 and 14044:2006. SimaPro™ comes fully integrated with several LCI databases including the extensive proprietary Ecoinvent database.

Using project-specific information, a SimaPro™ user compiles a number of materials, processes, and disposal practices from the LCI databases into user-made assemblies and life-cycles that describe the overall project. Footprint information or environmental impacts can then be obtained from the assemblies and life-cycles. Input is project specific and there are hundreds of output parameters, including total energy use, greenhouse gas emissions, NOx emissions, SOx emissions, PM emissions, releases of toxic chemicals to various environmental media (soil, water, and air) and the environmental impacts associated with these various emissions and releases.

SimaPro™ can cost between $3,000 and $12,000 (typically $9,000 for professionals) to purchase depending on the type of license, number of user licenses, and features. Service and support packages are available for additional cost. Impact assessment or characterization databases and methods are included to convert footprint information (such as SOx emissions) into environmental impacts (such as acidification). SimaPro™ generally requires approximately 40 hours of training or independent use with provided manuals and tutorials to learn how to apply the tool to a variety of remediation projects.

1.4 BRIEF SITE BACKGROUND AND REMEDY COMPONENTS ANALYZED

Operable Unit 2B (OU-2B) at Alameda Point in Alameda, California consists of Installation Remediation sites 3, 4, 11, and 21. The following are brief descriptions of these four sites:

- Site 3 is the Abandoned Fuel Storage area and is impacted with lead, PAHs and petroleum hydrocarbons including benzene, ethylbenzene, and naphthalene.

- Site 4 is associated with Building 360 (Aircraft Engine Facility) and is impacted by chlorinated solvents and metals. Polychlorinated biphenyls (PCBs) and pesticides have also been detected in the soil and remain present soil after limited excavation and removal of an oil water separator.

- Site 11 is associated with Building 360 (Engine Test Cell) and the soil at this site has limited polyaromatic hydrocarbon (PAH) and metals.

- Site 21 is associated with Building 162 (Ship Fitting and Engine Repair) and is primarily impacted by chlorinated solvents.

The April 2011 *Revised Draft Revision 2 Feasibility Study Report Operable Unit 2B, Installation Restoration Sites 3, 4, 11, and 21* prepared by Oneida Total Integrated Enterprises LLC on behalf of Naval Facilities Engineering Command documents analysis of remedial alternatives for these four sites. Information and data required to conduct the ESTCP footprint comparison at Alameda Point OU-2B was from this document including the cost estimating data in Appendix C and the Sustainable Environmental Remediation Evaluation provided in Appendix D. For the ESTCP project, the footprints calculated by SiteWise™ and SimaPro™ are compared for the following soil and groundwater remedial alternatives:

- Soil Alternatives:

    - S-2 – Excavation and Disposal of Impacted Soil

- Groundwater Alternatives:

    - G-2 – *In situ* Thermal Treatment (ISTT) of Hot-Spots, Control/Treatment at the Seaplane Lagoon using Permeable Reactive Barriers (PRBs), Monitored Natural Attenuation (MNA), and Institutional Controls (ICs)

    - G-3 – Hot-Spots Treatment, Shallow Groundwater Treatment, MNA, and ICs

    - G-4 – Treatment of Entire Plume using Groundwater Recirculation, PRBs, and ICs

Alternatives S-1 and G-1 are "No-Action" alternatives for soil and groundwater are assumed to have no environmental footprint. A brief description of the other alternatives is as follows:

- Alternative S-2 involves the following (see Tables 3, 5, and 7 of Appendix C of the FS):
    - Excavation and off-site disposal of impacted soil from Sites 3, 4, and 11
    - Dewatering and confirmation sampling
- Alternative G-2 involves the following (see Table 9 of Appendix C of the FS):
    - ISTT construction and operation
    - PRB installation for Control/Treatment at the Seaplane Lagoon
    - MNA of remaining groundwater plume
    - ICs
- Alternative G-3a involves the following (see Table 11 of Appendix C of the FS):
    - ISTT remedy – same as G-2
    - Shallow groundwater treatment with *in situ* chemical oxidation (ISCO)
    - MNA
    - ICs
- Alternative G-3b involves the following (see Table 13 of Appendix C of the FS):
    - ISTT remedy – same as G-2
    - Shallow groundwater treatment with *in situ* bioremediation
    - MNA – same as G-3a
    - ICs
- Alternative G-4 involves the following (see Table 15 of Appendix C of the FS):
    - Groundwater extraction, treatment, and reinjection
    - PRB installation
    - Plume and performance monitoring
    - ICs

This project applies SEFA to the same five alternatives and compares the footprint results to those calculated by SiteWise™ and SimaPro™ as part of the ESTCP project.

1.5 APPROACH AND MODEL INPUT

The approach used for this comparison involves the following steps:

- Obtain the input information used for SiteWise™ and SimaPro™.
- Input the same information into SEFA.
- Compare the SiteWise™, SimaPro™, and SEFA results.
- Evaluate the potential use of each tool for applying the Methodology.

The model inputs used by the three tools are provided in Attachment A. The tables in Attachment A are the tables compiled for the ESTCP project modified with an additional column to present the SEFA input. Where feasible, input for the three tools was made as similar as practical so that differences in the results could be attributed to differences in model calculations rather than differences in user input assumptions.

2.0 RESULTS

2.1 COMPARISON OF CALCULATED ENVIRONMENTAL FOOTPRINT METRICS

Tables 2 through 6 provide the results for environmental footprint metrics for the five remedial alternatives that were calculated by the three tools. Output from the various tools has been converted into common units to facilitate comparison. Using SEFA as an arbitrary benchmark, results that differ from the SEFA results are highlighted as follows:

- White – Different by a factor of less than 1.2
- Yellow – Different by a factor of 1.2 to 2
- Orange – Different by a factor of 2 to 10
- Red – Different by a factor of 10 or more

The differences highlighted in Tables 2 through 6 result from the following two items.

- SEFA and SimaPro™ calculate the NOx, SOx, and PM for all aspects of the remedy, but SiteWise™ recognizes the relatively local effects of NOx, SOx, and PM and therefore only calculates these parameters for remedial activities that are relatively local to the site. For example, SiteWise™ calculates NOx and SOx for electricity generation, transportation, and heavy equipment use and only calculates PM for transportation and heavy equipment use. This item explains the majority of the differences between SiteWise™ and SEFA and between SiteWise™ and SimaPro™.

- There are differences in the conversion factors that the various tools use to convert remedial activities into environmental footprints. Differences in conversion factors have a larger influence when they are associated with the primary aspects of a remedy, such as electricity for the ISTT remedy, iron for the PRB, or oxidant for the ISCO remedy. The various footprint contributions to each of the remedial alternatives and the influence of the conversion factors on those contributions are discussed in the next section.

2.2 FOOTPRINT CONTRIBUTIONS

Chart Set 1 (Charts 1a, 1b, and1c) illustrate the primary contributions to the energy, GHG, and NOx+SOx+PM footprints as calculated by the three tools. The contribution categories are ranked in decreasing order as calculated by SEFA, and the footprint values are plotted on a base 2 logarithmic scale such that each grid line represents a factor of 2 increase from the underlying gridline. That is, values that are separated by approximately one gridline are approximately a factor of 2 different from each other. Chart Sets 2, 3, 4, and 5 present the same information for Alternatives G-2, G-3a, G-3B, and G-4, respectively.

Observations pertaining to Chart Sets 1 through 5 include the following:

- Chart set 1 (Alternative S-2)

- With the exception of the fill used to backfill the excavation, the results from all three tools generally suggest the same ranking of the various energy and GHG footprint contributions.
- Most of the calculated energy footprints for waste transport and waste disposal are comparable. One exception is the waste transport energy footprint calculated by SimaPro™, which is one gridline (approximately a factor of 2) higher than the footprints calculated by the other tools.
- The materials transport energy and GHG footprints calculated by SimaPro™ are also approximately a factor of 2 higher than the materials transport energy footprints calculated by SEFA and SiteWise™.
- The SiteWise™ energy and GHG footprints for fill are approximately three gridlines (a factor of 8) higher than the footprints for fill calculated by SEFA and SimaPro™.
- The SEFA energy and GHG footprints for heavy equipment are almost a factor of 2 less than the equivalent footprints calculated by SiteWise™ and SimaPro™.
- The highest energy and GHG contributor (waste transport) is approximately five gridlines (a factor 32) higher than the lowest contributor displayed (personnel transport).
- The NOx+SOx+PM footprint for many categories are below one ton and are therefore not displayed.
- The NOx+SOx+PM footprint calculated by SiteWise™ and SEFA for waste disposal are almost identical but are a factor of 2 to 4 higher than the equivalent footprint for SimaPro™.
- The NOx+SOx+PM footprint calculated by SiteWise™ for waste transport is a factor of 2 to 4 lower than the equivalent footprints for SEFA and SimaProTM and are below 1 ton (and therefore not displayed).

- Chart set 2 (Alternative G-2)
  - The results from all three tools show that the ISTT electricity is the primary contributor to the all three footprint categories (energy, GHG, and NOx+SOx+PM); however, the results from all three tools do not necessarily suggest the same ranking of the other footprint contributions.
  - The energy footprint for ISTT electricity is approximately a factor of 8 higher than the next energy footprint contributor (zero valent iron for the PRB) as calculated by SiteWise™ and SEFA and approximately a factor of 32 higher than the next energy footprint contributor (zero valent iron for the PRB) as calculated by SimaPro™.
  - The SEFA energy footprint for the ISTT GAC and the ISTT electrodes are more than a factor of 2 lower than the equivalent footprints calculated by the other two tools. However, the SEFA GHG footprint for ISTT GAC is very comparable to the SimaPro™ GHG footprint for ISTT GAC.
  - The energy footprints for the other contributors are generally comparable amongst the three tools.
  - The energy and GHG footprints for the PRB zero valent iron for SimaPro™ are more than a factor of 4 lower than the equivalent footprints calculated by SEFA and SiteWise™.

- The SiteWise™ GHG footprint for the ISTT electrodes is a factor of approximately 4 to 8 times higher than the equivalent footprints calculated by the other tools.
- There are five contributors to the GHG footprint (personnel transport, on-site equipment, materials transport, ISTT electrodes, and well materials) that have footprints that are generally within a factor of 4 of each other.
- The waste transportation and disposal energy and GHG footprints are more than a factor of 1,000 (10 gridlines) lower than the highest contributor (electricity for the ISTT).
- The NOx+SOx+PM footprint for many categories are below one ton and are therefore not displayed.
- There is no NOx+SOx+PM footprint for several contribution categories because SiteWise™ does not calculate NOx, SOx, or PM footprints for materials.
- The SiteWise™ NOx+SOx+PM footprint for electricity is 8 times lower than the equivalent electricity footprints for SEFA and Simapro™.
- The SimaPro™ NOx+SOx+PM footprint for on-site equipment use (diesel combustion in heavy equipment) is more than a factor of 2 higher than the equivalent footprints for SEFA and SiteWise™.

- Chart set 3 (Alternative G-3A)
  - The results from the tools generally show that the ISTT electricity and ISCO reagents are the top two contributors to the energy, GHG, and NOx+SOx+PM footprints.
  - The energy footprints for all three tools are generally comparable (within a factor of 2) for on-site equipment (diesel combustion in heavy equipment), personnel transport, and materials transport.
  - Similar to the G-2 Alternative, the SEFA energy footprints for the ISTT GAC and the ISTT electrodes are more than a factor of 2 lower than the equivalent footprints calculated by the other two tools.
  - Similar to Alternative G-2, the waste transportation and disposal energy and GHG footprints are more than a factor of 1,000 (10 gridlines) lower than the highest contributor (electricity for the ISTT).
  - Similar to Alternative G-2, there are five contributors to the GHG footprint (personnel transport, on-site equipment, materials transport, ISTT electrodes, and well materials) that have footprints that are generally within a factor of 4 of each other.
  - The NOx+SOx+PM footprint for many categories are below one ton and are therefore not displayed.
  - With the exception of on-site equipment, the calculated NOx+SOx+PM footprint contributions are generally similar for SEFA and SimaPro™. However, the SEFA and SiteWise™ footprints for on-site equipment are very comparable.
  - Similar to Alternative G-2, the SiteWise™ NOx+SOx+PM footprint for electricity is 8 times lower than the equivalent electricity footprints for SEFA and Simapro™.
  - Similar to Alternative G-2, there is no NOx+SOx+PM footprint for several contribution categories because SiteWise™ does not calculate NOx, SOx, or PM footprints for materials.

- Chart set 4 (Alternative G-3B)
    - The observations for Alternative G-3B are very similar to those for Alternative G-3A except that in situ bioremediation reagents replace the ISCO reagents as a contribution category.

- Chart set 5 (Alternative G-4)
    - The energy, GHG, and NOx+SOx+PM footprints associated with the electricity for the UV/OX system are approximately 8 times higher than the energy, GHG, and NOx+SOx+PM footprints for the next highest contributors.
    - The tool calculations are generally similar with the following exceptions:
        - SimaPro™ has substantially lower energy and GHG footprints than the other two tools for the zero valent iron associated with the PRB.
        - SiteWise™ has a substantially lower NOx+SOx+PM footprint for electricity use than SEFA and SimaPro™.
        - SiteWise™ does not calculate NOx+SOx+PM footprints for materials, such as zero valent iron.
    - Several of the footprint contribution categories have NOx+SOx+PM footprints that are less than 1 ton and are therefore not displayed.

2.3 COMPARISON TO THE METHODOLOGY

The EPA Methodology discusses several green remediation metrics and provides several suggestions for gathering and screening site information, estimating unknown input values, and reporting results. Use of a particular tool, including SEFA, does not guarantee adherence to the Methodology. Because the information used for this project was obtained from an ESTCP project, and the ESTCP project was planned prior to finalization of the Methodology, the tools were not applied in a manner consistent with the Methodology. Key differences between the Methodology and the project-specific applications of these tools are as follows:

- A regional, rather than a site-specific, electricity generation mix from 2004 - 2005 was used to calculate the footprints from electricity use. Given that Alameda Point is a federal facility, it is possible (though not confirmed) that it has a more unique installation-specific electricity generation mix that includes a higher percentage of hydropower from the Western Area Power Administration. A higher percentage of hydropower in the electricity generation mix would reduce the footprints associated with electricity use and reduce the overall footprints for the various remedial alternatives.

- Professional judgment was used to eliminate various footprint contributions from consideration in the footprint calculations. Although the professional judgment used appears to be sound and consistent with the Methodology, it is not documented as rigorously as suggested in the Methodology.

- Some items specified in the Methodology, such as laboratory analysis, were not included as potential footprint contributions.

- Travel distances were frequently selected from local distributors with distances of approximately 50 miles rather than the distance from a manufacturer, which could be significantly further.

In addition, the structure of SiteWise™ and SimaPro™, which were developed prior to the Methodology, and for purposes other than applying the Methodology, somewhat limit the ability of these tools to fully adhere to the Methodology.

- In its current form SiteWise™ includes NOx, SOx, and PM contributions from some activities such as fossil fuel combustion, electricity generation (NOx and SOx only), potable water treatment and distribution, and landfill operations but not for others such materials manufacturing. The remedy NOx, SOx, and PM calculations, therefore, do not represent all potentially significant contributors or represent the NOx+SOx+PM metric in the Methodology.

- SiteWise™ and SimaPro™ are not organized to document or present all green remediation metrics defined in the Methodology. For example, SiteWise™ does not calculate HAP emissions. Many of the other metrics not calculated by SiteWise™ or SimaPro™ (for example, the materials, waste, and water metrics) can be quantified in a straightforward manner consistent with the Methodology without a complex footprint analysis tool.

- SimaPro™ cannot calculate the on-site NOx+SOx+PM and HAP emission metrics defined in the Methodology. Although SimaPro™ has significant flexibility, it is difficult to separate the footprint associated with on-site fossil fuel combustion from the footprint associated with extracting the fossil fuel and processing it at a refinery. For SiteWise™, the NOx, SOx, and PM emissions are essentially local or regional, which is a smaller boundary than total emissions but is broader than the on-site emissions metric documented in the Methodology.

- Conversion factors in SiteWise™ and SimaPro™ are not necessarily consistent with the conversion factors provided in the Methodology. The difference in conversion factors among the tools does not mean that those of any one tool are inappropriate. Rather, the differences emphasize the inherent difficulty in identifying consistent conversion factors given the number of references available. Selection of appropriate conversion factors is further complicated in SimaPro™ where many options from many LCI databases are available for use. For SiteWise™, this can be easily addressed by inputting the factors used in Methodology into the SiteWise™ lookup table in place of the default values.

- SiteWise™ has inherent calculations for estimating fuel use and footprints associated with drilling, other heavy equipment use, and materials or equipment transportation. These calculations are likely sound but differ from those in the Methodology, resulting in potentially different fuel usages and footprints between SiteWise™ and SEFA. This can be addressed by avoiding the use of certain components within SiteWise™ and instead using a more generic internal combustion engine component that allows more flexibility in the inputs. SimaPro™ also inherently estimates footprints based on a specific production rate for some types of heavy equipment.

- SimaPro™ is limited in transparency relative to expectations of the Methodology. For example, The proprietary nature of the primary database (Ecoinvent), the vast amounts of results produced, and the upfront cost for the software limit the ability to share and view results. Also, due to the library nature of SimaPro™, sharing project files is difficult even between SimaPro™ users because so many files and data (perhaps up to 1 gigabyte in size) need to be shared.

2.4 SENSITIVITY ANALYSIS

A sensitivity analysis is typically recommended to evaluate the sensitivity of results to variation or uncertainty in the input parameters or environmental footprint conversion factors. For the purpose of this document, the sensitivity analysis focuses on input assumptions that might have been different if the footprint analysis study had more directly considered the Methodology. Because of the similarity in the various remedial technologies used in the alternatives, sensitivity analyses are conducted only on specific remedial technologies.

2.4.1 ELECTRICITY GENERATION MIX FOR ISTT

The electricity generation mix used for all three of the tools is the 2004-2005 eGRID CAMX subregion generation mix. The specific electricity generation mix for Alameda Point is not known to the study team, but it is reasonable to assume that it may be similar to that of Travis AFB, which obtains its electricity from Western Area Power Authority (WAPA). Table 7 presents the fuels used for electricity generation in the eGRID CAMX subregion and WAPA, and Chart 6 presents the percent difference in the results of various footprint metrics for the ISTT remedy component if the WAPA electricity generation mix is used in place of the 2004-2005 eGRID CAMX subregion mix. The presented results were calculated using SEFA and may be slightly different if calculated using SiteWise™ or SimaPro™. It is apparent that the change in electricity generation mix is measureable but relatively small (i.e., less than 20% for most metric categories) with exception of the HAP metric, in which a 30% increase is observed.

2.4.2 LABORATORY ANALYSIS FOR MONITORED NATURAL ATTENUATION

The Methodology calls for including laboratory analysis in footprint calculations. For the ESTCP project, transport of samples to the laboratory was considered, but laboratory analysis was not considered. Chart 7 illustrates the percent change in the footprints for the MNA component of Alternative G-2 if laboratory analysis was considered. The consideration of laboratory analysis (which includes the transportation of the samples) suggested a 200% increase in the energy, GHG, and NOx footprints and significantly higher increases for SOx, PM, and HAPs. Due to a lack of publicly available analytical laboratory life-cycle inventory data, the laboratory analysis conversion factors provided in the Methodology are based on a comparison of analytical costs to national gross domestic product and nationwide emissions. As a result, the actual emissions associated with laboratory analysis may be significantly different than presented here. Nevertheless, the magnitudes of the increases shown in Chart 7 suggest that even if actual laboratory analysis conversion factors are significantly lower than those suggested in the Methodology, laboratory analysis could be a significant contribution to a remedy footprint, particularly an MNA remedy footprint.

2.4.3 DISTANCES USED FOR MATERIALS TRANSPORTATION FOR A PRB

The input data in the ESTCP project assumed relatively local sources of materials for the remedies and assumed approximately 50-mile one-way differences between the source of the material and the site. This might be representative of a local distributor of common materials. The Methodology suggests using the transport distances from the manufacturer and suggests default distances of approximately 500 miles. Chart 8 shows the percent change in the various footprint metrics for the PRB remedy in Alternative G-2 if the one-way transport distance for the zero valent iron was changed from 50 miles to 500 miles. Chart 8 shows that despite an order of magnitude increase in the transport distance, the footprints for the overall PRB remedy increased by less than 15%, and in many cases, by less than 5%. These results show that the PRB remedy is not very sensitive to the transportation distance used, and the primary reason is because the footprint associated with manufacturing the zero valent iron is so high relative to the transportation footprint. The calculations were done using SEFA, and steel was used as a surrogate for the zero valent

iron. If the footprint for zero valent iron is substantially lower than the footprint for steel, then the overall PRB remedy footprint might be more sensitive to the transportation of the zero valent iron. Additionally, if the actual transportation distance was closer to 1,000 miles, then the percent differences would be approximately double the values shown in Chart 8.

3.0 CONCLUSIONS

The following conclusions have been made based on the above-described analyses:

3.1.1 CONCLUSIONS REGARDING DIRECT COMPARISON OF TOOLS

The tool results are generally comparable with some noted exceptions. The largest discrepancies were in the NOx+SOx+PM footprints because SEFA and SimaPro™ consider the total emissions of these pollutants whereas SiteWise™ only considers relatively local emissions of these pollutants. Other differences among the tools result from different conversion factors used to translate remedial activities or materials into footprints. Each tool uses reasonable, referenced sources for these conversion factors, but there is sufficient variation in these referenced values that significant differences can result. When using SiteWise™, this factor can be addressed by inputting the factors used in the Methodology into the SiteWise™ lookup table in place of the default values. Additionally, materials used in the remedies were not readily available options within the tools and material surrogates were needed. In some cases, the choice of a surrogate material could result in substantial differences in tool output. For example, graphite, a material used in the ISTT electrodes, is not available in SEFA or SiteWise™ but is available in the proprietary databases used by SimaPro™. The SEFA user used an "unrefined construction material" as a surrogate for this material. The SiteWise™ user recognized that graphite would have a lower footprint than steel and developed a "Material A" as a surrogate that had a 50% lower energy and GHG footprint than steel. As a result of these assumptions, the SEFA footprints for the ISTT electrodes were generally a factor of 2 lower than the SimaPro™ footprints for the ISTT electrodes, and the SiteWise™ footprints for the ISTT electrodes were generally more than a factor of 4 higher than the SimaPro™ footprints for the ISTT electrodes.

These and other differences highlight the need to either accept a low degree of consistency in footprint calculations or the need to identify conversion factors for various materials that can be standardized and used by the various tools. Materials for which different or absent conversion factors was an issue in this study included graphite, zero valent iron, backfill, GAC, ISCO reagents, and bioremediation reagents.

There is also some difference in how the tools estimate the fuel usage and therefore the footprints associated with heavy equipment operation and materials transportation.

3.1.2 CONCLUSIONS REGARDING COMPARISON OF TOOLS AND RESULTS TO THE METHODOLOGY

Application of all the tools for this study did not necessarily follow the Methodology, demonstrating that use of a particular tool does not guarantee adherence to the Methodology. Although SEFA was prepared to assist with implementing the Methodology, simplifying input assumptions for this study did not necessarily follow the Methodology. This is primarily because the study involves comparing SEFA results to SiteWise™ and SimaPro™ results, the SEFA inputs were generally made consistent with the inputs for the other tools, and the inputs for the other tools were developed in a separate project.

SiteWise™ and SimaPro™ do not include features to assist with calculating the materials, waste, and water footprints described in the Methodology, but these calculations would be straightforward to conduct in a user-prepared spreadsheet.

Structural features of SiteWise™ and SimaPro™ present additional challenges when using these tools to implement the Methodology. For example, both tools cannot calculate the on-site NOx+SOx+PM footprint described in the Methodology in a straightforward manner. SiteWise™ also does not calculate the on-site or total HAPs footprints or consider emissions of NOx, SOx, and PM from materials manufacturing.

SiteWise™ and SEFA are very transparent, allow the user to see the intermediate calculations, and allow for easy sharing of files between users. SimaPro™ does not show the internal calculation because of the user interface. More importantly other features of SimaPro™ make it difficult to share files and results. One of these features is the proprietary nature of SimaPro™ and its inherent life-cycle inventory databases, which results in a cost of approximately $9,000 for each single-use software license. Another feature is the size of the libraries and files, which make it more difficult than SEFA and SimaPro™ to share files.

3.1.3 CONCLUSIONS REGARDING CONFIDENCE IN RESULTS

The relatively limited variation in results from the three different tools suggests reasonable confidence in the results as long as the assumptions, methodologies, and calculations used in applying the models is understood. For energy and GHG emissions, the results of SEFA and SiteWise™ were relatively consistent with 7 out of 10 results being different by a factor of less than 1.2 and the other three in the range of 1.2 to 2.0. The variation is greater for NOx, SOx, and PM for reasons previously discussed. Further increasing confidence in the results would require further evaluation of the potential footprint conversion factors available for use, the reasons for differences in the conversion factors, and the most appropriate conversion factors to use.

3.1.4 SUGGESTED CHANGES TO TOOLS TO IMPROVE USABILITY AND APPLICABILITY

Suggested changes to tools are only provided for SiteWise™ and SEFA.

SiteWise™ is in the process of being updated in the ongoing ESTCP project. Updates will include features to improve usability and the accuracy of results. Because SiteWise™ results were provided by the ESTCP project, and SiteWise™ was not directly utilized in this study, this study defers to the updates being made under the ESTCP project. With respect to results observed in this study, it is suggested that SiteWise™ include conversion factors for more materials and include NOx, SOx, and PM conversion factors for all remedial activities and materials in the tool for which energy and GHG conversion factors are provided.

SEFA would benefit from the following changes:

- To improve usability, a post-processor should be provided to help compile some of the intermediate calculations. For example, if a user wants to identify the footprint associated with electricity use, the user must add the results from three separate fields (electricity generation, resource extraction, and transmission losses). Additionally, if a user wants to identify the footprint associated with diesel equipment, the user must add the results from fuel use for that equipment and then add the footprint results associated with the production of that fuel.

- To improve accuracy, SEFA, like SiteWise™, would benefit from including conversion factors for a broader array of materials.

TABLES

Table 1. Metrics defined in the EPA Methodology

Core Element	Metric		Unit of Measure
Materials & Waste	M&W-1	Refined materials used on-site	tons
	M&W-2	Percent of refined materials from recycled or waste material	percent
	M&W-3	Unrefined materials used on-site	tons
	M&W-4	Percent of unrefined materials from recycled or waste material	percent
	M&W-5	On-site hazardous waste generated	tons
	M&W-6	On-site non-hazardous waste generated	tons
	M&W-7	Percent of total potential on-site waste that is recycled or reused	percent
Water		On-site water use (by source)	
	W-1	- Source, use, fate combination #1	millions of gals
	W-2	- Source, use, fate combination #2	millions of gals
	W-3	- Source, use, fate combination #3	millions of gals
	W-4	- Source, use, fate combination #4	millions of gals
Energy	E-1	Total energy use	MMBtu
	E-2	Total energy voluntarily derived from renewable resources	
	E-2A	- On-site generation or use and biodiesel use	MMBtu
	E-2B	- Voluntary purchase of renewable electricity	MWh
	E-2C	- Voluntary purchase of RECs	MWh
Air	A-1	On-site NOx, SOx, and PM10 emissions	lbs
	A-2	On-site HAP emissions	lbs
	A-3	Total NOx, SOx, and PM10 emissions	lbs
	A-4	Total HAP emissions	lbs
	A-5	Total GHG emissions	tons CO_2e
Land & Ecosystems	Qualitative description		

RECs = Renewable energy certificates
NOx = Nitrogen oxides
SOx = Sulfur oxides
PM10 = Particulate matter smaller than 10 microns in size
HAP = Hazardous Air Pollutants as defined by the Clean Air Act
MWh = megawatt-hour
MMBtu = million British thermal units

Table 2. Comparison of calculated footprint metrics for Alternative S-2

Metric	Unit	SiteWise™	SEFA	SimaPro™
Total Energy Used	MMBtu	18,876	12,189	21,813
Total NOx Emissions	Lbs	3,996	12,152	12,756
Total SOx Emissions	Lbs	1,653	3,048	3,134
Total PM Emissions	Lbs	8,373	8,557	1,269
Total GHG Emissions	Tons	1,319	943	1,365

Table 3. Comparison of calculated footprint metrics for Alternative G-2

Metric	Unit	SiteWise™	SEFA	SimaPro™
Total Energy Used	MMBtu	101,379	110,150	79,174
Total NOx Emissions	Lbs	6,962	21,391	23,153
Total SOx Emissions	Lbs	4,377	66,562	73,538
Total PM Emissions	Lbs	253	1,902	6,643
Total GHG Emissions	Tons	6,422	6,120	5,191

Table 4. Comparison of calculated footprint metrics for Alternative G-3a

Metric	Unit	SiteWise™	SEFA	SimaPro™
Total Energy Used	MMBtu	106,653	124,883	127,333
Total NOx Emissions	Lbs	7,116	24,294	29,995
Total SOx Emissions	Lbs	4,402	73,047	84,769
Total PM Emissions	Lbs	294	1,694	2,574
Total GHG Emissions	Tons	6,142	5,933	7,968

Table 5. Comparison of calculated footprint metrics for Alternative G-3b

Metric	Unit	SiteWise™	SEFA	SimaPro™
Total Energy Used	MMBtu	97,165	114,277	93,818
Total NOx Emissions	Lbs	6,496	20,326	21,624
Total SOx Emissions	Lbs	4,330	69,109	74,415
Total PM Emissions	Lbs	236	1,307	1,189
Total GHG Emissions	Tons	5,230	5,663	5,553

Table 6. Comparison of calculated footprint metrics for Alternative G-4

Metric	Unit	SiteWise™	SEFA	SimaPro™
Total Energy Used	MMBtu	210,464	246,370	171,417
Total NOx Emissions	Lbs	13,867	36,725	39,330
Total SOx Emissions	Lbs	10,533	151,077	175,354
Total PM Emissions	Lbs	185	2,041	5,388
Total GHG Emissions	Tons	9,330	11,443	11,346

Notes for Tables 2 through 6: Lbs=pounds; MMBtu=million British Thermal Units; NOx=nitrogen oxides; SOx=sulfur oxides; PM=particulate matter; HAP=hazardous air pollutions; GHG=greenhouse gas.

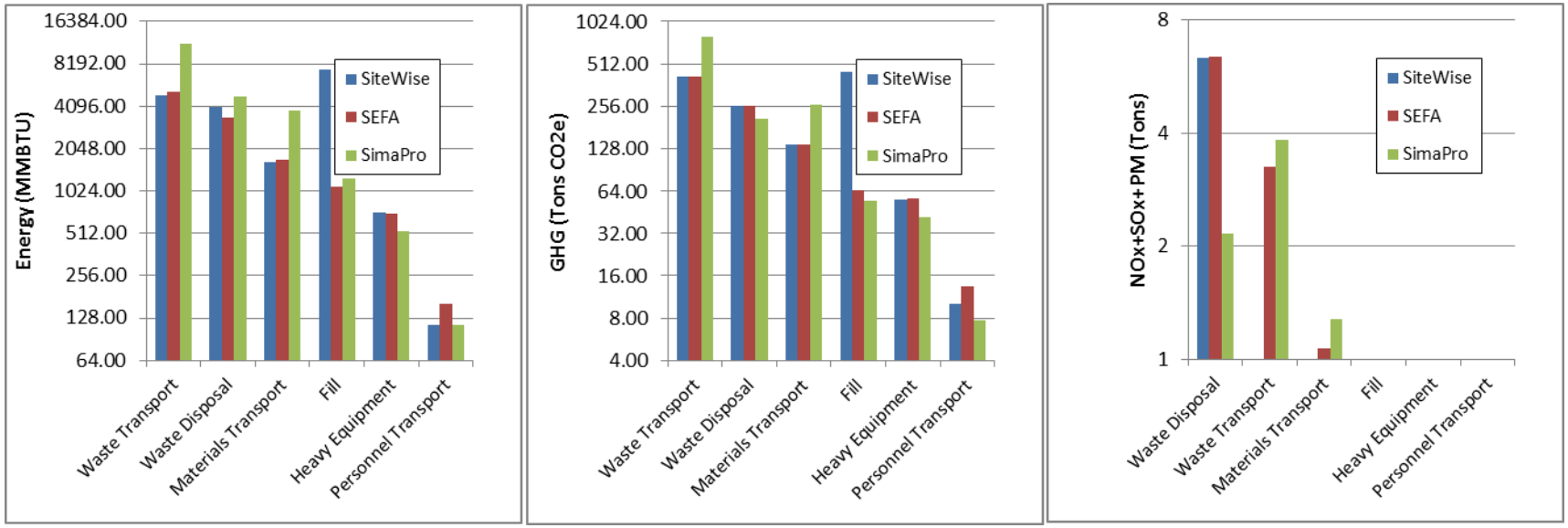
Table 7. Two Potential Electricity Generation Mixes for Alameda Point.

	Coal	Oil	Gas	Other Fossil	Biomass	Hydro	Nuclear	Wind Solar or Geo.
CAMX	11.9%	1.2%	42.3%	1%	2.6%	17.7%	16.5%	6.8%
WAPA	17.4%	0%	28.1%	0%	1.4%	40%	8.7%	4.4%

CAMX = eGRID subregion representing the California area for 2004-2005
WAPA = Western Area Power Authority

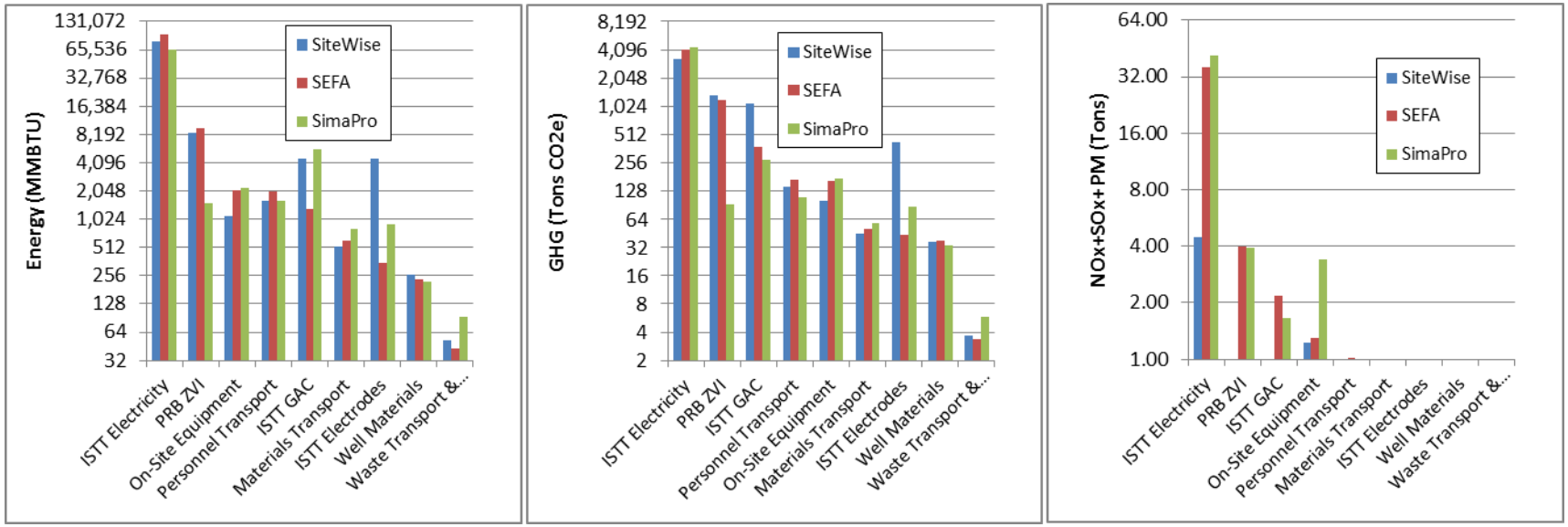
CHARTS

Chart Set 1 (Charts 1a, 1b, and 1c) – Energy (1a), GHG (1b), and NOx+SOx+PM (1c) Footprints by Footprint Contribution Category for Alternative S-2.



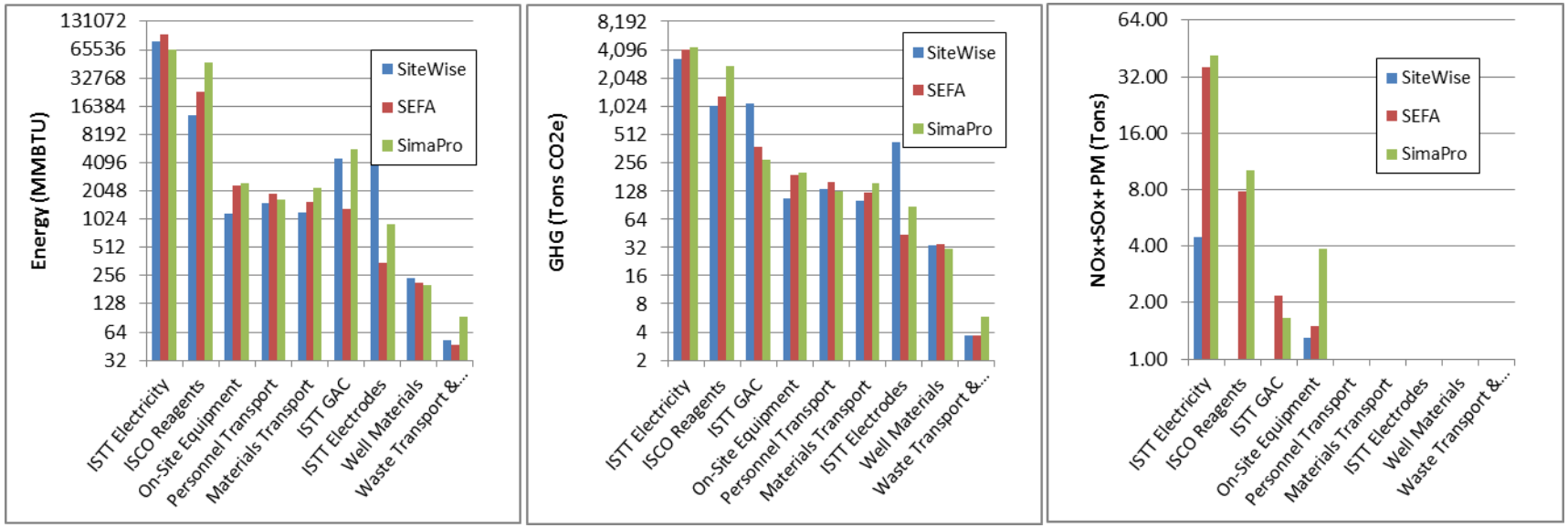
Footprint contribution categories are presented in decreasing order as calculated by SEFA. Vertical axes are plotted on a base 2 logarithmic scale such that the value at each gridline is a factor of 2 higher than the value at the underlying gridline.

Chart Set 2 (Charts 2a, 2b, and 2c) – Energy (2a), GHG (2b), and NOx+SOx+PM (2c) Footprints by Footprint Contribution Category for Alternative G-2.



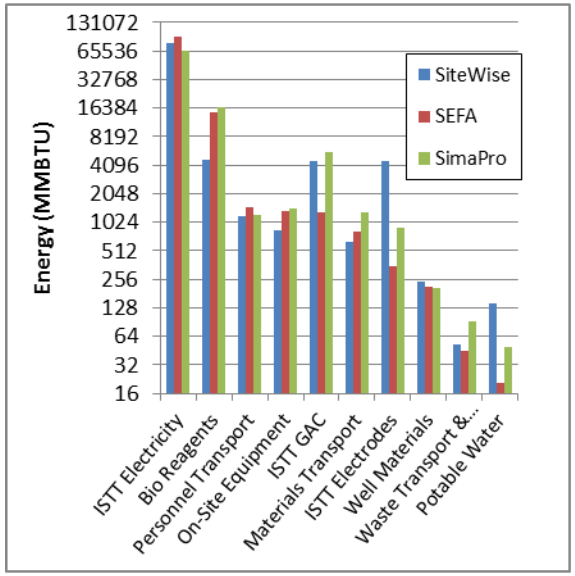
Footprint contribution categories are presented in decreasing order as calculated by SEFA. Vertical axes are plotted on a base 2 logarithmic scale such that the value at each gridline is a factor of 2 higher than the value at the underlying gridline.

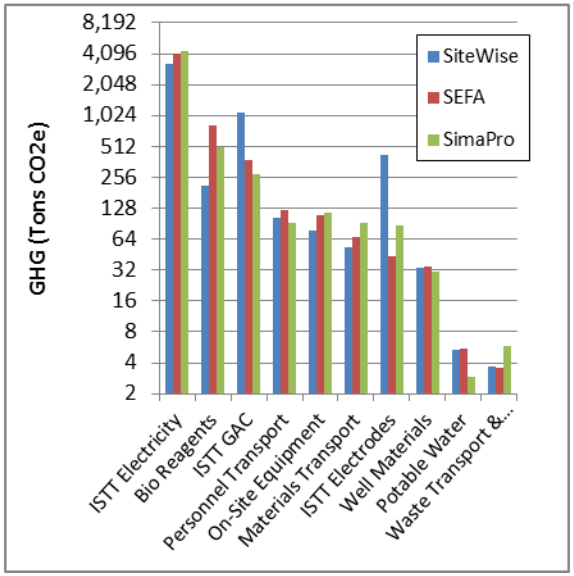
Chart Set 3 (Charts 3a, 3b, and 3c) – Energy (3a), GHG (3b), and NOx+SOx+PM (3c) Footprints by Footprint Contribution Category for Alternative G-3A.

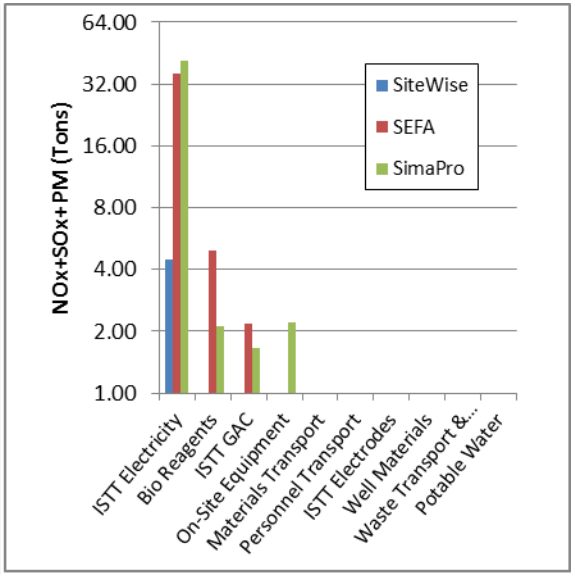


Footprint contribution categories are presented in decreasing order as calculated by SEFA. Vertical axes are plotted on a base 2 logarithmic scale such that the value at each gridline is a factor of 2 higher than the value at the underlying gridline.

Chart Set 4 (Charts 4a, 4b, and 4c) – Energy (4a), GHG (4b), and NOx+SOx+PM (4c) Footprints by Footprint Contribution Category for Alternative G-3B.

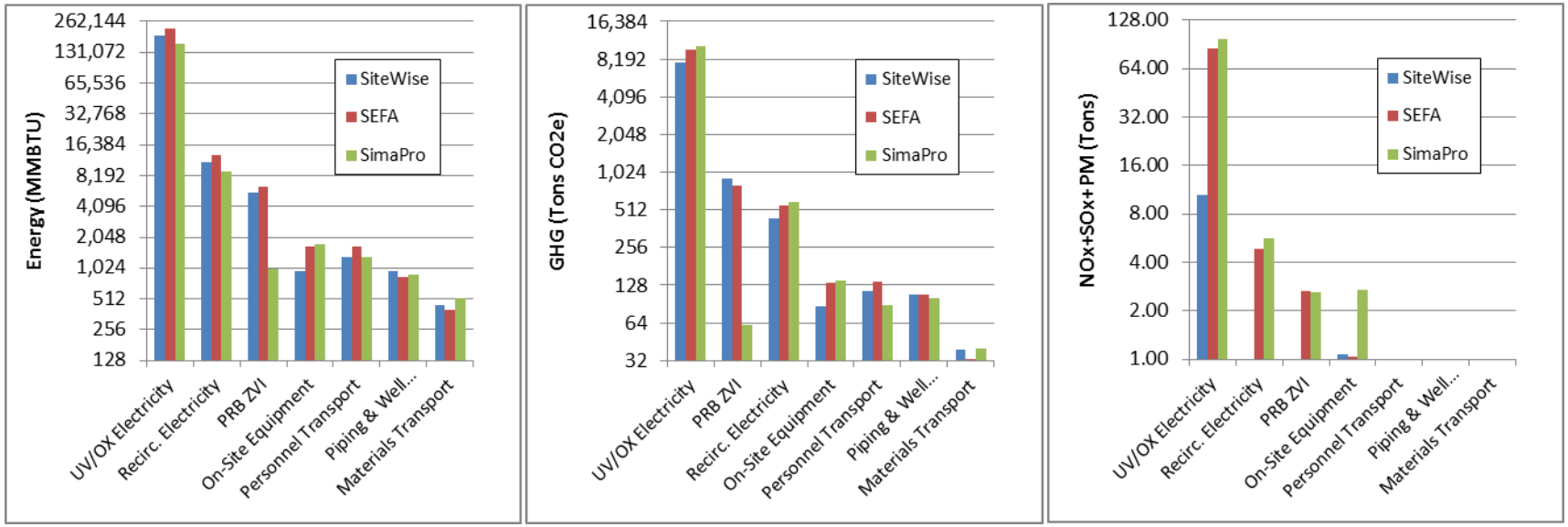






Footprint contribution categories are presented in decreasing order as calculated by SEFA. Vertical axes are plotted on a base 2 logarithmic scale such that the value at each gridline is a factor of 2 higher than the value at the underlying gridline.

Chart Set 5 (Charts 5a, 5b, and 5c) – Energy (5a), GHG (5b), and NOx+SOx+PM (5c) Footprints by Footprint Contribution Category for Alternative G-4.



Footprint contribution categories are presented in decreasing order as calculated by SEFA. Vertical axes are plotted on a base 2 logarithmic scale such that the value at each gridline is a factor of 2 higher than the value at the underlying gridline.

Chart 6. Percent Difference in ISTT Remedy Footprints from Using WAPA Electricity Generation Mix in Place of the 2004 – 2005 CAMX Electricity Generation Mix

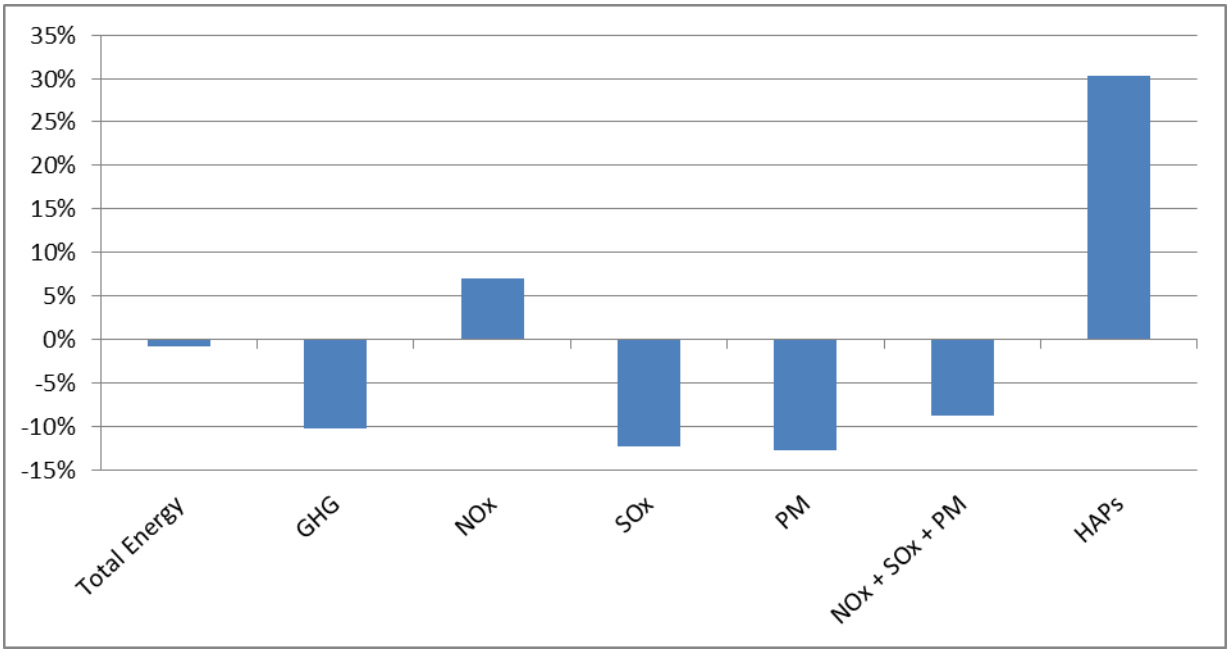


Chart 7. Percent Difference in Footprints of MNA Remedy Component in Alternative G-2 from Including Laboratory Analysis as a Footprint Contribution Category

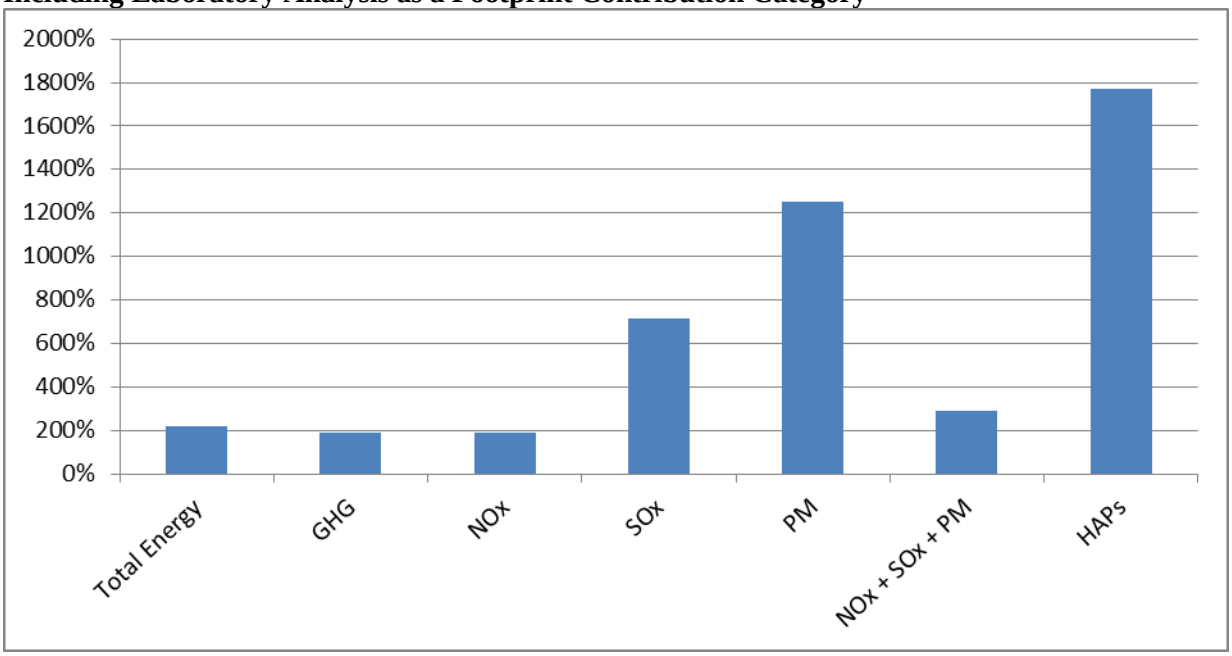
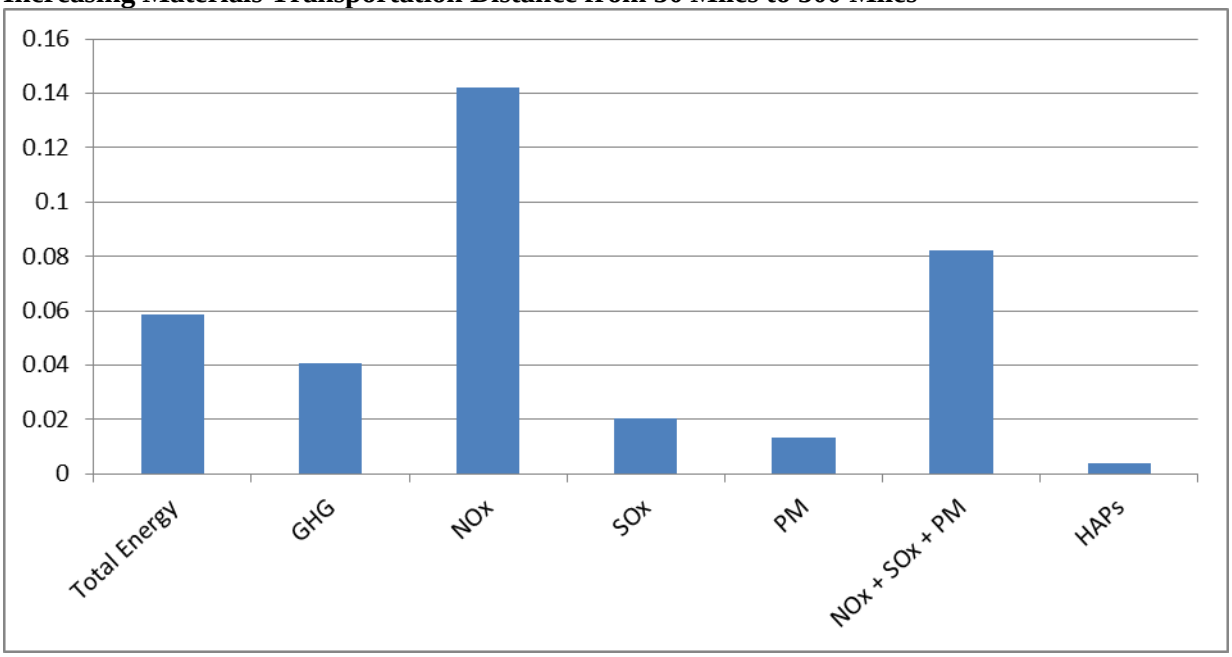


Chart 8. Percent Difference in Footprints of PRB Remedy Component in Alternative G-2 from Increasing Materials Transportation Distance from 50 Miles to 500 Miles



ATTACHMENT A

Coordination of Site Data Input

Provided by the ESTCP Project with Information Added for SEFA

Final 12/5/13

Coordination of Site Data Input: Alameda Point OU-2B

FOR

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

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INTRODUCTION

Operable Unit 2B (OU-2B) at Alameda Point in Alameda, CA consists of Installation Remediation sites 3, 4, 11, and 21. The following are brief descriptions of these four sites:

- Site 3 is the Abandoned Fuel Storage area and is impacted with lead, PAHs and petroleum hydrocarbons including benzene, ethylbenzene, and naphthalene.

- Site 4 is associated with Building 360 (Aircraft Engine Facility) and is impacted by chlorinated solvents and metals. Polychlorinated biphenyls (PCBs) and pesticides have also been detected in the soil and remain present soil after limited excavation and removal of an oil water separator.

- Site 11 is associated with Building 360 (Engine Test Cell) and the soil at this site has limited polyaromatic hydrocarbon (PAH) and metals.

- Site 21 is associated with Building 162 (Ship Fitting and Engine Repair) and is primarily impacted by chlorinated solvents.

The April 2011 *Revised Draft Revision 2 Feasibility Study Report Operable Unit 2B, Installation Restoration Sites 3, 4, 11, and 21* prepared by Oneida Total Integrated Enterprises LLC on behalf of Naval Facilities Engineering Command documents analysis of remedial alternatives for these four sites.

Information and data required for a GSR footprint evaluation for the groundwater remedy at Alameda Point was from this document including the cost estimating data in Appendix C and the Sustainable Environmental Remediation Evaluation provided in Appendix D.

For this evaluation, footprints will be evaluated for the following soil and groundwater remedial alternatives:

- Soil Alternatives:

    - S-2 – Excavation and Disposal of Impacted Soil

- Groundwater Alternatives:

    - G-2 – In-Situ Thermal Treatment (ISTT) of Hot-Spots, Control/Treatment at the Seaplane Lagoon using Permeable Reactive Barriers (PRBs), Monitored Natural Attenuation (MNA), and Institutional Controls (ICs)

    - G-3 – Hot-Spots Treatment, Shallow Groundwater Treatment, MNA, and ICs

    - G-4 – Treatment of Entire Plume using Groundwater Recirculation, PRBs, and ICs

Alternatives S-1 and G-1 are "No-Action" alternatives for soil and groundwater are assumed to have no environmental footprint. A brief description of the other alternatives is as follows:

- Alternative S-2 involves the following (see Tables 3, 5, and 7 of Appendix C of the FS):
    - Excavation and off-site disposal of impacted soil from Sites 3, 4, and 11
    - Dewatering and confirmation sampling

- Alternative G-2 involves the following (see Table 9 of Appendix C of the FS):
    - ISTT construction and operation
    - PRB installation for Control/Treatment at the Seaplane Lagoon
    - MNA of remaining groundwater plume
    - Institutional controls

- Alternative G-3a involves the following (see Table 11 of Appendix C of the FS):
    - ISTT remedy – same as G-2
    - Shallow groundwater treatment with in-situ chemical oxidation
    - MNA
    - Institutional controls

- Alternative G-3b involves the following (see Table 13 of Appendix C of the FS):
    - ISTT remedy – same as G-2
    - Shallow groundwater treatment with in-situ bioremediation
    - MNA – same as G-3a
    - Institutional controls

- Alternative G-4 involves the following (see Table 15 of Appendix C of the FS):
    - Groundwater extraction, treatment, and reinjection
    - PRB installation
    - Plume and performance monitoring
    - Institutional controls

The intent of this document is to provide a basis for the development of input for the SimaPro and SiteWise tools for these alternatives.

ALTERNATIVE S-2:
SOIL REMEDIATION OF SITES 3, 4, AND 11

Remedy Overview

The following table summarizes the excavation-related activities at the three sites included in Alternative S-2 (see Tables 3, 5, and 7 of Appendix C of the FS).

Parameter	Site 3	Site 4	Site 11	Total
Excavated Soil for Disposal	3,900 bcy	7,282 bcy	1,750 bcy	12,932
Excavated Uncontaminated Overburden	2,950 bcy	0 bcy	1,500 bcy	4,450
Maximum Depth of Excavation	8 feet bgs	15 feet bgs	8 feet bgs	Varies
Number of confirmation samples	25 (lead) 15 (PAH)	10 (PCBs*) 50 (As & An*)	20 (PAH)	Varies
Number of clean fill samples	13	16	6	35
Volume of Backfill	3,900 bcy	7,282 bcy	1,750 bcy	12,932
Volume of hazardous waste disposal	1,700 bcy	7,282 bcy	0 bcy	8,982
Volume of non-hazardous waste disposal	2,200 bcy	0 bcy	1,750 bcy	3,950
One-way transport distance for hazardous waste	200 miles	200 miles	NA	NA
One-way transport distance for non-hazardous waste	41 miles	NA	41 miles	NA

Site 3 excavation includes separate excavations for lead and PAH contaminated soil
Site 4 excavation includes separate excavation for PCB/pesticide contaminated soil and arsenic/antimony contaminated soil
Site 11 excavation includes excavation of PAH contaminated soil
PCBs refers to both PCB and pesticide analyses in this instance*
As & An refers to arsenic and antimony*

As indicated in the RACER input provided in Appendix C of the FS, excavation is assumed to require dewatering. After excavation, soil would be temporarily stockpiled and characterized for disposal. Confirmation soil samples would be collected from the sidewalls and bottoms of the excavations. The excavations will then be backfilled with unclassified fill. The disposal of the water is not considered as a cost of this remedy within the RACER files and therefore was not considered as an input to the GSR analysis.

Tetra Tech (TT) will estimate the parameters that are unavailable. Estimated data will include the distance of the laboratory relative to the site, the method of transportation for the samples to the laboratory, the round trip distance traveled by site workers and number of workers necessary for this alternative. TT will estimate the time to remedy operation and completion and equipment required, if information is not provided by site documents.

Detailed Basis for Footprint Evaluation

Tables S-2A through S-2I summarize the information that will serve as the basis for the footprint evaluation of Alternative S-2 ("Soil Remedy") and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-2: GROUNDWATER - ISTT OF HOT-SPOTS, CONTROL/TREATMENT AT SEAPLANE LAGOON USING PRB, MNA, AND ICS

Remedy Overview

Alternative G-2 involves the following (see Table 9 of Appendix C of the FS):

- ISTT remedy
    - Installation of 55 ISTT electrodes and co-located vapor extraction wells addressing approximately 29,100 square feet of hot-spots with depths ranging from 15 to 40 feet
    - Installation of power control units with a total of 3,100 kW
    - Installation of a vapor extraction piping and blowers
    - Operation of the ISTT system, including heating, vapor extraction, and vapor treatment with granular activated carbon (GAC)
    - Installation of 28 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 855 feet, including total combined screen length of 280 feet
    - 5 rounds of groundwater sampling from 53 monitoring wells (new and existing) for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, VOCs, and metals
- Control/Treatment at the Seaplane Lagoon
    - Installation of a 500-foot PRB to a depth of approximately 70 feet bgs by injection of 165 cubic yards of zero-valent iron with direct-push drill rigs (50 injection points)
    - Installation of 18 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 810 feet, including total combined screen length of 180 feet
    - 43 rounds of groundwater sampling from 18 wells over the course of 36 years for DO, ORP, pH, ferrous iron, VOCs, anions, metals, dissolved gases, and alkalinity
    - Two replacements of the PRB media with the same quantity and same method

- MNA (interpretation of data based on information provided in Table 9)
    - Installation of 68 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 2,690 feet, including total combined screen length of 680 feet
    - 17 rounds of groundwater sampling from 126 wells over the course of the first 10 years
    - 10 rounds of groundwater sampling from 96 wells over the course of years 11 through 20
    - 10 rounds of groundwater sampling from 66 wells over the course of years 21 through 30
    - 6 rounds of groundwater sampling from 36 wells over the course of years 31 through 36
    - Samples from all wells would be analyzed for DO, ORP, pH, and VOCs
    - 25% of the samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, total organic carbon (TOC), and dissolved gases
- Institutional controls
    - Activities with a negligible contribution to the footprint
- Replacement Wells
    - Based on TT interpretation of Table 9, 28 monitoring wells will need to be replaced over the course of the remedy. These wells are estimated to have an average depth of 45 feet, with 10 feet of screen. A hollow stem auger will be used to drill, and 2-inch Schedule 40 PVC will be placed for wells.

Detailed Basis for Footprint Evaluation

Tables G-2-A through G-2-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-2 and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-3A: GROUNDWATER - ISTT OF HOT-SPOTS, SHALLOW GROUNDWATER TREATMENT WITH ISCO, MNA, AND ICS

Remedy Overview

Alternative G-3a involves the following (see Table 11 of Appendix C of the FS):

- ISTT remedy – same as G-2
- Shallow groundwater treatment with in-situ chemical oxidation
    - 3 events
    - 656 injection points via direct-push per event from 5 to 30 feet bgs
    - 370,000 gallons of 12% hydrogen peroxide per event
    - 370,000 gallons of chelated iron catalyst per event
    - Installation of 29 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 730 feet, including total combined screen length of 290 feet
    - 6 rounds of groundwater sampling from 55 monitoring wells (new and existing) for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, ferrous iron, VOCs, and metals
- MNA
    - Installation of 39 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 1,960 feet, including total combined screen length of 390 feet
    - 8 rounds of groundwater sampling from 71 wells over the course of the first 3 years
    - 9 rounds of groundwater sampling from 126 wells over the course of years 4 through 10
    - 10 rounds of groundwater sampling from 88 wells over the course of years 11 through 20

  - 8 rounds of groundwater sampling from 50 wells over the course of years 21 through 28
  - Samples from all wells would be analyzed for DO, ORP, pH, and VOCs
  - 25% of the samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, total organic carbon (TOC), and dissolved gases

- Institutional controls
  - Activities with a negligible contribution to the footprint

- Replacement Wells
  - Based on TT interpretation of Table 9, 28 monitoring wells will need to be replaced over the course of the remedy. These wells are estimated to have an average depth of 45 feet, with 10 feet of screen. A hollow stem auger will be used to drill, and 2-inch Schedule 40 PVC will be placed for wells.

Detailed Basis for Footprint Evaluation

Tables G-3A-A through G-3A-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-3A and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-3B: GROUNDWATER - ISTT OF HOT-SPOTS, SHALLOW GROUNDWATER TREATMENT WITH BIOREMEDIATION, MNA, AND ICS

Remedy Overview

Alternative G-3b involves the following (see Table 13 of Appendix C of the FS):

- ISTT remedy – same as G-2
- Shallow groundwater treatment with in-situ bioremediation
    - One event with 656 injection points injecting 1,427 drums of EOS® emulsified oil (plus water) via direct-push from 5 to 30 feet bgs
    - A second event with 328 injection points injecting 713 drums of EOS® emulsified oil (plus water) via direct-push from 5 to 30 feet bgs
    - Installation of performance monitoring wells as in G-3a
    - 10 rounds of groundwater sampling from 55 monitoring wells (new and existing) for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, ferrous iron, VOCs, and metals
- MNA – same as G-3a
- Institutional controls
    - Activities with a negligible contribution to the footprint

Detailed Basis for Footprint Evaluation

Tables G-3B-A through G-3B-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-3B and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-4: GROUNDWATER – TREATMENT OF ENTIRE PLUME USING RECIRCULATION, PRBS, AND ICS

Remedy Overview

Alternative G-4 involves the following (see Table 15 of Appendix C of the FS):

- Recirculation systems
    - Installation of 19 6-inch PVC extraction wells
    - Installation of 24 6-inch PVC injection wells
    - Estimated combined flow rate of 100 gpm
    - 450 feet of 4-inch PVC pipe
    - 2,500 feet of 6-inch PVC pipe
    - 100 feet of 8-inch PVC pipe
    - Installation of UV/oxidation treatment system
    - Operation of the recirculation system and treatment system for 35 years
    - Installation of 68 2-inch PVC monitoring wells via hollow stem auger with a total depth of 2,690 feet and a total screened interval of 680 feet
    - 17 rounds of groundwater sampling from 126 wells over the course of the first 10 years
    - 10 rounds of groundwater sampling from 96 wells over the course of years 11 through 20
    - 10 rounds of groundwater sampling from 66 wells over the course of years 21 through 30
    - 5 rounds of groundwater sampling from 36 wells over the course of years 31 through 35
    - Samples from all wells would be analyzed for DO, ORP, pH, and VOCs.

  - 25% of the samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, total organic carbon (TOC), and dissolved gases

- Installation of two PRBs

  - 600-foot PRB constructed via direct-push injection of 170 cubic yards of zero valent iron

  - 500-foot PRB constructed via direct-push injection of 165 cubic yards of zero valent iron

  - Installation of 36 2-inch PVC monitoring wells via hollow stem auger with a total depth of 1,620 feet and a total screened interval of 360 feet

  - 42 rounds of groundwater sampling from 36 wells over the course of 35 years for DO, ORP, pH, ferrous iron, VOCs, anions, metals, dissolved gases, and alkalinity

Detailed Basis for Footprint Evaluation

Tables G-4-A through G-4-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-4 and the input parameters to SimaPro and SiteWise.

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TABLES

Note: Cells that are shaded in gray are entries that are the same as a previous alternative

Tables for Alternative S-2

Note: Cells that are shaded in gray are entries that are the same as a previous alternative

Table S2-A: Electricity Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Trash Pump	• Need based on comments in the Feasibility Study. No details or estimates for use provided. • Due to time of rental for trash pump (75 gpm, total 19 days), electricity usage assumed by TT to be de minimis to the footprint of this remedy. (Less than 1000 kWh)	de minimis	de minimis	de minimis

Table S2-B: Fuel Use for Equipment: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Heavy equipment for soil excavation • Assume an excavator (diesel) will be used to move 17,382 yd^3 (includes 12,932 yd^3 of excavated soil and 4,450 yd^3 excavated uncontaminated overburden)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Assumed use of excavator (TT estimate) • Assume medium excavator has 175 HP, .75 PLF, and 720 cy/day production rate • 17382 cy / 720 cy/day = 24.14 days x 8 hrs = 193 hrs	• Excavator to move 17,382 yd^3 *SimaPro Assembly Name: Fuel Use_S2_Excavation* *Process used: Excavation, hydraulic digger/RER U (Ecoinvent)* *Amount input: 17382 cu yd*	• Excavator to move 17,382 yd^3	*On-Site Equipment Use, etc.* Selected: "Excavator – medium", 175 HP, 75% load factor, Diesel fuel, 193 hours operated 1266.6 Gallons of Fuel Used *S-2_energy_(020513).xlsx → S-2 → Row 31*
Heavy equipment for soil backfill • Assume an excavator (diesel) will be used to move 17,382 yd^3 (includes 12,932 yd^3 of backfill plus replacement of 4,450 yd^3 of uncontaminated overburden)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Assumed use of excavator (TT estimate) • Assume medium excavator has 175 HP, .75 PLF, and 720 cy/day production rate • 17382 cy / 720 cy/day = 24.14 days x 8 hrs = 193 hrs	• Excavator to move 17,382 yd^3 *SimaPro Assembly Name: Fuel Use_S2_Backfill* *Process used: Excavation, hydraulic digger/RER U (Ecoinvent)* *Amount input: 17382 cu yd*	• Excavator to move 17,382 yd^3	*On-Site Equipment Use, etc.* Selected: "Excavator – medium", 175 HP, 75% load factor, Diesel fuel, 193 hours operated 1266.6 Gallons of Fuel Used *S-2_energy_(020513).xlsx → S-2 → Row 32*
Heavy equipment used for compaction • Assume a compactor	• Based on TT professional judgment of compaction equipment fuel consumption rate and required use.	• 1,000 gallons of diesel fuel *SimaPro Assembly Name: Fuel Use_S2_Compactor* *Process Used: Diesel, combusted in industrial equipment/US(USLCI)* *Amount input: 1000 gal**	• 1,000 gallons of diesel fuel entered into "Industrial Combustion Engine"	*On-Site Equipment Use, etc.* Input into blank row: Compactor, Diesel fuel 1000 Gallons of Fuel Used On-Site *S-2_energy_(020513).xlsx → S-2 → Row 39*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Dump truck used on site	• Assume fuel consumption rate of 1 gal/hr on site • Site team reported an estimate of 120 days of use for construction equipment • 120 days x 8 hrs per day = 960 gallons of diesel	• 960 gallons of diesel *SimaPro Assembly Name: Fuel Use_S2_Dump Truck* *Process Used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 960 gal**	• 960 gallons of diesel	*On-Site Equipment Use, etc.* Input into blank row: Dump truck, Diesel fuel 960 Gallons of Fuel Used *S-2_energy_(020513).xlsx → S-2 → Row 40*

Table S2-C: Materials Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Clean fill for excavated area • 12,932 yd^3 of clean soil	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards	• 12,932 yd^3 x 1.5 tons per yd^3 =19,398 tons of clean soil *SimaPro Assembly Name: Material Use_S2_Fill* *Materials/Assemblies used: Gravel, unspecified, at mine/CH U (Ecoinvent)* *Amount input: 19398 tn.sh*	• 19,398 tons of clean soil Input to SiteWise: Soil 38,796,000 lbs	*Material Use and Trans.* Selected: "Other unrefined construction material" Input: 38796000 lbs. *S-2_energy_(020513).xlsx → S-2 → Row 67* PLUS *Excavation and Disposal - Unrefined Materials Footprint Summary* Input: Clean Soil for excavated area (12932 cy), tons, 19398, 1, 0 *S-2_main_(020513).xlsx → Materials 1 → Row 56*

Table S2-D: Transport for Materials, Equipment, and Samples: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transportation of equipment • Excavator for excavation and backfill • Compactor	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight of equipment based on professional estimates • TT estimated that vehicle transporting each piece of equipment delivers equipment to site, leaves empty, returns to site empty and leaves with equipment, for a total of two round trips for each equipment use.	• 2 trips x 50 miles one way= 100 miles • Excavator weighs 26 tons • Diesel fuel AND • 2 trips x 50 miles one way= 100 miles • Compactor weighs 5 tons • Diesel fuel *Empty trips included* *SimaPro Assembly Name: Transport of Materials_S2_Equipment* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 2600 ton-miles AND 500 ton-miles*	• 2 trips x 50 miles one way=100 miles • Excavator weighs 26 tons • Assume diesel fuel AND • 2 trips x 50 miles one way= 100 miles • Compactor weighs 5 tons • Assume diesel fuel AND • 4 x 50= 200 miles return trip • Weight 0 tons • Assume diesel fuel	*Material Use and Trans.* <u>Excavator</u> Input: 2 roundtrips, 100 miles, Diesel *S-2_energy_(020513).xlsx → S-2 → Row 31* <u>Compactor</u> Input: 2 roundtrips, 100 miles, Diesel *S-2_energy_(020513).xlsx → S-2 → Row 33*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of clean fill for excavated area • 12,932 yds^3	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards • TT estimated dump truck volume of 20 yards • 12,932 yds^3 x 1.5 tons per yds^3 = 19,398 tons clean soil • 19,398 tons soil / 30 tons per dump truck = 647 dump truck loads (trips) • TT estimated 50 miles from fill source to site	• 647 trips x 50 miles one way = 32,350 miles • Weight of load for each trip = 30 tons *Empty trip included* *SimaPro Assembly Name: Transport of Materials_S2_clean fill* *Process used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount: 970,500 ton-miles*	Delivery • 647 trips • 30 tons • 50 miles one way Empty return trips • 647 trips • 0 tons • 50 miles one way	*Material Use and Trans.* Trips to Site Input: 50 one-way miles, 647 trips, Truck (mpg), Diesel 5391.7 Gallons of Fuel Used *S-2_energy_(020513).xlsx → S-2 → Row 67* Trips from Site (empty) Input: 50 one-way miles, 647 trips, Truck (mpg), Diesel 5391.7 Gallons of Fuel Used *S-2_energy_(020513).xlsx → S-2 → Row 68*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport for Samples to Lab	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C reports: o Chemical profiling will be performed for the dewatered soil and the water that results from the dewatering process o Confirmation soil samples taken from the bottom and sidewalls of the excavated pit will be taken to ensure compliance with RAOs. o Sampling for backfill for clean confirmation sampling will also take place • TT estimates this sampling to require 20 trips to lab • TT estimated a distance of 50 miles, one way, to lab	• 20 trips x 100 miles round trip to lab = 2000 miles • Assume light truck, gasoline *SimaPro Assembly Name: Transport_S2_samples to lab* *Process used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount: 2000 miles*	• 20 trips x 100 miles round trip to lab = 2000 miles • Assume light truck, gasoline	*Labor, Mobilization, etc.* Sample Transportation Input: 20 trips, 100 miles round trip, Light-Duty Truck, Gasoline 118 Gallons of Fuel Used *S-2_energy_(020513).xlsx → S-2 → Row 17*

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table S2-E: Waste Transport/Disposal: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of excavated soil to hazardous landfill • 8,982 yd^3 (13,473 tons) of excavated soil	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards • TT estimated dump truck volume of 20 yards • TT estimated 20 yd^3 (30 ton) dump truck volume • Dump truck volume and volume of soil transported requires 450 loads of soil • TT estimated 200 miles one way from site to landfill	• 450 trips x 200 miles one way = 90,000 miles one way driven for disposal • 30 tons each load • 90,000 miles x 30 tons= 2,700,000 tmi *Empty trip included* *SimaPro Assembly Name: Waste_S2_Transport of excavated soil* *Process used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount: 2700000 ton mile* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill* *30 tons x 450 trips = 13,473 tons*	Transport to landfill • 30 ton dump truck volume • 450 trips • 90,000 miles one way from site to landfill Empty trip • 0 ton dump truck volume • 450 trips • 90,000 miles one way from site to landfill 30 tons x 450 trips = 13,473 tons to hazardous landfill	*Waste Trans. and Disposal* Selected: "Hazardous waste landfill" Input: 13473 tons, 200 miles, 900 one-way trips, Truck (mpg), Diesel *S-2_energy_(020513).xlsx → S-2 → Row 89* PLUS *Excavation and Disposal – Waste Footprint Summary* Input: Soil to hazardous landfill, 13473 *S-2_main_(020513).xlsx → Waste 1 → Row 35*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of excavated soil to non-hazardous landfill • 3950 yd^3 of excavated soil	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards; 3950 yd^3 x 1.5 tons per yd^3 = 5925 tons • TT estimated dump truck volume of 30 tons • 5925 tons / 30 tons per load requires 198 loads of soil • 41 miles one way from site to Altamont Landfill (FS)	• 41 miles x 198 trips = 8,118 miles one way driven for disposal • 30 tons load • 8,118 miles x 30 tons= 243,540 tmi *Empty trip included* *SimaPro Assembly Name: Waste_S2_Transport of excavated soil NON hazardous* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount: 243540 ton mile* *Disposal as LC with dummy soil input.* *30 tons x 198 trips = 5,925 tons to non-hazardous landfill* *(Disposal, concrete, 5% water, to inert material landfill/CH U)*	Transport to landfill • 30 ton dump truck volume • 198 trips • 8,118 miles one way from site to landfill Empty trip: • 0 ton dump truck volume • 198 trips • 8,118 miles one way from site to landfill 30 tons x 198 trips = 5,925 tons to non-hazardous landfill	*Waste Trans. and Disposal* Selected: "Non-hazardous waste landfill" Input: 5925 tons, 41 miles, 396 one-way trips, Truck (mpg), Diesel *S-2_energy_(020513).xlsx → S-2 → Row 90* PLUS *Excavation and Disposal – Waste Footprint Summary* Input: Soil to non-hazardous landfill, 5925 *S-2_main_(020513).xlsx → Waste 1 → Row 47*

Table S2-F: Transport for Personnel: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport to site for labor performing excavation and backfilling	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Site team estimates 120 days for the crew to be on site to complete remedy • TT estimated four person crew • TT estimated 25 miles, one way for site labor to travel to site	• 4 x 120 = 480 trips • 50 miles, round trip • 480 trips x 50 miles round trip = 24000 miles • Assume car, gasoline • One passenger per vehicle *SimaPro Assembly Name: Trans for Personnel_S2_labor ex and backfill Materials/Assemblies used: Transport, passenger car/RER U (Ecoinvent) Amount input: 24000 pmi*	• 4 x 120 = 480 trips • 50 miles, round trip • Assume car, gasoline • One passenger per vehicle	*Labor, Mobilization, etc.* <u>Excavation and Backfill team</u> Input: 4 crew, 120 days, 8 hrs worked, 480 trips, 50 miles round trip, Car, Gasoline 24000 Total Miles *S-2_energy_(020513).xlsx → S-2 → Row 16*

Table S2-G: Potable Water Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant use of potable water identified for this alternative			

Table S2-H: Non-Potable Water Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant use of non-potable water identified for this alternative			

Table S2-I: Known Use of On-Site Renewables: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant use of on-site renewables identified for this alternative			

Table J: eGRID Subregion CAMX--WECC, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	11.9033	26,141,141.50
Oil	1.1747	2,579,750.70
Gas	42.2704	92,830,630.50
Other Fossil	1.0291	2,259,976.30
Nuclear	16.4631	36,154,898.00
Other Unknown / Purchased Fuel	0.0943	207,005.90
Nonrenewable Total	72.9348	160,173,402.90
Renewable Resource		
Wind	1.9396	4,259,490.60
Solar	0.2444	536,713.30
Geothermal	4.6211	10,148,526.60
Biomass	2.6088	5,729,247.80
Hydro	17.6513	38,764,274.90
Renewable Total	27.0652	59,438,253.30

Tables for Alternative G-2

Note: Cells that are shaded in gray are entries that are the same as a previous alternative

Table G2-A: Electricity Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Operation of ISTT Electrodes and vapor extraction • Includes 55 ISTT electrode	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 200 kWh per yd^3 based on TT engineering estimate (heating and vapor extraction) • Soil treated: 29,100 ft^2 x 36 ft = 1,047,600 ft^3= 38,800 yd^3 • 38,800 yd^3 x 200 kWh per yd^3 = 7,760,000 kWh	7,760,000 kWh *SimaPro Assembly Name: Electricity_G2_Op of ISTT* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 7760 p*	7,760,000 kWh	7,760,000 kWh *On-Site Electricity Use* Total Grid Electricity = 7760000 kWh *G-2_energy_(020513).xlsx → ISTT → Row 59* *Grid mix shown in Table 1-J entered into G-2_energy_(020513).xlsx → Grid Electricity → Fuel Mix for Grid Electricity*
PRB				
Pump for use with direct push injection rig	• TT estimated a 2.5 kWh daily electrical usage • (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C RACER appendix provides time for use of rig at 180 days • At 2.5 kWh per day x 180 days = 450 kWh	450 kWh *SimaPro Assembly Name: Electricity_G2_pump for direct push* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 0.450 p*	450 kWh	450 kWh *On-Site Electricity Use* Total Grid Electricity = 450 kWh *G-2_energy_(020513).xlsx → PRB → Row 59*

Table G2-B: Fuel Use for Equipment: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Equipment used for the construction of the ISTT system: • Installation of 55 ISTT electrodes and co-located vapor extraction wells (to address 29,100 ft^2 of hot spots with average depth of 36 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "Comparison of Construction Materials" provided by NAVFAC • 3-inch Schedule 80 steel pipe within a 12-inch diameter borehole • 55 electrodes to 36 feet deep = 1,980 linear feet • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 20, 8-hr days = 160 hours of use. • To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 160 x 0.050 x 0.75 = 900 gals (refer to EPA, 2012, pg 59)	• Equipment Type: Hollow stem auger • 55 electrodes to 36 feet deep = 1,980 linear feet • 160 hours Fuel Use= 900 gals *SimaPro Assembly Name: Fuel_G2_ISTT construction* *Process Used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 900 gal**	• Hollow stem auger • 160 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 160 hours operated 900 Gallons of Fuel Used *G-2_energy_(020513).xlsx → ISTT → Row 31*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Equipment used for the installation of 28 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 855 feet (including screen length of 280 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 9 days, 8-hr days= 72 hours of use. • To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 72 x 0.050 x 0.75 = 405 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • Drilling 855 linear feet 72 hours of use *SimaPro Assembly Name: Fuel_G2_construction 28 wells* *Process Used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 405 gal**	• Hollow stem auger • 72 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 72 hours operated 405 Gallons of Fuel Used *G-2_energy_(020513).xlsx → ISTT → Row 32*
PRB				
Direct Push Rig, Truck Mounted, Non-Hydraulic • Sampling and PRB media installation (By injection of 165 yds^3 of zero valent iron with direct push drill rigs • 180 days of use	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (RACER pdf pg. 148) • 180 days x 8 hours per day = 1,440 hours (on-site use) • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 1440 x 0.050 x 0.75 = 3240 gals (refer to EPA, 2012, pg 59)	• Direct push rig • 1,440 hours 3240 gals of fuel *SimaPro Assembly Name: Fuel_G2_PRB_PRB installation* *Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 3240 gal**	• Direct push rig • 1,440 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – direct push", 60 HP, 75% load factor, Diesel fuel, 1440 hours operated 3240 Gallons of Fuel Used *G-2_energy_(020513).xlsx → PRB → Row 33*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Equipment used for the installation of 18 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 810 feet (including screen length of 180 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 810 linear feet / 100 feet per day = 8.1, 8 hour days = 64.8 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 64.8 x 0.050 x 0.75 = 364.5 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 8.1 linear feet • 64.8 hours • 364.5 gals *SimaPro Assembly Name: Fuel_G2_PRB_18 new wells* *Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 364.5 gal**	• Hollow stem auger • 8.1 linear feet • 64.8 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 64.8 hours operated 364.5 Gallons of Fuel Used *G-2_energy_(020513).xlsx → PRB → Row 34*
Equipment used for the PRB Media Replacement • Two replacement events, total	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated the two replacement events as being twice the amount of equipment use in the original placement (1,440 hours x 2 = 2,880 hours) • Fuel Use = 2 x 3240 gals = 6480 gals	• Direct push drill: • 2,880 hours • Fuel use = 6480 gals *SimaPro Assembly Name: Fuel_G2_PRB_PRB replacement media* *Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 6480gal**	• Direct push drill • 2,880 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – direct push", 60 HP, 75% load factor, Diesel fuel, 2,880 hours operated 6480 Gallons of Fuel Used *G-2_energy_(020513).xlsx → PRB → Row 35*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
Equipment used for the installation of 68 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 2,690 feet (including screen depth of 680 feet)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012). • 2,690 linear feet / 100 feet per day = 27, 8 hour days = 216 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 216 x 0.050 x 0.75 = 1215 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 2,690 linear feet • 216 hours of use • Fuel use = 1215 gals *SimaPro Assembly Name: Fuel_G2_MNA_68 wells installed* *Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 1215 gal**	• Hollow stem auger • 216 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 216 hours operated 1215 Gallons of Fuel Used *G-2_energy_(020513).xlsx → MNA → Row 36*
Replacement of monitoring wells • Using hollow stem auger • Total combined depth of 1,260 ft (28 wells at an average of 45 feet deep)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf page 32) • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) 1,260 linear feet / 100 feet per day = 12.6, 8-hr days = 100.8 hours of use • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 100.8 x 0.050 x 0.75 = 567 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,260 linear feet • 100.8 hours of use Fuel use = 567 hours *SimaPro Assembly Name: Fuel_G2_MNA_replacement of monitoring wells* *Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 567gal**	• Hollow stem auger • 100.8 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 100.8 hours operated 567 Gallons of Fuel Used *G-2_energy_(020513).xlsx → MNA → Row 37*

Table G2-C: Materials Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment ***(all capital construction equipment not listed below, that is required, is assumed to be on-site , stored in Building 5 and reused from a previous pilot (Comparison of Construction Materials document provided by NAVFAC)therefor it is not being footprinted as a part of this GSR analysis, or are de minimis items.***				
GAC • Carbon change out for liquid and vapor phase units	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "List of ERH Materials and Estimated Technology Costs" provided by NAVFAC • TT professional judgment: carbon units will require quarterly carbon change outs for one year. • Estimates of carbon required developed from volume of GAC used in 2007 pilots, TT estimated the following usage (document above) based on those pilot studies: o Two 8,000 lbs vapor phase units o Two 3,000 lbs liquid phase units o Total per quarter = 22,000 lbs	22,000 lbs x 4 fills = 88,000 lbs. of GAC / 2.2 lbs per kg = 40,000 kg *SimaPro Assembly Name: Material_G2_ISTT_GACMaterials/Assemblies used: Virgin GAC Assembly_1kg(TT assembly) Amount input: 40000 p*	88,000 lbs. of GAC	*Material Use and Trans.* Selected: "Virgin GAC (coal based)" Input: 88000 lbs. *G-2_energy_(020513).xlsx → ISTT → Row 67* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: GAC, lbs., 88000, 1, 0 *G-2_main_(020513).xlsx → Materials 1 → Row 9*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Drilled Electrodes composition • Steel pipe (370 lbs/electrode) • Graphite (8,400 lbs/electrode) • Steel shot (1,040 lbs/electrode)	• Document, "Comparison of Construction Materials" provided by NAVFAC • Steel pipe: 370 lbs/electrode x 55 electrodes = 20,350 lbs of steel • Graphite: 8,400 lbs/electrode x 55 electrodes = 462,000 lbs of graphite • Steel shot: 1,040 lbs/electrode x 55 electrodes = 57,200 lbs of steel shot • Total Steel: Steel pipe + steel shot = 20,350 + 57,200 = 77,550 lbs of total steel	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs *SimaPro Assembly Name: Material_G2_ISTT_Electrodes* *Materials/Assemblies used: Steel, billets, at plant/US(USLCI)* *Amount input: 77550 lb* *AND* *Materials/Assemblies used: Graphite, at plant/RER U (Ecoinvent)* *Amount input: 462000 lb*	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite (Surrogate for graphite, Material A with one-half the emission footprint of iron) Amount: 462,000 lbs	*Material Use and Trans.* Selected: "Steel" Input: 20350 lbs. *G-2_energy_(020513).xlsx → ISTT → Row 69* PLUS Selected: "Steel" Input: 57200 lbs. *G-2_energy_(020513).xlsx → ISTT → Row 70* PLUS Selected: "Other refined construction materials" Input: 462000 lbs. *G-2_energy_(020513).xlsx → ISTT → Row 71* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: Steel, lbs., 77500, 1, 0 *G-2_main_(020513).xlsx → Materials 1 → Row 10* PLUS Input: Graphite, lbs., 462000, 1, 0 *G-2_main_(020513).xlsx → Materials 1 → Row 11*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PVC (for 28 new monitoring wells) • 2-inch, Schedule 40 • 855 ft total combined length • 280 feet of screen	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 581.4 lbs PVC	581.4 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_ISTT_PVC 28 mon wells* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 581.4*	Input to SiteWise: 855 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 581.4 lbs. *G-2_energy_(020513).xlsx → ISTT → Row 72* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: PVC, lbs., 581.4, 1, 0 *G-2_main_(020513).xlsx → Materials 1 → Row 12*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 855 ft = 11,115 lbs of grout/cement / 2000 lbs per ton = 5.6 tons of cement	5.6 tons of cement *SimaPro Assembly Name: Material_G2_ISTT_Grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 5.6 tn.sh.*	5.6 tons of cement Input to SiteWise: 11,200 lbs Typical Cement	*Material Use and Trans.* Selected: "Cement" Input: 11200 lbs. *G-2_energy_(020513).xlsx → ISTT → Row 73* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: Cement, lbs., 11200, 1, 0 *G-2_main_(020513).xlsx → Materials 1 → Row 13*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PRB				
Zero valent iron (a.k.a. "iron filings") • 165 cubic yards for injection	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (RACER pg 148) • Density of zero valent iron = ~2.6 grams/cm^3(http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • 2.6 g/cm^3 x 764554.858 cm^3 per yd^3/ 453.6 g per pound / 2000 lbs per ton = 2.19 ton per yd^3 ZVI. • 165 yds^3 of ZVI x 2.19 tons per cubic yard = 361.35 tons ZVI	361.35 tons zero valent iron (iron filings) *SimaPro Assembly Name: Material_G2_PRB_iron filings* *Materials/Assemblies used: Pellets, iron, at plant/GLO U (Ecoinvent)* *Amount input: 361.35*	361.35 tons zero valent iron (iron filings) Input to SiteWise: 722,700 lbs ZVI	*Material Use and Trans.* Selected: "Steel" Input: 722700 lbs. *G-2_energy_(020513).xlsx → PRB → Row 74* PLUS *Control/Treatment, etc. - Refined Materials Footprint Summary* Input: Zero Valent Iron, tons, 361.35, 2000, 0 *G-2_main_(020513).xlsx → Materials 2 → Row 9*
PVC (for 18 new monitoring wells) • 2-inch, Schedule 40 • 810 ft combined length • 180 screen length	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 810 ft x 0.68 lbs per ft = 550 lbs PVC	550 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_PRB_PVC 18 mw* *Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 550*	Input to SiteWise: 810 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 550 lbs. *G-2_energy_(020513).xlsx → PRB → Row 75* PLUS *Control/Treatment, etc. - Refined Materials Footprint Summary* Input: PVC, lbs., 550, 1, 0 *G-2_main_(020513).xlsx → Materials 2 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Two replacements of PRB media • 165 cubic yards for injection x 2 replacements = 330 cubic yards zero valent iron	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Density of zero valent iron = ~2.6 grams/cm^3 (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • (2.6 g/cm^3 x 764554.858 cm^3 per yard / 453.6 g per pound / 2000 lbs per ton = 2.19 ton per cubic yd ZVI. • 165 yds^3 of ZVI x 2.19 tons per cubic yard = 361.35 tons ZVI x 2= 722.7 tons ZVI	722.7 tons zero valent iron (iron filings) *SimaPro Assembly Name: Material_G2_PRB_two iron filings replacements* *Materials/Assemblies used: Pellets, iron, at plant/GLO U (Ecoinvent)* *Amount input: 722.7 tn.sh*	722.7 tons yards zero valent iron (iron filings)	*Material Use and Trans.* Selected: "Steel" Input: 1445400 lbs. *G-2_energy_(020513).xlsx → PRB → Row 76* PLUS *Control/Treatment, etc. - Refined Materials Footprint Summary* Input: Replacement Zero Valent Iron, tons, 722.7, 2000, 0 *G-2_main_(020513).xlsx → Materials 2 → Row 11*
Grout for Well Installation	• 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 810 ft = 10,530 lbs of grout/cement	10,530 lbs of cement *SimaPro Assembly Name: Material_G2_PRB grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 10530 lb*	10,530 lbs of cement	*Material Use and Trans.* Selected: "Cement" Input: 10530 lbs. *G-2_energy_(020513).xlsx → PRB → Row 77* PLUS *Control/Treatment, etc. - Refined Materials Footprint Summary* Input: Cement, lbs., 10530, 1, 0 *G-2_main_(020513).xlsx → Materials 2 → Row 12*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
PVC (for 68 new monitoring wells) • 2-inch, Schedule 40 • 2,690 ft combined length	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 2,690 ft x 0.68 lbs per ft = 1829 lbs PVC	1829 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_MNA PVC 68 mw* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 1829 lb*	1829 lbs of Schedule 40 PVC Input to SiteWise: 2,690 ft of 2" Sch 40 PVC (Reference Table 1-C from SiteWise spreadsheet provides a weight of 0.72 lbs/foot for 2" Sch 40 PVC pipe)	*Material Use and Trans.* Selected: "PVC" Input: 1829 lbs. *G-2_energy_(020513).xlsx → MNA → Row 78* PLUS *MNA - Refined Materials Footprint Summary* Input: PVC, lbs., 1829, 1, 0 *G-2_main_(020513).xlsx → Materials 3 → Row 9*
PVC (for Replacement Wells) • 2-inch, Schedule 40 • 1,260 ft combined length	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,260 ft x 0.68 lbs per ft = 856.8 lbs of Schedule 40 PVC	856.8 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_MNA PVC replacement wells* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 856.8 lb*	856.8 lbs of Schedule 40 PVC Input to SiteWise: 1,260 ft of 2" Sch 40 PVC (Reference Table 1-C from SiteWise spreadsheet provides a weight of 0.72 lbs/foot for 2" Sch 40 PVC pipe)	*Material Use and Trans.* Selected: "PVC" Input: 856.8 lbs. *G-2_energy_(020513).xlsx → MNA → Row 79* PLUS *MNA - Refined Materials Footprint Summary* Input: PVC (for replacement wells), lbs., 856.8, 1, 0 *G-2_main_(020513).xlsx → Materials 3 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Grout for Well Installation (for 68 new monitoring wells) • 2,690 ft combined length	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 2,690 ft= 34,970 lbs of grout/cement	34,970 lbs of cement *SimaPro Assembly Name: Material_G2_MNA grout mw* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 34970 lb*	34,970 lbs of cement (Typical cement)	*Material Use and Trans.* Selected: "Cement" Input: 34970 lbs. *G-2_energy_(020513).xlsx → MNA → Row 80* PLUS *MNA - Refined Materials Footprint Summary* Input: Cement (Grout), lbs., 34970, 1, 0 *G-2_main_(020513).xlsx → Materials 3 → Row 11*
Grout for Well Installation (for Replacement Wells) • 1,260 ft combined length	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1,260 ft=16,380 lbs of grout/cement	16,380 lbs of cement *SimaPro Assembly Name: Material_G2_MNA grout rw* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 16380*	16,380 lbs of cement (Typical cement)	*Material Use and Trans.* Selected: "Cement" Input: 16380 lbs. *G-2_energy_(020513).xlsx → MNA → Row 81* PLUS *MNA - Refined Materials Footprint Summary* Input: Cement (Grout for replacement wells), lbs., 16380, 1, 0 *G-2_main_(020513).xlsx → Materials 3 → Row 12*

Table G2-D: Transport for Materials, Equipment, and Samples: G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Transport of material for 55 electrodes.	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Delivery of steel pipe: 1 trip with 20,350 lbs (10.2 tons) • Delivery of graphite: 8 trips delivering 462,000 lbs (231 tons) ○ TT estimates 30 tons per truck, for 8 trucks necessary to deliver entire load. • Delivery of steel shot: 1 trip with 57,200 lbs (28.6 tons) • TT estimates distance from vendor to site at approximately 50 miles.	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trip Weight: 28.6 tons Miles, one way: 50 miles *SimaPro Assembly Name: Transport_G2_ISTT electrode materials* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input: 510 tmi* *Materials/Assemblies used: Transport, lorry >32t, EURO5/RER U (Ecoinvent)* *Amount input: 12000 tmi* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount input: 1430 tmi* *Empty trips included*	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trips Weight: 28.6 tons Miles, one way: 50 miles <u>Steel pipe</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 RETURN trips Weight: 0 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 miles	*Material Use and Trans.* <u>Steel pipe*</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 69* <u>Steel shot*</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 70* <u>Graphite**</u> Input: 50 miles, 16 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 71* *2 trips for each, accounting for delivery and return trip **16 trips accounting for 8 delivery and 8 return

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of PVC • 855 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) 855 ft x 0.68 lbs per ft = 582 lbs of Schedule 40 PVC / 2000 lbs per ton = 0.3 tons Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 15*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 72* *** One way only to match ESTCP
Transport of Cement for Well Installation	• 11,115 lbs of grout/cement (as per Table G2-C) • 11,115 lbs / 2000 lbs per ton = 5.56 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trips with 5.6 tons per trip	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent) Amount input: 280*	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* Cement Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 73*
Transport of heavy equipment used for electrode installation and well placement • Hollow stem auger	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C One mob. one demob., TT estimated as de minimis	de minimis	de minimis	de minimis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of samples • 5 rounds of sampling from 53 monitoring wells (DO, ORP, pH, temp, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimate of number of trips based on five wells per day being sampled. Sampling would take place over ~53 days and lab would pick up samples every other day, resulting number of trips would be ~27. • TT estimated the distance to lab as being 50 miles	27 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport_G2_ISTT sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 2700 miles*	27 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 27 trips, 100 miles round trip, Light-Duty Truck, Gasoline 2700 Total Miles *G-2_energy_(020513).xlsx → ISTT sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* ISTT Sampling Input: $200 Unit Cost, 265 Samples. $53000 Total Cost *G-2_energy_(020513).xlsx → ISTT lab analysis → Row 102* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of GAC	Total GAC required per quarter = 22,000 lbs TT estimated 1 flatbed truck for delivery TT estimated distance as 50 miles Weight per quarterly trip = 11 tons Assume spent GAC is sent back to regeneration facility on same truck that delivered the new batch of GAC.	• (4 delivery trips + 4 return trips) x 50 miles = 400 miles • Weight of load = 11 tons • 4400 ton-miles *SimaPro Assembly Name: Transport_G2_ISTT_GAC* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input: 4400 ton-miles*	# of trips: 4 11 tons, each 50 miles, one way # of trips: 4 (back to regeneration facility) 11 tons, each 50 miles, one way	*Material Use and Trans.* GAC* Input: 50 miles, 8 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 67* *Accounts for delivery and returns of all GAC material.
PRB				
Transport of PVC • 810 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 810 ft x 0.68 lbs per ft = 551 lbs / 2000 lbs per ton = 0.3 tons of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_PRB_PVC* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US(USLCI)* *Amount input: 15 ton-miles*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → PRB → Row 75* *** One way only to match ESTCP

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Cement for well installation	• 10,530 lbs of grout/cement (as per Table G2-C) • 10,530 lbs / 2000 lbs per ton = 5.3 tons cement • TT estimates 20 tons of cement per delivery truck • 1 trips with 5.3 tons per trip	# of trips: 1 delivery trip Weight: 5.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_PRB_Cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 265 ton-miles*	# of trips: 1 delivery trip Weight: 5.3 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → PRB → Row 77*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of samples • 43 rounds of sampling from 18 wells over 36 years (DO, ORP, pH, ferrous iron, VOCs, anions, metals, dissolved gases, and alkalinity)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • If five wells per day are sampled, sampling would take place over ~155 days and lab would pick up samples every other day, resulting number of trips would be ~78. • TT estimated distance to lab as 50 miles	78 trips 100 miles, round trip Van, gasoline *SimaPro Assembly Name: Transport_G2_PRB sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 7800 mile*	78 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 78 trips, 100 miles round trip, Light-Duty Truck, Gasoline 7800 Total Miles *G-2_energy_(020513).xlsx → PRB sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* PRB Sampling Input: $360 Unit Cost, 774 Samples. $278640 Total Cost *G-2_energy_(020513).xlsx → PRB lab analysis → Row 103* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of PRB media • Initial plus two replacements • 165 yds^3 of zero valent iron each trip for three events	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 3 one way trips • Density of zero valent iron = ~2.6 grams/cm^3 (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • 165 yds^3 x 2.19 tons per yard = 361.35 tons of ZVI • Assume flatbed delivery of 40 tons per trip • 10 x 3 =30 trips of 50 miles, one way (potential vendor located in Berkley, Ca)	30 trip x 40 tons x 50 miles 60,000= ton-miles *Empty return trip included* *SimaPro Assembly Name: Transport_G2_PRB media* *Materials/Assemblies used: Truck 40t (LCA Food)* *Amount input: 60000 ton-mile*	# of trips: 30 40 tons, each 50 miles, one way # of trips: 30 (empty) 0 tons, each 50 miles, one way	*Material Use and Trans.* PRB – Zero Valent iron Input: 50 miles, 60 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → PRB → Row 74*
MNA				
Transport of PVC • 2,690 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 2,690 ft x 0.68 lbs per ft = 1,829 lbs of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.9 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_MNA_PVC* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 45 ton-mile*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.9 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → MNA → Row 78* *** One way only to match ESTCP

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Cement for well installation (for 68 new monitoring wells)	• 34,970 lbs of grout/cement (as per Table G2-C) • 34,970 lbs / 2000 lbs per ton = 17.49 tons cement • Assume 20 tons of cement per delivery truck • 18 trips with ~20 tons per trip	# of trips: 18 delivery trip Weight: 20 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_MNA cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 18000*	# of trips: 18 delivery trip Weight: 20 tons Miles, one way: 50 # of trips: 18 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 36 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → MNA → Row 80*
Transport of Cement for well installation (for Replacement Wells)	• 16,380 lbs of grout/cement (as per Table G2-C) • 16,380 lbs / 2000 lbs per ton = 8.2 tons cement • Assume 20 tons of cement per delivery truck • 1 trip with 8.2 tons per trip	# of trips: 1 delivery trip Weight: 8.2 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_MNA cement replacement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 410*	# of trips: 1 delivery trip Weight: 8.2 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → MNA → Row 81*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Samples, parsed by time period within remedy: • 17 rounds x 126 wells = 2142 well samples • 10 rounds x 96 wells = 960 well samples • 10 rounds x 66 wells = 660 well samples • 6 rounds x 36 wells = 216 well samples • 2142 + 960 + 660 + 216 = 3978 samples total • 25% of samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, TOC and dissolved gases	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Frequency of sampling, number of people sampling, miles to lab and weight of coolers estimated by TT. • TT estimated trips to lab: If 5 wells are sampled per day and samples are picked up every other day: 398 trips • Assume 50 miles, one way, to lab • Assume van/light truck	398 trips x 100 miles round trip= 39,800 miles 39,800 miles *SimaPro Assembly Name: Transport_G2_MNA sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 39800 mile*	39,800 miles Van, light truck Gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 398 trips, 100 miles round trip, Light-Duty Truck, Gasoline 39800 Total Miles *G-2_energy_(020513).xlsx → MNA sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* MNA Sampling Input: $100 Unit Cost, 3978 Samples. $397800 Total Cost *G-2_energy_(020513).xlsx → MNA lab analysis → Row 104* *PLUS* ***Off-Site Laboratory Analysis* MNA Sampling Input: $260 Unit Cost, 995 Samples. $258700 Total Cost *G-2_energy_(020513).xlsx → MNA lab analysis → Row 105* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis. Off-Site Laboratory Analysis is only included as an alternative to make Chart 7.

Table G2-E: Waste Transport/Disposal: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Soil Transport and Disposal after placement of ISTT electrodes • 1.6 tons of soil cuttings produced per electrode • TT estimated the need for hazardous disposal of soil cuttings • 200 miles one way from site to landfill	• Document, "Comparison of Construction Materials" provided by NAVFAC • 55 electrodes x 1.6 tons per electrode = 88 tons of soil • TT estimated 3 trucks needed for removal from site	• 3 trips • 29.3tons of soil each trip • Transported to at hazardous landfill 200 miles, one way *SimaPro Assembly Name: Waste Transport_G2_soil disposal* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount input: 17,580 ton-miles* *Empty trip included* *Disposal:* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill, 88 tn.sh)*	3 trips 29.3 tons of soil each trip Transported to at hazardous landfill 200 miles, one way AND 3 empty trips 0 tons each trip Distance: 200 miles, one way AND Disposal: 88 tons of soil Hazardous landfill	*Waste Trans. and Disposal* Selected: "Hazardous waste landfill" Input: 88 tons, 200 miles, 6 one-way trips, Truck (mpg), Diesel *G-2_energy_(020513).xlsx → ISTT → Row 89* PLUS *ISTT remedy – Waste Footprint Summary* Input: Soil Disposal etc., 88 *G-2_main_(020513).xlsx → Waste 1 → Row 35*
Soil cuttings from all monitoring wells assumed to be non-hazardous and reused on site.		de minimis	de minimis	de minimis

Table G2-F: Transport for Personnel: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Total trips to site by personnel: 813 trips Installation of ISTT electrodes and vapor extraction wells • TT estimated to require 4 people on site for 20 work days. (80 trips) Installation of ISTT treatment system components • TT estimated requiring 5 people on site for 100 work days (500 trips) Operation of ISTT • TT estimated requiring 100 trips to site per year, for one person (100 trips) Installation of 28 monitoring wells • TT estimated requiring 3 people on site for 9 working days (27 trips) Sampling • 53 days on site for two people (106 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Trips: 80 + 500 + 100 + 27 + 106 = 813 trips total • Assume use of car (gasoline)	813 trips x 70 miles round trip = 56,910 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_ISTT* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 56910 pmi*	56,910 miles by car (gasoline)	*Labor, Mobilization, etc.* <u>ISTT Installation - electrodes</u> Input: 4 crew, 20 days, 8 hrs worked, 80 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → ISTT → Row 16* <u>ISTT Installation - construction</u> Input: 5 crew, 100 days, 8 hrs worked, 500 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → ISTT → Row 17* <u>ISTT Operation</u> Input: 1 crew, 100 days, 8 hrs worked, 100 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → ISTT → Row 18* <u>ISTT Installation – monitoring wells</u> Input: 3 crew, 9 days, 8 hrs worked, 27 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → ISTT → Row 19* <u>ISTT Sampling</u> Input: 2 crew, 53 days, 8 hrs worked, 106 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → ISTT → Row 20*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PRB				
Total trips to site by personnel: 1,390 trips Installation of PRB (including 18 wells) • Estimated to require 2 people on site for 180 days (360 trips) • Estimated to require 2 people on site for 2 events x 180 days per event for replenishment of PRB media (720 trips) Sampling • 155 days on site for two people (310 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Trips: 360 + 720 + 310 = 1,390 • Assume use of car (gasoline)	1,390 trips x 70 miles round trip = 97,300 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_PRB* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 97300 pmi*	97,300 miles by car (gasoline)	*Labor, Mobilization, etc.* <u>PRB Installation</u> Input: 2 crew, 540 days, 8 hrs worked, 1080 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → PRB → Row 21* <u>PRB Sampling</u> Input: 2 crew, 155 days, 8 hrs worked, 310 trips, 70 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → PRB → Row 22*
Project Engineer and Field Technician • 288 + 1800 hours= 261 days • 261 round trips x 2 people = 522 trips	• Hours per person as per RACER Appendix to the Alameda FS (pdf pg 346)\ • TT estimated 50 miles round trip commuting distance	• 522 trips x 50 miles = 26,100 miles by car, gasoline • One passenger per vehicle *SimaPro Assembly Name: Transport for Personnel_G2_PRB (see above)* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 26100 pmi*	• 522 trips x 50 miles = 26,100 miles by car, gasoline • One passenger per vehicle	*Labor, Mobilization, etc.* <u>PRB Project Personnel</u> Input: 2 crew, 261 days, 8 hrs worked, 522 trips, 50 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → PRB → Row 23*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
Sampling Personnel (see Table G2-D) events parsed by time period within remedy: • 17 rounds x 126 wells = 2142 well samples • 10 rounds x 96 wells = 960 well samples • 10 rounds x 66 wells = 660 well samples • 6 rounds x 36 wells = 216 well samples • 2142 + 960 + 660 + 216 = 3978 samples total • 796 days on site, per person x 2 people = 1,592 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. • Frequency of sampling and number of people sampling estimated by TT. • TT estimated 50 miles, one way, from home to site for each person sampling	1,592 trips x 100 miles round trip = 159,200 miles Car, gasoline One passenger per vehicle *SimaPro Assembly Name: Transport for Personnel_G2_MNA* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 159200* pmi	1,592 trips x 100 miles round trip = 159,200 miles Car, gasoline One passenger per vehicle	*Labor, Mobilization, etc.* MNA Sampling Personnel Input: 2 crew, 796 days, 8 hrs worked, 1,592 trips, 100 miles round trip, Car, Gasoline *G-2_energy_(020513).xlsx → MNA → Row 24*

Table G2-G: Potable Water Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G2-C): • ISTT: 11,115 lbs of cement PRB: 10,530 lbs of cement • PRB: 10,530 lbs of cement • MNA: 34,970 lbs of cement • MNA: 16,380 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement (EPA, 2012) • Total cement = 11,115 + 10,530 + 34,970 + 16,380 = 73,015 lbs • 73,015 lbs/ 94 lbs of neat cement x 6 gallons water = 4660.53 gallons of water x 8.34 lbs per gallon = 38868.82 lbs /2000 lbs per ton = 19.43 tons	4660.53 gallons of water Allocated: ISTT- 15.23 % = 2.96 tons PRB- 14.42 % = 2.80 tons MNA- 70.35 % = 13.67 tons *SimaPro Assembly Name: Potable Water_G2_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U (Ecoinvent)* *Amount input: 2.96 sh.tn. (ISTT), 2.80 sh.tn. (PRB) and 13.67 sh.tn (MNA)*	4660.53 gallons of water	*Material Use and Trans.* Public Water (for ISTT) Input: 0.715 *G-2_energy_(020513).xlsx → ISTT → Row 76* Public Water (for PRB) Input: 0.672 *G-2_energy_(020513).xlsx → PRB → Row 79* Public Water (for MNA) Input: 3.278 *G-2_energy_(020513).xlsx → MNA → Row 82*

Table G2-H: Non-Potable Water Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant non-potable water use identified for this alternative			

Table G2-I: Known Use of On-Site Renewables: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
• No known use of on-site renewable energy sources for this remedy			

Tables for Alternative G-3A

Note: Cells that are shaded in gray are entries that are the same as a previous alternative

Table G3A-A: Electricity Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Operation of ISTT Electrodes and vapor extraction • Includes 55 ISTT electrode	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 200 kWh per yd^3 based on TT engineering estimate (heating and vapor extraction) • Soil treated: 29,100 ft^2 x 36 ft = 1,047,600 ft^3= 38,800 yd^3 • 38,800 yd^3 x 200 kWh per yd^3 = 7,760,000 kWh	7,760,000 kWh *SimaPro Assembly Name: Electricity_G2_Op of ISTT* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 7760 p*	7,760,000 kWh	7,760,000 kWh *On-Site Electricity Use* Total Grid Electricity = 7760000 kWh *G-3A_energy_(020513).xlsx → ISTT → Row 59* *Grid mix shown in Table 1-J entered into G-3A_energy_(020513).xlsx → Grid Electricity → Fuel Mix for Grid Electricity*
In Situ Chemical Oxidation				
Pump for use with ISCO injection	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 219 days for remedy • TT estimated a 2.5 kWh daily electrical usage based on TT engineering estimate. • At 2.5 kWh per day x 219 days = 547.5 kWh x 3 events = 1,642.5 kWh	1,642.5 kWh *SimaPro Assembly Name: Electricity_G3_ISCO_Pump* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 1.6425 p*	1,642.5 kWh	1,642.5 kWh *On-Site Electricity Use* Total Grid Electricity = 1642.5 kWh *G-3A_energy_(020513).xlsx → ISCO → Row 59*

Table G3A-B: Fuel Use for Equipment: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Equipment used for the construction of the ISTT system: • Installation of 55 ISTT electrodes and co-located vapor extraction wells (to address 29,100 ft^2 of hot spots with average depth of 36 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "Comparison of Construction Materials" provided by NAVFAC • 3-inch Schedule 80 steel pipe within a 12-inch diameter borehole • 55 electrodes to 36 feet deep = 1,980 linear feet • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 20, 8-hr days = 160 hours of use. To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 160 x 0.050 x 0.75 = 900 gals (refer to EPA, 2012, pg 59)	• Equipment Type: Hollow stem auger • 55 electrodes to 36 feet deep = 1,980 linear feet • 160 hours Fuel Use= 900 gals *SimaPro Assembly Name: Fuel_G2_ISTT construction* *Process Used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 900 gal**	• Hollow stem auger • 160 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 160 hours operated 900 Gallons of Fuel Used *G-3A_energy_(020513).xlsx → ISTT → Row 31*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Equipment used for the installation of 28 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 855 feet (including screen length of 280 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 9 days, 8-hr days= 72 hours of use. • To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 72 x 0.050 x 0.75 = 405 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • Drilling 855 linear feet 72 hours of use *SimaPro Assembly Name: Fuel_G2_construction 28 wells* *Process Used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 405 gal**	• Hollow stem auger • 72 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 72 hours operated 405 Gallons of Fuel Used *G-3A_energy_(020513).xlsx → ISTT → Row 32*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Chemical Oxidation				
Direct Push Rig, Truck Mounted, Non-Hydraulic • 656 injection points • Depth from 5-30 ft bgs	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B (Appendix C) • 219 days of operation • Professional estimate assuming 3 injections point completed per day = 219 days of operation x 8hrs =1750 hours x 3 events = 5,250 hours • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 5250 x 0.050 x 0.75 = 11812.5 gals (refer to EPA, 2012, pg 59)	• Direct push rig • 5,250 hours • 11812.5 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_ISCO_injection rig* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 11812.5 gal**	• Direct push rig • 5,250 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – direct push", 60 HP, 75% load factor, Diesel fuel, 5250 hours operated 11812.5 Gallons of Fuel Used *G-3A_energy_(020513).xlsx → ISCO → Row 33*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Equipment used for the installation of 29 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 730 feet (including screen length of 290 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 730 linear feet / 100 feet per day = 7.3, 8 hour days = 58.4 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 58.4 x 0.050 x 0.75 = 328.5 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 730 linear feet • 58.4 hours • 328.5 gals fuel *SimaPro Assembly Name: Fuel Use_G3a_ISCO_Install 29 wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 328.5 gal**	• Hollow stem auger • 730 linear feet • 58.4 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 58.4 hours operated 328.5 Gallons of Fuel Used *G-3A_energy_(020513).xlsx → ISCO → Row 34*

MNA				
Equipment used for the installation of 39 new 2-inch Schedule 40 PVC wells • Using hollow stem auger • Total combined depth of 1,960 feet (including screen depth of 390 feet)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 19.6, 8-hr days. • 1,960 linear feet / 100 feet per day = 19.6, 8 hour days = 157 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 157 x 0.050 x 0.75 = 883.125 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,960 linear feet • 157 hours of use • 883,125 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 39 mw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 883.125 gal**	• Hollow stem auger • 157 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 157 hours operated 883.125 Gallons of Fuel Used *G-3A_energy_(020513).xlsx → MNA → Row 35*
Replacement of monitoring wells • Using hollow stem auger • Total combined depth of 1,575 ft (35 wells at an average of 45 feet deep)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf page 32) • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 15.75, 8 hour days • 1,575 linear feet / 100 feet per day = 15.75, 8-hr days = 126 hours of use • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 126 x 0.050 x 0.75 = 708.75 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,575 linear feet • 126 hours of use • 708.75 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 35 rw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 708.75 gal**	• Hollow stem auger • 126 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 126 hours operated 708.75 Gallons of Fuel Used *G-3A_energy_(020513).xlsx → MNA → Row 36*

Table G3A-C: Materials Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment ***(all capital construction equipment not listed below, that is required, is assumed to be on-site , stored in Building 5 and reused from a previous pilot (Comparison of Construction Materials document provided by NAVFAC)therefor it is not being footprinted as a part of this GSR analysis, or are de minimis items.***				
GAC • Carbon change out for liquid and vapor phase units	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "List of ERH Materials and Estimated Technology Costs" provided by NAVFAC • TT professional judgment: carbon units will require quarterly carbon change outs for one year. • Estimates of carbon required developed from volume of GAC used in 2007 pilots, TT estimated the following usage (document above) based on those pilot studies: o Two 8,000 lbs vapor phase units o Two 3,000 lbs liquid phase units o Total per quarter = 22,000 lbs	22,000 lbs x 4 fills = 88,000 lbs. of GAC / 2.2 lbs per kg = 40,000 kg *SimaPro Assembly Name: Material_G2_ISTT_GACMaterials/Assemblies used: Virgin GAC Assembly_1kg(TT assembly)* *Amount input: 40000 p*	88,000 lbs. of GAC	*Material Use and Trans.* Selected: "Virgin GAC (coal based)" Input: 88000 lbs. *G-3A_energy_(020513).xlsx → ISTT → Row 67* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: GAC, lbs., 88000, 1, 0 *G-3A_main_(020513).xlsx → Materials 1 → Row 9*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Drilled Electrodes composition • Steel pipe (370 lbs/electrode) • Graphite (8,400 lbs/electrode) • Steel shot (1,040 lbs/electrode)	• Document, "Comparison of Construction Materials" provided by NAVFAC • Steel pipe: 370 lbs/electrode x 55 electrodes = 20,350 lbs of steel • Graphite: 8,400 lbs/electrode x 55 electrodes = 462,000 lbs of graphite • Steel shot: 1,040 lbs/electrode x 55 electrodes = 57,200 lbs of steel shot • Total Steel: Steel pipe + steel shot = 20,350 + 57,200 = 77,550 lbs of total steel	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs *SimaPro Assembly Name: Material_G2_ISTT_Electrodes* *Materials/Assemblies used: Steel, billets, at plant/US(USLCI)* *Amount input: 77550 lb* *AND* *Materials/Assemblies used: Graphite, at plant/RER U (Ecoinvent)* *Amount input: 462000 lb*	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite (Surrogate for graphite, Material A with one-half the emission footprint of iron) Amount: 462,000 lbs	*Material Use and Trans.* Selected: "Steel" Input: 20350 lbs. *G-3A_energy_(020513).xlsx → ISTT → Row 69* PLUS Selected: "Steel" Input: 57200 lbs. *G-3A_energy_(020513).xlsx → ISTT → Row 70* PLUS Selected: "Other refined construction materials" Input: 462000 lbs. *G-3A_energy_(020513).xlsx → ISTT → Row 71* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: Steel, lbs., 77500, 1, 0 *G-3A_main_(020513).xlsx → Materials 1 → Row 10* PLUS Input: Graphite, lbs., 462000, 1, 0 *G-3A_main_(020513).xlsx → Materials 1 → Row 11*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PVC (for 28 new monitoring wells) • 2-inch, Schedule 40 • 855 ft total combined length • 280 feet of screen	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 581.4 lbs PVC	581.4 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_ISTT_PVC 28 mon wells* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 581.4*	Input to SiteWise: 855 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 581.4 lbs. *G-3A_energy_(020513).xlsx → ISTT → Row 72* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: PVC, lbs., 581.4, 1, 0 *G-3A_main_(020513).xlsx → Materials 1 → Row 12*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 855 ft = 11,115 lbs of grout/cement / 2000 lbs per ton = 5.6 tons of cement	5.6 tons of cement *SimaPro Assembly Name: Material_G2_ISTT_Grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 5.6 tn.sh.*	5.6 tons of cement Input to SiteWise: 11,200 lbs Typical Cement	*Material Use and Trans.* Selected: "Cement" Input: 11200 lbs. *G-3A_energy_(020513).xlsx → ISTT → Row 73* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: Cement, lbs., 11200, 1, 0 *G-3A_main_(020513).xlsx → Materials 1 → Row 13*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Chemical Oxidation				
PVC (for 29 new monitoring wells) • 2-inch, Schedule 40 • 730 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs PVC	496 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_ISCO pvc 29 mw* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 496 lb*	Input to SiteWise: 730 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 496 lbs. *G-3A_energy_(020513).xlsx → ISCO → Row 74* PLUS *ISCO remedy - Refined Materials Footprint Summary* Input: PVC, lbs., 496, 1, 0 *G-3A_main_(020513).xlsx → Materials 2 → Row 9*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 730 ft = 9,490 lbs of grout/cement / 2000 lbs per ton = 4.75 tons of cement	4.75 tons of cement *SimaPro Assembly Name: Material Use_G3a_ISCO grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 4.75 tn.sh*	4.75 tons of cement	*Material Use and Trans.* Selected: "Cement" Input: 9490 lbs. *G-3A_energy_(020513).xlsx → ISCO → Row 75* PLUS *ISCO remedy - Refined Materials Footprint Summary* Input: Cement, tons, 4.745, 2000, 0 *G-3A_main_(020513).xlsx → Materials 2 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
12% Hydrogen Peroxide • 3 events • 370,000 gallons each event	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Specific gravity of H_2O_2 = 1.045 • H_2O_2 lbs = 1,110,000 gallons x 8.34 lbs per gallons x 1.045 *0.12 = 1,160,877 lbs H_2O_2 • Water = 1,110,000 gallons x 8.34 lbs per gallon x 1.045 x 0.88/8.34 = 1,020,756 gallons of water *Note: Water use for solutions is accounted for in this "Materials" table and not in the "Potable Water" table. This is done to ensure that transportation weight include the water that is used to make the solutions in an offsite facility.*	$H_2O_{2=}$ 1,160,877 lbs of pure H_2O_2 AND Water= 1,020,756 gallons Surrogate for SimaPro: for use of only hydrogen peroxide material (50%), use the following input: • 2,321,754 lbs (2 x 1,160,877lbs) of 50% H_2O_2 solution is needed to yield 1,160,877 lbs of pure H_2O_2 • Half of the required amount of 50% H_2O_2 solution is water. • 50% H_2O_2 solution therefore yields 139,193 gallons (1,160,877 lbs ÷ 8.34 of water • Additional 881,563 gallons of water (1,020,756 gallons – 139,193 gallons) is needed, which is 7,352,235 lbs of water *SimaPro Assembly Name: Material Use_G3a_ISCO_H2O2* *Materials/Assemblies used: Hydrogen peroxide, 50% in H2O, at plant/RER U (Ecoinvent)* *Amount input: 2,231,754 lb* *AND* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 7,352,235 lb*	$H_2O_{2=}$ 1,160,877 lbs AND Water= 1,020,756 gallons	*Material Use and Trans.* Selected: "Other Treatment Chemicals" Input: 1160877 lbs. *G-3A_energy_(020513).xlsx → ISCO → Row 76* PLUS Selected: "Public water" Input: 1020.756 gal x 1000 *G-3A_energy_(020513).xlsx → ISCO → Row 77* PLUS *ISCO remedy - Refined Materials Footprint Summary* Input: H2O2, lbs., 1160877, 1, 0 *G-3A_main_(020513).xlsx → Materials 2 → Row 11* PLUS *ISCO remedy - Water Footprint Summary* Input: 1020.756 (1000 gallons) *G-3A_main_(020513).xlsx → Water 2 → Row 8*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Chelated Iron Catalyst • 3 events • 370,000 gallons each event • Assume 4% ferrous sulfate solution	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 3 x 370,000 gallons = 1,110,000 gallons of Chelated Iron Catalyst • 4% ferrous sulfate solution has a specific gravity of 1.0375 and 0.3463 lbs of $FeSO_4$ per gallon. (http://www.qccorporation.com/Liquid-Ferrous-Sulfate-Solutions.php) • $FeSO_4$ = 1,110,000 gallons x 0.3463 lbs per gallon = 384,393 lbs $FeSO_4$ • Water = 1,110,000 gallons x 8.34 lbs per gallon x 1.1.0375 x 0.96/8.34 = 1,105,560 gallons of water x 8.34 lbs per gallon = 9,220,370.4 lbs *Note: Water use for solutions is accounted for in this "Materials" table and not in the "Potable Water" table. This is done to ensure that transportation weight include the water that is used to make the solutions in an offsite facility.*	384,393 lbs $FeSO_4$ AND 1,105,560 gallons of water *SimaPro Assembly Name: Material Use_G3a_ISCO_iron* *Materials/Assemblies used: Iron sulphate, at plant/RER U (Ecoinvent)* *Amount input: 384393 lb* *AND* *Materials/Assemblies used: Tap water, at user/RER U (Ecoinvent)* *Amount input: 9220370.4 lb*	384,393 lbs $FeSO_4$ (Input to SiteWise as ZVI) AND 1,105,560 gallons of water	*Material Use and Trans.* Selected: "Other Treatment Chemicals" Input: 384393 lbs. *G-3A_energy_(020513).xlsx → ISCO → Row 78* PLUS Selected: "Public water" Input: 1105.56 gal x 1000 *G-3A_energy_(020513).xlsx → ISCO → Row 79* PLUS *ISCO remedy - Refined Materials Footprint Summary* Input: FeSO4, lbs., 384393, 1, 0 *G-3A_main_(020513).xlsx → Materials 2 → Row 12* PLUS *ISCO remedy - Water Footprint Summary* Input: 1105.56 (1000 gallons) *G-3A_main_(020513).xlsx → Water 2 → Row 8*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
PVC (for 39 new monitoring wells) • 2-inch, Schedule 40 • 1,960 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1333 lbs PVC	1333 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc 39 mw* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 1333 lb*	Input to SiteWise: 1960 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 1333 lbs. *G-3A_energy_(020513).xlsx → MNA → Row 80* PLUS *MNA - Refined Materials Footprint Summary* Input: PVC, lbs., 1333, 1, 0 *G-3A_main_(020513).xlsx → Materials 3 → Row 9*
PVC (for Replacement Wells) • 2-inch, Schedule 40 • 1,575 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC	1,071 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc rw* *Materials/Assemblies used: PVC pipe E* *Amount input: 1071 lb*	1,071 lbs of Schedule 40 PVC	*Material Use and Trans.* Selected: "PVC" Input: 1071 lbs. *G-3A_energy_(020513).xlsx → MNA → Row 81* PLUS *MNA - Refined Materials Footprint Summary* Input: PVC, lbs., 1071, 1, 0 *G-3A_main_(020513).xlsx → Materials 3 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1960 ft = 25,480 lbs of grout/cement / 2000 lbs per ton = 12.74 tons of cement	12.74 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 12.74 tn.sh*	12.74 tons of cement	*Material Use and Trans.* Selected: "Cement" Input: 25480 lbs. *G-3A_energy_(020513).xlsx → MNA → Row 82* PLUS *MNA - Refined Materials Footprint Summary* Input: Cement, lbs., 25480, 1, 0 *G-3A_main_(020513).xlsx → Materials 3 → Row 11*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1,575 ft = 20,475 lbs of grout/cement / 2000 lbs per ton = 10.24 tons of cement	10.24 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout 2* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 10.24 tn.sh*	10.24 tons of cement	*Material Use and Trans.* Selected: "Cement" Input: 20480 lbs. *G-3A_energy_(020513).xlsx → MNA → Row 83* PLUS *MNA - Refined Materials Footprint Summary* Input: Cement, lbs., 20480, 1, 0 *G-3A_main_(020513).xlsx → Materials 3 → Row 12*

Table G3A-D: Transport for Materials, Equipment, and Samples: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Transport of material for 55 electrodes.	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Delivery of steel pipe: 1 trip with 20,350 lbs (10.2 tons) • Delivery of graphite: 8 trips delivering 462,000 lbs (231 tons) ○ TT estimates 30 tons per truck, for 8 trucks necessary to deliver entire load. • Delivery of steel shot: 1 trip with 57,200 lbs (28.6 tons) • TT estimates distance from vendor to site at approximately 50 miles.	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trip Weight: 28.6 tons Miles, one way: 50 miles *SimaPro Assembly Name: Transport_G2_ISTT electrode materials* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent) Amount input: 510 tmi* *Materials/Assemblies used: Transport, lorry >32t, EURO5/RER U (Ecoinvent) Amount input: 12000 tmi* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent) Amount input: 1430 tmi Empty trips included*	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trips Weight: 28.6 tons Miles, one way: 50 miles <u>Steel pipe</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 RETURN trips Weight: 0 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 miles	*Material Use and Trans.* <u>Steel pipe*</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT → Row 69* <u>Steel shot*</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT → Row 70* <u>Graphite**</u> Input: 50 miles, 16 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT → Row 71* *2 trips for each, accounting for delivery and return trip **16 trips accounting for 8 delivery and 8 return

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of PVC • 855 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) 855 ft x 0.68 lbs per ft = 582 lbs of Schedule 40 PVC / 2000 lbs per ton = 0.3 tons Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 15*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT → Row 72* *** One way only to match ESTCP
Transport of Cement for Well Installation	• 11,115 lbs of grout/cement (as per Table G2-C) • 11,115 lbs / 2000 lbs per ton = 5.56 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trips with 5.6 tons per trip	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 280*	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* Cement Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT → Row 73*
Transport of heavy equipment used for electrode installation and well placement • Hollow stem auger	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C One mob. one demob., TT estimated as de minimis	de minimis	de minimis	de minimis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of samples • 5 rounds of sampling from 53 monitoring wells (DO, ORP, pH, temp, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimate of number of trips based on five wells per day being sampled. Sampling would take place over ~53 days and lab would pick up samples every other day, resulting number of trips would be ~27. • TT estimated the distance to lab as being 50 miles	27 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport_G2_ISTT sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 2700 miles*	27 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 27 trips, 100 miles round trip, Light-Duty Truck, Gasoline 2700 Total Miles *G-3A_energy_(020513).xlsx → ISTT sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* ISTT Sampling Input: $200 Unit Cost, 265 Samples. $53000 Total Cost *G-3A_energy_(020513).xlsx → ISTT lab analysis → Row 102* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of GAC	Total GAC required per quarter = 22,000 lbs TT estimated 1 flatbed truck for delivery TT estimated distance as 50 miles Weight per quarterly trip = 11 tons Assume spent GAC is sent back to regeneration facility on same truck that delivered the new batch of GAC.	• (4 delivery trips + 4 return trips) x 50 miles = 400 miles • Weight of load = 11 tons • 4400 ton-miles *SimaPro Assembly Name: Transport_G2_ISTT_GAC* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input: 4400 ton-miles*	# of trips: 4 11 tons, each 50 miles, one way # of trips: 4 (back to regeneration facility) 11 tons, each 50 miles, one way	*Material Use and Trans.* GAC* Input: 50 miles, 8 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT→ Row 67* *Accounts for delivery and returns of all GAC material.
In Situ Chemical Oxidation				
Transport of PVC • 730 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 12.5 ton-mile*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISCO → Row 74* *** One way only to match ESTCP

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Cement for Well Installation	• 9,490 lbs of grout/cement (as per Table G3A-C) • 9,490 lbs / 2000 lbs per ton = 4.75 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 4.75 tons per trip • Assume a vendor distance of 50 miles	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 237.5 ton-mile*	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISCO → Row 75*
Transport of Hydrogen Peroxide • 3 events • 370,000 gallons each event	• Delivery to site 3 times • Assume specific gravity of full preparation =1.045 • 370,000 gallons x 3 events x 8.33 lbs per gallon x 1.045 = 9,662,383.5 lbs / 2000 lbs per ton = 4831.2 tons • TT estimated that delivery truck can contain 21tons. Therefore, 231 delivery trucks would be required • TT estimated a vendor distance of 50 miles, one way	231 trips x 50 miles, one way x 21 tons = 242,550 ton-miles *Empty trips included* *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_H2O2* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 242550 ton-mile*	Delivery: 231 trips 50 miles 21 tons Return trips: 231 trips 50 miles 0 tons	*Material Use and Trans.* <u>Other (Hydrogen Peroxide)</u> Input: 50 miles, 462 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISCO → Row 76*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Chelated Iron Catalyst • 3 events • 370,000 gallons each event • Assume the solution contains.4 % ferrous sulfate	• Delivery to site 3 times • 4% ferrous sulfate solution has a specific gravity of 1.0375 and 0.3463 lbs of $FeSO_4$ per gallon. http://www.qccorporation.com/Liquid-Ferrous-Sulfate-Solutions.php • 3 x 370,000 gallons x 8.33 lbs per gallon x 1.0375 = 9593036 lbs / 2000 lbs per ton = 4,796.5 tons • TT estimates that delivery truck can contain 22 tons, 219 delivery trucks would be required • TT estimated a vendor distance of 50 miles, one way	219 trips x 50 miles, one way x 22 tons = 240,900 ton-miles *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_iron* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 240900 ton-mile*	Delivery: 219 trips 50 miles Weight: 22 tons Return trips: 219 trips 50 miles Weight: 0 tons	*Material Use and Trans.* Other (Chelated Iron Catalyst) Input: 50 miles, 438 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISCO → Row 78*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport for sampling for ISCO • 6 rounds of sampling from 55 monitoring wells (DO, ORP, pH, ferrous iron, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B • TT estimated trips to site for sampling based on five wells per day being sampled, therefor sampling would take place over ~66 days and lab would pick up samples every other day, resulting number of trips would be ~33. • TT estimated distance to lab as 50 miles	33 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 3300 mile*	33 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 33 trips, 100 miles round trip, Light-Duty Truck, Gasoline 3300 Total Miles *G-3A_energy_(020513).xlsx → ISCO sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* ISCO Sampling Input: $200 Unit Cost, 330 Samples. $66000 Total Cost *G-3A_energy_(020513).xlsx → ISCO lab analysis → Row 103* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
Transport of PVC(for 39 new monitoring wells) • 1,960 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1,333 lbs of Schedule 40 PVC x 2000 lbs per ton = 0.67 tons PVC • TT estimated 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc 39 mw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 33.5 ton-mile*	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>PVC***</u> Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → MNA → Row 80* *** One way only to match ESTCP
Transport of PVC (for Replacement Wells) • 1,575 ft combined length • 2-inch, Schedule 40	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC = 0.54 tons PVC • TT estimated 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc rw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 27 ton-mile*	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>PVC***</u> Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → MNA → Row 81* *** One way only to match ESTCP
Transport of Cement for well installation (Monitoring Wells)	• 25,480 lbs of grout/cement (as per Table G2A-C) • 25,480 lbs / 2000 lbs per ton = 12.74 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 12.74 tons per trip	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement mw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 637 ton-mile*	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 4 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → MNA → Row 82*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Cement for well installation (for Replacement Wells)	• 20,475 lbs of grout/cement (as per Table G2A-C) • 20,475 lbs / 2000 lbs per ton = 10.24 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 10.24 tons per trip	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement rw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 512 ton-mile*	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> ***Transportation Accounted for in Row 82 (Due to limitation of Excel Table setup)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Samples, parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 126 wells = 1134 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 50 wells = 400 well samples • 568 + 1134 + 880 + 400 = 2982 samples total • 25% of samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, TOC and dissolved gases	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated trips necessary for transport of samples based on five wells per day being sampled, sampling would take place over ~597days and lab would pick up samples every other day, resulting number of trips would be ~298. • TT estimated distance to lab is 50 miles	298 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3a_MNA_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 29800 mile*	298 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 298 trips, 100 miles round trip, Light-Duty Truck, Gasoline 29800 Total Miles *G-3A_energy_(020513).xlsx → MNA sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* MNA Sampling Input: $100 Unit Cost, 2982 Samples. $298200 Total Cost *G-3A_energy_(020513).xlsx → MNA lab analysis → Row 104* *PLUS* ***Off-Site Laboratory Analysis* MNA Sampling Input: $260 Unit Cost, 746 Samples. $193960 Total Cost *G-3A_energy_(020513).xlsx → MNA lab analysis → Row 105* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis. Off-Site Laboratory Analysis is only included as an alternative to make Chart 7.

Table G3A-E: Waste Transport/Disposal: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
ISTT				
Soil Transport and Disposal after placement of ISTT electrodes • 1.6 tons of soil cuttings produced per electrode • TT estimated the need for hazardous disposal of soil cuttings • 200 miles one way from site to landfill	• Document, "Comparison of Construction Materials" provided by NAVFAC • 55 electrodes x 1.6 tons per electrode = 88 tons of soil • TT estimated 3 trucks needed for removal from site	• 3 trips • 29.3tons of soil each trip • Transported to at hazardous landfill 200 miles, one way *SimaPro Assembly Name: Waste Transport_G2_soil disposal* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount input: 17,580 ton-miles* *Empty trip included* *Disposal:* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill, 88 tn.sh)*	3 trips 29.3 tons of soil each trip Transported to at hazardous landfill 200 miles, one way AND 3 empty trips 0 tons each trip Distance: 200 miles, one way AND Disposal: 88 tons of soil Hazardous landfill	*Waste Trans. and Disposal* Selected: "Hazardous waste landfill" Input: 88 tons, 200 miles, 6 one-way trips, Truck (mpg), Diesel *G-3A_energy_(020513).xlsx → ISTT → Row 89* PLUS *ISTT remedy – Waste Footprint Summary* Input: Soil Disposal etc., 88 *G-3A_main_(020513).xlsx → Waste 1 → Row 35*
Soil cuttings from all monitoring wells assumed to be non-hazardous and reused on site.		de minimis	de minimis	de minimis

Table G3A-F: Transport for Personnel: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Total trips to site by personnel: 813 trips Installation of ISTT electrodes and vapor extraction wells • TT estimated to require 4 people on site for 20 work days. (80 trips) Installation of ISTT treatment system components • TT estimated requiring 5 people on site for 100 work days (500 trips) Operation of ISTT • TT estimated requiring 100 trips to site per year, for one person (100 trips) Installation of 28 monitoring wells • TT estimated requiring 3 people on site for 9 working days (27 trips) Sampling 53 days on site for two people (106 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Trips: 80 + 500 + 100 + 27 + 106 = 813 trips total • Assume use of car (gasoline)	813 trips x 70 miles round trip = 56,910 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_ISTT* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 56910 pmi*	56,910 miles by car (gasoline)	*Labor, Mobilization, etc.* <u>ISTT Installation - electrodes</u> Input: 4 crew, 20 days, 8 hrs worked, 80 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISTT → Row 16* <u>ISTT Installation - treatment</u> Input: 5 crew, 100 days, 8 hrs worked, 500 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISTT → Row 17* <u>ISTT Operation</u> Input: 1 crew, 100 days, 8 hrs worked, 100 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISTT → Row 18* <u>ISTT Installation – monitoring wells</u> Input: 3 crew, 9 days, 8 hrs worked, 27 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISTT → Row 19* <u>ISTT Sampling</u> Input: 2 crew, 53 days, 8 hrs worked, 106 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISTT → Row 20*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Chemical Oxidation				
Total trips to site by personnel: 2,103 trips Injection of 656 injection points • Estimated to require 3 people on site for 219 days x 3 events (1971 trips) Includes driller, drillers helper and geologist. Sampling • 66 days on site for two people (132 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline)	2,103 trips x 70 miles round trip = 147,210 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_G3a_ISCO_total* *Materials/Assemblies used: Operation, passenger car, petrol, fleet average 2010/RER U* *Amount input: 147210 mile*	147,210 miles by car (gasoline) Assume one person per vehicle	*Labor, Mobilization, etc.* ISOC Installation Input: 3 crew, 657 days, 8 hrs worked, 1971 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISCO → Row 21* ISOC Sampling Input: 2 crew, 66 days, 8 hrs worked, 132 trips, 70 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → ISCO → Row 22*
MNA				
Sampling Personnel (see Table G2-D) events parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 128 wells = 1,152 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 21 wells = 168 well samples • 568 + 1152 + 880 + 168 = 2768 samples total • 554 days on site, per person x 2 people = 1108 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. • Frequency of sampling and number of people sampling estimated by TT. • TT estimated 50 miles, one way, from home to site for each person sampling	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle *SimaPro Assembly Name: Transport of Personnel_G3a_MNA_total* *Materials/Assemblies used: Operation, passenger car, petrol, fleet average 2010/RER U* *Amount input: 110800 mile*	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle	*Labor, Mobilization, etc.* MNA Sampling Personnel Input: 2 crew, 554 days, 8 hrs worked, 1108 trips, 100 miles round trip, Car, Gasoline *G-3A_energy_(020513).xlsx → MNA → Row 23*

Table G3A-G: Potable Water Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G2-C): • ISTT: 11,115 lbs of cement • ISCO: 9,490 lbs of cement • MNA: 25,480 lbs of cement • MNA: 20,475 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement (EPA, 2012) • Total cement = 11,115 + 9,490 + 25,480 + 20,475 = 66,560 lbs • 66,560 lbs/ 94 lbs of neat cement x 6 gallons water = 4248.5 gallons of water	4248.5 gallons of water *SimaPro Assembly Name: Potable Water_G3a_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U (Ecoinvent)* *Amount input: 2.96 tn.sh (ISTT), 2.52 tn.sh (ISCO), and 12.23 (MNA)tn.sh*	4248.5 gallons of water	*Material Use and Trans.* Public Water (for ISTT) Input: 0.715 *G-3A_energy_(020513).xlsx → ISTT → Row 76* Public Water (for ISCO) Input: 0.60574 *G-3A_energy_(020513).xlsx → ISCO → Row 81* Public Water (for MNA) Input: 2.93362 *G-3A_energy_(020513).xlsx → MNA → Row 78*
Water use for solutions	• *Note: Water use for solutions is accounted for in the "Materials" table and not in this "Potable Water" table. This is done to ensure that transportation weight includes the water that is used to make the solutions in an offsite facility.*			

Table G3A-H: Non-Potable Water Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant use of non-potable water identified			

Table G3A-I: Known Use of On-Site Renewables: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
• No known use of on-site renewable energy sources for this remedy			

Tables for Alternative G-3B

Note: Cells that are shaded in gray are entries that are the same as a previous alternative

Table G-3B-Table A: Electricity Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Operation of ISTT Electrodes and vapor extraction • Includes 55 ISTT electrode	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 200 kWh per yd^3 based on TT engineering estimate (heating and vapor extraction) • Soil treated: 29,100 ft^2 x 36 ft = 1,047,600 ft^3= 38,800 yd^3 • 38,800 yd^3 x 200 kWh per yd^3 = 7,760,000 kWh	7,760,000 kWh *SimaPro Assembly Name: Electricity_G2_Op of ISTT* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 7760 p*	7,760,000 kWh	7,760,000 kWh *On-Site Electricity Use* Total Grid Electricity = 7760000 kWh *G-3B_energy_(020513).xlsx → ISTT → Row 59* *Grid mix shown in Table 1-J entered into G-3B_energy_(020513).xlsx → Grid Electricity → Fuel Mix for Grid Electricity*
Bioremediation				
Pump for use with bio injection	• TT estimated a 2.5 kWh daily electrical usage based on TT engineering estimate. • At 2.5 kWh per day x 300 days (includes both events) = 750 kWh	750 kWh *SimaPro Assembly Name: Electricity_G3b_Bio_injection pump* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 0.75 p*	750 kWh	750 kWh *On-Site Electricity Use* Total Grid Electricity = 750 kWh *G-3B_energy_(020513).xlsx → BIO → Row 59*

Table G-3B-Table B: Fuel Use for Equipment: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Equipment used for the construction of the ISTT system: • Installation of 55 ISTT electrodes and co-located vapor extraction wells (to address 29,100 ft^2 of hot spots with average depth of 36 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "Comparison of Construction Materials" provided by NAVFAC • 3-inch Schedule 80 steel pipe within a 12-inch diameter borehole • 55 electrodes to 36 feet deep = 1,980 linear feet • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 20, 8-hr days = 160 hours of use. To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 160 x 0.050 x 0.75 = 900 gals (refer to EPA, 2012, pg 59)	• Equipment Type: Hollow stem auger • 55 electrodes to 36 feet deep = 1,980 linear feet • 160 hours Fuel Use= 900 gals *SimaPro Assembly Name: Fuel_G2_ISTT construction* *Process Used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 900 gal**	• Hollow stem auger • 160 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 160 hours operated 900 Gallons of Fuel Used *G-3B_energy_(020513).xlsx → ISTT → Row 31*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Equipment used for the installation of 28 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 855 feet (including screen length of 280 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 9 days, 8-hr days= 72 hours of use. • To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 72 x 0.050 x 0.75 = 405 gals (refer to EPA, 2012, pg 59) •	• Hollow stem auger • Drilling 855 linear feet 72 hours of use *SimaPro Assembly Name: Fuel_G2_construction 28 wells* *Process Used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 405 gal**	• Hollow stem auger • 72 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 72 hours operated 405 Gallons of Fuel Used *G-3B_energy_(020513).xlsx → ISTT → Row 32*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Bioremediation				
Direct Push Rig, Truck Mounted, Non-Hydraulic • 656 injection points initial event plus 328 points in second event = 984 injection points • Depth from 5-30 ft bgs	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B • 300 days (including both events) of operation x 8hrs =2400 hours • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 2400 x 0.050 x 0.75 = 5400 gals (refer to EPA, 2012, pg 59)	• Direct push rig • 2,400 hours • 5400 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3b_Bio_rig for injections* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 5400 gal**	• Direct push rig • 2,400 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – direct push", 60 HP, 75% load factor, Diesel fuel, 2400 hours operated 5400 Gallons of Fuel Used *G-3B_energy_(020513).xlsx → BIO → Row 33*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Equipment used for the installation of 29 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 730 feet (including screen length of 290 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 730 linear feet / 100 feet per day = 7.3, 8 hour days = 58.4 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 58.4 x 0.050 x 0.75 = 328.5 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 730 linear feet • 58.4 hours • 328.5 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3b_Bio_auger for 29 wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 328.5 gal**	• Hollow stem auger • 730 linear feet • 58.4 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 58.4 hours operated 328.5 Gallons of Fuel Used *G-3B_energy_(020513).xlsx → BIO → Row 34*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
Equipment used for the installation of 39 new 2-inch Schedule 40 PVC wells • Using hollow stem auger • Total combined depth of 1,960 feet (including screen depth of 390 feet)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 19.6, 8-hr days. • 1,960 linear feet / 100 feet per day = 19.6, 8 hour days = 157 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 157 x 0.050 x 0.75 = 883.125 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,960 linear feet • 157 hours of use • 883,125 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 39 mw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 883.125 gal**	• Hollow stem auger • 157 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 157 hours operated 883.125 Gallons of Fuel Used *G-3B_energy_(020513).xlsx → MNA → Row 35*
Replacement of monitoring wells • Using hollow stem auger • Total combined depth of 1,575 ft (35 wells at an average of 45 feet deep)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf page 32) • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 15.75, 8 hour days • 1,575 linear feet / 100 feet per day = 15.75, 8-hr days = 126 hours of use • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 126 x 0.050 x 0.75 = 708.75 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,575 linear feet • 126 hours of use • 708.75 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 35 rw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 708.75 gal**	• Hollow stem auger • 126 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 126 hours operated 708.75 Gallons of Fuel Used *G-3B_energy_(020513).xlsx → MNA → Row 36*

Table G-3B-Table C: Materials Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
GAC • Carbon change out for liquid and vapor phase units	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "List of ERH Materials and Estimated Technology Costs" provided by NAVFAC • TT professional judgment: carbon units will require quarterly carbon change outs for one year. • Estimates of carbon required developed from volume of GAC used in 2007 pilots, TT estimated the following usage (document above) based on those pilot studies: o Two 8,000 lbs vapor phase units o Two 3,000 lbs liquid phase units o Total per quarter = 22,000 lbs	22,000 lbs x 4 fills = 88,000 lbs. of GAC / 2.2 lbs per kg = 40,000 kg *SimaPro Assembly Name: Material_G2_ISTT_GACMaterials/Assemblies used: Virgin GAC Assembly_1kg(TT assembly) Amount input: 40000 p*	88,000 lbs. of GAC	*Material Use and Trans.* Selected: "Virgin GAC (coal based)" Input: 88000 lbs. *G-3B_energy_(020513).xlsx → ISTT → Row 67* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: GAC, lbs., 88000, 1, 0 *G-3B_main_(020513).xlsx → Materials 1 → Row 9*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Drilled Electrodes composition • Steel pipe (370 lbs/electrode) • Graphite (8,400 lbs/electrode) • Steel shot (1,040 lbs/electrode)	• Document, "Comparison of Construction Materials" provided by NAVFAC • Steel pipe: 370 lbs/electrode x 55 electrodes = 20,350 lbs of steel • Graphite: 8,400 lbs/electrode x 55 electrodes = 462,000 lbs of graphite • Steel shot: 1,040 lbs/electrode x 55 electrodes = 57,200 lbs of steel shot • Total Steel: Steel pipe + steel shot = 20,350 + 57,200 = 77,550 lbs of total steel	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs *SimaPro Assembly Name: Material_G2_ISTT_Electrodes* *Materials/Assemblies used: Steel, billets, at plant/US(USLCI)* *Amount input: 77550 lb* *AND* *Materials/Assemblies used: Graphite, at plant/RER U (Ecoinvent)* *Amount input: 462000 lb*	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite (Surrogate for graphite, Material A with one-half the emission footprint of iron) Amount: 462,000 lbs	*Material Use and Trans.* Selected: "Steel" Input: 20350 lbs. *G-3B_energy_(020513).xlsx → ISTT → Row 69* PLUS Selected: "Steel" Input: 57200 lbs. *G-3B_energy_(020513).xlsx → ISTT → Row 70* PLUS Selected: "Other refined construction materials" Input: 462000 lbs. *G-3B_energy_(020513).xlsx → ISTT → Row 71* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: Steel, lbs., 77550, 1, 0 *G-3B_main_(020513).xlsx → Materials 1 → Row 10* PLUS Input: Graphite, lbs., 462000, 1, 0 *G-3B_main_(020513).xlsx → Materials 1 → Row 11*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PVC (for 28 new monitoring wells) • 2-inch, Schedule 40 • 855 ft total combined length • 280 feet of screen	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 581.4 lbs PVC	581.4 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_ISTT_PVC 28 mon wells* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 581.4*	Input to SiteWise: 855 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 581.4 lbs. *G-3B_energy_(020513).xlsx → ISTT → Row 72* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: PVC, lbs., 581.4, 1, 0 *G-3B_main_(020513).xlsx → Materials 1 → Row 12*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 855 ft = 11,115 lbs of grout/cement / 2000 lbs per ton = 5.6 tons of cement	5.6 tons of cement *SimaPro Assembly Name: Material_G2_ISTT_Grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 5.6 tn.sh.*	5.6 tons of cement Input to SiteWise: 11,200 lbs Typical Cement	*Material Use and Trans.* Selected: "Cement" Input: 11200 lbs. *G-3B_energy_(020513).xlsx → ISTT → Row 73* PLUS *ISTT remedy - Refined Materials Footprint Summary* Input: Cement, lbs., 11200, 1, 0 *G-3B_main_(020513).xlsx → Materials 1 → Row 13*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Bioremediation				
PVC (for 29 new monitoring wells) • 2-inch, Schedule 40 • 730 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs PVC	496 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3_Bio_pvc 29 mw* *Materials/Assemblies used: PVC pipe E* *Amount input: 496 lb*	Input to SiteWise: 730 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 496 lbs. *G-3B_energy_(020513).xlsx → BIO → Row 74* PLUS *BIOREMEDIATION - Refined Materials Footprint Summary* Input: PVC, lbs., 496, 1, 0 *G-3B_main_(020513).xlsx → Materials 2 → Row 9*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 730 ft = 9,490 lbs of grout/cement / 2000 lbs per ton = 4.75 tons of cement	4.75 tons of cement *SimaPro Assembly Name: Material Use_G3b_Bio_grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 4.75 sh. tn*	4.75 tons of cement Input to SiteWise: Typical Cement 9,500 lbs	*Material Use and Trans.* Selected: "Cement" Input: 9490 lbs. *G-3B_energy_(020513).xlsx → BIO → Row 75* PLUS *BIOREMEDIATION - Refined Materials Footprint Summary* Input: Cement, tons, 4.745, 2000, 0 *G-3B_main_(020513).xlsx → Materials 2 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Emulsified Vegetable Oil (EOS ®) • 1,427, 55-gallon drums for initial event plus 713 drums for second event = 2,140 total drums	See RACER pdf 602 • 2140 drums x 55 gallons per drum = 117,700 gallons of emulsified vegetable oil • If specific gravity of EOS = 1, then 117700 gallons x 8.34 lbs per gallon = 981618 lbs / 2000 lbs per ton = 490.809 tons	2140 x 55 = 117,700 gallons of emulsified vegetable oil = 490.81tons *SimaPro Assembly Name: Material Use_G3_Bio_EOS* *Materials/Assemblies used:* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	2140 x 55 = 117,700 gallons of emulsified vegetable oil Input to SiteWise: 1,284,065 lbs (conversion of gallons to pounds based on a vegetable oil density of 10.912 lbs/gal)	*Material Use and Trans.* Selected: "Other Treatment Chemicals & Materials" Input: 981618 lbs. *G-3B_energy_(020513).xlsx → BIO → Row 76* PLUS *BIOREMEDIATION - Refined Materials Footprint Summary* Input: Emulsified Vegetable Oil, lbs., 981618,1 , 0 *G-3B_main_(020513).xlsx → Materials 2 → Row 11*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
PVC (for 39 new monitoring wells) • 2-inch, Schedule 40 • 1,960 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1333 lbs PVC	1333 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc 39 mw Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 1333 lb*	Input to SiteWise: 1960 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	*Material Use and Trans.* Selected: "PVC" Input: 1333 lbs. *G-3B_energy_(020513).xlsx → MNA → Row 80* PLUS *MNA - Refined Materials Footprint Summary* Input: PVC, lbs., 1333, 1, 0 *G-3B_main_(020513).xlsx → Materials 3 → Row 9*
PVC (for Replacement Wells) • 2-inch, Schedule 40 • 1,575 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC	1,071 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc rw Materials/Assemblies used: PVC pipe E Amount input: 1071 lb*	1,071 lbs of Schedule 40 PVC	*Material Use and Trans.* Selected: "PVC" Input: 1071 lbs. *G-3B_energy_(020513).xlsx → MNA → Row 81* PLUS *MNA - Refined Materials Footprint Summary* Input: PVC, lbs., 1071, 1, 0 *G-3B_main_(020513).xlsx → Materials 3 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1960 ft = 25,480 lbs of grout/cement / 2000 lbs per ton = 12.74 tons of cement	12.74 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 12.74 tn.sh*	12.74 tons of cement	*Material Use and Trans.* Selected: "Cement" Input: 25480 lbs. *G-3B_energy_(020513).xlsx → MNA → Row 82* PLUS *MNA - Refined Materials Footprint Summary* Input: Cement, lbs., 25480, 1, 0 *G-3B_main_(020513).xlsx → Materials 3 → Row 11*
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1,575 ft = 20,475 lbs of grout/cement / 2000 lbs per ton = 10.24 tons of cement	10.24 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout 2* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 10.24 tn.sh*	10.24 tons of cement	*Material Use and Trans.* Selected: "Cement" Input: 20480 lbs. *G-3B_energy_(020513).xlsx → MNA → Row 83* PLUS *MNA - Refined Materials Footprint Summary* Input: Cement, lbs., 20480, 1, 0 *G-3B_main_(020513).xlsx → Materials 3 → Row 12*

Table G-3B-Table D: Transport for Materials, Equipment, and Samples: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Transport of material for 55 electrodes.	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Delivery of steel pipe: 1 trip with 20,350 lbs (10.2 tons) • Delivery of graphite: 8 trips delivering 462,000 lbs (231 tons) ○ TT estimates 30 tons per truck, for 8 trucks necessary to deliver entire load. • Delivery of steel shot: 1 trip with 57,200 lbs (28.6 tons) • TT estimates distance from vendor to site at approximately 50 miles.	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trip Weight: 28.6 tons Miles, one way: 50 miles *SimaPro Assembly Name: Transport_G2_ISTT electrode materials* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent) Amount input: 510 tmi* *Materials/Assemblies used: Transport, lorry >32t, EURO5/RER U (Ecoinvent) Amount input: 12000 tmi* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent) Amount input: 1430 tmi Empty trips included*	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trips Weight: 28.6 tons Miles, one way: 50 miles <u>Steel pipe</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 RETURN trips Weight: 0 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 miles	*Material Use and Trans.* <u>Steel pipe*</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 69* <u>Steel shot*</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 70* <u>Graphite**</u> Input: 50 miles, 16 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 71* *2 trips for each, accounting for delivery and return trip **16 trips accounting for 8 delivery and 8 return

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of PVC • 855 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 582 lbs of Schedule 40 PVC / 2000 lbs per ton = 0.3 tons Schedule 40 PVC	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT pvc* *Materials/Assembles used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 15*	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>PVC***</u> Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 72* *** One way only to match ESTCP
Transport of Cement for Well Installation	• 11,115 lbs of grout/cement (as per Table G2-C) • 11,115 lbs / 2000 lbs per ton = 5.56 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trips with 5.6 tons per trip	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 280*	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 73*
Transport of heavy equipment used for electrode installation and well placement • Hollow stem auger	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C One mob. one demob., TT estimated as de minimis	de minimis	de minimis	de minimis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of samples • 5 rounds of sampling from 53 monitoring wells (DO, ORP, pH, temp, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimate of number of trips based on five wells per day being sampled. Sampling would take place over ~53 days and lab would pick up samples every other day, resulting number of trips would be ~27. • TT estimated the distance to lab as being 50 miles	27 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport_G2_ISTT sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 2700 miles*	27 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 27 trips, 100 miles round trip, Light-Duty Truck, Gasoline 2700 Total Miles *G-3B_energy_(020513).xlsx → ISTT sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* ISTT Sampling Input: $200 Unit Cost, 265 Samples. $53000 Total Cost *G-3B_energy_(020513).xlsx → ISTT lab analysis → Row 102* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of GAC	Total GAC required per quarter = 22,000 lbs TT estimated 1 flatbed truck for delivery TT estimated distance as 50 miles Weight per quarterly trip = 11 tons Assume spent GAC is sent back to regeneration facility on same truck that delivered the new batch of GAC.	• (4 delivery trips + 4 return trips) x 50 miles = 400 miles • Weight of load = 11 tons • 4400 ton-miles *SimaPro Assembly Name: Transport_G2_ISTT_GAC* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input: 4400 ton-miles*	# of trips: 4 11 tons, each 50 miles, one way # of trips: 4 (back to regeneration facility) 11 tons, each 50 miles, one way	*Material Use and Trans.* GAC* Input: 50 miles, 8 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 67* *Accounts for delivery and returns of all GAC material.
Bioremediation				
Transport of PVC • 730 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3b_Bio_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 12.5 ton-mile*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → BIO → Row 74* *** One way only to match ESTCP

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Cement for Well Installation	• 9,490 lbs of grout/cement (as per Table G3A-C) • 9,490 lbs / 2000 lbs per ton = 4.75 tons cement • Assume 20 tons of cement per delivery truck • 1 trip with 4.75 tons per trip • Assume a vendor distance of 50 miles	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3b_Bio_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 237.5 ton-mile*	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → BIO → Row 75*
Transport of EOS • 2140 drums, total	• TT estimates that delivery truck can contain 30 tons per tractor trailer delivery (~113 drums) • Estimate 17 trips to deliver drums • TT estimates a vendor distance of 500 miles, one way	17 trips x 500 miles, one way x 30 tons = 255,000 ton-miles *SimaPro Assembly Name: Transport of Materials_G3b_Bio_EOS* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 255000 ton mile*	Delivery: 17 trips 500 miles 30 tons Return trips: 17 trips 500 miles 0 tons	*Material Use and Trans.* <u>Emulsified Vegetable Oil</u> Input: 500 miles, 34 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → BIO → Row 76*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport for sampling for bioremediation • 10 rounds of sampling from 55 monitoring wells (DO, ORP, pH, ferrous iron, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B • TT estimated transport requirements based on five wells per day being sampled, sampling taking place over ~110 days and lab would picking up samples every other day, resulting in a number of trips of ~55. • TT estimates distance to lab as 50 miles	55 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3b_Bio_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 5500*	55 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 55 trips, 100 miles round trip, Light-Duty Truck, Gasoline 5500 Total Miles *G-3B_energy_(020513).xlsx → BIO sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* BIO Sampling Input: $200 Unit Cost, 550 Samples. $110000 Total Cost *G-3B_energy_(020513).xlsx → BIO lab analysis → Row 103* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
MNA				
Transport of PVC(for 39 new monitoring wells) • 1,960 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1,333 lbs of Schedule 40 PVC x 2000 lbs per ton = 0.67 tons PVC • TT estimated 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc 39 mw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 33.5 ton-mile*	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → MNA → Row 80* *** One way only to match ESTCP
Transport of PVC (for Replacement Wells) • 1,575 ft combined length • 2-inch, Schedule 40	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC = 0.54 tons PVC • TT estimated 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc rw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 27 ton-mile*	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* PVC*** Input: 50 miles, 1 one-way trip, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → MNA → Row 81* *** One way only to match ESTCP
Transport of Cement for well installation (Monitoring Wells)	• 25,480 lbs of grout/cement (as per Table G2A-C) • 25,480 lbs / 2000 lbs per ton = 12.74 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 12.74 tons per trip	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement mw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 637 ton-mile*	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* Cement Input: 50 miles, 4 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → MNA → Row 82*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Cement for well installation (for Replacement Wells)	• 20,475 lbs of grout/cement (as per Table G2A-C) • 20,475 lbs / 2000 lbs per ton = 10.24 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 10.24 tons per trip	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement rw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 512 ton-mile*	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> ***Transportation Accounted for in Row 82 (Due to limitation of Excel Table setup)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Samples, parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 126 wells = 1134 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 50 wells = 400 well samples • 568 + 1134 + 880 + 400 = 2982 samples total • 25% of samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, TOC and dissolved gases	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated trips necessary for transport of samples based on five wells per day being sampled, sampling would take place over ~597days and lab would pick up samples every other day, resulting number of trips would be ~298. • TT estimated distance to lab is 50 miles	298 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3a_MNA_sampling* *Materials/Assemblies used:* *Operation, van < 3,5t/RER U* *Amount input: 29800 mile*	298 trips 50 miles, one way Van, gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 298 trips, 100 miles round trip, Light-Duty Truck, Gasoline 29800 Total Miles *G-3B_energy_(020513).xlsx → MNA sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* MNA Sampling Input: $100 Unit Cost, 2982 Samples. $298200 Total Cost *G-3B_energy_(020513).xlsx → MNA lab analysis → Row 104* *PLUS* ***Off-Site Laboratory Analysis* MNA Sampling Input: $260 Unit Cost, 746 Samples. $193960 Total Cost *G-3B_energy_(020513).xlsx → MNA lab analysis → Row 105* ***Note: Off-Site Laboratory Analysis is only included as an alternative to make Chart 7.*

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis. Off-Site Laboratory Analysis is only included as an alternative to make Chart 7.

Table G-3B-Table E: Waste Transport/Disposal: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
ISTT				
Soil Transport and Disposal after placement of ISTT electrodes • 1.6 tons of soil cuttings produced per electrode • TT estimated the need for hazardous disposal of soil cuttings • 200 miles one way from site to landfill	• Document, "Comparison of Construction Materials" provided by NAVFAC • 55 electrodes x 1.6 tons per electrode = 88 tons of soil • TT estimated 3 trucks needed for removal from site	• 3 trips • 29.3tons of soil each trip • Transported to at hazardous landfill 200 miles, one way *SimaPro Assembly Name: Waste Transport_G2_soil disposal* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount input: 17,580 ton-miles* *Empty trip included* *Disposal:* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill, 88 tn.sh)*	3 trips 29.3 tons of soil each trip Transported to at hazardous landfill 200 miles, one way AND 3 empty trips 0 tons each trip Distance: 200 miles, one way AND Disposal: 88 tons of soil Hazardous landfill	*Waste Trans. and Disposal* Selected: "Hazardous waste landfill" Input: 88 tons, 200 miles, 6 one-way trips, Truck (mpg), Diesel *G-3B_energy_(020513).xlsx → ISTT → Row 89* PLUS *ISTT remedy – Waste Footprint Summary* Input: Soil Disposal etc., 88 *G-3B_main_(020513).xlsx → Waste 1 → Row 35*

Table G-3B-Table F: Transport for Personnel: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
In Situ Thermal Treatment				
Total trips to site by personnel: 813 trips Installation of ISTT electrodes and vapor extraction wells • TT estimated to require 4 people on site for 20 work days. (80 trips) Installation of ISTT treatment system components • TT estimated requiring 5 people on site for 100 work days (500 trips) Operation of ISTT • TT estimated requiring 100 trips to site per year, for one person (100 trips) Installation of 28 monitoring wells • TT estimated requiring 3 people on site for 9 working days (27 trips) Sampling 53 days on site for two people (106 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Trips: 80 + 500 + 100 + 27 + 106 = 813 trips total • Assume use of car (gasoline)	813 trips x 70 miles round trip = 56,910 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_ISTT Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 56910 pmi*	56,910 miles by car (gasoline)	*Labor, Mobilization, etc.* <u>ISTT Installation - electrodes</u> Input: 4 crew, 20 days, 8 hrs worked, 80 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → ISTT → Row 16* <u>ISTT Installation - treatment</u> Input: 5 crew, 100 days, 8 hrs worked, 500 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → ISTT → Row 17* <u>ISTT Operation</u> Input: 1 crew, 100 days, 8 hrs worked, 100 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → ISTT → Row 18* <u>ISTT Installation – monitoring wells</u> Input: 3 crew, 9 days, 8 hrs worked, 27 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → ISTT → Row 19* <u>ISTT Sampling</u> Input: 2 crew, 53 days, 8 hrs worked, 106 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → ISTT → Row 20*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Bioremediation				
Total trips to site by personnel: 1,120 trips Injection of 656 + 328 injection points to take 300 days • Estimated to require 3 people on site for 300 days (900 trips) Includes driller, drillers helper and geologist. Sampling • 110 days on site for two people (220 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline)	1,120 trips x 70 miles round trip = 78,400 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_Bio Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U Amount input: 78400 pmi*	78,400 miles by car (gasoline) Assume one person per vehicle	*Labor, Mobilization, etc.* BIO Installation Input: 3 crew, 300 days, 8 hrs worked, 900 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → BIO → Row 21* BIO Sampling Input: 2 crew, 110 days, 8 hrs worked, 220 trips, 70 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → BIO → Row 22*
MNA				
Sampling Personnel (see Table G2-D) events parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 128 wells = 1,152 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 21 wells = 168 well samples • 568 + 1152 + 880 + 168 = 2768 samples total • 554 days on site, per person x 2 people = 1108 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. • Frequency of sampling and number of people sampling estimated by TT. • TT estimated 50 miles, one way, from home to site for each person sampling	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle *SimaPro Assembly Name: Transport of Personnel_G3a_MNA_total Materials/Assemblies used: Operation, passenger car, petrol, fleet average 2010/RER U Amount input: 110800 mile*	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle	*Labor, Mobilization, etc.* MNA Sampling Personnel Input: 2 crew, 554 days, 8 hrs worked, 1108 trips, 100 miles round trip, Car, Gasoline *G-3B_energy_(020513).xlsx → MNA → Row 23*

Table G-3B-Table G: Potable Water Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G2-C): • ISTT: 11,115 lbs of cement • BIO: 9,490 lbs of cement • MNA: 25,480 lbs of cement • MNA: 20,475 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement • Total cement = 11,115 + 9,490 + 25,480 + 20,475 = 66,560 lbs • 66,560 lbs/ 94 lbs of neat cement x 6 gallons water = 4248.5 gallons of water	4248.5 gallons of water *SimaPro Assembly Name: Potable Water_G3b_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 2.96 tn.sh (ISTT), 2.52 tn.sh (BIO), and 12.23(MNA) tn.sh*	4248.5 gallons of water	*Material Use and Trans.* Public Water (for ISTT) Input: 0.715 *G-3B_energy_(020513).xlsx → ISTT → Row 76* Public Water (for BIO) Input: 0.60574 *G-3B_energy_(020513).xlsx → BIO → Row 79* Public Water (for MNA) Input: 2.93362 *G-3B_energy_(020513).xlsx → MNA → Row 78*
Water for EOS injections	• TT estimated the EVO would be delivered as a 5% solution by volume and that the water used is potable water from a fire hydrant or equivalent source. • Total EOS injected = 117,700 gallons / 0.05 = 2,340,000 gallons of solution, of which 95% is water: 2,340,000 x 0.95 = 2,223,000 gallons water required	Water: 2,223,000 gallons x 8.34 lbs per gallon = 18,539,820 lbs = 9269.91 tons *SimaPro Assembly Name: Potable Water_G3b_water for EOS injections* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 9269.91 tn.sh*	2,223,000 gallons of water	*Material Use and Trans.* Public Water (for BIO) Input: 2223 *G-3B_energy_(020513).xlsx → BIO → Row 78*

Table G-3B-Table H: Non-Potable Water Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant use of non-potable water identified			

Table G-3B-Table I: Known Use of On-Site Renewables: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
• No known use of on-site renewable energy sources for this remedy			

Tables for Alternative G-4
Note: Cells that are shaded in gray are entries that are the same as a previous alternative

Table G-4-Table A: Electricity Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Recirculation System				
Extraction well pump influent to supply an estimated combined flow rate of 100 gpm plus 100 gpm for recirculation/reinjection, for a total of – 200 gpm • Operation of recirculation and treatment system for 35 years	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • See Equation 1, below. Assume an efficiency of 0.8 for motor and 0.75 for pump and a TDH=55 ft. • Estimated daily energy requirement = 83 kWh per day (24 hour operation) • 83 kWh x 365 days x 35 years = 1,060, 325 kWh for entire remedy	1,060, 325 kWh *SimaPro Assembly Name: Electricity Use_G4_pump for recirc* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 1060.325 p*	1,060, 325 kWh	1,060,325 kWh *On-Site Electricity Use* "Equip. with kW rating" Input: 1000 Electrical Rating (kW), 1060.325 Hours Used *G-4_energy_(020513).xlsx → Recirc → Row 54* *Grid mix shown in Table 1-J entered into G-4_energy_(020513).xlsx → Grid Electricity → Fuel Mix for Grid Electricity*
Operation of UV/oxidation treatment system • Operation of recirculation and treatment system for 35 years	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 60 kW unit • 60 kW x 306,600 hours = 18,396,000 kWh	18,396,000 kWh *SimaPro Assembly Name: Electricity Use_G4_UV ox* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 18396 p*	18,396,000 kWh	18,396,000 kWh *On-Site Electricity Use* "Equip. with kW rating" Input: 1000 Electrical Rating (kW), 18396 Hours Used *G-4_energy_(020513).xlsx → Recirc → Row 55* Total Electricity Used = 19456325 kWh *G-4_energy_(020513).xlsx → Recirc → Row 59*

Equation 1

$$kWh = \frac{TDH \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$$

TDH = total dynamic head (ft)
Q = flow rate (gpm)
3956 = conversion factor used to convert ft-gpm to HP
0.746 = conversion factor from HP to kW
η_p = efficiency of pump (%)
η_m = efficiency of motor (%)

Table G4-B: Fuel Use for Equipment: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Recirculation System				
Equipment to install wells: • 1,311 linear feet for extraction wells • 1,680 linear feet for injection wells • 2,690 linear feet for monitoring wells • Total 5,681 linear feet	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 57, 8-hr days = 456 hours of use. • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 456 x 0.050 x 0.75 = 2565 gals (refer to EPA, 2012, pg 59)	Hollow stem auger 456 hours of use. 2565 gallons of fuel *SimaPro Assembly Name: Fuel Use_G4_Recirc_install wells_auger Process Used: Diesel, combusted in industrial equipment/US Amount input: 2565 gal**	Hollow stem auger 456 hours of use.	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 456 hours operated 2565 Gallons of Fuel Used *G-4_energy_(020513).xlsx → Recirc → Row 31*
Equipment to install trenching/piping • Equipment required: small backhoe, loader and compactor to excavate and replace approximately 228 bcy	• Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf pgs 795-798) • Assume fuel use de minimis	de minimis	de minimis	de minimis
PRB				
Equipment to install • East PRB: 600 foot PRB via direct push injection of 165 cubic yards of zero valent iron (60 injection locations), 220 days • West PRB: 500 foot PRB via direct push injection of 165 cubic yards of zero valent iron (50	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (See RACER pdf, pg 816) • 400 days x 8 hrs per day = 3,200 hours • Direct push rig • TT estimates use of a 60 HP direct push rig: Fuel	• Direct push rig • 3,200 hours of use • 7200 gallons of fuel *SimaPro Assembly Name: Fuel Use_G4_PRB_injection Process Used: Diesel, combusted in industrial*	• Direct push rig • 3,200 hours of use	*On-Site Equipment Use, etc.* Selected: "Drilling – direct push", 60 HP, 75% load factor, Diesel fuel, 3200 hours operated 7200 Gallons of Fuel Used *G-4_energy_(020513).xlsx → PRB → Row 32*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
injection locations), 180 days	Use (gal) = HP x hrs x BSFC x PLF = 60 x 3200 x 0.050 x 0.75 = 7200 gals (refer to EPA, 2012, pg 59	*equipment/US* *Amount input: 7200 gal**		
Equipment used for the installation of 36 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 1,620 feet (including screen length of 360 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 1620 linear feet / 100 feet per day = 17, 8 hour days = 136 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 136x 0.050 x 0.75 = 765 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1620 linear feet • 136 hours • 765 gallons of fuel *SimaPro Assembly Name: Fuel Use_G4_PRB_wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 765 gal**	• Hollow stem auger • 1620 linear feet • 136 hours	*On-Site Equipment Use, etc.* Selected: "Drilling – medium rig", 150 HP, 75% load factor, Diesel fuel, 136 hours operated 765 Gallons of Fuel Used *G-4_energy_(020513).xlsx → PRB → Row 33*

Table G4-C: Materials Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Recirculation System ***(individual one-time construction components considered de minimis if less than 1% of energy usage)***				
PVC • 19 6-inch extraction wells (95 + 380 linear feet, pg 674 RACER) • 24 6-inch injection wells (120 + 1,560 linear feet, pg 676 RACER) • 450 feet of 4-inch pipe • 2,500 feet of 6-inch pipe • 100 feet of 8-inch pipe • 2,690 feet of 2-inch wells	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 8"=5.39 lbs per linear foot • 6"=3.53 lbs per linear foot • 4"=2.01 lbs per linear foot • 2"= 0.68 lbs per linear foot • ((95+380+120+1,560+2,500) x 3.53 lbs per linear foot)=16,432 lbs PVC • 450 x 2.01 lbs per linear feet = 905 lbs PVC • 100 x 5.39 lbs per linear feet = 539 lbs PVC • 2,690 x 0.68 lbs per linear feet = 1,829 lbs PVC	16,432 + 905 + 539 + 1,829 = 19,705 lbs of PVC *SimaPro Assembly Name: Material Use_G4_Recirc_pvc multiple applications Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 19705 lb*	19,705 lbs of PVC Input to SiteWise 19,705 lbs PVC (entered in "Bulk Materials")	*Material Use and Trans.* Selected: "PVC" Input: 19705 lbs. *G-4_energy_(020513).xlsx → Recirc → Row 67* PLUS *Groundwater Treatment and Recirc. ect. - Refined Materials Footprint Summary* Input: PVC, lbs., 19705, 1, 0 *G-4_main_(020513).xlsx → Materials 1 → Row 9*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Grout for installation of wells • 100 feet of 8" PVC • 4,655 feet of 6" PVC • 450 feet of 4" PVC • 2,690 feet of 2" PVC	Cement requirement for well installation (as per EPA, 2012): • 8" PVC requires 32 lbs per foot • 6" PVC requires 25 lbs per foot • 4" PVC requires 19 lbs per foot • 2" PVC requires 13 lbs per foot • 100 feet x 32 lbs per foot = 3,200 lbs of cement • 4,655 feet x 25 lbs per foot = 116,375 lbs of cement • 450 feet x 10 lbs per foot = 4,500 lbs of cement • 2,690 feet x 13 lbs per foot = 34,970 lbs of cement • Total cement = 3,200 + 116,375 + 4,500 + 34,970 = 159,045 lbs of cement / 2000 lbs per ton = 79.5 ton	79.5 ton of cement *SimaPro Assembly Name: Material Use_G4_Recirc_grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 79.52*	159,045 lbs of cement	*Material Use and Trans.* Selected: "Cement" Input: 159045 lbs. *G-4_energy_(020513).xlsx → Recirc → Row 68* PLUS *Groundwater Treatment and Recirc. ect. - Refined Materials Footprint Summary* Input: Cement Grout, lbs., 159045, 1, 0 *G-4_main_(020513).xlsx → Materials 1 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PRB				
PRB media • 165 cubic yards for injection x 2 replacements = 330 cubic yards zero valent iron	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Density of zero valent iron = ~2.6 grams/cm^3 (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • (2.6 g/cm^3 x 764554.858 cm^3 per yard / 453.6 g per pound / 2000 lbs per ton = 2.19 ton per cubic yd ZVI. • 165 yds^3 of ZVI x 2.19 tons per cubic yard = 361.35 tons ZVI x 2= 722.7 tons ZVI	722.7 tons zero valent iron (iron filings) *SimaPro Assembly Name: Material_G4_PRB_iron filings* *Materials/Assemblies used: Pellets, iron, at plant/GLO U (Ecoinvent)* *Amount input: 722.7 tn.sh*	722.7 tons yards zero valent iron (iron filings)	*Material Use and Trans.* Selected: "Steel" Input: 1445400 lbs. *G-4_energy_(020513).xlsx → PRB → Row 69* PLUS *PRB installation - Refined Materials Footprint Summary* Input: Zero Valent Iron, tons., 722.7, 2000, 0 *G-4_main_(020513).xlsx → Materials 2 → Row 9*
PVC • 1,620 feet of 2-inch PVC wells	• 2" Schedule 40 PVC = 0.68 lbs per linear foot (EPA, 2012) • 1,620 x 0.68 lbs per linear foot = 1,102 lbs of PVC	1,102 lbs of PVC *SimaPro Assembly Name: Material Use_G4_PRB_pvc* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 1102 lb*	1,620 ft. of PVC	*Material Use and Trans.* Selected: "PVC" Input: 1102 lbs. *G-4_energy_(020513).xlsx → PRB → Row 70* PLUS *PRB installation - Refined Materials Footprint Summary* Input: PVC, lbs., 1102, 1, 0 *G-4_main_(020513).xlsx → Materials 2 → Row 10*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Grout for installation of wells • 1,620 feet of 2" PVC	• 2" PVC Schedule 40 requires 13 lbs of cement per foot (EPA, 2012) • 1,620 ft x 13 lbs per foot = 21,060 lbs of cement	21,060 lbs of cement *SimaPro Assembly Name: Material Use_G4_PRB_grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 21060 lb*	21,060 lbs of cement	*Material Use and Trans.* Selected: "Cement" Input: 21060 lbs. *G-4_energy_(020513).xlsx → PRB → Row 71* PLUS *PRB installation - Refined Materials Footprint Summary* Input: Cement, lbs., 21060, 1, 0 *G-4_main_(020513).xlsx → Materials 2 → Row 11*

Table G4-D: Transport for Materials, Equipment, and Samples: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Recirculation System				
Transport of 19,705 lbs of PVC	10 tons of PVC	# of trips: 5 delivery trip Weight: 2 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_Recirc_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 500 ton-miles*	<u>Schedule 40 PVC pipe</u> # of trips: 5 delivery trip Weight: 2 tons Miles, one way: 50	*Material Use and Trans.* <u>PVC</u> Input: 50 miles, 10 one-way trips, Truck (mpg), Diesel *G-4_energy_(020513).xlsx → Recirc → Row 67*
Transportation of cement for well installation	• 159,045 lbs of cement for recirculation system well installation (from Table G4-C) • 159,045 lbs x 2000 lbs per ton = 79.5 tons of cement • Assume 20 tons of cement per delivery truck • 4 trips with ~ 20 tons per trip	# of trips: 4 delivery trips Weight: 20 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_Recirc_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 4000 ton mile*	# of trips: 4 delivery trip Weight: 20 tons Miles, one way: 50 # of trips: 4 return trips Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 8 one-way trips, Truck (mpg), Diesel *G-4_energy_(020513).xlsx → Recirc → Row 68*
Transportation for one time use construction equipment considered de minimis, either because it is a single round trip, or because equipment may be on-site		de minimis	de minimis	de minimis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Samples 3,937 samples total	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Frequency of sampling, number of people sampling and miles to lab estimated by TT. • TT estimated trips: 5 wells are sampled per day and samples are picked up every other day: 385 trips • TT estimated 50 miles, one way, to lab • Van/light truck	385 trips x 100 miles round trip= 38,500 miles 38,500 miles *SimaPro Assembly Name: Transport of Materials_G4_Recirc_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 38500 mile*	38,500 miles Van, light truck Gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 385 trips, 100 miles round trip, Light-Duty Truck, Gasoline 38500 Total Miles *G-4_energy_(020513).xlsx → Recirc sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* Recirc Sampling Input: $100 Unit Cost, 3937 Samples. $393700 Total Cost *G-4_energy_(020513).xlsx → Recirc lab analysis → Row 102* *PLUS* ***Off-Site Laboratory Analysis* Recirc Sampling Input: $260 Unit Cost, 984 Samples. $255840 Total Cost *G-4_energy_(020513).xlsx → Recirc lab analysis → Row 103* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
PRB				
Transport of 330 yds^3 iron filing	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 2 one way trips • Density of zero valent iron = ~2.6 $grams/cm^3$ (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • 165 yds^3 x 2 x 2.19 tons per yard = 722.7 tons of ZVI • Assume flatbed delivery of 40 tons per trip • 19 trips of 50 miles, one way (potential vendor located in Berkley, Ca)	19 trip x 40 tons x 50 miles 38,000 ton-miles *Empty return trip included* *SimaPro Assembly Name: Transport_G4_PRB iron* *Materials/Assemblies used: Truck 40t* *Amount input: 38000 ton mile*	# of trips: 19 40 tons, each 50 miles, one way # of trips: 19 return trips Weight: 0 tons Miles, one way: 50 # of trips: 19 (empty) 0 tons, each 50 miles, one way	*Material Use and Trans.* Zero Valent Iron Input: 50 miles, 38 one-way trips, Truck (mpg), Diesel *G-4_energy_(020513).xlsx → PRB → Row 69*
Transport of 1,102 lbs of PVC	0.5 tons of PVC	# of trips: 1 delivery trip Weight: 0.5 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_PRB_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input:25 ton-miles*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.5 tons Miles, one way: 50 # of trips: 1 return trips Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* PVC Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-4_energy_(020513).xlsx → PRB → Row 70*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of cement for installation of wells	21,060 lbs of cement (as per Table G4-C) • 21,060 lbs / 2000 lbs per ton = 10.53 tons of cement • TT estimates 20 tons of cement per delivery truck • 1 trips with 10.5 tons per trip	# of trips: 1 delivery trip Weight: 10.5 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_PRB_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 525 ton-miles*	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 10.5 tons Miles, one way: 50 # of trips: 1 return trips Weight: 0 tons Miles, one way: 50	*Material Use and Trans.* <u>Cement</u> Input: 50 miles, 2 one-way trips, Truck (mpg), Diesel *G-4_energy_(020513).xlsx → PRB → Row 71*

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Transport of Samples • 1,512 samples total	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Frequency of sampling, number of people sampling and miles to lab estimated by TT. • If 5 wells are sampled per day and samples are picked up every other day: 151 trips • TT estimates 50 miles, one way, to lab • Van/light truck	151 trips x 100 miles round trip= 15,100 miles *SimaPro Assembly Name: Transport of Materials_G4_PRB_sampling* *Materials/Assemblies used:* *Operation, van < 3,5t/RER U* *Amount input: 15100 mile*	15,100 miles Van, light truck Gasoline	*Labor, Mobilization, etc.* <u>Transport of samples to lab</u> Input: 151 trips, 100 miles round trip, Light-Duty Truck, Gasoline 15100 Total Miles *G-4_energy_(020513).xlsx → PRB sample transport → Row 16* *PLUS* ***Off-Site Laboratory Analysis* PRB Sampling Input: $360 Unit Cost, 1512 Samples. $544320 Total Cost *G-4_energy_(020513).xlsx → PRB lab analysis → Row 104* ***Note: Lab Analysis only included as an alternative to make Chart 7*

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis. Lab Analysis only included as an alternative to make Chart 7

Table G4-E: Waste Transport/Disposal: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
Recirculation System			
No significant wastes identified			
PRB			

Table G4-F: Transport for Personnel: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Recirculation System				
Transport for recirculation system related items • 2 people to site for 770 days of sampling (1540 trips) • Estimated to require 3 people on site for 57 days (171 trips) Includes driller, driller's helper and geologist. (referencing time spent on auger use for well drilling) • System installation crew (includes trenching crew): 72 days, 5 man crew = 360 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimates an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline) • 2,071 total one way trips	2,071 trips x 70 miles round trip = 144,970 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_G4_Recirc Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U Amount input: 144970 pmi*	144,970 miles by car	*Labor, Mobilization, etc.* Recirculation System - Sampling Input: 2 crew, 770 days, 8 hrs worked, 1540 trips, 70 miles round trip, Car, Gasoline *G-4_energy_(020513).xlsx → Recirc → Row 16* Recirculation System - Drilling Input: 3 crew, 57 days, 8 hrs worked, 171 trips, 70 miles round trip, Car, Gasoline *G-4_energy_(020513).xlsx → Recirc → Row 17* Recirculation System - Installation Input: 5 crew, 72 days, 8 hrs worked, 360 trips, 70 miles round trip, Car, Gasoline *G-4_energy_(020513).xlsx → Recirc → Row 18*
PRB				
Total trips to site by personnel: 1,806 trips Installation of PRB (including 36 wells) • Driller, drillers helper, and project engineer for 400 days (1200 trips) Sampling • 303 days on site for two	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimates an average of 35 miles, one way, per person, from home to site. • Car (gasoline)	1,806 trips x 70 miles round trip = 126,420 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_G4_PRB Materials/Assemblies used: Transport,*	126,420 miles by car (gasoline)	*Labor, Mobilization, etc.* PRB - Installation Input: 3 crew, 400 days, 8 hrs worked, 1200 trips, 70 miles round trip, Car, Gasoline *G-4_energy_(020513).xlsx → PRB → Row 19* PRB - Sampling

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
people (606 trips)		*passenger car, petrol, fleet average/RER U Amount input: 126420 pmi*		Input: 2 crew, 303 days, 8 hrs worked, 606 trips, 70 miles round trip, Car, Gasoline *G-4_energy_(020513).xlsx → PRB → Row 20*

Table G4-G: Potable Water Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise	Input Values to SEFA
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G4-C): • Recirculation system: 159,045 lbs of cement • PRB: 21,060 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement • Total cement = 159,045 + 21,060 = 180,105 lbs • 180,105 lbs/ 94 lbs of neat cement x 6 gallons water = 11,496 gallons of water x 8.34 lbs per gallon = 95876.64 lbs	• 95,876.64 lbs of water • 88.3 % Recirc: 84,659.07 lbs • 11.7 % PRB: 11,217.57 lbs *SimaPro Assembly Name: Potable Water_G4_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 84659.07 lb (Recirc) and 11217.57 lb (PRB)*	11,496 gallons of water	*Material Use and Trans.* Public Water (for Recirc) Input: 10.1518 *G-4_energy_(020513).xlsx → Recirc → Row 71* Public Water (for PRB) Input: 1.34426 *G-4_energy_(020513).xlsx → PRB → Row 74*

Table G4-H: Non-Potable Water Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No significant non-potable water use identified			

Table G4-I: Known Use of On-Site Renewables: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise
No known use of on-site renewable energy sources for this remedy			