Environmental Remediation Optimization: Cost Savings, Footprint Reductions, and Sustainability Benchmarked at DOE Sites.

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FIU | Applied Research Center

Objective

To benchmark, train, and evaluate the cost-benefit of Green & Sustainable Remediation (GSR) practices applied to cleanup and closure projects at U.S. Department of Energy (DOE) field sites and DOE Headquarters' management of those projects.

SiteWise™

Excel-based program designed to calculate the environmental footprint of remedial alternatives in terms of sustainability metrics using a method similar to Life Cycle Assessment.
Tool can be applied at any stage: remedy selection, design, implementation, and remedy optimization.
SiteWise™ is designed by United States Navy, United States Army Corps of Engineers, and Battelle.

Input | Metrics

SiteWise™ requires inputs such as material production, transportation, equipment used, residual handling and resource consumption.
Metrics evaluated are greenhouse gas emissions, criteria pollutant emissions, energy consumption, water impact, resource consumption and worker's safety.

Analysis | Results

- Identify high footprint activities.
- Conduct comparative analysis among all of the remedial alternatives.
- Develop list of potential footprint reduction methods.
- Perform cost and footprint sensitivity analysis.
- Include the selected footprint reduction methods in the remedial design.

Case Study
Outfall 200 Mercury Treatment Plant

Two alternatives were analyzed using SiteWise™. Both remediation technologies use Granular Activated Carbon as a treatment media for mercury contaminated water. Alternative A uses virgin GAC, while alternative B uses regenerated GAC as other footprint reduction practices.

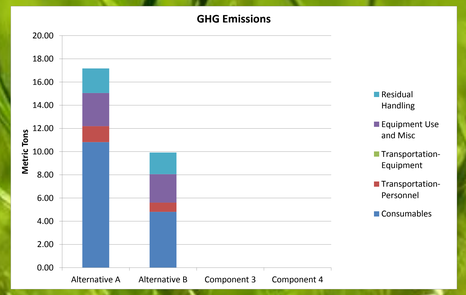

Figure 1: GHG emissions graph of alternatives A and B

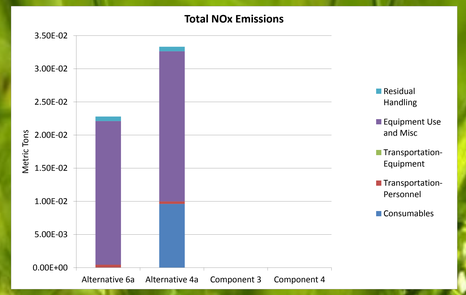

Figure 2: Total NO_x emissions graph of alternatives A and B

Results

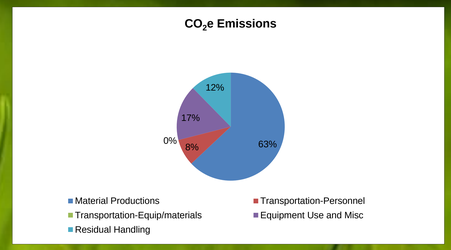

Figure 4: CO_2 equivalents emissions graph for Alternative A

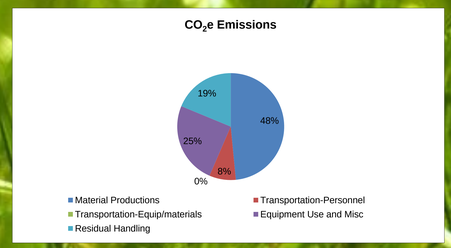

Figure 5: CO_2 equivalents emissions graph for Alternative B

Phase	Activities	GHG Emissions	Total Energy Used	Water Consumption	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton	metric ton	metric ton		
Alternative A	Consumables	10.82	5.7E+01	NA	NA	NA	NA	NA	2.2E-05	2.2E-05	1.1E-06	NA	NA
	Transportation-Personnel	1.38	1.7E+01	NA	NA	NA	NA	NA	4.2E-04	1.8E-05	8.6E-05	4.7E-05	3.8E-03
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	2.86	4.3E+01	0.0E+00	0.0E+00	2.0E-02	4.5E-03	1.4E-03	2.2E-02	5.5E-03	1.7E-03	9.1E-07	2.3E-04
	Residual Handling	2.12	2.9E+01	NA	NA	0.0E+00	0.0E+00	0.0E+00	6.8E-04	2.8E-05	5.5E-05	5.4E-06	4.3E-04
	Sub-Total	17.17	1.47E+02	0.00E+00	0.00E+00	1.97E-02	4.52E-03	1.45E-03	2.28E-02	5.61E-03	1.88E-03	5.31E-05	4.43E-03
Alternative B	Consumables	4.81	5.1E+01	NA	NA	NA	NA	NA	9.6E-03	1.3E-02	1.6E-03	NA	NA
	Transportation-Personnel	0.80	1.4E+01	NA	NA	NA	NA	NA	3.7E-04	4.1E-06	8.9E-05	4.7E-05	3.8E-03
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	2.45	5.4E+01	0.0E+00	0.0E+00	2.0E-02	3.7E-03	1.3E-03	2.3E-02	5.1E-03	1.8E-03	9.1E-07	2.3E-04
	Residual Handling	1.86	3.6E+01	NA	NA	0.0E+00	0.0E+00	0.0E+00	6.8E-04	9.8E-06	6.1E-05	5.4E-06	4.3E-04
	Sub-Total	9.92	1.55E+02	0.00E+00	0.00E+00	2.01E-02	3.68E-03	1.30E-03	3.33E-02	1.79E-02	3.53E-03	5.31E-05	4.43E-03

Figure 3: Results table comparing alternatives A and B

Conclusion

SiteWise™ is capable of comparing two or more remediation technologies to evaluate the cost-benefit of GSR practices. It calculates the remedy footprint generation and helps identify areas and methods for potential footprint reduction. In our case study we can see that no one alternative is the best, but we can identify aspects of both to combine them and come up with the most appropriate remediation technology.

Acknowledgements

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Background picture retrieved from hdw.eweb4.com (autoload)

DOE-EM Cooperative Agreement
Oak Ridge Remediation and Treatment Technology Development

by Michelle Embon (DOE Fellow), Himanshu Upadhyay & Angelique Lawrence

Intro

During the early 1950's,the Department of Energy began the production of thermonuclear armaments in support of the Cold War. One of the sites targeted to support the manufacturing of these nuclear weapons was the Oak Ridge Reservation. This site is now a Superfund area due to the high level of chemical and radioactive contamination left behind. The DOE Environmental Management program is addressing the need to remediate this region to remove the hazards from past research and defense operations.

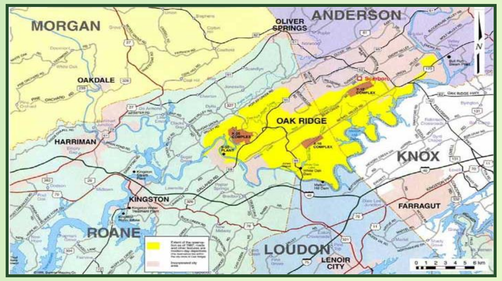

Figure 1. Oak Ridge Reservation

Objective

Provide technical assistance and perform research in support of the remediation and treatment technology development at Oak Ridge Reservation and the Moab Site.

Investigate downloadable free/open source GIS software for online querying of the geodatabase so the project derived data can be more easily shared with other project stakeholders (such as DOE personnel and ORR site contractors).

Design a Geodatabase that provides centralized spatial and tabular data storage as well as concurrent access and editing capabilities of observed and simulated model data.

Methodology

Use ArcGIS ModelBuilder and Python scripting to automate query and export hydrological modeling data for statistical analysis and the generation of maps, graphs, and reports.

Extend capabilities of the East Fork Poplar Creek (EFPC) geodatabase developed in FY11, which stores configuration and output data for modeling contaminant flow and transport in EFPC and White Oak Creek (WOC) watersheds at the Reservation.

Develop a toolbox which combines built-in ArcGIS geoprocessing tools coupled with customized Python scripts for use with the East EFPC model.

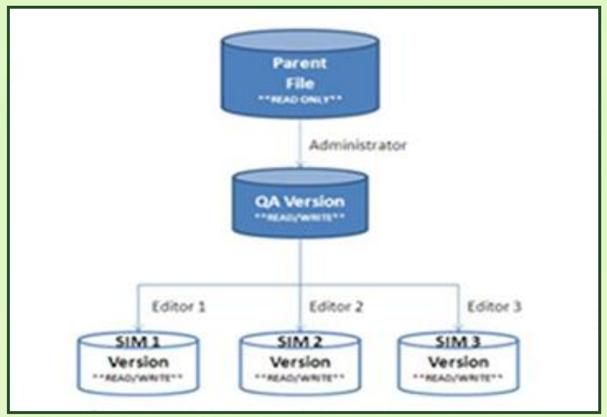

Figure 2: Multi-user editing and versioning capability of the ORR geodatabase.

Results

The capabilities of the geodatabase developed to support the hydrological modeling work were extended by creating a model using ArcGIS ModelBuilder and Python scripting to export data that can be used for statistical analysis and the generation of maps, graphs and reports.

Path Forward

Update geodatabase with recent Oak Ridge Reservation site/environmental data.

Develop a library of customized Python scripts to enhance querying capabilities and couple with existing libraries used for mathematics, science, and engineering to perform statistical analyses.

Use existing geodatabase structures to create similar databases to support modeling work conducted at Moab and DOE Idaho Sites.

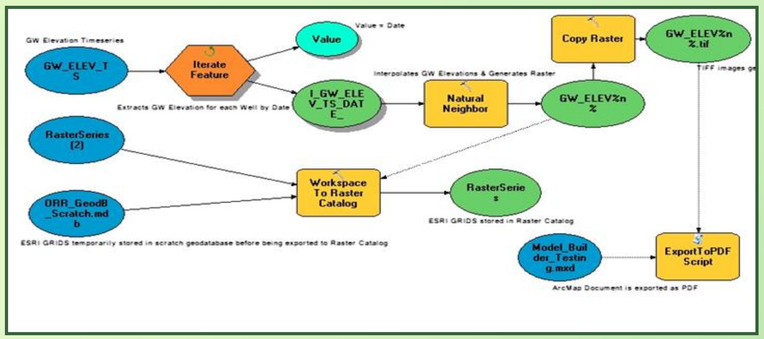

Figure 3: Free/Open Source GIS Software Reviewed by ARC-FIU

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Development of GIS REST Services for Hydrological Models Developed for the Oak Ridge Site

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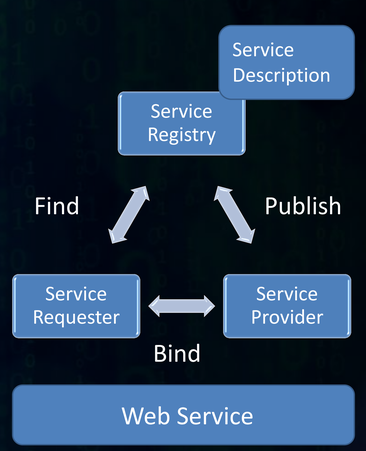
Introduction

- A Web Service exposes a simple method of communication between computers over the internet. These services can be efficiently consumed by clients such as smartphones, tablets , desktop and web applications utilizing the internet as a medium of exchanging data.
- ArcGIS is a framework used to create and analyze geographical information. ArcGIS for Server allows sharing of geographical data over the web using REST services.
- A REST (Representational State Transfer) Service will be created to publish hydrological models from the Oak Ridge site over the web using ArcGIS Server.



A Web Service is a function at a defined network address that can communicate to any application through the web using Hyper Text Transfer Protocol (HTTP). A Service Provider Registers its service to the Service Registry in a universal language like WSDL (Web Services Descriptions Language) which defines a web services' main functionality. Then clients or Service Requesters learn of service functions and requirements through this registry. Once both the Provider and the sender agree and become aware of each other they can exchange data typically in XML (Extensible Markup Language) or JSON (JavaScript Object Notation) format.

Methodology

- Using Microsoft's WCF (Windows Communication Foundation) framework, a REST Web Service will pull the data from the ArcGIS Server. Authentication will also be implemented using a Web Adaptor.
- The Web Adaptor is a separate piece of software that can be installed on a third-party server which allows a Web Service to connect to ArcGIS Server. Once connected, the Web Service will extract data from the ArcGIS server through its geodatabase.
- The information extracted from the ArcGIS Server will be published through a web application running on a web server.

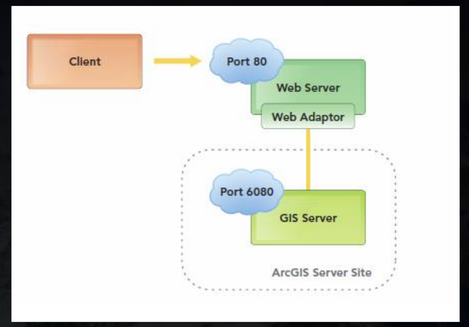


Figure 1. ArcGIS Server Architecture

Different data plotting and rendering techniques will be explored on the Web application to test the performance of the application with large Oak Ridge data models having more than a hundred thousand data points.

A clustering algorithm will be developed for large data sets to minimize the amount of data displayed on the map within a given area. The idea is to group the points on the map into smaller clusters when too many points are within a given area of the map, and ungroup when less points are being displayed.

Results

- A REST Service was created using Windows Communication Foundation (WCF) which communicates information in JSON (Javascript Object Notation). This service will be connected to a Web Adaptor to begin receiving models from the ArcGIS Server.
- Using ArcMap, various geographic models of the Oak Ridge site have been created from special data gathered on-site. These models will be published on an ArcGIS Server for displaying on the web.

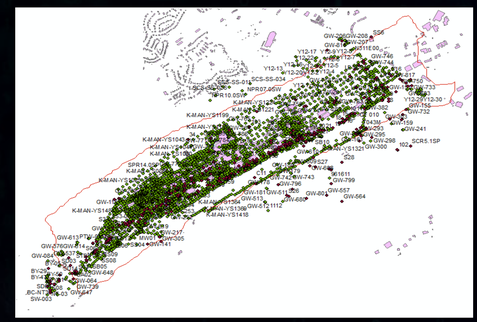


Figure 2. GIS model of Mercury Concentrations in Soil in the Watershed Model Domain

Mercury Concentration Model

This geographical model shows the Total Maximum Daily Loads (TMDLs) for mercury concentration in surface and ground water in the East Fork Popular Creek at the U.S. Department of Energy's Oak Ridge site. In total there are 54,000 mercury records/data points in this model and over 100,000 flow data records. There were four media types sampled: 1) surface water, 2) ground water, 3) soil, and 4) sediment. The modeling was used to determine the efficacy of stabilization in place with hydrological isolation for remediation of mercury contaminated areas in the Upper East Fork Popular Creek watershed in Oak Ridge, TN. The target mercury concentration for the site was determined based on Tennessee Department of Environment and Conservation (TDEC) regulations for surface waters.

Path Forward

The REST Service will be connected to the Web Adaptor and tested with actual GIS models from various Department of Energy sites for performance, scalability and management issues.