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Establishment of the TREECS Platform: A Survey of Existing Tools, Portals, and Frameworks

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PURPOSE: The Training Range Environmental Evaluation and Characterization System (TREECS) is being developed by the Environmental Laboratory of the U.S. Army Engineer Research and Development Center (ERDC) to provide a tool with varying levels of capability to forecast the fate of munitions constituents (MC) within and transported from ranges and provide the range manager with strategies to meet environmental compliance goals for human and ecological health. TREECS will be developed mainly as a web-enabled system although the more advanced analysis tiers may require the user to download analysis components that will need to be run on his/her system. TREECS initially focuses on contaminant stressors and health-based end points, but allows the addition of other stressors and environmental end-point metrics.

The general approach to developing TREECS is analysis of existing tools for use in training range environmental risk evaluation and the development of innovative adaptations of those tools that are appropriate and can easily be applied to manage ranges. This technical note describes the existing tools, portals, and frameworks that are undergoing evaluation for use with TREECS and whether the underlying technology/data of those and TREECS should support linkages to one another.

EXISTING TOOLS, PORTALS, AND FRAMEWORKS EVALUATED:

FRAMES. The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES, <http://mepas.pnl.gov/FAMESV1/index.stm>) is a software framework developed by Battelle Memorial Institute's Pacific Northwest National Laboratory (PNNL). FRAMES allows users to select and implement environmental software models for risk assessment and management problems. It is a flexible and holistic approach to understanding how activities affect humans and the environment. It links models that integrate across scientific disciplines, allowing for tailored solutions to specific activities, and provides meaningful information to business and technical managers (Castleton et al. 2006). The framework is adaptable and allows model developers to add their models to the framework by adhering to file specifications prescribed on the FRAMES website. The application is not web-based and therefore requires users to download and install it on their PCs. FRAMES mainly contains simplified screening-level models and is not a geospatial analysis tool. FRAMES is a major component of the Adaptive Risk Assessment Modeling System (ARAMS™), which includes FRAMES as well as additional models, tools and features. It is anticipated that TREECS will be linked to FRAMES as a tier I and II analysis tool where selected FRAMES models are included. This is described in more detail in the ARAMS™ section below. At the time of preparation of this technical note, the currently available version of FRAMES was 1.7. Figure 1 shows the FRAMES main screen.

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Figure 1. FRAMES main screen.

ARAMS™. The Adaptive Risk Assessment Modeling System (ARAMS™, <http://el.erd.usace.army.mil/arams/>, Figure 2) is a computer-based modeling, data delivery, and analysis system that integrates multimedia and multi-pathway fate/transport, exposure, intake/uptake, and effects of military relevant compounds and other constituents of potential concern to assess present and future human and ecological health impacts/risks associated with chronic exposure. ARAMS™ relies on FRAMES as its central hub, but includes many additional models, tools, and help information than the standard FRAMES application. One of these is the Munitions Residue Characterization and Fate Model (MRCFM), which was developed to address fate of MC on ranges. Additionally, ARAMS™ also contains a conceptual site model (CSM) planning tool (Figure 3) that allows the user to construct a standardized conceptual site model. ARAMS™ is not web-based, but does use web-based databases and web services, and like FRAMES, it is not a geospatial analysis tool.

A data import utility program was recently developed for ARAMS™ to allow the user to import data into a model from a Microsoft™ Excel™ spreadsheet, where the user maps the required model data from field(s) in the spreadsheet. Since Excel™ supports various import file formats, this allows the user to import data from several different file formats.



Figure 2. ARAMS™ main screen.

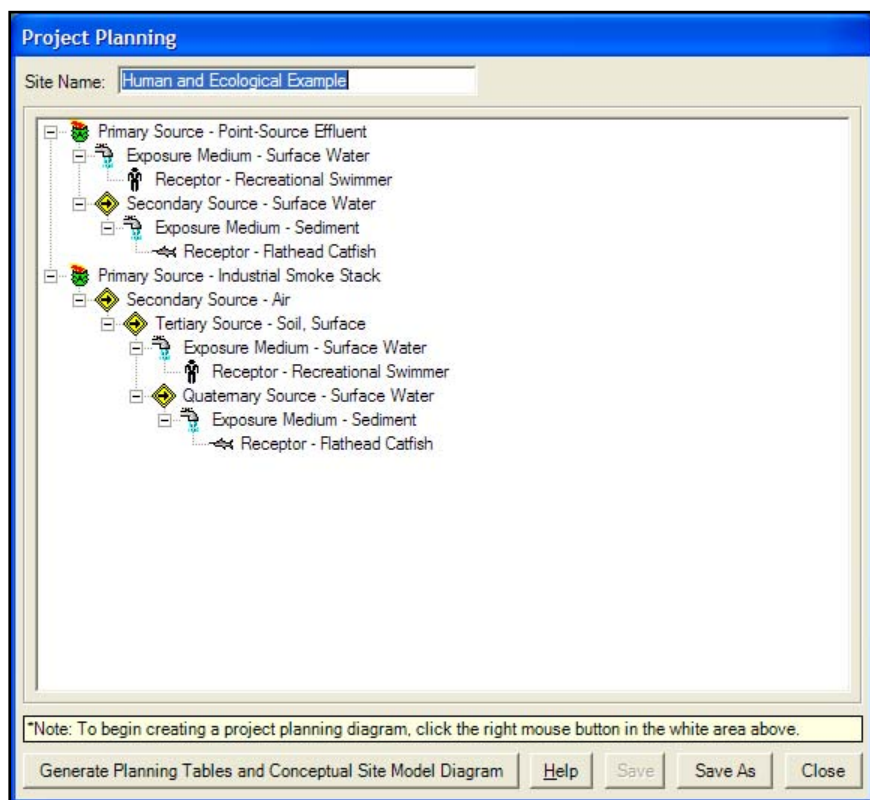


Figure 3. ARAMS™ CSM planning tool.

Selected ARAMS™ and FRAMES models and databases will be supported in TREECS as tier I and II analysis tools. However, new computer coding will be required to allow the TREECS system to supply as much data as possible from existing sources, including Geographic Information System (GIS) based system(s), in order to reduce and simplify the information that the user must supply to these models and databases. The ARAMS™ CSM planning tool will additionally be included in TREECS, thus allowing the user to develop CSM planning diagrams and Risk Assessment Guidance for Superfund (RAGS) planning tables. By providing TREECS with the ability to support the FRAMES I/O file format specifications, linkages to the models can be better supported. The model types that TREECS will support are soil, sediment, surface water, groundwater, and human and ecological risk. Additionally, of these model types, where multiple models are available for use for a given type in ARAMS™/FRAMES, only a limited selection of models for each type will be directly supported in TREECS. This will not preclude the use of other models, but the user will be required to supply model input data more directly for those models and with less automation as provided by the TREECS system. The constituent database (i.e. Risk Assessment Information System or RAIS), Terrestrial Toxicity Database (TTD) Soil Screening Levels (SSLs), TTD Toxicity Reference Values (TRVs), Environmental Residue and Effects Database (ERED), Biota-Sediment Accumulation Factor (BSAF), subset of the Munition Items Disposition Action System (MIDAS), and terrestrial and aquatic databases that currently exist in ARAMS as web services will be available for use in TREECS as needed. The currently available version of ARAMS™ is 1.4.

SADA. The Spatial Analysis and Decision Assistance (SADA, <http://www.tiem.utk.edu/~sada>) software application developed by The Institute for Environmental Modeling at the University of Tennessee incorporates tools for visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. SADA does not perform fate and transport modeling. This software is not web-based and therefore requires downloading and installation on the user's PC. The software supports the import of data files that are comma-separated values (CSV). TREECS will likely not directly support linkage to SADA, but by providing TREECS with the ability to export/import files in CSV format, an indirect linkage can be supported. The currently available version of SADA is 5.0. Figure 4 shows the SADA main screen.

CorpsGlobe. CorpsGlobe (<http://corpsglobe.usace.army.mil>) is the U.S. Army Corps of Engineers' (USACE) instance of the Google™ Earth Enterprise Server. The system provides imagery and national datasets from sources such as U.S. Geological Survey (USGS), National Elevation Dataset (NED), National Inventory of Dams (NID), U.S. Environmental Protection Agency (USEPA), MesoWest, and DBHYDRO. The CorpsGlobe main web page is shown in Figure 5. The "Current Client" link on the web page is where the user downloads the CorpsGlobe desktop application. The CorpsGlobe Enterprise Client graphical user interface (GUI) is shown in Figure 6. The application serves mainly as a viewer, but has the capability to allow the user to locate the datasets mentioned above for a specific location and download that data to his/her computer, provided the dataset exists for the user's selected location. Adding data sources to the application is designed to be relatively easy using the Google™ Application Programming Interface (API) and Keyhole Markup Language (KML). Having a direct link in TREECS to CorpsGlobe is not warranted at this time, but access to its data will be useful. This may involve incorporating any necessary Google API and KML code into TREECS in order to provide access to these datasets. Having a

Uniform Resource Locator (URL) link to it on the TREECS portal for the user to download the CorpsGlobe client if so desired may also be useful since it could be of value to the user.

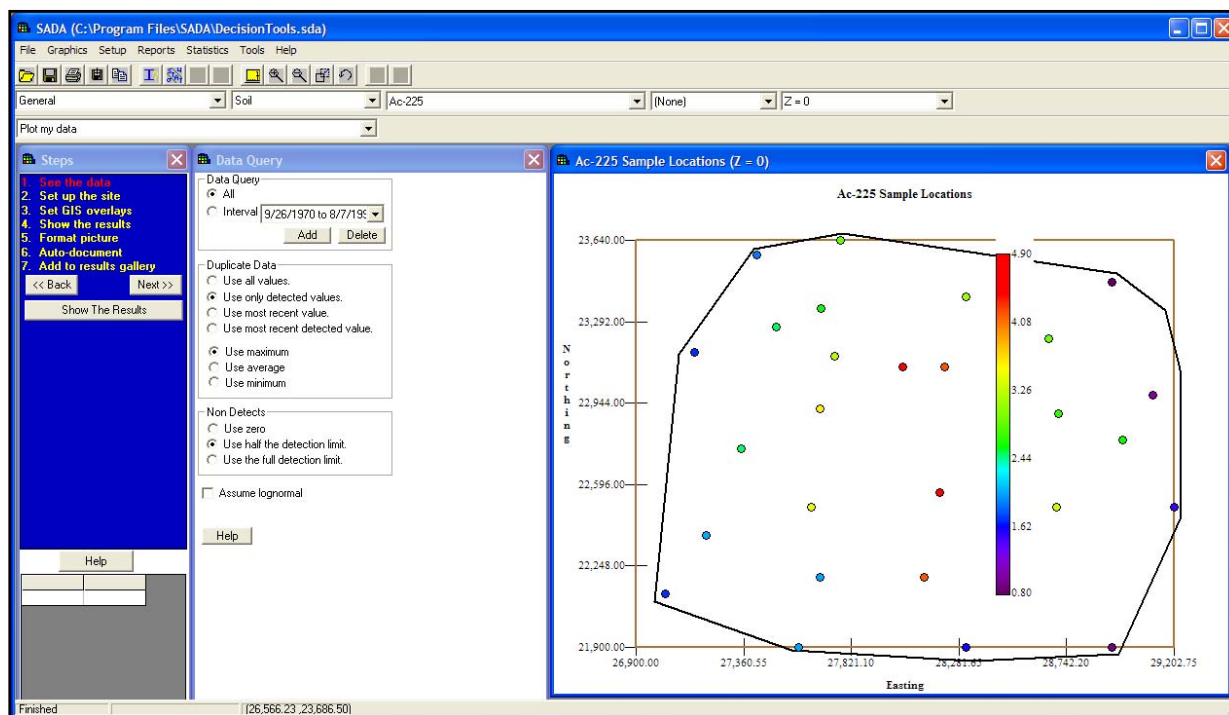


Figure 4. SADA main screen.

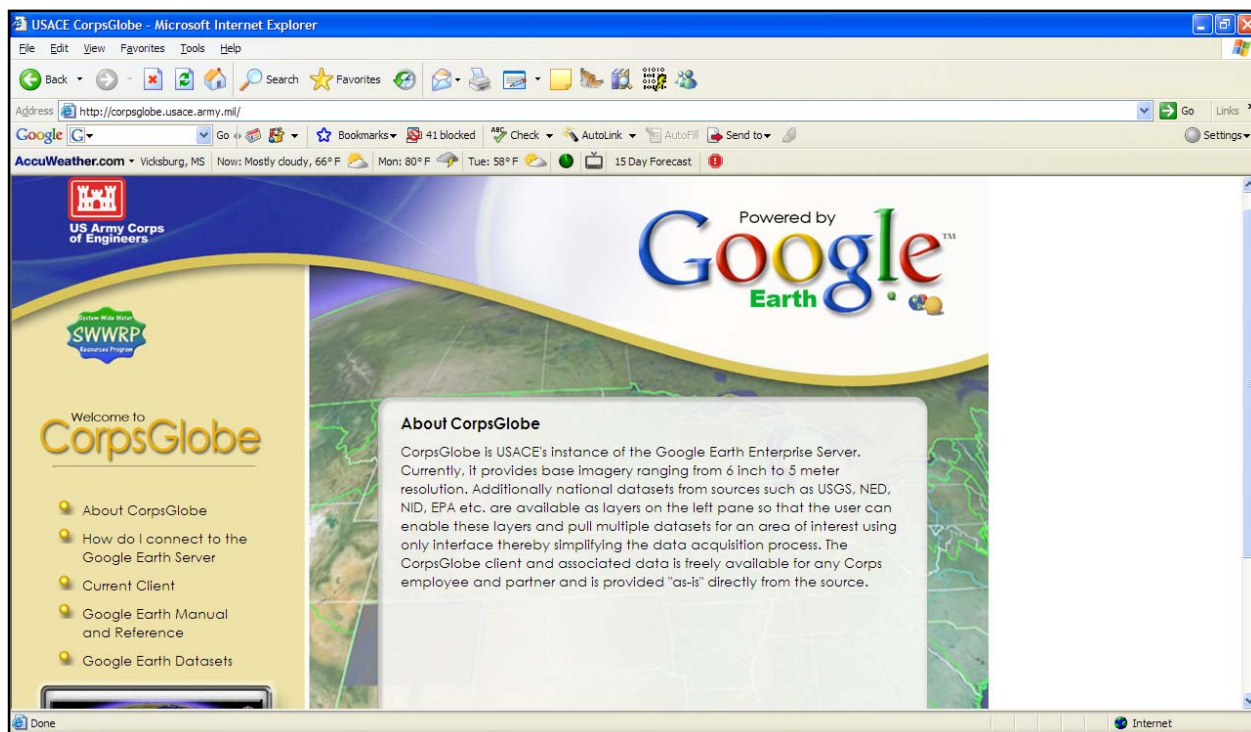


Figure 5. CorpsGlobe main portal page.

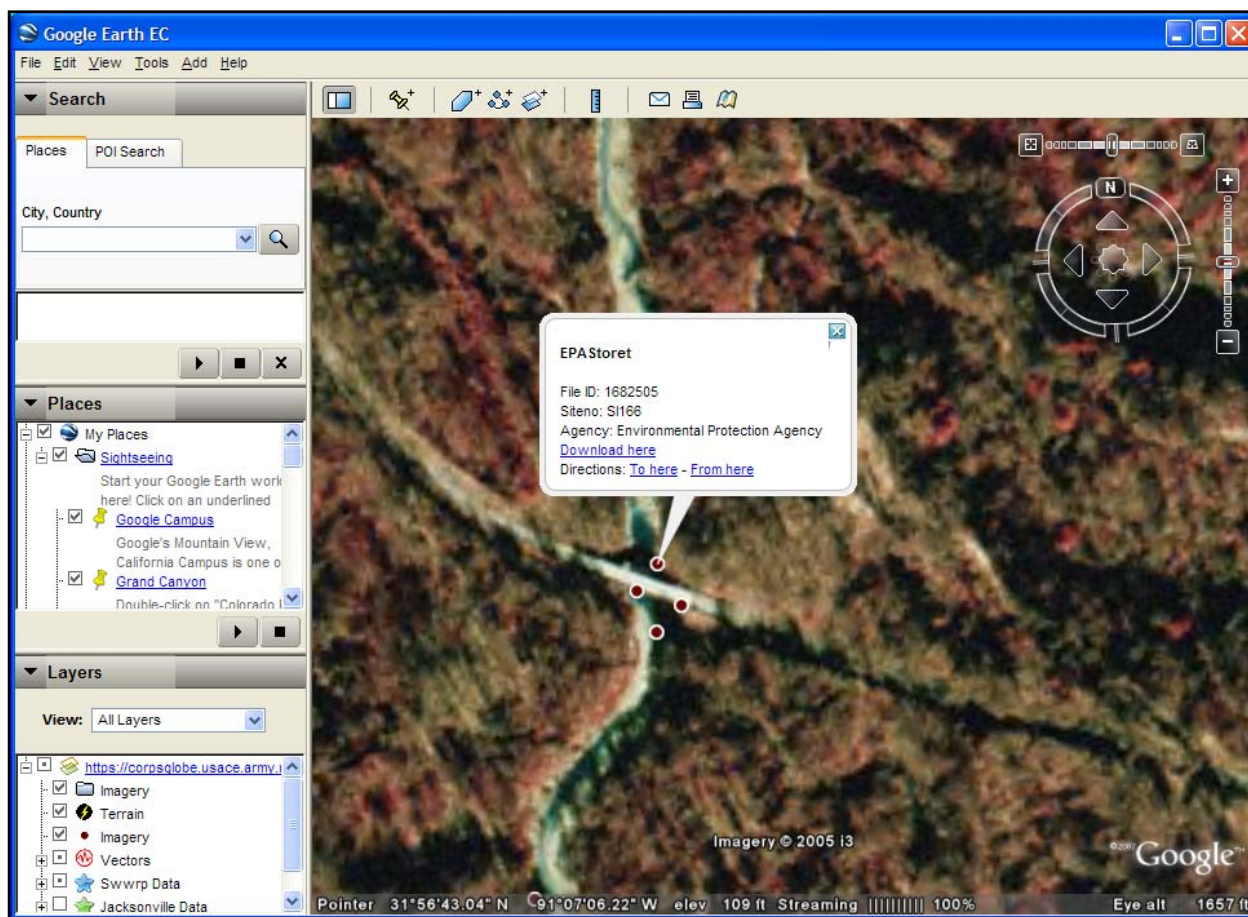


Figure 6. CorpsGlobe Google Earth Enterprise Client main screen.

CorpsMap. CorpsMap (<https://corpsmap.usace.army.mil>) is a web application that provides interactive mapping and analysis to Corps users. It also is a data warehouse for Corps spatial data. Table 1 shows the available data and services in CorpsMap. There are both public and internal versions of CorpsMap. The web portal has a Find feature that allows the user to search for data, locations, etc. The underlying architecture is based on Oracle Fusion/Application Server and the Environmental Systems Research Institute, Inc. (ESRI) ArcSDE products. It also provides full support for any client interface, contains a link to the Sustainable Installation Regional Resource Assessment (SIRRA) application, and can gather data from and provide data to the Project Management Information System (P2) system (Schlagel 2006). Administrators are able to update data and metadata via the “Administrative Toolkit.” CorpsMap uses web services as the integration platform and supports Google Earth and the Bentley Microstation. It is also standards based (i.e., ESRI, Oracle, and the Open Geospatial Consortium (OGC)). CorpsMap supports Service Oriented Architecture (SOA) by fully supporting integration via loosely coupled web services and supports Java 2 Platform, Enterprise Edition (J2EE) and .NET integration. It consumes web services, but it also can expose the web services that it uses. The data that are used are exposed as Simple Object Access Protocol (SOAP) Extensible Markup Language (XML). Additionally, CorpsMap can be queried and controlled with Java Messaging Services (JMS). Vector data are available as Web Feature Services (WFS) and raster data and map views are available as Web Map Services (WMS). Table 2 shows the CorpsMap vector data sources. Table 3 shows some of the web services available.

The TREECS web portal currently under development will be quite similar to the CorpsMap framework. Therefore, this seems to be a good framework from which to start the development of the TREECS system. The CorpsMap main portal page is shown in Figure 7.

Table 1. CorpsMap Available Data (adapted from Jensen 2006)			
Type	Type	Type	Type
Corps projects	Locks	Moderate Resolution Imaging Spectroradiometer (MODIS) Imagery	Seismic Hazard Maps
NID	Military Districts & Divisions	Federal Emergency Management Agency (FEMA) Q3 Flood Data & Regions	Volcanoes
Office of the Assistant Chief of Staff for Installation Management (OACSIM)	Civil Districts & Divisions	USGS Geographic Names Information System (GNIS)	Federal Land
TeleAtlas Basemap Data	Formerly Used Defense Site (FUDS) Locations	Congressional Districts	Mines
USEPA Facilities & Regions	Corps Offices	Principle and Alluvial Aquifers	Eco Regions
Ports	Population Data	Public Land Survey System (PLSS)	Bathymetry
River Miles	Nationwide Digital Orthoimagery Quarter Quadrangles (DOQQ's)	Hydrologic Unit Code (HUC)	SIRRA
Dredge Locations	Ikonos Imagery	Nuclear Reactors	Commercial Satellite Imagery Library (CSIL)

Table 2. CorpsMap Vector Data Sources (adapted from the CorpsMap website)	
Vector Data Source	
CENSUS	
USEPA	
ESRI	
FEMA	
TELEATLAS	
USGS	
ARMY	
FAA (Federal Aviation Administration)	
NRCS (National Resources Conservation Service)	
USFWS (United States Fish and Wildlife Service)	
NGA (National Geospatial-Intelligence Agency)	
NAVTEQ	
NASA (National Aeronautics and Space Administration)	
NEXRAD (Next Generation Radar)	
I-Cubed	
CRREL (U.S. Army Cold Regions Research and Engineering Laboratory)	
NPS (National Park Service)	

Table 3. CorpsMap Web Services Available (adapted from the CorpsMap website)		
Name	Description	Metadata
Raster Data		
Blue Marble, Global MODIS	Global MODIS Imagery	http://wms.jpl.nasa.gov/wms.cgi?service=wms&version=1.1.1&request=GetCapabilities
NEXRAD Radar	45-minute weather radar images (NEXRAD base reflectivity)	http://mesonet.agron.iastate.edu/cgi-bin/wms/nexrad/n0r.cgi?service=wms&version=1.1.1&request=GetCapabilities
Natural Vue	15-meter Conterminous US composite high-resolution imagery	http://iq.usgs.gov/cgi-bin/nuiwms.exe?service=wms&version=1.1.1&request=GetCapabilities
Ortho Imagery (I-Cubed Best of the US)	i-cubed's Best of the US series, bronze edition	http://www.datadoors.net/\$_streaminguid.9dddf91-6821-4227-8357-def5dbda4053/wms.ashx?service=wms&version=1.1.1&request=GetCapabilities
TerraServer DRG	TerraServer Digital Raster Graphic (DRG): USGS Topo Quads	http://terrasservice.net/OgcMap.ashx?service=wms&version=1.1.1&request=GetCapabilities
USGS Gulf/Atlantic Mosaic	15-meter resolution national image mosaic and high-resolution image mosaics for Gulf and Atlantic coastal regions	http://iq.usgs.gov/cgi-bin/nuiwms.exe?service=wms&version=1.1.1&request=GetCapabilities
WMS Data		
Navigation WMS	Web map service for the navigation theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_nav.xml?service=wms&version=1.1.1&request=GetCapabilities
Military WMS	Web map service for the Military theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_mil.xml?service=wms&version=1.1.1&request=GetCapabilities
Inland Electronic Navigation Charts (IENC) WMS	Web map service for the IENC theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_enc.xml?service=wms&version=1.1.1&request=GetCapabilities
Flood and Coastal Storm Damage Reduction (F&CSDR) WMS	Web map service for the F&CSDR theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_fcs.xml?service=wms&version=1.1.1&request=GetCapabilities
Environmental WMS	Web map service for the Environmental theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_env.xml?service=wms&version=1.1.1&request=GetCapabilities
Current Events WMS	Web map service for the Current Events theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_cur.xml?service=wms&version=1.1.1&request=GetCapabilities

Base Data WMS	Web map service for the base data used for all ComprMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_base.xml?service=wms&version=1.1.1&request=GetCapabilities
USACE Data WMS	Web map service for USACE data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_coe.xml?service=wms&version=1.1.1&request=GetCapabilities
National Atlas WMS	Web map service for National Atlas data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_nat.xml?service=wms&version=1.1.1&request=GetCapabilities
Reference Maps WMS	Web map service for Reference data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_ref.xml?service=wms&version=1.1.1&request=GetCapabilities
WFS Data		
Current Events WFS	Web feature service for the Current Events theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_cur.xml?service=wfs&version=1.0.0&request=GetCapabilities
F&CSDR WFS	Web feature service for the F&CSDR theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_fcs.xml?service=wfs&version=1.0.0&request=GetCapabilities
Environmental WFS	Web feature service for the Environmental theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_env.xml?service=wfs&version=1.0.0&request=GetCapabilities
Navigation WFS	Web feature service for the Navigation theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_nav.xml?service=wfs&version=1.0.0&request=GetCapabilities
Military WFS	Web feature service for the Military theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_mil.xml?service=wfs&version=1.0.0&request=GetCapabilities
IENC WFS	Web feature service for the IENC theme of CorpsMap	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_enc.xml?service=wfs&version=1.0.0&request=GetCapabilities
Base Data WFS	Web feature service for the base data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_base.xml?service=wfs&version=1.0.0&request=GetCapabilities
National Atlas WFS	Web feature service for the National Atlas data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_nat.xml?service=wfs&version=1.0.0&request=GetCapabilities
Reference Maps WFS	Web feature service for the Reference data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_ref.xml?service=wfs&version=1.0.0&request=GetCapabilities

USACE Data WFS	Web feature service for the USACE data used for all CorpsMap maps	https://maps.crrel.usace.army.mil/cgi-bin/wms/cm_coe.xml?service=wfs&version=1.0.0&request=GetCapabilities
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Figure 7. CorpsMap main portal page.

RDRET. The Range Design Risk Evaluation Tool (RDRET, <http://www.cecer.army.mil/td/tips/pub/details.cfm?PUBID=5286&RESEARCH=1>) is a web-based geospatial model and expert system layered over a GIS that responds to information about a proposed range project at one or more proposed locations. RDRET was developed by the ERDC Construction Engineering Research Laboratory (CERL). The tool considers up to 14 environmental factors, such as wetlands, cultural resources, noise, habitat, etc. for all live-fire range facilities in the Army. The tool also estimates risk of impacts to ranges related to encroachment as well as changes in risk due to management initiatives and mitigation activities. It should be noted that “risk” as used in RDRET is not related to human or ecological health risk. Mitigation strategies and costs to apply these strategies are provided by the model. Calculation of risk is presented in a matrix of risk criteria against range activities. The level of risk is depicted as red, amber, or green in the matrix. The tool then provides a map of the range project at the proposed site showing where risks are located, such as to cultural resources, wetlands, and important habitat. A text report generated by the application discusses each risk issue and the rationale for its particular rating as well as mitigation strategies that were identified by the user to reduce a risk rating (Loechl 2005). RDRET “evaluates” risk using its own methodology, but does not “assess” risk by following standardized risk assessment procedures. RDRET contains no fate and transport components. RDRET is a proof of concept product and is not actively maintained. RDRET has one GIS dataset available (i.e. Fort Benning, Georgia) for the user to select and use. No

direct link to/from TREECS will be made at this time. However, in the event RDRET becomes actively maintained and widely used, a link from TREECS will be considered as a tier I component of TREECS. Hence, the TREECS design allows for the addition of new components in a relatively easy manner. The ability to encompass this functionality will be incorporated during the development of TREECS. Including an indirect link to the Fort Future web site on the TREECS portal may be worthwhile as it would help tie applications together for the user's benefit. RDRET is a tool provided on the Fort Future web portal (<https://ff.cecer.army.mil/ff/home.do>) and an example of the output is shown in Figure 8.

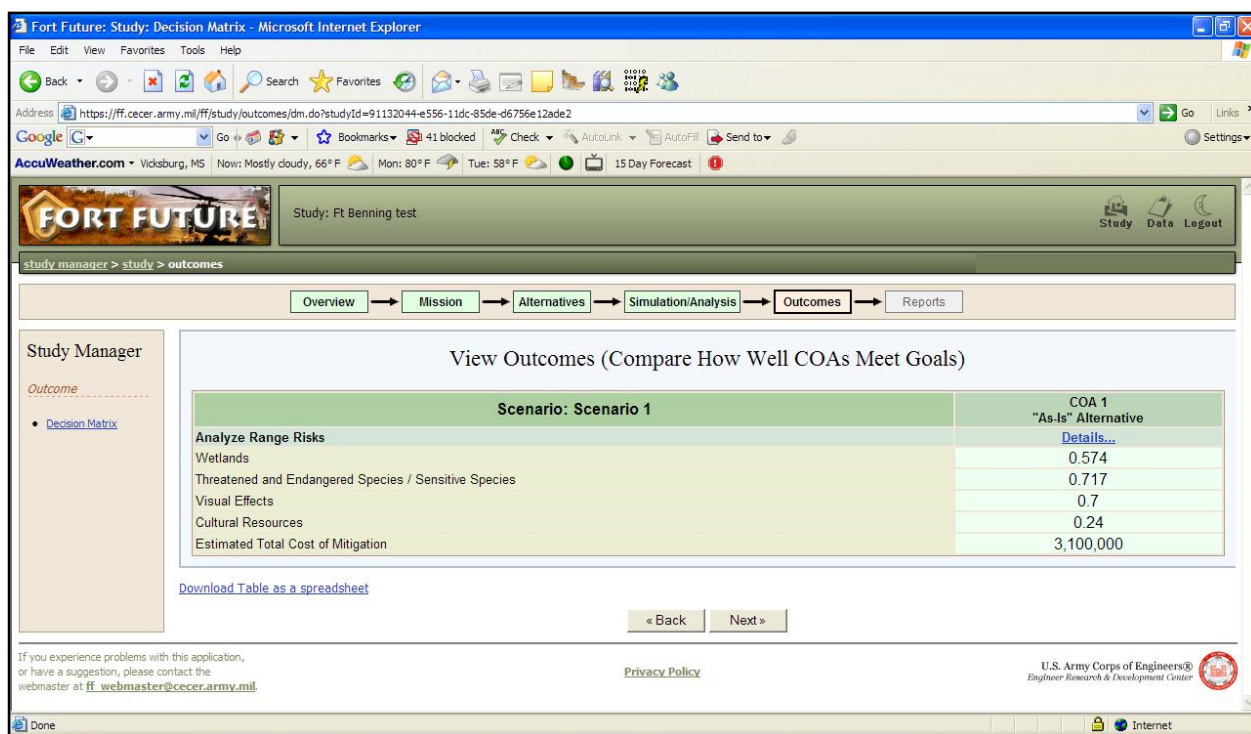


Figure 8. RDRET example output.

SIRRA. The SIRRA (<https://ff.cecer.army.mil/ff/sirra.do>) is a web-based analysis tool that provides a first level screening intended to assist users in estimating the sustainability of a range. The methodology is a process of characterizing the region surrounding a military installation based on an evaluation of 10 sustainability issue areas: air quality, air space, energy, urban development, threatened and endangered species (TES), location, water, economy, quality of life, and infrastructure (Jenicek and Goran 2005). Potential indicators for measuring regional resources within these themes are selected based on the following data requirements:

- Available at a uniform scale nationwide to ensure consistency in comparisons.
- Recorded for multiple time periods to enable the evaluation of change.
- Prepared by a reputable source, such as a government agency or professional data vendor, and accompanied by metadata for quality assurance.
- Provided in a digital format, to accelerate data gathering and preparation for analysis.
- Able to be converted to GIS format (Jenicek et al. 2004).

SIRRA relies on existing national data sets primarily from federal or other national organizations that manage or collect the data. Table 4 is a matrix of SIRRA indicators showing data source and data level. Information on SIRRA metadata can be found in Jenicek et al. 2006. The “air” issue is based on the USEPA’s criteria air pollutants (particulate matter, ground-level ozone, carbon monoxide, sulfur dioxides, nitrogen oxides, and lead) that make up the Air Quality Index (AQI). The USEPA regulates these on human health–based and/or environmentally based criteria, but SIRRA does not evaluate these in regards to human health risk. The “TES” issue is ecological risk of adverse impacts to TES. The “water” issue primarily considers groundwater depletion, flood risk, and low flow sensitivity. Water quality is a part of the issue, but risk of consumption to human health is not considered. A linkage from TREECS will be considered, but the benefit is questionable given the required setup of SIRRA just to obtain this single component. Since SIRRA already has a link from the CorpsMap portal, TREECS should take advantage of that linkage. SIRRA version 1a is a tool provided on the Fort Future web portal. Figure 9 shows the SIRRA main portal page.

Table 4. Matrix of SIRRA indicators broken out by issue area (adapted from Jenicek et al. 2006)			
Issue	Indicator	Data Source	Data Level
Air Quality Sustainability			
AQ1	Criteria pollutant non-attainment	USEPA/Energy Information Administration (EIA)	County
AQ2	Noise sensitivity	US Census Bureau	Installation
Airspace Sustainability			
AS1	Special Use Airspace (SUA), fighter range	FAA	Installation
AS2	SUA, bomber range	FAA	Installation
AS3	Terminal airspace	FAA	Installation
AS4	Military Training Routes (MTR), fighter range	FAA	Installation
AS5	MTR, bomber range	FAA	Installation
Energy Sustainability			
EN1	Electrical grid congestion	North American Electricity Reliability Council (NERC)	NERCSub
EN2	Electrical reserve margin	NERC	NERCReg
EN3	Renewable energy – wind	National Renewable Energy Laboratory (NREL)	Solargridunit
EN4	Renewable energy – solar	NREL	Windgridunit
EN5	Renewable energy – biomass	NREL	State
EN6	Electrical price structure (Deregulation)	Energy Information Administration (EIA)	State
EN7	Net metering	Green Power network	State
Urban Development Sustainability			
UD1	Regional population density	US Census Bureau	County
UD2	Incremental regional growth rate	US Census Bureau	County
UD3	Regional population growth	US Census Bureau	County
UD4	Regional land urbanization	National Land Use Data (NLCD)	Installation
UD5	State smart growth plans	American Planning Association (APA) web site	State
UD6	Joint Land Use Study (JLUS)	JLUS office	Installation
UD7	Proximity to Metropolitan Statistical Areas (MSA)	US Census Bureau	Installation

TES Sustainability			
TE1	# TES in state	USFWS	State
TE2	Species at risk	Journal of American Water Resources Association (JAWRA)	Watershed
TE3	Federally listed TES by ecoregion	NatureServe	Ecoregion
TE4	TES of concern	NatureServe	Ecoregion
Locational Sustainability			
LO1	Federally declared floods	FEMA database	County
LO2	Seismic zones	USGS maps	Zone
LO3	Weather-related damage	National Weather Service (NWS)/National Oceanic and Atmospheric Administration (NOAA)	State
LO4	Federally declared disasters	FEMA database	County
LO5	Tornadoes	NOAA	County
Water Sustainability			
WA1	Level of development	JAWRA	Watershed
WA2	Groundwater depletion	JAWRA	Watershed
WA3	Flood risk	JAWRA	Watershed
WA4	Low flow sensitivity	JAWRA	Watershed
WA5	Water quality	JAWRA	Watershed
Economic Sustainability			
EC1	Department of Defense (DoD) local employment	www.bea.gov U.S. Department of Commerce, Bureau of Economic Analysis (REIS)	County
EC2	Job availability/unemployment	Bureau of Labor Statistics	County
EC3	Housing affordability	US Census Bureau	County
EC4	Poverty	US Census Bureau	County
EC5	Average housing value of new construction	US Census Bureau	County
EC6	Housing permits issued	US Census Bureau	County
Quality of Life Sustainability			
QL1	Crime rate	National Archive of Criminal Justice Data (NACJD)	County
QL2	Housing availability	US Census Bureau	County
QL3	Rental availability	US Census Bureau	County
QL4	Healthcare availability	U.S. Department of Health and Human Services (HHS)	County
QL5	Educational attainment	US Census Bureau	County
QL6	Commute times	US Census Bureau	County
Transportation Sustainability			
TR1	Capacity of commercial airports	Terminal Aerodrome Forecasts (TAF) System	Installation
TR2	Airport suitability for C5 aircraft	FAA	Installation
TR3	Airport suitability for C141 aircraft	FAA	Installation
TR4	Railroad capacity	Federal Railroad Administration (FRA)	County
TR5	Proximity to Interstate	Intelligent Road/Rail Information Server (IRRIS)	Installation
TR6	Roadway congestion	2002 Urban Mobility & Federal Highway Administration (FHWA)	State
TR7	Traffic volume	Travel Time Index (TTI) & FHWA	State

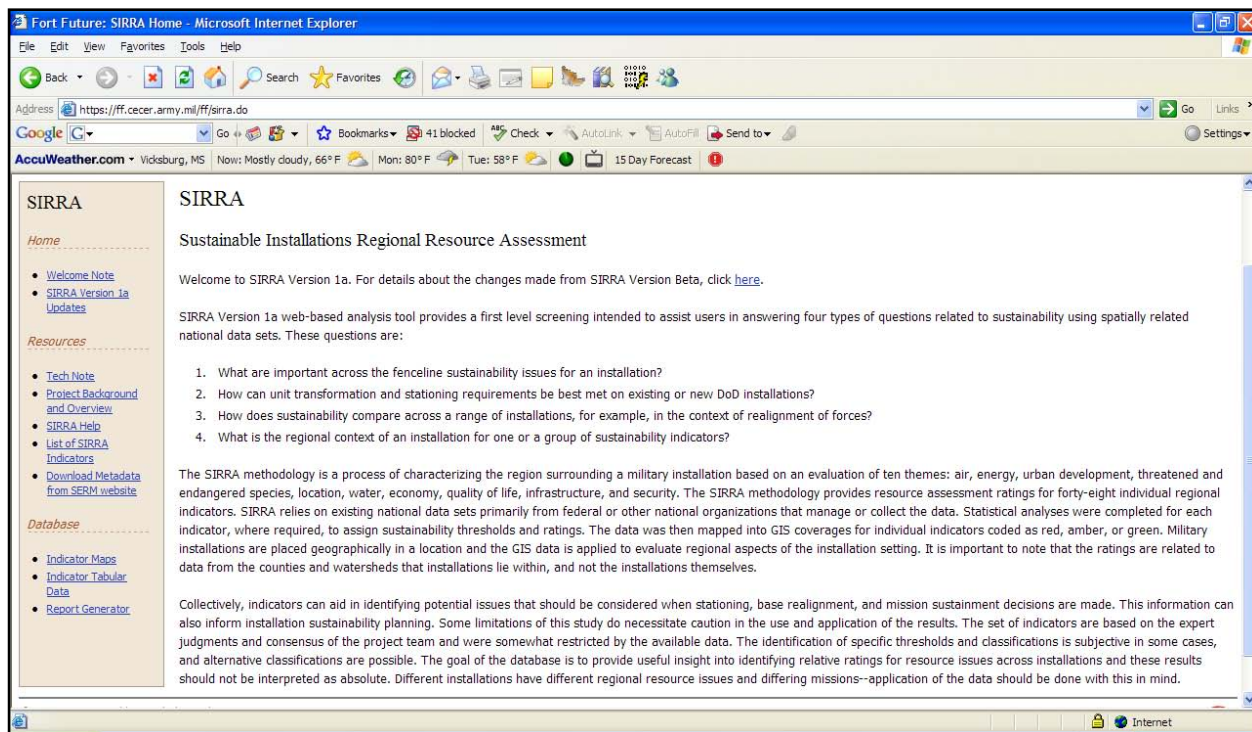


Figure 9. SIRRA main portal page.

RMTK. The Range Managers Toolkit (RMTK, <https://srp.army.mil/SrpWeb/Content.aspx?ModuleId=81>) is a suite of tools designed to aid range control staff with daily operations and planning tasks. The architecture uses Oracle relational database management system (RDBMS), ESRI ArcSDE, ArcIMS, and ArcGIS Server products (Hathcock et al. 2005). It aids in modernizing, operating, and managing ranges while allowing safe training. The toolkit includes a noise prediction and impact assessment software tool designed to enable range managers and trainers to quickly assess the noise impact of training or testing on any given day and for a variety of weather conditions, and also to plan preliminary range siting for noise (Swearingen 2006). The RMTK also has a tool for creating and managing surface danger zones (SDZ) for live-fire training exercises. The tool is additionally being funded by the U.S. Marine Corps (USMC) to add the Navy methodology for laser hazard danger zones (LHDZs) and the display of on-range explosive safety quantity distance (ESQD) arcs for temporary munitions storage (Hathcock et al. 2005). The application tools exist as desktop applications and are not web-based. Since RMTK does not have human or ecological risk or fate and transport modeling components, there is little need for a direct TREECS linkage. However, providing a URL link to it on the TREECS portal will help tie various applications together for the user. Table 5 shows the available tools for RMTK. Figure 10 shows an example of the RMTK Noise tool.

Table 5. RMTK Available Tools

Tool Name	Description
The RMTK Surface Danger Zone (SDZ) Tool	A tool that automates the creation of SDZs and LHDZs
The RMTK Noise Tool	A tool that models noise contours associated with live fire training
The RMTK Range Development and Planning (RDAP) Tool	A tool that allows users to create and modify TC 25-8 standard ranges and associated Range Operations Control Area (ROCA) facilities for planning purposes
The RMTK Explosive Training Range (ETR) Tool	A tool that allows the user to create explosive danger areas in order to evaluate explosive hazards associated with breaching exercises and explosives training on military ranges
The RMTK On Range Ammunition Handling Tool	A tool that allows users to create explosive danger areas in order to evaluate the explosive potential of ammunition temporarily stored on ranges during live fire exercises
The RMTK Training Events Planning System (TEPS)	A tool that allows users to visualize the training complex using SDZs and/or WDZs created using RMTK in a 3-D environment
The RMTK Weapon Danger Zone (WDZ) Tool	A tool that allows users to create WDZs for air to ground weapons

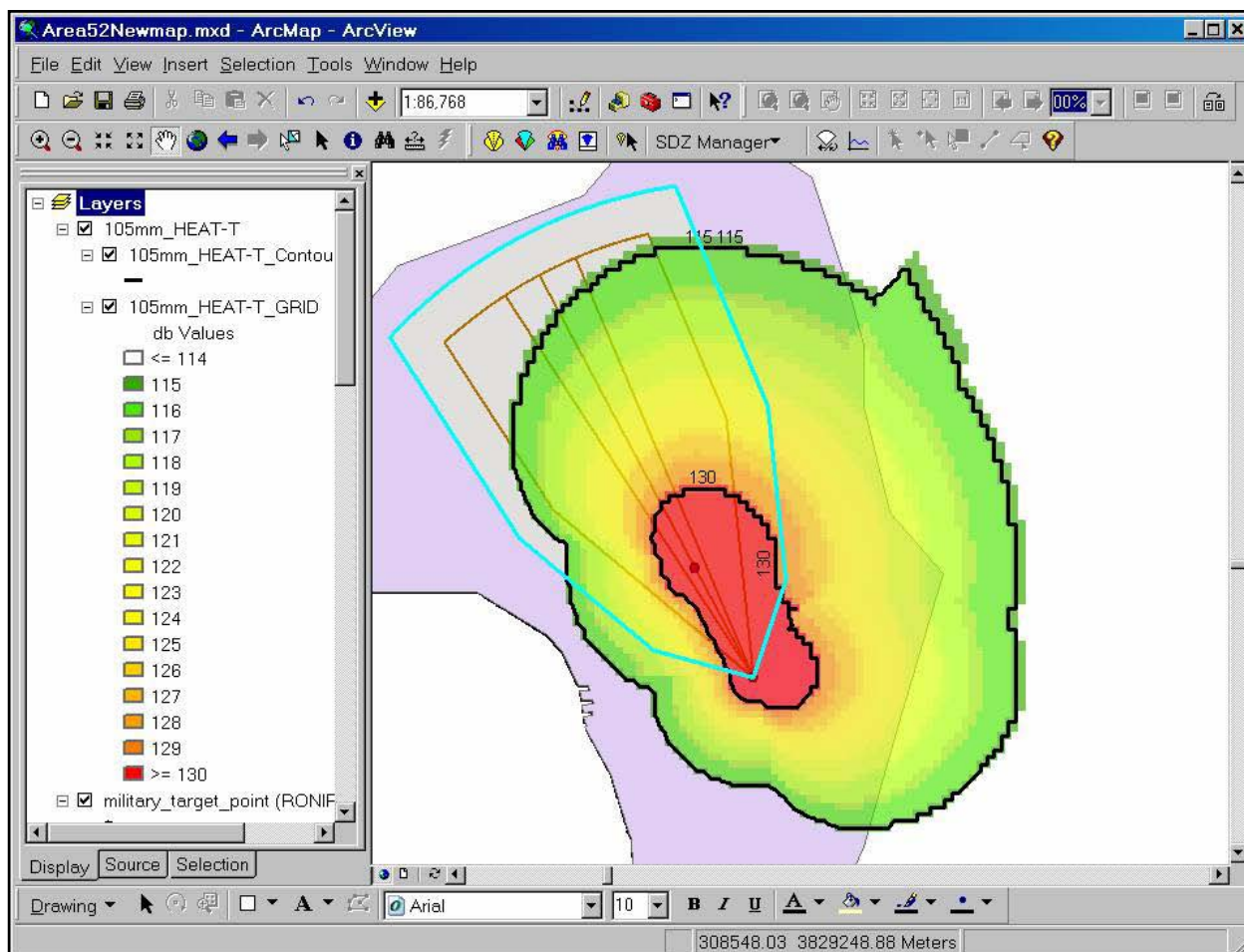


Figure 10. RMTK Noise tool (from Swearingen 2006).

GISR. The Army Geographic Information System Repository (GISR, <https://gis.hqda.pentagon.mil>) is the Army's central repository for GIS data and imagery for every major installation within the continental United States (CONUS). The user must log in with a computer access card (CAC) or an Army Knowledge Online (AKO) account. Behind the scenes at the application tier of the GISR structure are J2EE applications and the ESRI ArcIMS/ArcServer (Scott 2006). The Army is moving to the Army Mapper, and GISR has been discontinued. Therefore, a TREECS linkage for GISR is not planned. Figure 11 shows the GISR main portal page prior to its discontinuation.

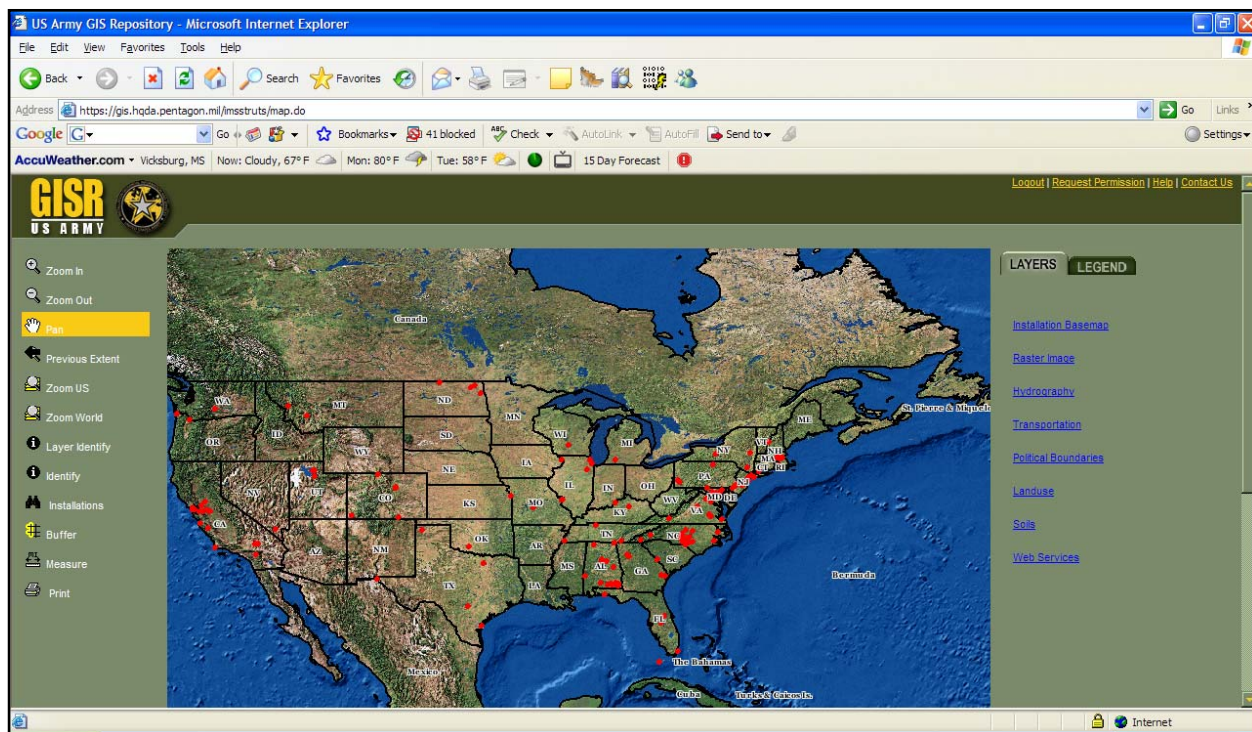


Figure 11. GISR main portal page.

Army Mapper. Army Mapper (<https://gisdev.hqda.pentagon.mil/>) is intended to replace the GISR. The Army Mapper web portal requires the user to log in with either a CAC or an AKO account. The initial operating capability (IOC) period ran from November 2007 through April 2008. The Post-IOC period is ongoing and will end in December 2009 when the system will be at full operating capacity (FOC) with scheduled lifecycle replacement in 3-5 years (Delmonico 2008). The geospatial repository leverages the Oracle RDBMS and ESRI ArcSDE. Army Mapper uses a data standardization process for the submission of data, quality control (QC), and the data which ultimately reside in the repository (Hargroves et al. 2008). More detailed information is provided in U.S. Army Sustainable Range Program (USASRP) 2008. The Army Mapper limited the user to four installations (Fort A.P. Hill, Fort Benning, Fort Sam Houston, and Fort Wainwright) during the IOC.

Army Mapper uses Bentley Microstation for Computer-Aided Design and Drafting (CADD) applications, ESRI ARC products for GIS applications, and a Citrix Presentation Server. The system also uses the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) data standard, web services, and supports Java and .NET programming languages (NAVAIR 2007). Since

Army Mapper is becoming the central repository for GIS data and imagery, TREECS will have the capability to access stored data. Figure 12 shows the main Army Mapper portal page.

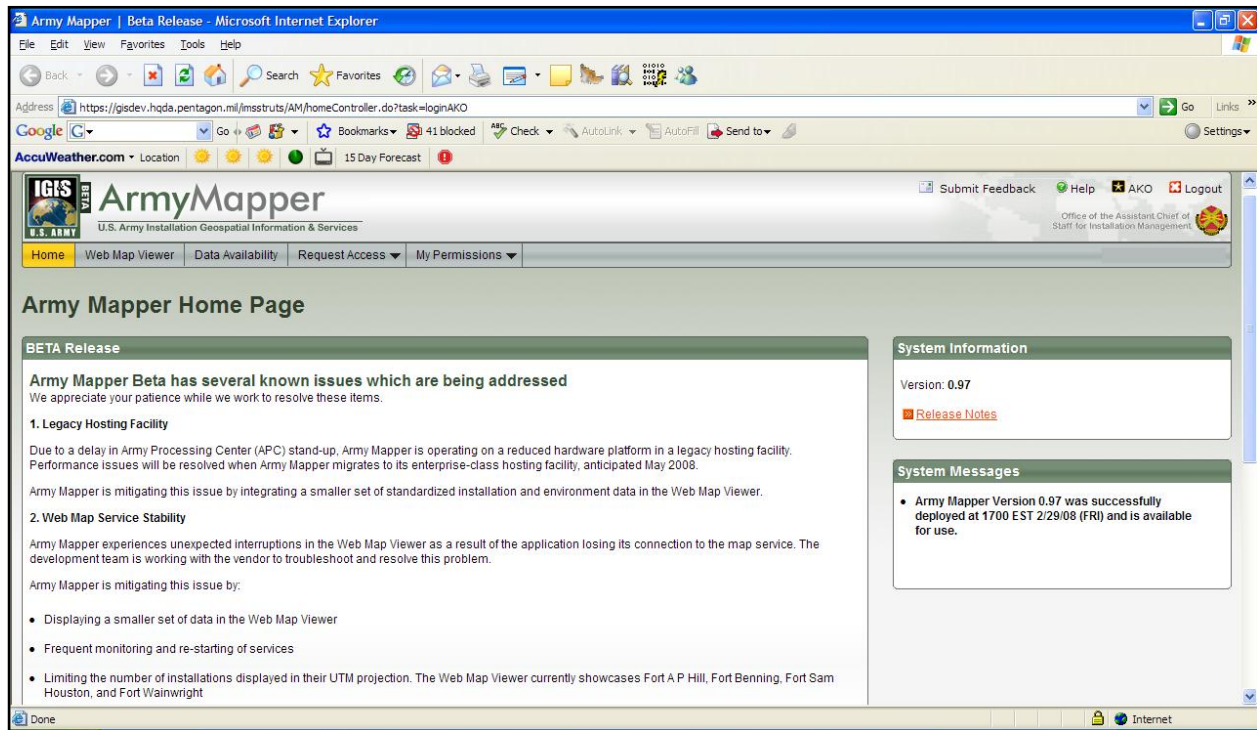


Figure 12. Army Mapper main portal page.

Integrated Training Area Management. The Army Integrated Training Area Management (ITAM, <https://srp.army.mil/SrpWeb/Content.aspx?ModuleId=89>) establishes procedures to achieve optimum, sustainable use of training and testing lands, by implementing a uniform land management program that includes inventorying and monitoring land conditions, integrating training and testing requirements with training land carrying capacity, educating land users to minimize adverse impacts, and providing for training land rehabilitation and maintenance (Department of the Army 1999). ITAM is comprised of six elements (<http://www.cecer.army.mil/facts/sheets/LL23.html>):

- Land Condition Trend Analysis (LCTA) — for inventorying and monitoring natural resources to document their condition and assess the ability of the land to withstand impacts from training and testing.
- Environmental awareness — to educate officers and enlisted troops in order to foster wise use of the land.
- Land Rehabilitation and Maintenance (LRAM) — for revegetation and erosion control to restore the land and enhance testing and training realism.
- Training Requirements Integration (TRI) — for optimization of land use by integrating mission requirements with carrying capacity of the land.
- Geographic Information Systems — tools such as Geographic Resources Analysis Support System (GRASS), to help manage and manipulate data.
- TES — an ecosystems approach to protecting and managing TES with the least impact on training land use.

ITAM is not a web-based application. The Military Activity Geographic Information System Interface Computer (MAGIC) is the modular GIS tool developed with ArcView™ that provides the ITAM program with a standardized capability for accessing GIS data from various data sources. Table 6 shows the core GIS data layers required by ITAM and the data layer type. Optional data layers can exist for a given site.

Table 6. Core GIS Data Layers Required by ITAM (adapted from Department of the Army 1999)	
Data Layer	Type^Y
General	
Aerial Photography	R
Cantonment Area/Camps	V
Contour Lines	V
Digital Elevation Maps (DEM)	R
Fire Breaks	V
Surface Type	T
Width	T
Maintenance Information	T
Grid Scale	V
Universal Transverse Mercator	V
Latitude/Longitude	V
Installation Boundary	V
Political Boundaries	V
County	V
City	V
Zoning, Deed Restriction, etc.	V
Railroads	V
# Spurs	T
Cars per Spur	T
Recreational Areas	V/T
Roads	V
By Type (Define)	T
With Bridge Classification	T
Culverts w/ Classification	T
Training Data	
Air Corridors	V
Airfields/Assault Strips	V
Artillery/Mortar Positions	S
Munitions Acceptable	T
Survey Points	T
Size	T
Constraints to Training e.g.	V
No Dig Areas	V
Pipelines w/Crossing Sites	V/T
Noise Limitation Areas	V
Limitations to Pyrotechnic Use	V
Limitations to Obscurant Use	V
Foot Traffic Only	V

Crossing Sites/Ford Sites	V
Unserviceable	T
Unimproved	T
Improved	T
Hardened Sites	T
Drop Zone (DZ)/Landing Zone (LZ)/ Pickup Zone (PZ)	V
Type	T
Overall Dimensions	T
Length in Seconds	T
Number of Ships by Type	T
Hardened Training Sites	V
Impact Areas, Dudded	V
Land Navigation Courses	V
Military Operations Areas (MOAs)	V
No Overflight Areas	V
NOE Training Areas	V
Operations and Plans (Ops)	V
Lines of Visibility	V
Linked to Firing Positions	T
Petroleum, Oil and Lubricant (POL) Sites, Field	V
Ranges/Training Facilities	V
Facility Category Group (FCG)	T
FCG Description	T
Category Code	T
Cat Code Description	T
Range Configuration	V/T
Number of Lanes	T
Left/Right Firing Limits	S
Safety Fan/Surface Danger Zone (SDZ)	V
Training Area Boundaries	V
Water Training Areas	V
Restrictions	T
Depth	T
Current	T
Public Works	
Power Lines	V
Height Above Ground	T
Depth Below Ground	T
Towers/Antennas	V
Height	T
Environmental	
Ag-Leasing	V
Archaeological/Cultural Sites	V
Cemeteries	V
Endangered Species Sites	V
Erosion Control Structures	V/T
Hydrology	V
Rivers/Streams	V
Lakes	V

Wetlands Inventory	V
Land Condition Trend Analysis (LCTA) Transects/Plots	V
Type of Plot	T
Monitoring Data	T
LRAM Projects	V/T
Date/Cost/Type	T
Soils	V/T
Vegetation Cover	V
* V=vector, R=raster, S=spatial, and T=tabular	

The ITAM web site contains links to detailed information on the GIS information used in ITAM (<https://srp.army.mil/SrpWeb/Content.aspx?ModuleId=26>). The major component of the ITAM GIS is the Regional Support Center (RGC), which provides data, analysis and technical support to Army installations. Currently, there are two RGCs in the ITAM program. The Western Regional Support Center (WRSC) is located at the Center for the Environmental Management of Military Lands (CEMML) Office, Colorado State University, Fort Collins, Colorado; and the Eastern Regional Support Center (ERSC) is located at Fort A.P. Hill, Bowling Green, Virginia. The U.S. Army Environmental Command (USAEC) maintains oversight of the RSCs. There are currently 55 installations that are fully supported by the RSCs. More detailed information on the GIS component of ITAM can be found in the USASRP (2008). The LCTA component of ITAM provides for the collection, inventory, monitoring, management, and analysis of tabular and spatial data concerning land condition on an installation. Data collected in LCTA have requirements that have been established by Headquarters, Department of the Army (HQDA), Major Army Command (MACOM), and installation levels (Department of the Army 1999). A part of the ITAM is the Army Training and Testing Carrying Capacity (ATTACC) program. ATTACC is a methodology to estimate the impact of training on land condition. In this regard, ATTACC adopts the Revised Universal Soil Loss Equation (RUSLE) to quantify the cost for using land for ground forces training. ERDC CERL previously developed a version of ATTACC called ATTACC for Munitions (AFM), which has a minor component that supports one of the ARAMS™ soil models (i.e. MRCFM) via the input file format from that model. The AFM allows the user to export a file that can be imported by the ARAMS™ model and used to estimate the munitions residue and fate from the training exercise. TREECS will be designed in such a way that it makes use of the ITAM data layers. Additionally, including a URL link to the ITAM web site on the TREECS page will help tie useful applications together for the user. AFM support of the ARAMS™ MRCFM model's input file format is an additional step toward a unified application system provided the AFM is kept up to date with changes to the MRCFM model's file format.

Microsoft™ TerraServer USA. Microsoft™ TerraServer USA (<http://terraserver-usa.com/>) is a website operated by the Microsoft Corporation that provides free public access to numerous aerial, satellite, and topographic images of the United States. The database is one the world's largest with terabytes of images stored on the site. TerraService (<http://terraservice.net/>) is a web service that provides programmatic access to the TerraServer database (Barclay et al. 2002). TerraService web service is a likely candidate for inclusion in the TREECS, but requires an understanding of the fundamental characteristics of the Universal Transverse Mercator (UTM) projection system. Table 7

shows the web methods available with TerraService 2.0 API. The TerraServer web page is shown in Figure 13.

Table 7 Web Methods Available with the TerraService 2.0 API (adapted from http://terraservice.net/about.aspx?n=AboutTerraServiceAPI)	
Web Method	Description
Search Methods	
GetPlaceFacts	Returns a structure with information from the first match for a specific place (city, state, country)
GetPlaceList	Returns an array of structure data for all names that match the specified place name
GetPlaceListInRect	Returns TerraServer Gazetteer data for a specific geographic rectangle
CountPlacesInRect	Returns a count of the matching places contained inside a specified rectangle
Projection Methods	
ConvertLocationLonLatPtToNearestPlace	Returns a string that describes the place name and direction to the closest place to the point specified via a given longitude and latitude
ConvertLonLatPtToUtmPt	Converts a point at the specified longitude and latitude to a corresponding point in UTM coordinates
ConvertUtmPtToLonLatPt	Converts a point at the specified UTM coordinates to a corresponding point with longitude and latitude
GetTheme	Returns the attributes that apply to all tiles belonging to a specified theme
GetLatLonMetrics	Describes the extent of available imagery for the specified point at the given longitude and latitude
Tile Information Methods	
GetAreaFromPt	Returns the tile meta-data for a geographic rectangle
GetAreaFromRect	Returns the tile meta-data for a geographic rectangle
GetAreaFromTileId	Returns a structure representing the area of the bounding box for a given tile
GetTileMetaFromLonLatPt	Returns a structure containing the meta-data for a single TerraServer image tile
GetTileMetaFromTileId	Returns a structure containing meta-data for a single TerraServer image tile.
GetTile	Returns an array of bytes containing the compressed data for the requested tile

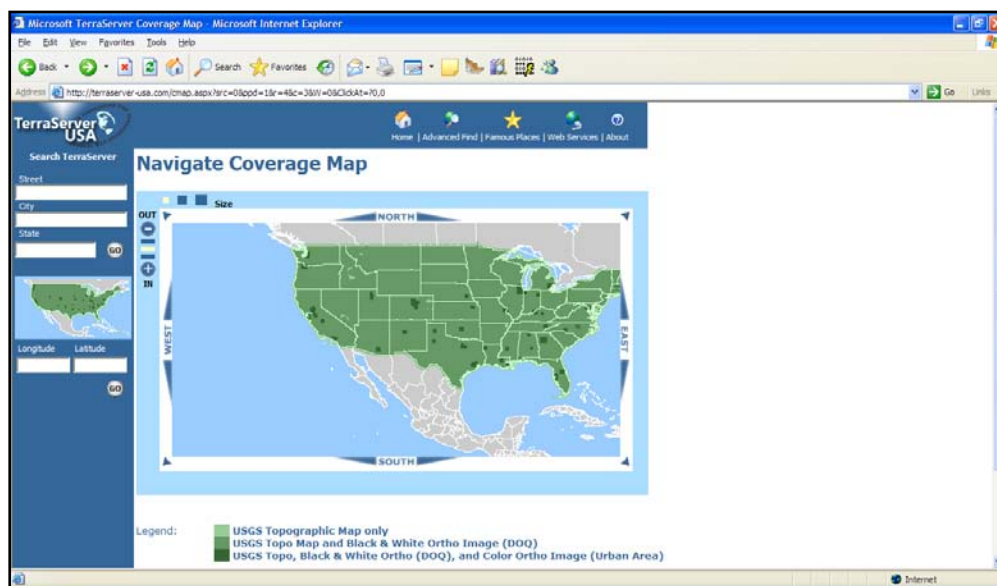


Figure 13. Microsoft™ TerraServer web page.

NASA World Wind. The National Aeronautics and Space Administration (NASA) World Wind (<http://worldwind.arc.nasa.gov/>) is an open source project that aggregates a multitude of public and private geographic datasets that provide access to NASA data, but also to data from other government agencies, industry, and the general public (Bell et al. 2007). Two versions of World Wind are available. One is an application that the user downloads and installs on his/her Windows™ based personal computer (PC), which is currently version 1.4. The other is a Java application that works over the web in the user's Java-enabled web browser, but requires a high-speed internet connection. The latter lacks some of the features of the PC-based installation version. However, there is a World Wind Java software development kit (SDK) that developers can use to embed World Wind technology into their own applications. A drawback to the SDK is that no documentation currently exists for it. Figure 14 shows an example of the PC-installed application version of the World Wind application. Table 8 shows a selection of some of the available datasets within World Wind. The Global Learning and Observations to Benefit the Environment (GLOBE) dataset mentioned in Table 8 is comprised of data collected worldwide by primary and secondary school students. The GLOBE website (<http://www.globe.gov>) indicates that GLOBE is an interagency program funded by NASA and the National Science Foundation (NSF). It is supported by the U.S. Department of State and implemented through a cooperative agreement between NASA and the University Corporation for Atmospheric Research (UCAR). Colorado State University is a key partner in GLOBE providing technical and Help Desk functions. GLOBE has over 100 countries in partnership with the United States. Because of the number of datasets available for World Wind, TREECS will consider incorporating user access to World Wind.

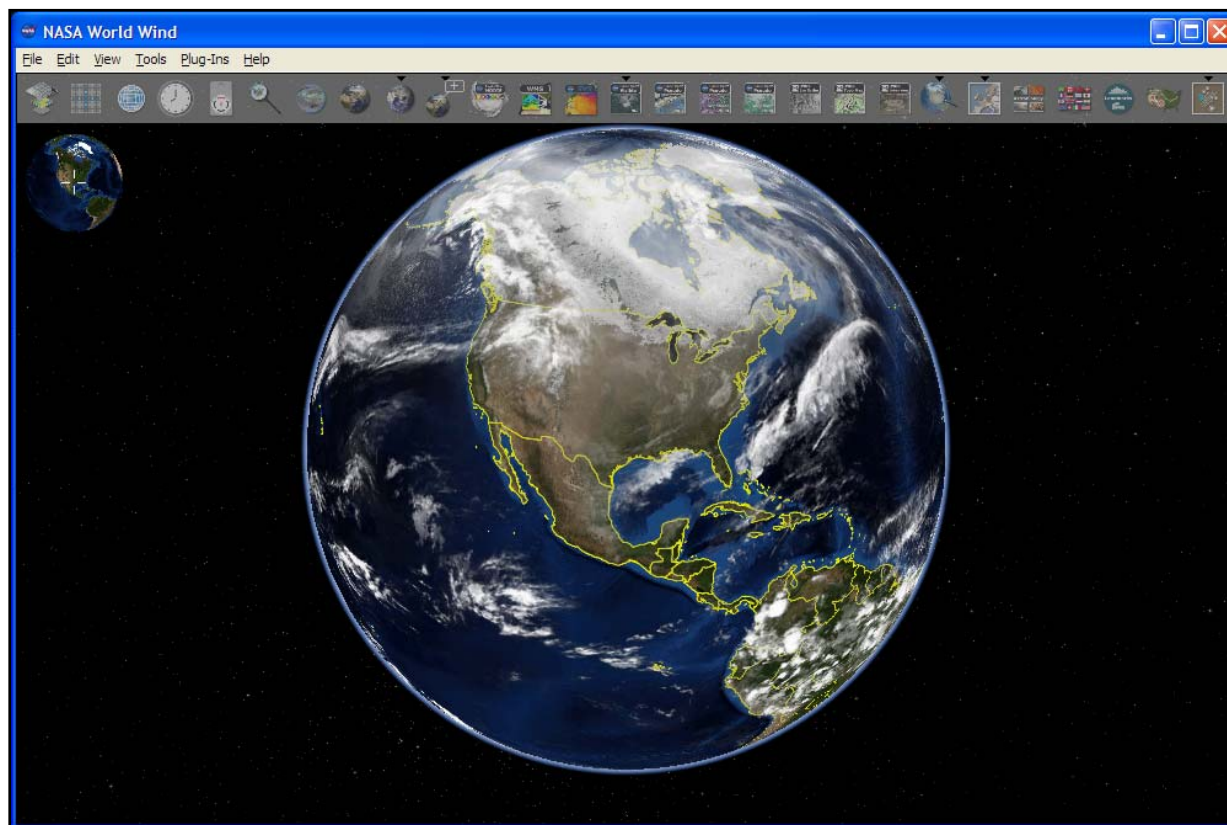


Figure 14. Main screen of the PC-installed application version of NASA World Wind.

Table 8. Selected NASA World Wind Datasets	
Dataset	Description
Land Sat 7	A collection of images from 1999-2003 at 15 m per pixel resolution. It also includes the infrared spectrum.
Shuttle Radar Topography Mission (SRTM)	A high-resolution digital topographic dataset on a near-global scale obtained from the Space Shuttle Endeavor in February 2000 (Rodriguez et al. 2005). An updated version of the data can be found at: ftp://e0srp01u.ecs.nasa.gov .
MODIS	A dataset of images as well as atmospheric trace gases, cloud cover, cloud type, solar radiation, tropospheric aerosols, land cover type and extent, surface temperature, leaf area index, fire occurrence, and chlorophyll-a concentration data.
GLOBE	Contains datasets such as relative humidity, precipitation, minimum and maximum air and soil temperature, soil moisture, soil bulk density, soil particle density, soil particle size distribution, soil and water pH, soil infiltration, water temperature, water dissolved oxygen, and water salinity among others. Protocols: http://www.globe.gov/fsl/html/templ.cgi?measpage&lang=en&nav=1 .
USGS TerraServer	A dataset of USGS imagery and topographic images.

NRCS Web Soil Survey. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (WSS, <http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>) is a web-based natural resource information system that provides the user with soil data and other related information from the National Cooperative Soil Survey. It is the largest natural resource information system in the world, with data available for over 95 percent of U.S. counties. Figure 15 shows the WSS. The system is used in a web browser where the user specifies an area of interest (AOI) using an interactive browser-based mapping tool that allows an AOI to be specified by means of a rectangle or a polygon. Once the AOI has been specified, the system passes the bounding box coordinates of the AOI to a web service backend of the WSS, which retrieves any available data for the AOI. Data retrieved from the web service is then displayed in the browser in graphical and tabular formats as shown in Figure 16. Data available include soil types, soil chemical properties (e.g. cation exchange capacity (CEC), pH, etc.), soil erosion properties (e.g. K Factor, T Factor, wind erodibility, etc.), soil physical properties (e.g. available water capacity, bulk density, percent organic matter, percent clay, etc.), soil quality and features (e.g. hydrologic soil group, depth to restrictive layer, etc.), and water features (e.g. depth to water table, flooding frequency class, etc.). Table 9 shows the web services and web methods that are available in WSS. The WSS system appears to be regularly and well maintained by NRCS. The currently available version of WSS is 2.1. Since WSS has a significant amount of the data that will be needed for the models in TREECS, TREECS will be linked to the WSS system for data transfer.

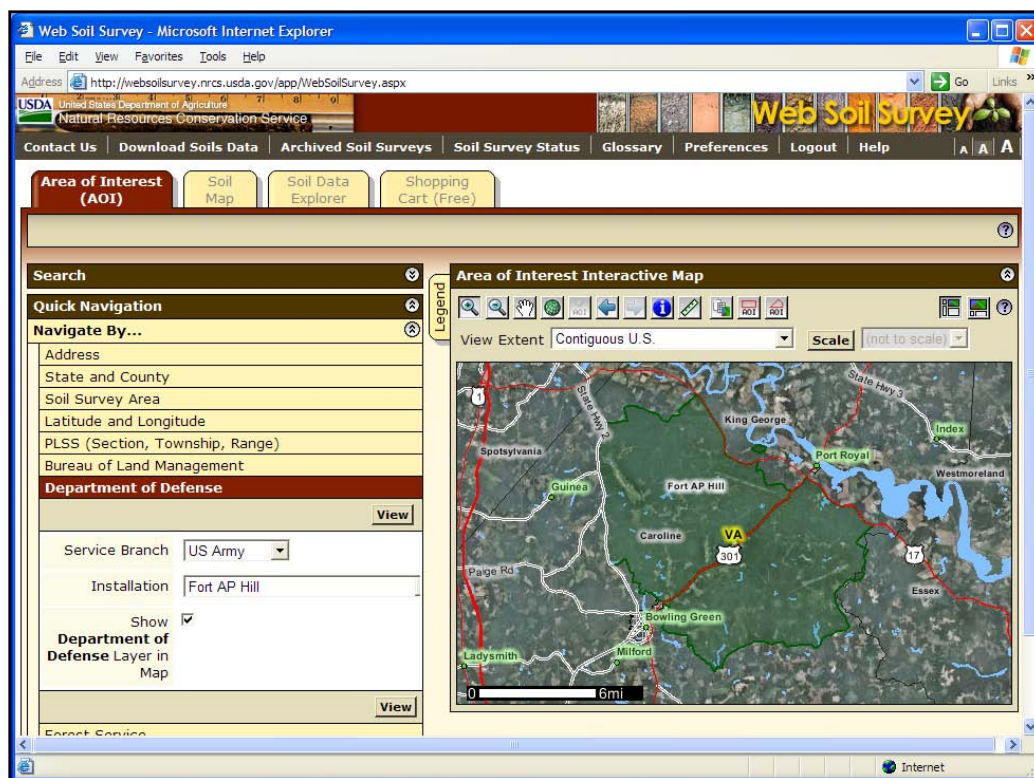


Figure 15. Main screen of the WSS.

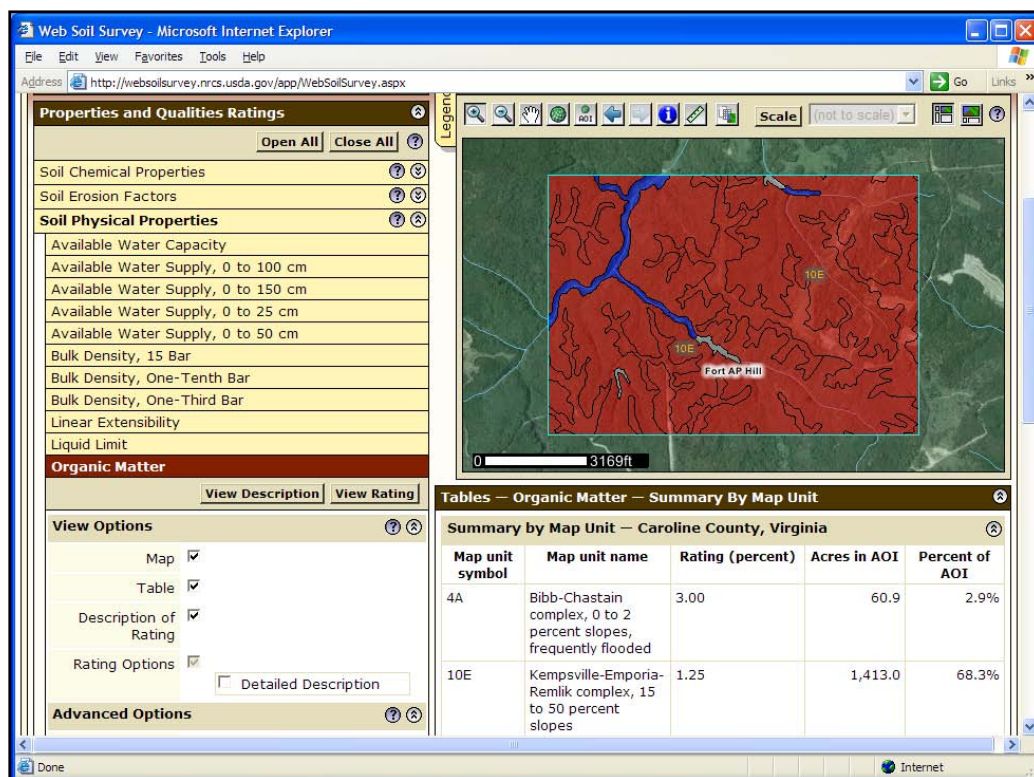


Figure 16. Example of the organic matter for an AOI.

Table 9. Web Soil Survey (WSS) web services (adapted from <http://sdmdataaccess.nrcs.usda.gov/WebServiceHelp.aspx>)

Web Service	Web Method	Description
http://SDMDataAccess.nrcs.usda.gov/Tabular/SDMTabularService.asmx	RunQuery	This method returns the output of one or more structured query language (SQL) "Select" statements.
http://SDMDataAccess.nrcs.usda.gov/Spatial/SDMNAD83Geographic.wfs	GetCapabilities	This method returns information about the corresponding web service and includes information about supported methods, supported feature types or layers, supported spatial filters, and supported projection(s).
	DescribeFeatureType	This method returns information about the types or layers supported by the corresponding web service and includes geometry type, attribute names, and data types.
	GetFeature	This method returns a feature collection for a single feature type or layer for the user-specified AOI.
http://SDMDataAccess.nrcs.usda.gov/Spatial/SDMWGS84Geographic.wfs	GetCapabilities	This method returns information about the corresponding web service and includes information about supported methods, supported feature types or layers, supported spatial filters, and supported projection(s).
	DescribeFeatureType	This method returns information about the types or layers supported by the corresponding web service and includes geometry type, attribute names, and data types.
	GetFeature	This method returns a feature collection for a single feature type or layer for the user-specified AOI.
http://SDMDataAccess.nrcs.usda.gov/Spatial/SDMNAD83UTM.wfs	GetCapabilities	This method returns information about the corresponding web service and includes information about supported methods, supported feature types or layers, supported spatial filters, and supported projection(s).
	DescribeFeatureType	This method returns information about the types or layers supported by the corresponding web service and includes geometry type, attribute names, and data types.
	GetFeature	This method returns a feature collection for a single feature type or layer for the user-specified AOI.
http://SDMDataAccess.nrcs.usda.gov/Spatial/SDM.wms	GetCapabilities	This method returns information about the corresponding web service and includes information about supported methods, supported feature types or layers, supported spatial filters, and supported projection(s).
	DescribeLayer	This method describes WMS named layers. If the named layer is not feature based, then the layer description is empty, otherwise, the WFS attribute gives the uniform resource locator (URL) prefix from the WFS containing the feature data.
	GetFeatureInfo	This method returns information about particular features shown on a map. It allows a client to request information about features on a map by adding to the map URL additional parameters specifying a location (as an X, Y offset from the upper left corner) and the number of nearby features about which to return information. A layer can be queried if the server supports the GetFeatureInfo operation on that layer, but the server may support GetFeatureInfo on some of its layers and not all layers.
	GetMap	This method returns a rectangular map graphic for one or more supported feature types or layers for the user-specified AOI. The layers returned by this method have map scale thresholds. Map unit features are not displayed unless map scale is in the range 1:0 to 1:75,000. Survey area features are not displayed unless map scale is in the range 1:100 to 1:5,000,000.

MapWindow. MapWindow (<http://www.mapwindow.org/>) is an open source programmable geographic information system (GIS) that is free, extensible, and supports manipulation, analysis, and viewing of geospatial data and associated attribute data in several standard GIS data formats. MapWindow was developed to address the need for a GIS programming tool that could be used in engineering research and project software, without requiring end users to purchase a complete GIS system, or become GIS experts. At the core of MapWindow is the MapWinGIS ActiveX control, which is also freely distributable and allows developers to program custom mapping functionality directly into their own software. The ActiveX control has a complete GIS API for shapefile and grid data with many built-in GIS functions. The advantage of using the MapWinGIS ActiveX control in the TREECS application is that it eliminates the need for each user to purchase a separate and, traditionally expensive, supporting GIS system. The MapWindow application is shown in Figure 17. The currently available version of MapWindow is 4.7 and 3.0 for the MapWinGIS ActiveX control. The MapWinGIS ActiveX control will be used in TREECS and will dictate that the TREECS system be a client-based system.

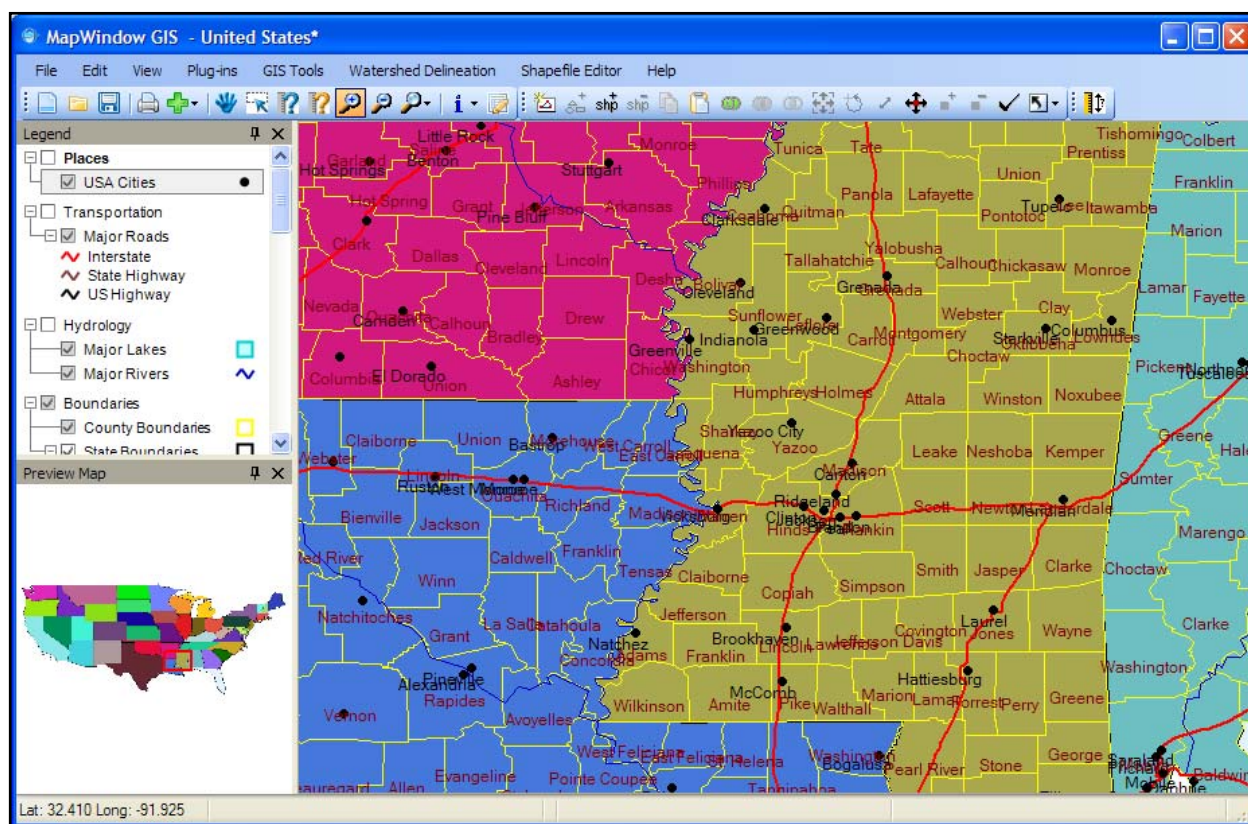


Figure 17. MapWindow application.

Summary. Table 10 summarizes the tools, portals, and frameworks evaluated and indicates whether a linkage to TREECS can be established and, if so, to what extent (e.g. model, URL link, data, etc.). The TREECS system will be a client-based system as opposed to a web-based system with support for GIS capabilities. However, being client-based does not preclude TREECS from being web-enabled, or having the ability to access information over the web. TREECS can then be extended to encompass the added functionality that is required of it.

Table 10. Summary of the Tools, Portals, and Frameworks Evaluated					
Tool, Portal, or Framework Name	Recommended Inclusion in TREECS				
	Models	File Format(s)	URL Linkage to Website	Data (or web service)	GIS Component
FRAMES		X		X	
ARAMS™	X	X		X	
SADA		X ¹	X		
CorpsGlobe			X	X	
CorpsMap		X	X	X	
RDRET			X		
SIRRA			X		
RMTK			X		
GISR					
Army Mapper		X	X	X	
ITAM		²	X	X ³	
Microsoft™ TerraServer USA				X ³	
NASA World Wind				X ³	
Web Soil Survey			X	X	
MapWinGIS					X
¹ Support for CSV file format only. ² Supported only through AFM and its link to ARAMS™, not bi-directional. ³ If time and budget permit.					

ADDITIONAL INFORMATION: This technical note was prepared by Jeffrey A. Gerald, research physical scientist, Dr. Mark S. Dortch, research civil engineer, Dr. Billy E. Johnson, research civil engineer, Environmental Laboratory, and Michael R. Fontan, computer scientist, Information Technology Laboratory, U.S. Army Engineer Research and Development Center. The study was conducted as an activity of the Environmental Quality Technology (EQT) research and development program. For information on EQT, please consult <http://el.erd.c.usace.army.mil/programs.cfm?Topic=eqt&Option=Program>. This technical note should be cited as follows:

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