

**WRAP Integrated Geospatial
Information Management Strategy (WIGIMS)**

Resource Inventory Report

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Submitted to:



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1.0 Introduction

The WRAP Integrated Geospatial Information Management Strategy (WIGIMS) project is designed to analyze WRAP's geospatial information and related decision support needs, and then plan for the development of WRAP's capability to fulfill its mission by fully leveraging existing and emerging geospatial information, standards, technologies, and applications in an efficient and integrated manner. The project will result in a strategy for developing a spatial data infrastructure (SDI) that meets the needs of WRAP and its user community. This infrastructure will provide the means to discover, evaluate, and/or access the emissions, monitoring, and modeling data related to air quality and visibility for the WRAP user region, and facilitate integration of these data for use in custom tools or applications. In doing so, WRAP's ability to provide the data and technical and policy tools to its clientele - state and tribal members, federal land managers, committees, forums, and all other interested parties - as well as to its own staff, will be improved both in the short- and long-term.

The WIGIMS project consists of three phases: Needs Assessment, Resource Inventory, and Strategy Development, all critical in developing an infrastructure that will meet the present and future functional requirements of WRAP staff and its clientele. After completing the Needs Assessment phase, Pangaea Information Technologies, Ltd. directed its attention to documenting all of the geospatial information and geo-information management resources that are presently or planned to be available and essential to meet needs as identified by WRAP staff and the Needs Assessment participants. This report lists, characterizes, and summarizes those resources.

It is important to note that this project is designed to produce strategy options for development of an *infrastructure* that provides access to integrated datasets and/or facilitates the integration of those datasets. It does *not* attempt to design or recommend *specific tools or applications* that support the particular needs of WRAP users, but rather to generate and evaluate options that, when implemented, would provide a robust platform upon which those tools and applications could be built.

This report is the second in the series of three WIGIMS publications, which include a *Needs Assessment Report*, and a *Geospatial Information Management Strategy and Implementation Recommendations Report*. Preliminary results of the WIGIMS project were presented at the Technical Oversight Committee meeting on 13 May 2004.

2.0 Executive Summary

The WRAP Integrated Geospatial Information Management Strategy (WIGIMS) Needs Assessment phase validated the assumption that WRAP users need access to integrated emissions, monitoring, modeling, and auxiliary geodata. In order to support this need, development of a WRAP spatial data infrastructure (SDI) of some type is required. A SDI is an integrated, on-line network that delivers geospatial data, services and information for applications, better business and policy decision-making, and value-added commercial activities. There are three primary components to an SDI:

- **Organizational commitment** and arrangements to stand-up and build upon spatial data and services within a heterogeneous community of producers and users
- The **spatial information**, and its integration
- **Technologies, standards, specifications** for discovery, visualization, and use of primarily digital geographic information

The needs assessment phase confirmed the *a priori* expectation that integrated geodata was needed by WRAP users, and that this geodata should be made available through a known, flexible platform upon which custom tools and applications can be built. At a minimum, the needed services available from that platform should include web-mapping for visualization and other interfaces that provide standardized data streams. Tools that facilitate discovery and evaluation, possibly through metadata, are also services that should be built from this infrastructure.

WRAP has extensive geodata resources available for developing its own spatial data infrastructure. At present, the fundamental **spatial information** components are already in place in the form of dataholdings at the EDMS, VIEWS, and the RMC as well as from the CoHA and Near projects. In addition, a wealth of ancillary geodata is available through the US, Canadian, and Mexican spatial data infrastructures. Finally, the large set of integrated datasets accessible through DataFed, which are relevant to the air quality management community, are all potentially accessible for incorporation into a WRAP SDI.

At present, the fundamental emissions, monitoring, or modeling information has not been made broadly available to the WRAP user community in an integrated manner. The limitation is not technological in nature: WRAP has access to a body of **technologies, standards, and specifications** that can enable discovery, evaluation, and access of its spatial information resources. These standards are necessary for elevating WRAP's geospatial interoperability to a level such that the burden of data standardization and integration does not fall on the end user (e.g., a state or tribe). To date, the standards and specifications have not been adopted at WRAP's data nodes (i.e., EDMS, VIEWS, RMC, and the CoHA system site at DRI), nor have policies or arrangements been put in place to promote interoperability. Several organizations are devoted entirely to developing geospatial interoperability standards and specifications, and helping organizations build their own SDI's that connect to those of other's (i.e., the US National Spatial Data Infrastructure). Other organizations, such as DataFed, offer mediation services for data standardization and integration.

A summary table presenting the key resources for a WRAP SDI is presented on page 5 of this document.

3.0 Resource Inventory

3.1 Overview and Scope of Inventory

The geospatial information resources available to WRAP can be classified into three basic types: data and information providers, data and information clearinghouses or gateways, and institutions that develop the policies, partnerships, and standards that facilitate data sharing within a distributed network of organizations. The report will first characterize the three primary WRAP geospatial data nodes responsible for providing either emissions, monitoring, or modeling information. Next the report will characterize WRAP projects that produce spatial information (e.g., maps), and/or aspatial information products that can be linked to a particular location (Class I Area, or IMPROVE site) possibly for a specific point in time. The report will then examine the non-WRAP organizations and initiatives most relevant to the development of a geospatial information management strategy for WRAP that efficiently meets its users' needs for in the short-term and is extensible.

The primary spatial extent of the data resources to be documented here is the WRAP region, consisting of the 14 member states and many tribal areas. In addition, data resources for bordering US regions (i.e., pertaining to the CENRAP region) and Canada and Mexico should be considered. The temporal extent of the data resources include the historic records of emissions, monitored and modeled air quality, and meteorological parameters, as well as modeled forecasts, emissions, and air quality scenarios for the future. Near real-time or “just in time” data and information relevant to the air quality management community is also included.

With respect to planned or available infrastructure, support, and policy, the inventory focuses on the United States federal government. Organizations responsible for international geospatial information standards are included as appropriate.

3.2 WRAP Geospatial Data and Information Resources

There are three primary “geospatial data nodes” that support WRAP activities: the Emissions Data Management System (EDMS), the Visibility Information Exchange Web System (VIEWS), and the Regional Monitoring Center (RMC). Given its voluminous warehouse of ancillary data and synthesized/derived data products, the Causes of Haze Assessment Project (CoHA), could be considered a fourth data node. Other geospatial information content exists in the projects associated with the “Sources Near and In Class I Areas” forum (e.g., In-Park Emissions, Near Emissions, and Gateway Community Demo), with future data content expected from the Attribution of Haze Project.

Summary information about WRAP’s geospatial information resources appear in the below table:

Resource Name	Resource Type	Content &/or Tool / Application Type	Web Delivery Format	*Adherence to Standards?	Web Service Development Staff?	Current Funding for WRAP Activities (% of total)
EDMS	Data Provider; Tools / Apps	Emissions; User-defined exports, SVG-based web-mapping	Data Files; Map images	No; GML via CDX?	Y	100; on-going
VIEWS	Data Provider; Tools / Apps	Monitoring; User defined exports; web-mapping	Data Files; Graphics; Services	No	Y	20; on-going
RMC	Data Provider	Scenario and Model Output	Data Files; Graphics	No	?	100; on-going
CoHA	Data Provider; Tools / Apps	Analysis Output; Ancillary Data	Data Files; Images; Graphics	No; meta-data?	?	75; on-going
ITEP	Data Provider	Tribal Boundaries; Demographics	Files upon request	No	N/A	unknown; on-going
The National Map	Data Provider Tools / Apps	Web-Mapping; Seamless Data Server	Files, Services & Documents	Yes; All	Y	0
CAPITA	Data Mediator; Tools / Apps; Web-services	Emissions; Monitoring; Meteorological; Analysis Output; Web-mapping; Re-usable components	Images and graphs;	No	Y	unknown; (\$40k per year through the Inter-RPO)
GOS	Tools / Apps	Portal	Documents and links to content	Yes; All	Y	0
FGDC	Standards; Policy; Support / Reference; Tools / Apps	Clearinghouse Network; Metadata tools; Metadata standards and profiles.	Services and Documents	Yes	Y	0
OGC; ISO	Standards; Support / Reference			N/A	N/A	0

*"Adherence to Standards" refers specifically to compliance with federally-adopted (FGDC) or commonly used standards (OpenGIS Consortium, i.e., OGC) that provide for geospatial interoperability in describing content (e.g., FGDC-STD-001-1998 [CSDGM], ISO-19115) or delivering that content over the Internet as map images (e.g., OGC WMS 1.1.1) or as feature-level (points, lines, polygons, rasters, lattices, n-dimensional matrices, etc) data packages (e.g., OGC WFS 1.0, OGC WCS 1.0).

3.3.1 Emissions Database Management System

The Emissions Database Management System (EDMS) is currently under development by E. H. Pechan & Associates, Inc. and will be operated out of University of North Carolina. The system requirements were well-defined, as is its development.

A. *Purpose:*

“The Emissions Data Management System (EDMS) is required to support state and tribal regional haze implementation plan development. This system is to be used for technical and policy evaluations by Western Regional Air Partnership (WRAP) members, stakeholders, and other interested parties in the region.

This Internet web page-based system is to be capable of:

- Receiving and storing emissions data in United States Environmental Protection Agency (EPA)-compliant emissions reporting formats commonly used by various agencies and sources with little or no additional effort;
- Receiving and storing EDMS-specific emissions information;
- Producing user-specified reports (including model-ready input);
- Performing user-selected quality control and assurance (QA/QC) tests;
- Allowing data queries and graphic display; and
- Presenting this information as geographic information system (GIS) displays, flat files, air quality model-ready input files, and in other formats.

The purpose of the EDMS is to be the home of emissions inventories that are the basis for emissions control and management programs to be adopted by states and tribes through their regional haze implementation plans. The EDMS will be able to provide output files for emissions analyses and air quality modeling applications. The EDMS is also to receive, store, process, and display combinations of the emissions and activity data, as well as emissions calculation methods used to estimate emissions inventories. The display capabilities will include GIS functionality; tabular, and flat file data formats; graphs and charts; and the ability to capture these displays in user-defined report formats.

No currently existing system meets this need.”

(<http://www.pechan.com/edms/EDMSDraft3ScopeOfWork.pdf>, accessed 1 May 2004)

B. *Description of Specific Resource(s):*

1) EDMS Production Database

- a) Information Content: Emissions Inventories of WRAP States and Tribes, starting with 2002 Base Year
- b) Availability: Plan to be operational 1 Oct 2004
- c) Static (y/n): Yes, once in production db. Annual state/tribal inventories to be added subsequently.
- d) Update Frequency: N/A
- e) Scale or Resolution: Accuracy of point data unknown. Probably 1:24000-scale or better; county-level resolution of area sources.
- f) Data Uniqueness: State/tribal/local air emissions data as reported, with QA

- & gap-filling in consultation with reporting entities, not the national database approach utilized by the NEI and TRI.
- g) Significance: Supports SIP/TIP development; facilitates technical and policy evaluations by WRAP members, stakeholders and other interested parties.
- h) Data Dictionary: Available
- i) Data Schema: Entity Relationship Diagram available
- j) Information Format
- (i) Available: * Query/Report Based Export - ASCII up to 1 MB
* Model-Ready Export - NIF (NEI), IDA (SMOKE-ready files) up to 1 MB
* RPO Data Exchange Protocol Export
* Special Analysis Data Export – provided as requested by the WRAP contract administrator. Can be provided in agreed upon, user-defined format and over 1MB.
- (ii) Planned/Potential: EPA NEI XML 3.0 (in Phase II, 2005) through the Central Data Exchange (CDX) Network. There is a possibility that the CDX will publish in GML format.
- k) File Naming conventions: Intelligent-filename approach for transfers to the RMC: filename describes the data in the file with the following general format:
- Sector . Year of Data . Data Version . Organization . Spatial Resolution . .dat
- l) Metadata:
- (i) Available: No standard specified; “detailed comment in the file”.
- (ii) Planned/Potential: Unknown
- m) Total Data Volume: Requires 5 GB per complete inventory year; 20 GB expected for four complete sector inventory types.
- 2) Direct Database Accessibility: Connectivity through port would be made available to other WRAP systems, as directed [presumably by WRAP contract administrator]. Would not want to compromise performance of core system requirements. (Steve Boone, Pechan, pers. comm. 30 April 04)
- 3) Web-mapping: HTML Browser site based on Scalable Vector Graphic (SVG) technology. Only the functionality is well-documented at this time. List of ancillary data to be included in this web-mapping component is present in development plan. No plans for implementing the OGC WMS 1.1.1 specification.

C. *User Guide and System Help*: Documentation Phase of system development is planned with reviewed User Guide to be published. Pechan will provide web-based, e-mail-based, and telephone support for the EDMS through the duration of the contract.

D. *Available Infrastructure*: Multi-server system. Oracle db. High-bandwidth.

E. *Percent of funding from WRAP*: 100%

F. *Duration of Funding*: Contract extends through 31 Dec 2004. On-going and updated yearly.

3.3.2 Visibility Information Exchange Web System

The Visibility Information Exchange Web System (VIEWS)

A. *Purpose*:

“The Visibility Information Exchange Web System is an online exchange of visibility data, research, and ideas designed to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze in national parks and wilderness areas. In addition to this primary goal, VIEWS supports global efforts to better understand the effects of air pollution on visibility and to improve air quality in general.”

(<http://vista.cira.colostate.edu/views/> , accessed 3 May 2004)

B. *Description of Specific Resource(s)*:

1) Monitoring Data

- a) *Information Content*: Time series point data from air quality monitoring networks including AQS, CASTNet, IMPROVE, MOHAVE, PREVENT, REVEAL, SEARCH, SEAVS. Focus on the IMPROVE db.
- b) *Availability*: Yes
- c) *Static (y/n)*: Yes; but data added as available from networks.
- d) *Update Frequency*: N/A -- additions, not updates.
- e) *Scale or Resolution*: Accuracy of point data unknown. Probably 1:24000-scale or better; Decimal degree (GRS) coordinates presented with 4 decimal places.
- f) *Data Uniqueness*: Available elsewhere, but not in integrated, discoverable, and accessible (i.e., searchable) format as is available within VIEWS. There is some overlap with the services provided by the CAPITA group (i.e., datafed.net).
- g) *Significance*: Supports SIP/TIP development; facilitates technical and policy evaluations by WRAP members, stakeholders and other interested parties.
- h) *Data Dictionary*: Upon request (VIEWS staff, pers. comm. 14 Jan 04)
- i) *Data Schema*: Upon request (VIEWS staff, pers. comm. 14 Jan 04)

- j) Information Format
- (i) Available: ASCII for full IMPROVE data sets, as well as other sliced/diced subsets (with comma- or tab-delimiter options from query wizard).
HTML and “Smart Grid” from query wizard.
 - (ii) Planned/Potential: XML
MS-Excel spreadsheets, pivot tables and charts.
Analysis products to be available in MS-Word and MS-Powerpoint formats.
- k) File Naming conventions: Not documented / documentation not found.
- l) Metadata:
- (i) Available: Based on Dublin Core. Metadata available for cached/processed monitoring datasets; for stations within each monitoring network. The Directory Interchange Format (DIF) is used for off-site resources available through the VIEWS Catalog service.
 - (ii) Planned/Potential: Same as above.
- m) Total Data Volume: 150 MB for uncompressed full IMPROVE dataset.
- 2) Direct Database Accessibility: Potential exists to allow direct connectivity. Staff suggested late night / early morning mirroring to remote cache. (VIEWS staff, pers. comm. 14 Jan 04). Presumably would not want to compromise performance of core system requirements.
- 3) Web-mapping: Data browser for viewing monitoring data in conjunction with ancillary geodata under development. Software used does not provide OGC WMS 1.1.1 compliant connectors. VIEWS staff stated that web interfaces compliant to OGC specs (i.e., WMS, WFS, WCS) would not be implemented in the foreseeable future.
- 4) Annual Summary: Summary and analysis products. Includes back trajectory maps with linked time-series graph of species concentration (very similar to those presented through the CAPITA site).
- 5) Catalogs Links to off-site resources listed in the Catalog service, with DIF used as metadata standard.
- 6) Images and image services Photos showing a range of visibility conditions and links to live feed and archives from web-cams at vistas.

C. <i>User Guide and System Help:</i>	Good site navigation tools and documentation of available tools and services, help documents, help request email services, etc.
D. <i>Available Infrastructure:</i>	See Nov 2003 presentation for system architecture. New web server and new data server. High bandwidth. In-house developer(s).
E. <i>Percent of funding from WRAP:</i>	20% of Inter-RPO funding. Substantial past investment.
F. <i>Duration of Funding:</i>	On-going.

3.3.3 Regional Modeling Center

The WRAP Regional Modeling Center (RMC) is composed of staff from the University of California Riverside (UCR), with additional staff from ENVIRON Corporation and the Carolina Environmental Program (CEP) of the University of North Carolina. The principal investigator and project manager for the RMC is Dr. Gail Tonnesen of UCR. The RMC is the contractor for air quality modeling simulations done for WRAP region states and tribes, providing analytical results used in developing implementation plans under the EPA Regional Haze rule.

A. *Purpose:*

WRAP is one of several Regional Planning Organizations (RPOs) each of which has the responsibility for conducting technical analyses and assisting in the development of SIPs and TIPs for regional haze in different areas of the US. The WRAP effort for regional haze modeling is considerably more advanced than that of other RPOs because several WRAP member states opted in to the special requirements of §309 of the Regional Haze Rule, addressing the states in the Grand Canyon Visibility Transport Commission region, and the tribes within those states.

To support the §309 regional haze plan development, the RMC performed annual modeling of regional haze using calendar year 1996 as a base case model validation study, and then performed additional modeling and control strategy evaluation using emissions projected for calendar year 2018. This work is described in the WRAP §309 Technical Support Document and on the RMC web page under the 309 tab found at: <http://pah.cert.ucr.edu/aqm/308/>.

Responsibilities of the RMC include:

- Emissions processing and modeling;
- Air quality and visibility modeling simulations;
- Analysis, display, and reporting of modeling results, and
- Storage/quality assurance of the modeling input and output files.

While the §309 modeling effort used the EPA's most advanced modeling system, the modeling effort was necessarily limited by the §309 time constraints. To support development of the §308 2007 Regional Haze SIPs and TIPs, WRAP and the RMC will develop new data sets and model validation studies for calendar year 2002. There are several advantages of using 2002:

- 2002 has a larger database of ambient monitoring data for use in model evaluation;

- It is the most recent year for which ambient data and emissions input data are available;
- Other RPOs also plan to model 2002 so there will be synergies in developing emissions inventories and performing model evaluations; and
- 2002 is near the midpoint of the 5-year baseline visibility period specified in the Regional Haze Rule.

(All above text from the 2004 RMC Workplan, as provided by Tom Moore.)

B. Description of Specific Resource(s):

1) Air Quality Model Outputs

- Information Content: Sensitivity, Base Case, Scenario Run outputs and Difference plots. Daily spatial plots are available for each day of year (or summer/winter season) for a suite of particulate (PM) and gaseous species. Hourly spatial plots are available for Jan/July pairs. Daily spatial plots can be viewed as “movies” showing changing concentrations over the course of a year, and for month at hourly time steps.

Modeling grid developed and spatial plots presented in Lambert Conic Conformal projection. This is of interest because the emissions and monitoring data is usually maintained in the Geographic Reference System (i.e., long/lat pairs, and technically not a projection). Reprojection processes / services are necessary in order to vertically integrate all three types of geodata.
- Availability: Currently available to view and/or download from website.
- Static (y/n): Yes
- Update Frequency: New output added as new scenarios are developed (e.g., control scenarios in 2005). Unsure of how model changes (improvements) are handled.
- Scale or Resolution: 36 km grid for US, 12 km modeling grid for WRAP area. Graphics / “Spatial Plots” at about 1:30,000,000.
- Data Uniqueness: Completely unique.
- Significance: States and tribes need to know what control strategies need to be implemented in order to meet the CAA requirements regarding Class I Areas within their boundaries or to which their emissions are transported. These changes in emissions would include both what they do and their neighboring states and tribes (and in some cases, Canada and Mexico) are doing. The RMC studies appear to be the only source of this information.
- Data Dictionary: Not discussed to date. An overview document of the web-site layout or of the web-page structure might be useful. The netCDF files are said to be self-describing.
- Data Schema: Not discussed to date.

- j. Information Format
 - (i) Available: Spatial plots available as .png or .gif images.
Data inputs available in ASCII format.
 - (ii) Planned/Potential: netCDF format files could be made available.
 - k. File Naming conventions: URL nomenclature not known at this time.
 - l. Metadata:
 - (i) Available: Not compliant. Limited text on website.
 - (ii) Planned/Potential: Unknown.
 - m. Total Data Volume: There are thousands of spatial plot images. Model outputs are stored in netCDF format and include terabytes of data. File size of surface layer information for suite of species for each day is about 150 GB.
- 2) Direct Database Accessibility: It is likely that this option could be arranged if requested by WRAP (Gail Tonneson, pers comm., 3 May 04)
 - 3) Web-mapping: Not available.
 - 4) Output Summaries: From web site as Excel spreadsheets.
- C *User Guide and System Help:* Much model documentation. Not much documentation on the sets of model results or on the structure/layout of the web site.
- D. *Available Infrastructure:* Web server. Database. High Bandwidth.
- E. *Percent of funding from WRAP:* 100% for WRAP activities
- F. *Duration of Funding:* Yearly contract; on-going.

3.3.4 Causes of Haze Assessment (CoHA) Project

The [Western Regional Air Partnership](#) (WRAP) and [Central Regional Air Planning Association](#) (CENRAP) are two of five Regional Planning Organizations (RPOs) that have been created to evaluate, determine methods to improve, and track improvements in regional haze at sensitive locations within their jurisdictions. RPOs are newly-defined entities that intend to respond to the transport of visibility-reducing pollutants within and across state and international boundaries. RPOs need to assess current haze conditions, establish baseline levels, specify and coordinate emissions reduction strategies, and evaluate the effectiveness of those strategies for the coming six decades. The goal is to achieve “natural” visibility conditions by 2065. Quantifying “natural” visibility levels beyond the defaults offered by U.S. EPA will be one of the major challenges faced by RPOs during its lifetime. Identifying the emissions sources causing excessive haze levels and determining where and when emissions reductions are needed to make reasonable progress is another major challenge.

The WRAP has formulated [specific questions](#) the answers to which will aid in the execution of its responsibilities. These questions are to be answered by the application of different data analysis methods to existing data sets. These analyses are independent of regional dispersion modeling and will help to form the conceptual models on which the regional models are based. Data analyses are intended to be interactive, with products made available on the internet as they are completed. This will facilitate feedback on and refinement of the results and presentation methods. The same question may be addressed several times, using different data analysis methods and data bases, to reduce uncertainties and to elucidate phenomena discovered in prior analyses. Answers to questions will be provided for every WRAP and CENRAP Class I area represented by an IMPROVE site as well as CENRAP and tribal IMPROVE protocol sites that tracks haze levels. In some cases these will be site specific, while in other cases the answers will apply to sub-regions that are shown to be affected by the same emission sources and meteorology.

A. Purpose:

The goal of the work is to answer questions about the chemical components that cause regional haze, relationships of haze to meteorology, the emissions that cause haze, and the effects of previous and future emissions reductions on the poorest and best visibility levels. Specific objectives are to:

1. Provide answers to specific questions for each western Class I area using several independent data analysis approaches and available data sets.
2. Evaluate the uncertainty and generality of these answers by quantitative error analysis, comparison of results from different approaches, and informed judgment.
3. Integrate and present results in concise and understandable language that can be used to support WRAP evaluation of and justification for actions that improve western visibility.
4. Post results on the COHA web site

(All above text from <http://coha.dri.edu/web/general/aboutcoha.html>, accessed 10 May 2004.)

The Causes of Haze Assessment “virtual report” will be available in the form of a website that answers questions about the chemical components that cause regional haze, the relationships of haze to meteorology, the emissions that cause haze, and the effects of previous and future emissions reductions on the poorest and best visibility levels.

Broadly speaking, the new website will:

- Describe the chemical components that cause regional haze, and the relationships of haze to meteorology;
- Catalog and depict the emissions that cause haze; and
- Analyze the effects of previous and future emissions reductions on the poorest and best monitored visibility levels.
- Publish results so that users can cut & paste to produce custom reports, and to share access to the tools and data sources for their own assessments, to support:
 - SIP & TIP development,
 - Regional air quality model evaluation & interpretation,

- Identification of monitoring gaps,
- Improved methodology for setting natural haze levels, &
- Tracking effectiveness of emission control programs

B. *Description of Specific Resource(s):*

- 1) Charts, Tables, and Maps addressing the CoHA questions; Hypertext links to original data sources.
 - a. Information Content: Results from multiple data analyses which incorporate emissions, monitoring, meteorological, and extensive auxiliary data (e.g. emissions, land-cover, terrain, land-use, satellite imagery, etc.),
 - b. Availability: At this point, the aerosol data descriptions are finished for all monitoring sites with at least 1 year of data, and the “hazagon” animations are complete for 1997-2002. Meteorological descriptions and map galleries for terrain, emissions, and land use surrounding the monitoring sites will be available soon.
 - c. Static (y/n): Yes
 - d. Update Frequency: Causes of haze for all WRAP Federal Class I Areas will be assessed on a periodic basis – every five years.
 - e. Scale or Resolution: Variable; generally 1:24,000-scale.
 - f. Data Uniqueness: Analytical output is unique. Ancillary data is not. However, to have all of the framework (base mapping) layers and other ancillary data vertically integrated on one server and available for computational analysis is unique at the present time. As Web Feature Services (WFS) and Web Coverage Services (WCS) featuring public datasets come online within the next 1-3 years, this uniqueness will diminish.
 - g. Significance: Broad and comprehensive set of analytical products, available for download and incorporation in user-defined manner. In addition, the data warehouse in and of itself represents a significant resource for WRAP users for visual products and computational analyses. However, the data has been irrevocably divorced from the data provider/steward, adding to maintenance costs. Contrast this approach with that taken by DataFed (below)
 - h. Data Dictionary: A list of all ancillary data layers that have been collected for the project and are now stored at DRI is found at <http://coha.dri.edu/web/general/cohadata.html>, listed in the following categories: Air Quality, Meteorological and Climate, Emissions, Spatial Data, and Other.
 - i. Data Schema: Files exist on file server, not in a database (e.g., Oracle).

j. Information Format	
(i) Available:	The analytical products available are tables (.html), charts and graphs (.gif), maps (.gif and .jpg), movies (hazagon time series), and database (MS-Access, for the Descriptive Analysis Database).
(ii) Planned/Potential:	ASCII summary files and shapefiles for trajectory Analyses. Database for episodes (possibly in MS-Access).
k. File Naming conventions:	Not specified.
l. Metadata:	
(i) Available:	Metadata collected during data harvest. Metadata not associated with maps or other spatial products at this time.
(ii) Planned/Potential:	Unknown.
m. Total Data Volume:	120 GB and growing.
2) Direct Database Accessibility:	N/A – files on file server, not in a database.
3) Web-mapping:	None planned, but being discussed.
4) Catalogs	Currently, only a listing of databases used in the analyses and a link to the data producer if one exists.
C. <i>User Guide and System Help:</i>	Good descriptions of products and good organization for website navigation. FAQ under development.
D. <i>Available Infrastructure:</i>	File server. Web server. High bandwidth.
E. <i>Percent of funding from WRAP:</i>	75%
F. <i>Duration of Funding:</i>	On-going.

3.3.5 NEAR Project

The Areas Within and Near Class I Areas Forum (hereinafter referred to simply as the Forum) of the Western Regional Air Partnership (WRAP) is responsible for implementing the recommendations of the Grand Canyon Visibility Transport Commission (GCVC) to expand data collection, improve modeling, and implement cooperative, enforceable management plans in and near Class I areas. The Forum is currently completing a detailed assessment of emissions within eight national parks on the Colorado Plateau, and the National Park Service is evaluating emissions in an additional twenty parks. The work to be performed by ENVIRON as described in this Work Plan is for characterizing emissions near Western Class I visibility areas. The Western States in the WRAP region to be included in this analysis are Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

A. Purpose:

The overall goal of the Near project is to develop a set of maps and tables that portray and characterize the emissions near Class I areas.

B. Description of Specific Resource(s):

1) Characterization of emissions within and near Class I Areas.

- a. Information Content: Tables, maps, and small relational databases.
 - b. Availability: Currently available through:
<http://www.wrapair.org/forums/class1/near/htmlfiles/main.html>
 - c. Static (y/n): Yes.
 - d. Update Frequency: None planned.
 - e. Scale or Resolution: None specified; (see GIS Data Sources in workplan)
<http://www.wrapair.org/forums/class1/near/htmlfiles/workplan.html>.
 - f. Data Uniqueness: Analytic products, developed from publicly-available geodata.
 - g. Significance: Broad and comprehensive set of analytical products, available for download and incorporation in user-defined manner.
 - h. Data Dictionary: N/A
 - i. Data Schema: N/A
 - j. Information Format
 - (i) Available: Maps (.jpg), charts and graphs (.gif), and Tables (.html and .xls) on website. Databases may be available upon request (MS-Access).
 - (ii) Planned/Potential: No additional products or files mentioned.
 - k. File Naming conventions: Specification not stated.
 - l. Metadata:
 - (i) Available: None presented
 - (ii) Planned/Potential: N/A.
 - m. Total Data Volume: Not stated.
- C. User Guide and System Help: N/A; straightforward hierarchical set of webpages.
- D. Available Infrastructure: N/A
- E. Percent of funding from WRAP: 100%
- F. Duration of Funding: Project Complete

3.3.6 Institute for Tribal Environmental Professionals

The Institute for Tribal Environmental Professionals (ITEP) maintains a digital geospatial data layer for tribal lands boundaries, which change frequently. The layer is updated annually and is available upon request. This resource is significant in that tribes need to query databases on the basis of their reservation boundary, and WRAP users need to be able to analyze data on the basis of reservation boundaries. ITEP also maintains associated demographic and socio-economic data that is reported to be unique. ITEP receives ongoing support from WRAP of unknown magnitude.

3.3.7 Center for Air Pollution Impact & Trend Analysis: *DataFed.net*

The Center for Air Pollution Impact & Trend Analysis (CAPITA) at Washington University (St. Louis, MO) is developing a data and application sharing infrastructure known as the DataFed. This initiative currently supports the air quality management domain of users, and provides data mediation services for public consumption. The CAPITA group has taken a mediation approach that:

- Assumes web-exposed, spontaneously and autonomously provided data.
- Non-intrusively wraps datasets for access by web services.
- Mediator software provides homogeneous data views integrating over space and time.

DataFed Software for the User includes:

- Data Catalog for finding and browsing the metadata of registered datasets
- Dataset Viewer/Editor for browsing specific datasets, linked to the Catalog
- Data Views - geo-spatial, time, trajectory etc. views prepared by the user
- Consoles, collections of views on a web page for monitoring multiple datasets
- Mini-Apps, small web-programs using chained web services (e.g. CATT, PLUME)

DataFed Software for the Developer includes:

- Registration software for adding distributed datasets to the data federation
- Web services for executing data access, processing and rendering tasks
- Web service chaining facility for composing custom-designed data views
- User oriented software includes a Data Catalog It includes allows databases

(from http://datafed.net/datafed_Q.asp accessed 8 May 2004)

A. *Purpose:*

DataFed provides data mediation between data users and data providers. This gateway service and the developed applications/tools are available for public consumption. DataFed's general goals are to:

- Facilitate the access and user-driven flow of aerosol data,
- Support the development of data processing value chains, and
- Evolve through participation in specific application projects.

B. *Description of Specific Resource(s):*

- 1) Discovery, Evaluation, and Access Services for Data that is useful to the Air Quality community.

- a. Information Content: Emissions, Monitoring, Modeling, Meteorological and Climate, Satellite Imagery, and Ancillary Data.
 - b. Availability: Currently available.
 - c. Static (y/n): No. Data is dynamically linked from the data producers' websites and/or ftp sites.
 - d. Update Frequency: Datasets are updated by data stewards, not by DataFed.
 - e. Scale or Resolution: Variable. Primarily regional or larger scale.
 - f. Data Uniqueness: None of the data is unique. The uniqueness of the resource lies in the mediation service, the translation of data streams through the "wrappers" to provide vertical (geospatial) and temporal integration of the producers' datasets, accessible through one single location but still actively linked to the data steward for additions and updates associated with data maintenance. However, at the present time, much of the vector data is available only as images, posing problems with portrayal at different scales, and some (classified) raster data is separated from the original data values (i.e., digital numbers). Contrast this approach with that of the data warehouse at the DRI, constructed for the CoHA project.
 - g. Significance: The discovery, evaluation, and access services offered through the DataFed represent an unprecedented resource for the air quality community. See Data Uniqueness, above.
 - h. Data Dictionary: List of available layers describe and indexed in the DataFed Catalog.
 - i. Data Schema: N/A
 - j. Information Format
 - (i) Available: ASCII, XML, and .gif (images from Viewers)
 - (ii) Planned/Potential: GML
 - k. File Naming conventions: Conventions of data providers used; temporal encoding for time series data present (but not explicitly documented) as well as those at the dataset level displayed in the Catalog.
 - l. Metadata:
 - (i) Available: Custom and not compliant to known standard. Available as XML from Catalog Editor tool.
 - (ii) Planned/Potential: Unknown.
 - m. Total Data Volume: N/A
- 2) Direct Database Accessibility: N/A

- 3) Web-mapping: The DataFed “Data Viewer” is unique in that all available data is either harvested in real-time or in some cases accessed from a temporary cache (e.g., IMPROVE dataset). One unusual and useful aspect of the interface is that it contains a time-series graph that is linked to the spatial display both in space and time, much like that available from the VIEWS site for the IMPROVE dataset. Additionally, the applications described below (see Tools) can be accessed for display within the Data Viewer window. The view can be saved as a .gif image, as XML that includes the URL that can be “imbedded” into user-defined applications or web-pages. Notably, a OGC-compliant Web Mapping Service (WMS) has recently been added. Though capabilities are still under development, this service will eventually allow all of the data in the Catalog to be displayed with standard GIS software packages and web-mapping products that provide OGC connectors (e.g., ESRI ArcMap, ArcExplorer, ArcIMS, etc. and Autodesk MapGuide, UMinn MapServer).
- 4) Tools DataFed.net provides a set of tools that can be integrated into the Data Viewer. These include back trajectory analyses (CATT and Kitty) and a “Plume” tool that shows dispersion from a user-defined location (by clicking on the map within the Data Viewer).
- C *User Guide and System Help:* Although site can be intuitively navigated by those familiar with data gateways, clearinghouses, and web-mapping applications, not much “help” is available online at the present time.
- D. *Available Infrastructure:* Web-server. High Bandwidth.
- E. *Percent of funding from WRAP:* Nominal. About \$40k / yr through Inter-RPO.
- F. *Duration of Funding:* 2004 for NSF grant. 2008 for NASA grant.

3.3.8 National Spatial Data Infrastructure

The United States' National Spatial Data Infrastructure (NSDI) is “a *physical, organizational, and virtual network designed to enable the development and sharing of this nation’s digital geospatial information resources. The NSDI can serve as the steward for a national geospatial information strategy that includes a distributed network of technology, cross-organizational partnerships, and the processes and standards needed to facilitate data sharing. It can also provide access to digital geospatial information that enables decision support at all levels of government.*”

(DeMulder,M.L. et al. A clear vision of the NSDI. *Geospatial Solutions*. April 2004)

At the federal level of government, the NSDI has three primary components: the Federal Geographic Data Committee, The National Map, and Geospatial One-Stop. These key elements are described below.

3.3.8.1 Federal Geographic Data Committee

The Federal Geographic Data Committee (FGDC) is the part of the NSDI responsible for policy, standards, advocacy, and some support of projects that need assistance in adopting and implementing FGDC standards and specifications. The best known FGDC standard is the Content Standard for Digital Geospatial Metadata (CSDGM, 1998), which includes “profiles” for metadata associated with specific types of geodata (e.g., shorelines, biological species, etc.) of interest to specific user communities. Two liaisons from the FGDC have been assigned to the Western Governors Association.

“FGDC has ongoing responsibility for coordinating geospatial activities...Since its inception, FGDC has worked to implement the six basic building blocks, or common elements, of the NSDI: metadata, clearinghouse, standards, framework, geospatial data, and partnerships. Each of these components serves as a cornerstone in establishing consistency and structure when it comes to documenting spatial data for everyday applications, as well as in building a distributed network of producers and users that facilitate data sharing.” [The six basic building blocks are described in detail at www.fgdc.gov.]

(DeMulder,M.L. et al. A clear vision of the NSDI. *Geospatial Solutions*. April 2004)

3.3.8.2 The National Map

The National Map is the component of the NSDI responsible for providing integrated geodata content that is considered to be useful to a wide spectrum of user communities. The primary layers in the National Map include: transportation, hydrology, administrative boundaries, elevation, orthoimagery, geographic names (i.e., toponomy), and land use and land cover. The National Map relies on the policies, standards, and partnerships of established through and facilitated by the FGDC in providing up-to-date content from a distributed network of local, state, and federal sources. The National Map, administered by the United States Geological Survey, provides the web-mapping viewer utilized by the Geospatial One-Stop portal.

3.3.8.3 Geospatial One-Stop

Geospatial One-Stop (GOS) is the part of the NSDI that provides for discovery and access to all forms of existing and planned geospatial information, particularly that produced by the federal

government, and including The National Map. GOS is an Office of Management and Budget (OMB) initiative that *“makes it easier, faster, and less expensive for all levels of government and citizens to access geospatial information... From a policy perspective, it adds three unique benefits to the implementation of the NSDI. These include raising the visibility of the strategic value of geographic information, increasing federal accountability for geospatial data stewardship, and establishing a collaborative model for an intergovernmental initiative... From a policy perspective, GOS implements the basic elements of the NSDI by providing an Internet portal (www.geodata.gov) to facilitate data sharing in favor of decision support and by encouraging partnerships across organizations.”*

(DeMulder, M.L. et al. A clear vision of the NSDI. *Geospatial Solutions*. April 2004)

It should be noted that in this sense, the basic services provided by both the GOS and the GeographyNetwork are not those unlike DataFed.

3.3.8.4 The Geography Network

The Geography Network is essentially a clearinghouse node of the NSDI, with an integrated web-mapping component, that is operated by Environmental Systems Research Institute (ESRI). The fundamental structure of this node is nearly identical to that of the GOS portal, as ESRI developed the current GOS portal. As a service provided by a private entity, the Geography Network (www.geographynetwork.com) offers an avenue for the discovery and access to for-profit geospatial information and services.

3.3.9 Other Geospatial Interoperability Standards Organizations

3.3.9.1 The OpenGIS Consortium

*“The Open GIS Consortium, Inc (OGC) is an international industry consortium of **257** companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications. **OpenGIS®** Specifications support interoperable solutions that “geo-enable” the Web, wireless and location-based services, and mainstream IT. The specifications empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.”*

(<http://www.opengis.org/about/> accessed 9 Mar 2004).

OGC is germane to this inventory in light of the specifications that allow system- and organization-level geospatial interoperability at the user interface. The OGC specification for Web Mapping Services have been widely adopted although not by the existing or planned WRAP data nodes that provide web-mapping viewers. Moreover, for the computational level of interoperability and data homogenization to occur, adoption of the WFS and WCS specifications and the use of GML (Geography Markup Language, a subset of XML) should be considered by WRAP.

Presently most of the leading GIS software manufacturers provide OGC-compliant WMS connectors (translators) for that provide for both 1) publication of information over Internet (web service) and 2) the ingestion of web services with data published by data providers that use any software as long as it adheres to the relevant OGC specification. This includes both Autodesk and ESRI, the latter of which had 75% of the market share for US federal organizations in 2003.

Combined these companies represented about half (47%) of the global market in 2003. The fact is that most of the GIS software interfaces on the desktops of the WRAP User Community – including tribes and states – are or ¹soon will be able to ingest data through OGC-compliant web services. These data can be integrated with data from other web services, as well as user-provided data from their own intranet or desktop.

3.3.9.2 International Organization for Standardization (ISO); InterNational Committee for Information Technology Standards (INCITS); American National Standards Institute (ANSI)

Explanation of the specific activities of these organizations and especially their inter-relationships is beyond the scope of this report. For a starting point for more details, see http://www.fgdc.gov/standards/related_activities.html.

The important point to remember is that standards and specifications are essential for the successful participation in and operation of the spatial data infrastructures (SDI). US national standards are required for the NSDI to work effectively. Similarly, international standards are required for full participation in and operation of the Global Spatial Data Infrastructure (GSDI). Finally, it should be pointed out that, knowingly or not, WRAP is building its own spatial data infrastructure. The extent to which WRAP is committed to making its SDI effective is likely tied directly to the awareness of its needs and an understanding of the opportunities for geospatial interoperability to enable discovery, evaluation, and access functionality.

3.3.10 Other Data Resources

Both the states and tribes represent essential resources for emissions and monitoring data. Moreover, they serve as invaluable providers of state and local-scale base geodata at resolutions higher than that available through federal sources. A starting point for a listing of these resources, grouped by state, is presented on the CoHA website (http://coha.dri.edu/web/general/cohadata_stategisdata.html).

Aside from the NSDI, other SDIs that currently exist and are relevant to WRAP are the Canadian Geospatial Data Infrastructure (CGDI), and the Mexican SDI – with development efforts coordinated through the Instituto Nacional de Estadística, Geografía e Informática (INEGI, <http://www.inegi.gob.mx>). A useful starting point for discovery of emissions and monitoring data from Canada and Mexico is the clearinghouse provided by DataFed Catalog: http://webapps.datafed.net/dvoy_services/datafed_catalog.aspx?mode=select.

¹ Full adherence to the WFS spec within ESRI products was questionable at the time of this report.

Appendix A – Glossary

aggregation: Combining data to a lower-level of spatial and/or temporal specificity; the grouping together of a selected set of like entities to form a single entity. For example, grouping sets of adjacent areal units to form larger units.

ancillary data: Geodata that provides context to aid in the interpretation and provide meaning to other geodata or geospatial information.

aspatial: A term that is used to describe non-spatial data that is usually referenced to spatial data, for example, attributes.

attribute: A characteristic of a geographic feature described by numbers, characters, images and CAD drawings, typically stored in tabular format and linked to the feature by a user-assigned identifier (e.g., the attributes of a well might include depth and gallons per minute); a column in a database table.

auxillary: See ancillary (above).

browser: Web browser such as Netscape Navigator or MS-Explorer.

cache: A repository, usually temporary.

catalog: Listing of data resources and/or collection of metadata files.

chaining: An operation that binds a sequence of services where, for each adjacent pair of services, occurrence of the first action is necessary for the occurrence of the second action.

Class I Area: Areas of special national or regional natural, scenic, recreational, or historic value for which the Prevention of Significant Deterioration (PSD) regulations provide special protection. Under the Clean Air Act (CAA), three kinds of Class I areas either have been, or may be, designated. These are “Mandatory Federal Class I areas”, “Federal Class I areas”, or “Non-Federal Class I areas.”

Clearinghouse: A decentralized system of web servers, sponsored by the FGDC, that supports a detailed metadata catalog service with support for links to spatial data and browse graphics through the individual metadata files.

controlled vocabulary: A prescribed set of consistently used and carefully defined terms.

cross-walk: A table that maps the relationships and equivalencies between two or more metadata formats. Crosswalks or metadata mapping support the ability of search engines to search effectively across heterogeneous databases, i.e. crosswalks help promote interoperability.

data dictionary: A catalog of all data held in a database, or a list of items giving data names and structures. Also referred to as DD/D for data dictionary/directory. Commercial RDBMSs have online data dictionaries stored in special tables called system tables.

data mediation: A service that bridges that gap between the data provider and the data consumer; can include format standardization and possibly integration.

data node: An organizational component that produces and/or maintains a significant amount of geodata. For WRAP, this would include EDMS, VIEWS, RMC, and CoHA (DRI).

data steward: The party responsible for the maintenance of a database or data set.

- database schema:** A collection of items that model part or all of a real world object.
- datum:** A set of parameters and control points used to accurately define the three-dimensional shape of the Earth (e.g., as a spheroid). The datum is the basis for a planar coordinate system. For example, the North American Datum for 1983 (NAD83) is the datum for map projections and coordinates within the United States and throughout North America.
- Dublin Core:** A standard set of 15 metadata elements for cross-domain information resource description; intended to facilitate discovery of electronic resources.
- entity:** In cartography, a real world object that cannot be further subdivided into similar objects, for example a road, or a building. In relational databases, an entity is an object and its associated attributes.
- entity relationship model:** A logical way of describing entities and their relationships within relational databases. An entity-relationship model is often used in the conceptual design phase of creating a relational database and is usually expressed as a diagram showing the entities and the linkages that exist between them.
- feature:** Abstraction of a real-world phenomena, normally associated with a location relative to the Earth.
- gateway:** An annotated directory of web resources; any mechanism for providing access to another system.
- geodata:** A geospatial database or data set.
- geographic information system:** A system of capturing, storing, checking, integrating, analyzing and displaying data about the earth that is spatially referenced. Normally includes hardware, software, data, and humans.
- geospatial:** A property denoting a locational reference the Earth's surface.
- hydrography:** The description and study of bodies of water or their representations on a map.
- integration:** The vertical, horizontal, and temporal alignment of geospatial information that allows spatial and temporal relationships among 2 or more databases to be discerned. Integration can take place at two levels: visual and computational.
- interoperability:** The capability to communicate, execute programs, or transfer spatial data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units.
- lattice:** A surface representation that uses a rectangular array of mesh points spaced at a constant sampling interval in the x and y directions relative to a common origin.
- metadata:** In general, "data about data;" functionally, "structured data about data." Information about an information resource.
- orthoimagery:** A modified version of a perspective photograph of the earth's surface with distortions due to tilt and relief removed.
- plot:** A map containing both geospatial data and cartographic elements.
- portal:** Typically a "Portal site" has a catalog of web sites, a search engine, or both. A Portal site may also offer other services to entice people to use that site as their main "point of entry" (hence "portal") to a particular information community.
- projection:** The representation on a plane surface of any part of the surface of the earth.

raster: A regular division of space, i.e., a grid of cells covering an area.

registry: A system to provide management of metadata elements, data elements, or web services. Metadata registries are formal systems that provide authoritative information about the semantics and structure of data elements. Each element will include the definition of the element, the qualifiers associated with it, mappings to multilingual versions and elements in other schema.

resolution: The smallest spacing between two display elements; the smallest size of feature that can be mapped or sampled.

scale: The relation between the size of an object on a map and its size in the real world.

spatial data infrastructure (SDI): An integrated, on-line network that delivers geospatial data, services and information for applications, better business and policy decision-making, and value-added commercial activities.

spheroid: Part of the mathematical model that describes the shape of the earth.

toponymy: A dataset which includes the names of geographic features, normally used for cartographic (map) product.

vector: Refers to potentially irregular divisions of space, based upon points; points can form lines, and lines can form polygons.

web mapping: A type of web service that provides static or interactive maps over the Internet.

web service: A network-based, distributed, modular component that performs specific tasks, and conforms to a specific set of technical specifications that make it interoperable with compatible components.

Glossary Acknowledgements:

The *GIS Dictionary*, by the Association for Geographic Information, <http://www.agi.org.uk/resources/index.htm>, accessed 25 May 2004.

The *Dublin Core Metadata Glossary*, by the Dublin Core User Guide Committee <http://dublincore.org/documents/2001/04/12/usageguide/glossary.shtml>, accessed 25 May 2004.

The ESRI *Glossary of GIS Terms*, <http://www.esri.com/library/glossary/glossary.html>, accessed 25 May 2004.

Appendix B – List of Acronyms

AoH - Attribution of Haze [Project]
ASCII - American Standard Code for Information Interchange
CAPITA - Center for Air Pollution Impact & Trend Analysis
CDX - Central Data Exchange
CENRAP - Central Regional Air Planning Association
CGDI - Canadian Geospatial Data Infrastructure
CIRA - Cooperative Institute for Research in the Atmosphere
CoHA - Causes of Haze Assessment [Project]
CSDGM - Content Standard for Digital Geospatial Metadata
DIF - Directory Interchange Format
DRI - Desert Research Institute
EDMS - Emissions Data Management System
ESRI - Environmental Systems Research Institute
FAQ - Frequently Asked Questions
FGDC - Federal Geospatial Data Committee
GCMD - Global Change Master Directory
GIS - geographic information system
GML - Geographic Markup Language
GOS - Geospatial One-Stop
GSDI - Global Spatial Data Infrastructure
GSM - General Service Model
HTML - hyper-text markup language
IMPROVE - Interagency Monitoring of Protected Visual Environments
INEGI - Instituto Nacional de Estadística, Geografía e Informática
ITEP - Institute for Tribal Environmental Professionals
ISO - International Organization of Standards
NEI - National Emissions Inventory
NIF - NEI Information (file) Format
NSDI - National Spatial Data Infrastructure
OGC - OpenGIS Consortium
RMC - Regional Monitoring Center
RPO - Regional Planning Organization
SDI - spatial data infrastructure

SIP - State Implementation Plan

SLD - Style Layer Descriptor

TIP - Tribal Implementation Plan

TRI - Toxic Release Inventory

UML - unified modeling language

URL - Universal Resource Locator

USGS - United States Geological Survey

IEWS - Visibility Information Exchange Web System

WIGIMS - WRAP Integrated Geospatial Information Management Strategy

WCS - Web Coverage Service

WFS - Web Feature Service

WMS - Web Mapping Service

WRAP - Western Regional Air Partnership

XML - Extensible Markup Language