WASP AT

Final Report: Enhancement and Demonstration of Stream Water Quality Modeling Using Analysis Tools for WASP 5.0

United States
Environmental
Protection Agency

Developed by the Integrated Decision Support Group at Colorado State University
for the United States Bureau of Reclamation and the Environmental Protection Agency.

WASP Analysis Tools (AT) are interactive Windows 95/98/NT computer programs for preparing and analyzing Water Quality Analysis Simulation Program Version 5.0 (WASP5) input/output files. GDP imports data from STORET, WATSTORE, and spreadsheets to combine and process it for water modeling tasks. Wasp Builder is a tool for building input files for EPA`s WASP 5.0 water quality program which supports the modeling of eutrophication, toxicity, and metal contaminant transport.

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Or, see our project web site:
http://www.ids.colostate.edu/projects/wasp

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I. Project Description

The objective of this project was to develop user-friendly tools to assess nutrients, contaminants and metal transformation and transport in riverine environments. WASP Analysis Tools are interactive Windows 95/98/NT computer-assisted programs with analysis tools for preparing and analyzing Water Quality Analysis Simulation Program Version 5.0 (WASP5) input/output files. There are two components that have been created for this project, Graphical Data Processor (GDP) and WASP Builder.

GDP can import data from STORET, WATSTORE, and ASCII delimited files and aggregate multiple parameters from a single station or from one parameter at several stations into one dataset. GDP can make unit conversions such as Fahrenheit to Celsius which saves time and labor in preparing data for analysis. GDP can also produce graphs of data values for analysis. This information can then be saved in a text file and exported to WASP Builder.

WASP Builder is a Windows 95/98/NT tool to build input files for EPA`s WASP5 water quality modeling program which supports, metal transport, nutrients, toxicity, and contaminant transport modeling. The META 4 version of the metals program for WASP5 was supported in this software development effort as well as the EUTRO and TOXI components. The WASP5 Analysis Tools are currently under development and maintained by the Integrated Decision Support Group (IDS) at Colorado State University. This software was made possible by funding from the United States Bureau of Reclamation (USBR) and the Environmental Protection Agency (EPA).

All the documentation and the software for this project will be available at the Integrated Decision Support Group web site:

http://www.ids.colostate.edu/projects/wasp

1.0 Purpose and Scope

1.1 Objective

Develop user-friendly tools to assess nutrients, contaminants and metal transformation and transport in riverine environments.

1.2 Expected Benefits

- Analysis tools for EPA's Water Analysis Simulation Program Version 5.0 (WASP5) including input data aggregation and sensitivity analysis tools contained in the Graphical Data Processor (GDP) and WASP Builder.
- Node-segment interface for entering WASP5 input data and data card processor in WASP Builder for creating WASP5 input files and viewing output files.
- Potential links to additional complementary EPA models such as MINTEQ and BASINS and the full inclusion of the metals version of WASP5 (i.e. META4).
- Documentation and technology transfer.

1.3 Scope

The Colorado State University Integrated Decision Support (IDS) Group, with cofunding from the U.S. Department of Interior Bureau of Reclamation (Reclamation) Land Suitability and Water Quality Group and the U.S. Environmental Protection Agency Office of Water, is assembling user-friendly analysis tools for EPA's WASP5. The object-oriented Graphical User Interface (GUI) system developed with Microsoft Visual C++ will allow users to more easily process data sets and apply them to riverine environments for the determination of toxic transport, such as heavy metals.

Temperature, salinity, oxygen, and simple nutrient budgets can be modeled with existing water quality models. However these models do not properly represent toxics that change rapidly with time and distance or that react, transform, or are adsorbed onto suspended materials. These processes need to be incorporated into existing models which can simulate parameters such as toxic metals. WASP5 is a computer program which provides a tool for modeling toxics, nutrients, and metals. WASP5 can be used to evaluate which intraphase or interphase exchange processes such as settling, suspension, adsorption, desorption, volatilization, or hydrolysis can be used to simulate the partitioning of chemicals and metals in the air, water, and soil. However, correctly assembling data for the WASP5 model is difficult. Therefore, a set of pre- and post-processors which provide data integration and data manipulation are being developed to make the WASP5 model easier to apply to problems and to better apply results from the model.

2.0 Project Progress

The analysis tools being developed by this project allow users to extract, analyze, and combine data from EPA's database STORET, the U.S. Geological Survey's (USGS) database WATSTORE, and comma delimited files from spreadsheets. The user can graphically determining the periods where data are available (using daily, weekly, or monthly time steps). The GDP tool can then be used to determine data availability and aggregate parameters and

stations to create a dataset for WASP. The system can also be used to determine periods of time where data are available for a given parameter from different stations, or when a station has data regardless of parameter type. The user can select a period of time, a time step, and a parameter to generate an output that can be incorporated into WASP5.

2.1 WASP5 Model Components

The functionality of WASP AT was expanded to support the EUTRO and TOXI options. The current development efforts for WASP AT support the TOXI, EUTRO, and META components of WASP5. The WASP5 dataset is divided into blocks of data referred to as cards, depending on the option of WASP5 that the user is running (EUTRO, TOXI, or META). Each dataset for a model is composed of a collection of data cards (blocks of data). The WASP Builder tool does error checking based on user defined criteria for parameter values and can also do sensitivity analysis on parameters such as flows.

2.2 META 4 Metals Component

Existing WASP5 input files created for the META or other components can be read into the system and used to populate the interface. The META4 fortran code has been updated to work with WASP5. From the Graphical User Interface (GUI) for WASP Builder a WASP5 input file can be generated.

2.3 Data Pre and Post Processing

WASP Analysis Tools can be used for data pre and post processing. The current version of the system runs on a personal computer (PC) under Windows 95/98/NT. The graphical interface uses a link-node approach to display a layout of water system networks. Each node on the screen describes a segment or a boundary between segments. When segments or boundaries are selected the user can import data files or populate them using an interface using windows with data entry fields corresponding to the options in the WASP5 data cards.

The user can enter boundary conditions for acceptable values and there is some error checking to determine if the data entered constitute a valid model run. WASP Builder provides the ability to generate multiple model runs for WASP5 and to analyze the differences in the output for user specified parameters. For example the temperature of water can be graphed for model runs where the flow at a gaging station is changed.

2.4 Documentation and Technology Transfer

A User Manual in hardcopy and on-line (Microsoft Help files) versions has been developed for the existing tools. In addition to the user-focused documentation, a programmers reference has been generated to document the routines developed for the interface. This report includes these documents in Appendix B and C, respectively. Task memos have been written to address specific issues and to document approaches to problems, these task memos are presented in Appendix A. A technical paper on this work was presented to the Federal Interagency Hydrological Modeling Conference in April of 1998 and an additional paper is being prepared for submittal to a refereed journal. The system has been tested, using datasets from California Gulch, Colorado in addition to a stream (high flow) application which is dominated by dissolved species of toxic metals.

3.0 Demonstration

Interested parties are invited to request a demonstration version of the software.The software and documentation for the WASP AT project is available on the website:

http://www.ids.colostate.edu/projects/wasp

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II. Work Tasks and Project Deliverables

1.0 Work Tasks

Task 1. Investigate Modification of Existing Graphical User Interfaces

The WASP Builder interface grew out of the Hydros Simulation System (HSS) Graphical User Interface (GUI) which was PC based. Some of the graphic designs came from HSS, but all the interface tools were developed in C++ code for PCs. UNIX interfaces were investigated. However, the difficulties in converting and porting UNIX code to PC environments were too costly, see Appendix A: Task Memo ##1.

Task 2. Investigate Cofunding and Grant Opportunities

A list of potential funding sources was drafted and the Environmental Protection Agency (EPA) was solicited for cofunding. Two proposals totally $90,000 were accepted and funded by EPA. A Category III funding proposal under the CALFED Ecosystem and Restoration program was also submitted without success, see Appendix A: Task Memo ##2.

Task 3. Investigate Hydrodynamic Programs

Flow models that could be used with WASP5 were investigated via literature and Internet searches. The complexity of using unsteady flow models would need to be economically justified. DYNHYD5 would likely suffice for most problems. The connections between WASP5 and DYNHYD5 can be used with the interface by building a WASP5 input file using DYNHYD5 and then editing the WASP5 input file in the WASP Builder interface.

Task 4. Investigate Existing California Gulch Model Segmentation and Data

The California Gulch dataset was run with the latest version of the EPA WASP5 model and the META4 component. California Gulch has been used to model metals transport from abandoned and active mines East of Leadville, Colorado. A dataset was available for the 1993 water year and has been used to test the functionality of the tools developed for this project. Results are presented in Appendix A: Task Memo ##3.

Task 4a. Investigate the WASP5 Metals Subprogram

META4, the undocumented untested version of the WASP5 metals subprogram was investigated by using the California Gulch dataset and it was included with the software development and testing.

Task 4b. Investigate Linking Point Data to Model Reaches

The task of assigning, distributing, and linking input data to segments and nodes of the modeled reaches was investigated. An interface was built to graphically represent link and

nodes for point data. The suggested methodology is to link a GIS coverage that is already constructed for the watershed to point data represented graphically in WASP Builder. This can be done by exporting datafiles from the GIS package and using the Graphical Data Processor (GDP) to process flat files to aggregate stations and/or parameters. The results of the aggregation can be imported into the data entry fields in WASP Builder for links or nodes to develop a WASP5 input file.

Task 5. Preliminary Model Calibration

Preliminary model calibration to the California Gulch dataset indicated problems with flows and the model geometry. A field visit to collect flow and channel cross sections was performed during 1998. After checking the flows with historical gage data and field measurements the flows from California Gulch appear reasonable, see Appendix A: Task Memo #3 although volumes of segments are questionable.

Task 5a. Assemble Tool for Documentation of Calibration and Sensitivity Analysis

A Revision Control System (RCS) tool was developed for WASP Builder to track calibration runs and significant changes. This system records differences between simulations. A sensitivity analysis tool and report generator were prototyped for use in multiple model runs needed for sensitivity analysis, see Appendix A: Task Memo #4.

Task 6. Assemble Data Sets for Verification

The California Gulch data set was investigated and the flow data seemed reasonable, a more detailed field study would need to be preformed to identify tributary inputs and groundwater interaction, see Appendix A: Task Memo #3.

Task 6a. Investigate Methods to Fill in Data Gaps

Methods to fill in data gaps were investigated. A tool to notify users of groups that contain incomplete data was incorporated into the GDP tool. Interpolation, correlation, and Thiessen network weighting techniques were investigated, but were left for future development efforts to include a GIS component. Also, since WASP5 allows the user to enter sparse data and it was determined that data filling was not required for most applications. However, a tool was developed for GDP to fill data gaps using a linear interpolation.

Task 6b. Investigate Linkage to Coefficient Databases or Files

The tasks required to link coefficient databases to the WASP5 model was investigated. Independently running MINTEQ to determine the dominant reactions and associated coefficients for metal precipitation and partitioning is typically used to develop the values for chemical parameters for metals and can be used to generate datafiles to be imported into the GDP tool for analysis and inclusion in the WASP Builder tool.

Task 6c. Error Checking

WASP Builder contains a feature that shows the user the missing data and zero values for each data group and is able to spot blank inputs or inputs outside the range of user defined values.

Task 7. Preliminary Sensitivity Analysis

Sensitivity to flow, geometry, and other variables has been explored with tools available in WASP Builder, results are presented in Appendix A: Task Memo #4.

Task 7a. Develop Sensitivity Analysis Tools

A tool to automatically generate a range of sensitivity runs was incorporated into WASP Builder. This tool can be set to run different percentages or user defined values for parameters in a set of WASP5 model runs. The output from the sensitivity runs are presented in a standard report format. Examples are given in Appendix A: Task Memo #4 for the use of these tools.

Task 8. Interim Data Deficiency Reports

Data deficiency reports were not needed due to the results of the analysis of the existing California Gulch dataset which proved sufficient, see Appendix A: Task Memo #3.

Task 9. Collection and Processing of Additional Data

Funding for additional data collection was not received. However some flow and geometrical data was collected during 1998 for model verification, see Appendix A: Task Memo #3.

Task 10. Model/Graphics Modifications and Debugging

The Graphical User Interface (GUI) was built to represent stream and groundwater nodes with links in a graphical format for data entry. A Graphics Server was incorporated into GDP and WASP Builder for plotting input and output graphs.

Task 10a. Input Section Development

A card system by which the user can easily interchange data sets was developed for WASP Builder.

Task 10b. Investigate Linkage to GIS

Linkages to a GIS were investigated. It was determined that spatial data needed to build WASP input files would not be adequate from existing sources such as Basins, but it may be useful to display output data in a GIS. It is recommended that ArcView be used to implement future versions by developing extensions in Avenue scripts, if it becomes important to automate output.

Task 10c. Investigate Linkage to BASINS Model

The Linkage to BASINS, EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model was investigated. A first step to integrating WASP Builder into BASINS would be to develop ArcView extension(s) to retrieve data from basins. The analysis of the linkage to BASINS showed the data collected in BASINS could be used for coarse background data, but additional data would be needed at a smaller scale to run WASP5.

Task 11. Draft Model Documentation

Technical reference manuals and user guides for both GDP and WASP Builder were developed and copies are available on the internet site as Adobe Portable Document Format

(PDF) Files. Powerpoint presentations were also developed and placed on the internet. One page brochures for both GDP and WASP Builder and a combined brochure covering all Analysis Tools were also prepared.

For more information see: http://www.ids.colostate.edu/projects/wasp

Task 11a. Internet Website

The internet site for WASP Analysis Tools (http://www.ids.colostate.edu/projects/wasp/) contains electronic copies of most of the documentation and versions of the software. There is a link to the EPA WASP page and a downloadable version of WASP 5.0 in case the WASP model is updated. Statistics have been collected about how often people download software and there is an option for the user to enter contact information. The website has been accessed from users as far away as Asia and some of the feed back from software users has been incorporated into the software development.

Task 11b. Microsoft On-line Help

Microsoft help files were developed for both GDP and WASP Builder and they include a comprehensive description of how to use the software.

Task 11c. Technical Software Development Documentation

A description of routines and functions for GDP and WASP Builder was developed and will also be available on the website (http://www.ids.colostate.edu/projects/wasp). They are also presented in this document, see Appendix F and G.

Task 12. Model Recalibration and Debugging

The field data collected during 1998 were used to determine if flow data from California Gulch META4 file were reasonable, see Appendix A: Task Memo #3. The California Gulch dataset was used for debugging the interface, but since additional data would be needed for a full model calibration and the funds to collect this data were not available only a basic model calibration was preformed using the flow data from the input and output files, see Appendix A: Task Memo #3 and #4.

Task 13. Model Verification

Sensitivity to major inputs such as flow, temperature, and model geometry have been investigated, see Appendix A: Task Memo #4 for more detail. The input and output of the California Gulch Meta4 input file were compared in Appendix A: Task Memo #3 for flow data.

Task 14. Final Sensitivity Analysis

A tool was developed for sensitivity analysis runs that can generate reports for changes in model parameters based on percentages of an original value. A sensitivity analysis with regard to major input variables was performed with the California Gulch dataset and is described in Appendix A: Task Memo #4.

Task 15. Interim Application Report

An interim application report for California Gulch was prepared and is included in Appendix A: Task Memo #3.

Task 16. Management Simulations

Management simulations have been investigated and additional functionality beyond the sensitivity analysis and report generator functions was not needed.

Task 17. Final Model and GUI Documentation

The last version of the model will be documented with a user manual, technical documentation, promotional material, and Microsoft online help. All software and documentation for this project is included on the website (http://www.ids.colostate.edu/projects/wasp).

Task 18. Final Report

A copy of this final report is also available on the website in its component form (http://www.ids.colostate.edu/projects/wasp).

Task 19. Technology Transfer

A technical paper on this work was presented to the Federal Interagency Hydrological Modeling Conference in April of 1998 and a refereed paper is being prepared. Reclamation staff have been testing the GDP and WASP Builder software.

2.0 Project Deliverables

2.1 Overall Project Deliverables

1. End of Year Reports and model Documentation.

The following documents have been produced for the WASP builder and GDP models:

a) A website with the ability to download software and documentation (http://www.ids.colostate.edu/projects/wasp/).
b) Task memos as needed to achieve project tasks, see Appendix A.
c) Microsoft on-line context sensitive help.
d) Hardcopy User Manuals.
e) Technical Reference Documentation.
f) Powerpoint presentations.
g) Brochures and promotional posters.

2. Software enhanced and tested with additional modeling capabilities as described in the project tasks.

The following modeling capabilities were created with the WASP Builder and GDP models:

a) The ability to notify users of groups that contain incomplete data, and data values that fall outside user specified parameters.

b) The ability to document input file changes within the graphical user interface via a note window and an Revision Control System (RCS) interface.
c) The ability to graphically add and delete nodes in a WASP5 network.
d) Created a GUI to support EUTRO, TOXI and META simulations.
e) A tool was added to assemble multiple model runs for sensitivity analysis and generate result reports.

3. *The user interface should be user friendly.*

2.2 Task-based Deliverables

1. *Summary task memos describe the following:*

a) Investigation of existing GUIs and the reuse of existing code is covered in Appendix A: Task Memo #1.
b) The linkage to WASP5 is covered in Appendix A: Task Memo #1.
c) Portability to PC-based environments from Unix software is covered in Appendix A: Task Memo #1.
d) List of possible funding sources was covered in Appendix A: Task Memo #2.
e) Investigation of California Gulch data set is covered in Appendix A: Task Memo #3.
f) A review of the sensitivity analysis preformed is presented in Appendix A: Task Memo #4.

2. *List of possible cofunding and grant sources and draft of a proposal seeking additional funding. See Appendix A: Task Memo #2.*

3. *Some of the issues concerning the usability of hydrodynamic programs are discussed in Appendix A: Task Memo #1.*

4. *Summary of the California Gulch data set describing hydrologic conditions, parameters and input coefficients.*

a) Documentation of the WASP5 metals subprogram input dataset is covered in Appendix A: Task Memo #3.
b) Methodology to generate segment data input from point data is covered in the User Manuals, see Appendix B and C.

5. *Model calibration including a GUI to track calibration and sensitivity analysis model runs.*

A tool was developed to run model calibration and sensitivity analysis that generates reports of multiple model runs. For an example see Appendix A: Task Memo #4.

6. *An assembled Verification data set.*

a) Summary of methods to fill in data gaps was not necessary since no funding was found for additional data gathering. However, some additional data was collected on a site visit.
b) The tasks required to link to coefficient databases or files was investigated with regard to MINTEQ and it was determined that a separate model run could be used to generate important chemical reactions and the results can be pasted into WASP Builder.
c) Some error checking capabilities were developed for building WASP5 input files.

7. *A sensitivity analysis of input parameters and coefficients with a scenario generator.*

   A review of the sensitivity analysis performed is presented in Appendix A: Task Memo #4.

8. *Interim Data deficiency report and a data collection plan if necessary.*

   This item was not needed due to a lack of additional funds for data gathering.

9. *Processing of stream geometry data.*

Since no additional funding was obtained to collect new data, stream geometry data were not collected and therefore data were not available for processing. However, some additional data was collected on a site visit and compared with existing stream geometry data.

10. *User-friendly graphics tool for displaying observed and modeled inputs and outputs.*

    a) An input card developer tool was created to enter data for building a WASP5 input file.
    b) The recommendation for linkage to GIS is to use GIS coverages to prepare node and link data that can be pasted into WASP Builder or develop output display linkages in future versions.
    c) Possible linkage to BASINS model was investigated, but the data resolution in BASINS is typically coarser then what would be needed for a WASP5 model run. Data could be pasted from BASINS into the card editor for WASP Builder.

11. *On-line documentation including a website and Microsoft help.*

    A website has been developed with copies of the software and most of the documentation that has been developed for the project. The address of the website is: http:// www.ids.colostate.edu/projects/wasp/. Microsoft online documentation was built for all the tools developed.

12. *Final recalibration report comparing observed and model data*

    Since no additional funding was obtained, no data were collected and therefore data were not available to compare with model data.

13. *A model verification report.*

    A review of the sensitivity analysis preformed is presented in Appendix A: Task Memo #4, and serves as a model verification report.

14. *Final sensitivity analysis reports.*

    A review of the sensitivity analysis preformed is presented in Appendix A: Task Memo #4, and serves as a model verification report.

15. *Text, tables, and graphics for an interim application report.*

    Quarterly progress reports and other documentation was produced.

16. *Summary of assumptions, inputs and model results of management simulations.*

    Sensitivity analysis and report generator functions was developed and used to develop management simulations, see Appendix A: Task Memo #4.

17. Final additions to user and reference documentation.

The final additions to the user and reference documentation have been completed and can be viewed in the appendixes and will be available on the website (http://www.ids.colostate.edu/projects/wasp).

18. Text, tables, and graphics for the final report. Attend one conference and submit one paper to a refereed journal.

A technical paper on this work was presented to the Federal Interagency Hydrological Modeling Conference in April of 1998 and a paper is being prepared for a refereed journal.

19. Technology transfer training for USBR staff.

Reclamation staff have been testing the GDP and WASP Builder software.