Loading Simulation Program in C++ (LSPC) Version 3.1 User's Manual

Development Team:

Tetra Tech
10306 Eaton Place
Suite 340
Fairfax, VA 22030

County of Los Angeles
Department of Public Works
Watershed Management Division
900 South Fremont Avenue, 11th Floor
Alhambra, CA 91803-1331

United States Environmental Protection Agency, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

United States Environmental Protection Agency, Region 4
Sam Nunn Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

December 11, 2009

HOA.912917.1 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

Disclaimer

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the United States Environmental Protection Agency (EPA). The Loading Simulation Program in C++ (LSPC) System described in this manual is applied at the user's own risk. Neither the EPA nor the system authors assume responsibility for system operation, output, interpretation, or use.

Acknowledgments

Several groups have influenced and contributed towards Tetra Tech's development of the Loading Simulation Program in C++ (LSPC) over its lifetime. Three of the key contributors include United States Environmental Protection Agency (EPA) Region 3, EPA Region 4, and the Los Angeles County Department of Public Works (LACDPW). LSPC builds upon the Mining Data Assessment System (MDAS), a precursor prototype previously developed under technical direction and guidance from EPA Region 3 for mining-related TMDL calculations. EPA Region 3 funded this important step in the lifecycle of LSPC. In 2003, EPA Region 4 supported the initial documentation, packaging, and distribution of LSPC Version 2 model through the Watershed and Water Quality Technical Support Center. LACDPW requested an updated public domain GIS interface (using the MapWindow platform) and supporting model documentation for the current version of the model for County training and use. They have graciously agreed to allow these work products to be freely shared to the broader community through EPA. Tetra Tech research and development funds have provided system conceptual design, core system implementation, extension implementation, system and code documentation, testing, and production services.

Suggested Document Citation

Tetra Tech, 2009. Loading Simulation Program in C++ (LSPC) Version 3.1 User's Manual. Fairfax, VA.

USER MANUAL DISCLAIMER

Information in this User Manual is provided in connection with the Los Angeles County Watershed Management Modeling System (WMMS) made available to the public by the Los Angeles County Flood Control District ("LACFCD"). No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document.
The LACFCD may make changes to WMMS and this User Manual at any time, without notice.

This User Manual is provided "as is" without any representations or warranties, express or implied, including for fitness for a particular purpose, merchantability, or infringement of any patent, copyright or other intellectual property right. The LACFCD makes no representations or warranties in relation to this User Manual or the information and materials provided herein. Although LACFCD may make an effort to include accurate and up to date information, without prejudice to the generality of this paragraph, LACFCD does not warrant that the information in this User Manual is complete, true, accurate or non-misleading.

This User Manual is provided solely for informational purposes. LACFCD will not be liable to you whatsoever for any damages (whether under the law of contract, the law of torts or otherwise) in relation to the contents of, or use of, or otherwise in connection with, this User Manual, including for any direct loss; for any indirect, special or consequential loss, for any business losses, loss of revenue, income, profits or anticipated savings, loss of contracts or business relationships, loss of reputation or goodwill, or failure to meet any state or federal requirements under any federal or state law, including, but not limited to the Clean Water Act and the Porter-Cologne Water Quality Control Act.

By using this User Manual, you agree to the terms, conditions and limitations of liability set forth herein, and that the exclusions and limitations of liability set forth in this User Manual disclaimer are reasonable. If you do not agree with the terms and conditions, or believe they are unreasonable, you must not use WMMS or this User Manual.

Without prejudice to the foregoing paragraph, you also agree that the limitations of warranties and liability set out in this User Manual disclaimer extend to LACFCD, the County of Los Angeles, and their respective its board, officers, employees, agents, subsidiaries, successors, assigns and sub-contractors.

If any provision of this User Manual disclaimer is, or is found to be, unenforceable under applicable law, that will not affect the enforceability of the other provisions of this User Manual disclaimer.

Los Angeles County Watershed Management Modeling System, WMMS, Los Angeles County Flood Control District, and LACFCD, and its associated names and logos, are marks of LACFCD. No marks may be used without the written permission of LACFCD. No part of this manual may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or information storage and retrieval systems, for any purpose other than the user's personal use, without the written permission of LACFCD.

 © 2012 County of Los Angeles. All rights reserved.

Contents

1 Introduction 1-1

2 LSPC Overview 2-1

2.1 Watershed Modeling 2-1

2.2 System Design and Considerations 2-1

2.3 EPA TMDL Modeling Toolbox 2-2

2.4 Hardware and Software Requirements 2-3

2.5 LSPC System Component Interaction 2-4

3 General GIS-Based Resources 3-1

3.1 Calibration Stations 3-1

3.2 Topography 3-1

3.3 Stream Reach 3-1

3.4 Soil 3-1

3.5 Point Sources 3-1

3.6 Land Use 3-1

3.7 Withdrawals 3-2

3.8 303(d) Listings 3-2

3.9 Subbasins 3-2

3.10 MapWindow ..... **Error! Bookmark not defined.**

4 GIS Processing for an LSPC Application 4-1

4.1 Subbasin Delineation 4-1

4.2 Stream Reach 4-1

4.3 Hydrologic Response Units 4-1

4.4 Weather Stations 4-2

5 MS Excel Setup Tool 5-1

5.1 Tabs FromGIS, Control, Landuse, and Reaches 5-1

5.2 Tabs F-Tables, LanduseCodeMD, ModelMapping, and Watershed_Physical 5-4

5.3 Tabs ReachModel and ReachNetwork 5-6

5.4 Tab DMR 5-7

5.5 Tabs WeatherTables and WeatherMapping 5-9

5.6 Tabs ModelPARM and OtherPointSourcePARM 5-11

5.7 Tab Model Parameters 5-13

5.8 Tab SelDischarge 5-15

6 MS Access Database 6-1

6.1 Copy/Paste from the MS Excel Setup Spreadsheet 6-1

6.2 Selection Tables 6-2

6.3 Point Sources/Sinks 6-3

6.4 Other Tables 6-4

 © 2012 County of Los Angeles. All rights reserved.

6.5 Macro/Query Execution 6-4
7 Weather Data 7-1
7.1 Sources 7-1
7.2 Processing 7-1
8 MapWindow for LSPC 8-1
8.1 Build a MapWindow LSPC Project 8-1
9 LSPC Model 9-1
9.1 Subfolder Structure 9-1
9.2 Loading an LSPC Model Application 9-2
9.3 Global Settings 9-5
9.4 Snow 9-7
9.5 Water Budget 9-8
9.6 Sediment 9-12
9.7 Temperature 9-13
9.8 GQUAL 9-16
9.9 RQUAL 9-19
9.10 TMDL Control Options 9-22
9.11 Output 9-22
10 Discussion and Examples 10-1
10.1 Hypothetical Example Application 10-1
10.2 Snow Simulation 10-2
10.3 Water Budget 10-3
10.4 Water Temperature 10-9
10.5 Nutrients 10-18
10.6 Sediment 10-35
10.7 Dissolved Oxygen/BOD 10-43
10.8 Cumulative Upstream Area 10-55
11 Model Updates 11-1
12 References 12-1

 © 2012 County of Los Angeles. All rights reserved.

Tables

Table 2-1. Highlighted Models and Assessment Resources Available with the TMDL Modeling Toolbox ... 2-3
Table 2-2. LSPC Hardware and Software Requirements ... 2-4
Table 4-1. Hypothetical Examples of HRUs ... 4-1
Table 6-1. Summary of Copy/Paste to MS Access Database from the MS Excel Tab ... 6-2
Table 6-2. Summary of Selection Tables Populated by a User ... 6-3
Table 7-1. Weather Parameters and IDs ... 7-1
Table 8-1. LSPC-MW Project File Names ... 8-2
Table 8-2. LSPC Map Tool Setting Descriptions ... 8-3
Table 10-3. Snow Budget Routine Cards ... 10-2
Table 10-4. Snow Simulation Card Parameter Definitions ... 10-3
Table 10-5. Water Budget Routine Cards ... 10-4
Table 10-6. Card 100 PWAT – Parameter 1 ... 10-5
Table 10-7. Card 110 PWAT – Parameter 2 ... 10-5
Table 10-8. Card 120 PWAT – Parameter 3 ... 10-5
Table 10-9. Card 140 PWAT – State 1 ... 10-6
Table 10-10. Hydrologic Example Scenarios ... 10-7
Table 10-11. Water Temperature Routine Cards ... 10-9
Table 10-12. Card 460 Soil Temperature Control Parameters ... 10-10
Table 10-13. Card 461 Soil Temperature Parameters ... 10-10
Table 10-14. Soil Temperature Parameter Interpretation by Selected Method and Soil Layer ... 10-11
Table 10-15. Card 470 Temperature Parameters for Land Groups ... 10-14
Table 10-16. Card 475 Temperature Parameters for Stream Groups ... 10-14
Table 10-17. Water Temperature Example Scenarios ... 10-17
Table 10-18. Nutrient Routine Cards ... 10-19
Table 10-19. Card 250 General Quality Constituent Control Parameters ... 10-20
Table 10-20. Card 255 Surface and Subsurface Quality Control Parameters ... 10-20
Table 10-21. Card 260 Qual-Input Storage on Surface and Nonseasonal Parameters ... 10-21
Table 10-22. Card 281 General Quality Constituent Control—Reach Parameters ... 10-22
Table 10-23. GQUAL Example Scenarios, Total Nitrogen (DWQID = 3) ... 10-22
Table 10-24. Card 500 Land to Stream Mapping Parameters ... 10-25
Table 10-25. Card 500 Land to Stream Mapping Parameters ... 10-25
Table 10-26. Card 520 Nutrients Control Parameters ... 10-26
Table 10-27. Card 521 Nutrients Parameters 1 ... 10-27
Table 10-28. Card 522 Nutrients Parameters 2 ... 10-28
Table 10-29. Card 523 Nutrients Parameters 3 ... 10-29
Table 10-31. Card 530 Plankton Flag Parameters ... 10-30
Table 10-32. Card 531 Plankton Parameters 1 ... 10-30
Table 10-33. Card 532 Plankton Parameters 2 ... 10-30
Table 10-34. Card 533 Plankton Parameters 3 ... 10-31
Table 10-35. Card 534 Plankton Parameters 4 ... 10-31
Table 10-36. RQUAL Nutrient and Phytoplankton Example Scenarios ... 10-31
Table 10-37. Sediment Routine Cards ... 10-35
Table 10-38. Card 440 Sediment Parameters Control ... 10-35
Table 10-39. Card 450 Sediment Parameters Group 1 ... 10-36
Table 10-40. Card 455 Sediment General Parameters Group 3 ... 10-38
Table 10-41. Card 456 Sediment Parameters Group 4 ... 10-39
Table 10-42. Dissolved Oxygen Routine Cards ... 10-43
Table 10-43. Card 510 Parameter REAMFG Reaeration Options ... 10-44
Table 10-44. Card 511 OX-PARM1 Variables ... 10-44
Table 10-45. Card 512 OX-PARM2 Variables ... 10-46
Table 10-46. Dissolved Oxygen Example Scenarios ... 10-51

 © 2012 County of Los Angeles. All rights reserved.

Figures

Figure 2-1. Generalized Schematic of Toolbox Components Interactions. 2-3
Figure 2-2. LSPC System Component Interactions. 2-4
Figure 4-1. Example of ASCII File from GIS Land Use Export. 4-2
Figure 5-1. The Control Tab of the MS Excel Setup Tool. 5-2
Figure 5-2. The Landuse Tab of the MS Excel Setup Tool. 5-3
Figure 5-3. The Reaches Tab of the MS Excel Setup Tool. 5-4
Figure 5-4. A Typical Example of the LanduseCodeMD Tab. 5-5
Figure 5-5. Example of HRU for the LanduseCodeMD Tab. 5-5
Figure 5-6. The ReachModel tab. 5-7
Figure 5-7. General Cross Section. 5-7
Figure 5-8. The DMR tab. 5-8
Figure 5-9. The WeatherTables tab. 5-10
Figure 5-10. The ModelPARM tab. 5-12
Figure 5-11. The OtherPointSourcePARM tab. 5-13
Figure 5-12. The Model Parameters tab. 5-14
Figure 5-13. The SelDischarge tab. 5-15
Figure 6-1. The Tables Section of the MS Access Database 6-1
Figure 6-2. PS_Timeseries Table. 6-3
Figure 7-1. Example ASCII Weather File (*.AIR). 7-2
Figure 8-1 Select the LSPC Plug-In for MapWindow GIS. 8-1
Figure 8-2 The New LSPC Menu and Icon Bar after the LSPC Plugin is Activated. 8-1
Figure 8-3 Save a MapWindow Project Dialog Box. 8-2
Figure 8-4 Save a MapWindow Project Icon. 8-2
Figure 8-5 Setup LSPC Project in MapWindow. 8-2
Figure 8-6 LSPC Map Tools Settings Dialog Box, Empty. 8-3
Figure 8-7 LSPC Map Tools Settings Dialog Box, Populated. 8-3
Figure 8-8 Selecting Subbasins. 8-4
Figure 8-9 Accessing Simulation Output. 8-5
Figure 8-10 Selecting an Output *.CSV File 8-6
Figure 9-1. Example Subfolder Structure. 9-1
Figure 9-2. LSPC Model Interface. 9-2
Figure 9-3. Dialog Box from the File Menu, Then Get From Database. 9-2
Figure 9-4. Option Selection Dialog Box from the File menu, Then Get From Database. 9-3
Figure 9-5. ASCII Project Input (*.INP) File. 9-4
Figure 9-6. LSPC Model Interface. 9-5
Figure 9-7. Land Use Attributes Window. 9-6
Figure 9-8. Parameter Info for Land Use Attributes Window. 9-6
Figure 9-9. Stream Network Window. 9-7
Figure 9-10. Parameter Info for Stream Network Window. 9-7
Figure 9-11. Snow Pack/Melt Parameter Group 1 Window. 9-8
Figure 9-12. Parameter Info for Snow Pack/Melt Parameter Group 1 Window. 9-8
Figure 9-13. Water Budget Parameter Group 1 Window. 9-9
Figure 9-14. Water Budget Parameter Group 2 Window. 9-9
Figure 9-15. Water Budget Parameter Group 3 Constant/Monthly Switches Window. 9-10
Figure 9-16. Water Budget Parameter Group 3 Constant Parameters Window. 9-10
Figure 9-17. Water Budget Parameter Group 3 Interception Storage Capacity Window. 9-11
Figure 9-18. Water Budget Initial Conditions Window. 9-11
Figure 9-19. Sediment Parameter Group 1 Window. 9-12
Figure 9-20. Sediment Parameter Group 2 Window. 9-12
Figure 9-21. Sediment Parameter Group 3 Window. 9-13

 © 2012 County of Los Angeles. All rights reserved.

Figure 9-22. Sediment Parameter Group 4 Window. 9-13
Figure 9-23. Soil Temperature Monthly Controls Window. 9-14
Figure 9-24. Soil Temperature Constant Parameters Window. 9-14
Figure 9-25. Soil Temperature Monthly Parameters ASLT for Surface Temperature Window. 9-15
Figure 9-26. Surface Temperature Parameters Window. 9-15
Figure 9-27. Stream Temperature Parameters Window. 9-16
Figure 9-28. Water Quality Constituents – GQUAL General Settings Window. 9-16
Figure 9-29. Water Quality Constituents – GQUAL Water Quality Controls Window. 9-17
Figure 9-30. Water Quality Constituents – GQUAL Constant Loading Parameters Window. 9-17
Figure 9-31. Water Quality Constituents – GQUAL Monthly Loading Parameters Accumulation Rate Window. 9-18
Figure 9-32. Water Quality Constituents – GQUAL Stream-Based Pollutant Contributions Water Quality Parameters Window. 9-18
Figure 9-33. Water Quality Constituents – RQUAL Land to Stream Mapping Window. 9-19
Figure 9-34. Water Quality Constituents—RQUAL Land-Based DO and CO2 Contributions General Settings Window. 9-20
Figure 9-35. Water Quality Constituents—RQUAL OXRX Parameters DO-BOD Parm1 Window. 9-20
Figure 9-36. Water Quality Constituents—RQUAL NUTRX Parameters NUT Parm1 Window. 9-21
Figure 9-37. Water Quality Constituents—RQUAL PLANK Parameters Plankton Controls Window. 9-21
Figure 9-38. TMDL Control Options Land-Based Controls Window. 9-22
Figure 9-39. Output Window. 9-23
Figure 10-1. Snow Simulation Schematic. 10-2
Figure 10-2. Water Budget Schematic. 10-4
Figure 10-3 Flow Comparison at Subbasin 101 for Scenario AGWRC. 10-7
Figure 10-4 Flow Comparison at Subbasin 101 for Scenario INFILT. 10-7
Figure 10-5 Flow Comparison at Subbasin 101 for Scenario LZSN. 10-8
Figure 10-6 Flow Comparison at Subbasin 101 for Scenario UZSN. 10-8
Figure 10-7 Flow Comparison at Subbasin 101 for Scenario SLSUR. 10-9
Figure 10-8. Example Soil Temperature Variation by Depth. 10-13
Figure 10-9. Mean Annual Earth Temperature Observations at individual Stations, Superimposed on Well-Water Temperature Contours. 10-13
Figure 10-10. Temperature Routine Diagram. 10-15
Figure 10-11. Simulation Comparisons of Water Temperature at Subbasin 101 for Scenario AGWT. 10-17
Figure 10-12. Simulation Comparisons of Water Temperature at Subbasin 101 for Scenario CFSAEX. 10-18
Figure 10-13. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario ACCUM. 10-23
Figure 10-14. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario SQOLIM. 10-23
Figure 10-15. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario WSQOP. 10-24
Figure 10-16. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario DECAY. 10-24
Figure 10-17. Simulation Comparisons of Nitrogen and Phytoplankton at Subbasin 101 for Scenario KTAM20. 10-32
Figure 10-18. Simulation Comparisons of Nitrogen and Phytoplankton at Subbasin 101 for Scenario MALGR. 10-33
Figure 10-19. Simulation Comparisons of Nitrogen and Phytoplankton at Subbasin 101 for Scenario NALDH. 10-34
Figure 10-20. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario KTAM20. 10-48
Figure 10-21. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario MALGR. 10-49
Figure 10-22. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario NALDH. 10-50
Figure 10-23. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario KBOD20. 10-52
Figure 10-24. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario REAK. 10-53
Figure 10-25. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario BENOD. 10-54
Figure 10-26. Temperature Correction Parameter for Various Rate Constants. 10-55

 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

1 Introduction

LSPC is the Loading Simulation Program in C++, a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by the U.S. Environmental Protection Agency (EPA) Region 3 (under contract with Tetra Tech) and has been widely used for mining applications and total maximum daily loads (TMDLs). In 2003 EPA Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the EPA TMDL Modeling Toolbox. Since its original public release, the in-stream model has been expanded to include additional HSPF GQUAL components for sorption/desorption of a quality constituent with sediment; enhanced temperature simulation; and the HSPF RQUAL module for simulating dissolved oxygen (DO), nutrients, and algae. LSPC has been customized to address simulation of other pollutants such as nutrients and fecal coliform bacteria, which have been shown to be common pollutants of concern in various parts of the country.

Because of its C++ programming architecture with no inherent limits on array size and spatial/temporal resolution associated with model setup, LSPC overcomes many of the difficulties experienced with large-scale watershed simulation (e.g., those on the order of 8-digit U.S. Geological Survey Hydrologic Cataloguing Units or larger). The system is limited only by computer memory and available storage, which are both virtually inconsequential for nearly all practical applications and are becoming increasingly abundant with time as computing power increases. The system automatically links upstream contributions to downstream segments, allowing users to freely model subareas while maintaining a top-down approach. The LSPC watershed model also enables users to link in-stream water quality directly to point and nonpoint source loads. Using specialized system components, valid wasteload and load allocations can be developed on the basis of analysis of each individual point and nonpoint source and its pollutant contributions.

Another key data management feature of this system is that it uses a Microsoft (MS) Access database to manage model configuration and parameterization data, and it uses open and editable weather text files to drive the simulation. For each model run, it automatically generates comprehensive, text-file output by subbasin for all lands, reaches, and simulated modules, which can be expressed at the frequency of the timestep of the weather data driving the model (usually hourly) or aggregated daily intervals. Output from LSPC has been efficiently linked to other model applications such as EFDC, WASP, and CE-QUAL-W2. The MS Visual C++ programming architecture also allows for seamless integration with modern-day, widely available software such as MS Access and Excel.

This manual describes the LSPC modeling system in detail. The discussion begins with a general overview of watershed modeling and watershed management questions and issues, highlights the LSPC modeling system components, and describes the special features of the system. In addition, it provides a discussion of hardware and software requirements, instructions for system installation, step-by-step procedures for setting up an LSPC watershed project, modeling a watershed, along with detailed examples throughout the discussion illustrating the various LSPC modeling system components and their interactions.

 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

2 LSPC Overview

2.1 Watershed Modeling

Watersheds form a natural organizing framework for the management of our environment. State and federal governments have embraced the watershed concept for program management, required reporting, and the design of monitoring and analysis techniques. Watershed systems are complex, including a variety of land uses, soils, topography, and hydrologic systems. Managers of such systems need technical tools to help them protect, manage, and restore watersheds and make cost-effective and unbiased decisions. The analysis techniques used to support decision making need to be defensible and credible. The public must also be able to understand and support the results of the analysis. The more accessible and defensible the analysis, the more effectively analytical tools can be incorporated into collective decision making and ongoing management of watersheds.

Watershed managers often need to answer questions and evaluate options for protecting or restoring the streams, rivers, lakes, reservoirs, or estuaries within their area. EPA's Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* 130) require states to develop a TMDL for pollutants and waters where water quality criteria, as defined in state water quality standards cannot be attained through technology-based effluent limitations on permitted point sources alone. TMDL development places specific requirements to explore the relationship between pollutant loading and receiving water standards. Some of the questions that watershed managers and TMDL developers might need to consider include the following:

- What is the condition of the waterbody? When are standards violated?
- What is the maximum pollutant loading the waterbody can receive and meet standards?
- When does the pollutant loading occur? What type of precipitation event could cause excessive loading? What type of flow condition causes unsuitable in-stream concentrations?
- Where is the pollutant load coming from? What is the distribution of the load between sources?
- Where could management be most effective?
- What will happen if the land use distribution changes?
- What is the effect of hydrologic variability on the watershed loading and receiving water (i.e., stream, lake) conditions?

Some of those questions can be answered through designing and implementing environmental monitoring programs. Monitoring can be used to evaluate the condition of receiving waters and support the estimation of tributary loadings. Monitoring is typically limited by practical and logistical resources to a finite number of stations and limited time frame (i.e., number of storms and duration of sampling period). The judicious use of watershed models can provide a technique for expanding the period of analysis and ability to explore future alternatives.

The design and application of any model must combine a careful consideration of the modeling objectives, the available information, and the scale and scope of the model application. This manual provides a comprehensive description of how to design watershed modeling applications using the LSPC Model within the LSPC modeling framework. The user should always focus on designing individual applications to meet the objectives of the study, and build into the analysis the testing of the results with locally collected monitoring information.

2.2 System Design and Considerations

To support watershed analysis and TMDL development, a watershed modeling system is needed that is technically robust and adaptable to a wide range of watershed and meteorological conditions throughout the country. The system must also support a highly efficient data repository and analysis framework. After reviewing the watershed activities and TMDL program requirements, user experience, and extensive watershed modeling applications, the following major needs and limitations were identified for the system:

- Technical credibility
- Consideration of nonpoint sources and point sources and their unique characteristics

 © 2012 County of Los Angeles. All rights reserved.

- High-resolution, small watershed and complex large watershed modeling capabilities
- Consistency from one region to the next
- Adaptable to a range of regional/meteorological conditions
- Reproducible results
- Ability to export/link externally with receiving water models
- Low system overhead
- Capability for future revisions
- Ease of use

While using LSPC can provide benefits in the form of those listed above, it is important to note that efficient use of the LSPC watershed modeling framework requires at least a basic knowledge of MS Access and an understanding of data management in light of the defined table structures and Structured Query Language (SQL) derived interfacing tools. It is designed to facilitate data management, organization, and modeling for large and complex systems. While it is possible to run LSPC using text files for model input, using a database provides flexibility. For example, one can dynamically query and generate model inputs for specific subsets of a large watershed system during a top-down calibration process. The details of model setup and execution are discussed in later sections.

2.3 EPA TMDL Modeling Toolbox

Watershed and TMDL analyses can include a variety of waterbody types including rivers, streams, lakes, reservoirs, and estuaries. Some waterbodies could have a variety of man-made structures or managed water systems including levees, canals, locks, gates, weirs, and dams. Those structures might affect the hydrologic and hydraulic characteristics of the waterbody and the associated water quality conditions. Watershed management analysis and TMDL development activities often require one or more models to evaluate the various components of the system. EPA Region 4, recognizing this need, sponsored the development of a TMDL Modeling Toolbox that provides a modular system of models designed to address the full range of waterbodies and pollutant types that might need to be addressed (USEPA 2008b). The TMDL Modeling Toolbox is designed using the concept of modules or individual models that can be independently maintained and applied. The toolbox provides a framework and data communication system that facilitates linkages between the various individual models. The toolbox defines linkages through data export/import and exchange protocols. This system of exchange allows users to apply a watershed model and detailed river/lake/estuary water quality model in tandem, passing information from one model to the next. In such a way, the integrity of the individual models is maintained while it facilitates the flexibility to use multiple models to address specific waterbodies types and pollutants. Figure 2-1 provides a generalized schematic of the component models of the toolbox. Table 2-1 describes the key models and assessment resources included in the toolbox.

 © 2012 County of Los Angeles. All rights reserved.

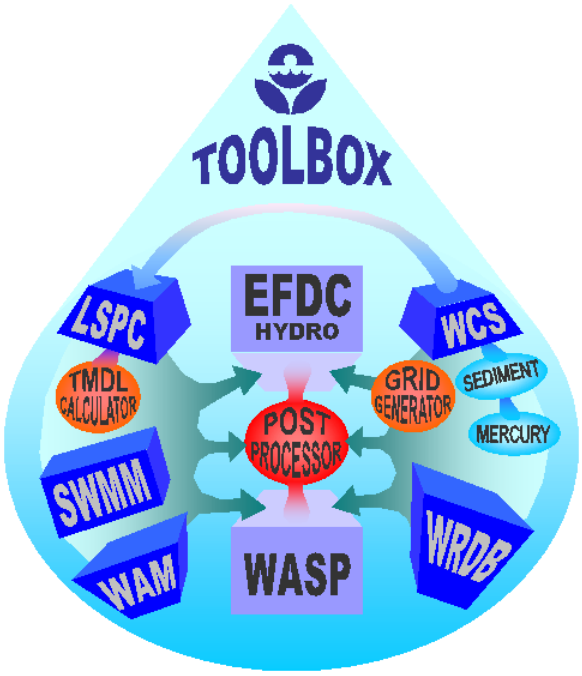


Figure 2-1. Generalized Schematic of Toolbox Components Interactions.

Table 2-1. Highlighted Models and Assessment Resources Available with the TMDL Modeling Toolbox

Toolbox Component	Description
BASINS	Watershed based data management and analysis tool. Using MapWindow, it provides tools for data extraction and exchange with other models.
WAMView	Watershed Assessment Model - A grid-based watershed simulation model that is especially applicable to areas where ground water flow and complex surface depressions predominate, as found in Florida.
LSPC	Watershed modeling system based on EPA supported HSPF model. Provides additional flexibility for data management and simulation of complex watersheds, especially in the case of TMDL development.
SWMM v5.0.014	Rainfall-runoff model, particularly applicable to urban drainage systems.
Grid Generator	An interactive GIS-enabled tool for designing and configuring orthogonal modeling grids for EFDC and WASP.
WASP	Receiving water quality model (1-D, 2-D, and 3-D).
EFDC	Hydrodynamic receiving water model (1-D, 2-D, and 3-D).
WRDB	Data management and analysis system.

The LSPC Model described in this user manual is the primary watershed model serving the EPA TMDL Modeling Toolbox. For further information on the TMDL Modeling Toolbox and future updates, check the following Web site: http://www.epa.gov/athens/wwqtsc/.

2.4 Hardware and Software Requirements

LSPC can be installed and operated on IBM-compatible personal computers (PCs) equipped with the software, random access memory (RAM), virtual memory, and hard disk space presented in Table 2-2. Because the performance (response time) under the minimum requirements option might be too slow for some users, especially when dealing with large data sets, a preferred set of requirements is also included in Table 2-2. The preferred set of requirements also includes suggestions for supporting software that will aid in using the LSPC system.

 © 2012 County of Los Angeles. All rights reserved.

Table 2-2. LSPC Hardware and Software Requirements

Hardware/Software	Minimum Requirements	Preferred Requirements
Processor	Pentium II – 500 MHz	Pentium III or IV processor or better
Hard drive space	Example application: 500 MB (10 MB for LSPC system, 250 MB for desired GIS data, 140 MB for environmental data, and 100 MB of free operational space)	1 GB or more, depending on the size of the model application and the expected output timestep and spatial coverage.
Random Access Memory (RAM)	128 MB	512 MB (run speed increases with RAM)
Compact disc drive	CD-ROM 4X (one time use for system installation)	CD-R/CD-RW (suggested for project backup/archival purposes)
Color monitor	Configured for 16 colors	Configured for at least 256 colors
Operating system	Windows 98, 2000, or NT	Windows 98 or later version
Database software†	Not Required	MS Access 97 or later version
Spreadsheet software‡	Not Required	MS Excel 97 or later version
GIS	Not Required	MapWindow

† MS Access is only required if a user intends to manually modify or customize the database file
‡ MS Excel is required if a user intends to use LSPC-associated calibration spreadsheet tools

2.5 LSPC System Component Interaction

The first thing to learn about the LSPC system is its component interactions. This manual has a section dedicated to each of the components to help a user understand what they are used for and how they fit together. Figure 2-2 provides a schematic of the component interactions; however, it is important to recognize that this schematic highlights only the primary components.

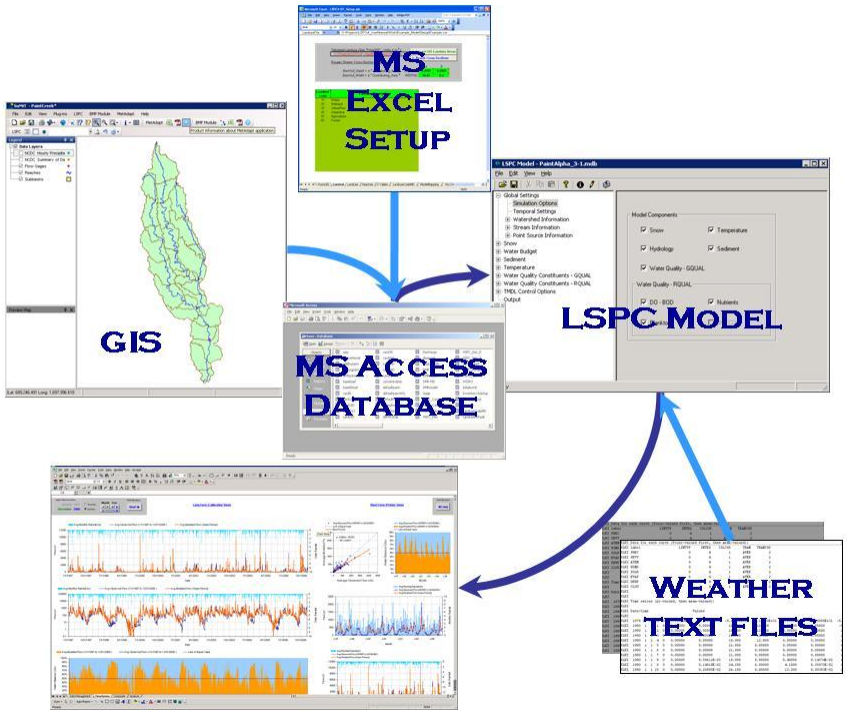


Figure 2-2. LSPC System Component Interactions.

The remainder of this manual describes the various components and shows how each fits together and culminates in the ultimate configuration, calibration, and application of an LSPC Model application. Sections 3 and 4 describe model data preprocessing actions that typically occur within a geographic information system (GIS) environment. GIS is useful for numerous critical input data development as well as general spatial visualization

 © 2012 County of Los Angeles. All rights reserved.

and understanding of the study area. Section 5 describes an intermediate MS Excel spreadsheet that have been created with successive tabs to aid a user in model input development. Once the setup work is complete in the MS Excel file, a user transfers the information into the MS Access database. Section 6 describes in detail the design and organization of the MS Access database file. Because LSPC is a rainfall-runoff model, it requires external ASCII files of weather information. Section 7 describes the general format and data requirements for the ASCII weather files. With the MS Access database populated, a user can either step directly into the LSPC Model (described in Section 9) or use the associated MapWindow GIS application to visualize, select, and launch the LSPC Model for subsets of the entire study area. Once the LSPC Model has been populated with data from a database, a user can save an intermediate model configuration ASCII (*.INP) file, and use it as part of the modeling record for the iterative work of calibration and validation. Those intermediate file(s) can also be opened in LSPC independently of the MS Access database during successive work sessions within the study area(s) of interest. Ultimately, the model process parameters for the final calibrated data set can also be saved back to the MS Access database to complete the information transfer cycle. Finally, executing the LSPC Model creates ASCII output files that the user can readily post-process within a MS Excel environment, for example.

Input for the LSPC model is organized into a series of cards. A connection of the input cards exists between both the LSPC Model interface and the ASCII (*.INP) input file. An understanding of the input cards and their connectivity through the various components becomes more and more familiar and intuitive with repeated use of LSPC. The primary objective of this manual is to help the user understand that connectivity through step-by-step discussion of the model setup and calibration process (Sections 9 and 10).

 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

3 General GIS-Based Resources

A variety of GIS-based resources are available to a user for developing input information to the watershed model. The following sections generally describe some of the basic data sets used to develop watershed model applications along with limited discussion.

3.1 Calibration Stations

Calibration stations are points at which model performance can be evaluated for flow or water quality. The stations could be maintained by federal, state, county, or other authorities. A user should become familiar with the location of stations and respective data records as an initial step in developing a watershed model. That information influences the subbasin delineation, simulation period, calibration period, and more.

3.2 Topography

Topography is used for either manual or automatic processing of watershed characteristics. The coverage is used for average land and reach elevation, slopes, and watershed delineations. Typically the coverage might be grid based with a 30-meter or 10-meter horizontal resolution. The USGS (http://ned.usgs.gov/) is a typical resource for such coverage.

3.3 Stream Reach

Stream reach, or reach, information is used in support of determining lengths, upstream and downstream elevations, subbasin connectivity, and more. The National Hydrography Dataset (http://nhd.usgs.gov/) (NHD) is a typical resource for gathering this coverage. Manual or automated GIS processing can be used to develop reach input information from this coverage.

3.4 Soil

The Hydrologic Soils Group (HSG), categorized as A, B, C, or D, is generally determined from a soils GIS coverage. This evaluation is used to help determine initial default hydrologic parameters assigned to a watershed application. The State Soil Geographic (STATSGO) Database and U.S. General Soil Map (STATSGO2) Database (http://soils.usda.gov/survey/geography/statsgo/) are generally more readily available and more coarse in spatial resolution. The Soil Survey Geographic (SSURGO) Database (http://soils.usda.gov/survey/geography/ssurgo/) is typically preferred if available for a subject study area.

3.5 Point Sources

Developing point source discharge information (particularly in urban areas) is usually a substantial task. Among the challenges are gathering information, verifying it, re-processing a variety of raw formats, and manipulating it to the desired input format. Sources for this discharge information could be the EPA PCS (http://www.epa.gov/enviro/html/pcs/pcs_query_java.html or http://www.epa-echo.gov/echo/compliance_report_water.html), state agencies, and dischargers. Note that LSPC locates all point sources within a given subbasin at the upstream end of the reach. Users should be aware of that when performing subbasin delineations.

3.6 Land Use

Land use information is important for hydrologic and water quality parameters, delineations, and more. Generally a source of land use is used and its categories are combined to model land units to be more manageable in the watershed application. A typical source for land use is the National Land Cover Data (http://www.epa.gov/mrlc/nlcd-2006.html). However, there might be state or local coverages that could serve the user's study area more appropriately.

 © 2012 County of Los Angeles. All rights reserved.

3.7 Withdrawals

Water withdrawal information, for example water for drinking or irrigation, can also be included in a watershed application. Note that they would be input as a point source with a negative flow and that they would be assigned a spatial location in the model at the headwater of the reach for the subbasin in which they are defined.

3.8 303(d) Listings

GIS coverages of 303(d) listings are typically readily obtainable or easily created. This information would be critical if the watershed application were to consider TMDLs.

3.9 Subbasins

Subbasin delineation is an important step and generally a time-intensive task. It is usually performed after the majority of other GIS coverages have been obtained, reviewed, and processed for a subject study area. The delineations must be performed with attention to connectivity, subbasin sizing, calibration station locations, and other important relevant considerations. Typically, the starting point for delineations is the 12-digit hydrologic unit code (HUC) (http://datagateway.nrcs.usda.gov/, http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/).

3.9.1 Numbering Convention

Numerous approaches exist for numbering the subbasin delineations. The following is one suggestion. For this discussion, it is assumed that there will be a couple hundred subbasins after delineation is complete. Begin by labeling the most downstream subbasin as 101, ensuring that all subbasins will be of three-character format. Looking upstream, start with the leftmost subbasin and number it 102. Then from the perspective of subbasin 102, again looking upstream, number the leftmost upstream subbasin 103. If there is another subbasin draining into 102, label it 104. Then back up, or move downstream, until the next subbasin to be labeled is found. Note that the subbasin IDs must be numeric.

3.10 MapWindow

The LSPC Model can be launched from the MapWindow environment. Section 8 presents step-by-step use of MapWindow for an LSPC Model application.

 © 2012 County of Los Angeles. All rights reserved.

4 GIS Processing for an LSPC Application

Chapter 3 presents general discussion on which GIS coverages are typically involved in building an LSPC application. This chapter provides more focused guidance regarding what is necessary in processing information to a format required for input to an LSPC application.

4.1 Subbasin Delineation

A variety of options (manual and automatic) are available to perform delineations across the various GIS platforms. Once a user has completed their initial discovery and gathering of the GIS coverages, they can begin making delineations. Manual delineation entails tracing ridge lines of a topographic coverage with other considerations. The other considerations can include the location of the calibrations stations (flow and water quality), point sources discharges, withdrawals, land use change, and/or other significant feature change. After the delineations are complete, the field <Subbasin> needs to be added to the attribute table as a numeric field. Then the user should populate the <Subbasin> field according to the adopted numbering convention.

4.2 Stream Reach

LSPC requires one representative reach for each subbasin. Typically, the NHD is used as a starting point. A mainstem reach is determined for each subbasin, and the remaining reach segments are deleted from the coverage. We can use a variety of ways to geoprocess the coverage. Generally, the processed reach coverage should be one continuous segment per subbasin, which could require clipping or joining or both. Once completed, the processed reach coverage should have the numeric field <Subbasin> added to its attribute table. Then a user should label the reaches with the ID of the respective host subbasin. That is, reach 101 belongs to subbasin 101.

4.3 Hydrologic Response Units

LSPC uses hydrologic response units (HRUs) in the model environment, which are flexible to customization. A users can choose to blend combinations of the following sections into their HRUs or leave them separate. Appendix A provides a detailed example of customized HRUs. Table 4-1 presents a hypothetical simplified example of HRUs, while the various components listed in the columns are discussed in the following sections.

Table 4-1. Hypothetical Examples of HRUs

Land Use	Imperviousness	Land Slope	HSG
Forest	Pervious	> 10%	B
Forest	Pervious	0–10%	B
Residential	Impervious	0–10%	Not Applicable
Residential	Pervious	0–10%	C

4.3.1 Land Use

Generally the GIS coverage for land use is grid based. Therefore, a comma-delimited ASCII table can be generated in which the columns are the land use numeric categories (or HRU numeric categories), and the rows are the subbasin IDs (Figure 4-1). Alternatively, iterative geoprocessing can occur with consideration of the following sections if the user wants more customized HRUs. After the selected processing, the information needs to be placed in a comma-delimited ASCII file to work with the MS Excel LSPC setup utility. However, there are alternative ways that the land use (HRUs) can be processed for input into the MS Access database file.

 © 2012 County of Los Angeles. All rights reserved.

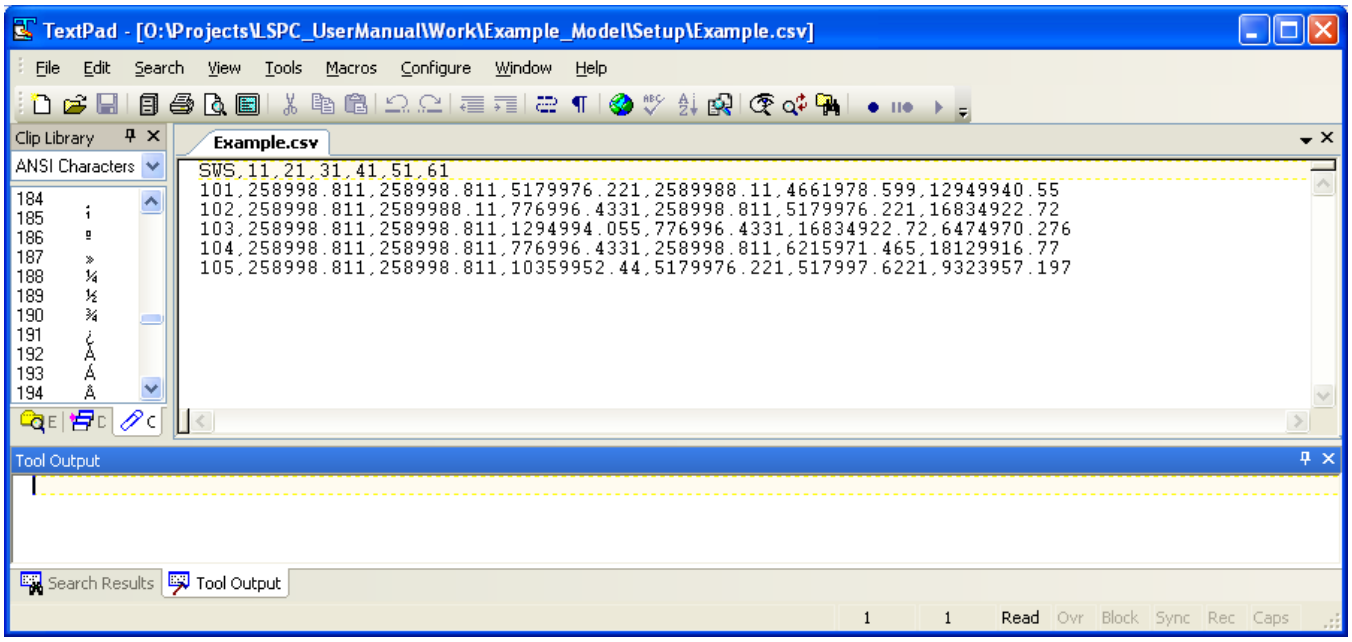


Figure 4-1. Example of ASCII File from GIS Land Use Export.

4.3.2 Imperviousness

LSPC simulates directly connected impervious area, not total impervious area. If a GIS coverage of impervious surfaces is available for a study area, it can be geoprocessed along with the land use to help break out the directly connected impervious and pervious land. Sutherland (1995) provided guidance on the directly connected fraction based of urban intensity. If an impervious GIS coverage is not available, the user could consult metadata from the source land use GIS coverage or resources such as TR-55 (NRCS 2002) to help determine estimates to assign for a project.

4.3.3 Land Slope

Subbasin land slopes affect the time it takes for overland runoff to contribute to a reach. It is the slope of a land use plane which drains to the reach network. This is a difficult parameter to geoprocess, along with length of the overland flow. Generally, a separation could be made of steep versus moderate slopes, which can then be used to define HRUs. Such a consideration can be broken out separately, or it can be included in the determination of the HRUs.

4.3.4 Soils

The HSGs are typically identified as A, B, C, or D and reflect infiltration capacities. These are generally determined as one value per modeled subbasin. They can also be included in the development of HRUs.

4.4 Weather Stations

The weather station coverage should be overlayed to the subbasin coverage. A user then assigns weather stations to each subbasin using geoprocessing tools (for example Thiessen polygons) or can create a printed copy. Furthermore, orographic effects should be taken into account, that is the influence of topographic variations. If available, the use of annual average precipitation coverages can support the weather station assignments.

 © 2012 County of Los Angeles. All rights reserved.

5 MS Excel Setup Tool

The setup spreadsheet provided with LSPC, is a tool designed to help populate the LSPC MS Access database. As the user steps through the process of setting an LSPC project, he or she fills out various parts of the spreadsheet. The user then runs two macros, and the spreadsheet generates most of the necessary tables that are input into the MS Access database.

The spreadsheet is set up with a color-coded system. The user fills out cells or columns that are highlighted in green. Any cells or columns that are highlighted in red are automatically filled out with macro execution. The spreadsheet has a pop-up help feature. By moving the mouse cursor over certain cells, a description of information in that cell or column pops up. The only requirement to operate the spreadsheet is that the user has created a comma-delimited file that contains areas tabulated for each land use (or HRU) within each subbasin. To create this file, see Section 4.3.1. Several graphics are in the spreadsheet that help to visually define various concepts such as channel cross section. The spreadsheet consists of 17 tabs; which are briefly described in the following sections. The order of the following sections is intended to be a recommendation to the user for the order in which to complete the spreadsheet.

5.1 Tabs FromGIS, Control, Landuse, and Reaches

The FromGIS tab is a scratch location where the land use (or HRU) comma-delimited ASCII file is written, a user does not have to work with this tab.

The Control tab (Figure 5-1) is important and first requires that the user populate the land use or HRU codes and corresponding descriptions exactly as the land use (or HRUs) in the comma-delimited ASCII file. This tab also provides user input to describe channel input dimensions which will be used in a cumulative upstream area calculation to determine channel geometry. The user could revise the bankfull depth and width parameters if desired, on the basis of regressions to field observations. Later, the information could be revised if F-Tables were available from other sources.

 © 2012 County of Los Angeles. All rights reserved.

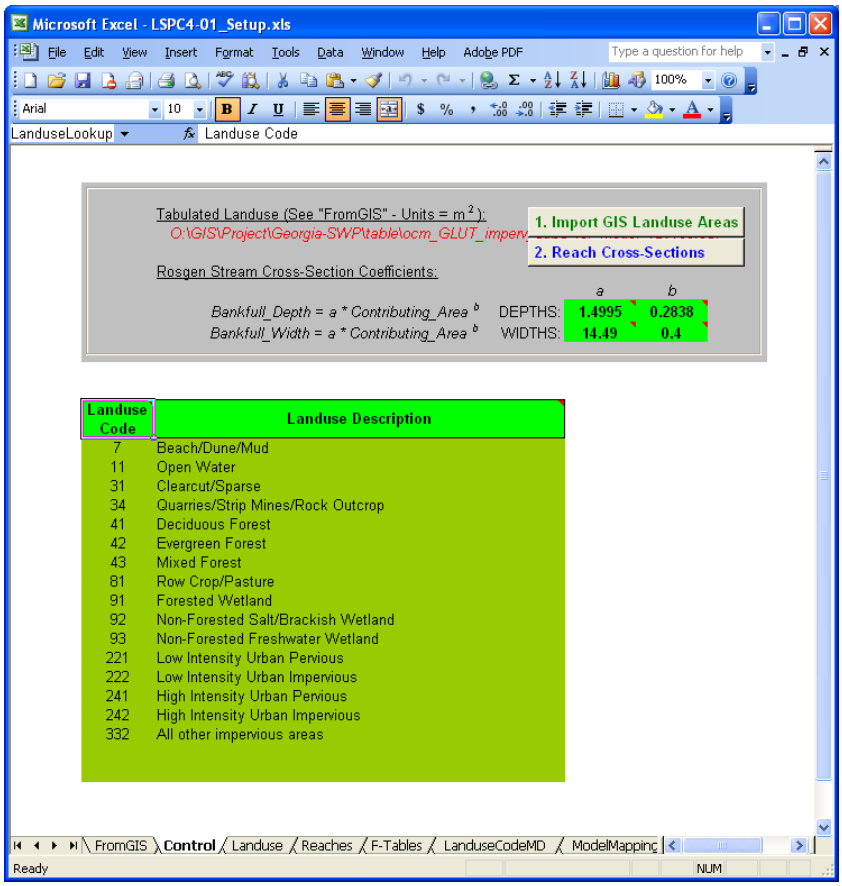
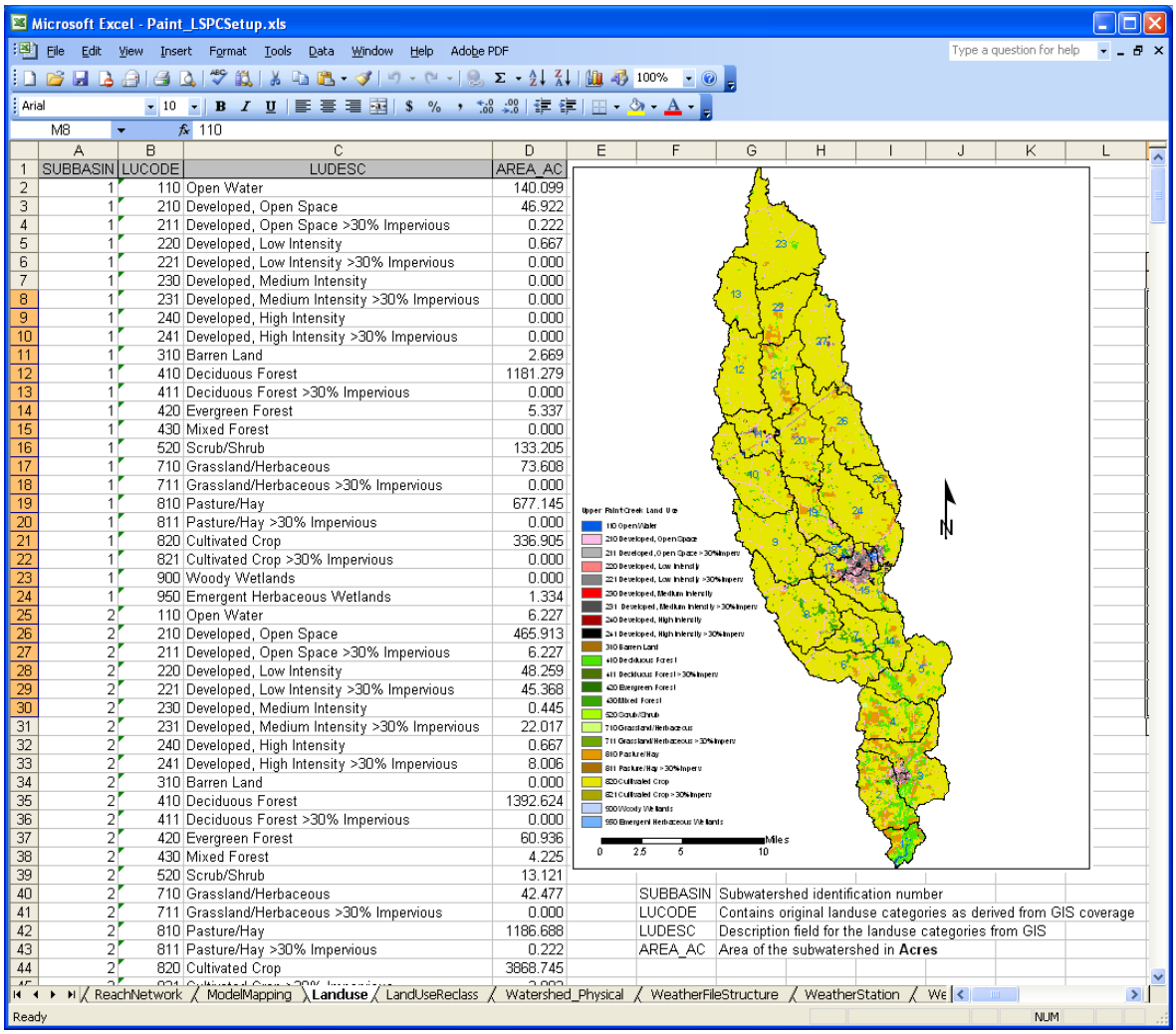


Figure 5-1. The Control Tab of the MS Excel Setup Tool.

The user can now click the Import GIS Landuse Areas button. A user can click *yes* in the pop-up dialog box if he or she wishes to have any previous entries in the Reaches tab to be deleted. Next, the user should navigate to the land use (or HRUs) in the comma-delimited ASCII file. It is suggested to place this in the same folder with the MS Excel setup tool. Figure 5-2 shows the Landuse tab of the MS Excel Setup Tool, the image shown in Figure 5-2 is not generated, it was provided for illustrative purposes.

A user must already have the connectivity, the relationship of upstream to downstream subbasins, established for the study area and should now populate the Downstream Reach Segment column in the Reaches tab (Figure 5-3). However, the Downstream Reach Segment column still needs to be ordered by The Reach Segment column, this can be achieved in a separate scratch MS Excel file. Note that –1 is used to indicate an exit (most downstream) subbasin. The user is ready to select the Reach Cross-Section button, on the Control tab, which populates the entire Landuse tab and most of the Reaches tab. Last, the user must go to the Reaches tab and populate the columns Length (m), Downstream Elevation (m), and Upstream Elevation (m) which are typically generated during geoprocessing.

 © 2012 County of Los Angeles. All rights reserved.

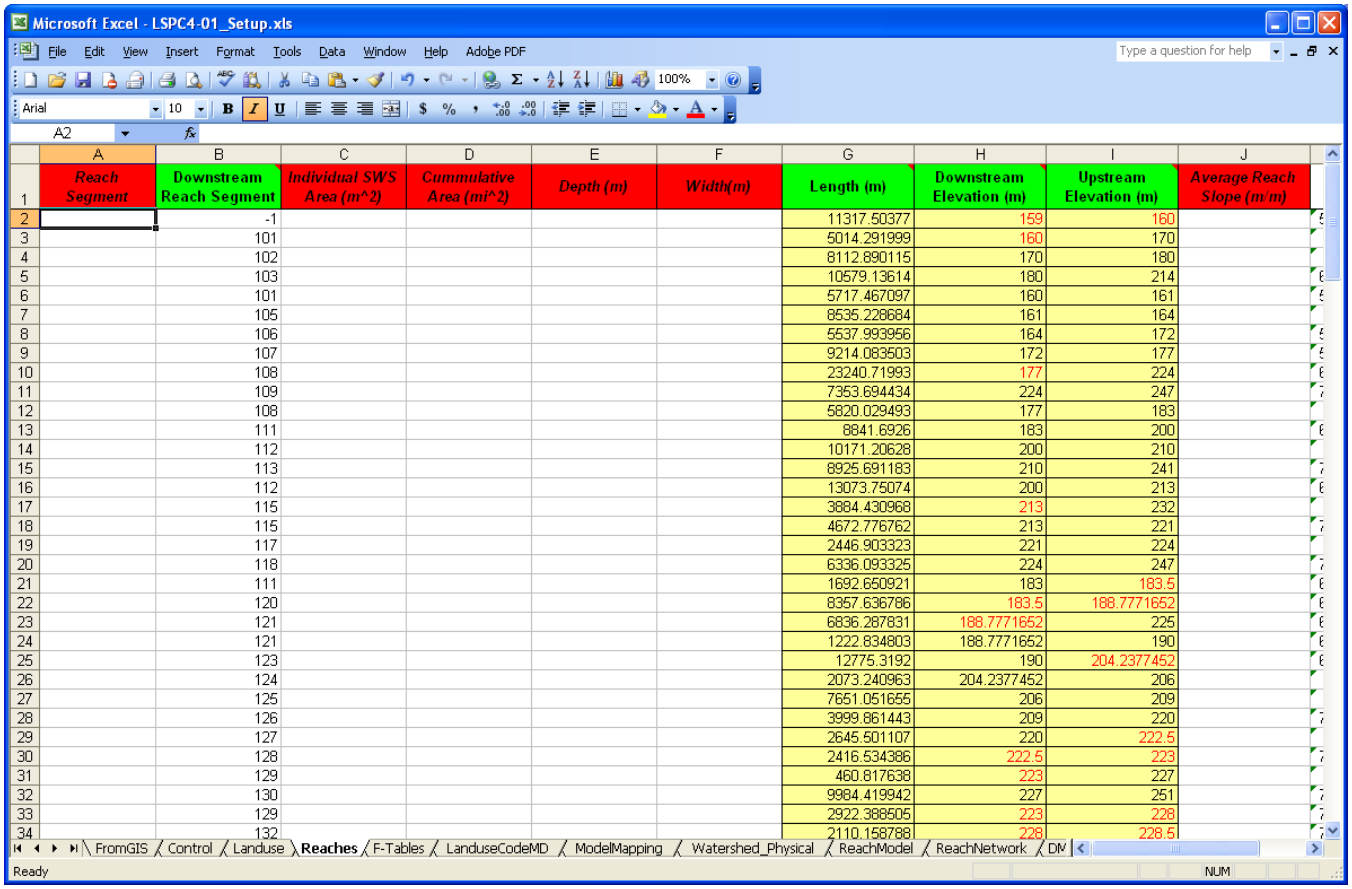


SUBBASIN	LUCODE	LUDESC	AREA_AC
1	110	Open Water	140.099
1	210	Developed, Open Space	46.922
1	211	Developed, Open Space >30% Impervious	0.222
1	220	Developed, Low Intensity	0.667
1	221	Developed, Low Intensity >30% Impervious	0.000
1	230	Developed, Medium Intensity	0.000
1	231	Developed, Medium Intensity >30% Impervious	0.000
1	240	Developed, High Intensity	0.000
1	241	Developed, High Intensity >30% Impervious	0.000
1	310	Barren Land	2.669
1	410	Deciduous Forest	1181.279
1	411	Deciduous Forest >30% Impervious	0.000
1	420	Evergreen Forest	5.337
1	430	Mixed Forest	0.000
1	520	Scrub/Shrub	133.205
1	710	Grassland/Herbaceous	73.608
1	711	Grassland/Herbaceous >30% Impervious	0.000
1	810	Pasture/Hay	677.145
1	811	Pasture/Hay >30% Impervious	0.000
1	820	Cultivated Crop	336.905
1	821	Cultivated Crop >30% Impervious	0.000
1	900	Woody Wetlands	0.000
1	950	Emergent Herbaceous Wetlands	1.334
2	110	Open Water	6.227
2	210	Developed, Open Space	465.913
2	211	Developed, Open Space >30% Impervious	6.227
2	220	Developed, Low Intensity	48.259
2	221	Developed, Low Intensity >30% Impervious	45.368
2	230	Developed, Medium Intensity	0.445
2	231	Developed, Medium Intensity >30% Impervious	22.017
2	240	Developed, High Intensity	0.667
2	241	Developed, High Intensity >30% Impervious	8.006
2	310	Barren Land	0.000
2	410	Deciduous Forest	1392.624
2	411	Deciduous Forest >30% Impervious	0.000
2	420	Evergreen Forest	60.936
2	430	Mixed Forest	4.225
2	520	Scrub/Shrub	13.121
2	710	Grassland/Herbaceous	42.477
2	711	Grassland/Herbaceous >30% Impervious	0.000
2	810	Pasture/Hay	1186.688
2	811	Pasture/Hay >30% Impervious	0.222
2	820	Cultivated Crop	3868.745

SUBBASIN	Subwatershed identification number
LUCODE	Contains original landuse categories as derived from GIS coverage
LUDESC	Description field for the landuse categories from GIS
AREA_AC	Area of the subwatershed in **Acres**

Figure 5-2. The Landuse Tab of the MS Excel Setup Tool.

 © 2012 County of Los Angeles. All rights reserved.



Microsoft Excel - LSPC4-01_Setup.xls

	A	B	C	D	E	F	G	H	I	J
1	Reach Segment	Downstream Reach Segment	Individual SWS Area (m^2)	Cummulative Area (mi^2)	Depth (m)	Width(m)	Length (m)	Downstream Elevation (m)	Upstream Elevation (m)	Average Reach Slope (m/m)
2		-1					11317.50377	159	160	
3		101					5014.291999	160	170	
4		102					8112.890115	170	180	
5		103					10579.13614	180	214	
6		101					5717.467097	160	161	
7		105					8535.228684	161	164	
8		106					5537.993956	164	172	
9		107					9214.083503	172	177	
10		108					23240.71993	177	224	
11		109					7353.694434	224	247	
12		108					5820.029493	177	183	
13		111					8841.6926	183	200	
14		112					10171.20628	200	210	
15		113					8925.691183	210	241	
16		112					13073.75074	200	213	
17		115					3884.430968	213	232	
18		115					4672.776762	213	221	
19		117					2446.903323	221	224	
20		118					6336.093325	224	247	
21		111					1692.650921	183	183.5	
22		120					8357.636786	183.5	188.7771652	
23		121					6836.287831	188.7771652	225	
24		121					1222.834803	188.7771652	190	
25		123					12775.3192	190	204.2377452	
26		124					2073.240963	204.2377452	206	
27		125					7651.051655	206	209	
28		126					3999.861443	209	220	
29		127					2645.501107	220	222.5	
30		128					2416.534386	222.5	223	
31		129					460.817638	223	227	
32		130					9984.419942	227	251	
33		129					2922.388505	223	228	
34		132					2110.158788	228	228.5	

FromGIS | Control | Landuse | Reaches | F-Tables | LanduseCodeMD | ModelMapping | Watershed_Physical | ReachModel | ReachNetwork | DM

Ready NUM

Figure 5-3. The Reaches Tab of the MS Excel Setup Tool.

5.2 Tabs F-Tables, LanduseCodeMD, ModelMapping, and Watershed_Physical

Stream reaches can be described by function tables (F-Table). They contain information such as relationships among depth, discharge, volume and surface area in a reach. A user can enter the detailed reach information in the F-Table tab at his or her discretion.

The LanduseCodeMD tab links and reduces the information in the comma-delimited ASCII file into modeling units. First, here is a brief description of the fields.

- DELUID. The ID assigned to the model land unit used by LSPC.
- DELUNAME. The name of the model land unit used by LSPC.
- LUCODE. The source ID from the comma-delimited ASCII text file from either just the land use coverage or from the geoprocessed HRU coverage.
- LUDESC. The source name associated with the comma-delimited ASCII text file from either just the land use coverage or from the geoprocessed HRU coverage.
- LU_PCT. Indicates the percentage of the source land use or HRU (LUCODE) that is assigned to the model land unit (DELUID) used by LSPC, assigned as zero to one.
- PERIMP. Indicates either impervious (1) or pervious (2).

A user can employ various approaches for this step; two are discussed for illustration. A more simplified example is presented in Figure 5-4. Source land use codes (LUCODE) 41 and 42 are combined into model land unit 8 (DELUID). One hundred percent (LU_PCT = 1) of each of those source land uses are combined into the model land unit. They were each assigned as completely pervious (PERIMP = 2). The single source low intensity urban (LUCODE = 22) land use was broken out here into two model land units (DELUID 3 and 4). It was assumed that 90 percent (LU_PCT = 0.9) was pervious (PERIMP = 2) and the remaining 10 percent (LU_PCT = 0.1) was connected impervious (PERIMP = 1).

 © 2012 County of Los Angeles. All rights reserved.

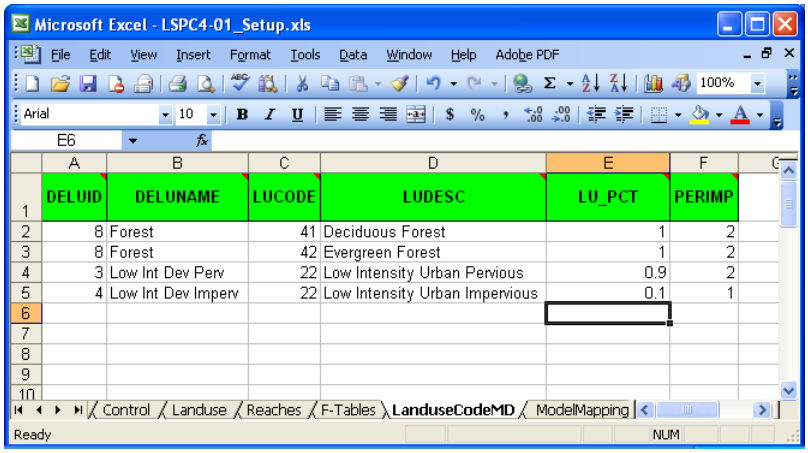


Figure 5-4. A Typical Example of the LanduseCodeMD Tab.

The following example illustrates the concept of HRUs. There is no difference in how the source forest (LUCODE 41 and 42) are reduced to model land units. However, the source low-intensity urban component reflects the concept of HRU. That is, during the development period, the land use coverage and the imperviousness coverage were geoprocessed to create one grid that was then cookie-cut by the subbasin delineations. Therefore HRUs were created that captured the consideration of impervious areas. Because this work (Figure 5-5) was done before creating the comma-delimited ASCII file, the HRU (LUCODE = 221) for low-intensity, urban-only contains pervious area; thus, 100 percent (LU_PCT = 1) of it is a pervious (PERIMP = 2) modeling unit. Likewise, the HRU (LUCODE = 222) for low-intensity, urban-only contains impervious area; thus, 100 percent (LU_PCT = 1) of it is an impervious (PERIMP = 1) model land unit.

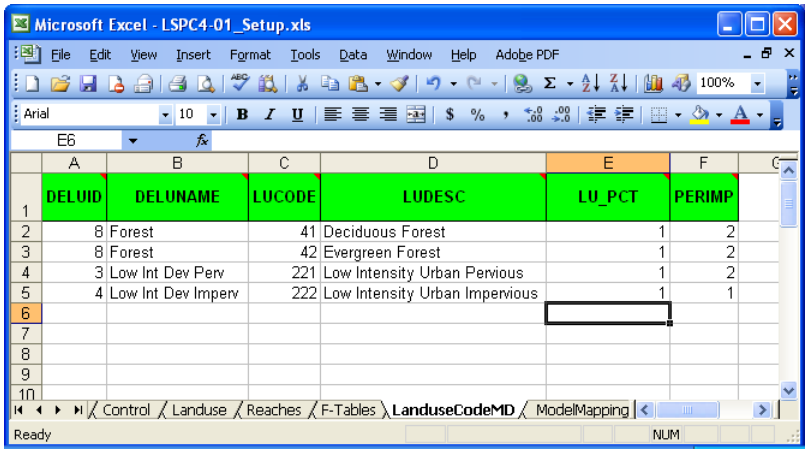


Figure 5-5. Example of HRU for the LanduseCodeMD Tab.

The ModelMapping tab in the classic sense is used to define which HSG is characteristic of a given subbasin. This definition creates default parameters for hydrology and water quality within the LSPC project. But it is not limited to the standard four categories of A, B, C, and D. A user can define more than four as warranted for a study area. Recall too that a user could choose to roll the HSG into the definition of HRU.

The Watershed_Physical tab is populated by the user with respect to the model land units (DELUID). For each subbasin and model land unit combination a user needs to populate the following:

- SLSUR. Overland flow slope which might or might not be assigned for each subbasin-model land unit combination.
- LSUR. Length (feet) of overland flow to stream which might or might not be assigned for each subbasin-model land unit combination. A typical value could be used or unique values could be determined from geoprocessing.

 © 2012 County of Los Angeles. All rights reserved.

- MELEV. Mean elevation of the model land unit in feet. This might or might not be assigned for each subbasin-model land unit combination.
- RMELEV. Mean reach elevation in feet. Typically it is the average of the upstream and downstream reach elevations.

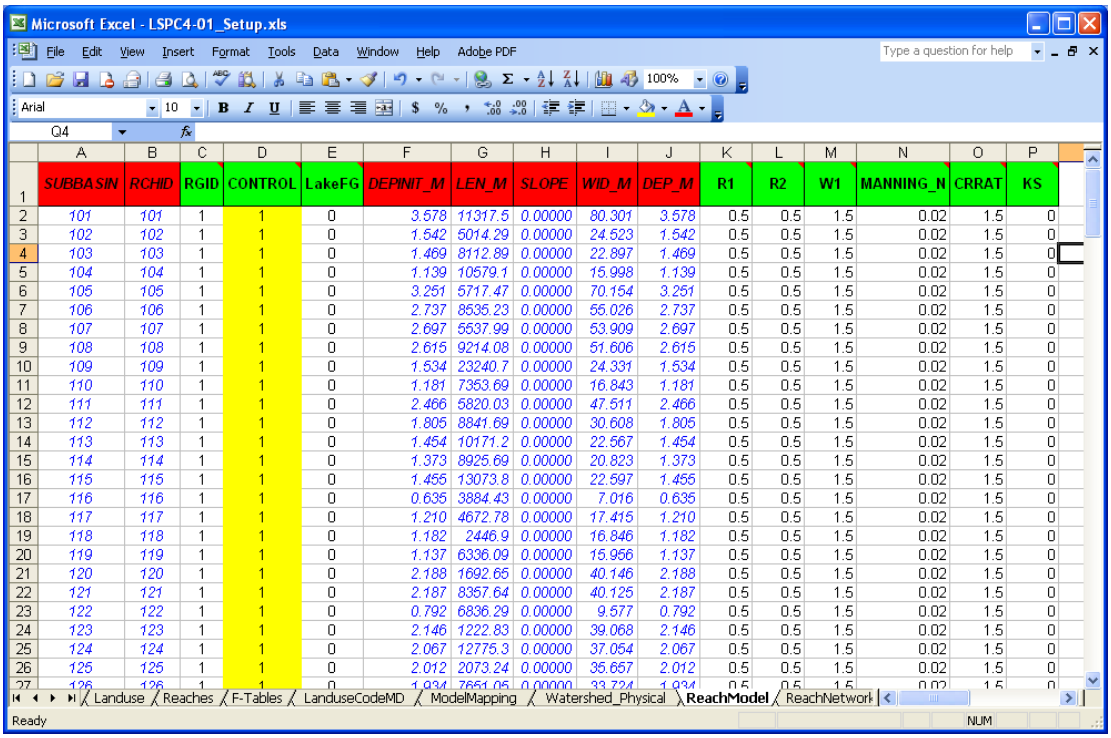
The MELEV and RMELEV are important only when a user is executing a model that includes temperature simulation. In such cases the air temperature reported at a weather station is corrected for elevation differences.

5.3 Tabs ReachModel and ReachNetwork

Portions of the ReachModel tab (Figure 5-6) are completed when a user executes the macro on the Control tab. The user should hover the mouse pointer over the red column headings and review the popup messages, which, combined with the column label provides sufficient understanding. The entries a user must populate are discussed below.

- RGID. The reach group ID for reaches with similar in-stream process parameters, such as rate constants and kinetics
- CONTROL. A value of 1 means that an output file for this subbasin/reach is created, and a value of 0 means that no output is written. It is recommended, particularly during the initial construction and execution of an application, that a user turn output off for the majority of the subbasins. Turn on output for the limited number of subbasins where comparison to observations is desired. This allows for shorter run times during the preliminary model executions which are primarily aimed at debugging.
- LakeFG.
    - 0 = Segment is a reach segment.
    - 1 = Segment is a lake with rectangular weir overflow.
    - 2 = Segment is a lake with triangular weir overflow.
- R1. The factor that is multiplied by the bankfull width to determine the bottom channel width. The default value is 0.2. See Figure 5-7. If the reach is a lake, R1 is the height from the lake bottom to the center of the orifice.
- R2. The slope of the sides of the overflow channel. The default value is 0.5. See Figure 5-7.
- W1. The factor that is multiplied by the bankfull width to determine the width of the floodplain. The default value is 1.5. See Figure 5-7.
- MANNING_N. The Manning's roughness value, *n*.
- CRRAT. The ratio of maximum velocity to mean velocity in the RCHRES cross-section under typical flow conditions. The default value is 1.5.
- KS. The weighting factor for hydraulic routing (calibration). The default is zero. LSPC should be used with this set to zero.

 © 2012 County of Los Angeles. All rights reserved.



Microsoft Excel - LSPC4-01_Setup.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	SUBBASIN	RCHID	RGID	CONTROL	LakeFG	DEPINIT_M	LEN_M	SLOPE	WID_M	DEP_M	R1	R2	W1	MANNING_N	CRRAT	KS
2	101	101	1	1	0	3.578	11317.5	0.00000	80.301	3.578	0.5	0.5	1.5	0.02	1.5	0
3	102	102	1	1	0	1.542	5014.29	0.00000	24.523	1.542	0.5	0.5	1.5	0.02	1.5	0
4	103	103	1	1	0	1.469	8112.89	0.00000	22.897	1.469	0.5	0.5	1.5	0.02	1.5	0
5	104	104	1	1	0	1.139	10579.1	0.00000	15.998	1.139	0.5	0.5	1.5	0.02	1.5	0
6	105	105	1	1	0	3.251	5717.47	0.00000	70.154	3.251	0.5	0.5	1.5	0.02	1.5	0
7	106	106	1	1	0	2.737	8535.23	0.00000	55.026	2.737	0.5	0.5	1.5	0.02	1.5	0
8	107	107	1	1	0	2.697	5537.99	0.00000	53.909	2.697	0.5	0.5	1.5	0.02	1.5	0
9	108	108	1	1	0	2.615	9214.08	0.00000	51.606	2.615	0.5	0.5	1.5	0.02	1.5	0
10	109	109	1	1	0	1.534	23240.7	0.00000	24.331	1.534	0.5	0.5	1.5	0.02	1.5	0
11	110	110	1	1	0	1.181	7353.69	0.00000	16.843	1.181	0.5	0.5	1.5	0.02	1.5	0
12	111	111	1	1	0	2.466	5820.03	0.00000	47.511	2.466	0.5	0.5	1.5	0.02	1.5	0
13	112	112	1	1	0	1.805	8841.69	0.00000	30.608	1.805	0.5	0.5	1.5	0.02	1.5	0
14	113	113	1	1	0	1.454	10171.2	0.00000	22.567	1.454	0.5	0.5	1.5	0.02	1.5	0
15	114	114	1	1	0	1.373	8925.69	0.00000	20.823	1.373	0.5	0.5	1.5	0.02	1.5	0
16	115	115	1	1	0	1.455	13073.8	0.00000	22.597	1.455	0.5	0.5	1.5	0.02	1.5	0
17	116	116	1	1	0	0.635	3884.43	0.00000	7.016	0.635	0.5	0.5	1.5	0.02	1.5	0
18	117	117	1	1	0	1.210	4672.78	0.00000	17.415	1.210	0.5	0.5	1.5	0.02	1.5	0
19	118	118	1	1	0	1.182	2446.9	0.00000	16.846	1.182	0.5	0.5	1.5	0.02	1.5	0
20	119	119	1	1	0	1.137	6336.09	0.00000	15.956	1.137	0.5	0.5	1.5	0.02	1.5	0
21	120	120	1	1	0	2.188	1692.65	0.00000	40.146	2.188	0.5	0.5	1.5	0.02	1.5	0
22	121	121	1	1	0	2.187	8357.64	0.00000	40.125	2.187	0.5	0.5	1.5	0.02	1.5	0
23	122	122	1	1	0	0.792	6836.29	0.00000	9.577	0.792	0.5	0.5	1.5	0.02	1.5	0
24	123	123	1	1	0	2.146	1222.83	0.00000	39.068	2.146	0.5	0.5	1.5	0.02	1.5	0
25	124	124	1	1	0	2.067	12775.3	0.00000	37.054	2.067	0.5	0.5	1.5	0.02	1.5	0
26	125	125	1	1	0	2.012	2073.24	0.00000	35.657	2.012	0.5	0.5	1.5	0.02	1.5	0

Landuse | Reaches | F-Tables | LanduseCodeMD | ModelMapping | Watershed_Physical | ReachModel | ReachNetwork

Ready

Figure 5-6. The ReachModel tab.

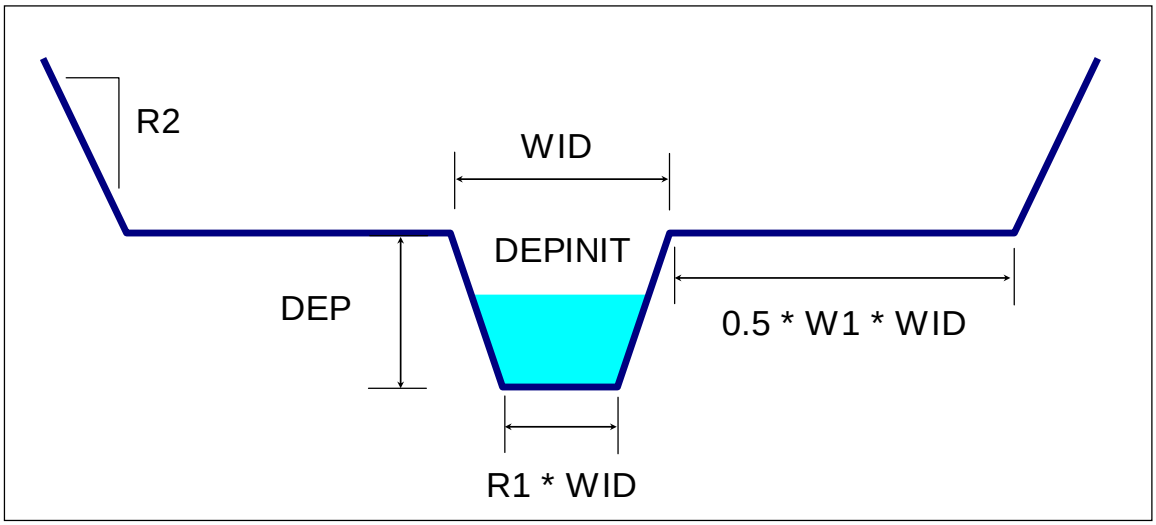


Figure 5-7. General Cross Section.

The ReachNetwork tab is available for when a user constructs an application with the use of F-Tables. Then, the user can set the number of outlets per subbasin to reflect the F-Tables. Otherwise, this tab should be developed with the Outlet column set to 1.

5.4 Tab DMR

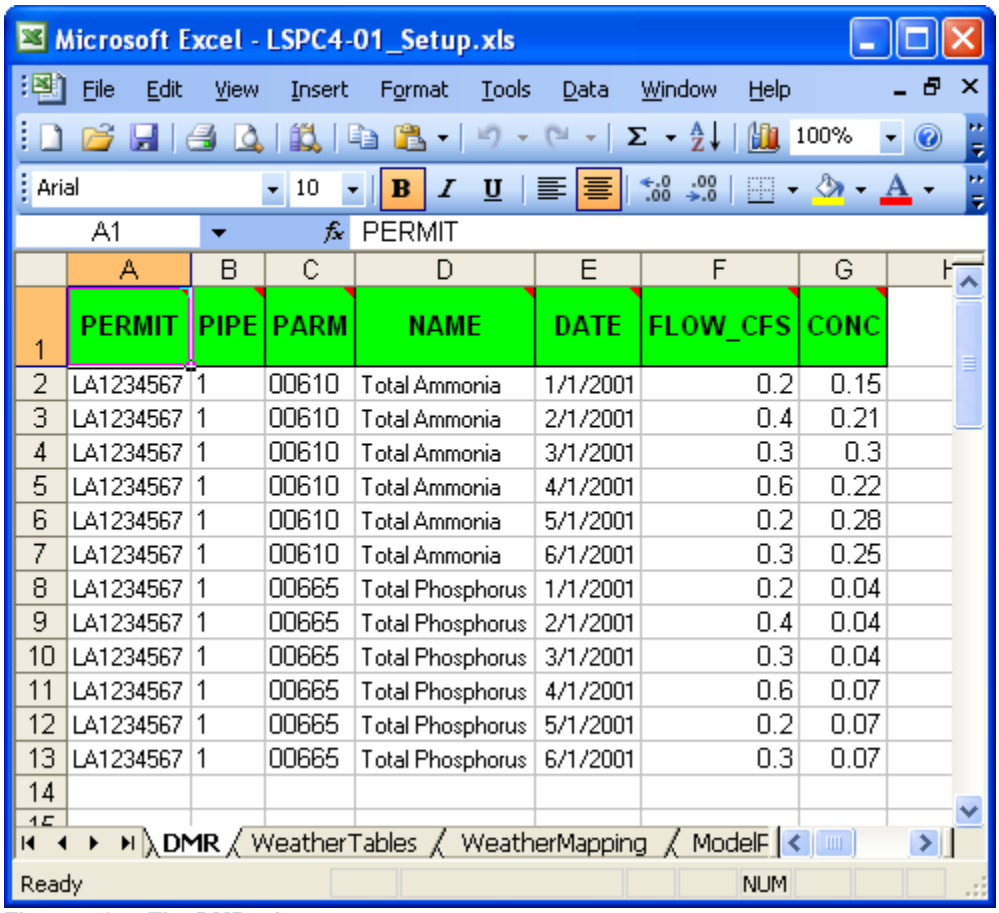
DMR stands for Discharge Monitoring Report—a term common to the National Pollutant Discharge Elimination System (NPDES). The DMR tab is available to assist in processing point source information. However, it is not the only means for a user to process point source information. It is available here because a similar table exists in the MS Access database and is linked to a macro that converts the information into the require format and table. This is further discussed in a later section. The columns on the DMR tab are described as follows.

- PERMIT. Typically the NPDES ID for a discharger, but it can be any alphanumeric ID.

 © 2012 County of Los Angeles. All rights reserved.

- PIPE. The outfall designation for a discharger. This field allows for the possibility of more than one outfall for a discharger. This is also alphanumeric.
- PARM. The typical convention is to use the STORET parmeter code. PARM values associated with point source discharges should be present in the MS Access database ModelPARM table (when simulating GQUAL) or MS Access database OtherPointSourcePARM table (when simulating sediment, temperature, DO, or RQUAL). It is important that this value be consistent with the PARM filed from the ModelPARM tab and the PARM field from OtherPointSourcePARM tab.
- NAME. The parameter name that corresponds to the parameter code, typically following STORET.
- DATE. The date for a given record. Note: To represent a constant point source, include two records with both start and end dates and repeated flow and concentration values.
- FLOW_CFS. The flow in cubic feet per second (cfs) associated with this record. Flow must *always* be specified for every point source concentration entry.
- CONC. The concentration for the discharge. This should be expressed as typically milligrams per liter (mg/L) for most constituents, #/100 mL for bacteria, or degrees Celsius (°C) for water temperature.

It is important to note that an entry must be made for each constituent a user selects for a discharger. If flow and ammonia are reported monthly and total phosphorus is reported quarterly, a user must make entries for total phosphorus for each month to be temporally consistent with flow and ammonia. Flow values are repeated on each record for the same date for each of the constituents. Figure 5-8 illustrates this example. Note that the quarterly values of total phosphorus (assumed at January and April) are repeated for the remaining months until the next reported value. Also, note that the six flow values for the same dates are equal for each total ammonia and total phosphorus. The DMR tab can also be used for representing withdrawals. A withdrawal is represented the same way as a point source inflow; however, the flow values (cfs) should be negative. For more information, see Section 6.3.



	A	B	C	D	E	F	G
1	PERMIT	PIPE	PARM	NAME	DATE	FLOW_CFS	CONC
2	LA1234567	1	00610	Total Ammonia	1/1/2001	0.2	0.15
3	LA1234567	1	00610	Total Ammonia	2/1/2001	0.4	0.21
4	LA1234567	1	00610	Total Ammonia	3/1/2001	0.3	0.3
5	LA1234567	1	00610	Total Ammonia	4/1/2001	0.6	0.22
6	LA1234567	1	00610	Total Ammonia	5/1/2001	0.2	0.28
7	LA1234567	1	00610	Total Ammonia	6/1/2001	0.3	0.25
8	LA1234567	1	00665	Total Phosphorus	1/1/2001	0.2	0.04
9	LA1234567	1	00665	Total Phosphorus	2/1/2001	0.4	0.04
10	LA1234567	1	00665	Total Phosphorus	3/1/2001	0.3	0.04
11	LA1234567	1	00665	Total Phosphorus	4/1/2001	0.6	0.07
12	LA1234567	1	00665	Total Phosphorus	5/1/2001	0.2	0.07
13	LA1234567	1	00665	Total Phosphorus	6/1/2001	0.3	0.07
14							

Figure 5-8. The DMR tab.

 © 2012 County of Los Angeles. All rights reserved.

5.5 Tabs WeatherTables and WeatherMapping

The WeatherTables tab is used as setup for four tables in the MS Access database. Those four tables are summarized below.

WeatherFilenames

- WFILEID. The model ID number of the weather file used by LSPC. That is, 1, 2, 3, and so on.
- FILENAME. The actual file name of a weather file. Multiple weather files (each with separate parameter components) can be combined to define a weather set. The weather file name must be a continuous string. Do not use spaces in the file name.
- WFILETYPE. The weather file type ID. Further definition of the weather file type ID is completed on table WeatherFileStructure.

WeatherFileStructure

- WFILETYPE. The ID for the weather file type. It should be repeated according to the number of expected columns in the associated file for each file type. A WFILETYPE of 1 could mean all seven WPARMIDs are included, and a WFILETYPE of 2 could mean that only the first two WPARMIDs are included in a respective weather file. A user prescribes this value and the associated weather constituents primarily on the basis of minimizing file sizes and avoiding duplication of a specific series in weather files. For example, if there are four unique precipitation records but each will use the same air temperature record, rather than repeat the air temperature record four times it may be placed in its own ASCII file with a unique WFILETYPE.
- WCOLUMN. The column in the weather file where the data is stored. The date/time columns are already accounted for; thus, the first weather data column should begin with 1.
- WPARMID. The weather parameter code IDs are fixed, that is 1 must always be associated with precipitation. The codes are presented in the following bullets:
    - 1 = Precipitation, PREC (inches/timestep).
    - 2 = Potential evapotranspiration, PEVT (inches/timestep).
    - 3 = Air temperature, ATEM (degrees F).
    - 4 = Wind speed, WIND (miles/timestep).
    - 5 = Solar radiation, SOLR (langley/timestep).
    - 6 = Dewpoint temperature, DEWP (degrees F).
    - 7 = Cloud cover, CLOU (tenths).

WeatherCombinations

- WSTNUM. A unique ID that defines a unique group of weather parameters to be applied by subbasin. It should be repeated according to the number of weather files used per WSTNUM set.
- WFILENUM. If only one WFILETYPE is used per WSTNUM location, this value should always be 1. If multiple files are used to define a WSTNUM, this value should increment according to the number of WFILEIDs needed to completely define a WSTNUM.
- WFILEID. This corresponds to the WFILEID from the WeatherFilenames table.

WeatherElevations

- WSTNUM. This is a unique ID that defines a unique set or group of weather parameters, to be applied by subbasin. There should only be one unique value for each WSTNUM because there can be only one air temperature timeseries per WSTNUM set.
- Elevation_FT. This is the weather station elevation. It should be the elevation at which air temperature is measured for the WSTNUM. When water temperature is simulated, this value is used to compute lapse rate according to the difference between gage and watershed and reach elevations.

LSPC offers significant flexibility in developing weather tables. The primary benefits of this are file size space savings and data management. Typically, there are more unique rainfall observation locations than the remaining

 © 2012 County of Los Angeles. All rights reserved.

weather parameters. Thus, instead of, for example, copying the same regional air temperature record into many model weather files, one air temperature record can be referenced by multiple model defined weather stations.

Figure 5-9 presents an example of weather station definition for discussion. Under table WeatherFilenames, five weather files are defined and labeled Example1.air through Example5.air. Where files Example1.air through Example4.air contain precipitation (PREC) and potential evapotranspiration (PEVT) only. File Example5.air contains all other parameters except precipitation (PREC) and potential evapotranspiration (PEVT). That is, Example5.air contains air temperature (ATEM), wind speed (WIND), solar radiation (SOLR), dewpoint temperature (DEWP), and cloud cover (CLOU). Note that the order of the columns of weather parameters must be the same in the *.AIR files, review parameter WPARMID above. That means for the files Example 1.air through Example4.air only the first two data columns need to be populated in the *.AIR files. However, for Example5.air, all seven data columns need to be populated in the *.AIR file, but the first two (PREC and PEVT) can be zero because they are coded not to be read in table WeatherFileStructure. In Figure 5-9, WFILETYPE equals 1 applies only to Example5.air and is directing LSPC to read data columns (WCOLUMN) 3 through 7, which corresponds to the WPARMIDs noted above. WFILETYPE equals 2 applies to the remaining example *.AIR files and directs LSPC to read columns (WCOLUMN) 1 and 2, corresponding to precipitation (PREC) and potential evapotranspiration (PEVT).

The table WeatherCombinations is where groups of the ASCII *.AIR weather files (WFILEID) are linked to model weather stations (WSTNUM) to derive the required weather forcing information. In Figure 5-9 WSTNUM equal to 1 consists of two ASCII *.AIR files, Example1.air (WFILEID = 1) and Example5.air (WFILEID = 5).

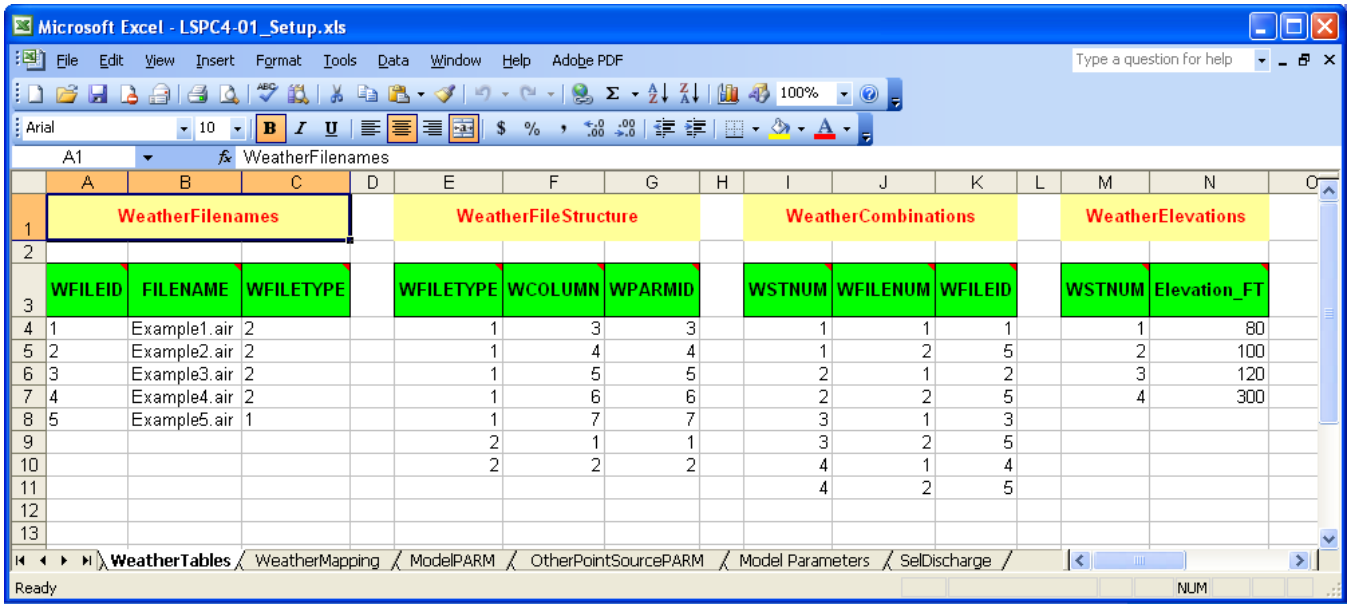


Figure 5-9. The WeatherTables tab.

The WeatherMapping tab is used to assign model weather stations (WSTNUM) to subbasins. More than one may be assigned to a subbasin along with user specified weighting and rank. Although this table allows a user to assign up to five weather stations to a single subbasin by specifying rank and fraction-weight, this practice is not recommended. In certain cases, the act of weighting multiple gages tends to dampen all storm peaks when storms are not well aligned on a small timestep basis. The following bullets summarize the fields.

- SUBBASIN. The subbasin ID.
- WSTNUM. The model weather station ID number, defined in the WeatherFileStructure table. If multiple model weather stations are used for a subbasin, multiple records for that subbasin must be included here.
- FRACTION. Default value is 1 (recommended) when one weather station is used for each subbasin. If multiple stations are used, the weighted fraction of each gage must be included here. To maintain mass balance, the sum of weights for each subbasin set should equal 1.0.

 © 2012 County of Los Angeles. All rights reserved.

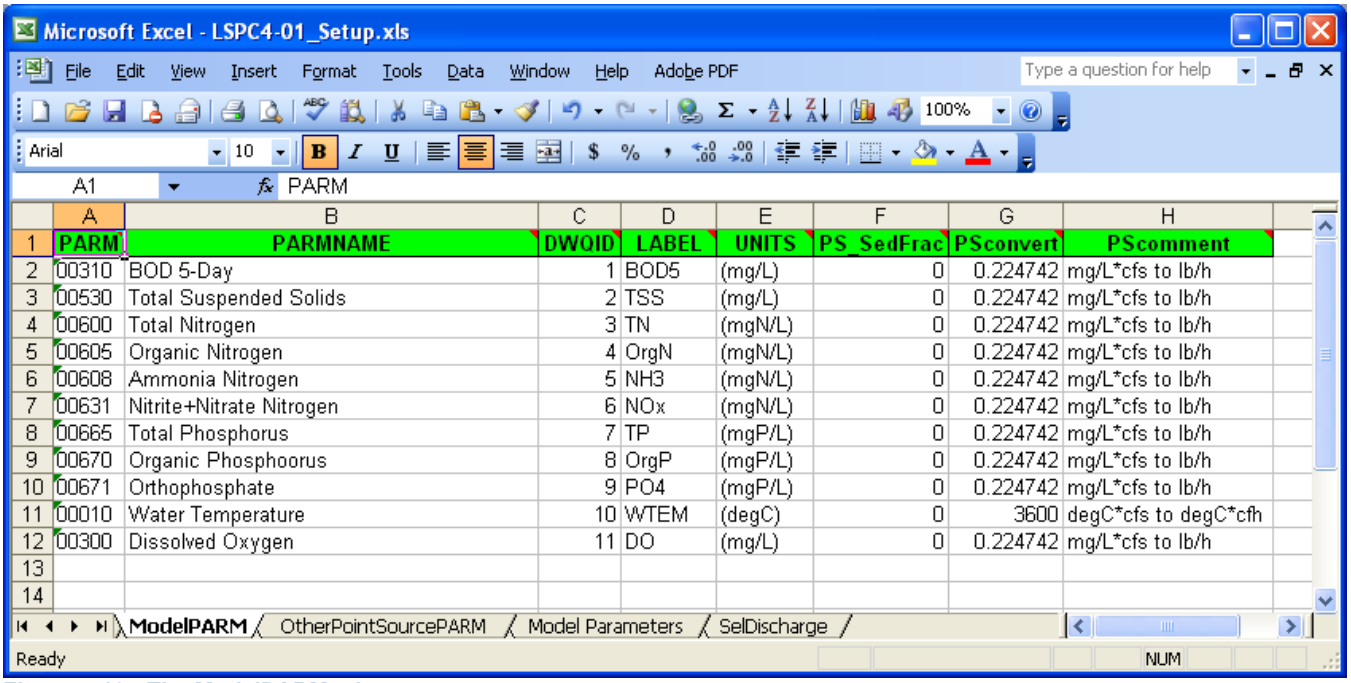
- WSRANK. Default value is 1 (recommended) when one weather station is used for each subbasin. If multiple stations are used, the ranking order of each gage should be included here. The user may specify up to 5 weighted weather gages per subbasin.

5.6 Tabs ModelPARM and OtherPointSourcePARM

The ModelPARM tab (Figure 5-10) enables the definition of the water quality constituents that will be simulated in an LSPC application. The fields are described as follows.

- PARM. Typically this is the STORET parameter code. It is important that this value be consistent with the PARM filed from the DMR tab and the PARM field from OtherPointSourcePARM tab.
- PARMNAME. Typically the STORET parameter name.
- DWQID. The user-defined default water quality ID associated with this PARM. The model uses this ID for mapping process parameters.
- LABEL. The label corresponding to the DWQID. This is used to identify the parameter in model output, in the user interface, and in saved model input files. Be sure to use a continuous string (i.e., no spaces in the label).
- UNITS. The in-stream water quality concentration units associated with this parameter. It should be noted and confirmed that all nitrogen species are as nitrogen, for example (mgN/L), and all phosphorus species are as phosphorus, for example (mgP/L). Other examples include (#/100 mL), (µgN/L), and (degC). Always include parentheses.
- PS_SedFrac. If point source inputs are represented for this parameter, the user can specify the fraction of the constituent to be considered as sediment associated. The sediment associated portion will have the same distribution as sediment from point sources. The remaining portion will be considered as dissolved. For example, assume that the sediment size fraction distributions have been specified in table OtherPointSourcePARM for sand, silt, and clay as 0.1, 0.5, and 0.4, respectively. Had a value of 0.5 been specified for PS_SedFrac for total phosphorus, 50 percent of the point source load would have been considered as sediment associated (meaning 5 percent sand, 25 percent silt, and 20 percent clay associated), with the remaining 50 percent entering as dissolved. This option is valid only for modeling sediment associated pollutants in GQUAL (ModelPARM table).
- PSconvert. The unit conversion for transforming point source load, for example to lb/hr. A few examples are presented as follows.
    - 0.224742 to go from cfs × mg/L to lb/hr.
    - 1,019,412 to go from cfs × #/100mL to #/hr (derived by setting 1 in-stream “mg” equal to 1 “#”).
    - 3,600 to go from cfs × degC to cubic feet per hour × degC. This is conceptually analogous to creating a flow-weighted contribution of temperature to the in-stream value.
- PScomment. Comment for the PSconvert field.

 © 2012 County of Los Angeles. All rights reserved.



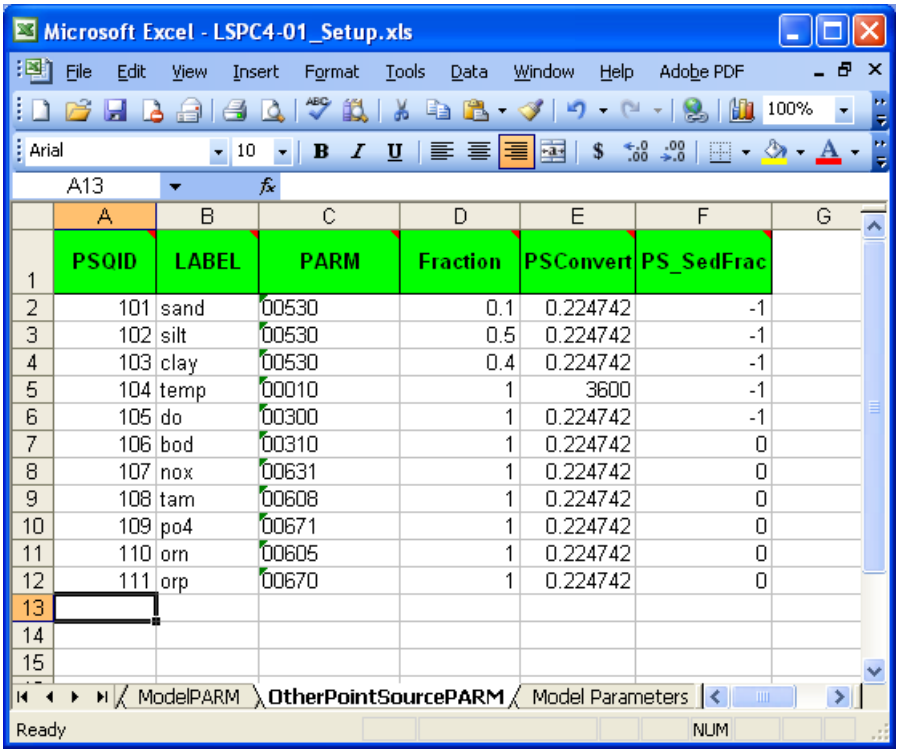
	A	B	C	D	E	F	G	H
1	PARM	PARMNAME	DWOID	LABEL	UNITS	PS_SedFrac	PSconvert	PScomment
2	00310	BOD 5-Day	1	BOD5	(mg/L)	0	0.224742	mg/L*cfs to lb/h
3	00530	Total Suspended Solids	2	TSS	(mg/L)	0	0.224742	mg/L*cfs to lb/h
4	00600	Total Nitrogen	3	TN	(mgN/L)	0	0.224742	mg/L*cfs to lb/h
5	00605	Organic Nitrogen	4	OrgN	(mgN/L)	0	0.224742	mg/L*cfs to lb/h
6	00608	Ammonia Nitrogen	5	NH3	(mgN/L)	0	0.224742	mg/L*cfs to lb/h
7	00631	Nitrite+Nitrate Nitrogen	6	NOx	(mgN/L)	0	0.224742	mg/L*cfs to lb/h
8	00665	Total Phosphorus	7	TP	(mgP/L)	0	0.224742	mg/L*cfs to lb/h
9	00670	Organic Phosphoorus	8	OrgP	(mgP/L)	0	0.224742	mg/L*cfs to lb/h
10	00671	Orthophosphate	9	PO4	(mgP/L)	0	0.224742	mg/L*cfs to lb/h
11	00010	Water Temperature	10	WTEM	(degC)	0	3600	degC*cfs to degC*cfh
12	00300	Dissolved Oxygen	11	DO	(mg/L)	0	0.224742	mg/L*cfs to lb/h
13								
14								

Figure 5-10. The ModelPARM tab.

Tab OtherPointSourcePARM (Figure 5-11) is used for defining other *reserved* water quality parameters for an LSPC application. The reserved codes are for the sediment module (101–103 for sand, silt, and clay, respectively), the temperature module (104), and the RQUAL module (105–112). These represent specific internal compartments (or state variables associated with specific modules) into which information from an external point source data set can be directly inserted. The fields are described as follows:

- PSQID. The model defined point source water quality ID associated with sediment, DO, temperature, and RQUAL constituents. The ID used by the model to add a point source input into the correct associated reserved compartment.
- LABEL. The label corresponding to the PSQID. This is used to identify the parameter in model output, in the user interface, and in saved model input files. Be sure to use a continuous string (i.e., no spaces should be used in the label). This label should be the same as LABEL on the ModelPARM tab.
- PARM. Typically this is the STORET parameter code. It is important that this value be consistent with the PARM filed from the DMR tab and the PARM field from ModelPARM tab.
- Fraction. This column defines the split of a point source input into different components, for example TSS into sand/silt/clay.
- PSConvert. The unit conversion for transforming point source load, for example to lb/hr. A few examples are presented as follows.
    - 0.224742 to go from cfs × mg/L to lb/hr.
    - 1,019,412 to go from cfs × #/100mL to #/hr (derived by setting 1 in-stream "mg" equal to 1 "#").
    - 3,600 to go from cfs × degC to cubic feet per hour × degC. This is conceptually analogous to creating a flow-weighted contribution of temperature to the in-stream value.
- PS_SedFrac. See discussion of this term under ModelPARM. Sediment is specified as –1 because using this term for sediment is redundant and meaningless.

 © 2012 County of Los Angeles. All rights reserved.



	A	B	C	D	E	F	G
1	PSQID	LABEL	PARM	Fraction	PSConvert	PS_SedFrac	
2	101	sand	00530	0.1	0.224742	-1	
3	102	silt	00530	0.5	0.224742	-1	
4	103	clay	00530	0.4	0.224742	-1	
5	104	temp	00010	1	3600	-1	
6	105	do	00300	1	0.224742	-1	
7	106	bod	00310	1	0.224742	0	
8	107	nox	00631	1	0.224742	0	
9	108	tam	00608	1	0.224742	0	
10	109	po4	00671	1	0.224742	0	
11	110	orn	00605	1	0.224742	0	
12	111	orp	00670	1	0.224742	0	
13							
14							
15							

Figure 5-11. The OtherPointSourcePARM tab.

Three different fields are used among these two tables to specify pollutant IDs (PARM, PSQID, and DWQID). PARM is common between the two tables. Notice that PARM is defined according to the STORET code for the pollutant in question. When point source data is derived directly from sources such as PCS, the STORET code is used as the pollutant ID. The use of the STORET PARM code allows the point source data, which might be in its original coding convention, to be cross-linked with a user-defined model GQUAL pollutant code (DWQID), or an internally reserved LSPC code (PSQID). The DWQID is the same parameter code that is linked to land-generated pollutants, whereas the PSQID is linked only to the in-stream compartments for sediment, temperature, and RQUAL.

5.7 Tab Model Parameters

The number of individual model parameters associated with a watershed model configuration can be extremely large, depending on the spatial and temporal resolution of how the parameters are defined. Because LSPC Model information is organized in a database, a few key indexes have been created to organize and categorize the parameter information. The two primary indexes divide land based processes from stream processes. The Hydrologic Default Parameter Group (DEFID) index is reserved for land-based processes, while the Reach Default Group Index (RGID) is for stream-based processes. Other indexes are associated with either DEFID or RGID. The model land unit (or Landuse Index – DELUID) is strictly associated with DEFID, whereas the Default Water Quality Parameter Index (DWQID), which is used to identify modeled water quality parameters, can be associated with both land (for pollutant generation processes) and stream (for pollutant fate and transport processes).

The Model Parameters tab (Figure 5-12) is particularly important because it relates to key setup and initialization of the MS Access database. It is used to stage the setup of five tables in the MS Access database. Those tables and fields are briefly described in this section.

USERLIST-DEFID

- DEFID. Hydrologic parameter group ID. There should be, at a minimum, one entry for each unique DEFID prescribed from the ModelMapping tab.

 © 2012 County of Los Angeles. All rights reserved.

USERLIST-RGID

- RGID. Reach parameter group ID. There should be, at a minimum, one entry for each unique RGID on the ReachModel tab.

USERLIST-Landuse

- DELUID. Model land unit ID. List of DELUID entries from the LanduseCodeMD tab. These are the model land units, which are based on either grouping source land uses or HRUs or linked to a single land use or HRU.

USERLIST-SedClass

- SedClass. List if IDs for each cohesive sediment class. Note: Do not include an entry for sand because one non-cohesive class is always assumed. For example, to model sand, silt, and clay, this list should include two entries, 1 for silt and 2 for clay.

USERLIST-DWQID

- DWQID. List the general water quality (GQUAL) IDs to be modeled. There should be at a minimum, one entry for each unique DWQID from the ModelPARM tab that is being modeled. The list does not have to include the complete list of DWQIDs, assuming a user has defined more than they intend to use on the ModelPARM tab. By limiting the USERLIST-DWQID table to only the desired DWQIDs the database is more compact.

These tables are important and are further discussed in Section 6.5. A series of macros are available to the user regarding specific setup and initialization of the MS Access database once the copy/paste actions have been completed.

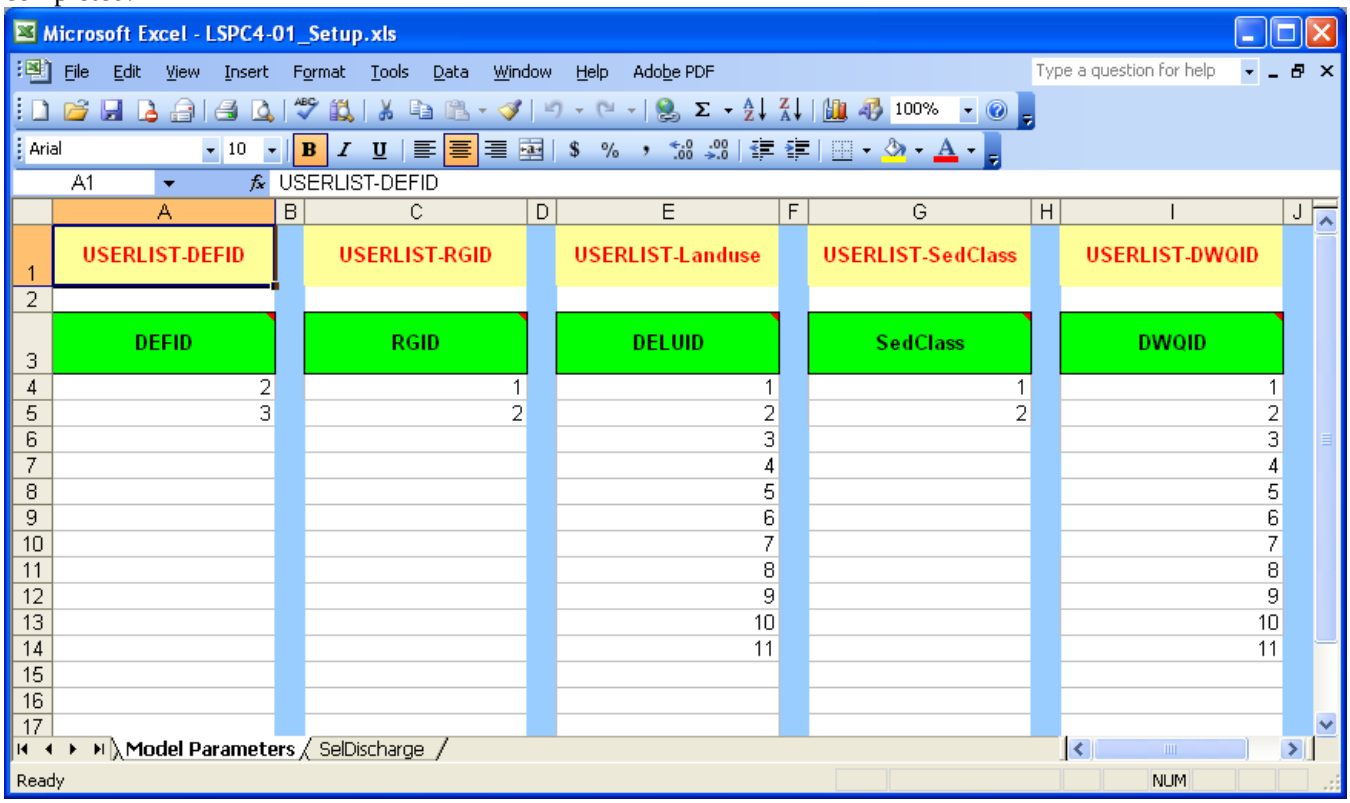


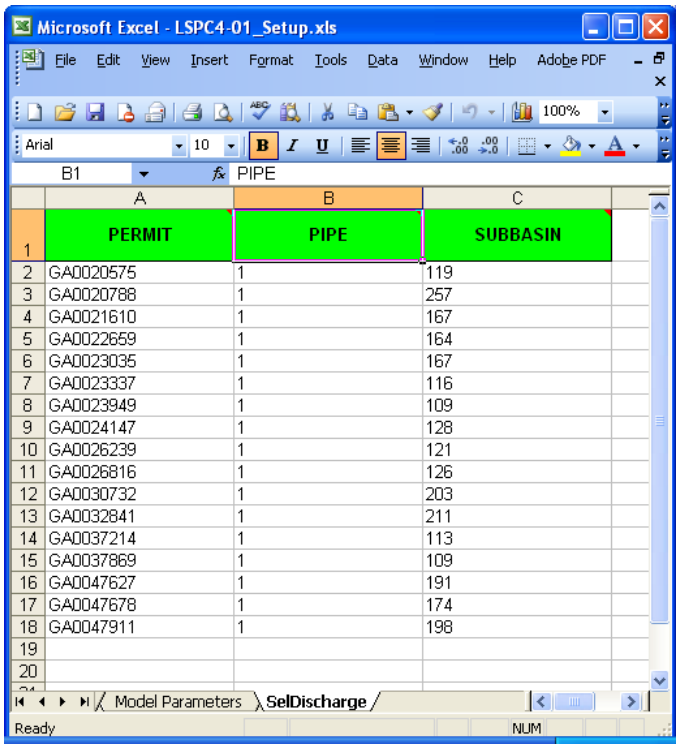
Figure 5-12. The Model Parameters tab.

 © 2012 County of Los Angeles. All rights reserved.

5.8 Tab SelDischarge

The combinations of permit ID, outfall ID, and subbasin are defined in the SelDischarge tab (Figure 5-13). A user can populate the MS Access database table PS_Timeseries with more dischargers than noted in SelDischarge. The SelDischarge table is used to tell the model which dischargers are included in a given simulation. The fields are described as follows.

- PERMIT. The discharger ID, typically the NPDES permit number.
- PIPE. The outfall ID. Typically use a value of 1 unless there is more than one outfall for a discharger.
- SUBBASIN. The subbasin ID receiving the discharge. Note that the input of the point source is the upstream end of the reach in the specified subbasin.



	A	B	C
1	PERMIT	PIPE	SUBBASIN
2	GA0020575	1	119
3	GA0020788	1	257
4	GA0021610	1	167
5	GA0022659	1	164
6	GA0023035	1	167
7	GA0023337	1	116
8	GA0023949	1	109
9	GA0024147	1	128
10	GA0026239	1	121
11	GA0026816	1	126
12	GA0030732	1	203
13	GA0032841	1	211
14	GA0037214	1	113
15	GA0037869	1	109
16	GA0047627	1	191
17	GA0047678	1	174
18	GA0047911	1	198
19			
20			

Figure 5-13. The SelDischarge tab.

 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

6 MS Access Database

The MS Access database serves as the key repository for the primary model input. The GIS and spreadsheet work completed in the previous sections can now be communicated to the MS Access database.

6.1 Copy/Paste from the MS Excel Setup Spreadsheet

The previous work summarized in Section 5 can now be used in copy/paste actions to populate the MS Access database. Figure 6-1 presents a sample of the tables available, though not all are used to copy/paste the information from the MS Excel setup file to the MS Access database.

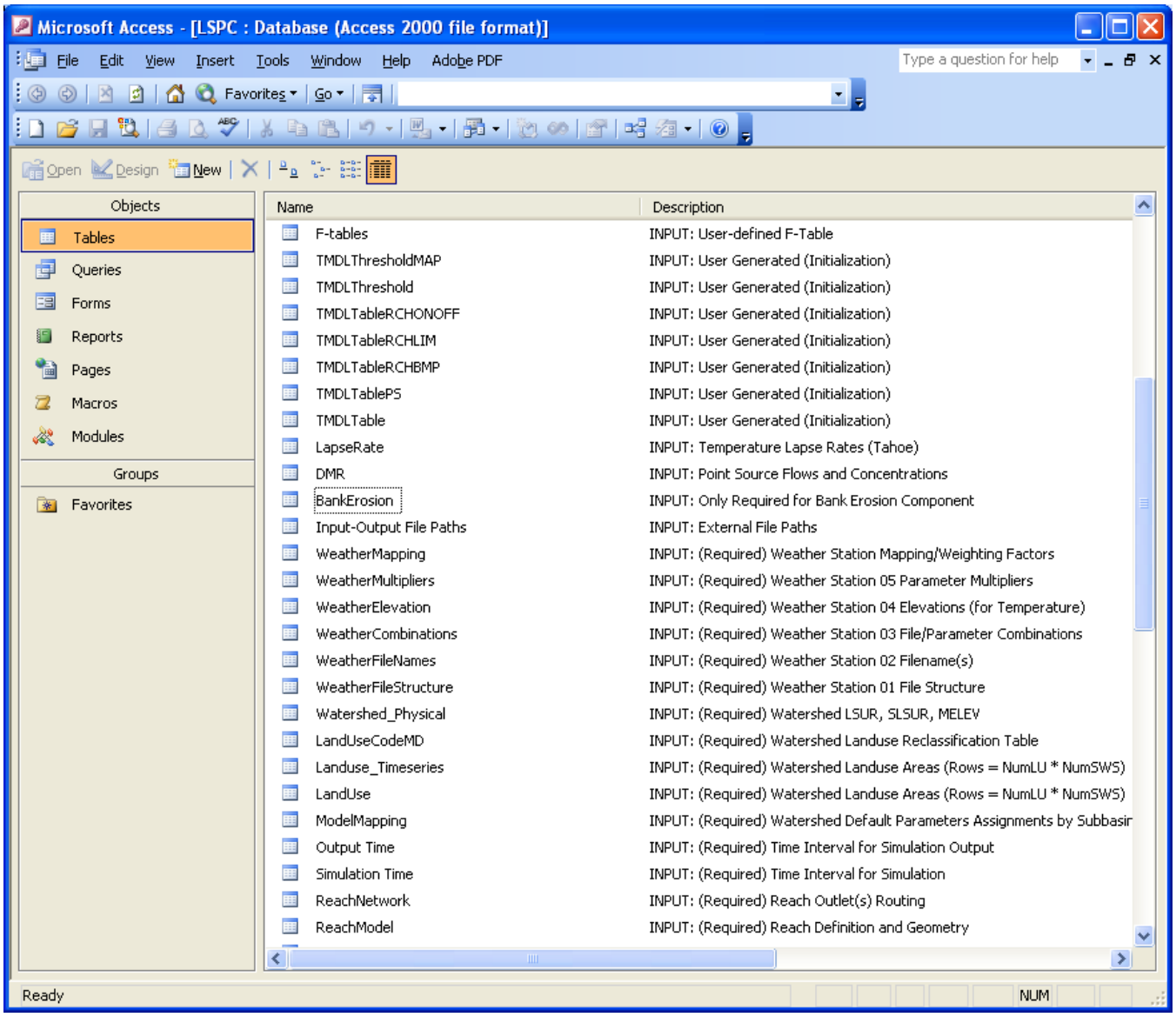


Figure 6-1. The Tables Section of the MS Access Database.

Table 6-1 summarizes the relationship of the tab name in the MS Excel setup file with the table name in the MS Access database. A checkbox column has been provided for the user to mark as complete as the respective MS Access database tables have been populated. Once the MS Excel setup file is satisfactorily completed, the user can perform a simple copy/paste action to move the information into the respective locations of the MS Access

 © 2012 County of Los Angeles. All rights reserved.

database. Before beginning the copy/paste process, the user should first ensure that all undesired records are removed from the MS Access database.

Table 6-1. Summary of Copy/Paste to MS Access Database from the MS Excel Tab

Check as Completed in MS Access Database	MS Access Table Name	MS Excel Tab Name	Comment
□	Landuse	Landuse	Land use or HRU information.
□	F-tables	F-Tables	User-specified reach properties.
□	LandUseCodeMD	LandUseCodeMD	Summary of how source land use or HRU will be combined to modeling units.
□	ModelMapping	ModelMapping	Relationships of subbasin IDs to default parameter group ID.
□	Watershed_Physical	Watershed_Physical	Combinations by subbasin and modeling unit of overland flow characteristics and elevations.
□	ReachModel	ReachModel	Geometric properties used for reach calculations when F-Tables are not used, reach group default IDs, and other flags.
□	ReachNetwork	ReachNetwork	Connectivity of upstream to downstream subbasins; a value of –1 means end of model.
□	DMR	DMR	One method for generating the required point source input.
□	WeatherFileNames	WeatherTables	List of external ASCII *.AIR files with ID and type.
□	WeatherFileStructure	WeatherTables	Defines which data columns in the external ASCII *.AIR files are read by the designated user-specified types. The order of the data columns in the external files is prescribed by the model, not a user choice.
□	WeatherCombinations	WeatherTables	Defines the weather station IDs that the model uses in execution. These IDs can include use of more than one of the external ASCII *.AIR files.
□	WeatherElevations	WeatherTables	The elevation of the weather station locations used by the model; used only when temperature simulation is turned on.
□	WeatherMapping	WeatherMapping	Defines the subbasin and weather station combinations.
□	ModelParm	ModelPARM	Water quality parameter definition and conversion, GQUAL.
□	OTHERPointSourcePARM	OtherPointSourcePARM	Water quality parameter definition and conversion, RQUAL and point sources.
□	USERLIST-DEFID	Model Parameters	List of hydrologic parameter IDs.
□	USERLIST-RGID	Model Parameters	List of reach default parameter IDs.
□	USERLIST-Landuse	Model Parameters	List of modeling land units.
□	USERLIST-SedClass	Model Parameters	List of cohesive sediment classes.
□	USERLIST-DWQID	Model Parameters	List of water quality parameter IDs.
□	SelDischarge	SelDischarge	Defines permit number/outfall ID/subbasin combinations to include in an application.

6.2 Selection Tables

A series of user-defined input selection tables are available, which are typically populated after completing the copy/paste transfer from the MS Excel setup file (Table 6-2). They drive the model construction when the user is ready to execute. Thus, a user can set the selection tables to model the entire domain of defined subbasins or a subset that he or she might want for run-time considerations or area focus. Also, the user can select the full suite of water quality parameters or a subset.

 © 2012 County of Los Angeles. All rights reserved.

Table 6-2. Summary of Selection Tables Populated by a User

MS Access Table Name	Comment
SelDischarge	A user must prescribe the permit ID/outfall ID/subbasin combination. The user can make the selection
SelParm	The PARM values a user wants to simulate. These must correspond exactly with the DWQIDs populated on the USERLIST-DWQID table.
SelWatershed	The subbasin IDs to be simulated.

6.3 Point Sources/Sinks

Point source representation can be a significant and time-consuming task. Earlier, it was mentioned that one method to developing this information is to populate the DMR tab in the MS Excel setup file. When LSPC executes, it reads from the PS_Timeseries table. The DMR table is a staging table. A macro, which is discussed in Section 6.5.1, uses the DMR table to create the PS_Timeseries table. The PS_Timeseries table presents the information in a slightly different format, although flow is still in units of cfs and can be developed by a user in a spreadsheet application or other means. Figure 6-2 shows the PS_Timeseries table in the MS Access database. This example is coded with constant values for the water quality parameters. Also, note how the same flow value is repeated for every coincident date, though this is a simple example. The LOAD field for typical water quality parameters is in units of cfs × mg/L. The units for water temperature would be cfs × degrees C; and for fecal coliform, they would be cfs × #/100mL.

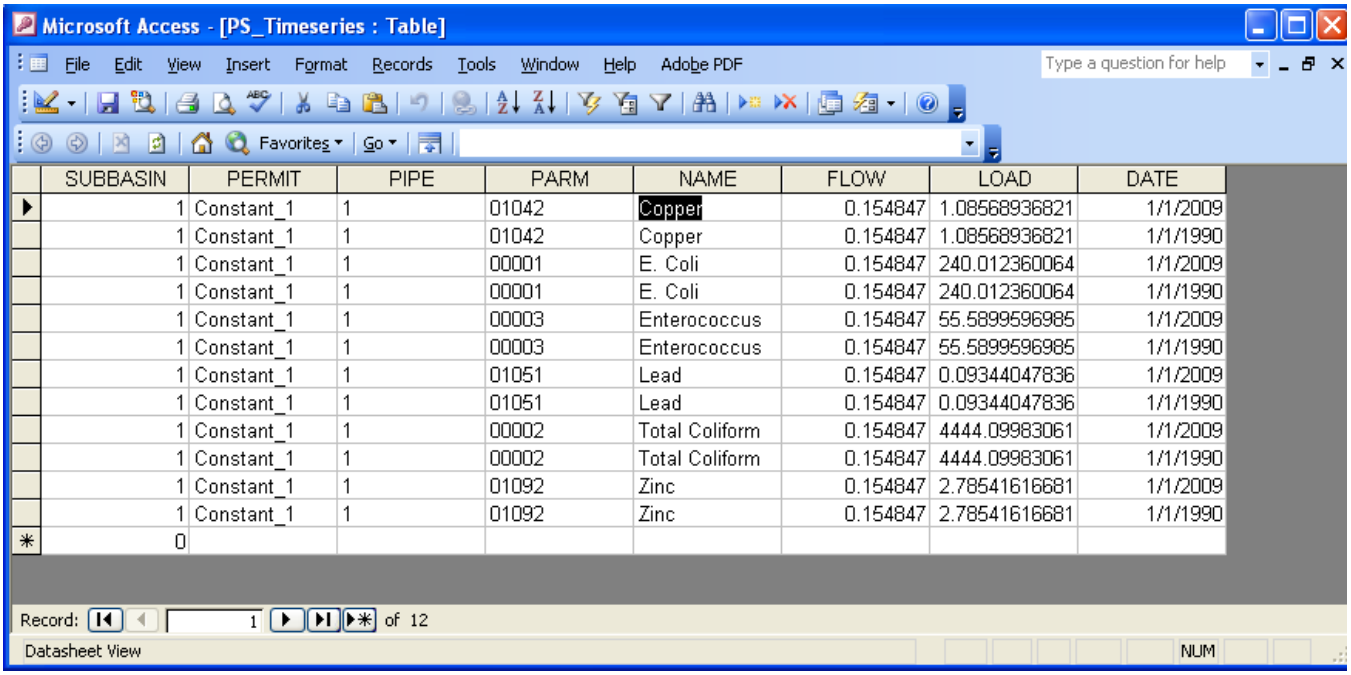


Figure 6-2. PS_Timeseries Table.

The PS_Timeseries table can also be used for representing withdrawals. A withdrawal is represented the same way as a point source inflow; however, the flow values (cfs) should be negative. Because records in the PS_Timeseries table require flow values to be specified with a corresponding pollutant load, withdrawals must be specified as if they were associated with one of the pollutants being modeled. Furthermore, because flows and loads are independent of each other, although additive among themselves, zero load must be specified if no additional load is being added while a withdrawal is occurring. LSPC automatically removes the in-stream pollutant mass associated with the withdrawal using the dissolved in-stream concentration of the pollutant and the withdrawal volume. For each withdrawal that occurs in PS_Timeseries, the PS_Withdrawal_Target table must also be populated with a target subbasin/reach for the water if the withdrawal is a diversion, or simply an unassigned value of –1 if the withdrawn water will not return to the model. In the case of a diversion, the net

 © 2012 County of Los Angeles. All rights reserved.

pollutant mass is preserved system-wide because the withdrawn flow and pollutant mass (flow multiplied by current in-stream concentration for all dissolved constituents) is routed to the target reach.

6.4 Other Tables

Note that the MS Access database contains more tables than has been discussed in this manual. A few of the more relevant tables with regard to developing an LSPC application are discussed in this section. They are important because if they are not completed properly, the data does not load into the model, or it loads and then promptly crashes.

Simulation Time

- RUNSTART. Simulation start date.
- RUNEND. Simulation end date.
- DELT_MIN. Timestep for model execution (minutes). Typically 60 minutes; however, the DELT_MIN value is being overridden by the timestep of the input weather data.

Output Time

- OUTSTART. Output start date. Can be set later than the simulation start date (RUNSTART) if spin-up is desired.
- OUTEND. Output end date.
- OUTOPTION. A value of 1 indicates daily output; a value of 2 indicates output at the simulation timestep (See the comments under DELT_MIN in Table Simulation Time)

Input-Output File Paths

- OUTPUT_PATH. The location to write the output files.
- WEATHER_PATH. The location of the ASCII *.AIR weather files.

6.5 Macro/Query Execution

Once the MS Access database has been populated with the work from the MS Excel setup file, the user must consider the selection input tables; the begin/end dates; and file paths, a series of macros, and one query. The first macro is optional and based on whether a user is using the DMR table to populate the PS_Timeseries table. The next three macros are key array initialization macros that are required after populating the MS Access database with the input tables but before launching and running the LSPC Model. The last item is a query that produces cumulative upstream area to each subbasin in the project study area.

6.5.1 Generate Point Source Timeseries from DMR

If the user populated the DMR table, he or she must execute this macro to populate the PS_Timeseries table. This macro preserves the flow values in units of cfs but takes the concentration values multiplied by the flow values to populate the LOAD field in PS_Timeseries table. If the user has performed the development of the point source information another way and already populated the PS_Timeseries table, the user should not execute this macro. This macro deletes all previous entries in table PS_Timeseries.

6.5.2 Initialize Default Parameters

This macro constructs the model parameter tables with the proper dimensions according to all the input provided by the user (such as the number of land use categories, default groups, and modeled water quality constituents). The actions of this macro are summarized as follows.

1. Delete contents of table DefaultParm. The parameters are related to hydrology, sediment, and RQUAL.
2. Delete contents of table DefaultParmWQ. The parameters are related to GQUAL.
3. Delete contents of table LapseRate. This table contains air temperature lapse rates for snow simulation.
4. Executes query <1 - Make_DefaultParm_General>. Retrieves information from tables USERLIST-Landuse and USERLIST-DEFID (numbered list of default groups) to build all relevant parameter records

 © 2012 County of Los Angeles. All rights reserved.

that are combinations of number of land uses and number of default parameters. The basis table, DP_General, contains one set of unique default parameters listed for one land use type.

5. Executes query <2 - Make_DefaultParm_Other>. Uses the basis table DP_Other along with information from table USERLIST-RGID (numbered list of reach groups) to build all relevant parameter records that are just a function of the number or reach groups (RGID).
6. Executes query <3 - Make_DefaultParm_SedClass>. Sediment initialization, which is the construction of the relevant sediment parameter cards by number of sediment classes and number of RGID, is performed from information in table USERLIST-RGID and USERLIST-SedClass.
7. Executes query <4 - Make_DefaultParmWQ_General>. Uses the basis table DPWQ_General, which contains a set of unique default parameters listed for one land use type, default group, and water quality identifier combination, along with information from table USERLIST-DEFID, USERLIST-DWQID (numbered list of default water quality constituents), and USERLIST-Landuse.
8. Executes query <5 - Make_DefaultParmWQ_Other>. Uses the basis table DPWQ_Other along with information from table USERLIST-RGID and USERLIST-DWQID to build all relevant parameter records that exist as combinations of the number of RGID and number of DWQID.
9. Executes query <6 - Make_DefaultParmWQ_GQSD>. When a user wants to model sediment as a general quality constituent on the land but link directly to the in-stream sediment transport model by particle class, this table is used to create placeholders for the relevant parameter slots using information from table USERLIST-DEFID and USERLIST-DWQID.
10. Executes query <7 - Make_DefaultParmWQ_RGID>. This query is used to build table 500, which links GQUAL on land to RQUAL in the stream using information from table USERLIST-RGID, USERLIST-DWQID, and a fixed set of four land layers (FIXEDLIST-Landlayers).
11. Executes query <8 - Make_LapseRate_Multiplier>. Initializes table LapseRate multipliers to values of 1.0 by DEFID. During calibration, the placeholders in the LapseRate table allow a user to change the default lapse rate by changing the value to a value other than 1.0.

6.5.3 Initialize TMDL Tables

The TMDL tables are provided for the benefit of iterative execution of LSPC when considering scenarios for TMDL or wasteload allocation development work. The values in this table are multipliers that are applied to the baseline calibration during each iterative scenario. These tables must be initialized for size and content according to the number of land uses, subbasins, and point sources in use. The actions of this macro are summarized as follows.

1. Delete contents of the TMDLTable table (which contains multipliers for each land use/subbasin pair)
2. Execute query <MakeTMDLTable_FLOW>. Creates a multiplier for flow for each land use and default group combination.
3. Execute query <MakeTMDLTable_GQUAL>. Creates a multiplier for each water quality constituent, land use, and default group combination.
4. Execute query <MakeTMDLTable_SED >. Creates a multiplier for each sediment particle class (sand, silt, and clay) by land use and default group combination.
5. Delete contents of the TMDLTablePS table (which contains multipliers for each point source facility).
6. Execute query <MakeTMDLTablePS_FLOW>. Creates a multiplier for point source flow from each discharge according to table SelDischarge.
7. Execute query <MakeTmdlTablePS_GQUAL >. Creates a multiplier for each discharge and GQUAL pollutant combination. Uses the SelDischarge and ModelParm tables.
8. Execute query <MakeTMDLTablePS_OTHER >. Creates a multiplier for each discharge and sediment, temperature, and/or RQUAL pollutant combination. Uses the SelDischarge and OTHERPointSourcePARM tables.
9. Execute query <Make_PS_Withdrawal_Target>. Recreates the entire PS_Withdrawal_Target table according to the number of withdrawals found in PS_Timeseries. As previously noted, withdrawals are designated in PS_Timeseries with negative flow values. By default, each withdrawal is assigned a target reach ID of –1 (meaning that the withdrawal is a loss, and not a water diversion). If the withdrawal is a diversion, the user is responsible for setting the target reach for the withdrawal.

 © 2012 County of Los Angeles. All rights reserved.

6.5.4 Initialize Weather Multipliers

The weather assignments and information are populated in a variety of tables. For each combination of weather parameters (precipitation, potential evapotranspiration, etc.) a multiplier can be used to scale and modify the original values either for calibration or for scenarios. This macro summaries the unique set of weather parameter combinations and creates a multiplier for each. The actions of this macro are summarized as follows.

1. Delete contents of the WeatherMultipliers table .
2. Execute query <MakeWeatherMultipliers>. Creates a table of mutipliers using the WeatherCombinations, WeatherFileNames, and WeatherFileStructure tables.

 © 2012 County of Los Angeles. All rights reserved.

7 Weather Data

LSPC is a rainfall-runoff model and thus requires weather forcing as input to drive the model. Gathering, processing, and developing weather input files is a significant task that typically requires substantial effort. The weather files developed for LSPC input are ASCII files, which can be free or fixed format.

7.1 Sources

Many sources exist for gathering weather information. The most well-known resource is the National Climate Data Center (NCDC), which offers a variety of data at different frequencies. Perhaps the next most common resource is State Climate Offices. However, many other sources could be used, including the USGS, university-affiliated monitoring networks, state environmental agencies, citizens groups, municipalities, and more. Ideally there would be sufficient spatial coverage of weather observation stations in a study area. Weather data can also be obtained from WDM files available through the BASINS4 product (USEPA 2008a). Appendix B discusses how to create ASCII weather files for LSPC from a binary WDM file.

7.2 Processing

Processing weather information for model input is typically an intensive effort. The continuity and quality of the various time series (rainfall, temperature, humidity, and such) must be reviewed and patched if needed. This processing can be done with customized programmed tools developed by a user, a utility such as WDMUtil (USEPA 2008a), or another method. LSPC requires seven weather constituents in the ASCII file (*.AIR), these are presented in Table 7-1. LSPC expects the ID parameter *WPARMID*. That is, a user cannot use 7 for WPARMID for precipitation, WPARMID must always be 1 for precipitation. Figure 7-1 provides an example of a free-format ASCII weather file.

Table 7-1. Weather Parameters and IDs

WPARMID	Description
1	Precipitation, PREC (in/interval)
2	Potential evapotranspiration, PEVT (in/interval)
3	Air temperature, ATEM (degree F)
4	Wind speed, WSPD (mile/interval)
5	Solar radiation, SOLR (langley/interval)
6	Dew point temperature, DEWP (degree F)
7	Cloud cover, CLOU (tenth)

 © 2012 County of Los Angeles. All rights reserved.

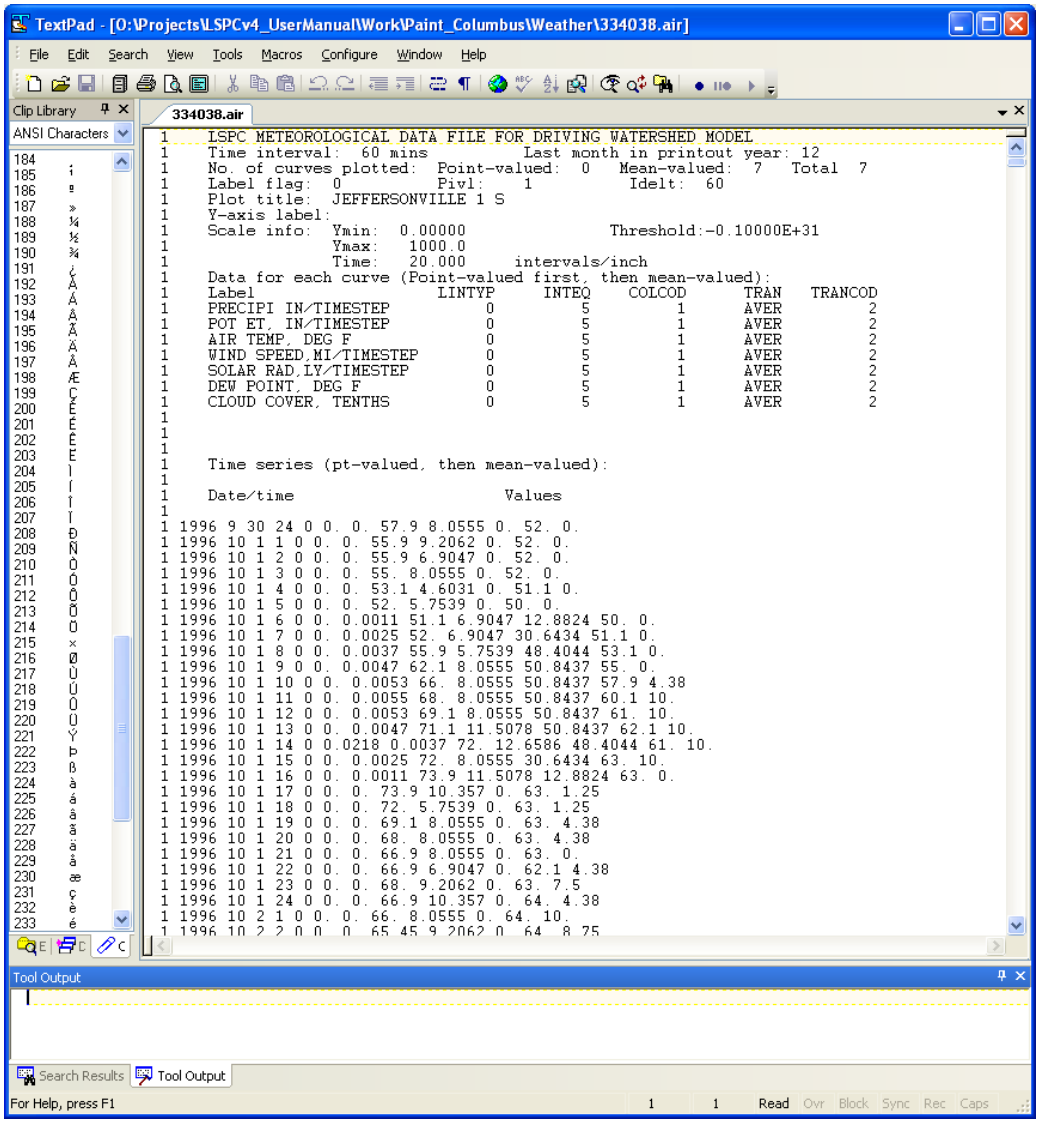


Figure 7-1. Example ASCII Weather File (*.AIR).

 © 2012 County of Los Angeles. All rights reserved.

8 MapWindow Interface for LSPC

A plug-in was developed to allow the use of MapWindow to launch the LSPC Model along with other functionality. The LSPC Model can be launched with or without a GIS application. Launching the LSPC Model from MapWindow has spatial advantages (visualization and context) along with output review benefits.

8.1 Build a MapWindow LSPC Project

Open an application of MapWindow GIS from the MS Windows **Start** button on the computer desktop. The LSPC plug-in needs to be turned on. To do this, click the **Plug-ins** menu and select **Watershed Models** (Figure 8-1). Then select **LSPC Map Tools**. Another pulldown menu selection **LSPC** and icon bar appears in the MapWindow GIS interface (Figure 8-2).

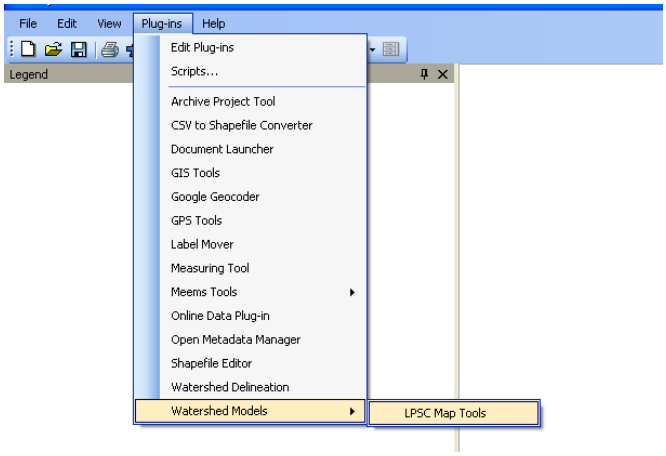


Figure 8-1 Select the LSPC Plug-In for MapWindow GIS.

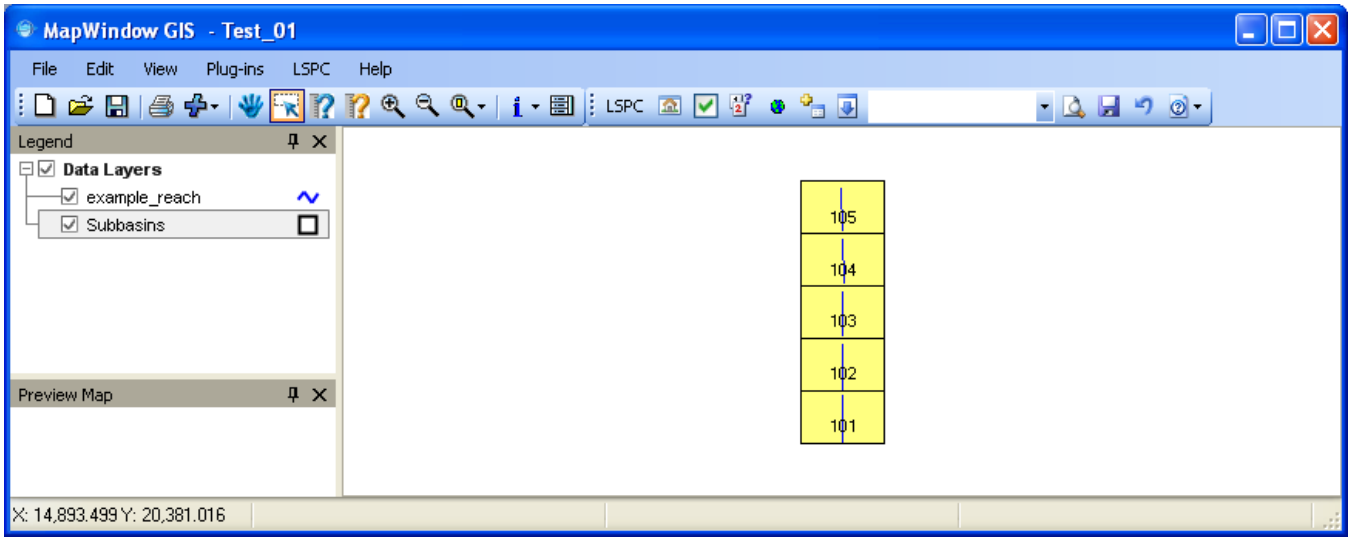


Figure 8-2 The New LSPC Menu and Icon Bar after the LSPC Plugin is Activated.

Once the LSPC plug-in is active, save the MapWindow project (Figure 8-3 and Figure 8-4). Create a project, for example, named LSPC_Tester. Then use MS Windows Explorer to navigate to the project directory. The files listed in Table 8-1 were created when the project was saved. The LSPC-MW configuration file and log is always created or updated when the plug-in is loaded. The naming convention for the configuration file is always <Map Window project name>_LspcConfig.xml. The naming convention for the log file is always <Map Window project name>_<current date>.log.

 © 2012 County of Los Angeles. All rights reserved.

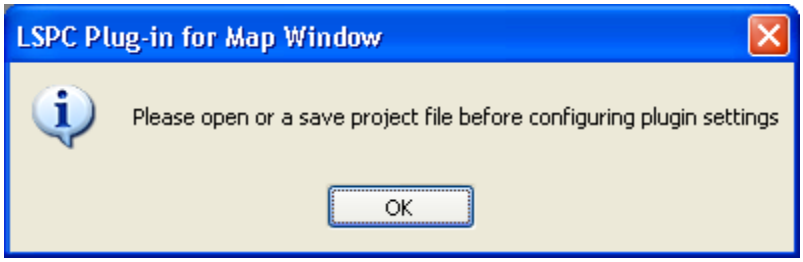


Figure 8-3 Save a MapWindow Project Dialog Box.

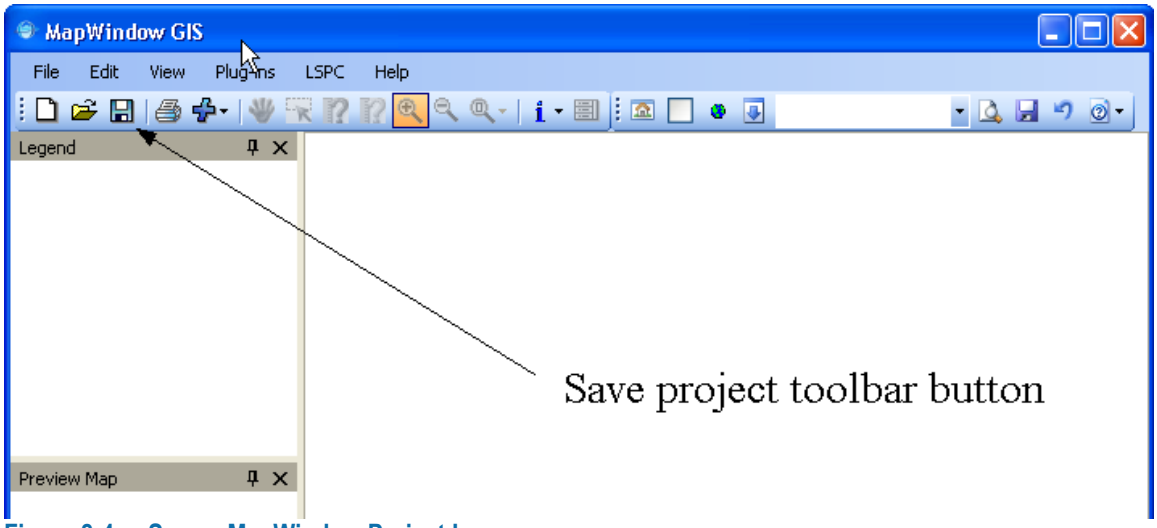


Figure 8-4 Save a MapWindow Project Icon.

Table 8-1. LSPC-MW Project File Names

File Name	File Extension	Description
LSPC_Tester	*.MWPRJ	MapWindow project file
LSPC_tester_LspcConfig	*.LOG	LSPC-MW configuration file
LSPC_tester_5_4_2009	*.XML	LSPC-MW log file

The **Modify LSPC application settings…,** option seen in Figure 8-5, is important for setting up the MapWindow project. A dialog box opens (Figure 8-6), which requires input by a user. This dialog box is shown again in Figure 8-7, already populated. Explanations regarding the options in the dialog box are presented in Table 8-2.

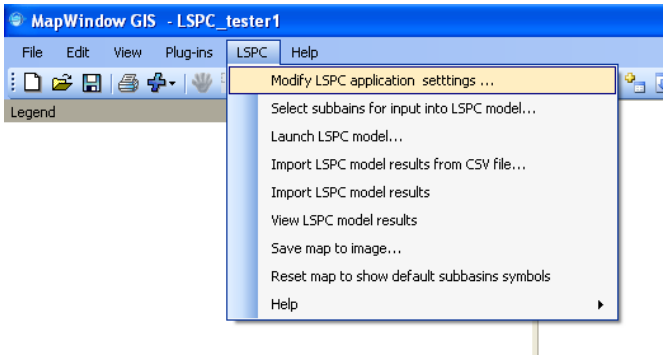


Figure 8-5 Setup LSPC Project in MapWindow.

 © 2012 County of Los Angeles. All rights reserved.

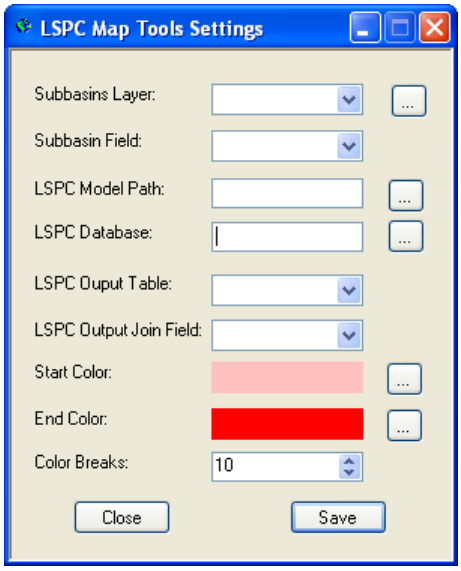


Figure 8-6 LSPC Map Tools Settings Dialog Box, Empty.

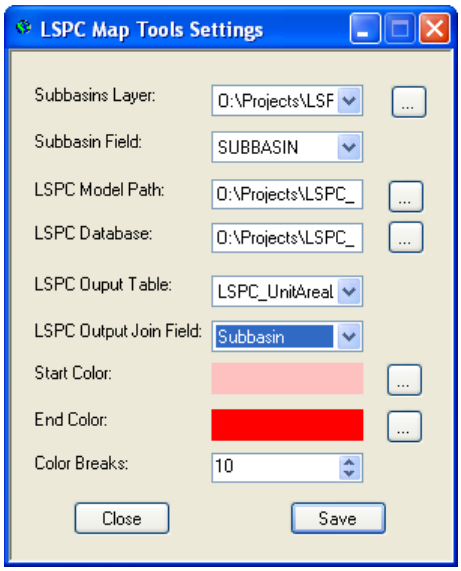


Figure 8-7 LSPC Map Tools Settings Dialog Box, Populated.

Table 8-2. LSPC Map Tool Setting Descriptions

Input	Description
Subbasin Layer	The navigation button allows the selection of the subbasin GIS coverage, which has been prepared with numeric subbasin IDs.
Subbasin Field	The field that contains the subbasin IDs
LSPC Model Path	The navigation button allows the selection of the LSPC Model executable file.
LSPC Database	The navigation button allows the selection of the MS Access database that was developed for the current application.
LSPC Output Table	Once the location of the MS Access database has been set, this field is automatically populated.
LSPC Output Join Field	The field that contains the subbasin IDs.
Start Color, End Color, and Color Breaks	The user can customize the color selection for output illustration as well as the number of breaks.

 © 2012 County of Los Angeles. All rights reserved.

After the setup dialog box has been populated, the subbasin GIS coverage appears in the MapWindow interface. Figure 8-8 illustrates an example of a hypothetical five subbasin watershed with all subbasins selected, which is highlighted in yellow. The menu also reveals the option to select subbasins, further confirmed with the check mark to the left of the menu choice. This feature enables all subbasins upstream of a selected subbasin to be automatically selected, which requires the MS Access database to have a table with this information called UpstreamNetwork.

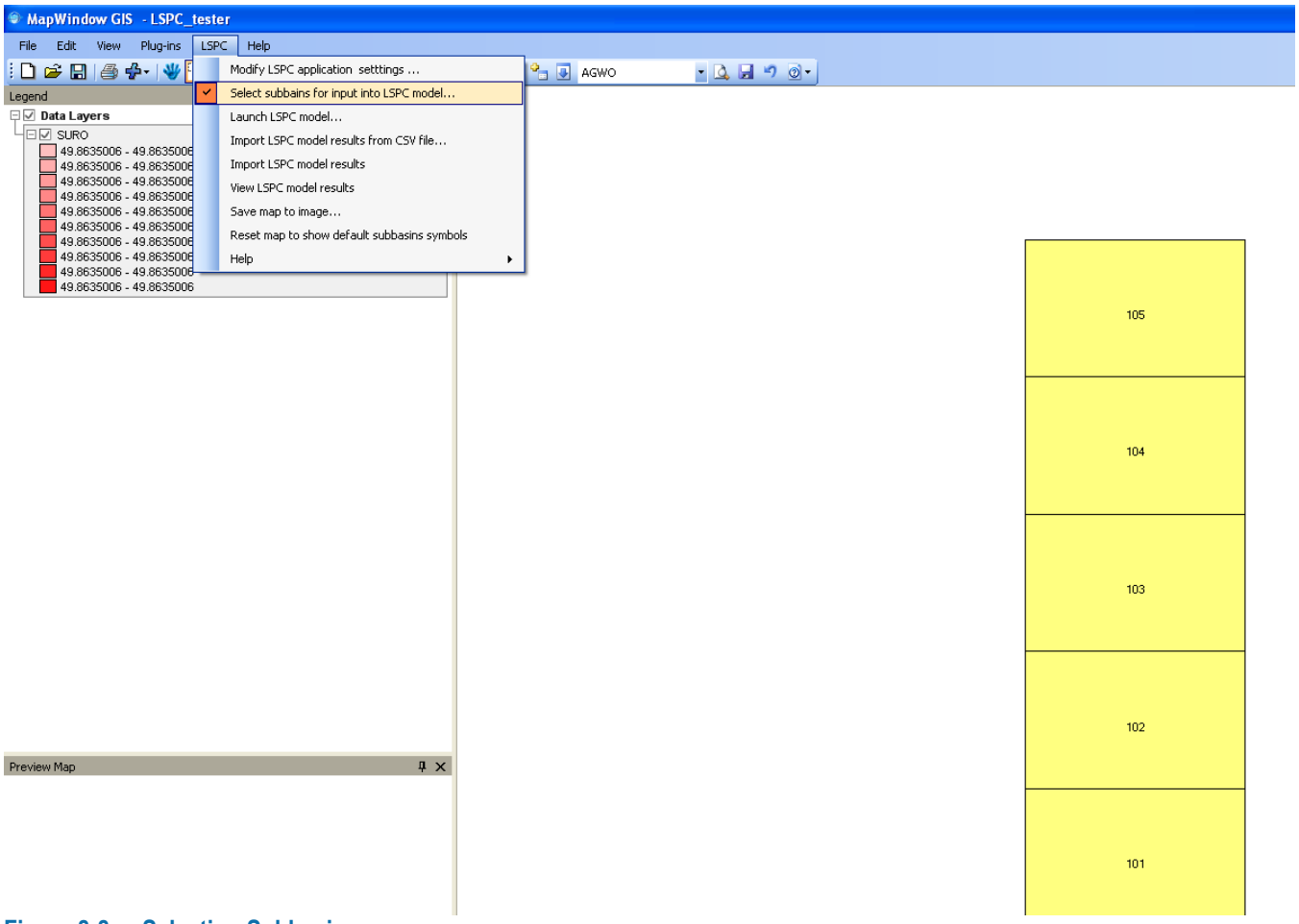


Figure 8-8 Selecting Subbasins.

From the LSPC pulldown menu, the **Create and manage scenarios…** option allows a user to save carious subbasin selections for iterative execution. First the user must select the desired subbasins before choosing this menu option. The simple LSPC project example provided with this manual has five subbasins, which can be seen in Figure 8-9. Once the LSPC Map Tools Model Scenarios pops up the user can type in the Scenario Name and Scenario Description. Then the second choice in the dropdown menu for Update Scenario Subbasins with Map Selection should be selected. Select the Apply icon then the save icon on this pop-up dialog box. The dialog box can then be closed and project should be saved. Assuming that a few other scenarios have been built, a user can come back to this menu option later and select from the previously saved scenarios which can be useful during the iterative model execution process.

 © 2012 County of Los Angeles. All rights reserved.

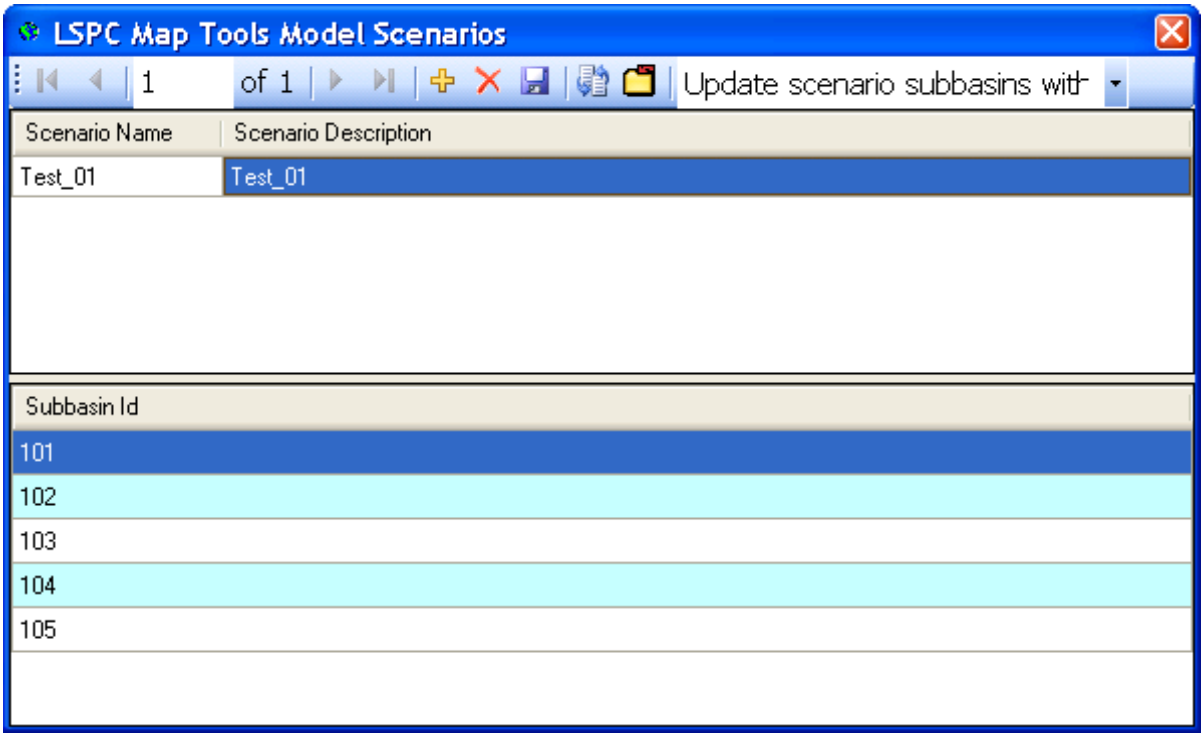


Figure 8-9 Create and Manage Scenarios.

Selecting the **Launch LSPC model…** menu item or using the button on the toolbar, copies the selected subbasin identifiers to the LSPC input table in the MS Access database and opens the LSPC Model interface. For running the LSPC Model, see Section 9. Once a simulation is complete, LSPC-MW allows a few output review options (Figure 8-10 and Figure 8-11). That joins the output data to the subbasin GIS shapefile, allowing a user to toggle through the various fields of the output.

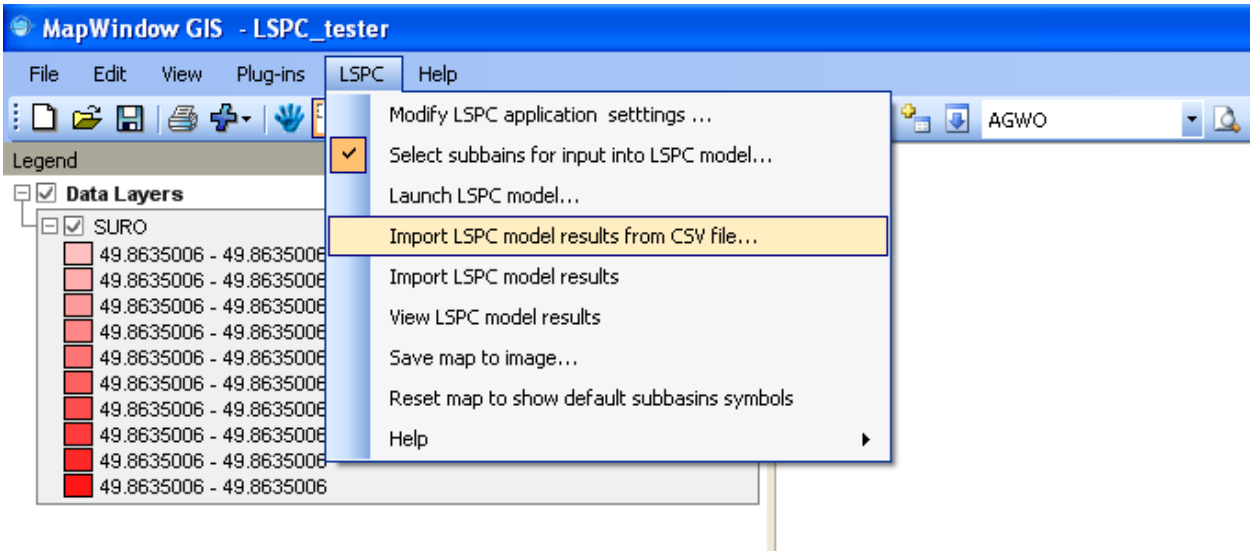


Figure 8-10 Accessing Simulation Output.

 © 2012 County of Los Angeles. All rights reserved.

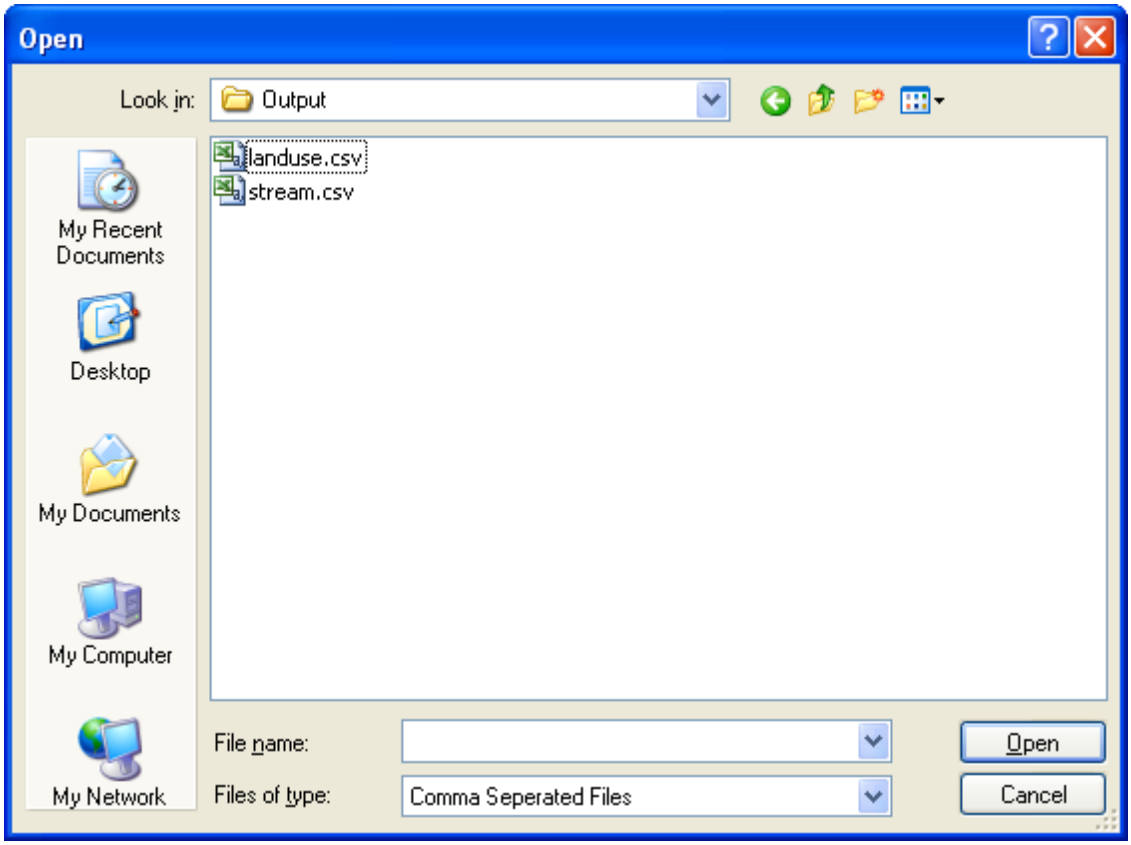


Figure 8-11 Selecting an Output *.CSV File.

To visualize model results, select **View LSPC model results** or use the icon on the toolbar. Numeric output fields are symbolized using the Start Color, End Color, and Color Breaks application settings. Text fields are symbolized using random colors for each unique output field value. The **Save map to image…** option allows you to create figures for reporting or presentations.

 © 2012 County of Los Angeles. All rights reserved.

9 LSPC Model

The LSPC Model is used in a convenient PC-based windows interface and includes streamlined HSPF algorithms for simulating hydrology, temperature, sediment and general water quality on land. The model is capable of efficiently simulating large watersheds with high spatial resolution for assessment and allocation to multiple point and nonpoint sources. LSPC overcomes the difficult simulation of large-scale watersheds (e.g., those on the order of 8-digit USGS HUCs or larger), while maintaining a high level of detail. The system automatically links upstream contributions to downstream segments, allowing users to freely model subareas while maintaining a top-down approach (i.e., from upstream reaches to downstream segments). The model simulates watershed hydrology and pollutant transport, as well as stream hydraulics and in-stream water quality. It is capable of dynamically simulating flow, sediments, metals, and temperature, as well as other conventional pollutants for pervious and impervious lands and waterbodies of varying order.

The LSPC Model interface provides a user-friendly way to review/revise the input during the iterative process of model development. The interface was developed with a tool, the Parameter Info icon (also accessed from the **View** menu, then selecting **Parameter Info**), which provides thorough descriptions and abbreviations of the variables available in a window. The LSPC Model interface windows allow for easy copy/paste actions that enable seamless communication with spreadsheet software such as MS Excel.

9.1 Subfolder Structure

LSPC was designed to handle flexible input structure. However, a specific subfolder structure is recommended. Recall that paths were set in the MS Access database table Input-Output File Paths for the output files and weather files locations. Figure 9-1 presents an example of a subfolder structure.

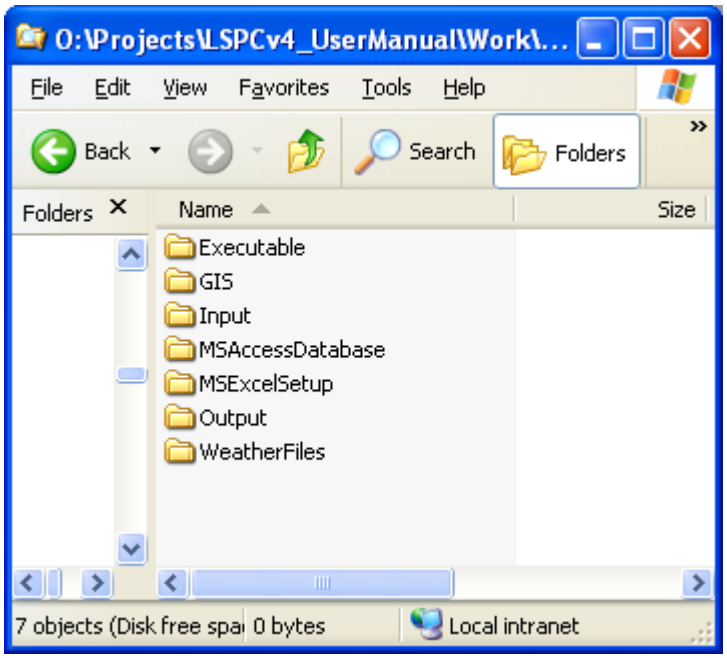


Figure 9-1. Example Subfolder Structure.

The Executable folder would contain the LSPC Model executable file. The GIS folder would hold the coverages specific to the LSPC project, for example if MapWindow was used to launch LSPC Model. Once ASCII *.INP files are developed and iteratively created, they can be stored in the Input folder. The MS Access database would be in the MSAccessDatabase folder. The setup file and accompanying land use (or HRU) ASCII *.CSV file can be in MSExcelSetup. Iterative scenario or calibration output runs could be further nested within subfolders in the Output folder. Last, the ASCII weather *.AIR files would be placed in the WeatherFiles folder.

 © 2012 County of Los Angeles. All rights reserved.

9.2 Loading an LSPC Model Application

The LSPC Model interface is a relatively simplified way of interacting with a complex model. It provides significant user access to developing, debugging, and executing simulations. The user has two ways to load data into the LSPC Model, which are discussed in the following sections.

9.2.1 Loading from MS Access Database

The initial way that an LSPC Model application is built is to retrieve model input from the MS Access database that has been developed through the previous sections. The LSPC Model interface is presented in Figure 9-2. To do this, select the **File** menu, then select **Get From Database**. A dialog box Figure 9-3 opens allowing the user to navigate to the MS Access database and select it.

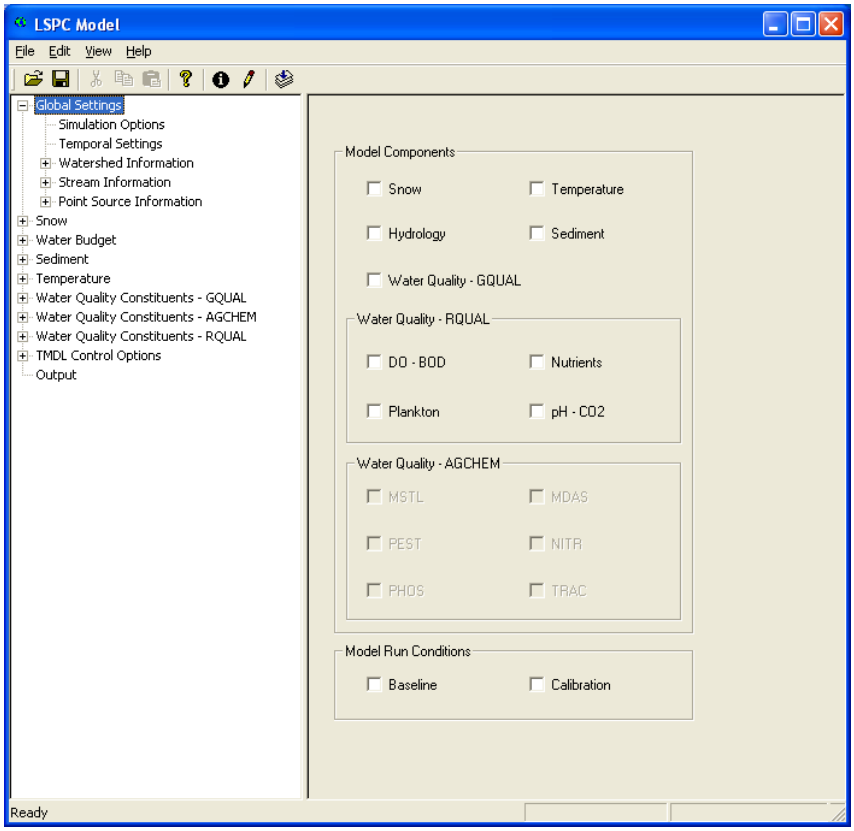


Figure 9-2. LSPC Model Interface.

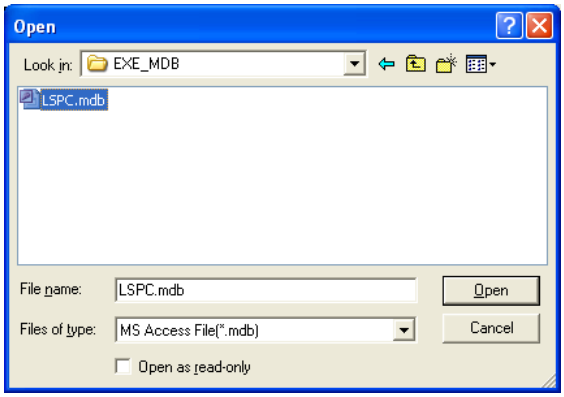


Figure 9-3. Dialog Box from the File Menu, Then Get From Database.

 © 2012 County of Los Angeles. All rights reserved.

Once the MS Access database is selected, a dialog box opens where the user must set a series of switches (Figure 9-4). It is important that a user make the appropriate selections. For example, if the user first wants to run upper-zone nominal storage (VUZFG) as a constant value but then later wants to run it with monthly values, it is a cumbersome revision. However, it is easier to switch to constant values after initially selecting monthly values.

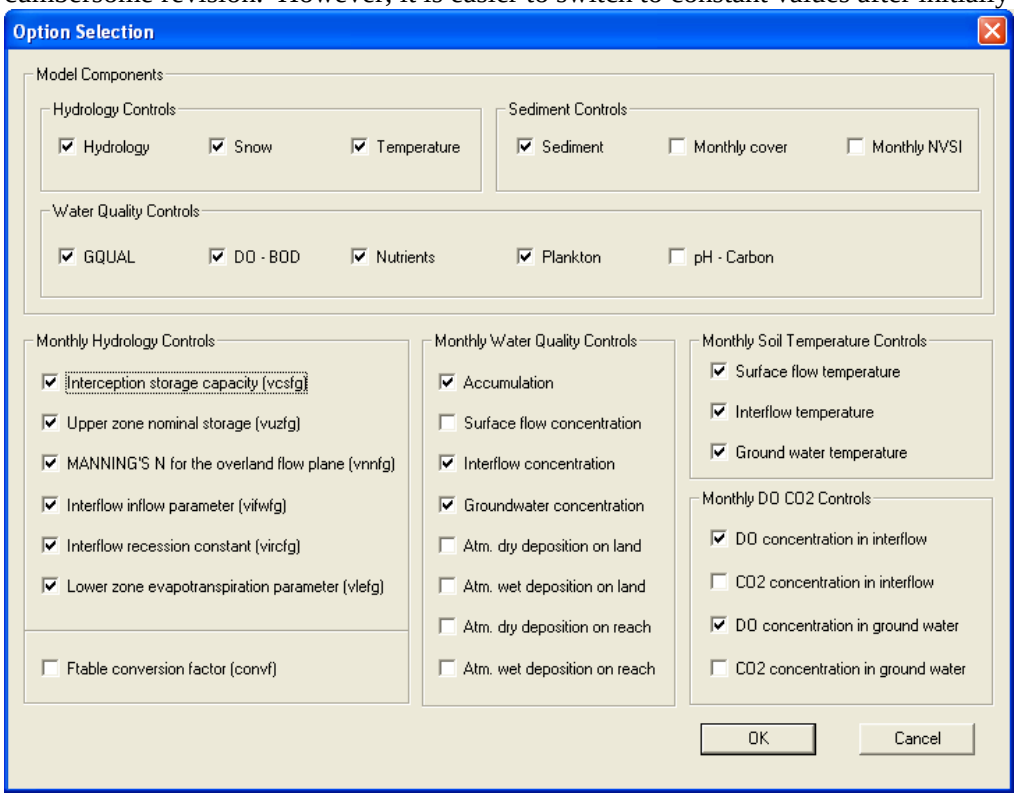


Figure 9-4. Option Selection Dialog Box from the File menu, Then Get From Database.

Once the information has been read from the MS Access database and loaded into the LSPC Model application, a user can save the application as an ASCII file (*.INP). This is done by clicking the **File** menu, then selecting **Save As**. It is recommended to save this ASCII *.INP file in the Input folder.

9.2.2 Loading from an ASCII Input File

An LSPC Model application can be iteratively worked with by accessing the ASCII *.INP input file. From the **File** menu, select **Open** and navigate to the file in the subfolder Input. The ASCII *.INP input file is constructed of many cards. Some of these cards are discussed in the following sections. Generally, the cards correspond to tables in the MS Access database and the interactive windows of the graphical user interface (GUI) for the LSPC Model. An example of the ASCII input file can be seen in Figure 9-5. Cards 0 10 and 15 can be seen in their entirety in this screen capture, which provides an illustration of generally how the remaining cards appear in the file. The descriptions provided at the top of each card are consistent with those available from using the Parameter Info feature of the interface.

 © 2012 County of Los Angeles. All rights reserved.

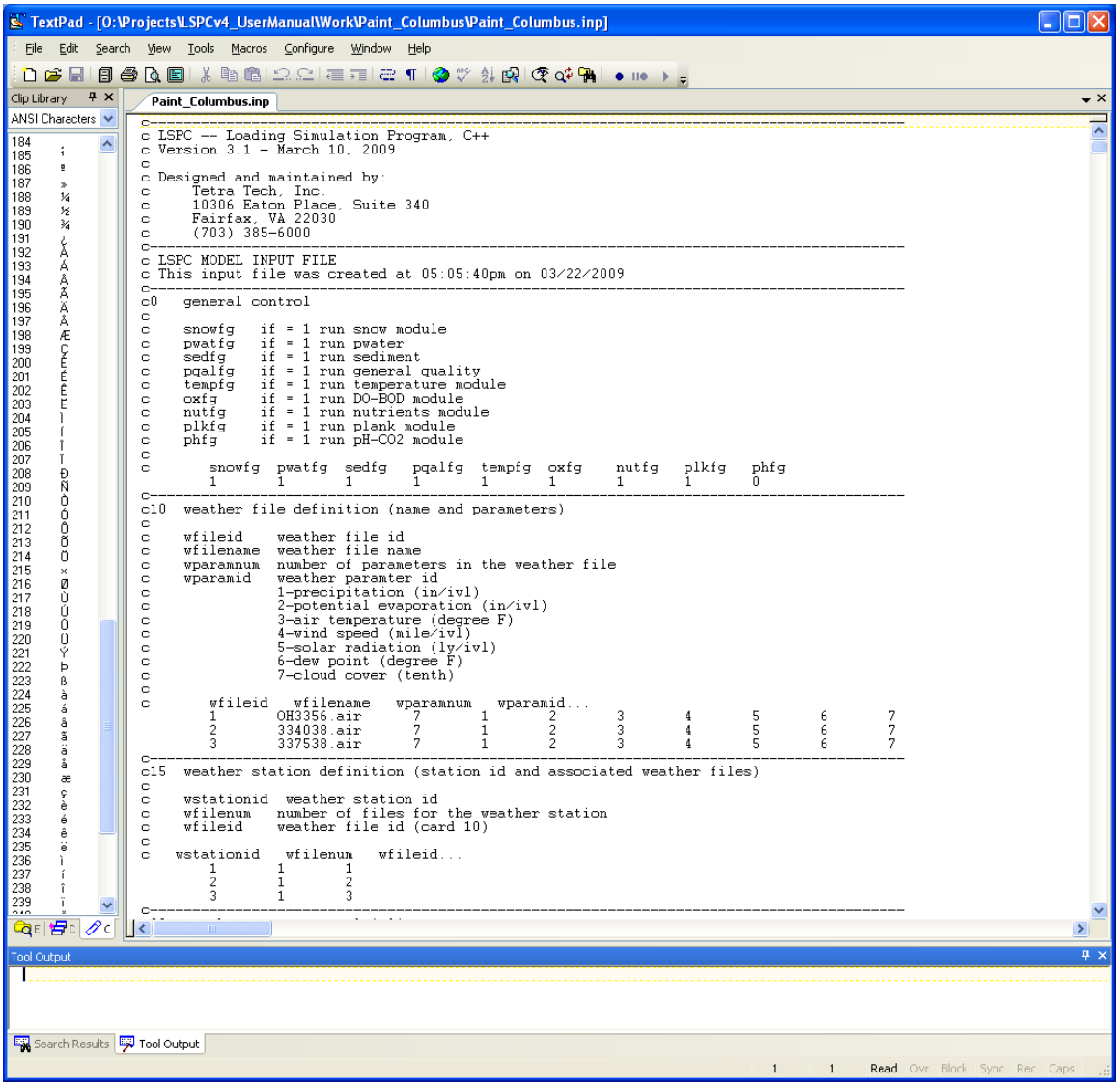


Figure 9-5. ASCII Project Input (*.INP) File.

9.2.3 Load Point Sources When Using ASCII Project Input File

When a session of LSPC Model is initiated by opening a project ASCII input file the point source information will automatically be red in. If a user modifies the point source information while an application of LSPC Model is open they may wish to load that revised point source information. The typical way to do this is by using the **File** menu, then selecting **Load/Reload Point Source Data From Database**. The ASCII input file already has the path information to navigate to the MS Access database file, on card 31.

9.2.4 Save Default Parameters Back to Database

The MS Access database has many advantages including housing all the input information, except for weather information, which is stored in ASCII text files. An additional feature is the ability to write back the calibrated default values to the database. While saving a project to a text file allows for archival of intermediate runs of the model, the step of saving model parameters back to the database, which can take several minutes, is typically done at the conclusion of a project after a final calibrated data set has been achieved. Below is a list of tables with records that are updated during this process:

- DefaultParm – records associated with all selected and active processes
- DefaultParmWQ – records associated with selected water quality constituents
- ModelFlags – All selected processes, flags, and selected model output options

 © 2012 County of Los Angeles. All rights reserved.

- TMDLTable – All values for all selected subbasin, land use, and pollutant combinations
- TMDLTablePS – All values associated with selected discharge and pollutant combinations

Note: The only tables that are updated are those containing model process-associated parameters. All other tables (such as land use, watershed physical, or weather station assignments) are not updated during this process. The reason for this is that because those other features represent physical characteristics of the watershed, which would not be changeable during calibration. For example, one would not typically change the area distribution of land use categories within a subbasin during a calibration process. Two example parameters in the set of values that are not updated include length of overland flow (LSUR) and slope of overland flow (SLSUR). While HSPF considers those to be parameters for calibration, LSPC treats the as physical features of the watershed. Therefore, they are stored as part of the land use card and not the hydrology parameters. The default parameters (which include parameters such as the infiltration index, upper and lower zone storage, and pollutant build-up/wash-off rates and in-stream transformation rates) represent process parameters that would be candidates for change from run to run during the calibration process. A change in any other features of the watershed would require a user to change the original model configuration for that change to be reflected in the database.

9.2.5 LSPC Model Interface

Once an application has been opened from either the MS Access database or an ASCII input file, the user can interact with the LSPC Model interface. As seen in Figure 9-2, the interface is relatively straightforward. It consists of several menus and icons across the top. On the left-hand side of the interface, the user can click to access various input windows regarding hydrology, water quality, and more. The various windows allow for parameter revisions, flag settings, and more. Later sections provide more discussion regarding the windows. The following sections discuss windows that present more general information or options.

9.3 Global Settings

Figure 9-6 presents the options under Global Settings. Generally these describe the framework of the application, the basic information about the subbasin land use, reaches, connectivity and more. Additionally, the user can review point source inputs to ensure inclusion in an application.

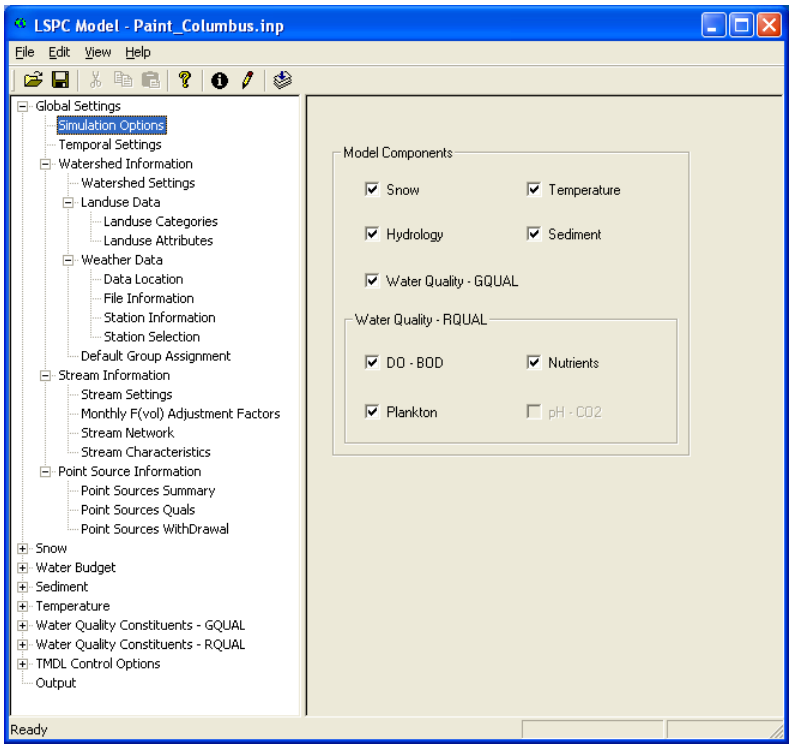
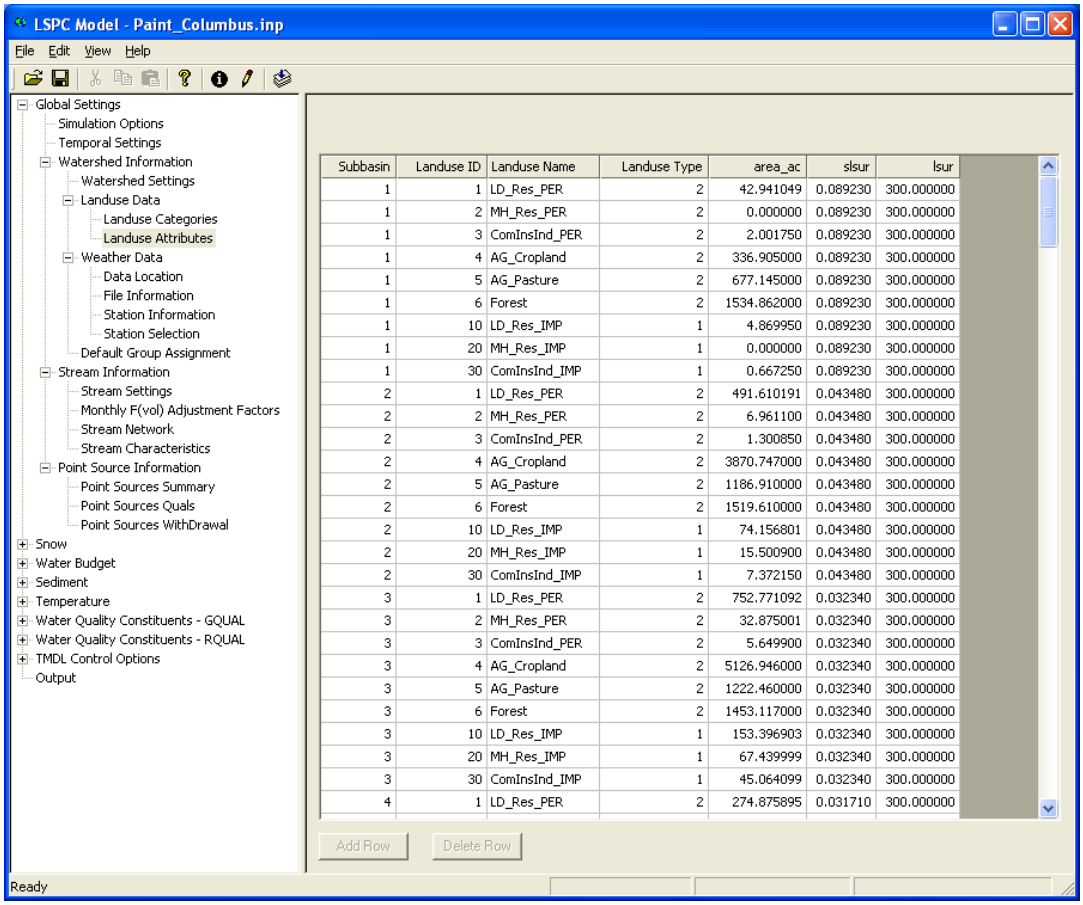


Figure 9-6. LSPC Model Interface.

 © 2012 County of Los Angeles. All rights reserved.

Figure 9-7 shows the land use (or HRU) information, and Figure 9-8 shows the dialog box from accessing the Parameter Info feature of the interface. (The Parameter Info feature can be accessed by clicking the button in the icon row at the top of the screen.) This is an appropriate example to step back and review Section 5.1, which describes with the MS Excel setup file to note how it related to what is seen in the LSPC Model interface. Furthermore, the Parameter Info (Figure 9-8) window provides explanations of the variables and indicates which card number it pertains to in the ASCII input file. The information is sorted by subbasin and shows the breakdown by model land unit, whether it is pervious or impervious, and the area in acres.



Subbasin	Landuse ID	Landuse Name	Landuse Type	area_ac	slsur	lsur
1	1	LD_Res_PER	2	42.941049	0.089230	300.000000
1	2	MH_Res_PER	2	0.000000	0.089230	300.000000
1	3	ComInsInd_PER	2	2.001750	0.089230	300.000000
1	4	AG_Cropland	2	336.905000	0.089230	300.000000
1	5	AG_Pasture	2	677.145000	0.089230	300.000000
1	6	Forest	2	1534.862000	0.089230	300.000000
1	10	LD_Res_IMP	1	4.869950	0.089230	300.000000
1	20	MH_Res_IMP	1	0.000000	0.089230	300.000000
1	30	ComInsInd_IMP	1	0.667250	0.089230	300.000000
2	1	LD_Res_PER	2	491.610191	0.043480	300.000000
2	2	MH_Res_PER	2	6.961100	0.043480	300.000000
2	3	ComInsInd_PER	2	1.300850	0.043480	300.000000
2	4	AG_Cropland	2	3870.747000	0.043480	300.000000
2	5	AG_Pasture	2	1186.910000	0.043480	300.000000
2	6	Forest	2	1519.610000	0.043480	300.000000
2	10	LD_Res_IMP	1	74.156801	0.043480	300.000000
2	20	MH_Res_IMP	1	15.500900	0.043480	300.000000
2	30	ComInsInd_IMP	1	7.372150	0.043480	300.000000
3	1	LD_Res_PER	2	752.771092	0.032340	300.000000
3	2	MH_Res_PER	2	32.875001	0.032340	300.000000
3	3	ComInsInd_PER	2	5.649900	0.032340	300.000000
3	4	AG_Cropland	2	5126.946000	0.032340	300.000000
3	5	AG_Pasture	2	1222.460000	0.032340	300.000000
3	6	Forest	2	1453.117000	0.032340	300.000000
3	10	LD_Res_IMP	1	153.396903	0.032340	300.000000
3	20	MH_Res_IMP	1	67.439999	0.032340	300.000000
3	30	ComInsInd_IMP	1	45.064099	0.032340	300.000000
4	1	LD_Res_PER	2	274.875895	0.031710	300.000000

Figure 9-7. Land Use Attributes Window.

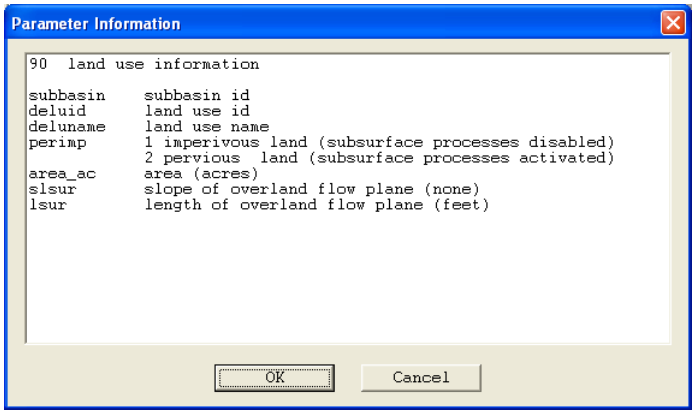


Figure 9-8. Parameter Info for Land Use Attributes Window.

Figure 9-9 shows the Stream Network window; Figure 9-10 shows the associated Parameter Info dialog box. Again, note that the Parameter Info dialog box also indicates the card number from the associated ASCII input file. The option to control writing output for a subbasin can be revised here. The run-time of an application can

 © 2012 County of Los Angeles. All rights reserved.

be reduced by only writing output for the subbasins of interest to a project (i.e., for comparing to observed data or transferring/linking output from LSPC to another model application). The connectivity can also be reviewed from this window as the receiving or downstream subbasin is noted.

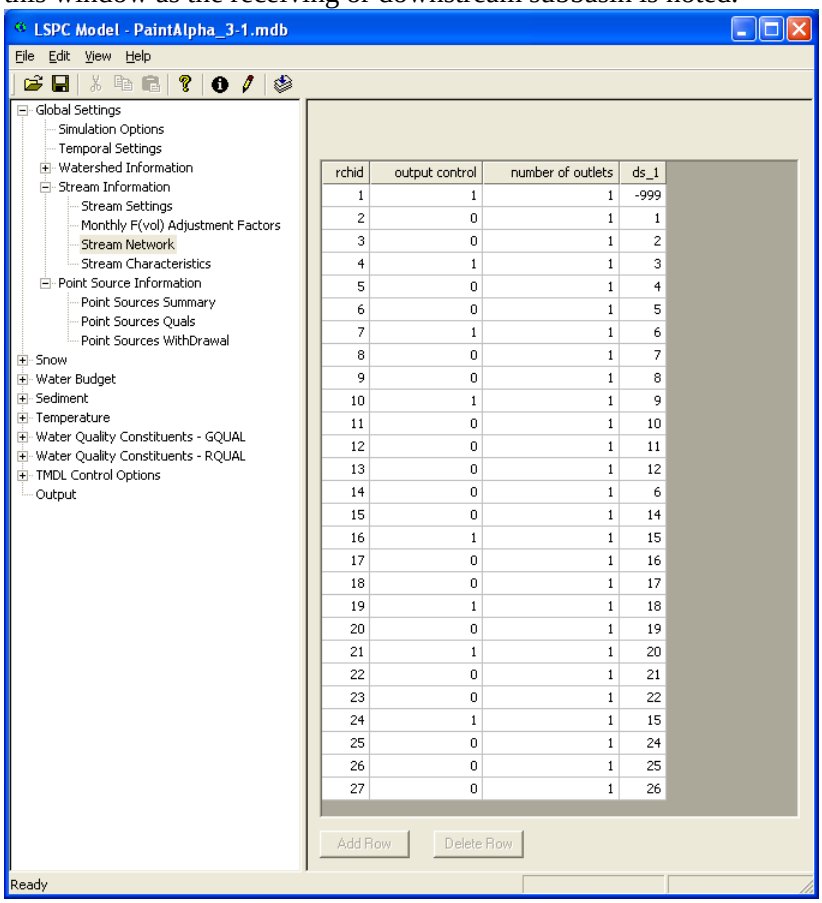


Figure 9-9. Stream Network Window.

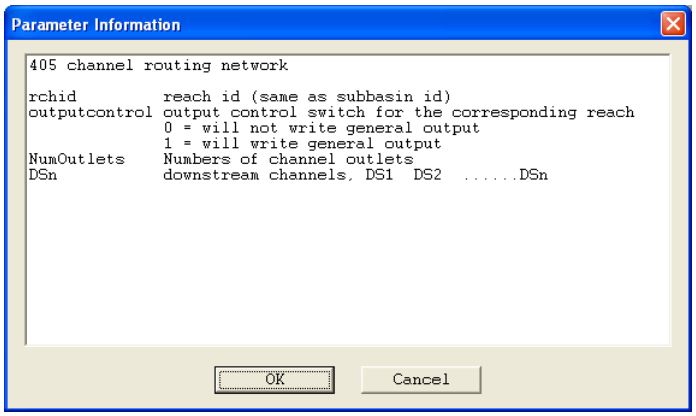


Figure 9-10. Parameter Info for Stream Network Window.

9.4 Snow

LSPC uses an energy balance approach to simulate snowfall and snow melt because it offers the most comprehensive physical basis for snow simulation. Although HSPF provides both an energy balance and a simpler degree-day option for snow simulation, LSPC only offers the energy balance option. Figure 9-11 shows the required snow parameter information for parameter group 1. Figure 9-12 shows the Parameter Info dialog box; note that card 93 in the ASCII input file is the corresponding card number for parameter group 1.

 © 2012 County of Los Angeles. All rights reserved.

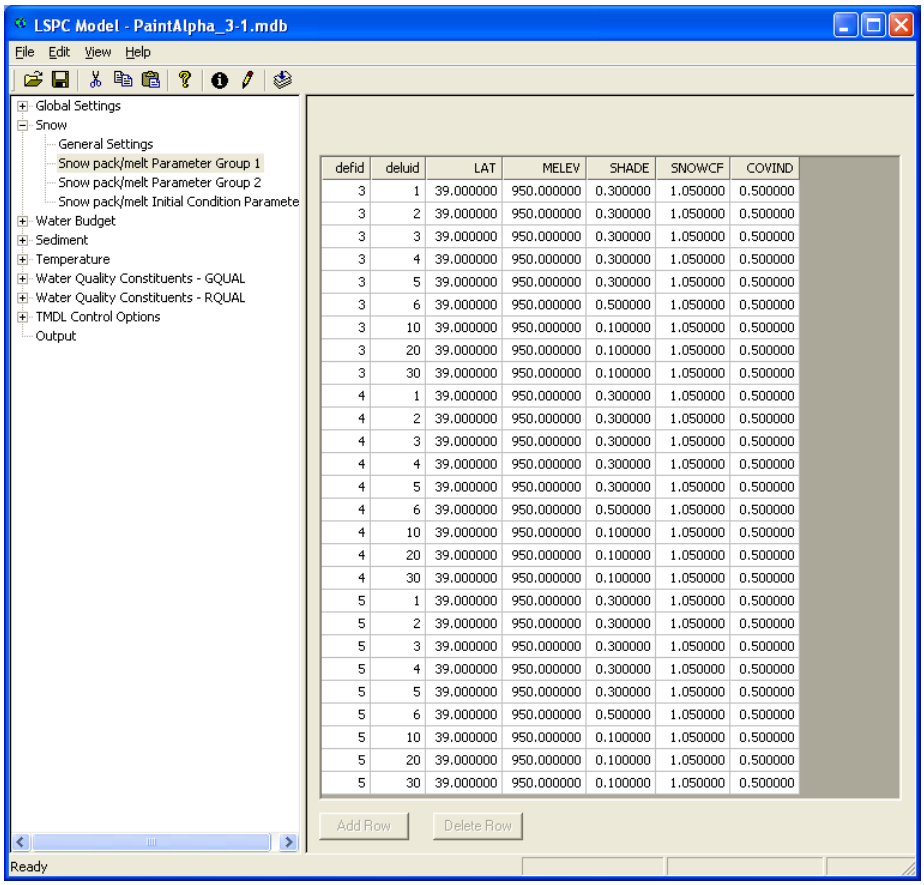


Figure 9-11. Snow Pack/Melt Parameter Group 1 Window.

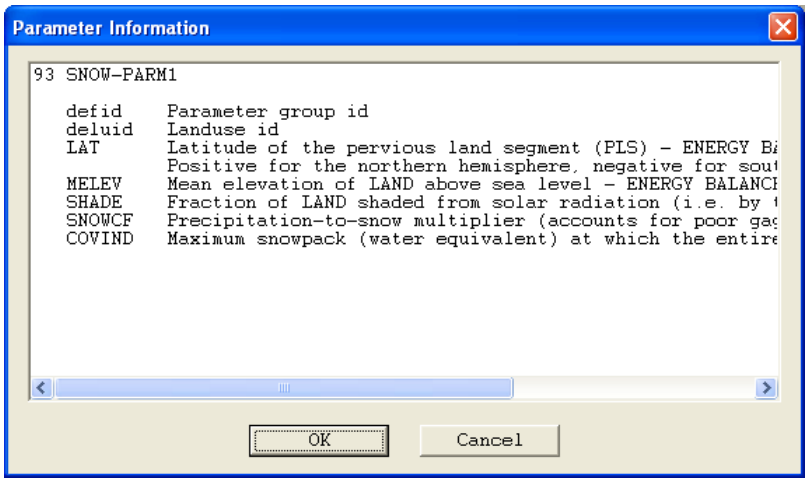


Figure 9-12. Parameter Info for Snow Pack/Melt Parameter Group 1 Window.

9.5 Water Budget

The water budget simulation is the cornerstone to an application. The water budget parameters are related to the default parameter group (DEFID) and model land units (DELUID). In addition to using the Parameter Info button on any window of the LSPC Model interface, Section 10.3 provides further description of the parameters and the card numbers. Figure 9-13 and Figure 9-14 show the parameters that are set as constant values only. Figure 9-15 shows the parameters that a user can choose to simulate as constant or monthly varying, Figure 9-16 shows where a user would input the values if the constant option is chosen. If a user chooses monthly, it is a good practice to enter zero for the parameters in the Water Budget Parameter Group 3 constant window. Figure 9-17 provides an

 © 2012 County of Los Angeles. All rights reserved.

example of monthly varying interception. The remaining five parameters from Water Budget Parameter Group 3 have similar input windows. Initial conditions for a simulation can be edited from the water budget initial conditions window (Figure 9-18).

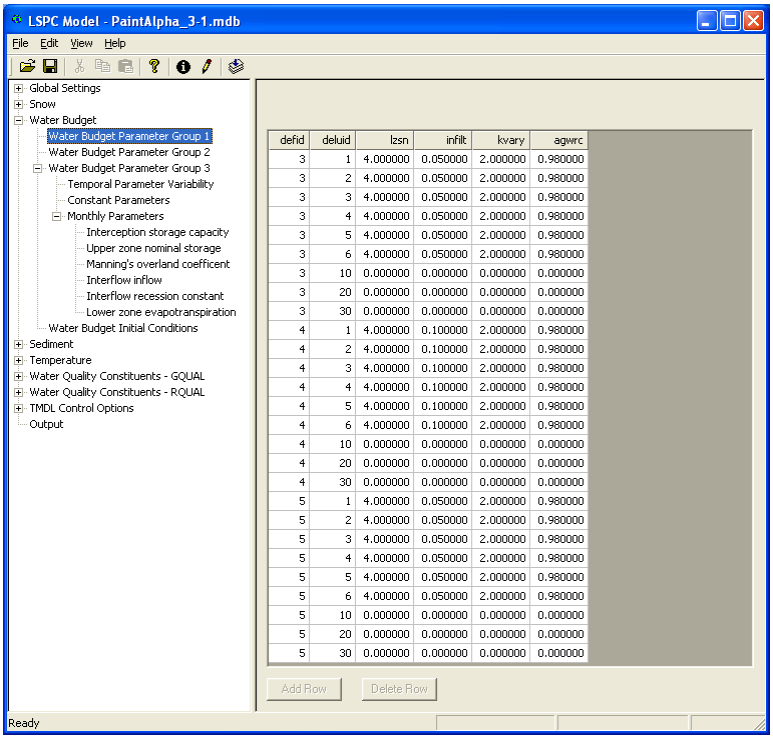


Figure 9-13. Water Budget Parameter Group 1 Window.

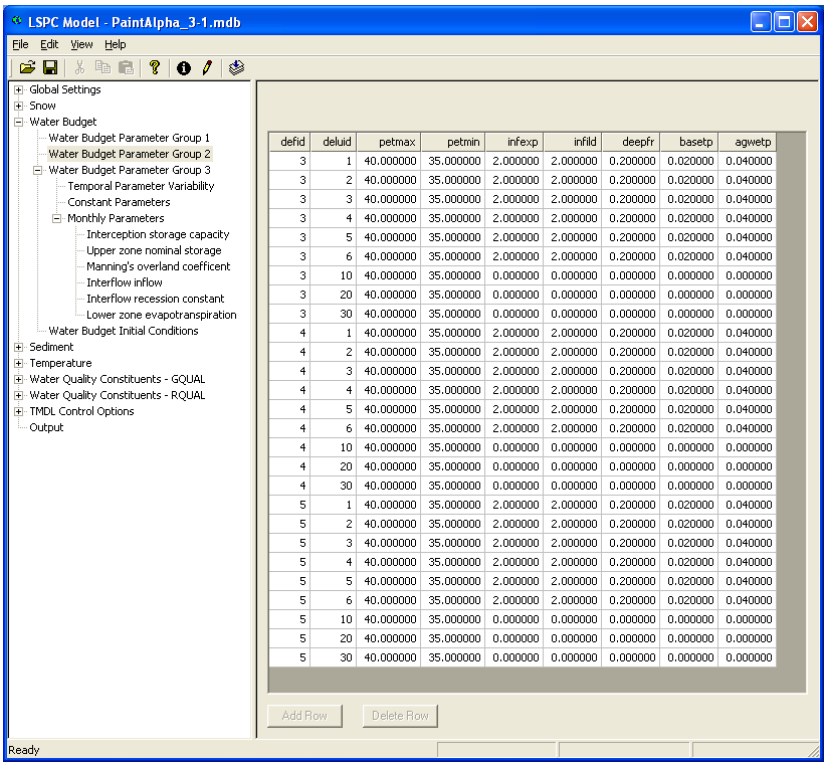


Figure 9-14. Water Budget Parameter Group 2 Window.

 © 2012 County of Los Angeles. All rights reserved.

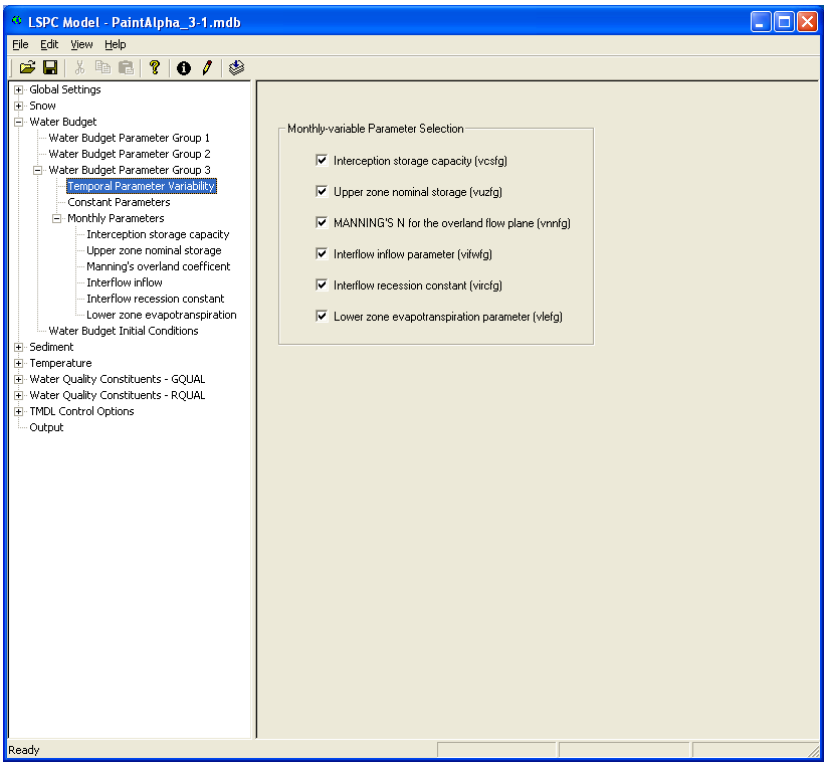
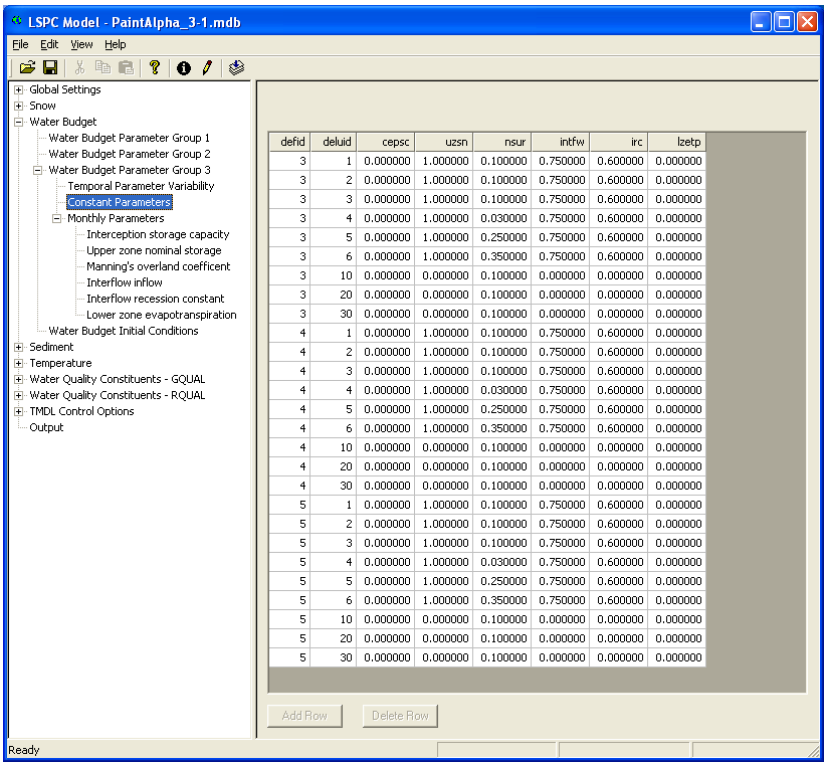


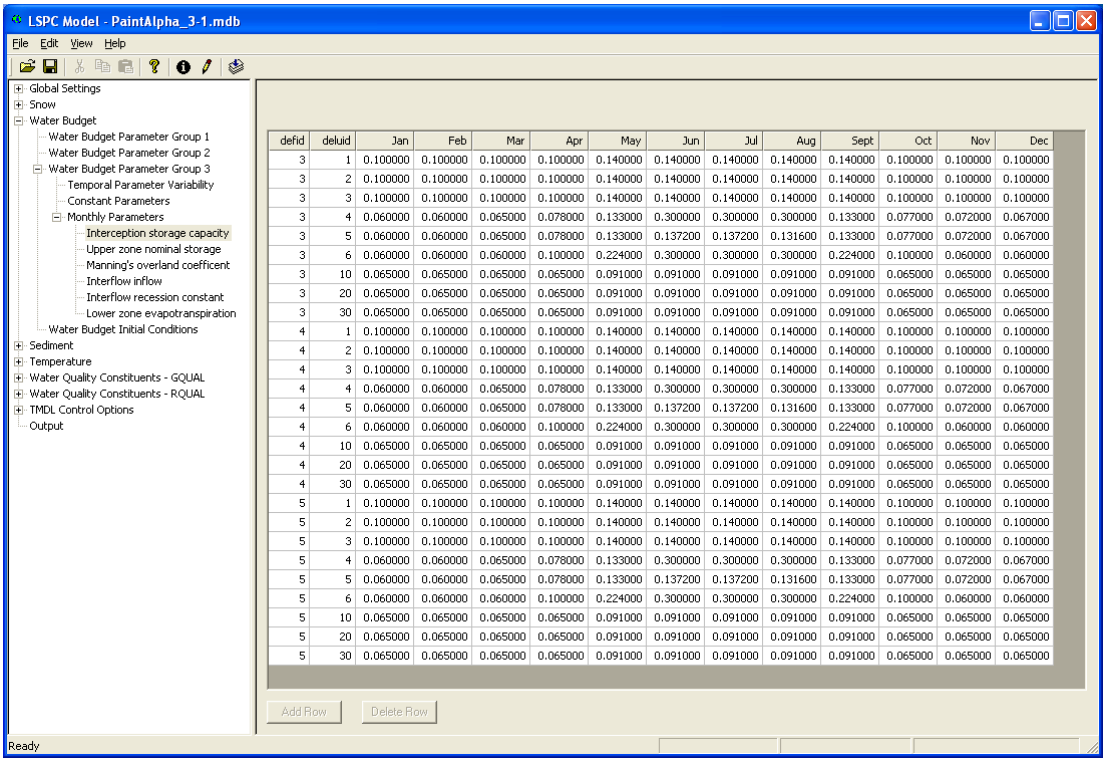
Figure 9-15. Water Budget Parameter Group 3 Constant/Monthly Switches Window.



defid	deluid	cepsc	uzsn	nsur	intfw	irc	lzetp
3	1	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
3	2	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
3	3	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
3	4	0.000000	1.000000	0.030000	0.750000	0.600000	0.000000
3	5	0.000000	1.000000	0.250000	0.750000	0.600000	0.000000
3	6	0.000000	1.000000	0.350000	0.750000	0.600000	0.000000
3	10	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
3	20	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
3	30	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
4	1	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
4	2	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
4	3	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
4	4	0.000000	1.000000	0.030000	0.750000	0.600000	0.000000
4	5	0.000000	1.000000	0.250000	0.750000	0.600000	0.000000
4	6	0.000000	1.000000	0.350000	0.750000	0.600000	0.000000
4	10	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
4	20	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
4	30	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
5	1	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
5	2	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
5	3	0.000000	1.000000	0.100000	0.750000	0.600000	0.000000
5	4	0.000000	1.000000	0.030000	0.750000	0.600000	0.000000
5	5	0.000000	1.000000	0.250000	0.750000	0.600000	0.000000
5	6	0.000000	1.000000	0.350000	0.750000	0.600000	0.000000
5	10	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
5	20	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000
5	30	0.000000	0.000000	0.100000	0.000000	0.000000	0.000000

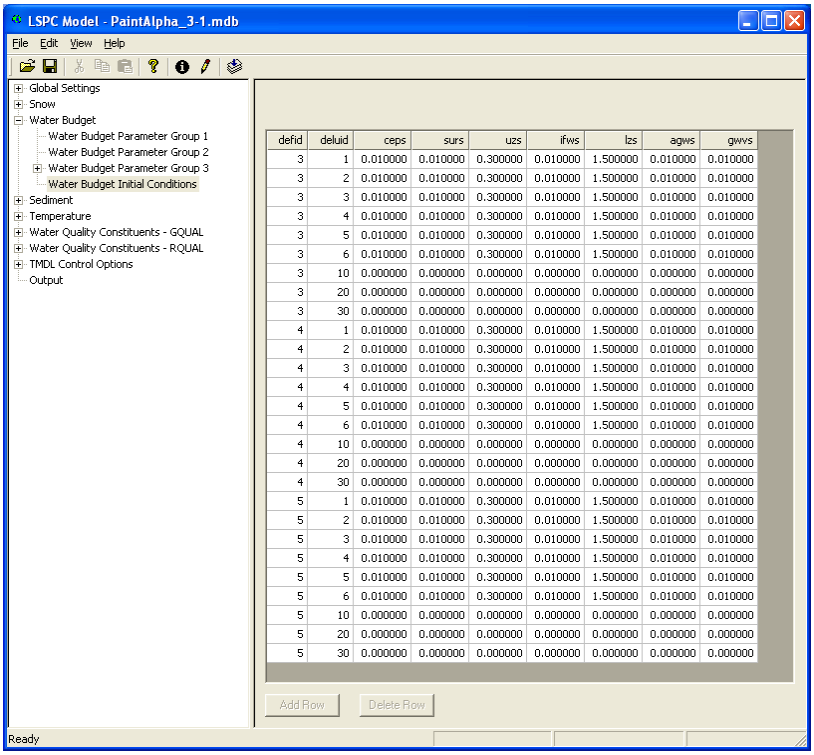
Figure 9-16. Water Budget Parameter Group 3 Constant Parameters Window.

 © 2012 County of Los Angeles. All rights reserved.



defid	deluid	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
3	1	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
3	2	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
3	3	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
3	4	0.060000	0.060000	0.065000	0.078000	0.133000	0.300000	0.300000	0.300000	0.133000	0.077000	0.072000	0.067000
3	5	0.060000	0.060000	0.065000	0.078000	0.133000	0.137200	0.137200	0.131600	0.133000	0.077000	0.072000	0.067000
3	6	0.060000	0.060000	0.060000	0.100000	0.224000	0.300000	0.300000	0.300000	0.224000	0.100000	0.060000	0.060000
3	10	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
3	20	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
3	30	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
4	1	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
4	2	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
4	3	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
4	4	0.060000	0.060000	0.065000	0.078000	0.133000	0.300000	0.300000	0.300000	0.133000	0.077000	0.072000	0.067000
4	5	0.060000	0.060000	0.065000	0.078000	0.133000	0.137200	0.137200	0.131600	0.133000	0.077000	0.072000	0.067000
4	6	0.060000	0.060000	0.060000	0.100000	0.224000	0.300000	0.300000	0.300000	0.224000	0.100000	0.060000	0.060000
4	10	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
4	20	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
4	30	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
5	1	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
5	2	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
5	3	0.100000	0.100000	0.100000	0.100000	0.140000	0.140000	0.140000	0.140000	0.140000	0.100000	0.100000	0.100000
5	4	0.060000	0.060000	0.065000	0.078000	0.133000	0.300000	0.300000	0.300000	0.133000	0.077000	0.072000	0.067000
5	5	0.060000	0.060000	0.065000	0.078000	0.133000	0.137200	0.137200	0.131600	0.133000	0.077000	0.072000	0.067000
5	6	0.060000	0.060000	0.060000	0.100000	0.224000	0.300000	0.300000	0.300000	0.224000	0.100000	0.060000	0.060000
5	10	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
5	20	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000
5	30	0.065000	0.065000	0.065000	0.065000	0.091000	0.091000	0.091000	0.091000	0.091000	0.065000	0.065000	0.065000

Figure 9-17. Water Budget Parameter Group 3 Interception Storage Capacity Window.



defid	deluid	ceps	surs	uzs	ifws	lzs	agws	gwvs
3	1	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
3	2	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
3	3	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
3	4	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
3	5	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
3	6	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
3	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	30	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	1	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
4	2	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
4	3	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
4	4	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
4	5	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
4	6	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
4	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	30	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	1	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
5	2	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
5	3	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
5	4	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
5	5	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
5	6	0.010000	0.010000	0.300000	0.010000	1.500000	0.010000	0.010000
5	10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	30	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 9-18. Water Budget Initial Conditions Window.

 © 2012 County of Los Angeles. All rights reserved.

9.6 Sediment

The sediment module is used to represent three classes of sediment, silt, clay, and sand. A few of the LSPC Model interface windows are presented in Figure 9-19 through Figure 9-22. Reviewing these along with the further discussions in Section 10.6 help a user understand the various cards and parameters. In addition, while using the LSPC Model interface, a user can access the Parameter Info function on any window.

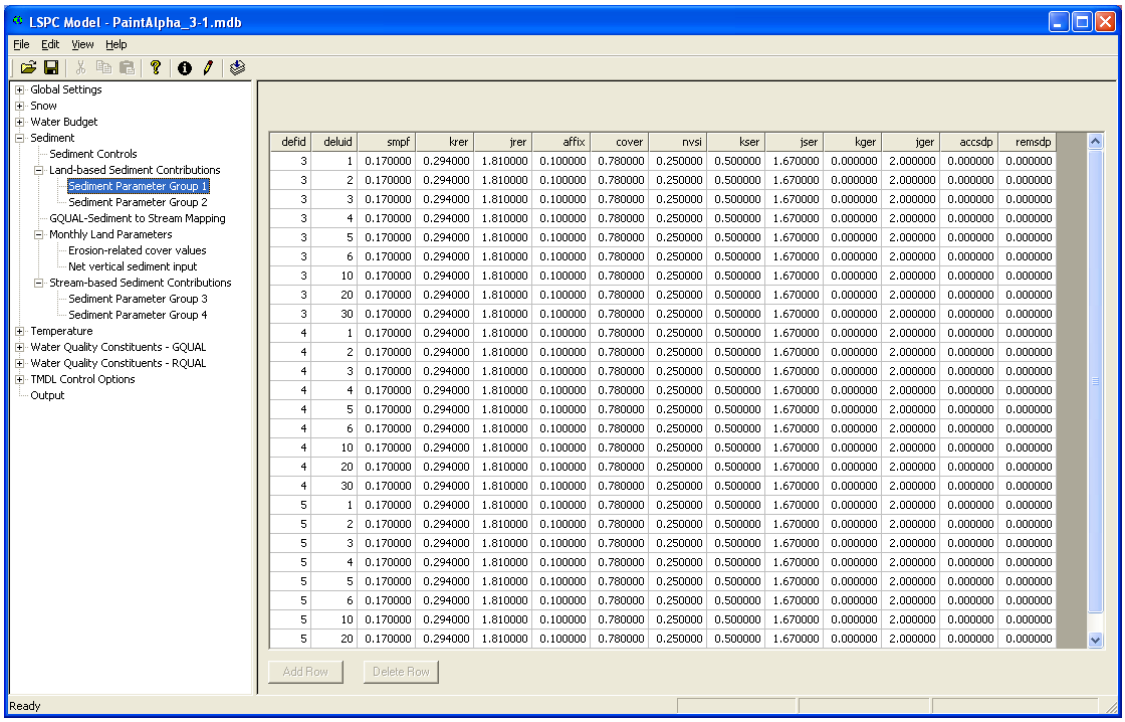


Figure 9-19. Sediment Parameter Group 1 Window.

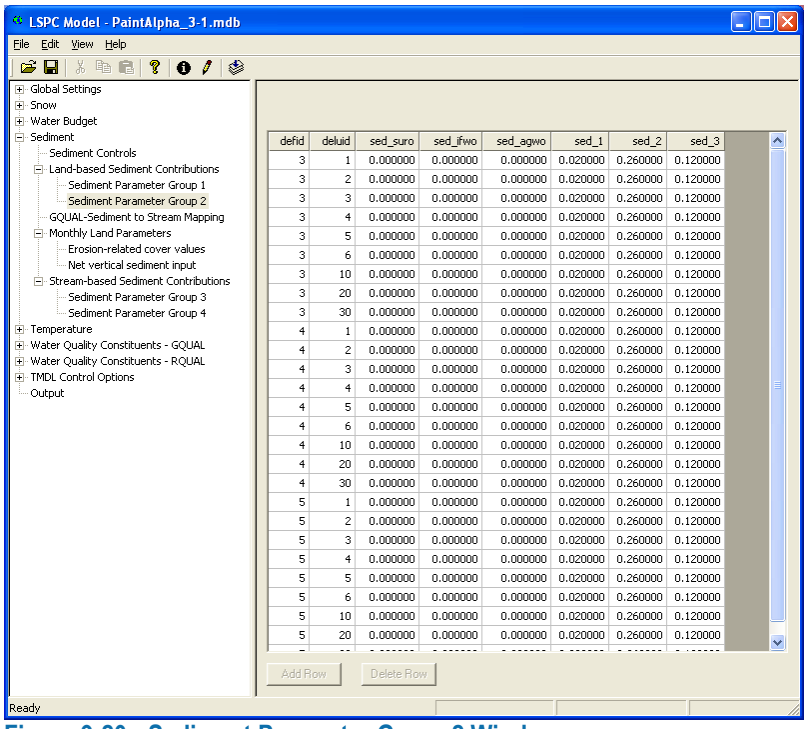


Figure 9-20. Sediment Parameter Group 2 Window.

 © 2012 County of Los Angeles. All rights reserved.

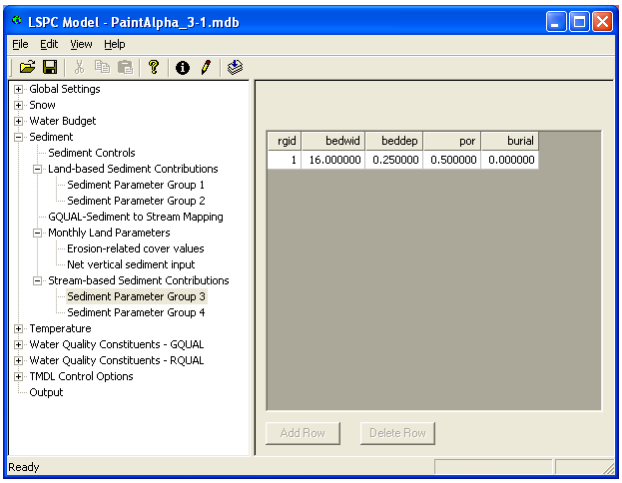


Figure 9-21. Sediment Parameter Group 3 Window.

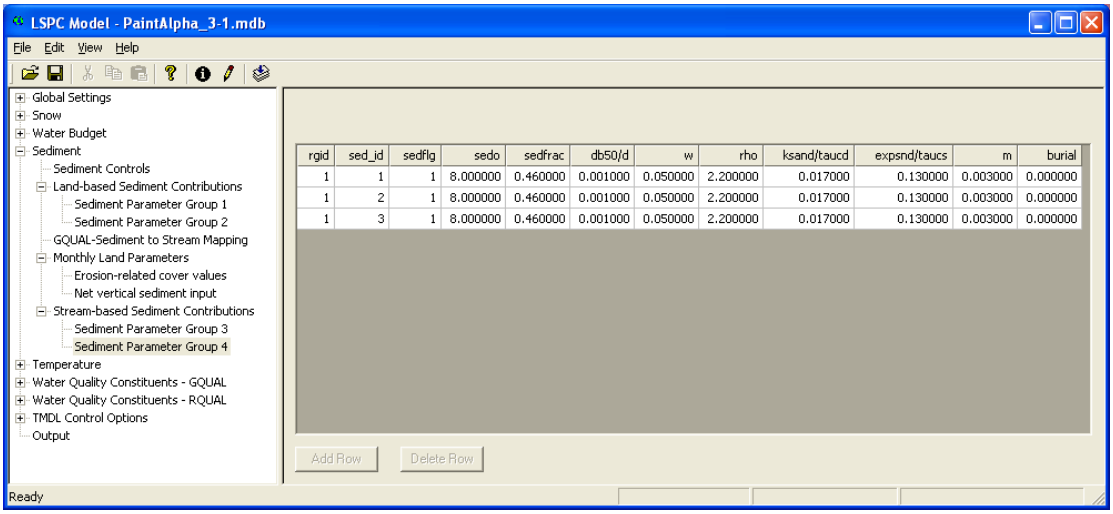


Figure 9-22. Sediment Parameter Group 4 Window.

9.7 Temperature

The temperature module represents water temperature from the three flowpaths of the land surface as well as stream heat budget interaction with the atmosphere. Further discussion regarding the temperature module is in Section 10.4. Figure 9-23 shows the window used for the setting of constant or monthly values for water temperature parameters by flowpath. If constant values were selected, they would be set in the Soil Temperature Constant Parameters window (Figure 9-24). Parameter ASLT is shown in Figure 9-25 to illustrate the population of a monthly varying parameter by flowpath, which is similar for the remaining monthly parameters. The Surface Temperature Parameters (Figure 9-26) indicate elevation differences between combinations of default parameter group (DEFID) and model land unit (DELUID) and the assigned weather station. The last figure (Figure 9-27) shows the stream temperature parameters.

 © 2012 County of Los Angeles. All rights reserved.

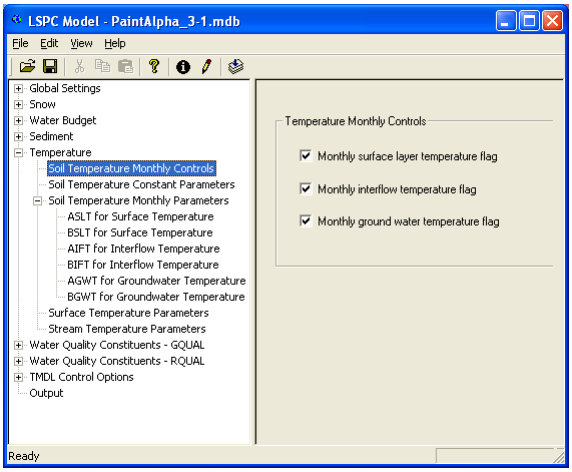


Figure 9-23. Soil Temperature Monthly Controls Window.

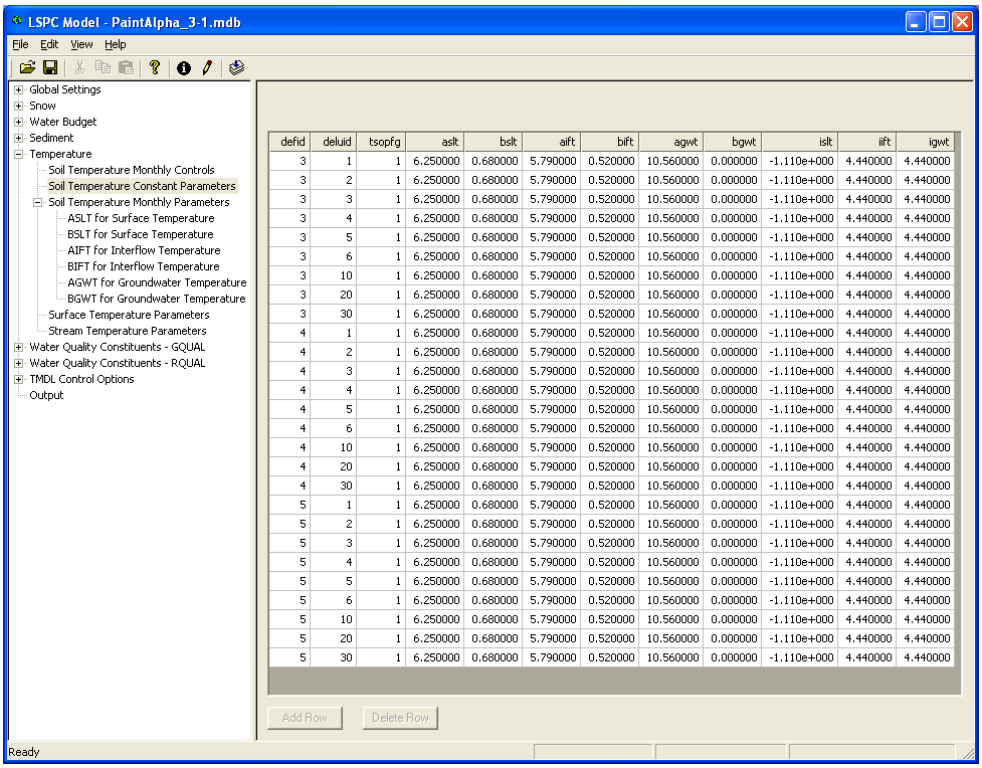
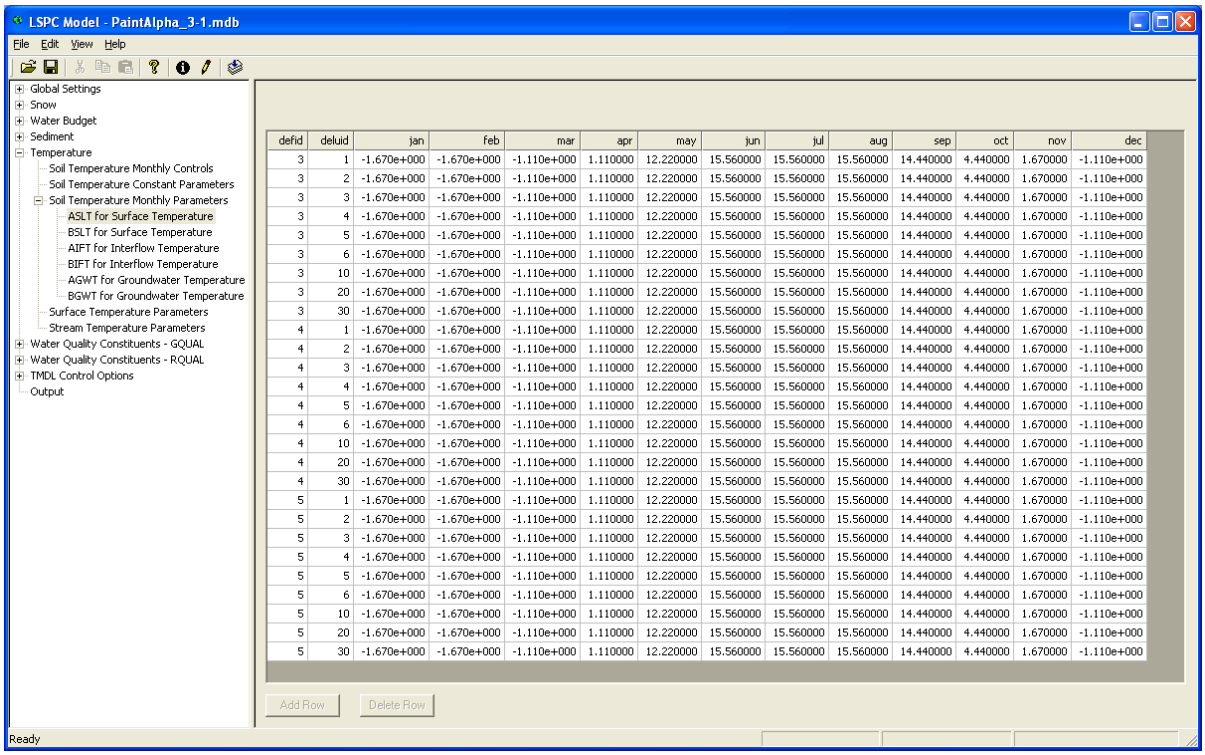


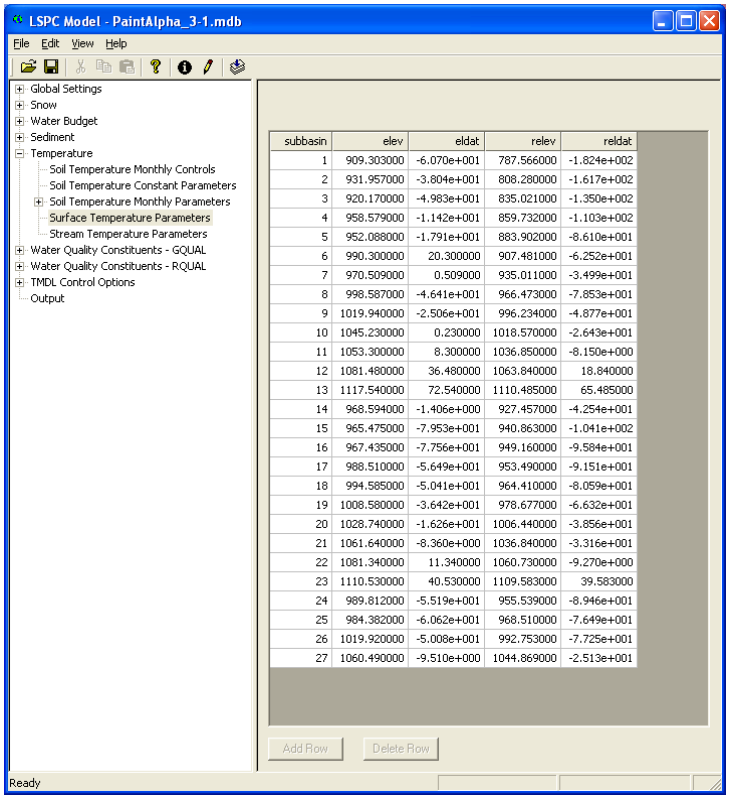
Figure 9-24. Soil Temperature Constant Parameters Window.

 © 2012 County of Los Angeles. All rights reserved.



defid	deluid	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
3	1	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	2	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	3	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	4	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	5	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	6	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	10	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	20	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
3	30	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	1	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	2	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	3	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	4	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	5	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	6	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	10	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	20	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
4	30	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	1	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	2	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	3	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	4	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	5	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	6	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	10	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	20	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000
5	30	-1.670e+000	-1.670e+000	-1.110e+000	1.110000	12.220000	15.560000	15.560000	15.560000	14.440000	4.440000	1.670000	-1.110e+000

Figure 9-25. Soil Temperature Monthly Parameters ASLT for Surface Temperature Window.



subbasin	elev	eldat	relev	reldat
1	909.303000	-6.070e+001	787.566000	-1.824e+002
2	931.957000	-3.804e+001	808.280000	-1.617e+002
3	920.170000	-4.983e+001	835.021000	-1.350e+002
4	958.579000	-1.142e+001	859.732000	-1.103e+002
5	952.088000	-1.791e+001	883.902000	-8.610e+001
6	990.300000	20.300000	907.481000	-6.252e+001
7	970.509000	0.509000	935.011000	-3.499e+001
8	998.587000	-4.641e+001	966.473000	-7.853e+001
9	1019.940000	-2.506e+001	996.234000	-4.877e+001
10	1045.230000	0.230000	1018.570000	-2.643e+001
11	1053.300000	8.300000	1036.850000	-8.150e+000
12	1081.480000	36.480000	1063.840000	18.840000
13	1117.540000	72.540000	1110.485000	65.485000
14	968.594000	-1.406e+000	927.457000	-4.254e+001
15	965.475000	-7.953e+001	940.863000	-1.041e+002
16	967.435000	-7.756e+001	949.160000	-9.584e+001
17	988.510000	-5.649e+001	953.490000	-9.151e+001
18	994.585000	-5.041e+001	964.410000	-8.059e+001
19	1008.580000	-3.642e+001	978.677000	-6.632e+001
20	1028.740000	-1.626e+001	1006.440000	-3.856e+001
21	1061.640000	-8.360e+000	1036.840000	-3.316e+001
22	1081.340000	11.340000	1060.730000	-9.270e+000
23	1110.530000	40.530000	1109.583000	39.583000
24	989.812000	-5.519e+001	955.539000	-8.946e+001
25	984.382000	-6.062e+001	968.510000	-7.649e+001
26	1019.920000	-5.008e+001	992.753000	-7.725e+001
27	1060.490000	-9.510e+000	1044.869000	-2.513e+001

Figure 9-26. Surface Temperature Parameters Window.

 © 2012 County of Los Angeles. All rights reserved.

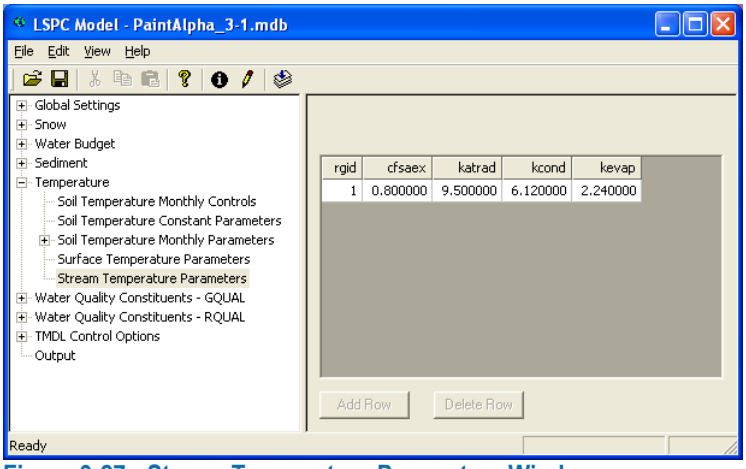


Figure 9-27. Stream Temperature Parameters Window.

9.8 GQUAL

The general quality (GQUAL) routine is used to represent water quality constituents derived from the land surface, via the three flowpaths (surface, interflow, and ground water) used in the model. It is important to recognize that GQUAL primarily relates to the land processes and is separate from RQUAL, see Section 10.5.1 for further discussion. It is a combination of build-up/wash-off process and concentration assignments. The constituents selected for an application are shown in the General Settings window (Figure 9-28). The selection of constant or monthly values for specific parameters is shown in Water Quality Controls (Figure 9-29). If constant values are used for a parameter, they would be prescribed in the Constant Loading Parameters window (Figure 9-30). Figure 9-31 shows an example of monthly input values for accumulation rate, the windows for the other user-selected monthly varying parameters would look similar. The GQUAL routine also offers a first-order decay representation of stream kinetics (Figure 9-32).

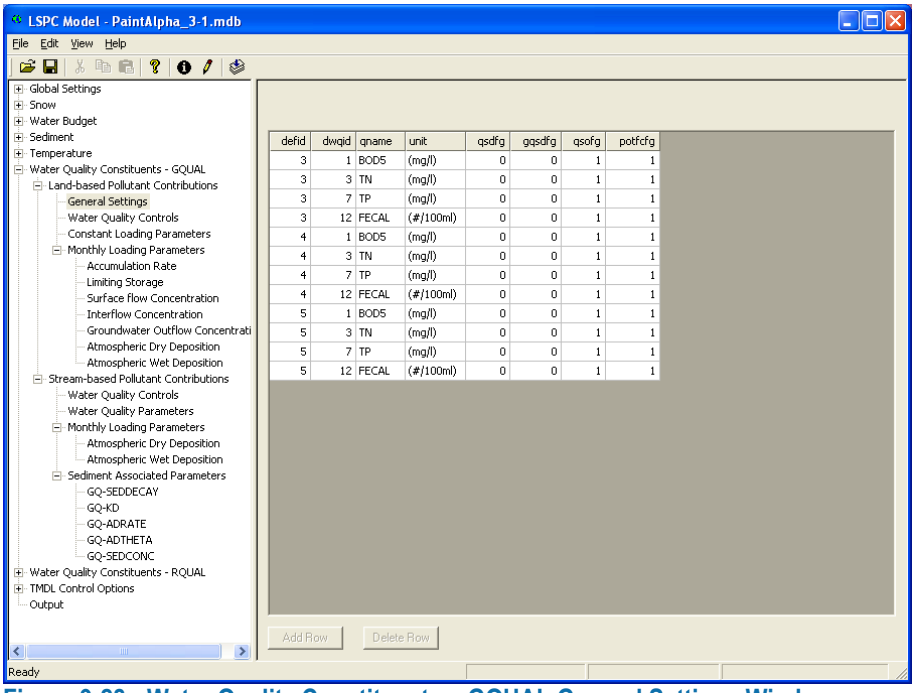


Figure 9-28. Water Quality Constituents – GQUAL General Settings Window.

 © 2012 County of Los Angeles. All rights reserved.

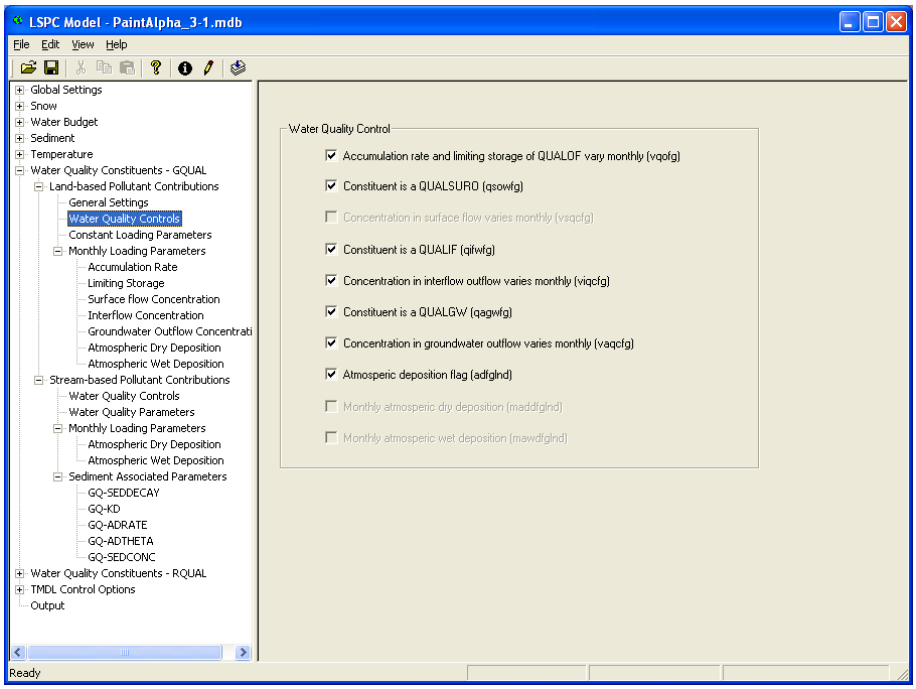


Figure 9-29. Water Quality Constituents – GQUAL Water Quality Controls Window.

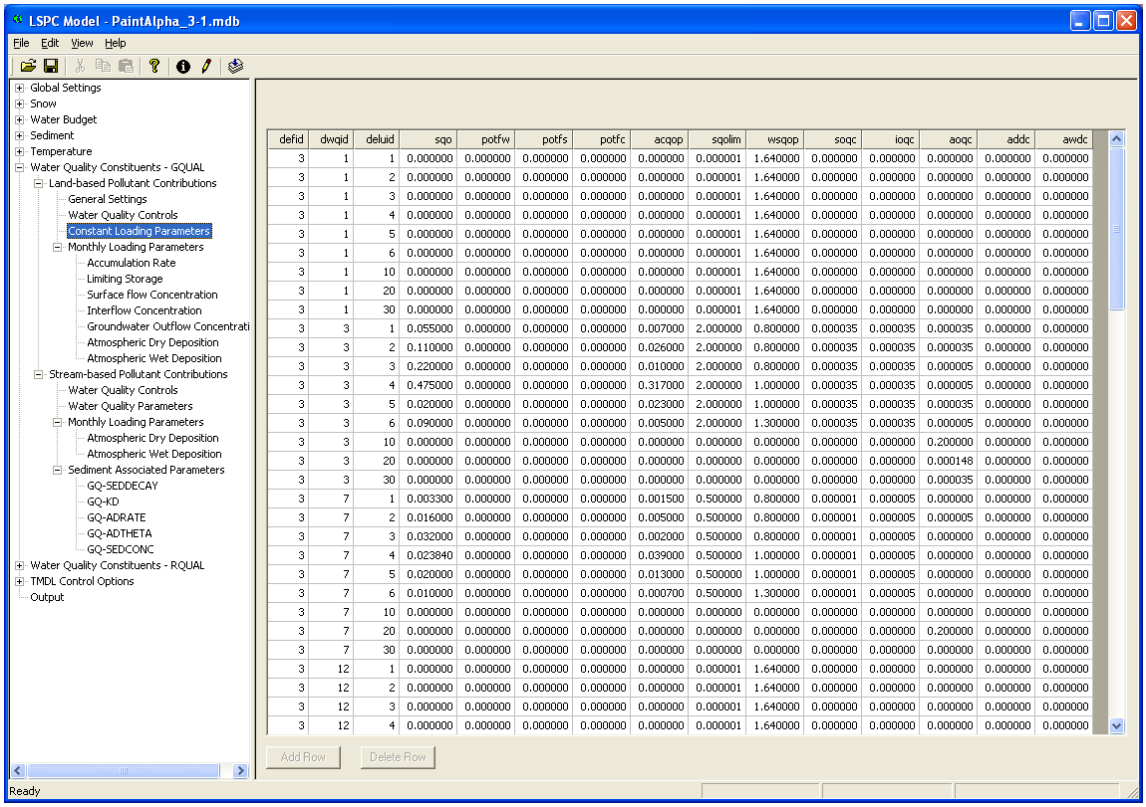


Figure 9-30. Water Quality Constituents – GQUAL Constant Loading Parameters Window.

 © 2012 County of Los Angeles. All rights reserved.

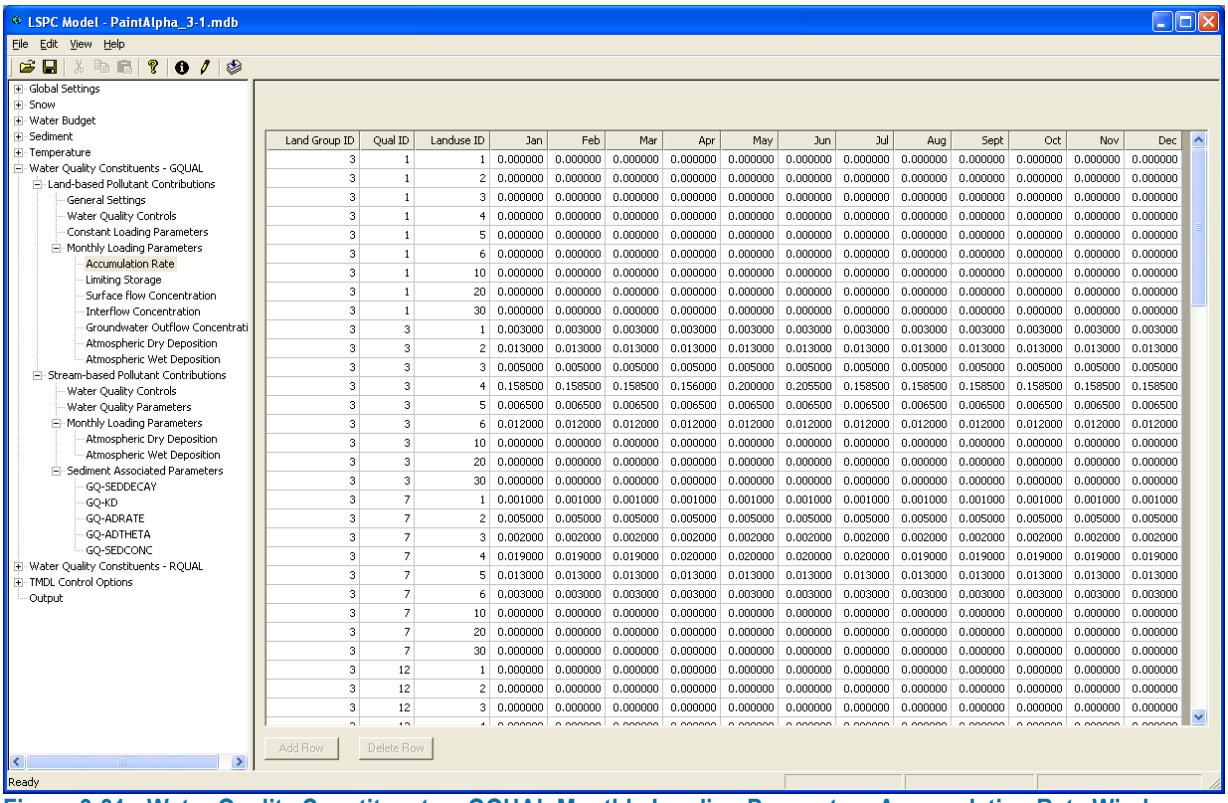


Figure 9-31. Water Quality Constituents – GQUAL Monthly Loading Parameters Accumulation Rate Window.

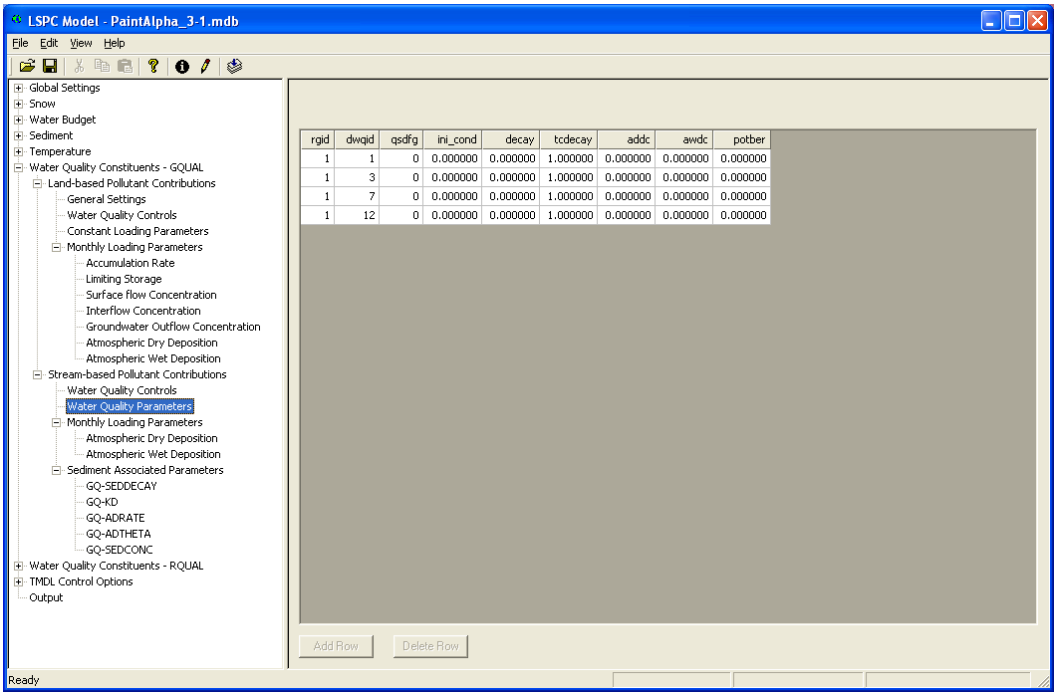


Figure 9-32. Water Quality Constituents – GQUAL Stream-Based Pollutant Contributions Water Quality Parameters Window.

 © 2012 County of Los Angeles. All rights reserved.

9.9 RQUAL

The reach quality (RQUAL) module allows for more robust simulation of stream kinetics. It includes simulation of the various nitrogen and phosphorus species, DO-BOD, plankton, and more. Note, again, that it is important to understand the general difference of GQUAL (land-based water quality and first-order stream representation) and RQUAL (robust stream kinetics). Also, the land representation of water quality from GQUAL can be mapped to the stream simulation of RQUAL (Figure 9-33). Figure 9-34 through Figure 9-37 provide a sample of various windows accessible from the LSPC Model interface; however, further discussion of the RQUAL cards and parameter descriptions is in Section 10.5.2 and Section 10.5.3.

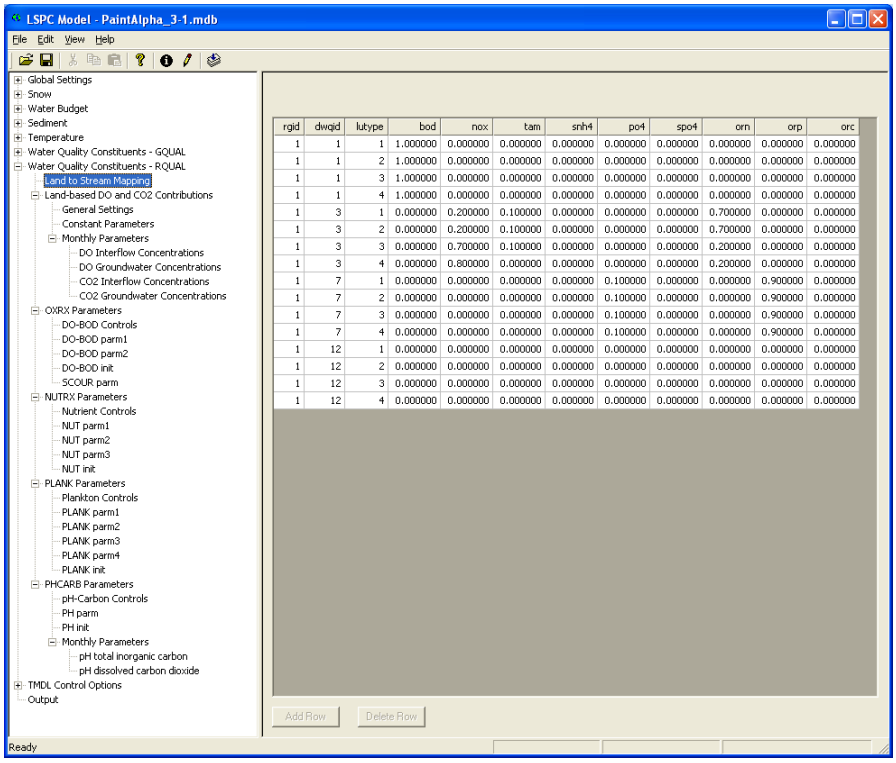


Figure 9-33. Water Quality Constituents – RQUAL Land to Stream Mapping Window.

 © 2012 County of Los Angeles. All rights reserved.

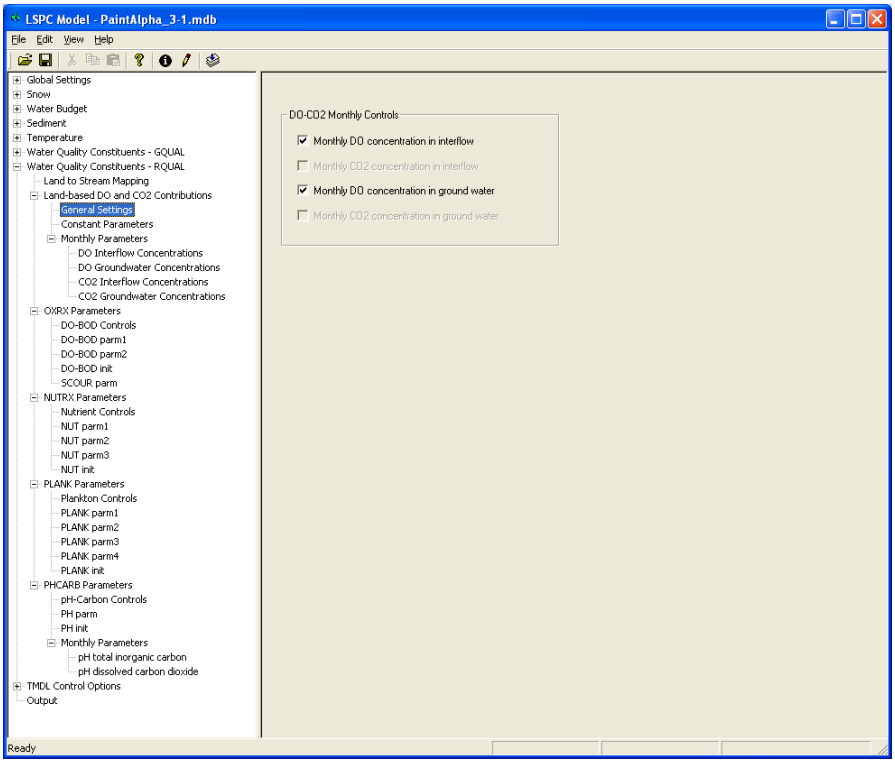


Figure 9-34. Water Quality Constituents—RQUAL Land-Based DO and CO2 Contributions General Settings Window.

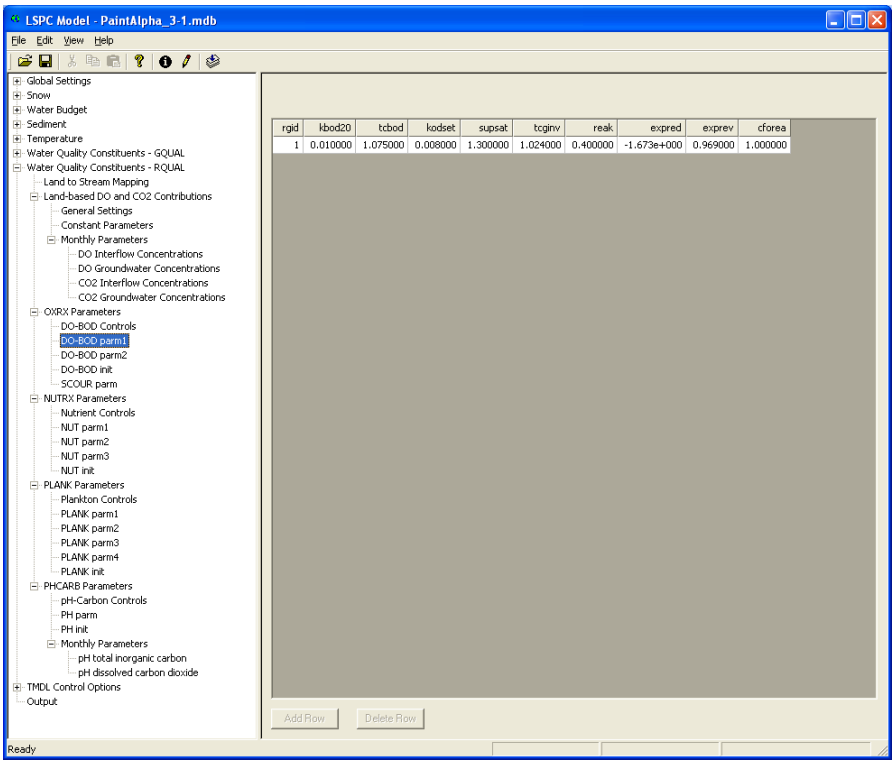


Figure 9-35. Water Quality Constituents—RQUAL OXRX Parameters DO-BOD Parm1 Window.

 © 2012 County of Los Angeles. All rights reserved.

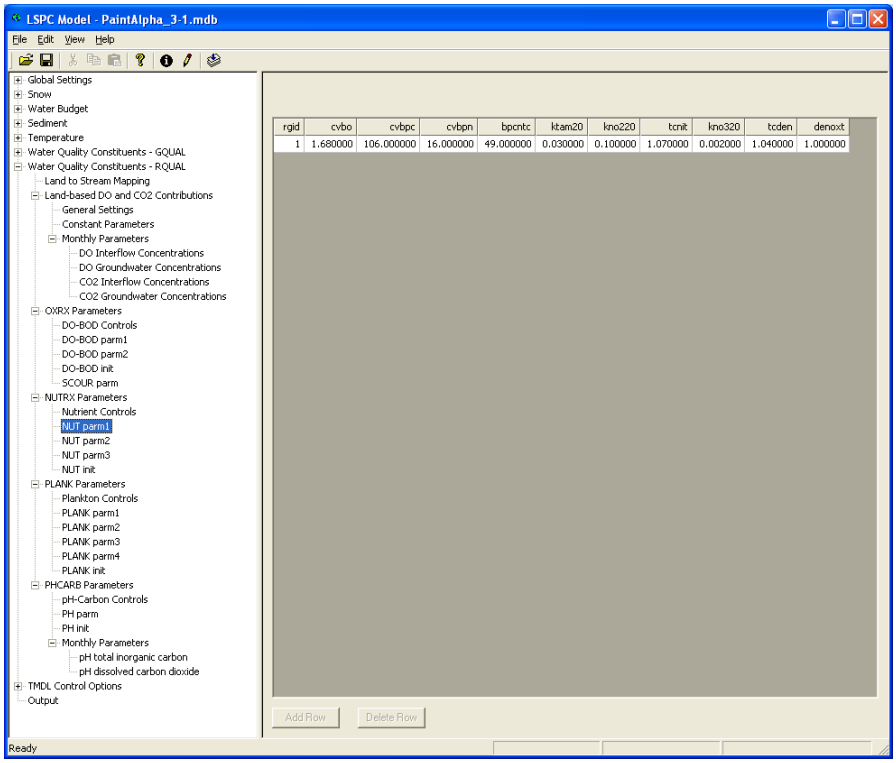


Figure 9-36. Water Quality Constituents—RQUAL NUTRX Parameters NUT Parm1 Window.

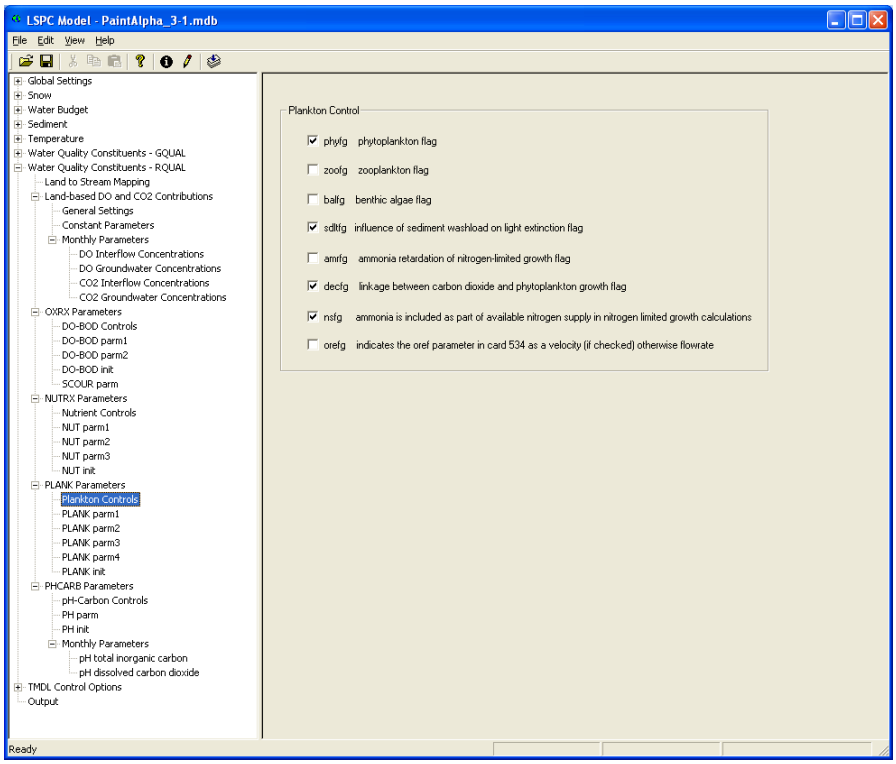
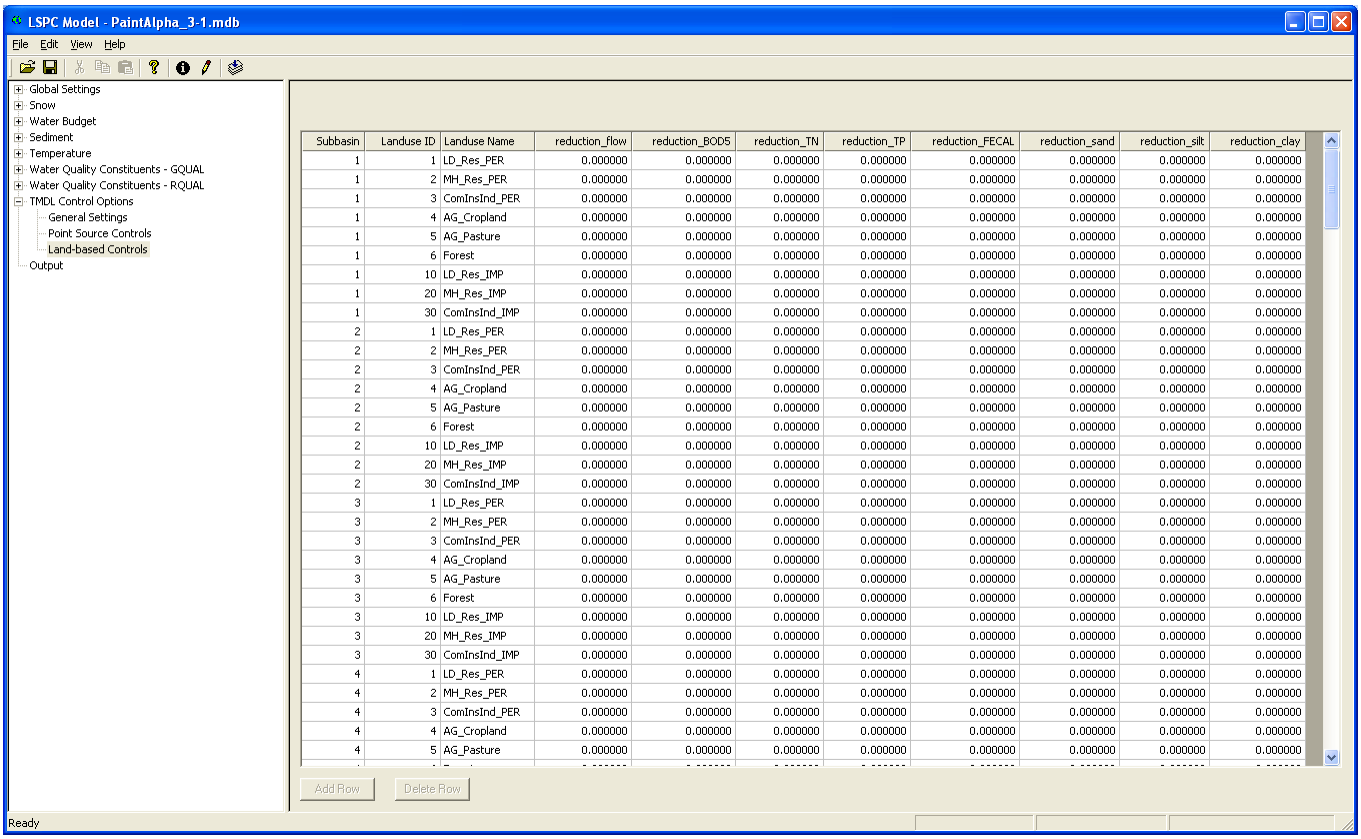


Figure 9-37. Water Quality Constituents—RQUAL PLANK Parameters Plankton Controls Window.

 © 2012 County of Los Angeles. All rights reserved.

9.10 TMDL Control Options

The TMDL control option allows a user to explore a variety of simple reduction scenarios. A user can apply a reduction factor to land-based or point-source-based pollutant load contributions. The factors can be different for each point source and pollutant combination. Figure 9-38 shows the Land-Based Controls window where a user can apply flow or quality constituent reduction factors (or both) to any combination of subbasin and model land unit (DELUID).



Subbasin	Landuse ID	Landuse Name	reduction_flow	reduction_BOD5	reduction_TN	reduction_TP	reduction_FECAL	reduction_sand	reduction_silt	reduction_clay
1	1	LD_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	2	MH_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	3	ComInsInd_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	4	AG_Cropland	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	5	AG_Pasture	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	6	Forest	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	10	LD_Res_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	20	MH_Res_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	30	ComInsInd_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	1	LD_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	2	MH_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	3	ComInsInd_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	4	AG_Cropland	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	5	AG_Pasture	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	6	Forest	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	10	LD_Res_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	20	MH_Res_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	30	ComInsInd_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	1	LD_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	2	MH_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	3	ComInsInd_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	4	AG_Cropland	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	5	AG_Pasture	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	6	Forest	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	10	LD_Res_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	20	MH_Res_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	30	ComInsInd_IMP	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	1	LD_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	2	MH_Res_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	3	ComInsInd_PER	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	4	AG_Cropland	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	5	AG_Pasture	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 9-38. TMDL Control Options Land-Based Controls Window.

9.11 Output

A user has the choice of running a simulation with standard output selected (Figure 9-39) or customizing the output to serve specific needs. Standard output includes hydrologic and water quality output by flowpath as well as module used, that is GQUAL, RQUAL, and .or sediment. A user can also choose to output preselected groups of model time series for specific simulation modules or fully customize output by selecting from a comprehensive list of available model time series. Note that LSPC outputs information for only those modules that are active among the simulation options.

LSPC also provides the option of outputting time aggregated model summary results by land use (surface, interflow, and ground water) or by stream segment. The results for those two options are time aggregated over the user-defined simulation output period. For example, if the user selects “Landuse Summary” and “Av_Annual,” and the output period is defined as 9/30/1998–10/31/2008, the model creates a “landuse.csv” file that contains 10-year average annualized results by land use and subbasin for each modeled land constituent (such as surface, interflow, and ground water contributions for flow, sediment, and pollutant load). Similar to the Landuse Summary option, the Stream Summary option generates a “stream.csv” file that contains time aggregated results by stream segment. For each stream segment, it creates a full mass-balance suite of outputs such as inflows, outflows by outlet, point source contributions, and withdrawals. Both of these files are designed for easy

 © 2012 County of Los Angeles. All rights reserved.

linkage and association within a database file for generating additional summaries and reports (such as unit area loading by land use or subbasin).

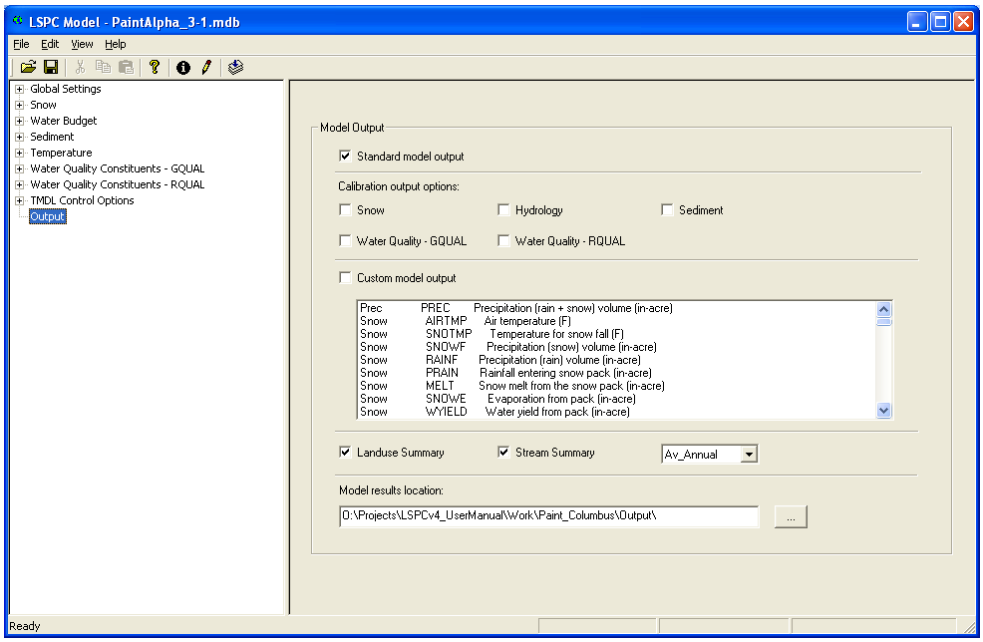


Figure 9-39. Output Window.

 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

10 Discussion and Examples

This chapter highlights the routines available in LSPC. Recall that LSPC is based on the HSPF algorithms; therefore, the HSPF documentation is often quoted in the following sections. The equations and formulas from existing HSPF documentation are not repeated in this manual. The purpose of this chapter is to provide discussion and examples, by way of parameter sensitivity analyses, of the most commonly used parameters. The objective is to provide the reader with a practical and functional understanding of the behavior and sensitivity of selected model parameters. The reader is encouraged to access and review the equations from HSPF user manual to supplement the LSPC user manual.

When an LSPC project is loaded into the model interface for simulation, all the physical configuration data and associated process parameter information are categorized into a series of cards. In HSPF, the cards are analogous to parameter blocks. In most cases, the variable names for process parameters that are used in the LSPC cards are the same as those used in HSPF.

10.1 Hypothetical Example Application

A hypothetical LSPC application was constructed for instructive purposes. This example application is referenced in some of the following sections. The application consists of five subbasins in series (Figure 8-8). Each subbasin is the same area (6,400 acres or 10 square miles) and the total area for the example application is 32,000 acres (50 square miles). The land use breakdown is presented in Table 10-1 and Table 10-2. Note that 50 percent of the example application was set to forest (DELUID = 6) and 6 percent was set to urban impervious (DELUID = 4). The upstream watershed is subbasin 105 and the downstream watershed is subbasin 101. Each subbasin has a reach of 2.5 miles in length and a slope of 0.001 m/m. One weather station was applied to all subbasins in the example application.

Table 10-1 Example Application Land Use Areas (Acres)

Subbasin	Water DELUID = 1	Wetland DELUID = 2	Urban Pervious DELUID = 3	Urban Impervious DELUID = 4	Agriculture DELUID = 5	Forest DELUID = 6	Total
101	64	64	1,280	640	1,152	3,200	6,400
102	64	640	192	64	1,280	4,160	6,400
103	64	64	320	192	4,160	1,600	6,400
104	64	64	192	64	1,536	4,480	6,400
105	64	64	2,560	1,088	128	2,496	6,400
Total	320	896	4,544	2,048	8,256	15,936	32,000

Table 10-2 Example Application Land Use Areas (Percent)

Subbasin	Water DELUID = 1	Wetland DELUID = 2	Urban Pervious DELUID = 3	Urban Impervious DELUID = 4	Agriculture DELUID = 5	Forest DELUID = 6	Total
101	1%	1%	20%	10%	18%	50%	100%
102	1%	10%	3%	1%	20%	65%	100%
103	1%	1%	5%	3%	65%	25%	100%
104	1%	1%	3%	1%	24%	70%	100%
105	1%	1%	40%	17%	2%	39%	100%
Total	1%	3%	14%	6%	26%	50%	100%

The ASCII input files for all the examples discussed in this manual are in the <\INP\> subfolder, which was included with the installation of LSPC. These files were developed by first extracting from the MS Access database, then creating the baseline input file <Baseline_Full.inp>, and then modifying the baseline file to create a respective example scenario.

 © 2012 County of Los Angeles. All rights reserved.

10.2 Snow Simulation

In certain locations, snowfall and snowmelt have a dominant impact on hydrology and associated water quality. The method used to simulate snow behavior in LSPC is the energy balance method. In addition to precipitation, the energy balance requires temperature, dew point temperature, wind speed, and solar radiation as meteorological drivers. The SNOW module uses the meteorological information to determine whether precipitation falls as rain or snow, how long the snowpack remains, and when snowpack melting occurs. Heat is transferred into or out of the snowpack through net radiation heat, convection of sensible heat from the air, latent heat transfer by moist air condensation on the snowpack, rain, and conduction from the ground beneath the snowpack. The snowpack essentially acts like a reservoir that has specific thermodynamic rules for how water is released. Melting occurs when the liquid portion of the snowpack exceeds the snowpack's holding capacity; melted snow is added to the hydrologic cycle. Figure 10-1 is a schematic of the snow process. Table 10-5 is a list of SNOW parameter cards. Table 10-6 lists and describes the SNOW parameters.

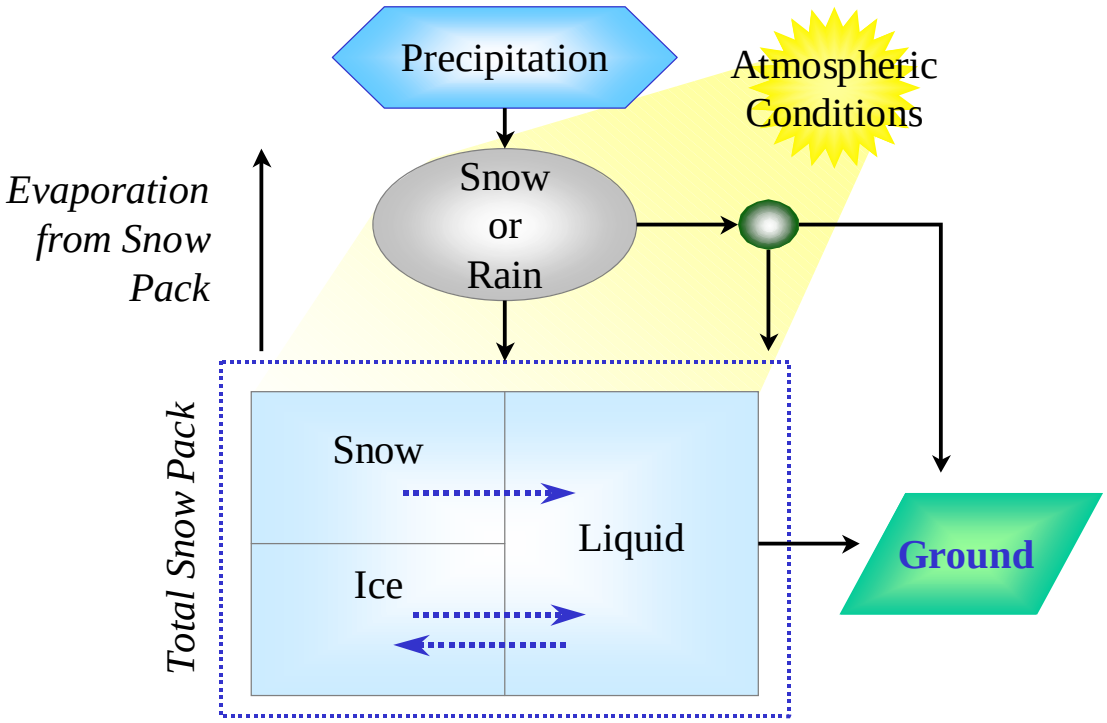


Figure 10-1. Snow Simulation Schematic.

Table 10-3.Snow Budget Routine Cards

Card	Name
92	SNOW Settings
93	SNOW Parameter 1
94	SNOW Parameter 2
96	SNOW Initial Conditions

 © 2012 County of Los Angeles. All rights reserved.

Table 10-4.Snow Simulation Card Parameter Definitions

Card	Parameter	Definition
92	ICEFLAG	0 = Ice formation in the snow pack is not simulated 1 = Ice formation is simulated
	FOREST	0.0 - 1.0 Fraction of LAND covered by Forest (winter transpiration).
93	LAT	Latitude of the pervious land segment (PLS). Positive for the northern hemisphere, negative for southern.
	MELEV	Mean elevation of LAND above sea level.
	SHADE	Fraction of LAND shaded from solar radiation (i.e., by trees).
	SNOWCF	Precipitation-to-snow multiplier (accounts for poor gage-catch efficiency during snow).
	COVIND	Maximum snowpack (water equivalent) at which the entire LAND is covered with snow.
94	RDCSN	Density of cold, new snow relative to water (For snow falling at temps below freezing. At higher temperatures the density of snow is adjusted).
	TSNOW	Air temperature below which precipitation will be snow, under saturated conditions. Under non-saturated conditions the temperature is adjusted slightly.
	SNOEVP	Adapts sublimation equation to field conditions.
	CCFACT	Adapts snow condensation/convection melt equation to field conditions.
	MWATER	Maximum water content of the snow pack, in depth of water per depth of water.
	MGMELT	Maximum rate of snowmelt by ground heat, in depth of water per day. This is the value that applies when the pack temperature is at the freezing point.
96	Pack-snow	Initial quantity of snow in the pack (water equivalent).
	Pack-ice	Initial quantity of ice in the pack (water equivalent).
	Pack-watr	Initial quantity of liquid water in the pack.
	RDENPF	Density of the frozen contents (snow and ice) of the pack, relative to water.
	DULL	Index of the dullness of the snow pack surface, from which albedo is estimated.
	PAKTMP	Mean temperature of the frozen contents of the snow pack.
	COVINX	Current snow pack depth (water equivalent) required to obtain complete areal coverage of LAND. If the pack is less than this amount, areal coverage is prorated (PACKF/COVINX).
	XLNMLT	Current remaining possible increment to ice storage in the pack. Relevant when Ice formation is simulated (ICEFLAG = 1).
	SKYCLR	Fraction of sky that is assumed to be clear at present.

10.3 Water Budget

The hydrologic (water budget) process is complex and interconnected. Rain falls from the sky and lands on constructed landscapes, vegetation, and soil. Varying soil types allow the water to infiltrate at different rates, while evaporation and plant matter exert a demand on available water. Water flows overland and through the soil matrix. The land representation in the LSPC Model environment is considered by three flowpaths: surface, interflow, and ground water outflow. This section presents the relevant cards for hydrology (Table 10-5) with limited discussion. *BASINS Technical Note 6* (Appendix C) has been attached to this manual and is an excellent resource for estimating values and reading further descriptions about the hydrologic parameters. The parameters related to water budget that are available in LSPC are shown schematically in Figure 10-2.

 © 2012 County of Los Angeles. All rights reserved.

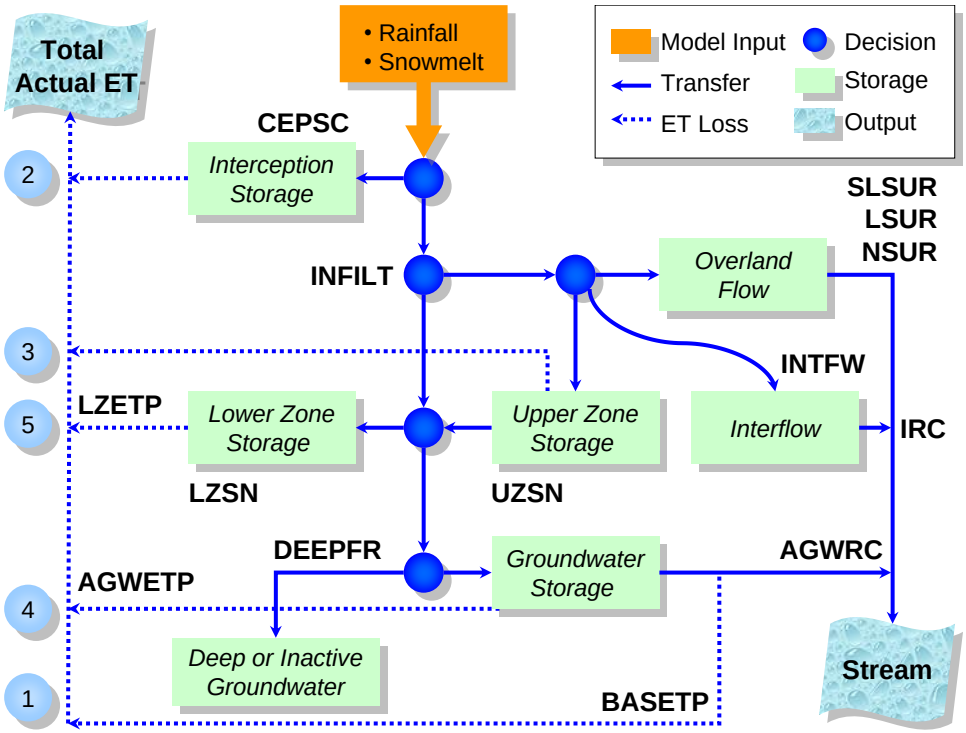


Figure 10-2. Water Budget Schematic.

Table 10-5.Water Budget Routine Cards

Card	Name
100	PWAT Parameter 1
110	PWAT Parameter 2
120	PWAT Parameter 3
130	PWAT Parameter 4
140	PWAT – State 1
150	Monthly Interception Storage
160	Monthly Upper Zone Nominal Storage
170	Monthly Manning's Roughness Coefficient
180	Monthly Interflow Parameter
190	Monthly Interflow Recession Constant
200	Monthly Lower Zone Evapotranspiration Parameter

Users can set six hydrologic parameters as constant or monthly varying, the temporal flags are on card 100 (Table 10-6). The LSPC Model interface toggles these parameters with checkboxes while the ASCII input file uses 0 and 1. These parameters describe processes affecting the hydrology that are most likely to vary seasonally. A user can select one, all, or any combination of the parameters to be monthly. For the parameters that are selected to be constant, the values must be entered on card 130. If monthly values are to be used for a parameter, note the card used for this information in Table 10-6. Interception storage refers to vegetation that catches rainfall where it sits and evaporates. Also, LSPC uses this parameter to represent interception on urban surfaces, from parking lots and rooftops for example, which is a separate parameter in HSPF.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-6.Card 100 PWAT – Parameter 1

Parameter	Definition
VCSFG	Interception storage capacity 0 = constant, see card 130 1 = monthly, see card 150
VUZFG	Upper zone nominal storage 0 = constant, see card 130 1 = monthly, see card 160
VNNFG	Manning's n for the overland flow plane 0 = constant, see card 130 1 = monthly, see card 170)
VIFWFG	Interflow inflow parameter 0 = constant, see card 130 1 = monthly, see card 180
VIRCFG	Interflow recession constant 0 = constant, see card 130 1 = monthly, see card 190
VLEFG	Lower zone evapotranspiration parameter 0 = constant, see card 130 1 = monthly, see 200

Card 110 (Table 10-7) and 120 (Table 10-8) contain constant parameters by hydrologic parameter group (DEFID) and model land unit (DELUID), which are available only as constant parameters. Initial conditions for a simulation can be edited from card 140 (Table 10-9).

Table 10-7.Card 110 PWAT – Parameter 2

Parameter	Definition
DEFID	Hydrologic parameter group ID
DELUID	Model land unit ID
LZSN	Lower zone nominal storage (inch)
INFILT	Index to infiltration capacity of the soil (in/hr)
KVARY	Variable ground water recession (1/inch)
AGWRC	Base ground water recession (no units)

Table 10-8.Card 120 PWAT – Parameter 3

Parameter	Definition
DEFID	Hydrologic parameter group ID
DELUID	Model land unit ID
PETMAX	Air temperature below which ET is reduced (deg F)
PETMIN	Air temperature below which ET is set to zero (deg F)
INFEXP	Exponent in the infiltration equation (none)
INFILD	Ratio between the maximum and mean infiltration capacities over the pervious surface (none)
DEEPFR	Fraction of ground water outflow that enters deep ground water (none)
BASETP	Fraction of remaining potential ET that can be satisfied from baseflow (none)
AGWETP	Fraction of remaining potential ET that can be satisfied from active ground water (none)

 © 2012 County of Los Angeles. All rights reserved.

Table 10-9.Card 140 PWAT – State 1

Parameter	Definition
DEFID	Parameter group ID
DELUID	Model land unit ID
CEPS	Initial interception storage
SURS	Initial surface (overland flow) storage
UZS	Initial upper zone storage
IFWS	Initial interflow storage
LZS	Initial lower zone storage
AGWS	Initial active ground water storage
GWVS	Initial index to ground water slope

A set of exploratory example scenarios was developed to aid in learning about a few of the hydrologic parameters. The hypothetical example application was used for such instructive purposes, and Table 10-10 presents the scenarios and respective baseline values. The scenarios were purposefully labeled with the parameter being toggled. When appropriate, the only land use toggled was forest (DELUID = 6) because it makes up 50 percent of the land area for the example application. Technical Note 6 was used to help determine which values to select for a given scenario, typically a maximum or minimum recommended value was selected. Figure 10-3 through Figure 10-7 present the comparison results of the baseline to scenario flow at subbasin 101. The y-axis was set at the same range for each of the figures to enhance interpretation of the scenario results against each other.

AGWRC relates to ground water recession, (i.e., how fast or slow water is released into the stream from the ground water). Scenario AGWRC reveals that an adjustment from 0.99 to 0.97 for 50 percent of the watershed (forest, DELUID = 6) creates a significant lowering of flow values during drier periods. The peak flows appear almost unchanged. When the soil matrix is wetter, the early part of 2005, the effect of AGWRC is less because more water is going to the ground water from above, but when the soil matrix dries out, the effect of lowering AGWRC becomes more dynamic to the low-flow simulation.

The INFILT parameter was set to 0.01 for forest, DELUID = 6. This can be thought of as armoring 50 percent of the watershed against receiving water into the soil matrix. As expected, the peak flows went up sharply, and the baseflow generally sagged everywhere because less water was replenishing the soil matrix.

Two general root zones are considered in the LSPC Model, the lower- and upper-zone nominal storage (see Figure 10-2). Scenario LZSN showed much greater effects than scenario UZSN. This is to be expected because LZSN is intended to represent the deeper root zone, while UZSN represents the shallow root zone. Regarding scenario LZSN, the storage was reduced from 9 to 2 inches; thus, during wet periods, more water is passed from the upper zone to the stream because it cannot be passed to the saturated, lower zone. An interesting observation is noted when the flow of scenario LZSN exceeds baseline. That might be explained by the baseline value being 9 inches and that during those periods, the baseline lower zone was not saturated and storage was occurring. Scenario UZSN revealed minimal difference to the baseline. It might be described that during wetter periods, the smaller value for UZSN, 0.05 inch, resulted in more overland flow and interflow because it was easily and frequently saturated. Then, during drier periods, the difference to baseline becomes imperceptible.

Last, scenario SLSUR provided no difference from baseline. This could be partially an artifact of the construction of the example application. Users should perform their own sensitivity test on their specific application, for this parameter, and any other they deem important.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-10. Hydrologic Example Scenarios

Scenario	Baseline Value	Scenario Value	Comment
AGWRC	DELUID = 6, Forest – 0.99	DELUID = 6, Forest – 0.97	Dimensionless, Card 110.
INFILT	DELUID = 6, Forest – 0.20	DELUID = 6, Forest – 0.01	in/h, Card 110.
LZSN	DELUID = 6, Forest – 9	DELUID = 6, Forest – 2	inches, Card 110.
UZSN	DELUID = 6, Forest – 0.2 to 1.2	DELUID = 6, Forest – 0.05	inches, Card 160. Baseline was monthly varying, scenario set to constant
SLSUR	Globally – 0.05	Globally – 0.15	Card 90.

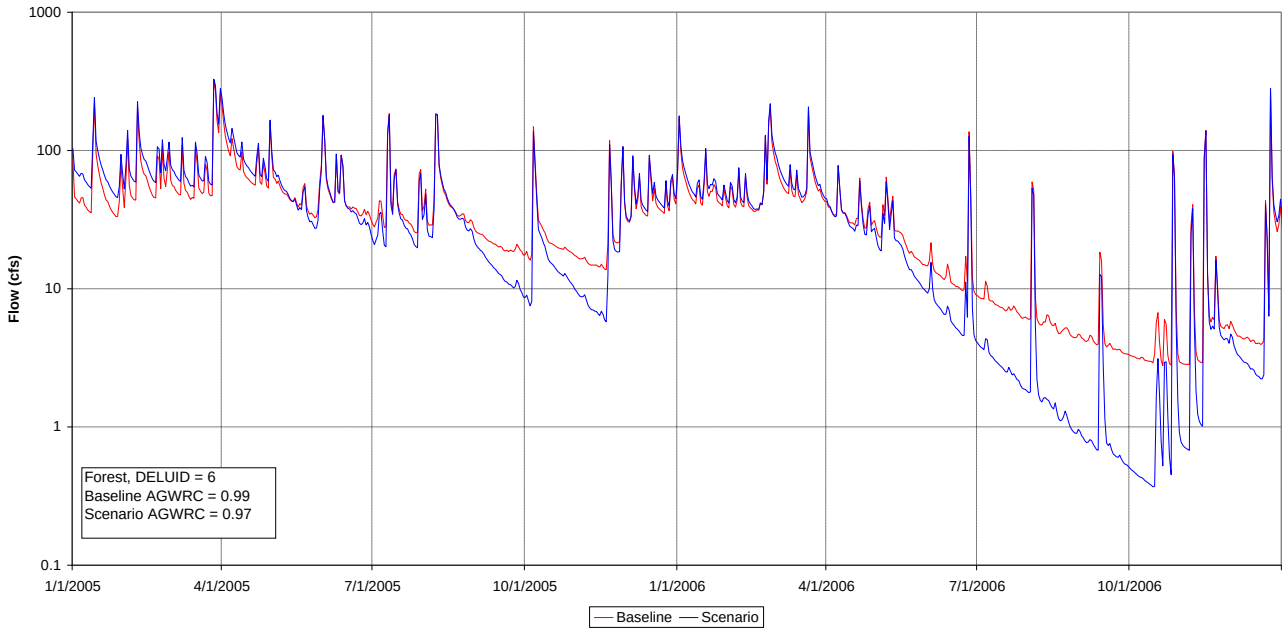


Figure 10-3 Flow Comparison at Subbasin 101 for Scenario AGWRC.

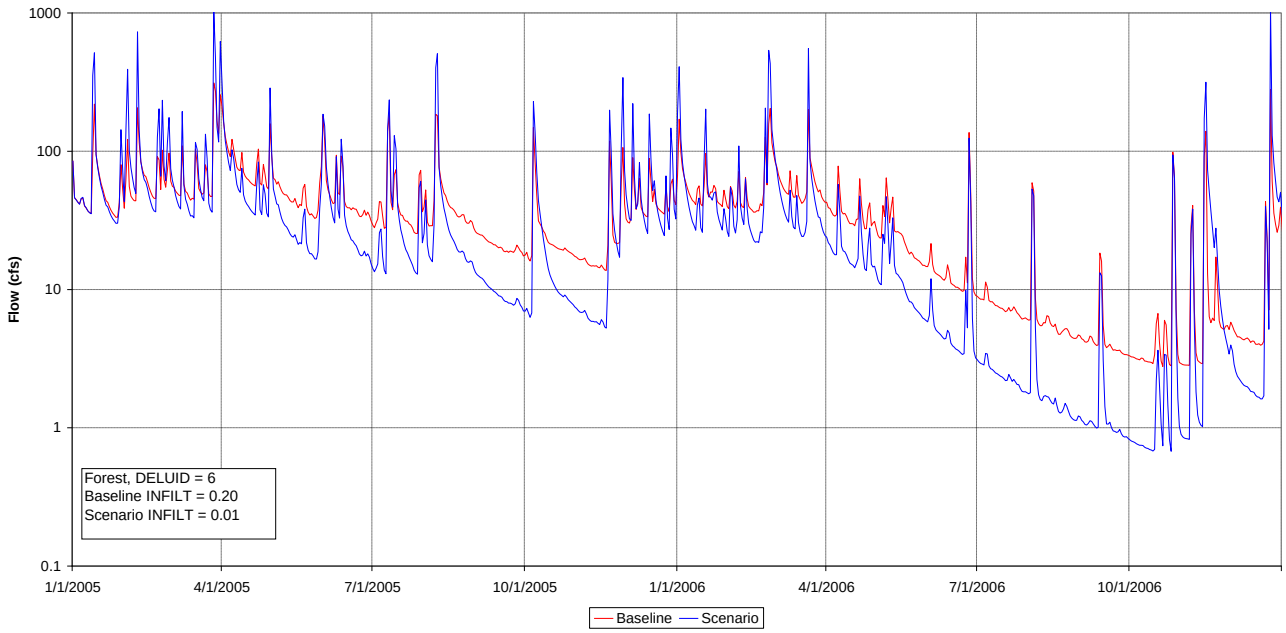


Figure 10-4 Flow Comparison at Subbasin 101 for Scenario INFILT.

 © 2012 County of Los Angeles. All rights reserved.

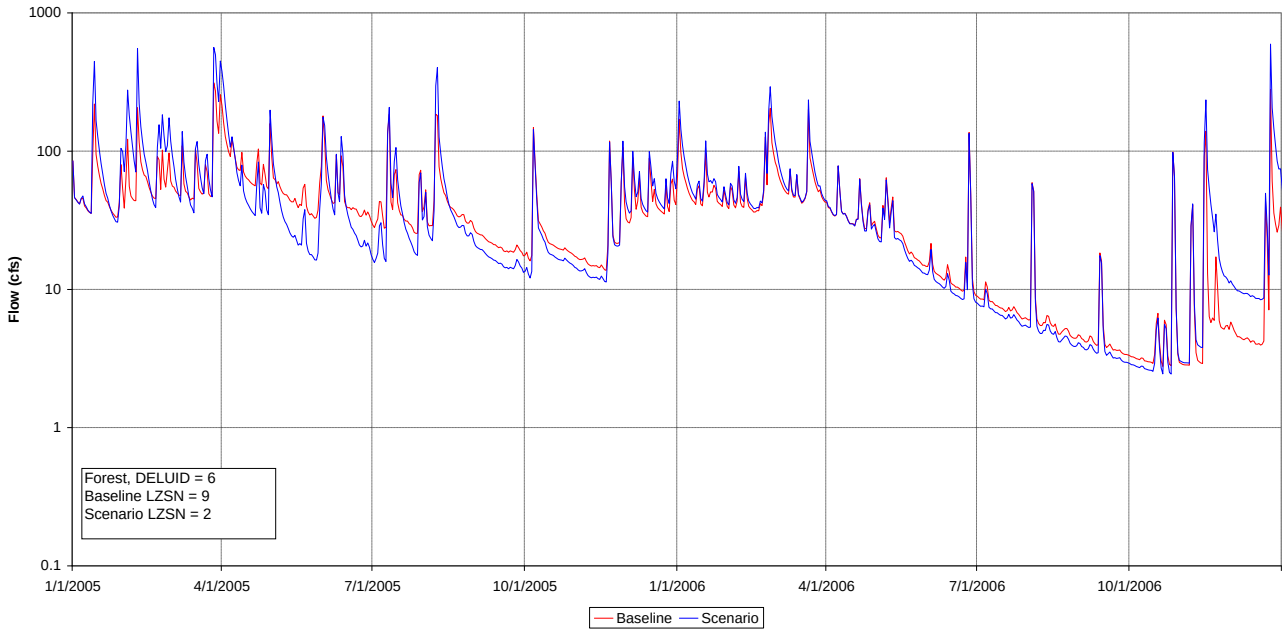


Figure 10-5 Flow Comparison at Subbasin 101 for Scenario LZSN.

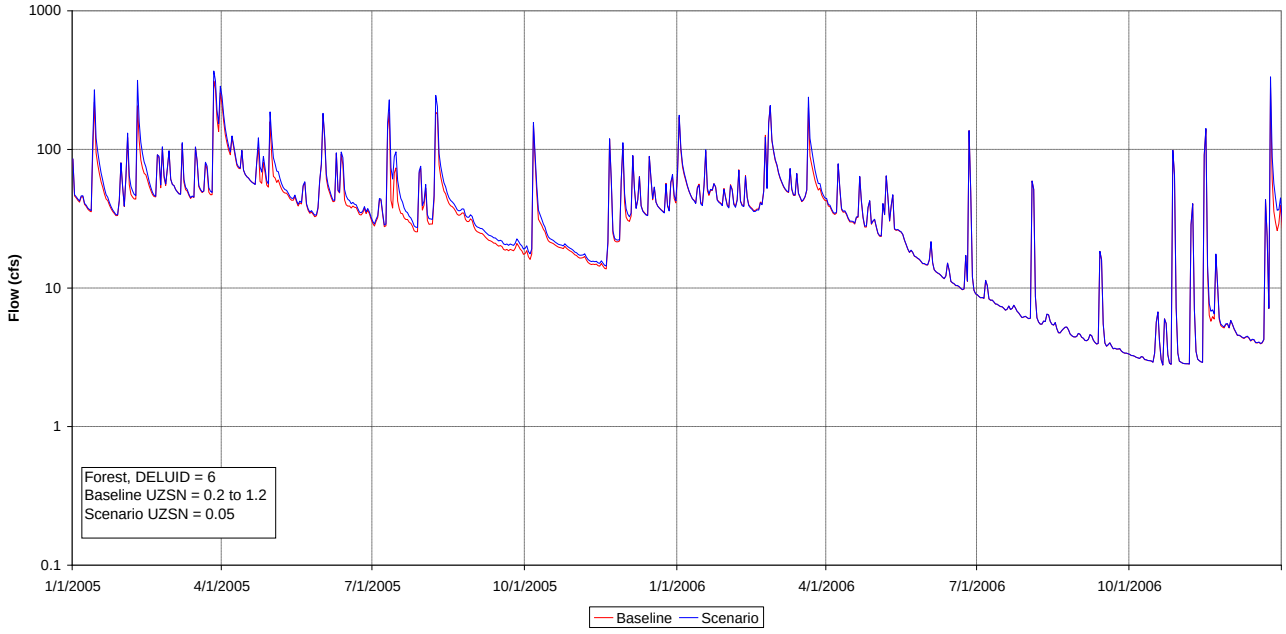


Figure 10-6 Flow Comparison at Subbasin 101 for Scenario UZSN.

 © 2012 County of Los Angeles. All rights reserved.

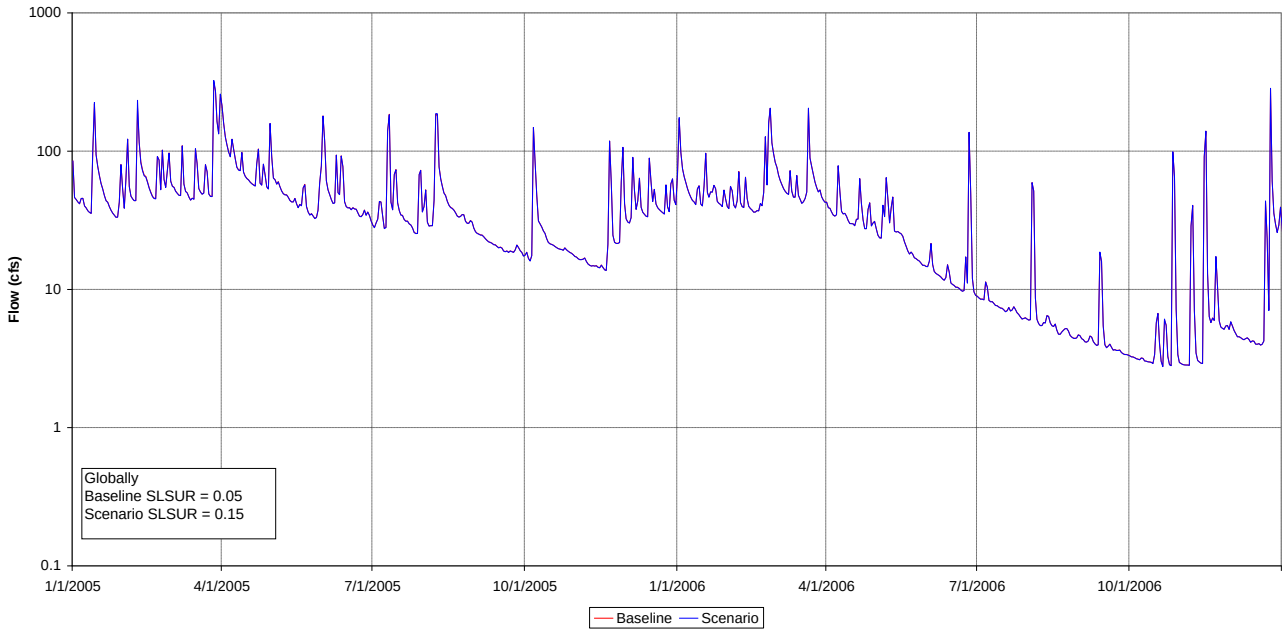


Figure 10-7 Flow Comparison at Subbasin 101 for Scenario SLSUR.

10.4 Water Temperature

The water temperature module in LSPC is analogous to the three HSPF modules of ATEMP (air temperature lapse rate adjustment for SNOW), PSTEMP (estimate soil temperature from land segments), and HTRCH (heat exchange and in-stream water temperature). When temperature is turned on in LSPC, all three modules are activated; however, the user needs to parameterize only each section as needed. The land temperature routine estimates outflow temperatures by land segment and vertical soil layer (surface, interflow, and ground water). The air temperature in the external ASCII weather file (*.AIR) provides input to various options used to calculate water temperature by vertical soil layer. The stream temperature routine simulates temperature for each stream segment by solving a heat exchange balance between current, in-stream heat and heat inputs from land inflows, point source inflows, direct precipitation, and solar radiation. The temperature routine cards are summarized in Table 10-11. The water temperature module is on if the checkbox is selected during the initial loading of the model from the MS Access database (TEMPFG = 1 on card 0).

Table 10-11. Water Temperature Routine Cards

Card Number	Card Name
460	Soil Temperature Control
461	Soil Temperature
462	Monthly ASLT
463	Monthly BSLT
464	Monthly AIFT
465	Monthly BIFT
466	Monthly AGWT
467	Monthly BGWT
470	Temperature Parameters for Land Groups
475	Temperature Parameters for Stream Groups

Card 460 is the control card for setting parameters as either constant or monthly variable by vertical layer (Table 10-12). First, card 461 is another control card for the temperature routine. It is used to set temperature routine options by hydrologic parameter group (DEFID) and model land unit (DELUID) with regard to the temperature

 © 2012 County of Los Angeles. All rights reserved.

option, constant parameter input values and initial conditions. These parameters are further discussed in Table 10-13 and Table 10-14.

Table 10-12. Card 460 Soil Temperature Control Parameters

Parameter	Definition
MSLTFG	ASLT and BSLT parameters in surface outflow temperature calculation 0 = Constant 1 = Monthly
MIFTFG	AIFT and BIFT parameters in interflow outflow temperature calculation 0 = Constant 1 = Monthly
MGWTFG	AGWT and BGWT parameters in ground water outflow temperature calculation 0 = Constant 1 = Monthly

Table 10-13. Card 461 Soil Temperature Parameters

Parameter	Definition
DEFID	Parameter Group ID
DELUID	Model land unit ID
TSOPFG	0 = Compute temperatures using a mean departure from air temperature plus a smoothing factor 1 = Compute subsurface temperature using regression 2 = The lower/ground water layer temperature is a function of upper-layer temperature instead of air temperature
ASLT	Surface layer temperature when the air temperature 0 °C
BSLT	Slope of the surface layer temperature regression equation
AIFT	For parameter interpretation by TSOPFG, See Table 10-14.
BIFT	For parameter interpretation by TSOPFG, See Table 10-14.
AGWT	For parameter interpretation by TSOPFG, See Table 10-14.
BGWT	For parameter interpretation by TSOPFG, See Table 10-14.
ISLT	Initial surface outflow temperature (°C)
IIFT	Initial interflow outflow temperature (°C)
IGWT	Initial ground water outflow temperature (°C)

 © 2012 County of Los Angeles. All rights reserved.

Table 10-14. Soil Temperature Parameter Interpretation by Selected Method and Soil Layer

Soil Temperature Method (TSOPFG)	Ground Layer Temperature	Equation (value for the next timestep)	Variable Interpretation and Usage
0	Surface (SLTMP)	ASLT + BSLT × AIRTMP	Regression as a function of AIRTMP (from AIR file, °C)
	Interflow (IFTMP)	IFTMP + BIFT (AIRTMP + AIFT – IFTMP)	Mean difference (AIFT, °C) from AIRTMP (from AIR file, °C), plus smoothing factor (BIFT)
	Ground water (GWTMP)	GWTMP + BGWT (AIRTMP + AGWT – GWTMP)	Mean difference (AGWT, °C) from AIRTMP (from AIR file, °C), plus smoothing factor (BGWT)
1	Surface (SLTMP)	ASLT + BSLT × AIRTMP	Regression as a function of AIRTMP (from AIR file, °C)
	Interflow (IFTMP)	AIFT + BIFT × AIRTMP	Regression as a function of AIRTMP (from AIR file, °C)
	Ground water (GWTMP)	AGWT	Constant or monthly variable temperature value
2	Surface (SLTMP)	ASLT + BSLT × AIRTMP	Regression as a function of AIRTMP (from AIR file, °C)
	Interflow (IFTMP)	IFTMP + BIFT (AIRTMP + AIFT – IFTMP)	Mean difference (AIFT, °C) from AIRTMP (from AIR file, °C), plus smoothing factor (BIFT)
	Ground water (GWTMP)	GWTMP + BGWT (IFTMP + AGWT – GWTMP)	Mean difference (AGWT, °C) from IFTMP, plus smoothing factor (BGWT)

As previously mentioned, soil temperature simulation is represented at three vertical layers per land segment: surface outflow, interflow outflow, and ground water outflow. The temperature routine in LSPC always calculates surface outflow temperature using the linear regression equation, regardless of the value of TSOPFG. The user determines whether this calculation is monthly or constant.

$$Y = A + B \times X$$

where

Y = Surface outflow water temperature (°C)
A = The y-intercept of the temperature regression equation (surface – ASLT)
B = Slope of temperature regression equation (surface – BSLT)
X = Air temperature from ASCII *.AIR file (°C)

If TSOPFG is set to 0, the interflow outflow and ground water outflow water temperatures are computed using a mean departure from air temperature and smoothing factors. The equation follows.

$$TMP = TMPS + SMO \times (AIRTMP + TDIF - TMPS)$$

where

TMP = Interflow outflow or ground water outflow water temperature at end of current interval (°C)
SMO = Smoothing factor (interflow – *BIFT*, ground water – *BGWT)*
AIRTMP = Air temperature at the start of the current interval (°C)

 © 2012 County of Los Angeles. All rights reserved.

TDIF = Difference between the mean air temperature and the mean temperature of the soil layer (°C) (interflow – AIFT, ground water – AGWT)

TMPS = Interflow outflow or ground water outflow water temperature at the start of the current interval (°C)

If TSOPFG is set to 1, the interflow outflow is calculated from a linear regression equation while the ground water outflow water temperature is input directly. The equation for interflow outflow water temperature follows.

$$Y = A + B \times X$$

where

Y = Interflow outflow water temperature (°C)

A = The y-intercept of the temperature regression equation (interflow – AIFT)

B = Slope of temperature regression equation (interflow – BIFT)

X = Air temperature from ASCII *.AIR file (°C)

The ground water outflow water temperature is constant and, thus, equal to the user setting of the y-intercept, AGWT. The BGWT value is not used. The user should set the slope of the regression equation, BGWT to zero to avoid potential misinterpretation.

If TSOPFG is set to 2, the interflow outflow water temperature is computed using a mean departure from air temperature and smoothing factors as noted above for when TSOPFG is set to 0. However, the ground water outflow water temperature is calculated using the following equation (note that the difference is because of using the interflow outflow-computed temperature instead of the air temperature).

$$TMP = TMPS + SMO \times (IFTMP + TDIF - TMPS)$$

where

TMP = Ground water outflow water temperature at end of current interval (°C)

SMO = Smoothing factor (ground water – BGWT)

IFTMP = Interflow outflow water temperature at the start of the current interval (°C)

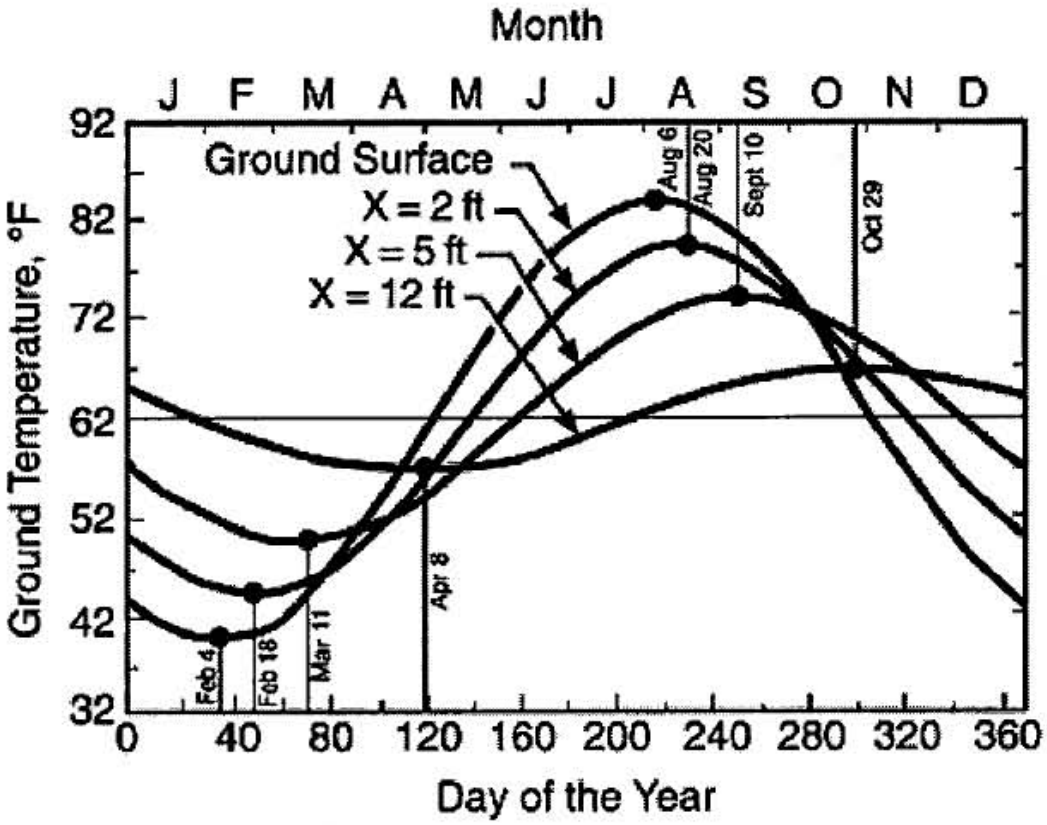
TDIF = Difference between the mean air temperature and the mean temperature of the soil layer (°C) (ground water – *AGWT*)

TMPS = Ground water outflow water temperature at the start of the current interval (°C)

If a user selects constant temperature forcings, he or she need only input values for the parameters on card 461 but still must be aware of which option was selected for TSOPFG. This is important because it influences, for example whether parameter BIFT is the slope of a linear regression equation or a smoothing factor. Likewise, selecting TSOPFG determines, whether parameter AIFT is the y-intercept of a linear regression equation or a mean temperature difference. However, if monthly forcings are specified, cards 462 through 467 become active. Cards 462 and 463 are for surface outflow water temperature parameters (ASLT and BSLT), cards 464 and 465 are for interflow outflow (AIFT and BIFT), and cards 466 and 467 are for ground water outflow (AGWT and BGWT).

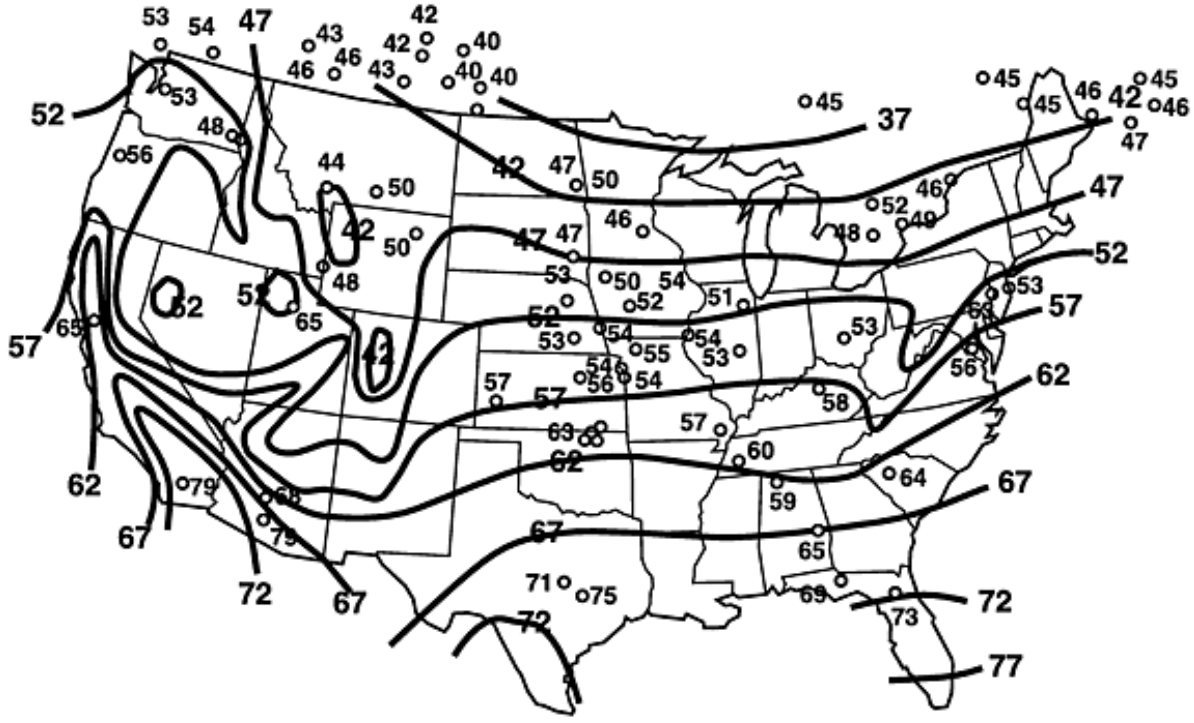
Figure 10-8 represents an example of soil temperature variation with depth. Generally, the deeper the location beneath the surface, the less variable temperature is during a year. At approximately 30 to 50 feet below the surface, the soil, and water, temperature become approximately constant. Figure 10-9 presents a general contour map of this mean earth temperature for the contiguous United States.

 © 2012 County of Los Angeles. All rights reserved.



Source: http://www.geo4va.vt.edu/A1/A1.htm

Figure 10-8. Example Soil Temperature Variation by Depth.



Source: http://www.geo4va.vt.edu/A1/A1.htm

Figure 10-9. Mean Annual Earth Temperature Observations at individual Stations, Superimposed on Well-Water Temperature Contours.

 © 2012 County of Los Angeles. All rights reserved.

The subbasin average model land unit elevation and average reach elevation are contained on card 470. The difference between each of these and the elevation of the weather station assigned to the subbasin is also input to the card. Table 10-15 summarizes the parameters on card 470.

Table 10-15. Card 470 Temperature Parameters for Land Groups

Parameter	Definition
SUBBASIN	Subbasin ID
MELEV	Mean subbasin elevation (ft)
ELDAT	Difference in elevation between subbasin and the air temperature gage (ft) (positive if stream is higher than the gage)
RMELEV	Mean stream elevation (ft)
RELDAT	Difference in elevation between the stream and the air temperature gage (ft) (positive if stream is higher than the gage)

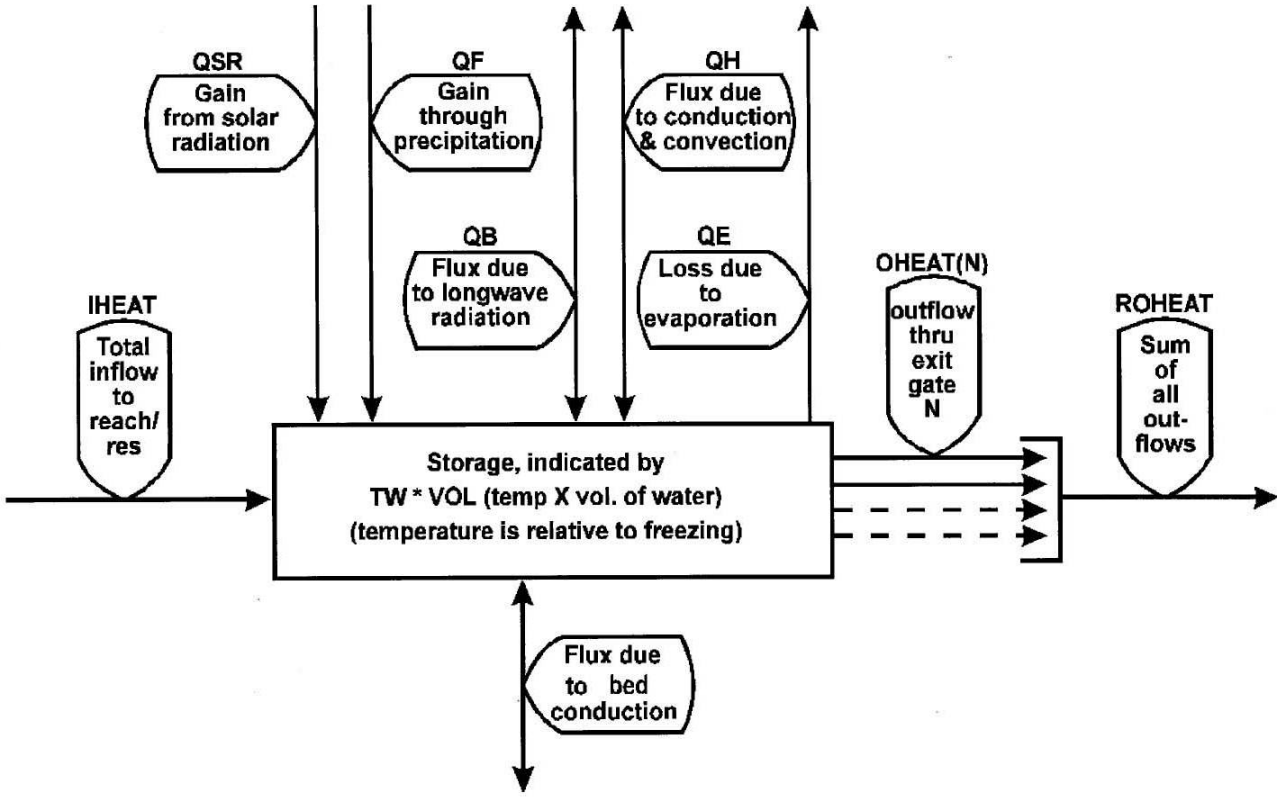
The previous discussion is primarily focused on the model land units, that is, the land-based processes and flowpaths of water moving toward the stream. Card 475 is related to the water in the stream, after the various flowpaths have contributed to the stream. The parameters relate to the heat budget by stream group ID (RGID) (Table 10-16).

Table 10-16. Card 475 Temperature Parameters for Stream Groups

Parameter	Definition
RGID	Stream group ID
CFSAEX	Correction factor for solar radiation; fraction of stream surface exposed to radiation, default value is 1.0
KATRAD	Longwave radiation coefficient, default value is 9.37
KCOND	Conduction-convection heat transport coefficient, default value is 6.12
KEVAP	Evaporation coefficient, default value is 2.24

The following discussion on stream (RCHRES) heat calculations is from Bicknell et al. 2004 (Figure 10-10).

 © 2012 County of Los Angeles. All rights reserved.



Source: Bicknell et al. 2004

Figure 10-10. Temperature Routine Diagram.

Heat is transported across the air-water interface by a number of mechanisms, and each must be evaluated individually. The net transport across the air-water interface is the sum of the individual effects. Mechanisms which can increase the heat content of the water are absorption of solar radiation, absorption of longwave radiation, and conduction-convection. Mechanisms which decrease the heat content are emission of longwave radiation, conduction-convection, and evaporation.

Shortwave Solar Radiation

The shortwave radiation absorbed by a RCHRES is approximated by the following equation:

$$QSR = 0.97 \times CFSAEX \times SOLRAD \times 10.0$$

where

QSR	= shortwave radiation (kcal/m2/interval)
0.97	= fraction of incident radiation which is assumed absorbed (3 percent is assumed reflected)
CFSAEX	= ratio of radiation incident to water surface to radiation incident to gage where data were collected. This factor also accounts for shading of the waterbody, e.g., by trees
SOLRAD	= solar radiation (langleys/interval)
10.0	= conversion factor from langleys to kcal/m2

Longwave Radiation

All terrestrial surfaces, as well as the atmosphere, emit longwave radiation. The rate at which each source emits longwave radiation is dependent upon its temperature. The longwave radiation exchange between the atmosphere and the RCHRES is estimated using the formula

$$QB = SIGMA \times ((TWKELV^4) - KATRAD \times (10^{-6}) \times CLDFAC \times (TAKELV^6)) \times DELT60$$

 © 2012 County of Los Angeles. All rights reserved.

where

QB	= net transport of longwave radiation (kcal/m2/interval)
SIGMA	= Stephan-Boltzman constant multiplied by 0.97 to account for emissivity of water
TWKELV	= water temperature (degrees Kelvin)
KATRAD	= atmospheric longwave radiation coefficient with a typical value of 9.0
CLDFAC	= $1.0 + (.0017 \times C^2)$
TAKELV	= air temperature corrected for elevation difference (deg K)
C	= cloud cover, expressed as tenths (range = 0 – 10)
DELT60	= DELT(minutes) divided by 60

Both atmospheric radiation to the waterbody and back radiation from the waterbody to the atmosphere are considered in this equation. QB is positive for transport of energy from the waterbody to the atmosphere.

Conduction-Convection

Conductive-convective transport of heat is caused by temperature differences between the air and water. Heat is transported from the warmer medium to the cooler medium; heat can therefore enter or leave a waterbody, depending upon its temperature relative to air temperature. HSPF assumes that the heat transport is proportional to the temperature difference between the two media. The equation used is

$$QH = CFPRES \times (KCOND \times 10^{-4}) \times WIND \times (TW - AIRTMP)$$

where

QH	= conductive-convective heat transport (kcal/m2/interval)
CFPRES	= pressure correction factor (dependent on elevation)
KCOND	= conductive-convective heat transport coefficient (typically in the range 1 – 20)
WIND	= wind speed (m/interval)
TW	= water temperature (deg C)
AIRTMP	= air temperature (deg C)

QH is positive for heat transfer from the water to the air.

Evaporative Heat Loss

Evaporative heat transport occurs when water evaporates from the water surface. The amount of heat lost depends on the latent heat of vaporization for water and on the quantity of water evaporated. For purposes of water temperature simulation, HSPF uses the following equation to calculate the amount of water evaporated:

$$EVAP = (KEVAP \times 10^{-9}) \times WIND \times (VPRESW - VPRESA)$$

where

EVAP	= quantity of water evaporated (m/interval)
KEVAP	= evaporation coefficient with typical values of 1 – 5
WIND	= wind movement 2 m above the water surface (m/interval)
VPRESW	= saturation vapor pressure at the water surface (mbar)
VPRESA	= vapor pressure of air above water surface (mbar)

The heat removed by evaporation is then calculated

$$QE = HFACT \times EVAP$$

where

QE	= heat loss due to evaporation (kcal/m2/interval)
HFACT	= heat loss conversion factor (latent heat of vaporization multiplied by density of water)

 © 2012 County of Los Angeles. All rights reserved.

The heat exchange calculations do not give realistic results when the waterbody becomes excessively shallow. Consequently, heat transport processes are not considered if the average depth of water in the RCHRES falls below 2 inches. When this happens, the water temperature is set equal to the air temperature.

LSPC makes a few assumptions with regard to some of the stream boundary conditions. First, LSPC does not currently represent heat flux due to bed conduction. This process was less important for the projects for which the LSPC temperature routines were developed and applied. Bed conduction has a more pronounced effect on water temperature in shallow streams; therefore, the modeling ramifications of this assumption must be weighed under these conditions. Second, if stream temperature is being simulated and point source inflows are entering the stream segment, LSPC assumes that the inflowing temperature is equal to the temperature of the stream water at the beginning of the interval, resulting in no net change in in-stream temperature as a function of the point source inflow. If water temperature is specified for the point source inflow, this value overrides the default assumption, allowing for user-specified, point source temperature variation. Finally, precipitation water falling directly on the surface of the waterbody is always assumed to be at the same temperature as the stream water at the beginning of the interval; therefore, precipitation water is assumed to have no net effect on stream temperature.

Water temperature is a key component in water quality simulation. Scenarios AGWT and CFSAEX (Table 10-17) were used to investigate ground water assignments and shading, respectively. The baseline assignment of water temperature for ground water was monthly varying, and scenario AGWT set these to a constant value of 10 °C. Note that ground water flow is a large percentage of flow contribution to the stream. The result (Figure 10-11) was that the annual range of the stream water temperature simulation was generally smaller. Scenario CFSAEX investigated the effects of solar radiation on water temperature by reducing the percentage of the stream exposed to solar radiation from 50 percent to 10 percent. Figure 10-12 shows a generally cooler water temperature simulation as compared to the baseline.

Table 10-17. Water Temperature Example Scenarios

Scenario	Baseline Value	Scenario Value	Comment
AGWT	Range 3.33–20.56	10	°C, Card 466.
CFSAEX	0.5	0.1	Card 475.

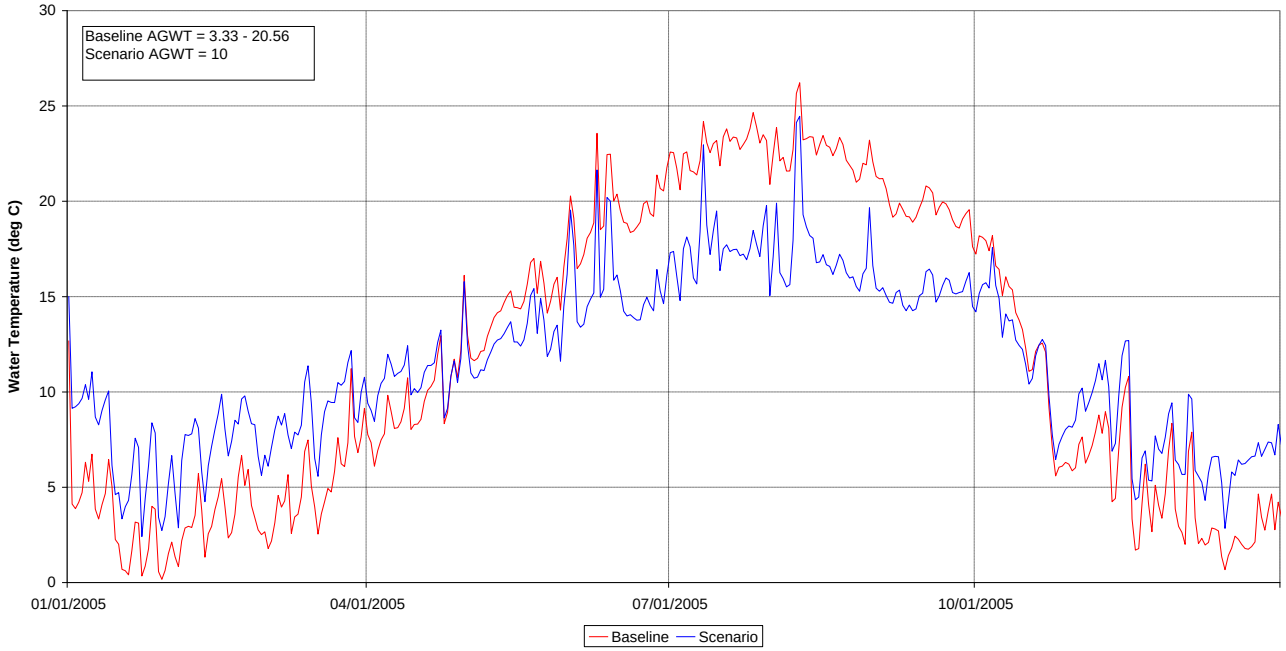


Figure 10-11. Simulation Comparisons of Water Temperature at Subbasin 101 for Scenario AGWT.

 © 2012 County of Los Angeles. All rights reserved.

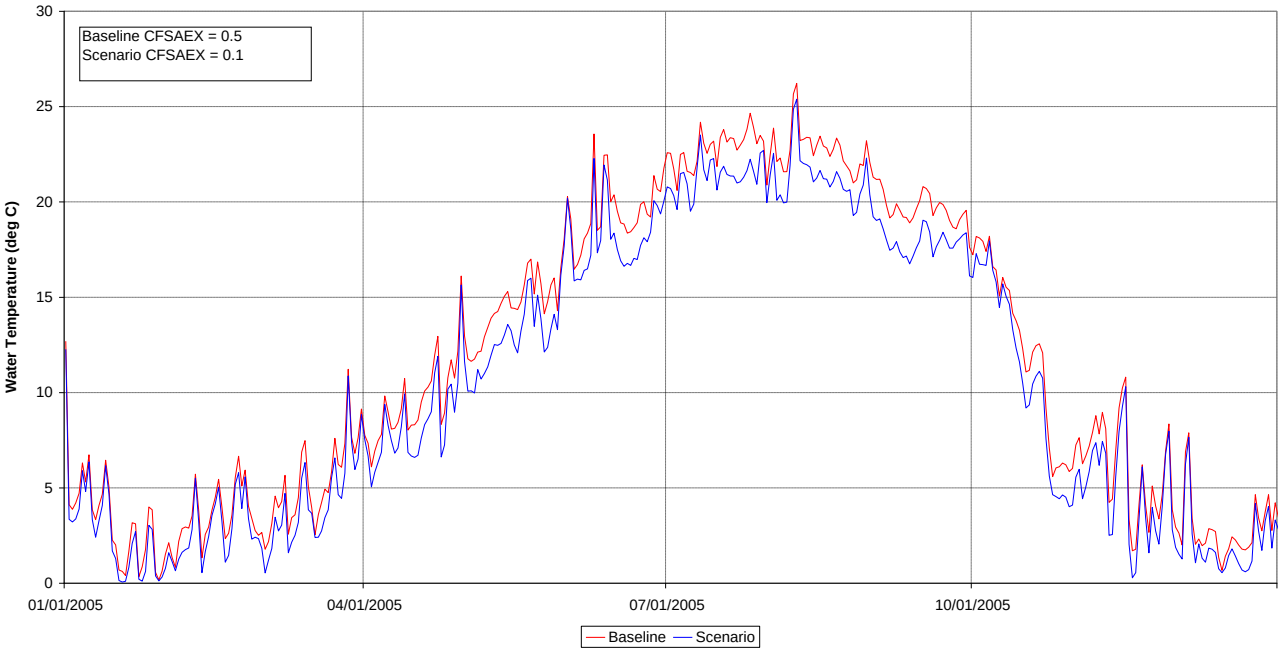


Figure 10-12. Simulation Comparisons of Water Temperature at Subbasin 101 for Scenario CFSAEX.

10.5 Nutrients

Pervious and impervious lands contain nitrogen and phosphorus in the soil matrix as well as overland wash-off. An over-introduction of nutrients into streams, lakes, and ground water can be detrimental to the health of the system. Nitrogen and phosphorus are essential plant nutrients, but when available in excess to certain surface waters they can increase productivity. Table 10-18 presents the cards used for GQUAL simulated constituents (nutrients, metals, etc.). The cards 250 through 289 are for the GQUAL routine, 500 through 524 are for the RQUAL routine, and 530 through 535 are for plankton.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-18. Nutrient Routine Cards

Card Number	Card Name
GQUAL Routine Cards	
250	General Quality (GQUAL) Constituent Control
255	Subsurface Quality Control
260	Qual Input, Storage on Surface of Non-seasonal Parameters
270	Monthly Accumulation Rate
271	Monthly Storage Limit
272	Monthly Surface Outflow Concentration
273	Monthly Interflow Outflow Concentration
274	Monthly Ground water Outflow Concentration
275	Monthly Atmospheric Dry Deposition Flux
276	Monthly Atmospheric Wet Deposition Concentration
280	Stream Water Quality Control
281	General Quality (GQUAL) Constituent Control
282	Monthly Atmospheric Dry Deposition Flux
283	Monthly Atmospheric Wet Deposition Concentration
285	Parameters for Decay of Contaminant Adsorbed to Sediment
286	Sediment Adsorption Coefficients
287	Sediment Adsorption/Desorption Coefficients
288	Sediment Adsorption/Desorption Temperature Correction Parameters
289	Initial Concentrations on Sediment
RQUAL Routine Cards	
500	Land to Stream Mapping
520	Nutrients Control
521	Nutrient Parameters 1
522	Nutrient Parameters 2
523	Nutrient Parameters 3
524	Nutrient Initial Conditions
Plankton Routine Cards	
530	Plankton Flags
531	Plankton Parameters 1
532	Plankton Parameters 2
533	Plankton Parameters 3
534	Plankton Parameters 4
535	Plankton Initial Conditions

10.5.1 GQUAL Nutrient Cards

Card 250 sets initial characteristics of the general quality parameters (DWQID) selected for an application by hydrologic parameter group (DEFID). The parameters for the card are presented in Table 10-19.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-19. Card 250 General Quality Constituent Control Parameters

Parameter	Definition
DEFID	Hydrologic parameter group ID
DWQID	GQUAL ID
QNAME	Name of constituent (no spaces in string name)
QUNIT	Units
QSDFG	0 = QUAL not sediment associated 1 = sediment associated in pervious/impervious land (QSDFG should be > 0 in card 281) 2 = sediment associated in pervious/impervious land and sediment associated QUAL is added to the dissolved part
GQSDFG	0 = GQUAL constituent 1 = GQUAL constituent simulated as sediment associated (only one QUAL can be simulated as sediment associated in each group)
QSOFG	1 = accumulation and removal occur daily 2 = accumulation and removal occur every model simulation interval
POTFCFG	1 = apply background concentration potency factor (card 260) to only surface output 2 = apply background concentration potency factor (card 260) to total land output

Card 255 controls whether parameter assignments will be constant or monthly for the parameters noted in Table 10-20. The LSPC Model interface has checkbox input, while the ASCII input file shows a value of 0 or 1. Those parameters include surface characteristics, interflow and ground water concentration, and atmospheric deposition. In GQUAL, it is possible to add constituent mass to surface flow by using both the accumulation rate and limiting storage in combination with concentration assignment. This might be desirable to maintain some lower threshold value of a constituent in surface flow.

Table 10-20. Card 255 Surface and Subsurface Quality Control Parameters

Parameter	Definition
VQOFG	0 = constant accumulation rate and limiting storage of surface outflow, see card 260 1 = monthly accumulation rate and limiting storage of surface outflow, see cards 270, 271
QSOWFG	0 = no concentration assignment to surface outflow 1 = concentration assignment to surface outflow
VSQCFG	0 = constant concentration assignment to surface outflow, see card 260 1 = monthly concentration assignment to surface outflow, see card 272
QIFWFG	0 = no concentration assignment to interflow outflow 1 = concentration assignment to interflow outflow
VIQCFG	0 = constant concentration assignment to interflow outflow, see card 260 1 = monthly concentration assignment to interflow outflow, see card 273
QAGWFG	0 = no concentration assignment to ground water outflow 1 = concentration assignment to ground water outflow
VAQCFG	0 = constant concentration assignment to ground water outflow, see card 260 1 = monthly concentration assignment to ground water outflow, see card 274
ADFGLND	0 = no atmospheric deposition on land 1 = atmospheric deposition on land
MADDFGLND	0 = constant atmospheric dry deposition on land, see card 260 1 = monthly atmospheric dry deposition on land, see card 275
MAWDFGLND	0 = constant atmospheric wet deposition on land, see card 260 1 = monthly atmospheric wet deposition on land, see card 276

The parameters on card 260 (Table 10-21) are defined by hydrologic parameter group (DEFID), GQUAL constituent (DWQID), and model land unit (DELUID). A user inputs the constant values on card 260 for the parameters specified in card 255. Parameter SQO is used to prescribe the initial storage of a constituent on the surface. In addition, there are parameters related to sediment if a user is running that module (POTFW, POTFS, and POTFC). If a user selects constant values for build up (ACQOP), maximum storage (SQOLIM), and wash-off (WSQOP) those values are prescribed on card 260. Wash-off (WSQOP) is the surface runoff rate (in/hr) that removes 90 percent of the stored GQUAL constituent. The next five parameters are used for prescribing constant values of the respective parameters.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-21. Card 260 Qual-Input Storage on Surface and Nonseasonal Parameters

Parameter	Definition
DEFID	Hydrologic parameter group ID
DWQID	GQUAL constituent ID
DELUID	Model land unit ID
SQO	Initial storage of qual on surface (lb or #)
POTFW	Wash-off potency factor if QSDFG > 0 on card 250 (lb or #)/ton-sediment
POTFS	Scour potency factor if QSDFG > 0 on card 250 (lb or #)/ton-sediment
POTFC	Background concentration potency factor if QSDFG > 0 on card 250 (lb or #)/ton-sediment
ACQOP	Accumulation rate of qual on surface (lb or #)/acre/day
SQOLIM	Maximum storage of qual on surface (lb or #)/acre
WSQOP	Rate of surface runoff that removes 90% of stored qual per hour (in/hr)
SOQC	Concentration of constituent in surface outflow (mg/L), (µg/L), or (#/100mL)
IOQC	Concentration of constituent in interflow outflow (mg/L), (µg/L), or (#/100mL)
AOQC	Concentration of constituent in ground water outflow (mg/L), (µg/L), or (#/100mL)
ADDC	Atmospheric dry deposition flux (lb/acre/day or #/acre/day)
AWDC	Atmospheric wet deposition concentration (mg/L), (µg/L), or (#/100mL)

The parameters on card 270 and 271 are defined by hydrologic parameter group (DEFID), GQUAL constituent (DWQID), and model land unit (DELUID). Card 270 is used to define the accumulation rate (MON-ACQOP) of a constituent by month. The user assigns the rate (lb/acre/day) at which the constituent builds up on the model land unit (DELUID) after being washed off by a storm. A constituent continues to build up until it reaches the asymptotic storage limit (MON-SQOLIM), which is prescribed on card 271. The asymptotic storage limit (MON-SQOLIM) on the model land unit needs to be larger than the accumulation rate (MON-ACQOP).

The parameters on card 272, 273, and 274 are defined by hydrologic parameter group (DEFID), GQUAL constituent (DWQID), and model land unit (DELUID). Card 272 is used to define the surface outflow concentration, card 273 is used for interflow outflow concentration, and ground water outflow concentration is prescribed by month on card 274. The concentration assignments may be in units of mg/L, µg/L, or #/100mL.

Monthly varying atmospheric dry deposition flux (lb/ac/day or #/ac/day) is defined on card 275 for model land units. That is, the monthly values are prescribed by model land unit (DELUID) and hydrologic parameter group (DEFID) for each GQUAL constituent (DWQID). A similar card exists for defining these values for a reach—card 282. On card 282, these values are prescribed by reach group ID (RGID) and GQUAL constituent (DWQID) for each month.

Monthly varying atmospheric wet deposition concentration in rainfall (mg/L, µg/L, or #/100mL) is prescribed by hydrologic parameter group (DEFID), GQUAL constituent (DWQID), and model land unit (DELUID) on card 276. In-stream assignments of monthly varying atmospheric wet deposition concentrations are made on card 283 by reach ID group (RGID) and GQUAL constituent (DWQID).

The direction for cards 282 and 283 just previously mentioned comes from card 280. Card 280 describes whether streams in the GQUAL routine receive atmospheric deposition and whether it is constant or monthly.

Card 281 (Table 10-22) is a GQUAL constituent control card. It is important with regard to parameters for reach groups (RGID). The card is used to set parameters by reach group (RGID) and GQUAL constituent (DWQID). Some of the parameters are similar to those defined for model land unit (DELUID) of a hydrologic parameter group (DEFID); therefore, a user must be sure if he or she is intending to set a parameter by default parameter group (DEFID) or reach group (RGID).

 © 2012 County of Los Angeles. All rights reserved.

Table 10-22. Card 281 General Quality Constituent Control—Reach Parameters

Parameter	Definition
RGID	Reach parameter group ID
DWQID	GQUAL constituent ID
QSDFG	0 = no sediment associated in-stream QUAL 1 = sediment associated in-stream QUAL, see cards 285, 286, 287, 288, and 289
INICOND	Initial in-stream concentration at start of simulation by RGID (mg/L), (µg/L), or (#/100mL)
DECAY	General first-order in-stream loss rate of QUAL by RGID (1/day) at 20 deg C
TCDECAY	Temperature correction coefficient for first-order decay of QUAL (min=1, max=2)
ADDC	Atmospheric dry deposition flux (lb/acre/day or #/acre/day)
AWDC	Atmospheric wet deposition concentration (mg/L), (µg/L), or (#/100mL)
POTBER	Scour potency factor for stream bank erosion if QSDFG > 0, (lb or #)/ton-sediment

Cards 285 through 289 are used to prescribe parameters within the GQUAL routine for the sediment associations and rates/exponents of the GQUAL constituents (DWQID).

The example application was used to explore a few scenarios with GQUAL parameters related to total nitrogen only (DWQID = 3). The GQUAL output variable CONC2 (total nitrogen, mgN/L) was used for comparing the simulation to baseline output. The scenarios are summarized in Table 10-23 and named with the parameter being toggled. The parameters affect the water quality of surface flow, which tends to be approximately 15 to 30 percent of the average in-stream flow. Figure 10-13 through Figure 10-15 present the comparisons of each scenario. Scenario ACCUM explored setting the accumulation of total nitrogen on the land surface at zero. The result was that during periods of no rain (i.e., no surface runoff), the in-stream concentration is driven by the assignments of interflow and ground water concentrations. When it does rain, the surface runoff acts to dilute (Figure 10-13) the in-stream concentration because it was assigned a zero value for accumulation (buildup). Scenario SQOLIM doubled the amount of total nitrogen that can be stored on the land surface as compared to the baseline. As shown in Figure 10-14 the scenario SQOLIM simulation created higher in-stream concentrations of total nitrogen. Scenario WQSOP lowered the surface runoff rate, which removed 90 percent of the material on the land surface. This created interesting results that help us understand the parameter. In early February 2005, this scenario created higher in-stream concentrations of total nitrogen than scenario SQOLIM, while in the late February 2005 scenario, WSQOP created lower in-stream concentration than scenario SQOLIM. Recall that scenario WSQOP lowered the runoff rate that washes off 90 percent of the total nitrogen on the land surface, thus creating more opportunity because of the lower runoff rate to wash-off more material. GQUAL represents stream processes with an optional first order decay. Scenario DECAY (Figure 10-16) presents the impacts of a first order decay rate applied to the GQUAL total nitrogen simulation. Generally the scenario presents a lower storm and baseflow concentration of total nitrogen.

Table 10-23. GQUAL Example Scenarios, Total Nitrogen (DWQID = 3)

Scenario	Baseline Value	Scenario Value	Comment
ACCUM	Range 0.0071–0.2	Globally 0.0	lb/ac/d, Card 270
SQOLIM	Range 0.028–3.2	Doubled baseline values	lb/ac, Card 271
WSQOP	Range 0.4–0.7	Globally 0.1	in/h, Card 260
DECAY	0.0	0.8	1/d, Card 281

 © 2012 County of Los Angeles. All rights reserved.

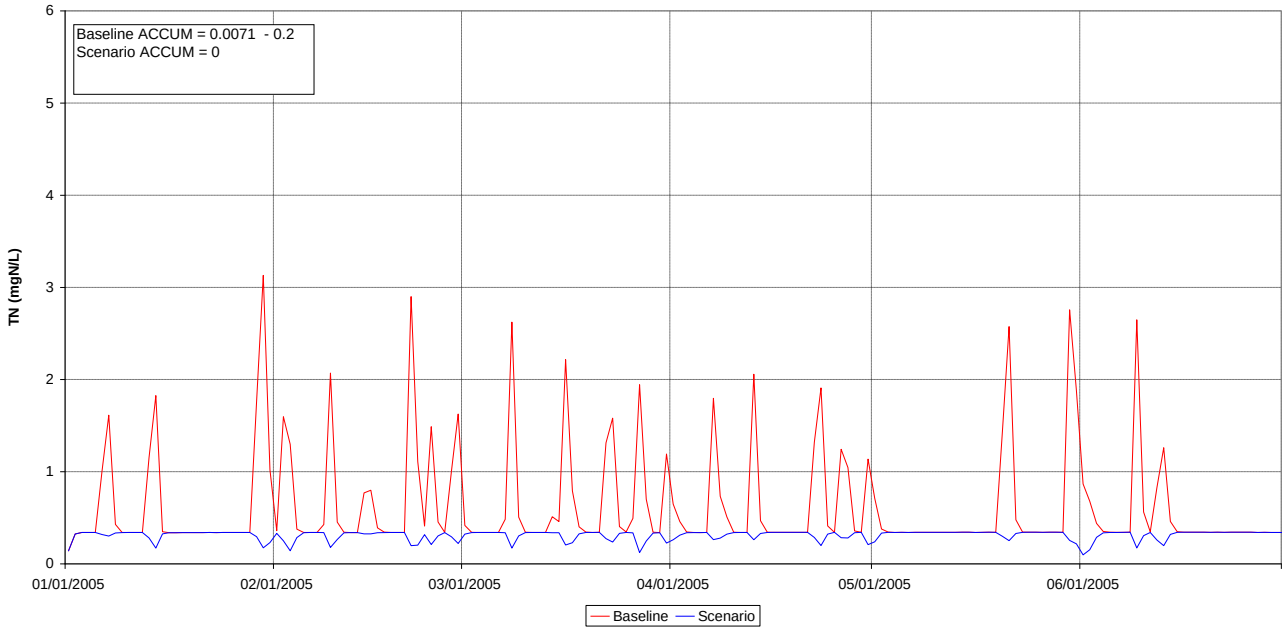


Figure 10-13. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario ACCUM.

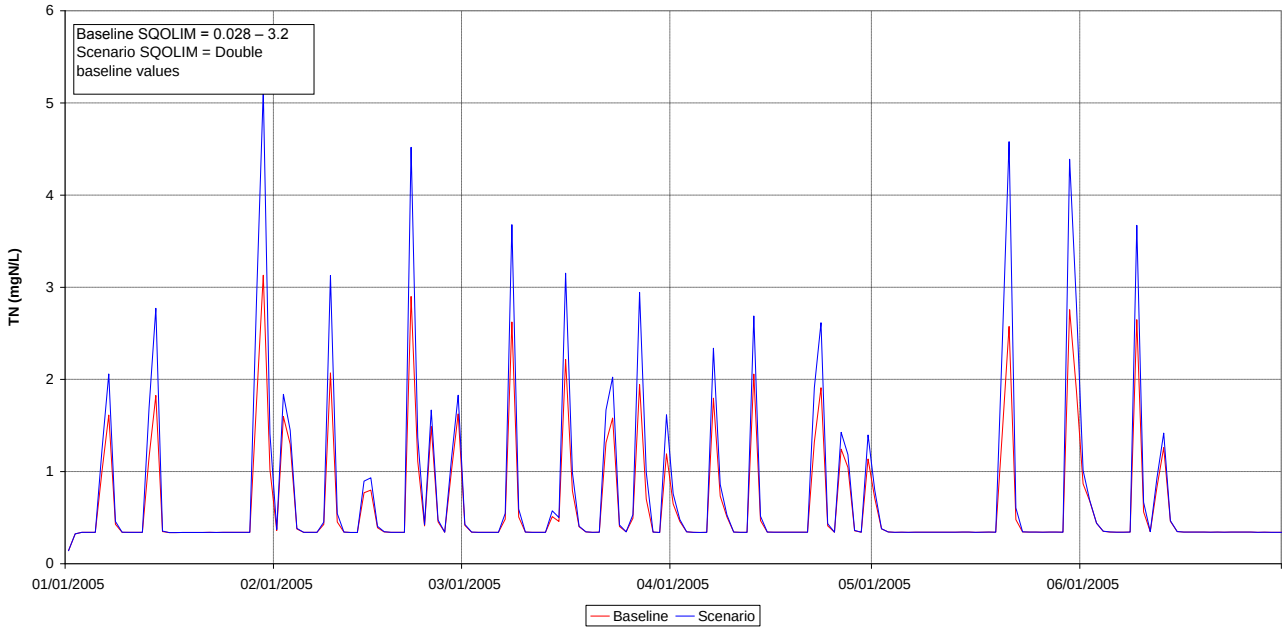


Figure 10-14. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario SQOLIM.

 © 2012 County of Los Angeles. All rights reserved.

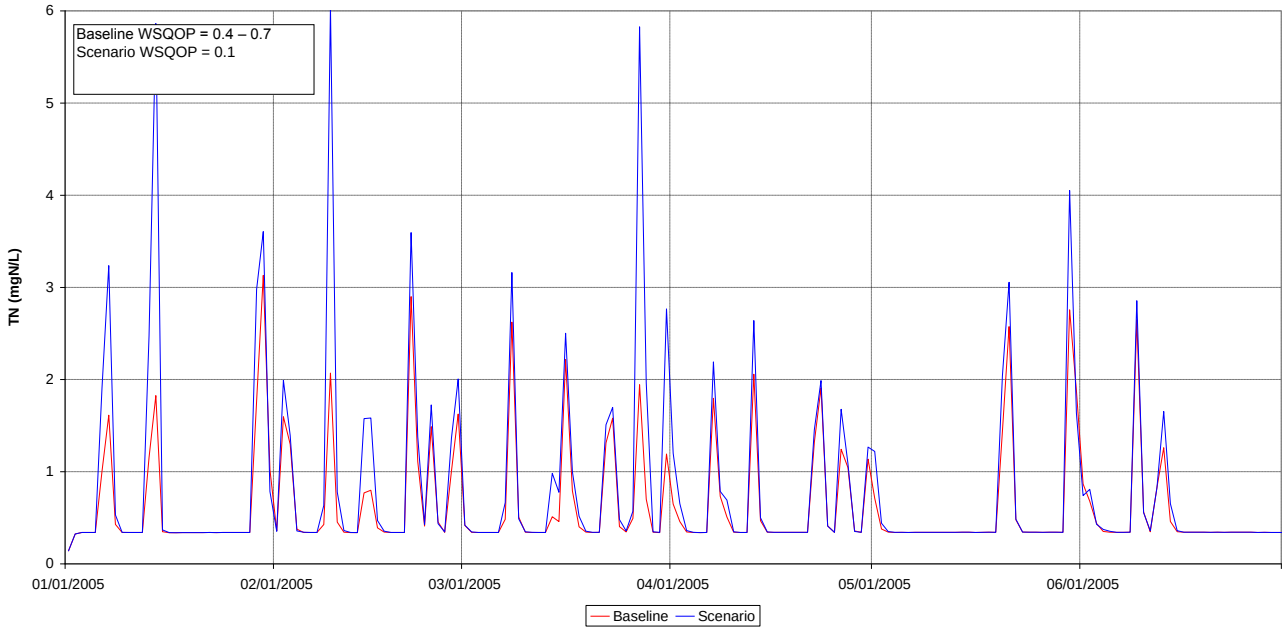


Figure 10-15. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario WSQOP.

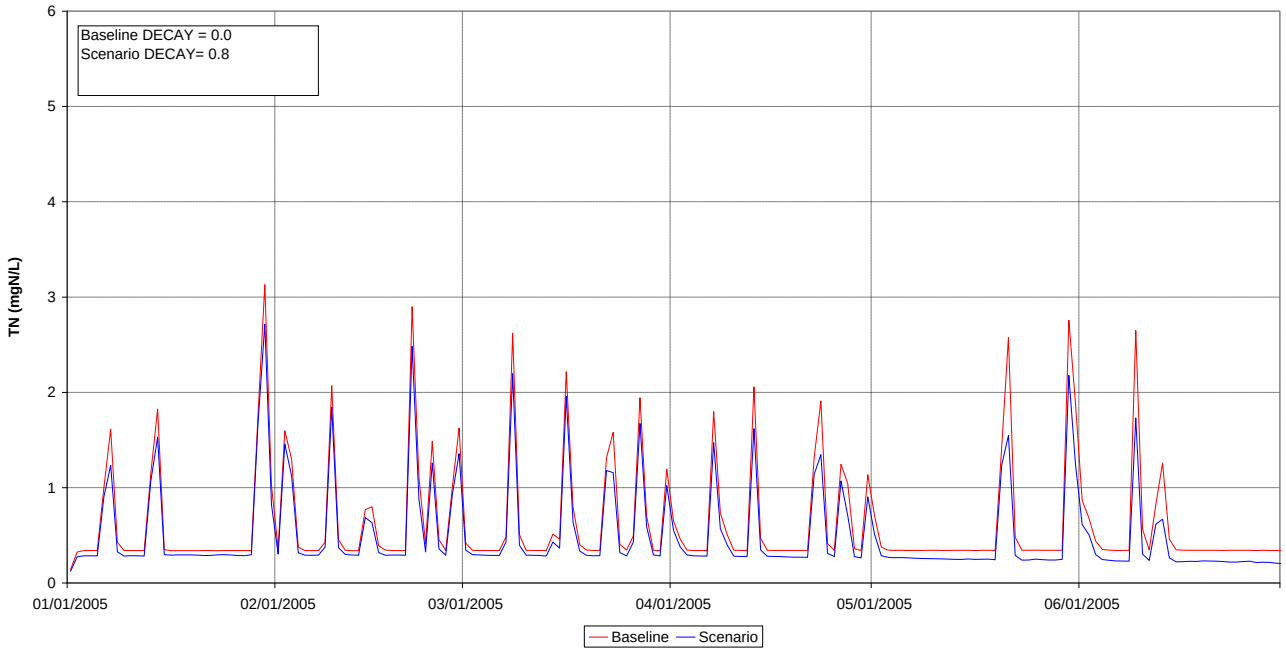


Figure 10-16. Total Nitrogen Concentration Comparison at Subbasin 101 for Scenario DECAY.

10.5.2 RQUAL Nutrient Cards

The reach quality routine (RQUAL) enables a more robust representation of in-stream kinetics and reactions than GQUAL. GQUAL can be used to represent the pervious and impervious model land units simulation as well as the reach simulation, or GQUAL can be used to link to the RQUAL routine for streams. Card 500 contains information to guide the mapping of GQUAL constituents (DWQID) to RQUAL constituents. The fractionation is assigned by reach parameter group (RGID), GQUAL constituent (DWQID), and flow type (LUTYPE) (see Table 10-24).

 © 2012 County of Los Angeles. All rights reserved.

Table 10-24. Card 500 Land to Stream Mapping Parameters

Parameter	Definition
RGID	Reach parameter group ID
DWQID	GQUAL constituent ID
LUTYPE	Model land unit flow type 1 = Impervious surface outflow 2 = Pervious surface outflow 3 = Pervious interflow outflow 4 = Pervious ground water outflow
BOD	BOD fraction of GQUAL constituent
NOX	Nitrate fraction of GQUAL constituent
TAM	Total ammonia fraction of GQUAL constituent
SNH4	Particulate ammonium fraction (NH4-N) of GQUAL constituent
PO4	Orthophosphate fraction of GQUAL constituent
SPO4	Particulate orthophosphate fraction of GQUAL constituent
ORN	Organic nitrogen fraction of GQUAL constituent
ORP	Organic phosphorus fraction of GQUAL constituent
ORC	Organic carbon fraction of GQUAL constituent

An example of card 500 is shown in Table 10-25. The example is for one reach parameter group (RGID) and three GQUAL constituents (DWQID). The table is color coded to clarify. The constituents can be determined by viewing the table; DWQID = 1 is BOD, DWQID = 3 is total nitrogen and DWQID = 7 is total phosphorus. Regarding BOD, this example conveys 37.7 percent of the GQUAL pervious surface outflow BOD to RQUAL. For total nitrogen, this example considers the dissolved constituent only; there is no sediment-associated fraction.

Table 10-25. Card 500 Land to Stream Mapping Parameters

RGID	DWQID	LUTYPE	BOD	NOX	TAM	SNH4	PO4	SPO4	ORN	ORP	ORC
1	1	1	0.921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	2	0.377	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	3	0.921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	4	0.921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	3	1	0.0	0.62	0.03	0.0	0.0	0.0	0.35	0.0	0.0
1	3	2	0.0	0.72	0.03	0.0	0.0	0.0	0.25	0.0	0.0
1	3	3	0.0	0.90	0.03	0.0	0.0	0.0	0.07	0.0	0.0
1	3	4	0.0	0.89	0.04	0.0	0.0	0.0	0.07	0.0	0.0
1	7	1	0.0	0.0	0.0	0.0	0.23	0.0	0.0	0.27	0.0
1	7	2	0.0	0.0	0.0	0.0	0.23	0.0	0.0	0.27	0.0
1	7	3	0.0	0.0	0.0	0.0	0.80	0.0	0.0	0.20	0.0
1	7	4	0.0	0.0	0.0	0.0	0.80	0.0	0.0	0.20	0.0

The following discussion on the constituents involved in biochemical transformations for RQUAL is from Bicknell et al. 2004.

> RQUAL is the parent routine to the four subroutine groups [that] simulate constituents involved in biochemical transformations. Within the module section RQUAL, the following constituents may be simulated: DO, biochemical oxygen demand, ammonia, nitrite, nitrate, orthophosphorus, phytoplankton, benthic algae, zooplankton, dead refractory organic nitrogen, dead refractory organic phosphorus, dead refractory organic carbon, pH, and carbon dioxide.
>
> Four additional quantities are estimated from simulation of these constituents. These quantities are total organic nitrogen, total organic phosphorus, total organic carbon, and potential biochemical oxygen demand. The definition of these quantities is determined by their method of calculation:

 © 2012 County of Los Angeles. All rights reserved.

$TORN = ORN + CVBN \times (ZOO + PHYTO + BOD / CVBO)$

$TORP = ORP + CVBP \times (ZOO + PHYTO + BOD / CVBO)$

$TORC = ORC + CVBC \times (ZOO + PHYTO + BOD / CVBO)$

$POTBOD = BOD + CVNRBP \times (ZOO + PHYTO)$

where

TORN = total organic nitrogen (mgN/L)
TORP = total organic phosphorus (mgP/L)
TORC = total organic carbon (mgC/L)
POTBOD = potential BOD (mgO/L)
ORN = dead refractory organic nitrogen (mg/L)
ORP = dead refractory organic phosphorus (mg/L)
ORC = dead refractory organic carbon (mg/L)
BOD = biochemical oxygen demand from dead non-refractory organic materials (mgO/L)
CVBN = conversion from mg biomass to mg nitrogen
CVBP = conversion from mg biomass to mg phosphorus
CVBC = conversion from mg biomass to mg carbon
CVNRBO = conversion from mg biomass to mg biochemical oxygen demand (with allowance for non-refractory fraction)
CVBO = conversion from mg biomass to mg oxygen
ZOO = zooplankton (mg biomass/L)
PHYTO = phytoplankton (mg biomass/L)

A user can set which processes are to be considered in the RQUAL simulation on card 520. The flags are shown in Table 10-26.

Table 10-26. Card 520 Nutrients Control Parameters

Parameter	Definition
TAMFG	0 = Total ammonia off 1 = Total ammonia on
NO2FG	0 = Nitrite off 1 = Nitrite on
PO4FG	0 = Orthophosphorus off 1 = Orthophosphorus on
AMVFG	0 = Ammonia volatilization off 1 = Ammonia volatilization on
DENFG	0 = Denitrification off 1 = Denitrification on
ADNHFG	0 = Ammonium (NH_4) adsorption off 1 = Ammonium (NH_4) adsorption on
ADPOFG	0 = Orthophosphorus adsorption off 1 = Orthophosphorus adsorption on
MPHFG	Monthly pH flag (not supported in this version)

Mass conversions and rate constants are defined on card 521. The conversions relate nutrients, oxygen, and biomass. The rate constants are for various kinetics (see Table 10-27).

 © 2012 County of Los Angeles. All rights reserved.

Table 10-27. Card 521 Nutrients Parameters 1

Parameter	Definition
CVBO	Conversion from milligrams biomass to milligrams oxygen demand (mg/mg), default value is 1.98
CVBPC	Conversion from biomass expressed as phosphorus to carbon (mols/mol), default value is 106.0
CVBPN	Conversion from biomass expressed as phosphorus to nitrogen (mols/mol), default value is 16.0
BPCNTC	Percentage of biomass which is carbon (by weight), default value is 49.0 percent
KTAM20	Nitrification rate of ammonia at 20 °C (1/hr)
KNO220	Nitrification rate of nitrite at 20 °C (1/hr)
TCNIT	Temperature correction coefficient for nitrification, default value is 1.07
KNO320	Nitrate denitrification rate at 20 °C (1/hr)
TCDEN	Temperature correction coefficient for denitrification, default value is 1.07
DENOXT	Dissolved oxygen concentration threshold for denitrification, default value is 2.0 mg/L

The following discussion of nitrification and denitrification is from Bicknell et al. 2004.

NITRIF simulates the oxidation of ammonium and nitrite by chemoautotrophic bacteria. This oxidation provides energy for bacteria much the same way that sunlight provides energy for photosynthetic algae. The *Nitrosomonas* genera are responsible for conversion of ammonium to nitrite, and *Nitrobacter* perform oxidation of nitrite to nitrate. Oxidation of inorganic nitrogen is dependent upon a suitable supply of DO. NITRIF does not simulate nitrification if the DO concentration is below 2 mg/L.

The rate of nitrification is represented by a first order equation in which nitrification is directly proportional to the quantity of reactant present, either ammonia or nitrite. The equation used to calculate the amount of NH_3 oxidized to NO_2 is

$$TAMNIT = KTAM20 \times (TCNIT\text{^}(TW - 20)) \times TAM$$

where

TAMNIT = amount of NH_3 oxidation (mgN/L per interval)
KTAM20 = ammonia oxidation rate coefficient at 20 degrees C (per interval)
TCNIT = temperature correction coefficient, default to 1.07
TW = water temperature (degrees C)
TAM = total ammonia concentration (mgN/L)

Similarly, if nitrite is simulated, the amount of nitrite oxidized to nitrate is determined by the equation:

$$NO2NIT = KNO220 \times (TCNIT\text{^}(TW - 20)) \times NO2$$

where

NO2NIT = amount of NO_2 oxidation (mgN/L per interval)
KNO220 = NO_2 oxidation rate coefficient at 20 degrees C (per interval)
NO2 = nitrite concentration (mgN/L)

The amount of oxygen used during nitrification is 3.43 mg oxygen per mg NH_3-N oxidized to NO_2-N. and 1.14 mg oxygen per mg NO_2-N oxidized to NO_3-N. In the RCHRES module, these numbers are adjusted to 3.22 mg and 1.11 mg, respectively, to account for the effects of carbon dioxide fixation by bacteria (Wezerak and Gannon 1968). Thus, the oxygen demand due to nitrification is evaluated as

$$DODEMD = (3.22 \times TAMNIT) + (1.11 \times NO2NIT)$$

where

DODEMD = loss of DO from the reach due to nitrification (mgO/L per interval).

If the value of DODEMD is greater than available DO, the amounts of oxidation from NH_3 to NO_2 and from NO_2 to NO_3 are proportionally reduced, so that the DO maintains a non-negative value. If nitrite is not simulated, the calculated amount of oxidized ammonia is assumed to be fully oxidized to nitrate.

 © 2012 County of Los Angeles. All rights reserved.

DENIT simulates the reduction of nitrate by facultative anaerobic bacteria such as *Pseudomonas*, *Micrococcus*, and *Bacillus*. These bacteria can use NO_3 for respiration in the same manner that oxygen is used under aerobic conditions. Facultative organisms use oxygen until the environment becomes nearly of totally anaerobic, and then switch over to NO_3 as their oxygen source. In HSPF, the end product of denitrification is assumed to be nitrogen gas.

Denitrification does not occur in the RCHRES module unless the DO concentration is below a user-specified threshold value (DENOXT). If that situation occurs, denitrification for the interval is calculated by the following equation:

$$DENNO3 = KNO320 \times (TCDEN^{(TW - 20)}) \times NO3$$

where

DENNO3	= amount of NO_3 denitrified (mgN/L per interval)
KNO320	= NO_3 de-nitrification rate coefficient at 20 degrees C (/interval)
TCDEN	= temperature correction coefficient for denitrification
NO3	= nitrate concentration (mgN/L)

Card 522 is used to prescribe benthic fluxes, both under aerobic and anaerobic conditions. The nutrient benthic constituent considered are ammonia and orthophosphorus. The following is quoted from Bicknell et al. 2004.

Two release rates are required for each of the constituents: one for aerobic conditions and one for anaerobic conditions. Typically, the aerobic release rate is less than the anaerobic rate, because a layer of oxidized materials forms on the benthal surface during aerobic periods, and this layer retards the release rate of additional benthal materials. The choice of which release rate used is determined by comparing the current value of DO to ANAER.

The parameter ANAER is prescribed on card 523. Table 10-28 presents the parameters and descriptions for card 522.

Table 10-28. Card 522 Nutrients Parameters 2

Parameter	Definition
RGID	Reach parameter group ID
BRTAM_1	Benthic release rate of ammonia under aerobic condition (mgN/m^2/hr)
BRTAM_2	Benthic release rate of ammonia under anaerobic condition (mgN/m^2/hr)
BRPO4_1	Benthic release rate of orthophosphorus under aerobic condition (mgP/m^2/hr)
BRPO4_2	Benthic release rate of orthophosphorus under anaerobic condition (mgP/m^2/hr)
BNH4(1-3)	Constant bed concentrations of ammonium-N adsorbed to sand, silt, and clay (mg/kg)
BPO4(1-3)	Constant bed concentrations of orthophosphorus-P adsorbed to sand, silt, and clay (mg/kg)

The following discussion on benthic releases (card 522) is from Bicknell et al. 2004.

This subroutine checks to see whether present water conditions are aerobic or anaerobic, calculates benthal release for a constituent based on this check and updates the concentration of the constituent. The equation used to calculate release is:

$$RELEAS = BRCON(I) \times SCRFAC \times DEPCOR$$

where

RELEAS	= amount of constituent released (mg/L per interval)
BRCON(*I*)	= benthal release rate (BRTAM of BRPO4) for constituent (mg/m^2 per interval)
SCRFAC	= scouring factor, dependent on average velocity of the water (SCRFAC is computed in RQUAL)
DEPCOR	= conversion factor from mg/m^2 to mg/L

The DO concentration below which anaerobic conditions are considered to exist is determined by the input parameter ANAER. Two release rates are required for each of the constituents: one for aerobic

 © 2012 County of Los Angeles. All rights reserved.

conditions and one for anaerobic conditions. Typically, the aerobic release rate is less than the anaerobic rate, because a layer of oxidized materials forms on the benthal surface during aerobic periods, and this layer retards the release rate of additional benthal materials. BRCON(1) is the aerobic release rate and BRCON(2) is the anaerobic rate. The choice of which release rate is used is determined by comparing the current value of DO to ANAER.

If ammonia is simulated, the inorganic nitrogen release from the benthos is assumed to be in the form of ammonia, and the NH_3 (TAM) state variable is updated. If ammonia is not simulated, benthal release of inorganic nitrogen is assumed to not occur. If orthophosphate is simulated, an additional call is made to BENTH to account for release of PO_4.

As noted previously, parameter ANAER is defined on card 523. It is the concentration of DO below which anaerobic conditions are assumed to exist. The other parameters on card 523 set adsorption coefficients and volatilization exponents. Table 10-29 summarizes the parameters from card 523.

Table 10-29. Card 523 Nutrients Parameters 3

Parameter	Definition
RGID	Reach parameter group ID
ANAER	Concentration of DO below which anaerobic conditions are assumed to exist (mg/L)
ADNHPM(1-3)	Adsorption coefficients (Kd) for ammonia-N adsorbed to sand, silt, and clay (cm^3/g)
ADPOPM(1-3)	Adsorption coefficients for orthophosphate-P adsorbed to sand, silt, and clay (cm^3/g)
EXPNVG	Exponent in the gas layer mass transfer coefficient equation for NH_3 volatilization, default value is 0.5
EXPNVL	Exponent in the liquid layer mass transfer coefficient equation for NH_3 volatilization, default value is 0.6667

Card 524 is used to assign initial conditions to the inorganic constituents in RQUAL. A reasonable assessment of initial conditions might help a user minimize spin-up time of the model, however stream initial conditions are often quickly washed out of the system. The parameters are described in Table 10-30.

Table 10-30. Card 524 Nutrients Initial Conditions Parameters

Parameter	Definition
RGID	Reach parameter group ID
NO3	Initial concentration of nitrate (mgN/L)
TAM	Initial concentration of total ammonia (mgN/L)
NO2	Initial concentration of nitrite (mgN/L)
PO4	Initial concentration of orthophosphorus (mgP/L)
SNH4(1-3)	Initial suspended concentration of ammonia-N adsorbed to sand, silt, and clay (mg/kg)
SPO4(1-3)	Initial suspended concentration of orthophosphorus-P adsorbed to sand, silt, and clay (mg/kg)

10.5.3 Phytoplankton Cards

The input for phytoplankton simulation is controlled through cards 530 to 535. This includes both planktonic and benthic algae.

A user selects the form of plankton desired for a simulation on card 530 and what processes are going to be acting on the growth and death of plankton. All values on card 530 are either 0 for off or 1 for on, except as noted. Note that the LSPC Model interface presents checkboxes for those parameters. The parameters are summarized in Table 10-31.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-31. Card 530 Plankton Flag Parameters

Parameter	Definition
PHYFG	Phytoplankton flag
ZOOFG	Zooplankton flag
BALFG	Benthic algae flag 0 = Benthic algae not simulated 1 = single species of benthic algae with growth/respiration proportional to phytoplankton (PHYFG must be on) 2 = multiple species of benthic algae (between 1 and 4) using different kinetics (PHYFG can be on or off)
SDLTFG	Influence of sediment washload on light extinction flag 0 = not considered separately 1 = influence of sediment washload on light extinction is simulated using computed or input sediment concentration 2 = based on linear regression on flow (requires input of Table-type BENAL-LIGHT)
AMRFG	Ammonia retardation of nitrogen-limited growth flag
DECFG	Linkage between carbon dioxide and phytoplankton growth flag 0 = linkage of carbon dioxide to phytoplankton can be considered as limiting 1 = linkage of carbon dioxide to phytoplankton decoupled
NSFG	Ammonia is included as part of available nitrogen supply in nitrogen limited growth calculations
OREFG	Indicates the OREF parameter on card 534 as; 0 = flow rate (cms) 1 = velocity (m/s)

Card 531 (Plankton Parameters 1) supplies values for equations associated with the cards below it. This card controls the ratio in biomass of chlorophyll *a* to phosphorus and the non-refractory portion of algae and zooplankton. Other settings include the contribution of sediment to light extinction and algal rates. For further discussion, see Table 10-32. A user supplies values for limiting phytoplankton growth on card 532 (Plankton Parameters 2). The growth of plankton is related to the amount of light, availability of nutrients, and water temperature. Plankton require an optimum light availability to start growing. If there are not enough nutrients available, plankton will not thrive. Plankton growth is also sensitive to water temperature. Table 10-33 shows the parameters for card 532. Card 533 controls the death rates using user-prescribed concentration values and oxygen conditions. For further descriptions, see Table 10-34. Card 534 (Table 10-35) controls plankton parameters relating to advection. It is also used to input settling rates, solar radiation adjustment, and growth and respiration of benthic algae. Card 535 is used to set initial conditions.

Table 10-32. Card 531 Plankton Parameters 1

Parameter	Definition
RGID	Reach parameter group ID
RATCLP	Ratio of chlorophyll *a* content of biomass to phosphorus content, default value is 0.6
NONREF	Non-refractory fraction of algae and zooplankton biomass, default value is 0.5
LITSED	Multiplication factor to total sediment concentration to determine sediment contribution to light extinction (L/mg×ft), default value is 0.0
ALNPR	Fraction of nitrogen requirements for phytoplankton growth that is satisfied by nitrate, default value is 1.0
EXTB	Base extinction coefficient for light (1/m)
MALGR	Maximum unit algal growth rate (1/hr), default value is 0.3

Table 10-33. Card 532 Plankton Parameters 2

Parameter	Definition
RGID	Reach parameter group ID
CMMLT	Michaelis-Menten constant for light limited growth (ly/min), default value is 0.033
CMMN	Nitrate Michaelis-Menten constant for nitrogen limited growth (mg/L), default value is 0.045
CMMNP	Nitrate Michaelis-Menten constant for phosphorus limited growth (mg/L), default value is 0.0284
CMMP	Phosphate Michaelis-Menten constant for phosphorus limited growth (mg/L), default value is 0.015
TALGRH	Temperature above which algal growth ceases (°C), default value is 35.0
TALGRL	Temperature below which algal growth ceases (°C), default value is 6.1
TALGRM	Temperature below which algal growth is retarded (°C), default value is 25.0

 © 2012 County of Los Angeles. All rights reserved.

Table 10-34. Card 533 Plankton Parameters 3

Parameter	Definition
RGID	Reach parameter group ID
ALR20	Algal unit respiration rate at 20 °C (1/hr), default value is 0.004
ALDH	High algal unit death rate (1/hr), default value is 0.01
ALDL	Low algal unit death rate (1/hr), default value is 0.001
OXALD	Increment to phytoplankton unit death rate due to anaerobic conditions (1/hr), default value is 0.03
NALDH	Inorganic nitrogen concentration below which high algal death rate occurs (as nitrogen) (mgN/L)
PALDH	Inorganic phosphorus concentration below which high algal death rate occurs (as phosphorus) (mgP/L)

Table 10-35. Card 534 Plankton Parameters 4

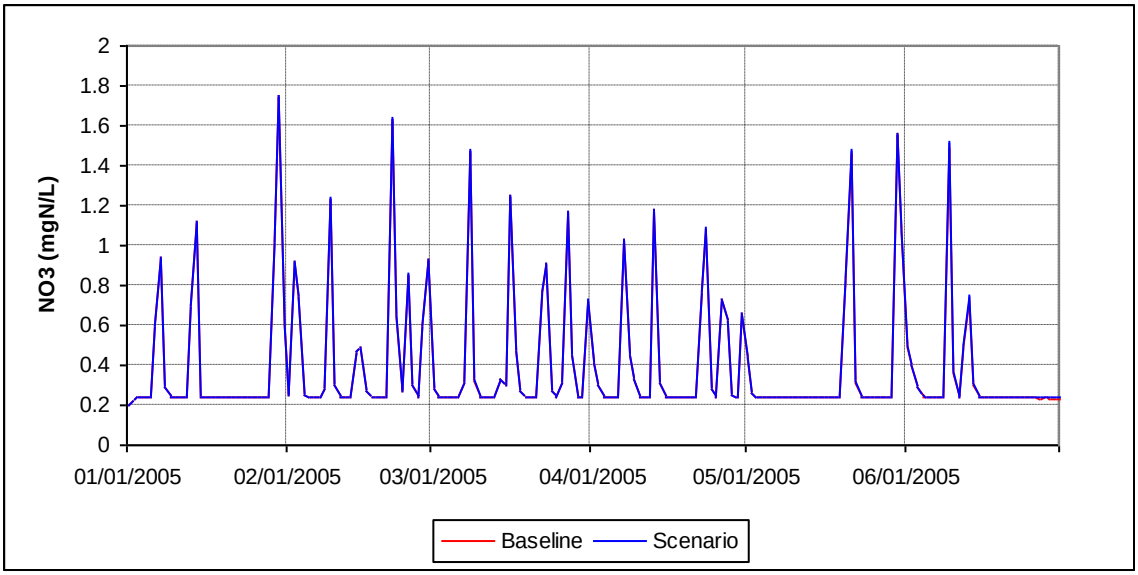
Parameter	Definition
RGID	Reach parameter group ID
PHYCON	Constant inflow concentration of plankton from land to reach (mg/L)
SEED	Minimum concentration of plankton not subject to advection (i.e., at high flow) (mg/L)
MXSTAY	Concentration of plankton not subject to advection at very low flow (mg/L)
OREF	Velocity/outflow at which the concentration of plankton not subject to advection is midway between SEED and MXSTAY, see card 530 (m/s or m3/s)
CLALDH	Chlorophyll *a* concentration above which high algal death rate occurs (µg/L), default value is 50.0
PHYSET	Phytoplankton settling rate (m/hr)
REFSET	Settling rate for dead refractory organics (m/hr)
CFSAEX	This factor is used to adjust the input solar radiation to make it applicable to the RCHRES; for example, to account for shading of the surface by trees or buildings
MBAL	Maximum benthic algae density (as biomass) (mg/m^2), default value is 600.0
CFBALR	Ratio of benthic algal to phytoplankton respiration rate, default value is 1.0
CFBALG	Ratio of benthic algal to phytoplankton growth rate, default value is 1.0

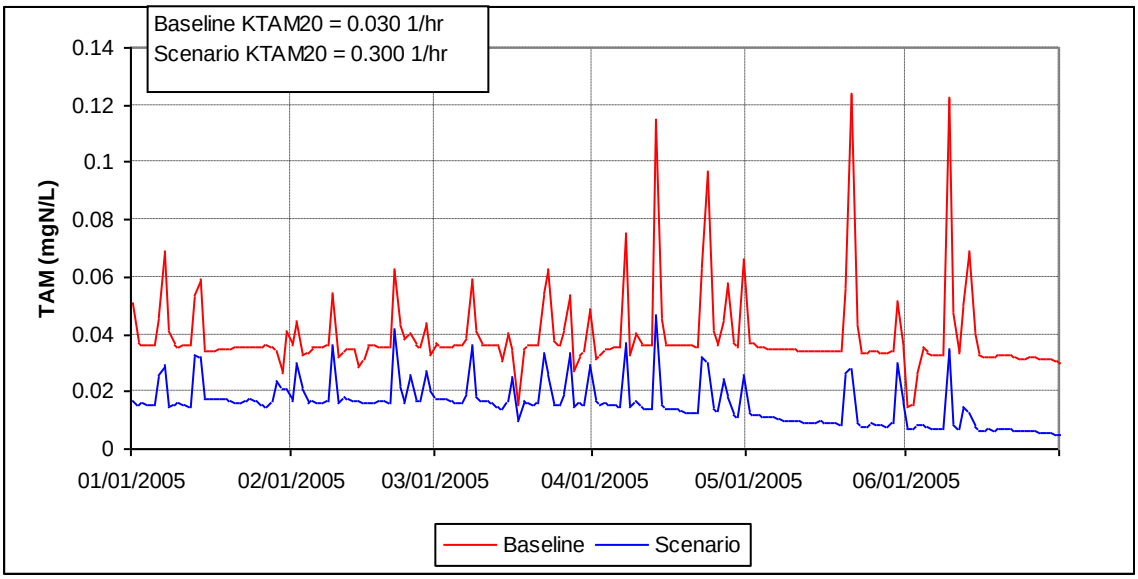
The example application was used to explore a few parameters in the RQUAL module related to nutrients and phytoplankton. Three scenarios (Table 10-36) were investigated by reviewing three output variables each. The three output variables were total ammonia (TAM, mgN/L), nitrate (NO_3, mgN/L), and chlorophyll *a* (PHYCLA, µg/L), DO examples will be considered later. Scenario KTAM20 raised the nitrification rate by an order of magnitude, from 0.03 to 0.30 1/hr. Nitrification is the process with bacteria present that converts ammonia to nitrite and then nitrate using oxygen. Figure 10-17 shows that during periods without runoff the ammonia concentration was reduced by approximately half and that during runoff periods, the peak ammonia concentrations were significantly reduced. Scenario MALGR was used to revise the phytoplankton growth rate by an order of magnitude from 0.1 to 1.0 1/hr (Figure 10-18). These examples are being provided for instructive value, but it must be noted that other factors are affecting the chlorophyll *a* response variable. Scenario MALGR affects the chlorophyll *a* variable, but as a further example, water temperature does too, and that is why the response in chlorophyll *a* is not observed until approximately April. The last example was scenario NALDH, which toggles the parameter for the inorganic nitrogen concentration (mgN/L) below which high phytoplankton death rate occurs. The parameter was changed from 0.01 to 0.50 mgN/L. The result (Figure 10-19) was that the chlorophyll *a* simulation was significantly reduced, note that 0.50 mgN/L was selected specifically because the baseline simulation presents inorganic nitrogen values above 0.50 mgN/L most of the time.

Table 10-36. RQUAL Nutrient and Phytoplankton Example Scenarios

Scenario	Baseline Value	Scenario Value	Comment
KTAM20	0.03	0.30	1/hr, Card 521
MALGR	0.1	1.0	1/hr, Card 531
NALDH	0.01	0.50	mgN/L, Card 533

 © 2012 County of Los Angeles. All rights reserved.





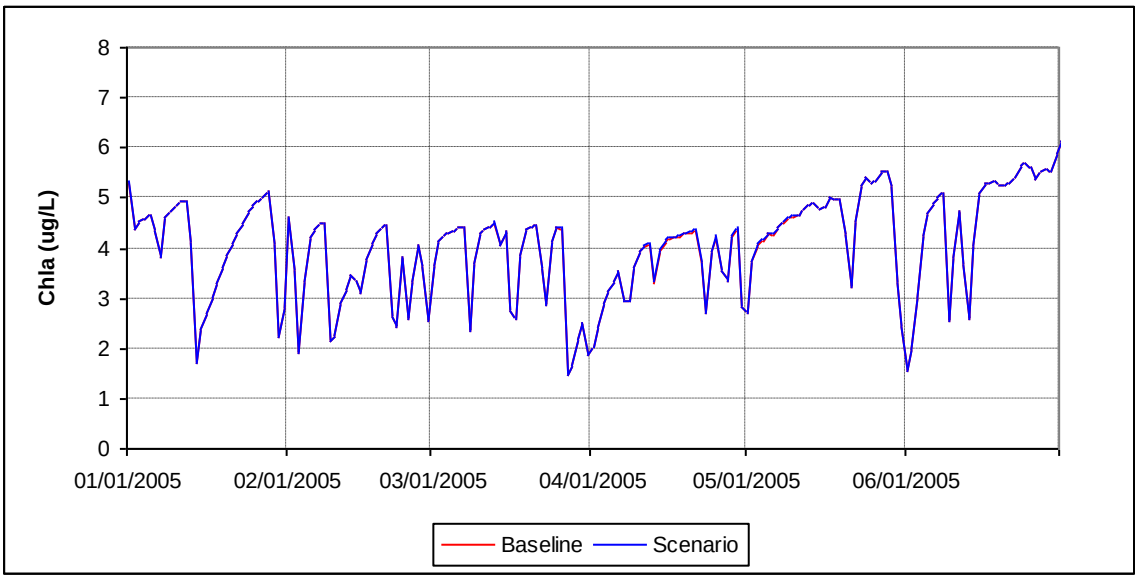
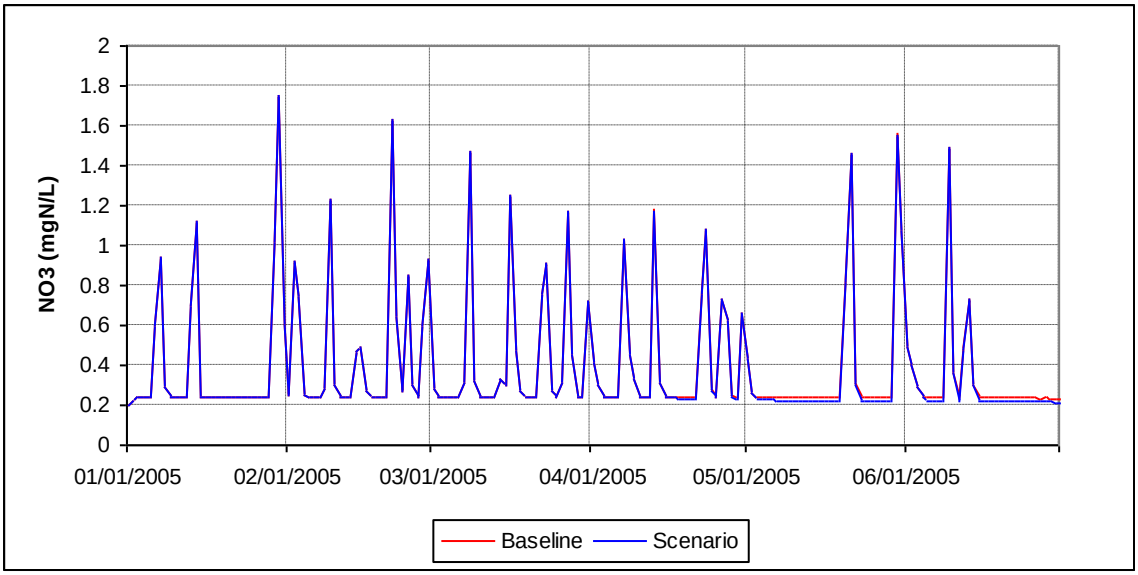
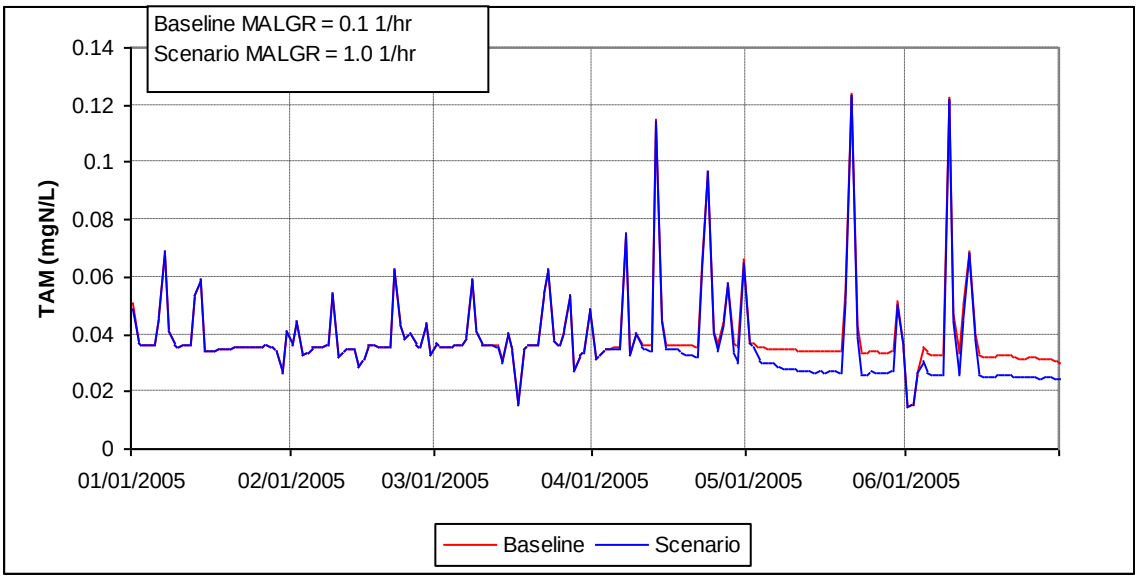


Figure 10-17. Simulation Comparisons of Nitrogen and Phytoplankton at Subbasin 101 for Scenario KTAM20.

 © 2012 County of Los Angeles. All rights reserved.





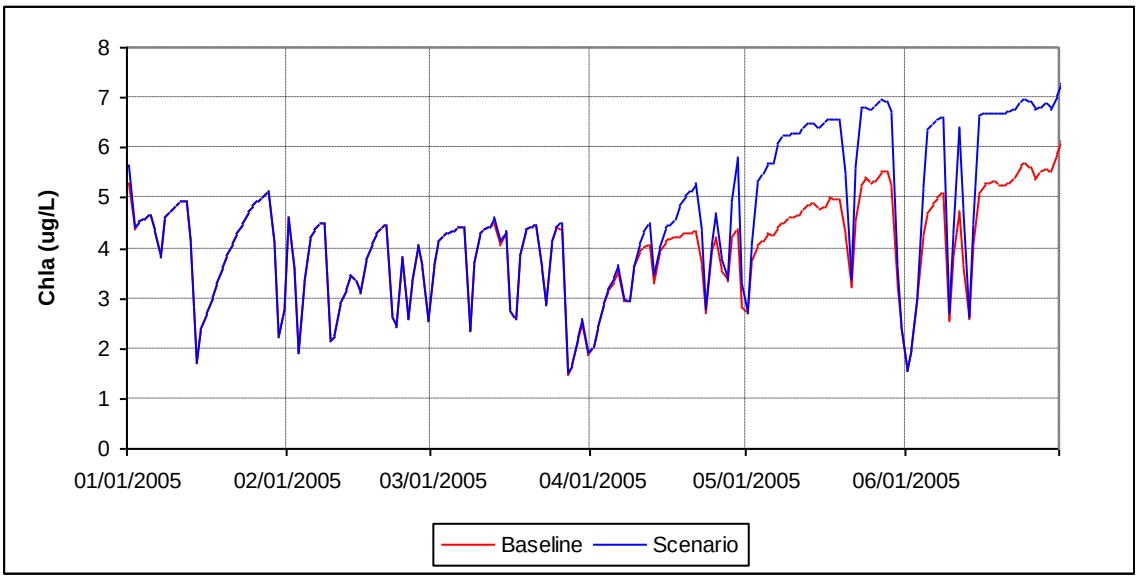


Figure 10-18. Simulation Comparisons of Nitrogen and Phytoplankton at Subbasin 101 for Scenario MALGR.

 © 2012 County of Los Angeles. All rights reserved.

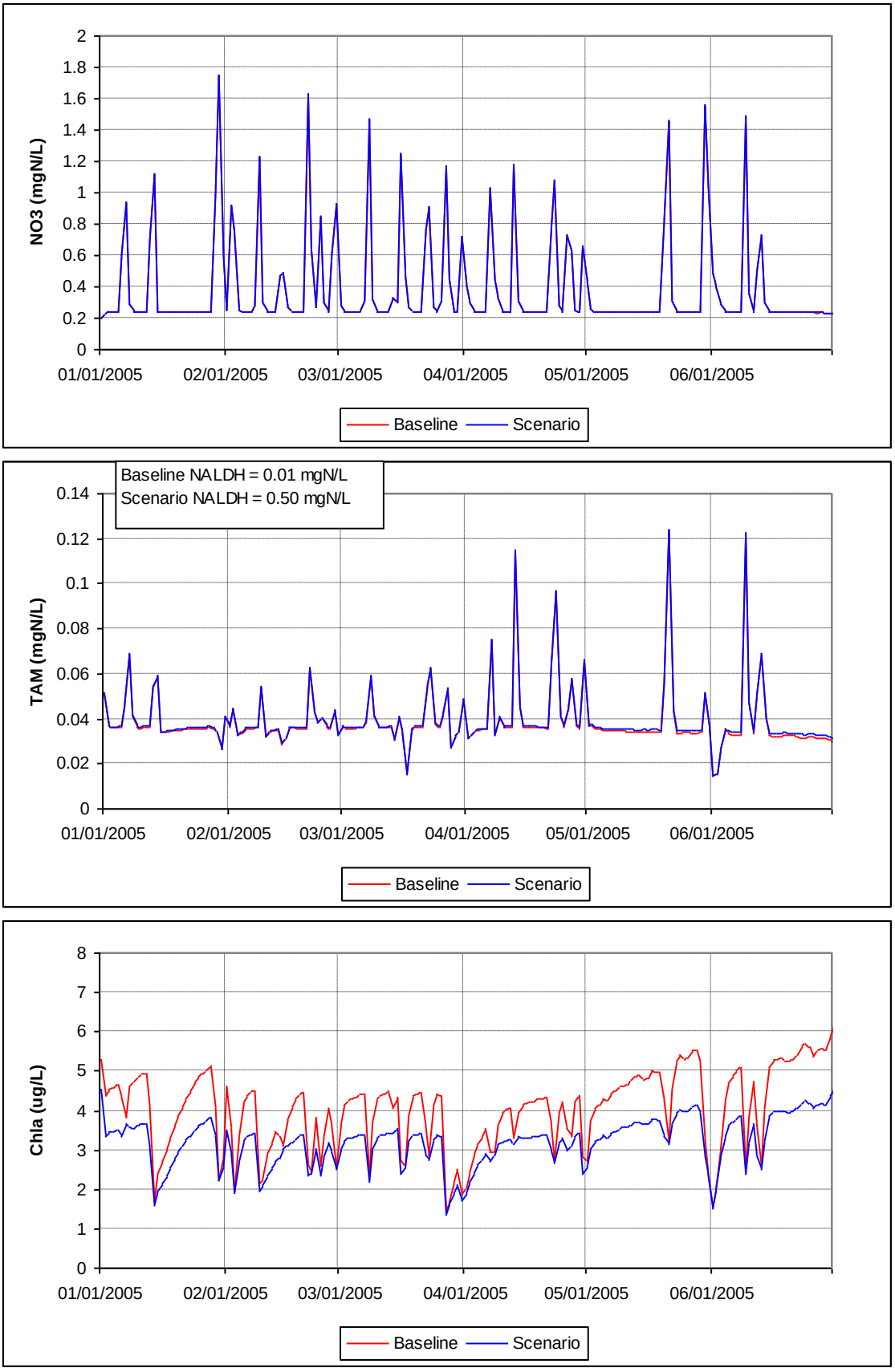


Figure 10-19. Simulation Comparisons of Nitrogen and Phytoplankton at Subbasin 101 for Scenario NALDH.

 © 2012 County of Los Angeles. All rights reserved.

10.6 Sediment

The sediment routine represents the general detachment of sediment from rainfall, overland and in-stream transport, attachment when there is no rainfall, and scour. Land disturbance can occur from construction or agricultural practice, disturbing native vegetative cover and leaving the soil susceptible to rainfall. With the native cover disturbed, a rainfall event might cause detachment and provide sufficient rainfall in combination with the lack of vegetative cover to cause scour and further erosion as the overland flow proceeds to a defined channel. The sediment can be defined as organic, inorganic, or both. LSPC uses the cards noted in Table 10-37 to define the sediment routine input.

Table 10-37. Sediment Routine Cards

Card Number	Card Name
440	Sediment Parameter Controls
450	Sediment Parameters Group 1
451	Sediment Parameters Group 2
452	GQUAL-Sediment to Stream Mapping (Read if Sediment as GQUAL)
453	Monthly Erosion Related Cover Values
454	Monthly Net Vertical Sediment Input
455	Sediment Parameters Group 3
456	Sediment Parameters Group 4

Card 440 is used to define initial controls for the sediment routine. That includes setting certain parameters as constant or monthly as well as prescribing other important switches for the simulation (Table 10-38).

Table 10-38. Card 440 Sediment Parameters Control

Parameter	Description
CRVFG	Erosion-related cover 0 = Constant 1 = Monthly, see card 453
VSIVFG	Net vertical sediment input (NVSI) 0 = Not simulated 1 = Monthly, see card 454 2 = Added to the detached sediment storage only on days when no rainfall occurred during the previous day
SANDFG	Sand transport capacity 0 = Not simulated 1 = Calculated using the Toffaleti method 2 = Calculated using the Colby method 3 = Calculated using the power function of velocity

Card 450 (Table 10-39) is the control point for detachment of soil by rainfall, reattachment of detached sediment, removal of detached sediment by surface flow, and allows for the accumulation and removal of solids independent of runoff.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-39. Card 450 Sediment Parameters Group 1

Parameter	Description
DEFID	Parameter group ID
DELUID	Model land unit ID
SMPF	Supporting management practice factor, default value is 1.0
KRER	Coefficient in the soil detachment equation
JRER	Exponent in the soil detachment equation
AFFIX	Fraction by which detached sediment storage decreases each day as a result of soil compaction. (1/day)
COVER	Fraction of land surface which is shielded from rainfall erosion
NVSI	Rate at which sediment enters detached storage from the atmosphere (lb/ac/day) negative value may be used to simulate removal by human activity or wind
KSER	Coefficient in the detached sediment wash-off equation
JSER	Exponent in the detached sediment wash-off equation
KGER	Coefficient in the matrix soil scour equation, which simulates gully erosion
JGER	Exponent in the matrix soil scour equation, which simulates gully erosion
ACCSDP	Rate at which solids accumulate on the land surface (used in impervious land)
REMSDP	Fraction of solids storage which is removed each day when there is no runoff, for example, because of street sweeping (used in impervious land)

The following discussion of the various sediment processes represented in the model is from Bicknell et al. 2004.

Detach Soil by Rainfall

Kinetic energy from rain falling on the soil detaches particles, which are then available to be transported by over land flow. The equation that stimulates detachment is

$$DET = DELT60 \times (1.0 - CR) \times SMPF \times KRER \times (RAIN / DELT60)^{\wedge} JRER$$

where

DET = sediment detached from soil matrix by rainfall (tons/ac/interval)
DELT60 = number of hours/interval
CR = fraction of the land covered by snow and other cover
SMPF = supporting management practice factor
KRER = Detachment coefficient dependent on soil properties
RAIN = rainfall (in/interval)
JRER = detachment exponent dependent on soil properties.

The variable CR is the sum of the fraction of the area covered by the snowpack, if any, and the fraction that is covered by anything else (e.g., monthly cover values).

Re-attachment of Detached Sediment

Attachment to the soil matrix is simulated by merely reducing DETS. Because the soil matrix is considered to be unlimited, no addition to the soil matrix is necessary when this occurs. DETS is diminished at the start of each day that follows a day with no precipitation by multiplying it by (1.0-AFFIX). This represents a first order rate of reduction of the detached soil storage

DETS = detached sediment storage (tons/ac)
AFFIX = the fraction by which detached sediment storage decreases each day as a result of soil compaction.

Atmospheric Deposition

Atmospheric deposition of sediment is added directly to the detached sediment storage variable DETS. NVSI represents any net external additions or removals of sediment caused by human activities or wind.

Removal by Surface Flow

 © 2012 County of Los Angeles. All rights reserved.

When simulating the wash-off of detached sediment, the transport capacity of the overland flow is estimated and compared to the amount of detached sediment available. The transport capacity is calculated by the equation

$$STCAP = DELT60 \times KSER \times ((SURS + SURO) / DELT60)^{JSER}$$

where

STCAP	= capacity for removing detached sediment (tons/ac/interval)
DELT60	= hr/interval
KSER	= coefficient for transport of detached sediment
SURS	= surface water storage (inches)
SURO	= surface outflow of water (in/interval)
JSER	= exponent for transport of detached sediment

When STCAP is greater than the amount of detached sediment in storage, wash-off is calculated by

$$WSSD = DETS \times SURO / (SURS + SURO)$$

If the storage is sufficient to fulfill the transport capacity, the following relationship is used:

$$WSSD = STCAP \times SURO / (SURS + SURO)$$

where

WSSD	= wash-off of detached sediment (tons/ac/interval)
DETS	= detached sediment storage (tons/ac)

WSSD is then subtracted from DETS

Transport and detachment of soil particles from the soil matrix is simulated with the following equation:

$$SCRSD = SURO / (SURS+SURO) \times DELT60 \times KGER \times ((SURS + SURO) / DELT60)^{JGER}$$

where

SCRSD	= scour of matrix soil (tons/ac/interval)
KGER	= coefficient for scour of the matrix soil
JGER	= exponent for scour of the soil matrix

The sum of the two fluxes, WSSD and SCRSD, represent the total sediment outflow from the land segment.

Accumulate and Remove Solids Independently of Runoff

The storage is updated once a day, on those days when precipitation did not occur during the previous day, using the equation

$$SLDS = ACCSDP + SLDSS \times (1.0 - REMSDP)$$

where

ACCSDP	= accumulation rate of the solids storage (tons/ac/day)
SLDS	= solids in storage at end of day (tons/ac)
SLDSS	= solids in storage at start of day (tons/ac)
REMSDP	= unit removal rate of solids in storage (i.e., fraction removed per day)

Note: If no runoff occurs, the previous equation causes the solids storage to asymptotically approach a limiting value, the limit, found by setting SLDS and SLDSS to the same value (SLDSL), is

$$SLDSL = ACCSDP / REMSDP$$

Card 451 (Sediment Parameter Group 2) is for assigning background concentrations (mg/L) of sediment in surface, interflow, and ground water outflow. This card defines the fraction of sand, silt, and clay, after the

 © 2012 County of Los Angeles. All rights reserved.

background concentrations and input to the stream from the land flowpaths have been combined. The fractions of the sediment into sand, silt, and clay must sum to 1.

If sediment were simulated as a GQUAL constituent instead of using the overland sediment routine, a user would set card 452 to map the GQUAL constituent to the stream.

Cards 453 (Monthly Erosion Related Cover Values MON-COVER) and 454 (Monthly Net Vertical Sediment Input MON-NVSI)) are used to input monthly values. The cover parameter is used to reflect protection from rainfall erosivity, the vegetative canopy and residue cover over the course of the growing season. If a user set a value of 97 percent for cover, the LSPC Model will interpret that as 3 percent of the model land unit (DELUID) for a given default parameter group (DEFID) is available for sediment detachment by rainfall. The net vertical sediment value can be negative to reflect actions like street sweeping in urban areas or positive to reflect deposition from wind/dust storms.

The previous cards were used to define mostly land-based or model land unit (DEFID) parameters. The following cards are related to reach parameter groups. The following section is from Bicknell et al. 2004 and provides explanation to parts of the stream (RGID) portion of the sediment routine.

> Both the migration characteristics and the adsorptive capacities of sediment vary significantly with particle size. Consequently, HSPF divides the inorganic sediment load into three components (sand, silt, and clay), each with its own properties. Parametric information required for cohesive sediments (silt and clay) include
>
> 1. particle diameter – D
> 2. particle settling velocity in still water – W
> 3. particle density – RHO
> 4. critical shear stress for deposition – TAUCD
> 5. critical shear stress for scour – TAUCS
> 6. erodibility coefficient – M
>
> Parameter values required for noncohesive, or sand, particles depend on the method used to compute sand load (alternate methods are described in the functional description of subroutines SANDLD, TOFFAL, and COLBY). If the Toffaleti method is used, values must be defined for median bed sediment diameter (DB5O) and particle settling velocity (W). The Colby method requires a value for DB5O, and the power function method requires both a coefficient (KSAND) for the power function and an exponent (EXPSND).
>
> The same material fluxes are modeled for all three fractions of sediment. Only the methodology used to determine fluxes between suspended storage and bed storage differ.
>
> HSPF assumes that scour or deposition of inorganic sediment does not affect the hydraulic properties of the channel. Furthermore, it is assumed that sand, silt, and clay deposit in different areas of the RCHRES bed; consequently, the deposition or scour of each material is not linked to the other fractions (i.e., *armoring* is not modeled). Longitudinal movement of bed sediments is not modeled.

The parameters for cards 455 and 456 are summarized in Table 10-40 and Table 10-41.

Table 10-40. Card 455 Sediment General Parameters Group 3

Parameter	Description
RGID	Reach parameter group ID
BEDWID	Bed width (ft) used for sediment deposition—this is constant for the entire simulation period
BEDDEP	Initial bed depth (ft)
POR	Porosity (volume voids/total volume), used to estimate bed depth
BURIAL	>0 = Burial rate of aggregated sediment layer (in/day) 0 = Burial rate defined on card 456

 © 2012 County of Los Angeles. All rights reserved.

Table 10-41. Card 456 Sediment Parameters Group 4

Parameter	Description
RGID	Reach parameter group ID
SED_ID	Sediment class ID
SEDFLG	Sediment flag indicating sediment class 0 = sand 1 = silt 2 = clay
SEDO	Initial sediment concentration in fluid phase (mg/L)
SEDFRAC	Initial sediment fractions (by weight) in the bed material
DB50/D	Sand—Median diameter of the non-cohesive sediment (in) (SANDFG = 1 or 2) Silt and clay—Effective diameter of the cohesive particles (in)
W	Corresponding fall (settling) velocity of the particle in still water (in/s)
RHO	Density of the particles (gm/cm^3)
KSAND/TAUCD	If SANDFG =3, coefficient in the sandload power function formula If SANDFG <>3, critical bed shear stress for deposition of the cohesive particle—generally TAUCD ≤ TAUCS (lb/ft^2) - If TAU > TAUCD, no deposition - If TAU < TAUCD, deposition rate approaches settling velocity, W
EXPSND/TAUCS	If SANDFG =3, exponent in the sandload power function formula If SANDFG <>3, critical bed shear stress for scour of the cohesive particle (lb/ft^2) - If TAU < TAUCS, no scour - If TAU > TAUCS, scour steadily increases
M	Erodibility coefficient of the cohesive particle (lb/ft^2/day)
BURIAL	Burial rate of the sediment particle (in/day)

Note that the BURIAL terms in Cards 455 and 456 are unique to LSPC, and are not available in HSPF. If BURIAL in card 455 is greater than zero, then an aggregate sediment removal rate (in/day) is applied to all sediment classes according to the bed-depth proportion of that class. For example, if three sediment classes are being simulated, and each class has equal bed depth, then sediment will be permanently immobilized equally for all sediment classes for that time step. Alternatively, if BURIAL in card 455 is zero, then the model will check to see if class-specific burial rates are defined in card 456. If these are also zero, then no burial is simulated.

The following discussion is from Bicknell et al. 2004.

> The details of the transport, deposition, and scour techniques are outlined in the functional descriptions of the lower level routines of the SEDTRN module section. Following these calculations, the depth of sediment in the RCHRES bed is determined in order to warn the user whenever the deposited sediment exceeds a pre-specified level. First, the volume occupied by each fraction of bed sediment is calculated:
>
> $$VOLSED(J) = RSED(J + 3) / RHO(J) \times 1.0E06$$
>
> where
>
> $VOLSED(J)$ = volume occupied by bed sediment of fraction J (m^3 or ft^3)
> $RSED(J + 3)$ = bed storage of sediment fraction J ($mg \times m^3/L$ or $mg \times ft^3/L$)
> $RHO(J)$ = particle density of fraction J (gm/cm^3)
>
> The volumes of the three fractions of bed sediment are summed, and the total bed volume is adjusted to account for the fraction of the volume which is void of sediment (i.e., the porosity):
>
> $$VOLSEDA = VOLSED / (1.0 - POR)$$
>
> where
>
> VOLSEDA = volume of bed adjusted to account for volume occupied by materials other than sediment

 © 2012 County of Los Angeles. All rights reserved.

VOLSE = volume of sediment contained in the bed (sand + silt + clay)
POR = porosity of bed sediment (ratio of pore volume to total volume)

Finally, the depth of bed sediment is calculated for use as an indicator of excessive deposition:

$$BEDDEP = VOLSEDA / (LEN \times BEDWID)$$

where

BEDDEP = depth of bed (m or ft)
VOLSEDA = volume of bed (m^3 or ft^3)
LEN = length of RCHRES (m or ft)
BEDWID = effective width of bed for calculation of bed thickness (an input parameter expressed in m or ft)

Noncohesive sediment

Erosion and deposition of sand, or noncohesive sediment, is affected by the amount of sediment the flow is capable of carrying. If the amount of sand being transported is less than the flow can carry for the hydrodynamic conditions of the RCHRES, sand will be scoured from the bed. This occurs until the actual sand transport rate becomes equal to the carrying capacity of the flow or until the available bed sand is all scoured. Conversely, deposition occurs if the sand transport rate exceeds the flow's capacity to carry sand.

The SANDLD subroutine allows the user to calculate sand transport capacity for a RCHRES with three methods. Depending on the value of SANDFG specified in the User's Control Input, either the Toffaleti equation (SANDFG = 1), the Colby method (SANDFG = 2), or an input power function of velocity (SANDFG = 3) is used. If sand transport capacity is calculated using the Toffaleti or Colby methods, the potential sand load concentration is determined by the following conversion:

$$PSAND = (GSI \times TWIDE \times 10.5) / ROM$$

where

PSAND = potential sandload (mg/L)
GSI = sand transport capacity (tons/day/ft of width) (calculated in COLBY or TOFFAL)
TWIDE = width of RCHRES (ft)
10.5 = conversion factor
ROM = total rate of outflow of water from the RCHRES (m^3/sec)

If carrying capacity is a power function of velocity, PSAND is calculated as

$$PSAND = KSAND \times AVVELE^{EXPSND}$$

where

KSAND = coefficient in the sand load suspension equation (input parameter)
EXPSND = exponent in sand load suspension equation (input parameter)
AVVELE = average velocity (ft/sec)

The potential outflow of sand during the interval is

$$PROSND = (SANDS \times SROVOL) + (PSAND \times EROVOL)$$

where

PROSND = potential sand outflow
SANDS = concentration of sand at start of interval (mg/L)
SROVOL = outflow volume component based on start of interval (ft^3/interval)
EROVOL = outflow volume component based on end of interval (ft^3/interval)

The potential scour from, or deposition to, the bed storage is found using the continuity equation:

 © 2012 County of Los Angeles. All rights reserved.

$$PSCOUR = (VOL \times PSAND) - (VOLS \times SANDS) + PROSND - ISAND$$

where

PSCOUR	= potential scour (+) or deposition (-)
VOL	= volume of water in the reach at the end of the interval (ft^3)
VOLS	= volume of water in the reach at the start of the interval (ft^3)
ISAND	= total inflow of sand into reach during interval

The terms in the previous two equations have the units of concentration. The potential scour is compared to the amount of sand material of the bottom surface available for resuspension. If scour demand is less than available bottom sands, the demand is satisfied in full and the bed storage is adjusted accordingly. The new suspension concentration is PSAND. If the potential storage cannot be satisfied by bed storage, all the available bed sand is suspended, and bed storage is exhausted. The concentration of suspended sandload is calculated as:

$$SAND = (ISAND + SCOUR + SANDS \times (VOLS - SROVOL)) / (VOL + EROVOL)$$

where

SAND	= concentration of sand at end of interval
SCOUR	= sand scoured from, or deposited to, the bottom
SANDS	= concentration of sand at start of interval

The total amount of sand leaving the reach during the interval is

$$ROSAND = SROVOL \times SANDS + EROVOL \times SAND$$

If a reach goes dry during an interval or if there is no outflow from the reach, all the sand in suspension at the beginning of the interval is assumed to settle out, and the storage is correspondingly increased.

Cohesive Sediment

Exchange of cohesive sediments with the bed is dependent on the shear stress exerted on the bed surface. The shear stress within the RCHRES is calculated in subroutine SHEAR of the HYDR section. Whenever shear stress (TAU) in the RCHRES is less than the user-supplied critical shear stress for deposition (TAUCD), deposition occurs; whenever shear stress is greater than the user-supplied critical shear stress for scour (TAUCS), scouring of cohesive bed sediments occurs. The rate of deposition for a particular fraction of cohesive sediment is based on a simplification of Krone's (1962) equation to the following form

$$D = W \times CONC \times (1.0 - TAU / TAUCD$$

where

D	= rate at which sediment fraction settles out of suspension (mass/len2.ivl)
W	= settling velocity for cohesive sediment fraction (len/ivl)
CONC	= concentration of suspended sediment fraction ($mass/len^3$)
TAU	= shear stress (lb/ft^2 or kg/m^2)
TAUCD	= critical shear stress for deposition (lb/ft^2 or kg/m^2)

The rate of change of suspended sediment fraction concentration in the RCHRES due to deposition can be expressed as

$$d(CONC) / dt = -(D / AVDEPM)$$

where

AVDEPM	= average depth of water in RCHRES (m)

By substituting the expression for deposition rate (D) from Equation 4, the following equation is obtained:

$$d(CONC) / dt = -(W \times CONC / AVDEPM) \times (1 - TAU / TAUCD)$$

 © 2012 County of Los Angeles. All rights reserved.

By integrating and rearranging this equation, a solution can be obtained for the concentration of suspended sediment lost to deposition during a simulation interval (DEPCONC):

$$DEPCONC = CONC \times (1.0 - \text{EXP}((-W / AVDEPM) \times (1.0 - TAU / TAUCD))$$

where

CON	= concentration of suspended sediment at start of interval (mg/L)
W	= settling velocity for sediment fraction (m/ivl)
AVDEPM	= average depth of water in RCHRES in meters (calculated in HYDR)
TAU	= shear stress (lb/ft^2 or kg/m^2)
TAUCD	= critical shear stress for deposition (lb/ft^2 or kg/m^2)

The user must supply values for settling velocity (W) and critical shear stress for deposition (TAUCD) for each fraction of cohesive sediment (silt and clay).

Following the calculation of DEPCONC, the storage of sediment in suspension and in the bed is updated:

$$SUSP = SUSP - (DEPCONC \times VOL)$$
$$BED = BED + (DEPCONC \times VOL)$$

where

SUSP	= suspended storage of sediment fraction ($mg.ft^3/L$ or $mg.m^3/L$)
BED	= storage of sediment fraction in bed ($mg.ft^3/L$ or $mg.m^3/L$)
VOL	= volume of water in RCHRES (ft^3 or m^3)

The rate of resuspension, or scour, of cohesive sediments from the bed is derived from a modified form of Partheniades' (1962) equation:

$$S = M \times (TAU / TAUCS - 1.0)$$

where

S	= rate at which sediment is scoured from the bed ($mass/len^2.ivl$)
M	= erodibility coefficient for the sediment fraction ($kg/m^2.ivl$)
TAUCS	= critical shear stress for scour (lbs/ft^2 or kg/m^2)

The rate of change of suspended sediment fraction concentration in the RCHRES due to scour can be expressed as

$$d(CONC) / dt = S / AVDEPM$$

By substituting the expression for scour rate (S) from Equation 10 the following equation is obtained:

$$d(CONC) / dt = (M / AVDEPM) \times (TAU / TAUCS - 1.0)$$

By integrating and rearranging this equation, a solution can be obtained for the concentration of suspended sediment added to suspension by scour during a simulation interval (SCRCONC)

$$SCRCONC = M / AVDEPM \times 1000 \times (TAU / TAUCS - 1.0)$$

where

M	= erodibility coefficient ($kg/m^2.ivl$)
AVDEPM	= average depth of water (m)
1000	= conversion from kg/m^3 to mg/L

The user is required to supply values for the erodibility coefficient (M) and critical shear stress for scour (TAUCS) for each fraction of cohesive sediment (silt and clay) which is modeled.

Following the calculation of SCRCONC, the storage of sediment in suspension and in the bed is updated:

 © 2012 County of Los Angeles. All rights reserved.

BED = BED – (SCRCONC × VOL)
SUSP = SUSP + (SCRCONC × VOL)

If the amount of scour calculated is greater than available storage in the bed, the bed scour is set equal to the bed storage, and the bed storage is set equal to zero. Because the value specified for TAUCS should be greater than that for TAUCD, only one process (deposition or scour) occurs during each simulation interval.

10.7 Dissolved Oxygen/BOD

DO concentration is typically an important parameter in natural aquatic environments. If an aquatic system is altered or if pollution is contributing to the environment, the DO concentration balance becomes affected, typically through depressed levels. LSPC continues the algorithms used in HSPF and adopts DO and carbonaceous biochemical oxygen demand (BOD) as state variables. The model represents a single BOD class. Quoting from Bicknell et al. 2004,

> The [DO] state variable represents the total quantity of oxygen available to satisfy oxygen requirements in the system. The BOD state variable represents the total quantity of oxygen required to satisfy the first-stage (carbonaceous) biochemical oxygen demand of dead nonrefractory organic materials in the water.

If the user selects the checkbox to include DO (OXFG = 1) when building the LSPC Model application from the MS Access database, a series of related cards is active. The following discussion provides the cards, parameters, and equations that LSPC uses to estimate DO. A summary of the cards are in Table 10-42.

Table 10-42. Dissolved Oxygen Routine Cards

Card Number	Card Name
502	Gases Control
503	DO-CO2 Control Constants
504	Monthly DO in Interflow
505	Monthly DO in Ground water
510	DO/BOD Control
511	OX-Parm 1
512	OX-Parm 2
513	OXRX-Initial Conditions
514	OX-Scour Parms

Card 502 is used to define monthly or constant concentrations of DO and CO_2 in interflow and ground water (0 = constant, 1 = monthly). If pH is not being simulated, CO_2 is not considered. Card 503 is where constant DO (mg/L) and CO_2 (mgC/L) values are assigned for surface, interflow and ground water flow paths. If a user selected monthly varying DO concentrations on card 502, the constant values here will be ignored. The monthly values of DO for interflow (card 504) and ground water (card 505) also vary by model land unit (DELUID) and default parameter group (DEFID). The DO concentration values should be input in units of mg/L. Likewise, cards 506 and 507 allow monthly definition, as well as by model land unit (DELUID) and default parameter group (DEFID), of CO_2 (mgC/L).

Card 510 is used to indicate if benthic fluxes are considered (BENRFG, 1 = on and 0 =off). The parameter REAMFG is used to indicate which reaeration option is considered in an LSPC Model application. The three options are summarized in Table 10-43. When option 1 (REAMFG = 1) is selected, a user must populate parameter REAK on card 511 with the escape coefficient. The Covar method (REAMFG = 2) requires no input from the user because the program selects one of three reaeration formulas on the basis of hydraulic depth and velocity. The remaining option (REAMFG = 3) enables the user to specify parameters REAK, EXPREV, and EXPRED (card 511) at his or her discretion.

 © 2012 County of Los Angeles. All rights reserved.

Table 10-43. Card 510 Parameter REAMFG Reaeration Options

REAMFG Value	Definition
1	Tsivoglou-Wallace formula Parameter REAK (c511) used as escape coefficient (1/ft)
2	Covar method, which will use one of the following three methods based on depth and velocity 1 - Owen's formula, depth less than 2 feet; REAK = 0.906, EXPREV = 0.67, and EXPRED = -1.85 2 – Churchill's formula, high velocity, depth less than 2 feet; REAK = 0.484, EXPREV = 0.969, and EXPRED = -1.673 3 - O'Connor-Dobbins formula, low velocity, depth greater than 2 feet; REAK = 0.538, EXPREV = 0.5, and EXPRED = -1.5
3	User-specified power function based on hydraulic depth and velocity

Source: Bicknell et al. 2004

Card 511 contains input related to the kinetics (source and sink) of BOD and reaeration. The BOD decay and settling parameterization is prescribed. The process of reaeration is important in oxygen balance, and a user has options to select when defining the input. The variables of card 511 are summarized in Table 10-44.

Table 10-44. Card 511 OX-PARM1 Variables

Parameter	Definition
KBOD20	BOD decay rate at 20 °C (1/hr)
TCBOD	Temperature adjustment coefficient for BOD decay
KODSET	BOD settling rate (1/hr)
SUPSAT	Maximum allowable DO supersaturation concentration (percent)
TCGINV	Temperature correction coefficient for surface gas invasion
REAK	Empirical constant in the equation used to calculate reaeration coefficient (1/hr)
EXPRED	Exponent to depth in the reaeration coefficient equation
EXPREV	Exponent to velocity in the reaeration coefficient equation
CFOREA	Correction factor in the lake reaeration equation

The following sequence of equations is from Bicknell et al. 2004. They represent the equations used by LSPC regarding BOD decay in the LSPC Model as

$$BODOX = (KBOD20 \times (TCBOD\text{^}(TW \times 20))) \times BOD$$

where

BODOX = Quantity of oxygen required to satisfy BOD decay (mg/L/interval)
KBOD20 = BOD decay rate at 20 degrees C (1/interval)
TCBOD = Temperature correction coefficient, default is 1.075
TW = Water temperature (deg C)
BOD = BOD Concentration (mg/L)

If there is not sufficient DO available to satisfy the entire demand exerted by BOD decay, only the fraction that can be satisfied is subtracted from the BOD state variable, and the DOX variable (DO mg/L) is set to zero.

The following sequence of equations is from Bicknell et al. 2004. They represent the equations used by LSPC regarding BOD settling in the LSPC Model.

$$SNKOUT = BODCONC \times (KDOSET / AVDEPE)$$

where

SNKOUT = Fraction of material which settles out (reduction of concentration/interval)
BODCONC = Concentration of BOD material before deposition
KDOSET = BOD sinking rate (ft/interval)
AVDEPE = Average depth of water

 © 2012 County of Los Angeles. All rights reserved.

In any interval in which KDOSET in greater than AVEDEPE, all BOD material sinks.

The mass of BOD material sinking is calculated as

$$SNKMAT = SNKOUT \times VOL$$

where

SNKMAT = Mass of material that settles out during the interval (mass × ft^3/L/interval or mass × m^3/L/interval)
VOL = Volume of water in the reach (ft^3 or m^3)

A user can set variable SUPSAT to control the maximum allowable saturation DO concentration. The calculation is described below.

$$MSATDO = SATDO \times SUPSAT$$

where

MSATDO = Maximum allowable saturation dissolved concentration (mg/L)
SATDO = Saturated concentration of DO (mg/L)
SUPSAT = Maximum DO supersaturation multiplier (percent)

Generally, reaeration is complex and the options are important to the DO balance in the model. The following descriptions are from Bicknell et al. 2004 regarding the three stream reaeration options (subroutine OXREA).

For REAMFG = 1

$$KOREA = REAKT \times (DELTHE/FLOTIM) \times (TCGINV^{(TW-20.)}) \times DELTS)$$

where

REAKT = escape coefficient with a typical value between 0.054/ft and 0.110/ft.
DELTHE = drop in energy line along length of RCHRES (ft)
FLOTIM = time of flow through RCHRES (seconds)
TCGINV = temperature correction coefficient for gas invasion rate with a default value of 1.047
DELTS = conversion factor from units of /second to units of /interval

For REAMFG = 2 or 3

$$KOREA = REAK \times (AVVELE\text{^}EXPREV) \times (AVDEPE\text{^}EXPRED) \times (TCGINV\text{^}(TW - 20)) \times DELT60$$

where

KOREA = Reaeration coefficient (per interval)
REAK = Empirical constant for reaeration equation (1/hour)
AVVELE = Average velocity of water (ft/s)
EXPREV = Exponent to velocity function
AVDEPE = Average water depth (ft)
EXPRED = Exponent to depth function
TCGINV = Temperature correction coefficient for reaeration defaulted to 1.047
DELTE60 = Conversion factor from units of per hour to units of per interval

REAMFG = 3. Users can select their own power function of hydraulic depth and velocity for use under all conditions of depth and velocity. In this case, the user supplies values for REAK, EXPREV, and EXPRED. This option is selected by setting the reaeration method flag (REAMFG) to 3.

The general equation for reaeration is

$$DOX = DOXS + KOREA \times (SATDO - DOXS)$$

where

 © 2012 County of Los Angeles. All rights reserved.

DOX = DO concentration after reaeration (mg/L)
DOXS = DO concentration at start of interval (mg/L)
KOREA = Reaeration coefficient calculated in OXREA
SATDO = Saturated concentration of DO (mg/L)

The saturation concentration of DO is computed at prevalent atmospheric conditions by the equation:

$$SATDO = (14.652 + (TW \times (-0.41022 + TW \times (0.007991 - 0.777E\text{-}4 \times TW))) \times CFPRES$$

where

SATDO = Saturated concentration of DO (mg/L)
TW = Water temperature (degrees C)
CFPRES = Ratio of site pressure to sea level pressure (CFPRES is calculated by the Run Interpreter dependent upon mean elevation of RCHRES)

Card 512 (OX-PARM2) is used for prescribing benthic interactions of BOD. The benthic oxygen demand represents the exertion of the benthos on the water column DO. The benthic release represents the BOD moved to the water column from the benthos. Table 10-45 represents the parameters and description.

Table 10-45. Card 512 OX-PARM2 Variables

Parameter	Definition
BENOD	Benthic oxygen demand as 20 °C ($mg/m^2/hr$)
TCBEN	Temperature correction coefficient for benthic oxygen demand
EXPOD	Exponential factor in the DO term of the benthic oxygen demand equation
BRBOD	Benthic release rate of BOD under aerobic conditions ($mg/m^2/hr$)
BRBOD_INC	Increment to benthic release of BOD under anaerobic conditions ($mg/m^2/hr$)
EXPREL	Exponent in the DO term of the benthic BOD release equation

The following description of the benthic algorithm is from Bicknell et al. 2004.

The user approximates the oxygen demand of the bottom muds at 20 degrees Celsius by assigning a value to BENOD for each reach group. The effects of temperature and DO concentration on realized benthal demand are determined by the following equation:

$$BENOX = BENOD \times (TCBEN\text{^}TW20) \times (1.0 - \text{Exp}(-EXPOD \times DOX))$$

where

BENOX = Amount of oxygen demand exerted by benthal muds (mg/m^2/interval)
BENOD = Reach dependent benthal oxygen demand at 20 deg C (mg/m^2/interval)
TCBEN = Temperature correction factor for benthal oxygen demand
TW20 = Water temperature 20.0 (deg C)
EXPOD = Exponential factor to benthal oxygen demand function (default = 1.22)
DOX = Dissolved oxygen concentration (mg/L)

The first portion of the equation above adjusts the demand at 20 degrees Celsius to a demand at any temperature. The second portion of the equation above indicates that low concentrations of DO suppress realized oxygen demand. For example, 91 percent of BENOD can be realized at a DO concentration of 2 mg/L, 70 percent at 1 mg/L, and none if the water is anoxic.

After the value of BENOX has been calculated, the DO state variable is updated:

$$DOX = DOX - BENOX \times DEPCOR$$

where

DEPCOR = Factor that converts from mg/m^2 to mg/L based on the average depth of water in the reach during the simulation interval. (DEPCOR is calculated in a subroutine RQUAL).

 © 2012 County of Los Angeles. All rights reserved.

Benthal Release of BOD

Bottom releases of BOD are a function of scouring potential and DO concentration. The equation used to calculate BOD release is

$$RELBOD = (BRBOD + BRBOD_INC \times \text{Exp}(-EXPREL \times DOX)) \times SCRFAC$$

where

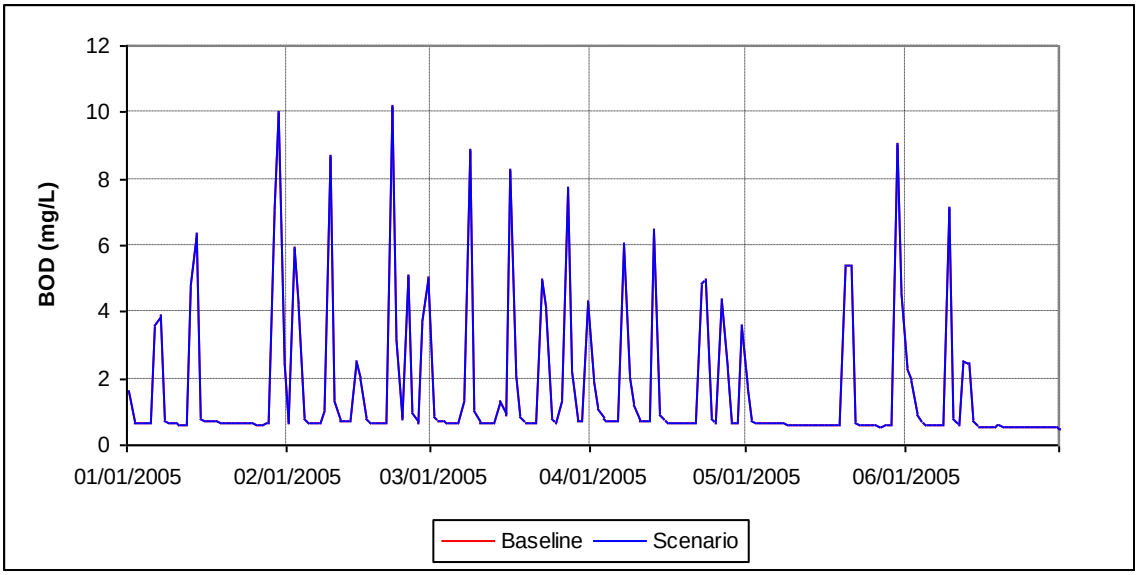
RELBOD	= BOD released by bottom muds (mg/m^2/interval)
BRBOD	= Base release rate of BOD materials aerobic (mg/m^2/interval)
BRBOD_INC	= Increment to bottom release rate due to decreasing DO concentration
EXPREL	= Exponential factor to BOD benthal release function (default = 2.82)
DOX	= DO concentration (mg/L)
SCRFAC	= Scouring factor dependent on average velocity of water

The above equation accounts for the fact that benthal releases are minimal during conditions of low velocity and ample DO. Under these conditions a thin layer of hardened, oxidized material typically retards further release of materials from the benthos. However, anaerobic conditions or increased velocity of overlying water disrupts this layer, and release rates of BOD and other materials are increased. Solution of the above equation indicates that 6 percent of the incremental release rate (BRBOD_INC) occurs when 1 mg/L of DO is present, 75 percent occurs when 0.1 mg/L is present, and the entire increment occurs under anoxic conditions.

Card 513 (OXRX-Initial Conditions) is used to set initial conditions of DO (water column and saturation value) and BOD. Card 514 (OX Scour Parameters) controls the bed scouring of BOD material. The amount scoured is dependent on a threshold velocity (SCRVEL, m/s), which is set by the user, above which the benthic release increases by a multiplier (SCRMUL).

The three scenarios from the RQUAL sections in this document on nutrients and phytoplankton (Table 10-36) are also presented to provide insight to any response they might have had on DO (Figure 10-20 through Figure 10-22). Scenarios KTAM20 and NALDH had negligible effects on the DO simulation. Scenario MALGR resulted in a slight increase in DO levels.

 © 2012 County of Los Angeles. All rights reserved.



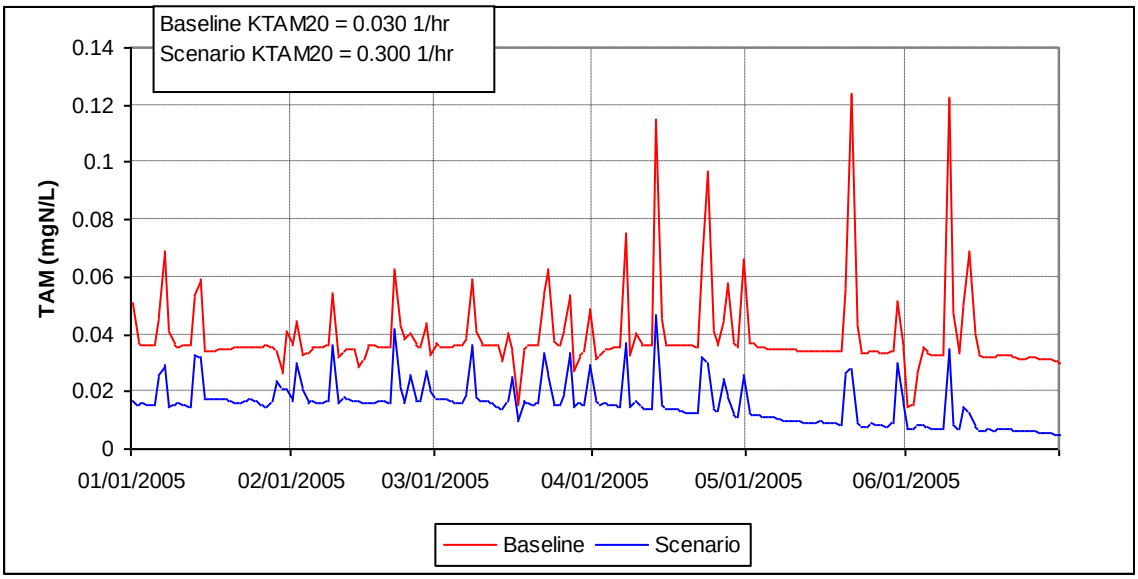
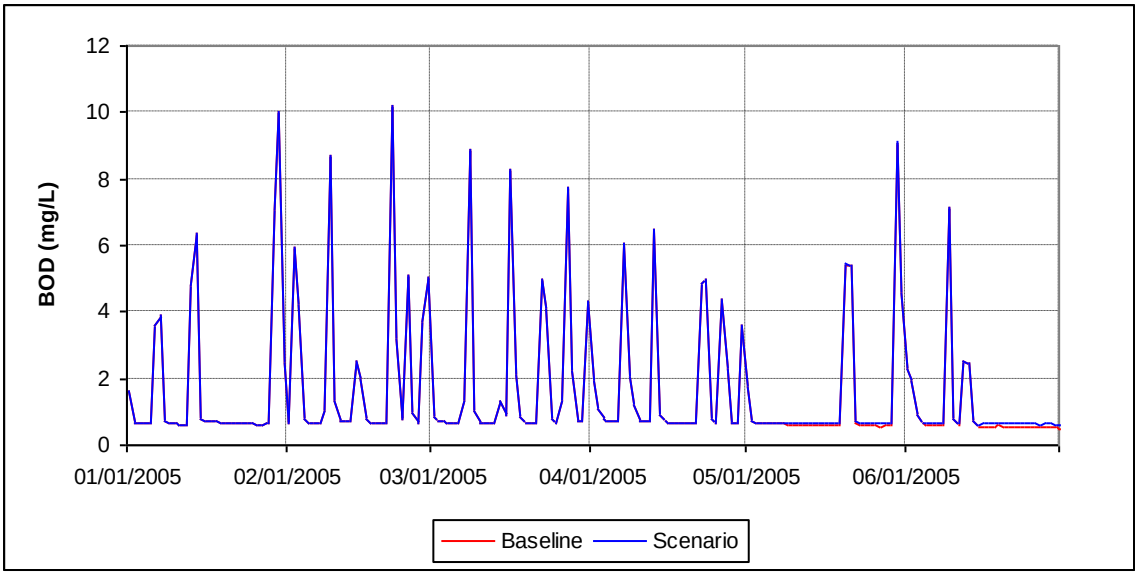
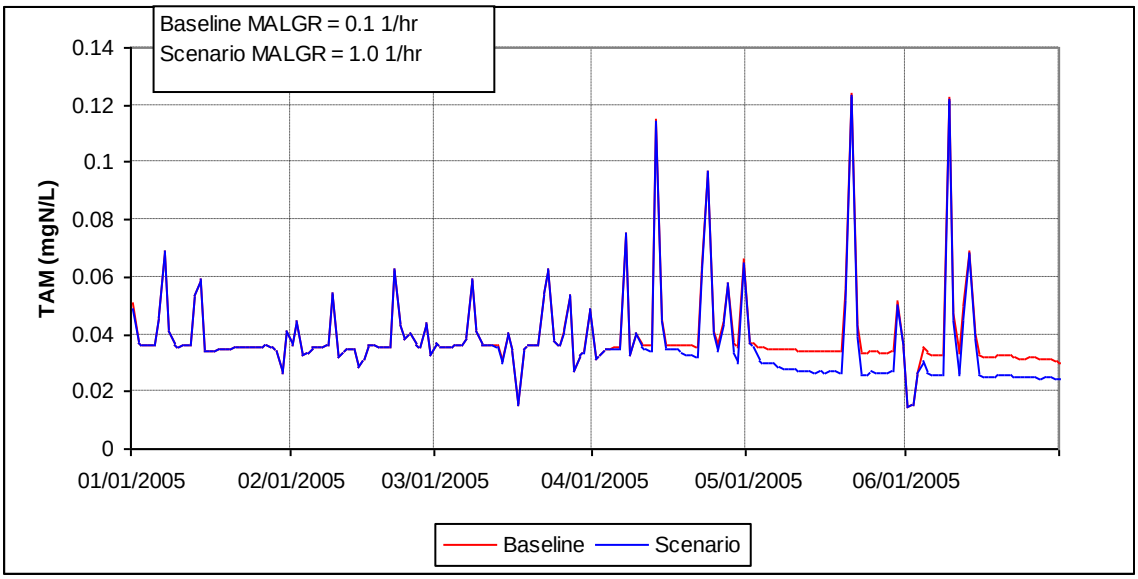


Figure 10-20. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario KTAM20.

 © 2012 County of Los Angeles. All rights reserved.





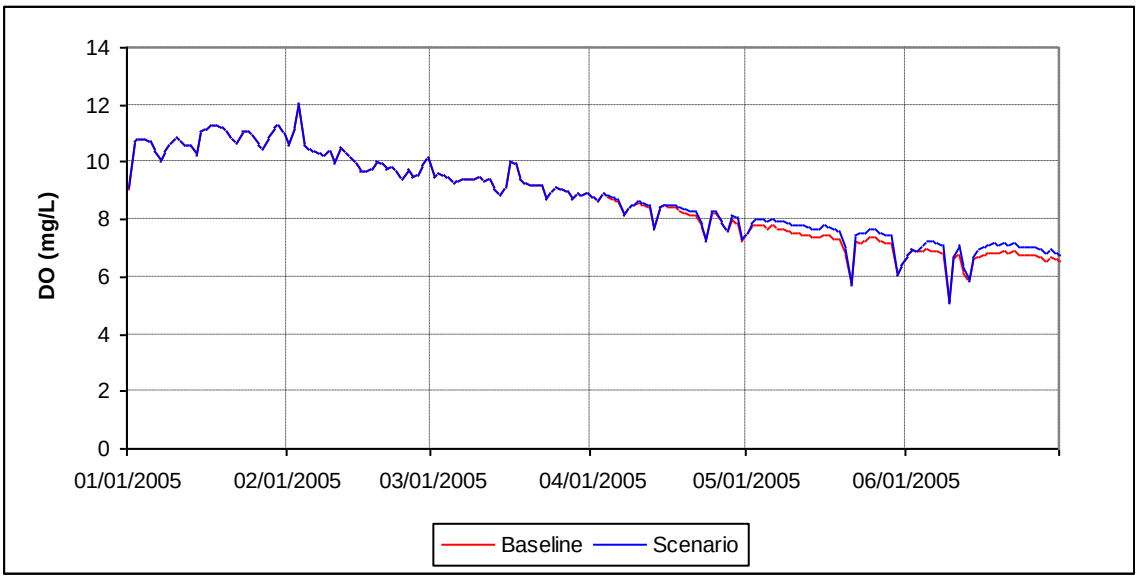
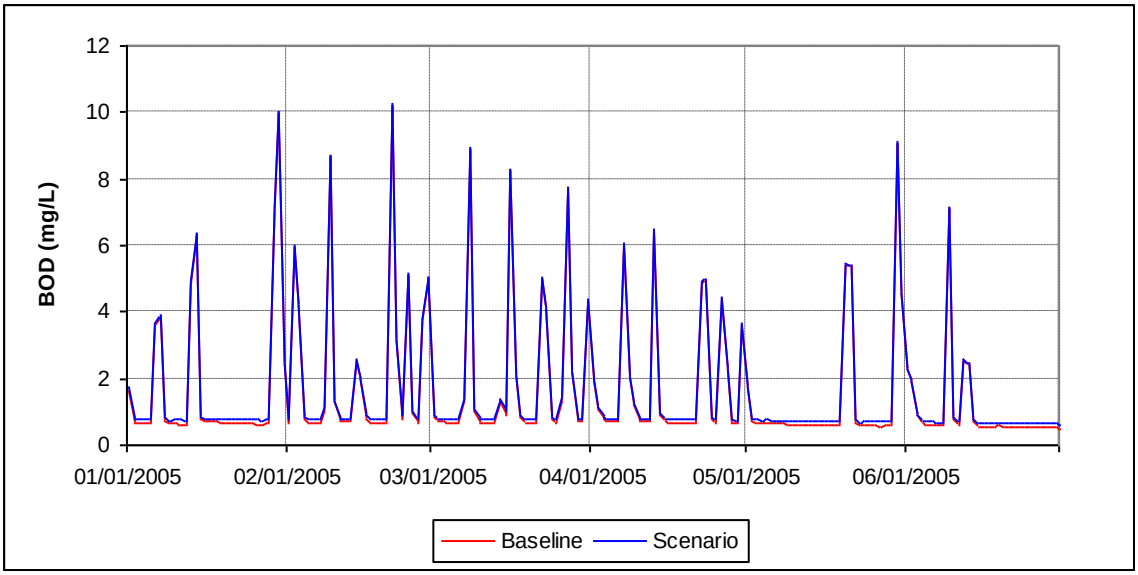


Figure 10-21. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario MALGR.

 © 2012 County of Los Angeles. All rights reserved.



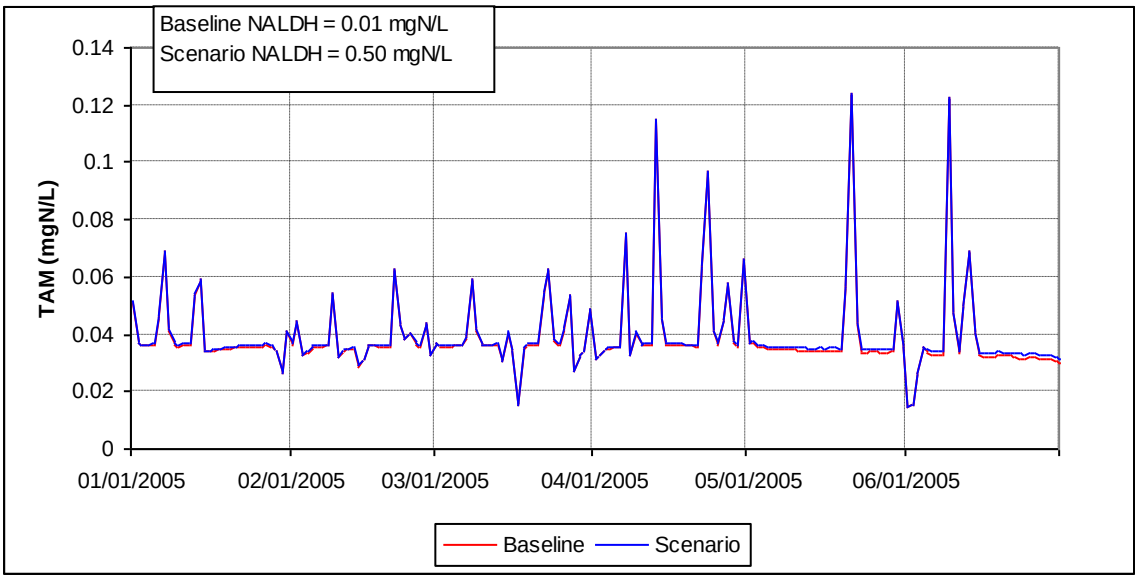


Figure 10-22. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario NALDH.

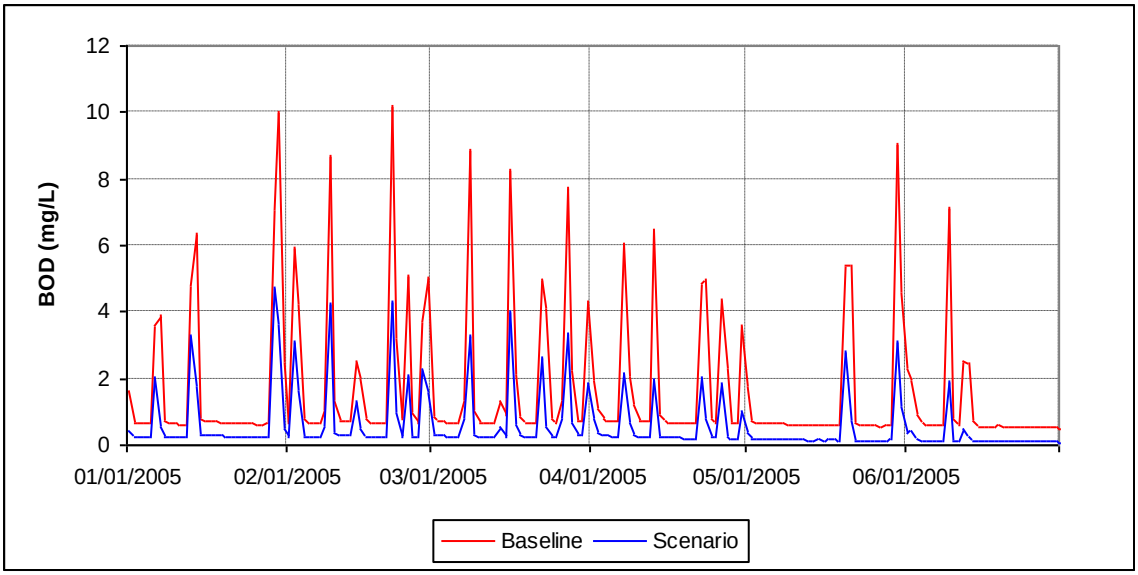
 © 2012 County of Los Angeles. All rights reserved.

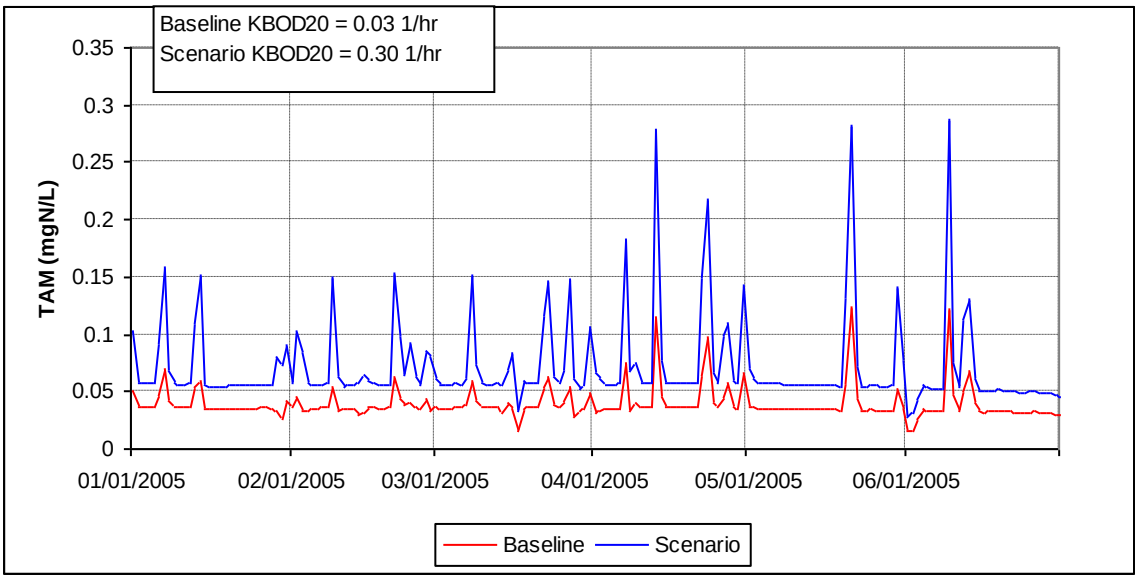
Three scenarios were developed in this section (Table 10-46) regarding biochemical oxygen demand (BOD) and DO and presented in Figure 10-23 through Figure 10-25. Scenario KBOD20 increased the BOD decay rate by an order of magnitude and the BOD and DO concentrations were less than the baseline. Scenario REAK increased the reaeration rate by approximately a factor of two, the BOD simulation was unaffected and the DO concentrations increased by approximately 2 mg/L. Scenario BENOD increased the benthic oxygen demand from 20 to 40 $mg/m^2/hr$. The result was a slight depression of the DO concentration compared to baseline.

Table 10-46. Dissolved Oxygen Example Scenarios

Scenario	Baseline Value	Scenario Value	Comment
KBOD20	0.03	0.30	1/hr, Card 511.
REAK	0.1 and 0.4	0.8	1/hr, Card 511.
BENOD	20	40	$mg/m^2/hr$, Card 512.

 © 2012 County of Los Angeles. All rights reserved.





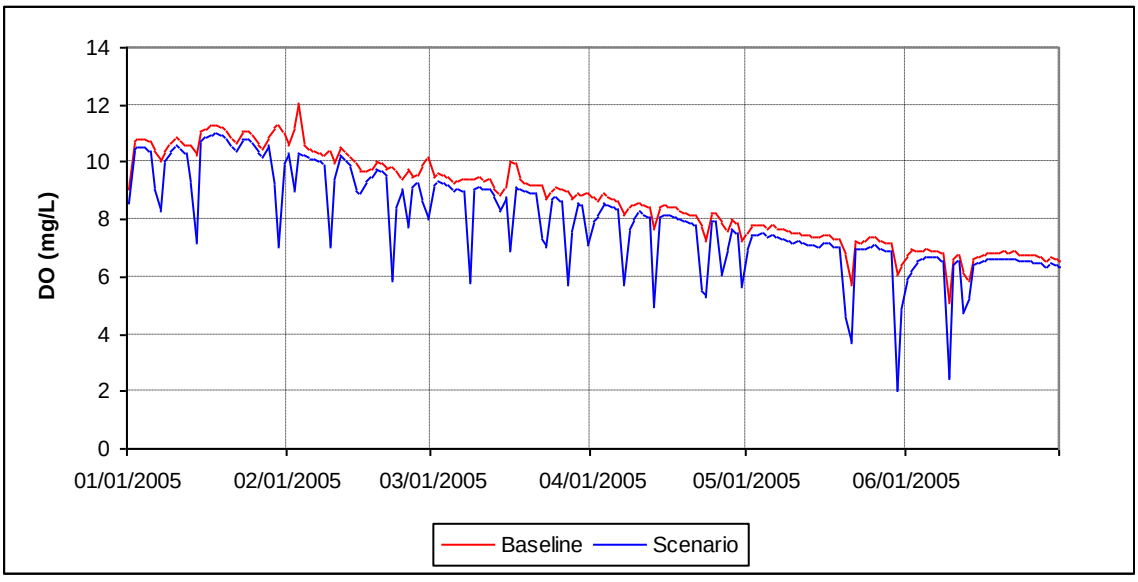
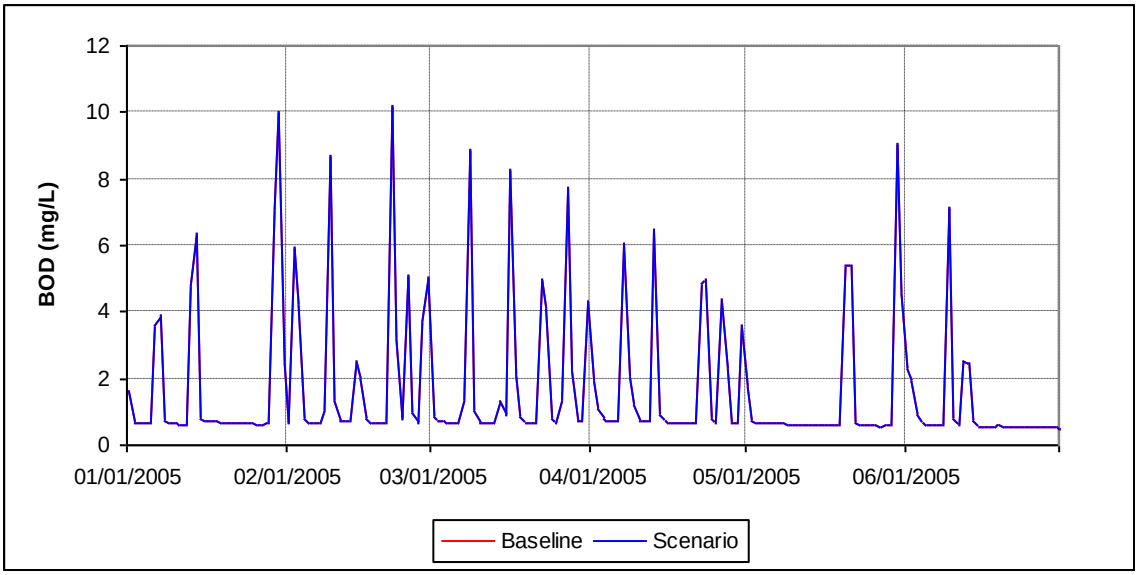
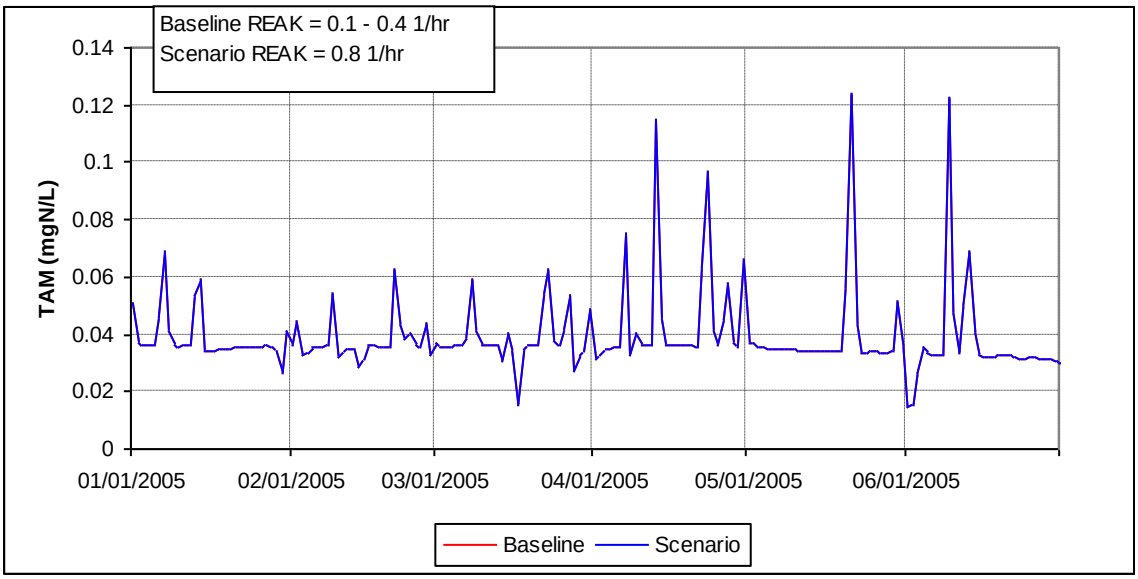


Figure 10-23. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario KBOD20.

 © 2012 County of Los Angeles. All rights reserved.





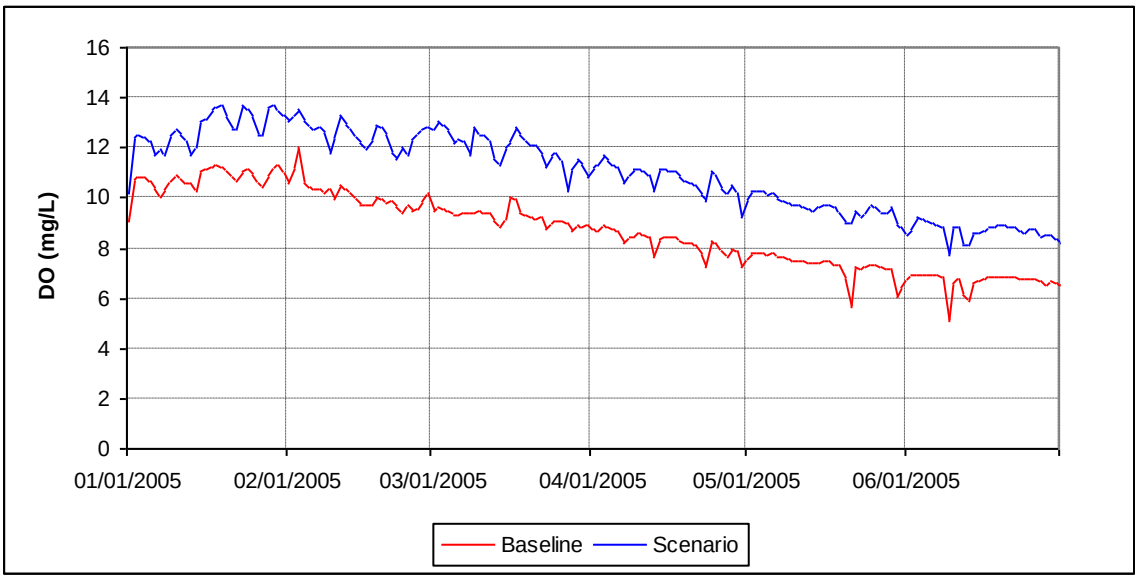
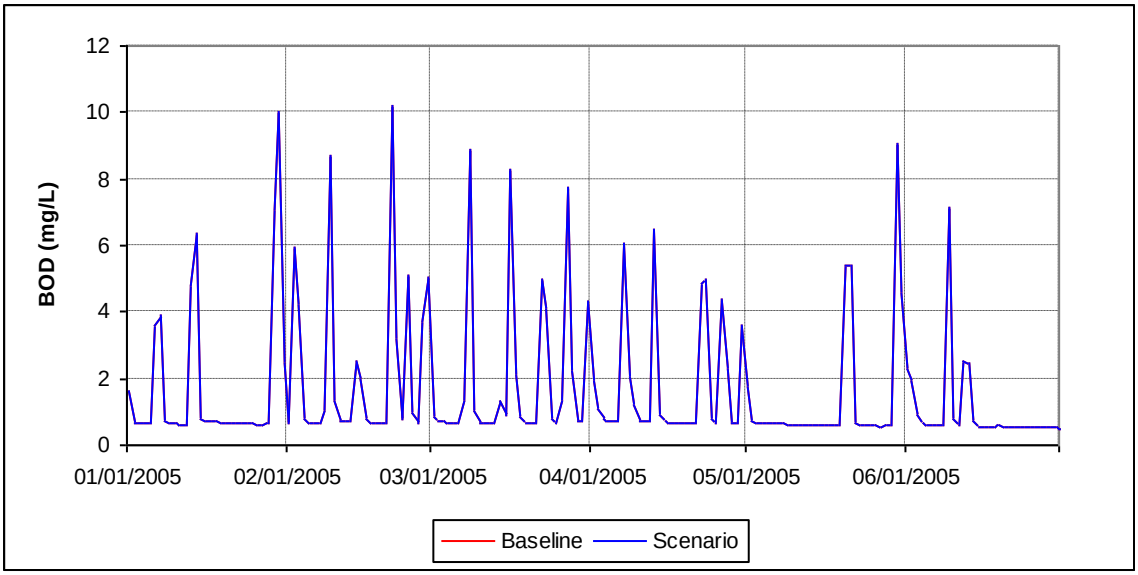
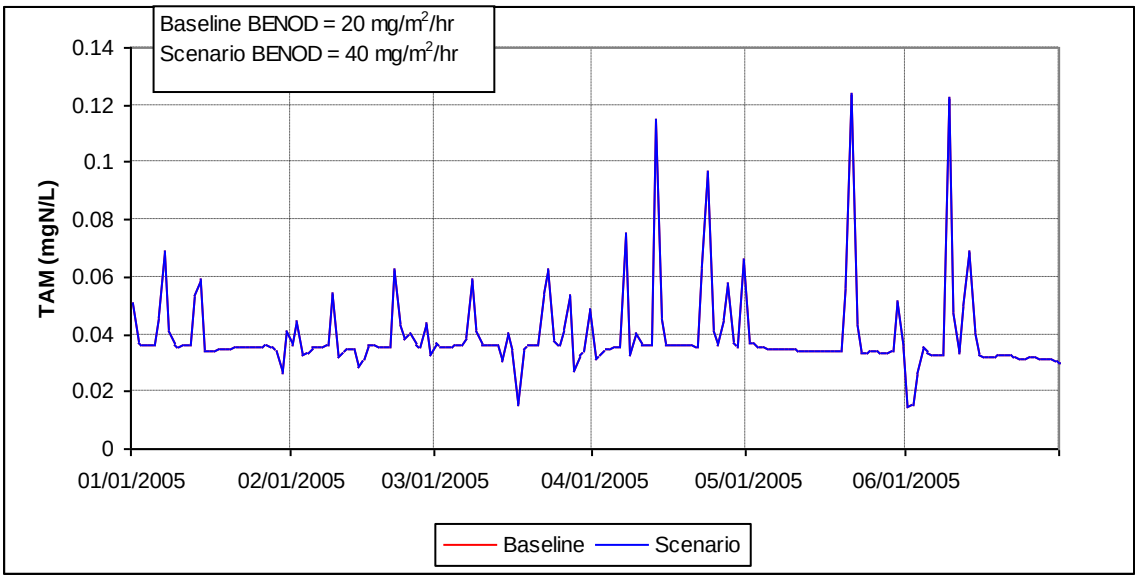


Figure 10-24. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario REAK.

 © 2012 County of Los Angeles. All rights reserved.





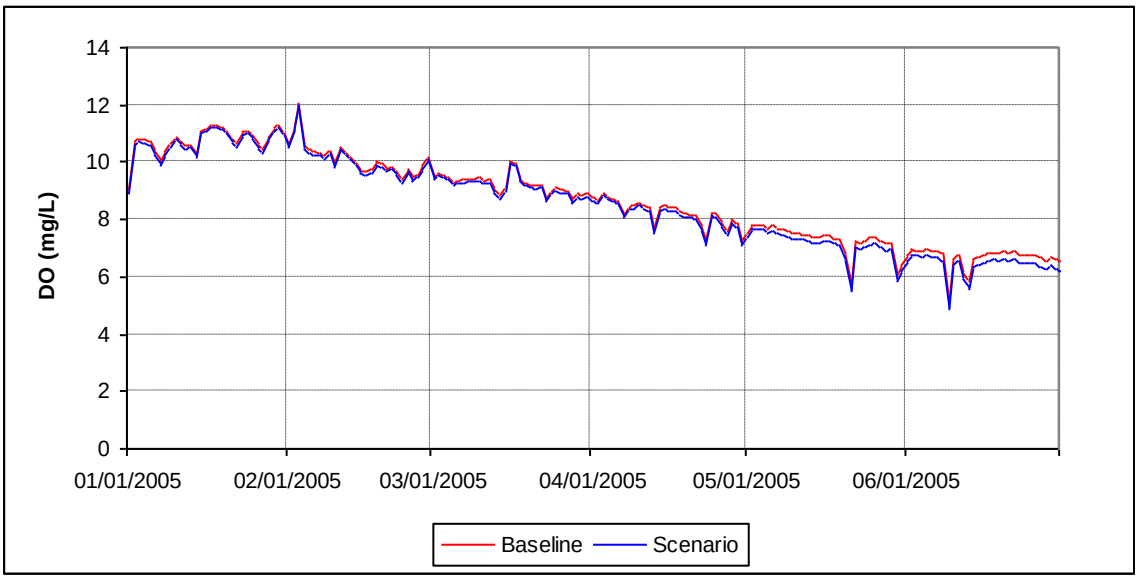


Figure 10-25. Simulation Comparisons of BOD, Ammonia, and DO at Subbasin 101 for Scenario BENOD.

 © 2012 County of Los Angeles. All rights reserved.

All three of the dissolved oxygen scenarios explored rate constant parameters which are also affected by temperature correction parameters. The three scenario rate constant parameters are all prescribed at 20 degrees C but the simulation goes through the annual range of water temperature. The program uses the rate constant parameters prescribed at 20 degrees C along with the temperature correction parameters in its algorithm. Figure 10-26 provides an example arbitrary rate constants and temperature correction values to illustrate the impacts to the rate constants used in a simulation. The closer the temperature correction value is to one, the more linear the change in the rate constant is across various temperatures. Conversely, the higher the temperature correction value, the more nonlinear the rate constant is, the more active the reaction is in warmer temperature and less active during cooler temperatures.

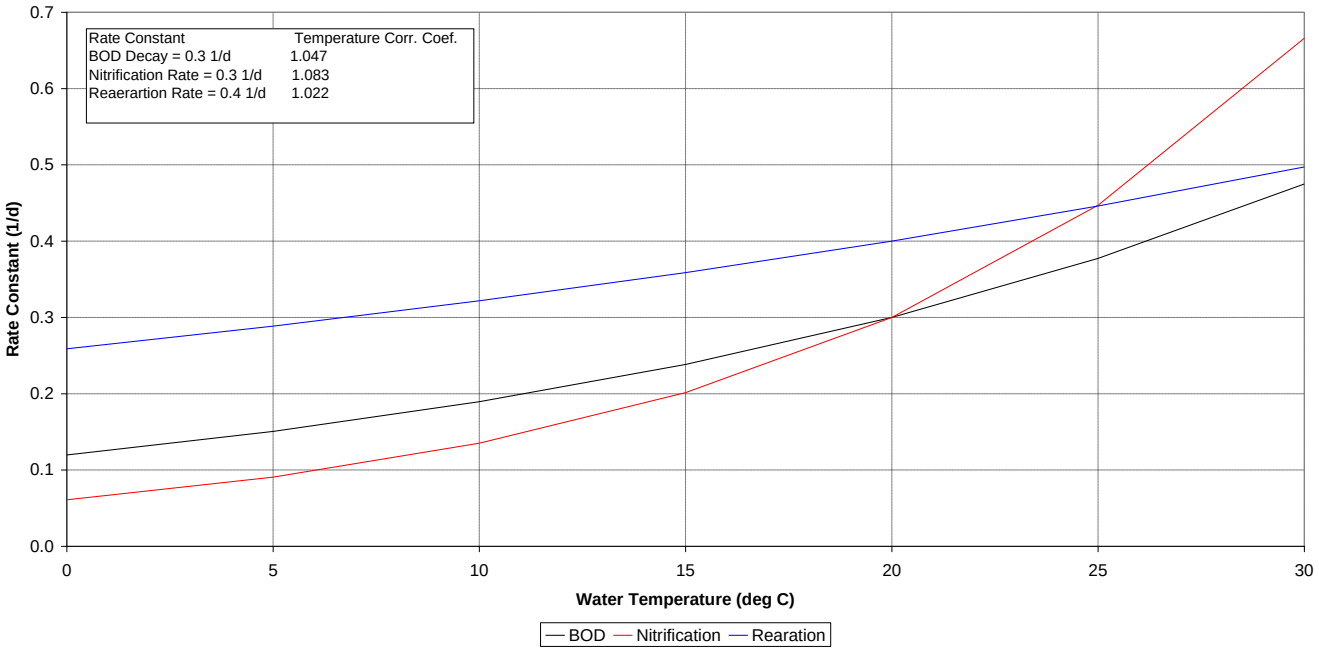


Figure 10-26. Temperature Correction Parameter for Various Rate Constants.

10.8 Cumulative Upstream Area

When the setup MS Excel files execute, it creates an ASCII file called **Network.csv**. That file is comma delimited and contains a listing of all the subbasins upstream of each subbasin in a study area. The user should copy/paste that file (or import it from MS Excel) into the UpstreamNetwork table in the MS Access database. Once the UpstreamNetwork table has been populated in the MS Access database, the user should execute query <Cumulative_Upstream_Landuse>. That populates the Network table in the MS Access database and produces a table of the upstream areas by DELUID to each subbasin in the study area. The table that is produced is very useful during the calibration process for both flow and water quality because it enables a user to review which are the dominant model land units (DELUID) to a subbasin or drainage pour point.

 © 2012 County of Los Angeles. All rights reserved.

This page was intentionally left blank.

 © 2012 County of Los Angeles. All rights reserved.

11 Model Updates

As with all water resource modeling applications, upkeep and improvement are continually occurring. Key improvements from the initial public release of LSPC (November 2003) are listed below.

1. User-defined F-tables.
    a. If a user defines an F-table for a given segment, it is used in place of the default 60-layer internal trapezoidal channel.
    b. User can define multiple outlets for an F-table and reroute each outlet independently to any other reach segment in the system.
    c. The entire routing algorithm has been changed so that only a downstream segment is required to be identified—there are no more requirements for identifying upstream left and right segments. With this change, several streams can discharge into any given segment; likewise, each stream outlet can be rerouted to a different segment.
2. Introduced *Reach Group* (RGID) mapping concept.
    a. Applies to in-stream modeling parameter mapping including in-stream sediment and GQUAL, and all RQUAL processes.
    b. DEFID was previously used for both land and in-reach parameter mapping. Because there is a lot more variability in how in-reach parameters are defined, having RGID independent of DEFID keeps LSPC from inordinately increasing file size and complexity whenever a new parameter group is added for localized, in-stream processes.
3. Revised Sediment Module.
    a. The revised model conforms to HSPF.
    b. Unlimited number of cohesive sediment classes allowed.
    c. Ability to add constant surface (SED_SURO), interflow (SED_IFWO), and/or ground water-associated (SED_AGWO) trace sediment concentrations to match baseflow observations during calibration.
    d. Ability to model sediment as a GQUAL and link to in-stream sediment settling and resuspension processes.
    e. Added SAND simulation options from HSPF.
    f. Added a burial term (in/day) for the bed layer of each in-stream sediment class. Buried sediment is permanently lost and is not subject to resuspension. Proportional fraction of sediment associated QUAL is also lost (burial term is not available in HSPF).
4. Updated Lake Module.
    a. A lake segment can be included either by defining an F-table or by using the internal CSTR-Lake option.
    b. Header information provided to guide parameterization of CSTR Lake.
    c. CSTR Lake specifications include: length/width; maximum overflow depth; overflow weir type, height, and size; orifice height and size; background infiltration rate.
5. Point Sources Definitions.
    a. Instead of one representative point source per reach segment, each point source input (PERMIT/PIPE) can be defined uniquely, with multiple point sources per reach segment.
    b. TMDL controls for point sources are also defined by PERMIT/PIPE.
    c. Eliminated constant point sources option (a constant point source can be specified using time-variable option by defining start and end dates then using a constant flow and load for the two dates).
    d. Assumes linear interpolation between consecutive reported discharges.
6. Revisions to GQUAL.
    a. Restructured GQUAL parameter cards (sorted by GID, QUALID, and LUID instead of GID, LUID, and QUALID). All parameters for one constituent appear in one convenient block for all land uses.

 © 2012 County of Los Angeles. All rights reserved.

    b. Added SOQC option (surface outflow quality concentration), so that surface pollutant concentrations can be specified in a similar way as IOQC and AOQC. This option can be used either in place of or in conjunction with existing build-up wash-off formulation. May also vary monthly.
    c. Added POTFC factor that functions in the same way as existing POTFW and POTFS, except that POTFC applies sediment specified using the fixed SED_SURO, SED_IFWO, or SED_AGWO concentrations. Added POTFCFG flag to GQUAL control card 250 (1 = apply POTFC to SED_SURO only, or 2 = apply POTFC to all three).
    d. Added in-stream sediment-association routines directly from HSPF (GQ-SEDDECAY, GQ-KD, GQ-ADRATE, GQ-ADTHETA, GQ-SEDCONC).
7. RQUAL in-stream routines added from HSPF.
    a. Ability to simulate detailed DO-BOD reactions (OXRX), nutrient transformations (NUTRX), Phytoplankton (PLANK), and pH Carbon Dioxide (PHCARB).
    b. Linkage table to divide land-based constituents into RQUAL compartments (i.e., TN to NO_2+NO_3, NH_4, Org-N; TP to PO_4, Org-P). This linkage allows different fractions to be assigned for surface, interflow, and ground water sources from the land.
8. Global option for direct precipitation and evaporation from waterbody surfaces.
9. Added CONVF option from HSPF, applied by Reach Group (RGID).
10. Simulation output time independent of simulation time. Output can be either daily summary or at the simulation timestep.
11. Refined output manager.
    a. Updated to include output options for all new modules and processes.
    b. Added a land use summary output option that writes one database-friendly file with flows and loads for each land use/subbasin combination. Option to output on a monthly, yearly, or average annual basis for the entire output period.
    c. Added a stream summary output option that writes one database-friendly file with inflows, outflows, loads in, and loads removed (each with unique source/sink identifiers) for each reach/lake segment. Option to output on a monthly, yearly, or average annual basis for the entire output period.
12. Atmospheric deposition to GQUAL.
    a. Dry deposition inputs can be specified as constant or monthly variable and have units of mass flux (lb/acre/day), just like existing ACQOP parameter.
    b. Wet deposition inputs can be specified as constant or monthly variable and have units of concentration (mg/L, µg/L, or #/100mL) to be applied to incoming precipitation timeseries.
    c. Both wet and dry deposition can also be applied directly to the surface of stream segments by Reach Group (RGID).
13. Updates to the TMDL Control Options: This whole section has been restructured and simplified to contain (1) point source controls, (2) land use controls by subbasin, and the following functionality:
    a. Land based TMDL reductions option (Card 600, ncland). If the value of this flag is 1, land-based TMDL reductions apply only to surface loads. If the value is 2, TMDL reductions apply to surface, interflow, and ground water loads.

 © 2012 County of Los Angeles. All rights reserved.

12 References

Bicknell, B.R., J.C. Imhoff, J.L. Kittle, Jr., T.H. Jobes, A.S. Donigian, Jr. 2004. HSPF Version 12 User's Manual. Aqua Terra Consultants in Cooperation with the U.S. Geological Survey for the U.S. Environmental Protection Agency, National Exposure Research Laboratory, Office of Research and Development, Athens, GA.

NRCS (Natural Resources Conservation Service). 2002. WinTR-55 User Manual. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC.

Sutherland, R.C. 1995. Methodology for estimating the effective impervious area of urban watersheds. In *The Practice of Watershed Protection*, ed. T. Schueler and H. Holland. Center for Watershed Protection, Ellicott City, MD.

USEPA (U.S. Environmental Protection Agency). 2008a. BASINS (Better Assessment Science Integrating point & Non-point Sources). U.S. Environmental Protection Agency. Washington DC. <http://www.epa.gov/waterscience/ftp/basins/system/BASINS4/>. 2009.

USEPA (U.S. Environmental Protection Agency). 2008b. Watershed and Water Quality Modeling Technical Support center. U.S. Environmental Protection Agency. Athens, GA. <http://www.epa.gov/athens/wwqtsc/>. 2009.

 © 2012 County of Los Angeles. All rights reserved.