Total Maximum Daily Loads of PCBs in the Houston Ship Channel
Quality Assurance Project Plan for Modeling
Revision 0

Type of Model(s): Water Quality Analysis Simulation Program (WASP)

Segment(s): 1007, 1006, 1005, 0901, 2421, 2426, 2427, 2428, 2429, 2430, 2436, 2438

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Total Maximum Daily Load Program
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This QAPP is effective for a period of one year from approval date.

Questions concerning this QAPP should be directed to Hanadi Rifai.

SECTION A: PROJECT MANAGEMENT

A1 APPROVAL PAGE

Texas Commission on Environmental Quality
Chief Engineer's Office, Water Programs

_____
Faith Hambleton, Program Manager Date
Total Maximum Daily Load Program

_____
Lauren Bilbe, Grant Manager Date
319 04-08 NPS

_____
Larry Koenig, Project Manager Date
Total Maximum Daily Load Program

Office of Compliance and Enforcement
Compliance Support Division

_____
Stephen Stubbs, Manager Date
Quality Assurance Program

_____
Kyle Girten, Quality Assurance Specialist Date
Quality Assurance Program

Signatures below indicates commitment to follow the procedures in this QAPP:

_____
Hanadi Rifai, Project Manager Date
University of Houston

_____
Nathan Howell, Quality Assurance Officer Date
University of Houston

Note: The UH Quality Assurance Officer will secure written documentation (such as the letter in Appendix A) from each sub-tier project participant (e.g., subcontractors, other units of government) stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The UH

Quality Assurance Officer will maintain the documentation as part of the project's quality assurance records, and will ensure that the document is available for review. **Copies of this documentation will also be submitted as deliverables to the TMDL Project Manager within 30 days of final TCEQ approval of the QAPP.**

U.S. Environmental Protection Agency, Region 6

_____

Donna Miller, Chief Date
State/Tribal Programs Section
Assistance Programs Branch

_____

Randall Rush, Project Officer Date
Assistance Programs Branch

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A3 DISTRIBUTION LIST

List the individuals and their organizations who need copies of the approved QA Project Plan and any subsequent revisions, including all persons responsible for implementation (e.g., project managers), the QA Managers, and representatives of all groups involved. Paper copies need not be provided to non-TCEQ individuals if equivalent electronic information systems can be used.

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A3-1 List of Acronyms

CAR	Corrective Action Report
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
QAM	Quality Assurance Manual (or Manager)
QAPP	Quality Assurance Project Plan
QAS	Quality Assurance Specialist
QMP	Quality Management Plan
RE	Relative Error
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency

A4 PROJECT/TASK ORGANIZATION

U.S. EPA Region 6

Randall Rush
EPA Project Officer
Responsible for managing the project for EPA. Reviews project progress and reviews and approves QAPP and QAPP amendments.

TCEQ Chief Engineer's Office
Water Programs

Faith Hambleton
TMDL Program Manager
Responsible for managing the TCEQ TMDL Program. Supervises the TMDL staff. Oversees the development of QA guidance for the TMDL Team to ensure it is within pertinent frameworks of the TCEQ. Reviews and/or approves all TMDL Projects, QA audits, QAPPs, agency QMPs, corrective action reports, work plans, and contracts. Enforces corrective action where QA protocols are not met. Ensures TCEQ TMDL personnel are fully trained and TMDL projects are adequately staffed.

Larry Koenig
TMDL Project Manager
Responsible for ensuring that the project delivers products of known quality, quantity, and type on schedule to achieve project objectives. Provides the primary point of contact between the UH and the TCEQ. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified in the contract. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TCEQ participants. Responsible for verifying that the QAPP is followed by the UH. Notifies the TCEQ QAS, TMDL QAS, and the Program Manager of significant project nonconformances, CARs, and corrective actions taken as documented in quarterly progress reports from UH Project Manager.

TCEQ Compliance Support Division

Kyle Girten
TMDL Quality Assurance Specialist
Assists the TCEQ TMDL Project Manager and the TMDL QAS on QA-related issues. Coordinates reviews and approves QAPPs and amendments or revisions. Conveys QA problems to appropriate TCEQ management. Monitors implementation of corrective actions. Coordinates and conducts audits.

University of Houston (UH)

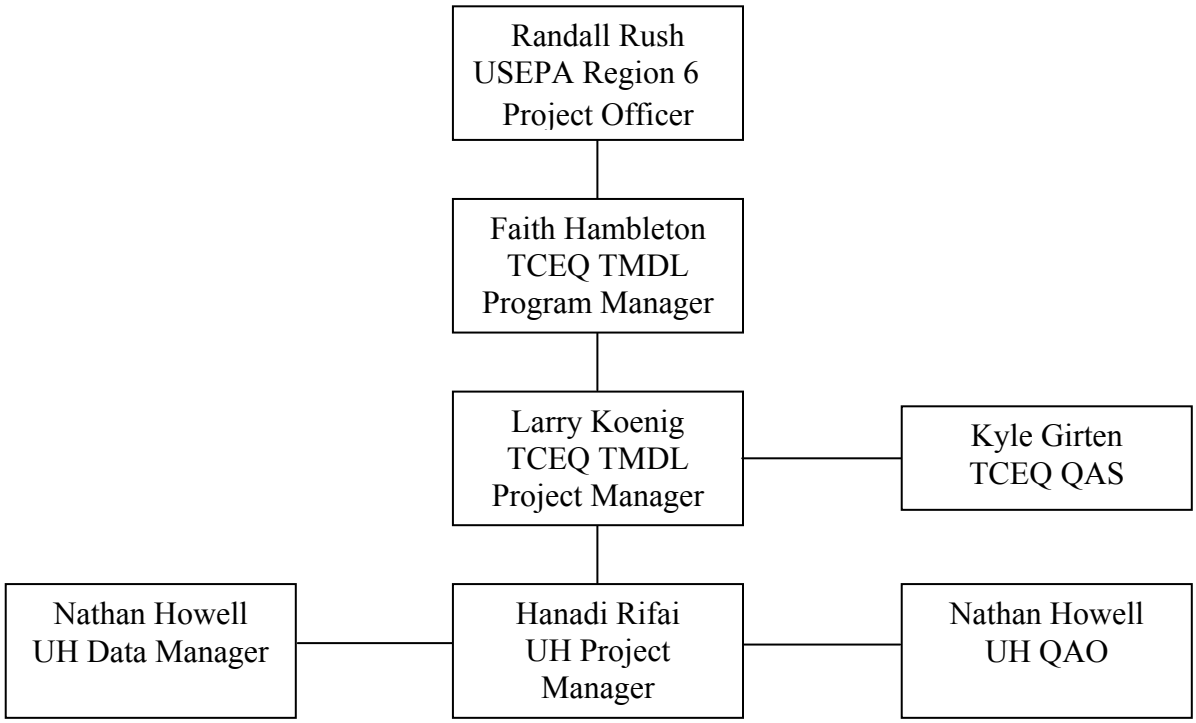
Hanadi Rifai
University of Houston Project Manager
The UH Project Manager is responsible for ensuring that tasks and other requirements in the contract are executed on time and with the quality assurance/quality control requirements in the system as defined by the contract and in the project QAPP; assessing the quality of subcontractor/participant work; submitting accurate and timely deliverables to the TCEQ TMDL Project Manager; and coordinating attendance at conference calls, training, meetings, and related project activities with the TCEQ. Verifies that the data and model outputs meet the data quality objectives of the project and are suitable for reporting to TCEQ. Responsible for verifying that the QAPP is distributed and followed by the UH (including all subcontractors) and that the project is producing products of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in the project, including the facilitation of audits and the implementation, documentation, verification and reporting of corrective actions. Ensures modeling work satisfies project objectives and contract and workplan requirements.

Nathan Howell
University of Houston Quality Assurance Officer
Responsible for coordinating development and implementation of the UH's QA program. Responsible for writing and maintaining the QAPP and monitoring its implementation. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Ensures the data acquired for the project is of known and acceptable quality and adheres to the specifications of the QAPP. Assists Project Manager and modeling staff in verifying that the data and model outputs meet the data quality objectives of the project and are suitable for reporting to TCEQ. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Also responsible for maintaining records of QAPP distribution. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for compiling and submitting any QA report (audit results, CARS, etc). Responsible for coordinating with the TCEQ QAS to resolve QA-related issues. Notifies the UH Project Manager and TCEQ Project Manager of particular circumstances which may adversely affect the quality of the products. Coordinates the research and review of technical QA material and data related to the model system design and analytical techniques. Conducts assessments of participating organizations during the life of the project as noted in Section C1. Implements or ensures implementation of corrective actions needed to resolve nonconformances noted during assessments.

Nathan Howell
University of Houston Data Manager
Responsible for the monitoring the acquisition, processing, transfer, and archiving of applicable data and/or model outputs (finished data). Oversees data management for the project. Responsible for ensuring that all model input and output data are properly reviewed and submitted in the format specified in the contract or by the TMDL Project Manager. Performs data quality reviews (data is of right type and quality, and format) prior to transfer of applicable

data to TCEQ. Provides the point of contact for the TCEQ TMDL Project Manager to resolve issues related to the data and assumes responsibility for the correction of any data errors.

Figure A4.1 Organization Chart



A5 PROBLEM DEFINITION/BACKGROUND

A5-1 Purpose

The purpose of the QAPP is to clearly delineate the University of Houston's QA policy, management structure and procedures to implement the QA requirements necessary to verify, calibrate, and validate the output of the modeling process. This QAPP is reviewed by the TCEQ to help ensure that the outputs and data generated for the purposes described within are scientifically valid and legally defensible. This process will facilitate the use of project outputs and data by the TMDL program and other programs deemed appropriate by the TCEQ.

A5-2 PCBs in the Houston Ship Channel (HSC)

Polychlorinated biphenyls (PCBs) are widespread organic contaminants that are environmentally persistent and can be harmful to human health even at low concentrations. A major route of exposure for PCBs worldwide is through food consumption, and this route is especially

significant in seafood. The discovery of PCBs in seafood tissue has led the Texas Department of State Health Services to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Two specific advisories have been issued for all finfish species based on concentrations of PCBs, organochlorine pesticides, and dioxins. ADV-20 was issued in October 2001 and includes the HSC upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge. ADV-28 was issued in January 2005 for Upper Galveston Bay (UGB) and the HSC and all contiguous waters north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. These two advisories represent a large surface water system for which TMDLs need to be developed and implemented.

PCB concentrations have been sampled in water, sediment, and tissue in the HSC as early as 1974 (in the case of sediment and water). Concentrations, initially in terms of Aroclors and later in terms of total PCBs, have been a concern since that time. Various industries have made or used PCBs along the HSC since before the 1970s, and the persistent nature of these PCBs means that sediments have served as a repository for the contaminant. PCBs can reenter the water column and are incorporated into fish, or the organisms that come in contact with sediment may take them in directly. Industrial production and use of PCBs has been banned in the US since 1977 (De Voogt and Brinkman, 1989), but contemporary sources to the HSC may still exist in the form of dry and wet air deposition, runoff from PCB disposal areas, illegal PCB disposal, or incidental PCB production in chemical wastewater streams. A focus of the sampling effort will be to determine the contributions of these various sources and transport mechanisms in order to correctly model the effects for better HSC understanding and decision-making. Where these contributions cannot be easily measured, assumptions will be made to model the effects.

A 2002-2003 PCB sampling effort in the Channel was conducted as part of the HSC dioxin TMDL. That study showed that “hot spot” regions exist in the HSC concentrated around the largest industrialized segments, segments 1006 and 1007 (Figure A5-1) It also pointed at the possibility of unique contemporary sources because unusual non-Aroclor PCB congener 209 was found. And finally sediment transport of PCBs seemed likely since some of the congener profiles in various tributaries and main channel segments were similar.

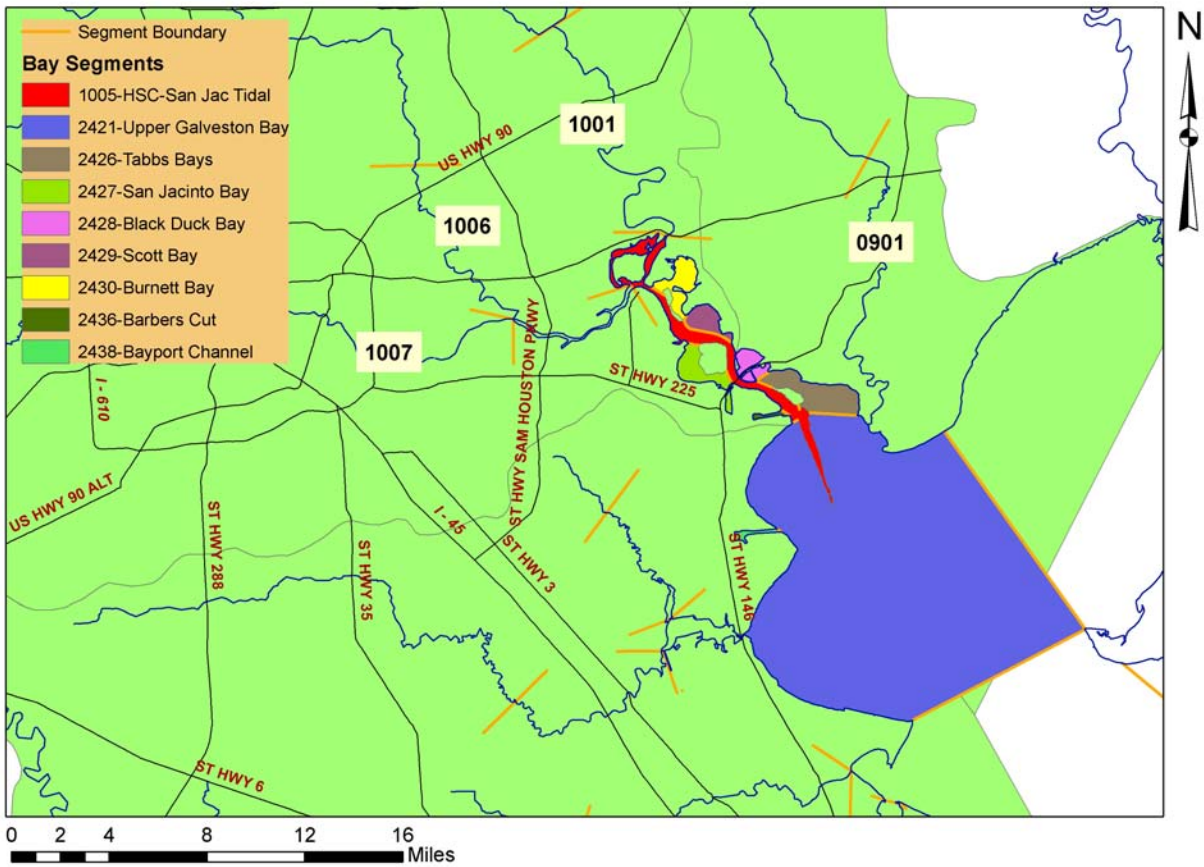


Figure A5-1. Houston Ship Channel Site Segmentation

The objectives of the TMDL modeling is to characterize the state of PCBs in the HSC, define the inputs to the HSC system, and understand the way that the HSC system would respond to changes put upon it either by natural or anthropogenic means. In order to do that, sampling will be conducted by the University of Houston to gather necessary model inputs into an RMA2-WASP7 (combination hydrodynamic-water quality) model similar to what was used in the dioxin TMDL. The model combined with a load allocation spreadsheet will allow scenarios to be run on a virtual HSC that can help decision-makers to attain water quality standards and safety in the HSC through the manipulation of loads into the HSC (e.g. regulating PCB releasing facilities, dredging sediment) or by altering components of the system (e.g. changing the way channel maintenance is done, restricting activities from certain parts of the channel) that affect transport within the HSC system.

A6 PROJECT TASK/DESCRIPTION AND SCHEDULE

Project tasks related to the determination of a PCB TMDL in the HSC include the following:

1. Task 1 - Develop a Water Quality Model of the HSC to Use in Connection with the Existing Hydrodynamic Model
    - Sub-Task 1.1 - Gather Non-Directly Measured Input Data
    - Sub-Task 1.2 - Gather and Organize New Monitoring Data
    - Sub-Task 1.3 - Modify Existing Setup of the Dioxin TMDL Water Quality Model
    - Sub-Task 1.4 - Develop Calibrated and Validated Water Quality Model using WASP7
    - Sub-Task 1.5 – Predictive Application of the Calibrated/Validated Model
2. Task 2 – Document Model Progress and Conclusions
    - Sub-Task 2.1 – Develop Draft Quarterly and Final Project Reports for the entire PCB TMDL Work Order
    - Sub-Task 2.2 – Prepare Revised Drafts of Quarterly and Final Project Reports for the entire PCB TMDL Work Order
    - Sub-Task 2.3 - Produce TCEQ Approved Quarterly and Final Project Reports for Task 1 Activities

A6-1 Project Task Descriptions

The previous task list is here further explained.

<u>Task 1 - Develop a Water Quality Model of the HSC to Use in Connection with the Existing Hydrodynamic Model.</u> The existing hydrodynamic HSC model is an RMA2 model that was used in the Dioxin TMDL Project. That TCEQ approved model will predict the hydrodynamics of the HSC system in order to generate hydrodynamic time series output in the form of flows and water surface elevations. That data combined with other channel data (both data in existence and that which will be collected during the project) will be used to create a water quality model relevant to PCBs using the WASP7 simulation program. The interactions of these two models are detailed in Figure A6-1, and the final output of the water quality model will be the spatial, temporal, and possibly vertical variability of the total PCBs in the HSC.

Sub-Task 1.1 – Gather Non-Directly Measured Input Data. There is a large set of data needs including channel geometry, tributary and upstream channel flow time series, previously collected PCB water and sediment concentrations, and other data sets mentioned in section B9 that need to be gathered, organized, and formatted for input into the WASP7 model. Part of this task will be to look at all of the model inputs required by WASP7 and checking those needs against the data that is available. The other large part of this task will be gain understanding about the RMA2 model output and the HSCREAD (Rifai, 2006) interface that loads it into WASP7. That output will need to be matched up correctly with the HSCREAD code in such a way to match the model grid that is needed to model PCBs as they are likely to be transported in the HSC.

Sub-Task 1.2 – Gather and Organize New Monitoring Data. New monitoring data will be gathered for many water quality parameters as well as fish and sediment concentrations beginning in the Fall of 2007. The data will be gathered according to the HSC PCB TMDL Project Plan and the Monitoring QAPP. The data will need to be examined once it is received from the lab in order to ascertain the presence of outliers and to decide how best to divide the data into subsets for validation. It is anticipated that the previous monitoring data of 2002-2003 will serve as a calibration data set while the new data will be used for validation. In addition to dividing the new data for potential use in multiple validation sets, it will also need to be examined with the non-directly measured data gathered in Sub-Task 1.1 to determine the channel conditions during the time span of data collection. That is to say that the data needs to be assessed to provide data sets that focus on specific channel conditions of flow, rainfall patterns, and seasonality.

Sub-Task 1.3 - Modify Existing Setup of the Dioxin TMDL Water Quality Model. The current Dioxin TMDL Water Quality Model exists in WASP7. There are, however, the following fundamental differences in concept between modeling these two different constituents.

- Known PCB "hot spots" in the HSC are somewhat different than those found for dioxin
- Evidence exists that PCB transport may occur through model boundaries by way of sediment transport which was not the case for dioxin
- Point source loads may be more difficult to model for PCBs because current industrial sources of PCB are not as well understood
- A need for more vertical modeling of PCBs may be required since some vertical PCB monitoring will now be occurring as stated in the Project Plan.

These differences and other differences that have not yet been determined means that at least initially the first difference between the two WASP7 models may be a change in the model grid layout. Furthermore, the physical coefficients that define contaminant behavior in WASP7 will be different. Though one might be able to look at such coefficient changes as a simple numbers changes, it is likely that these changes may make the running of the model completely different

Sub-Task 1.4 - Develop Calibrated and Validated Water Quality Model using WASP7. Once the model has been setup according to the best conceptualization of the channel and the physical-chemical properties of PCBs, then the model needs to be calibrated and verified. Briefly, the process of calibration is to first calibrate the dispersion coefficients using measured salinity data from the 2002-2003 sampling event. Salinity is considered a conservative tracer, which should have the same dispersive behavior as PCBs. Once the dispersion coefficient has been calibrated using salinity that parameter will be set, and the other unknown parameters will be calibrated using measured PCB data from 2002-2003. The calibration parameters for the model are explained in more detail in section B7, and they will be calibrated using data from the 2002-2003 PCB sampling set. Validation will happen through the data that will be collected in the Project Plan.

Sub-Task 1.5 – Predictive Application of the Calibrated/Validated Model. The intended use of the completed model is to predict what will happen to water concentrations under varying load

scenarios. Scenarios that could be run include elimination of point sources, elimination of non-point sources, removal of internal sediment loadings, etc. The model should give an accurate predictor of PCB levels under different loading scenarios so that an effective load reduction strategy can be formulated.

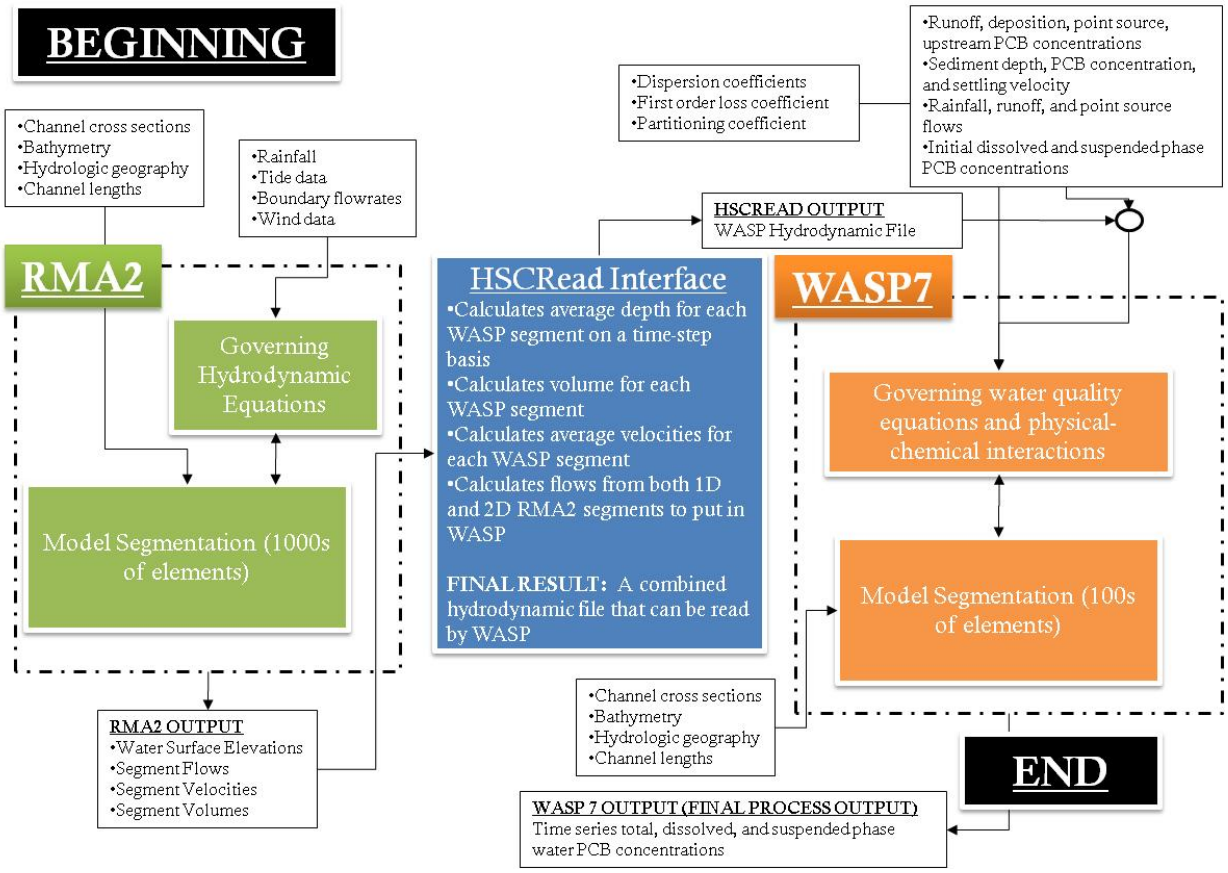


Figure A6-1. Coupling of the RMA2 hydrodynamic and WASP7 water quality models to simulate total PCB concentrations in the HSC. The HSCRead Interface serves as the connecting protocol to convert hydrodynamic output from RMA2 into hydrodynamic input into WASP7.

Task 2 – Document Model Progress and Conclusions. Model progress will be formally communicated to the TCEQ Project Manager by way of standard quarterly reports. Issues encountered in modeling and latest conclusions will be given. At some point, most of the modeling work will be complete. When that happens, most of the project will focus on dealing with the analysis of the model results and the various load scenarios that are needed. The completed modeling work will be documented in a quarterly report in a more final and conclusionary manner. The quarterly reports will continue to be generated for every year the project continues under each new work order. Each year will conclude with a summary final report, and the end of the project will have an all-encompassing project final report.

A6-2 Model Strategy

The dioxin TMDL project developed the hydrodynamic RMA2 model that was used for a three-year simulation for the years 2002-2005. The hydrodynamic output (water surface elevation, velocity, and flowrate) was used as input into the WASP7 water quality model. The fact that the dioxin TMDL has already been conducted helps to streamline the model development. The hydrodynamic model is non-specific to any particular contaminant describing only the behavior of the water in time. Contaminant fate and transport depends on these conditions as well as others. Thus, the RMA2 part of the model needs no specific further development work for the project. WASP7 is contaminant-specific, needing physical and chemical constants as well as calibration and verification datasets to make it predictive for PCBs. The general strategy then would be to apply the RMA2 model used in the dioxin TMDL to a different time span, and then to feed that output to a newly developed WASP7 module specific to PCBs. The RMA2 model might need some verification data applied to it since the time span is different, but it should be minimal. The WASP7 model might need a slightly different strategy in terms of water depth segmentation. The deeper parts of the HSC are scheduled to be measured at different depths. So it might be helpful in those places to have water layers divided into surficial and deep.

A6-3 Project Goal Completion

The model will serve the main project goal of achieving a PCB TMDL for the HSC by providing the TCEQ Project Manager with a reasonable approximation of likely channel behavior when various load reductions are attempted. The model will be presented to the TCEQ Project Manager in such a way that they can use it to understand the contaminant situation in the channel and make hypothetical changes in a realistic way.

A6-4 QAPP Revision

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date, or revised and reissued within 120 days of significant changes, whichever is sooner. The last approved versions of QAPPs shall remain in effect until revised versions have been fully approved; the revision must be submitted to the TCEQ for approval before the last approved version has expired. If the entire QAPP is current, valid, and accurately reflects the project goals and the organization's policy, the annual re-issuance may be done by a certification that the plan is current. This certification can be accomplished by submitting a cover letter stating the status of the QAPP and a copy of new, signed approval pages for the QAPP.

A6-5 QAPP Amendments

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and nonconformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the UH Project Manager to the TCEQ TMDL Project Manager in writing using the TMDL QAPP Expedited Amendment form. The changes are effective immediately upon approval by the TCEQ TMDL Project Manager and TCEQ Quality Assurance

Specialist, or their designees, and the EPA Project Officer (if applicable). Amendments to the QAPP and the reasons for the changes will be documented, and copies of the approved QAPP Expedited Amendment form will be distributed to all individuals on the QAPP distribution list by the UH QAO.

Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process or within 120 days of the initial approval in cases of significant changes.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS

The project objective is to complete a model which may be used to support decisions related to TMDL development, stream standards modifications, permit decisions, and water quality assessments.

The QAPP is reviewed by the TCEQ to help ensure that data generated for the purposes described herein are scientifically valid and legally defensible. This review process will also help ensure that products submitted to the TCEQ have been analyzed in a way that guarantees its reliability.

A7-1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of data, define the types of data needed to support a decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error because of uncertainty in the data. Data required will come in two main forms, that which is collected by the project team through monitoring activities and that which come from outside sources. For the most part, data from outside of the team's own monitoring activities will not require specific acceptance criteria since it is from the government sources, which have already been subjected to QA/QC procedures. That data will be checked against independently monitored measurements performed by the project team, and it may be replaced by project team data if it appears less accurate or suspect.

The data that is collected by the project team will come in two main forms

- Data that is measured and reported directly by project staff and
- Data which is measured by project staff but reported through outside contractors

Data of the first type will be flow measurements taken in tributaries and water quality parameters that can easily be measured and reported in the field in real time (e.g. pH, salinity, temperature, specific conductivity). The quality of flow data will be ascertained through multiple measurement repeatability and comparison to USGS gauges and other independent measurements wherever possible. Flow data that is not reproducible, exhibits high relative standard deviation between readings (>25%), or is simply not intuitive will be discarded. Water quality parameters will not, in most cases, need much quality assurance because most of it will not be used in any modeling efforts. Salinity is the one exception to this rule, and can be

evaluated in the same manner as the flow data. If it is later determined that only a certain range of salinity is reasonable or that more strict quantitative guidelines are needed for salinity to be authoritative for use in the model, then those guidelines will be added. Data reported by outside contractors, which in this case are the labs, will be parameters such as PCB concentrations, TSS, TPH, POC, sediment characteristics, etc. The QA/QC programs at the labs approved for the project will be stringent enough to merit their use in the model. This is the case for data that was already gathered in 2002-2003 and data that will be gathered under the Project Plan and Monitoring QAPP.

The use of the data can be broadly classified into data that is needed for model input and data that is generated as model output. Input data needs to be checked against acceptance criteria to ensure that accurate data goes into the model while output data is checked by way of an observed validation data set[*]. An acceptance failure in input data means that the data should be rejected. An invalidation of model output means that a problem in the modeling itself has occurred and should be traced through the process going first to the calibration parameters that were determined and then moving farther back to the input data itself if the modeling error still cannot be resolved.

A7-2 Input Data

Table A7-1 gives the model input data. It consists of only input needed for the WASP7 water quality model since the RMA2 model has already been developed.

[*] The observation validation data set will subject to the same DQO as the input data described above. In most cases, this is the data reported by approved laboratories with satisfactory QA/QC protocol.

Table A7-1. WASP model input data requirements

Data Group	Description	Source
A	**Model Identification and Simulation Control** Differential equation solution technique (Euler method) Model simulation time span Model type (simple toxicant) Time step	Problem statement definitions and modeler's professional judgment
B	**Exchange Coefficients** Dispersion coefficient-water column Dispersion coefficient-pore water Cross-sectional area Characteristic length	 Calibration to salinity values[2] Literature values[3] Galveston District Army Corps of Engineers[4] Galveston District Army Corps of Engineers[4]
C	**Volumes** For water column: number of segments and volumes for each time step For benthic segments: number of segments and volumes	 RMA 2 hydrodynamic file as it converted by HSCRead Number of segments equal to water column segments, volumes calculated using site data
D	**Flows** *- Surface Water* Flow routing Flow time function *- Pore Water* Flow routing Flow time function *- Sediment Transport* Area for settling and resuspension Flow routing Velocity (settling or resuspension)	 RMA 2 hydrodynamic file as it converted by HSCRead RMA 2 hydrodynamic file as it converted by HSCRead RMA 2 hydrodynamic file as it converted by HSCRead Literature values[3] Galveston District Army Corps of Engineers[4] Conceptual model Use previous sediment load study rates, and these may be refined based on reassessment of study performed by Dr. Strom.
E	**Boundary Concentrations**	

	Concentrations for each system at segments that import, export, or exchange water with locations outside the network	PCB dataset collected for this project
F	**Waste Loads**	
	Point source loadings	NPDES permit files[5], future effluent sampling from direct HSC outfalls, and regressions using SIC code matching for non-measured outfalls
	Non-point source loadings	Estimated using GIS and spreadsheet models[6]
G	**Parameters**	
	Spatially variable characteristics of the water body that affect the particular processes being modeled.	
	Dissolved organic carbon concentration	Dataset collected for this project
	Fraction organic carbon of solids	Dataset collected for this project
	Total lumped first-order decay rate	Literature values
H	**Constants**	
	Organic carbon partitioning coefficient	Measured effective coefficients using data collected in this project (not needed if DOC and f_{oc} are input in Data Group G)
	First-order loss rate constant	Literature values[3]
	Volatilization rate constant	Literature values[3] (will be lumped into single first order decay constant)
	Water column biodegradation rate	Literature values[3] (will be lumped into single first order decay constant)
	Benthic biodegradation rate	Literature values[3] (will be lumped into single first order decay constant)
	Photolysis rate	Literature values[3] (will be lumped into single first order decay constant)
I	**Kinetic Time Functions**	
	Not used in the PCB model	
J	**Initial Conditions**	
	Concentration of each modeled system (PCB and TSS) for each segment	PCB dataset collected for this project

[1]Please note that all references to PCB concentrations imply a sum of all 209 congeners as per the Project Plan.
[2]Salinity measurements using the calibration dataset of 2002-2003 have already been obtained from prior sampling. Other salinity measurements will be taken from the future PCB sampling events.
[3]All literature values will generally be pulled from the "Physical-Chemical Properties and Environmental Fate for Organic Chemicals on CD-ROM" by Mackay, D. et al. 2006.

[4] http://beams.swg.usace.army.mil/surveys.html
[5] http://www.epa.gov/enviro/index.html
[6]Non-Point Source (NPS) loadings include dry deposition, wet deposition, and runoff. ΣPCB concentrations will be determined from sampling efforts for each of these NPS loads and then calculated in time using runoff flows and the number of wet and dry hours during the time span of the model run. The NPS spreadsheet will be linked to the model to deliver these loads as an NPS load total to each model segment.

A7-3 Output Data

The output data for the WASP7 model is data generated by the model that will be used to aid in calibration and that will evaluated for model validation. Assuming that the RMA2 hydrodynamics model is usable, the only output that will be of any concern is salinity concentrations and total PCBs[*].

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A7-4 Performance and Acceptance Criteria

The performance and acceptance criteria are the qualitative and quantitative metrics by which the model will be evaluated. Evaluation will be determined most practically on a pass-fail type assessment (e.g. The results may be used for decision-making or they may not be used.) Secondarily, the evaluation can take on a quantitative or degree of accuracy nature in the sense that one could say that beyond a simple acceptable rating of the model, to what degree it is acceptable. Understanding the quantitative model evaluation will give a sense of the strength of the model since there are other factors in the decision-making process other than simply the technical model result. If the model is weaker in some areas of prediction (e.g. certain output parameters or certain ranges of those parameters, under certain circumstances, in certain segments of the HSC), then decision-makers would have cause to consider other factors more strongly.

It was previously stated that there are both qualitative and quantitative criteria for the model. The qualitative criteria are graphical assessments of predicted data against observed data. Two methods of performing this assessment are currently in view though others may be justifiable in time.

1. Modeler's Professional Judgment: Volatile swings in PCB concentration in time or space and unrealistic results (e.g. negative concentrations, concentrations above a solubility limit, etc.) are scenarios where the modeler has discretion to reject results from model output and then adjust modeling to correct.
2. One-to-One Plots: The accuracy of PCB concentration predictions is paramount to this project. A mis-estimation of concentration in an area of high flow could create enormous load errors, which would give bad information for decision making. Thus, it is reasonable to make Predicted vs. Observed concentration plots with validation data sets to determine how viable the model is.

[*] TPH is also a potential model output. It may be a useful output parameter if in fact there exists a relationship between total PCBs and TPH, but this has not as yet been determined.

The quantitative criteria to be used are the same criteria that were used to evaluate the WASP and RMA2 modeling performed it in the Dioxin TMDL study. Four statistical criteria were used. They are given here in brief and explained in more detail in the original dioxin modeling documentation in Appendix B.

1. Correlation coefficient (r): Measures the tendency of predicted and observed values to vary linearly. Acceptable values will be 0.75 and higher.
2. Model Efficiency (MEF): Measures how well a model predicts relative to the average of observations. Acceptable values will be 0.6 or higher.
3. Index of Agreement (d): High value indicates that there is an agreement between the model and observations. Acceptable values will be 0.8 or higher.
4. Root Mean Squared Error (RMSE): Magnitude of discrepancies between predicted and observed values. To make this parameter more general in its specification, the RMSE will be normalized by the average of the measured values to arrive at the RMSE%. Acceptable values of RMSE% will be 10% or lower.

Ideally a model validation exercise would pass all qualitative and quantitative criteria. In the case where this does not happen and the model is validated anyway, an explanation will be given as to why the model was deemed valid without complete criteria compliance.

There is the possibility that a genuine invalidation of model results will occur. In this situation, as mentioned earlier, the following sources of error will be checked in the following sequence to improve model results:

1. Software execution (Is there a problem with the software on a particular computer?)
2. Parameter entry (Were all of the input parameters entered correctly? Did all of the data from the hydrodynamic file get moved to the correct segments?)
3. Calibration parameters (Were the parameters chosen in fact reasonable? Was the calibration data set reliable?)
4. Input parameters (Do these need to be adjusted, averaged, augmented, discarded, or remeasured? Were incorrect assumptions made? If parameters were taken from literature or experience, should those parameters actually have been measured for the HSC?)
5. Model geometry/segmentation (Do more segments needed to be created or should there be more segment layers to better visualize depth profiles?)

If these avenues have been exhausted, it is still possible that the model may be used given written limitations and qualifications of use. Such a situation would be well documented and explained though it is certainly the least desirable of alternatives. The process just described is presented conceptually in Figure A7-1.

The possible sources of error give what may be called a scenario of “false negatives” in the modeling process. It is usually obvious to the modeler that “false negatives” need to be explored because if these negatives cannot be explained, then the model cannot be used. It is less obvious

and less likely that modeler would normally make these same kind of rigorous assessments to determine if the model has "false positives", which is to say that a model might pass all of the validation criteria and be an inaccurate model without anyone being aware of the inaccuracy. In general, all of the checks in the previous list will be performed prior to any model even enters the validation stage and possibly before even the calibration stage. (It would be irresponsible for the modeler to do otherwise.) The possibility of model invalidation prompts a "second check" in these avenues, and in general one would not make the check if the model passes validation. Since the process should be as rigorous as possible, however, **these items will be checked and documented** after validation to make doubly sure that the model is not exhibiting a "false positive."

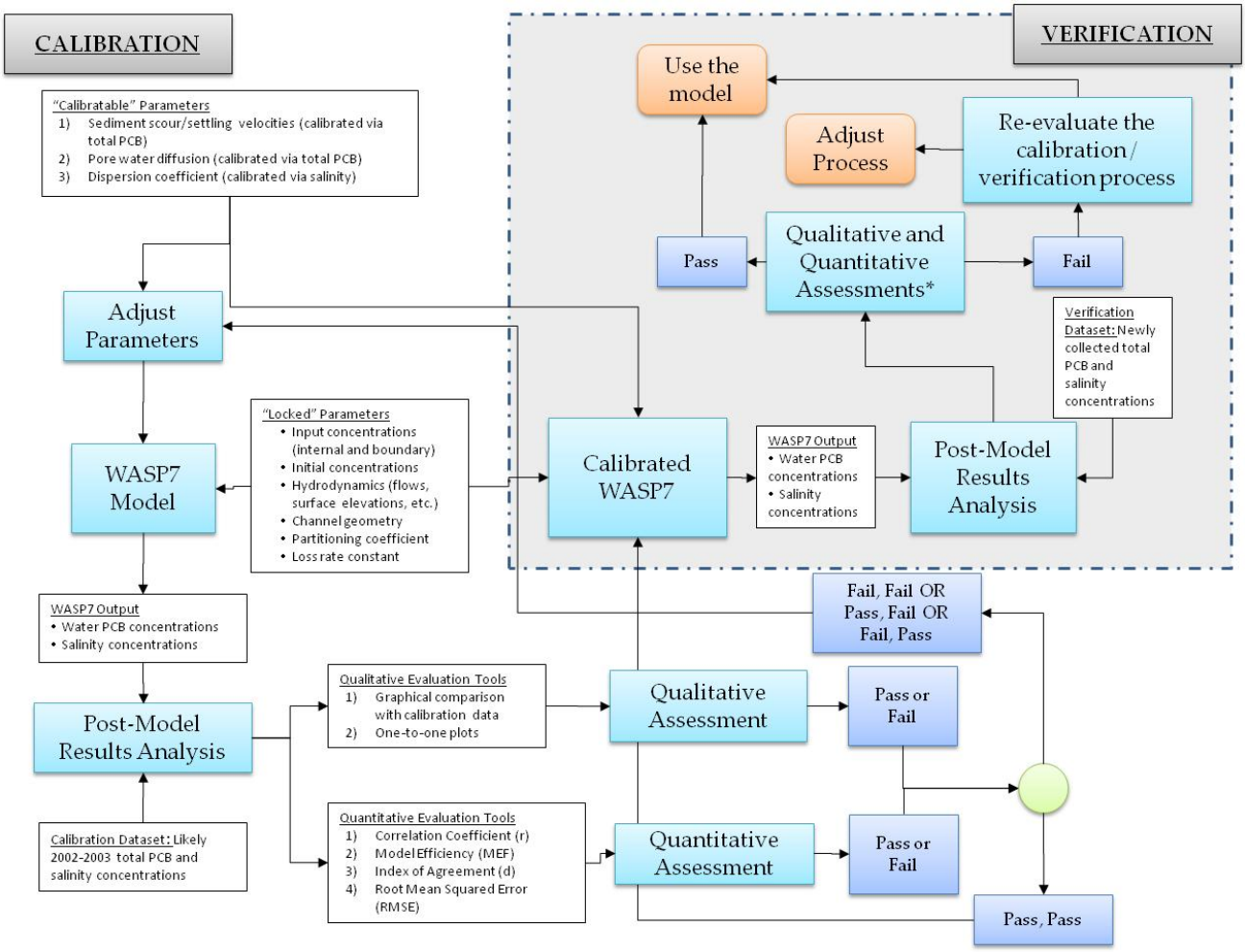

Figure A7-1. The calibration and verification process for WASP7. The "Qualitative and Quantitative Assessments" section of verification is abbreviated in the diagram because it is the same process seen for model calibration.

A7-5 Intended Uses of Model Output

Modeled salinity concentrations are a model output that will be used only as a calibration tool for the eventual modeling of PCBs. Its use in this capacity was explained in section A6. The key model output is the total PCB concentration in water within the HSC segments. The output will first be used to do sensitivity analyses to determine the effect of the parameters (both calibrated and input) on the final model result. This will provide a context of understanding as to what parameters are most influential. The TMDL will then be developed using various scenarios to ascertain what allowable total PCB load[*] will put water concentrations in all segments at the regulatory standard or better. Some points about modeling total PCB concentrations in WASP7 should be made.

- WASP7 cannot literally model total PCBs because total PCBs is the sum of all congeners, and the congeners can have widely varying physical and chemical properties. The parameter input process for WASP7 does not allow for an aggregate partitioning coefficient or loss coefficient to be used nor would it be possible to easily define such constants to describe total PCB fate and transport behaviors.
- The dioxin TMDL project chose to model the most significant 6 congeners in order to assess the effects on the HSC. A similar approach will likely be applied to the PCB TMDL project.
- At this point it is not clear which PCB congeners are most significant and should be modeled on their own. It is not clear for reasons of (1) further sampling is data is needed and (2) it is not certain if congener significance depending on what media (channel water, runoff water, deposition water, sediment, or biota) is being considered. Thus, the choice of which and how many congeners will be modeled will be made after more sampling and analysis has been conducted.

A8 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

The University of Houston is the lead organization with Parsons engineering as subcontractor. Student personnel on the project will be constantly learning new skills from class and research experience. This process combined with the ability to self-teach should provide the necessary knowledge to complete the task. Parsons has extensive modeling knowledge and expertise. Their experience in specific reference to the Dioxin TMDL project provides skills that will aid in the PCB TMDL since the problems are similar in the kind of contaminant modeled and the same in the location. Thus, the experience and skills of the team should not require any special training or certifications at this time.

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[*] It is not completely foreseeable if the load scenarios used in the TMDL will be performed in terms of individual congeners or as a total PCB load. The total PCB (ΣPCB) load seems most intuitive at the planning stage, but it may not be used in the final step. The dioxin TMDL project stakeholders group eventually decided that it was more protective of human health to model and consider loads in terms of individual congeners. It is not clear at this time if this alteration will need to be made for PCBs or not.

A9 DOCUMENTATION AND RECORDS

The University of Houston is responsible for the adapted use of the HSC RMA2 hydrodynamic model coupled with the development of a WASP7 water quality model specific for PCBs. The TCEQ project manager will be provided with all model results for both models to provide the technical information needed to establish a PCB TMDL in the HSC. The QAPP is a working document, updated yearly by design and including amendments when needed. All changes and current versions of the QAPP will be provided to the TCEQ Project Manager by the UH QAO with help from the UH Project Leader.

The documents and records that describe, specify, report, or certify activities, requirements, procedures, or results and the items and materials that furnish objective evidence of the quality of items or activities are listed in Table A9.1. The TCEQ may request records at any time and/or elect to take possession of records at the conclusion of the specified retention period.

Table A9-1. Project Documents and Records

Document/Record	Location	Retention*[a]	Form
QAPPs, amendments, and appendices	Univ. of Houston	5 years	Paper
QAPP distribution documentation	Univ. of Houston	5 years	Paper
SOPs	Univ. of Houston	5 years	Paper
Model User's Manual or Guide (including application-specific versions)	Univ. of Houston	5 years	Paper
Assessment reports for acquired data	Univ. of Houston	5 years	Paper/Electronic
Raw data files	Univ. of Houston	5 years	Paper/Electronic
Model input files	Univ. of Houston	5 years	Electronic
Model output files	Univ. of Houston	5 years	Electronic
Model Log	Univ. of Houston	5 years	Electronic
Code Verification Reports	Univ. of Houston	5 years	Paper
Interim results from iterative calibration runs	Univ. of Houston	5 years	Electronic
Calibration Report	Univ. of Houston	5 years	Paper
Model Assessment Reports	Univ. of Houston	5 years	Paper
Progress report/CAR/final report/data	Univ. of Houston / TCEQ	3 years	Paper/Electronic

*a – After the close of the project

Greater explanation for some of these items is given below.

A9-1 Modeling Log

A modeling log will be kept to document the calibration and verification model runs that are made. Every run will be kept in enough detail for someone to duplicate the work that was done. This project will not require much coding for the modeling effort, and so the format of the modeling log will be a spreadsheet that details setup conditions used for each run along with date of the run and comments on the outcome. In addition to providing a record for later consideration, the log will prevent duplicate model runs from occurring.

A9-2 Information to be Included in Reporting Packages

At the time of writing (July 2007), the HSC PCB TMDL project consists of HSC sampling and hydrodynamic-water quality modeling program. This QAPP reports only on the modeling side of that scope, and the following documentation will be provided as part of this modeling component:

- An inventory of data input parameters for WASP7 including parameters used for model calibration, validation, and sensitivity analyses
- All hydrodynamic and water quality model input files provided both in their original format and in the format required by the RMA2 and WASP7 models (where those formats are different)
- Output results generated by the RMA2 and WASP7 models
- Compiled executable files for the current RMA2 and WASP7 models
- Quarterly progress reports
- Draft final and final technical reports documenting the data sources, methods, and finding of the hydrodynamic and water quality modeling efforts

A9-3 Data Reporting Package Format and Documentation Control

The UH Project Leader is responsible for retaining information that exists in both electronic and hardcopy formats and disseminating that information to the TCEQ Project Manager. Proper records of all of the modeling activities will be maintained such that the work could be duplicated by a knowledgeable person. The modeling activities will be distributed to the TCEQ Project Manager mainly in the forms of reports. These reports are usually quarterly and final reports which will be a combination of electronic and hardcopy formats. The reports will be archived and backed up on UH computers, and two versions identical in format to what is sent to TCEQ will also be kept at UH. Disseminations to TCEQ in formats other than the reports will be performed upon request by the TCEQ Project Manager, and there will likely be many forms of intermediary data sent to TCEQ and the project team at large whenever such data is useful in the project. This more draft form of data will be destroyed when superseding reports are issued. A summary of all documents is provided in Table A9-1.

SECTION B: MEASUREMENT AND DATA ACQUISITION

B1 SAMPLING PROCESS DESIGN

Please see the approved project Monitoring QAPP. (Rifai, 2007)

B2 SAMPLING METHODS

Please see the approved project Monitoring QAPP. (Rifai, 2007)

B3 SAMPLE HANDLING AND CUSTODY

Please see the approved project Monitoring QAPP. (Rifai, 2007)

B4 ANALYTICAL METHODS

Please see the approved project Monitoring QAPP. (Rifai, 2007)

B5 QUALITY CONTROL

Please see the approved project Monitoring QAPP. (Rifai, 2007)

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

Please see the approved project Monitoring QAPP. (Rifai, 2007)

B7 MODEL CALIBRATION

B7-1 Model Calibration Objectives

The parameters that need calibration are the objectives of the model calibration. These will be the same as those used in the Dioxin TMDL study. Those parameters, the way they will be calibrated, and the reason that they need calibration are given.

1. Sediment scour/settling velocities: The sediment scour/settling velocities will be calibrated using the total PCB concentrations from the calibration dataset. These rates could be measured through a sediment study performed on the HSC, but no study to this effect has been found or conducted. WASP does not estimate these rates from any parameter modeled in the system (e.g. water column shear stress), and thus it is left as a calibrated parameter. A relationship between scour and settling was assumed in the dioxin project of 2:1 settling:scour. This relationship will still be used until cause is given to change it. Studies that are conducted on scour/settling velocities (if these studies ever occur) will support the parameterization that occurs in calibration by providing reasonable ranges for the final values that are chosen.

2. Pore water diffusion: Pore water diffusion will be calibrated by way of total PCB concentration. This diffusion is difficult to measure, and it is preferable to calibrate it.

3. Dispersion coefficient: It will be calibrated using salinity concentrations in the water

column because it is a measure of longitudinal mixing in the column.

For all of these objectives, the parameters will be calibrated via the four model statistics described in section A7. Further information into the details of how the calibration will be performed are in Appendix B..

B7-2 Frequency of Model Calibration

The model will likely only be calibrated once with a single data set. This data set will likely be the data that was taken in 2002-2003 by the Dioxin TMDL project team. More data sets would be preferable, but it is not certain at this point if more data will exist to calibrate more than once. Extra data sets will be prioritized for use in model validation rather than calibration. The reason for this prioritization is that since validation is the final step before the model is used, it is best to make certain at the final step rather than an intermediate one.

B7-3 Justification of Calibration Approach and Acceptance Criteria

The calibration approach and acceptance criteria given here are nearly the same that was used in the Dioxin TMDL. Since PCBs are of a similar contaminant class, and this project is in the same location as the Dioxin TMDL, it stands to reason that the same approach may be used. Uncovering of weaknesses in the previous approach, new challenges presented by a different contaminant, or different project needs will warrant changes in the method.

B7-4 Method of Acquiring the Input Data

Some of the input data has already been acquired from previous sampling, some will be pulled from public record, and the remainder will be sampled by the project team. See the Monitoring QAPP for further detail on data acquisition.

B7-5 Types of Output Generated by the Model Calibration

The output generated from the model calibration are the three parameters given as objectives of the model calibration and the four acceptance criteria statistics to assess calibration.

B7-6 Method of Assessing the Fit of the Calibration to the Equation

The equations used in the WASP water quality model are diffusive/dispersive/advective mass balances in 1D and 2D geometries. These equations are explained directly in Appendix B, but the calibration approach here does not assess directly a fit to the fundamental equations. The approach assesses the equation in terms of model output rather than equation examination. Thus, the equations are incorporated into the assessment in an indirect way.

B7-7 Method of Incorporating Variability and Uncertainty in the Model Calibration Results

Variability and uncertainty will be quantified and understood through the use of the sensitivity analyses. WASP7 currently has no method rigorously propagating errors in input values all the way through to model output. Therefore, an understanding of how much predictions change when calibratable parameters and model values are altered slightly will give a sense of the range of error in a prediction.

B7-8 Corrective action to be taken if acceptance criteria are not met

The corrective action sequence given in section A7 should suffice to get an acceptable calibration.

B7-9 Model Sensitivity

Sensitivity analyses will be run on the WASP7 model in order to determine the robustness of the model to changes in parameters and to determine what parameters (those that were calibrated or input) are most influential to the final result of the modeling. In keeping with conventions used in the Dioxin TMDL, sensitivity analyses will be run on each parameter at division and multiplication factors of 2, 5, and 10 wherever model results are still reasonable. The parameters currently considered are settling velocity, scouring velocity, pore water dispersivity, water column dispersivity, lumped first order decay constant (volatilization, biodegradation, photolysis), organic-carbon normalized partition coefficient, non-point source loads, point source loads, runoff loads, and upstream of model system loads. Channel spatial and temporal profiles will be generated under these conditions to see how much influence each parameter has. The source and certainty of more influential parameters will be examined to make certain of their accuracy and precision in the final validated model.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Please see the approved project Project Plan and Monitoring QAPP. (Reference those documents here.)

B9 NON-DIRECT MEASUREMENTS (DATA ACQUISITION REQUIREMENTS)

Table B9-1 presents a set of known data needs that will be supplied from non-direct data sources, sources that will not be directly measured by the project team. The data is taken from two main types of sources: governmental databases and literature sources.

Table B9-1 Non-direct data sources used for the WASP water quality model

Type of Measurement or Analysis	Type of Data (time series, rate, constant, statistic, taxa, etc.)	Units	Source	Quality Assurance Documentation	Use
Channel Cross-Section	Spatial	meters squared	Channel Data[a]		Model grid
Channel characteristic length	Spatial (xy)	meters	Channel Data[a]		Model grid, dispersional mixing calculation
Pore water dispersion coefficient	Constant	m^2/sec	Literature[b]		Mixing calculation
Shore and channel line	Spatial (xy)	meters	TCEQ GIS Shapefiles[c]		Model grid
Channel depths	Spatial (z)	meters	Channel Data[a]		Model grid
Settling / resuspension areas	Spatial (xy)	meters squared	Channel Data[a]		PCB sediment transport calculation
∑PCB calibration concentrations	Time series and spatial	ng/L	TCEQ SWQM database[d]		Calibration
Rainfall	Time series and spatial	in	HCOEM Website[e]		Wet depositional load
Upstream inflows	Rate	m^3/sec	USGS Gauge Records[f]		Boundary condition
Point source flows	Rate	m^3/sec	NPDES Records[g]		Outside load

Lumped first order decay rate (biodegradation, photolysis, and volatilization)	Constant	1/day	Literature[b]		Loss calculation
Organic carbon partitioning coefficient	Constant	unitless	Literature[b]		Transport calculation

[a]Channel data sources are for the 1-D sections of the model are from the deep draft channel survey at http://beams.swg.usace.army.mil/surveys.html (HSC cross-section) and TSARP data (housed at UH) for the major tributaries. For 2-D sections of the model, bathymetry will be obtained from the Texas General Land Office at http://www.glo.state.tx.us/.
[b]See "Physical-Chemical Properties and Environmental Fate for Organic Chemicals on CD-ROM" by Mackay, D. et al. 2006.
[c]http://www.tceq.state.tx.us/gis/SpatialIndex.html
[d]http://www.tceq.state.tx.us/compliance/monitoring/crp/data/crp-resources.html
[e]Harris County Office of Emergency Management (www.hcoem.org)
[f]http://waterdata.usgs.gov/nwis/rt
[g]http://www.epa.gov/enviro/

Governmental database sources have already undergone QA/QC procedures before being posted for public use. Thus, no specific quality assurance procedure or documentation is needed to verify the quality of the data. While QA/QC documentation is not needed, an explanation for the choice of which data to use (when duplicate values exist) and the limitation of the data is necessary. In the case of Channel Data, channel geometries have been measured for many years, and the most recent measurements will be used in order to get the closest approximation to the channel as it exists today. The same is true for the TCEQ data, USGS gauge records, and NPDES records. The most recent data is considered the valuable data source. If the most recent data is not used, an explanation will be given in the quarterly reports. Relevant data limitations on this governmental data do not exist for the most part other than the data sets that are more time-specific. USGS flow measurements, the SWQM data, and NPDES outfall flows are tied to a specific measurements in time. These data sets will be limited to those measured time periods except for purposes of estimating stream flows or outfall flows that will not be measured directly or are not known.

Literature data sources are a potential source of error in terms of what physical constants are chosen because there are often many constants that could be chosen. In the HSC PCB TMDL project, all of the literature values will be drawn from The Second Edition of Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. (Mackay et al., 2006) The handbook lists all constants from all literature sources on PCB from 2005 and earlier. Criteria for choosing values using this data source will be frequency of the value measured from different data sources, frequency of citation of that value by other authors, and greatest similarity to the HSC system in the study that was used to get the value.

It is not yet clear if all of the data mentioned will be a complete data set for what is required. If data is missing entirely or entered incorrectly, then a method will need to be determined to compensate for the loss. In general, averaging techniques, extrapolations, and possibly literature estimations will be used to handle the missing data. Specific techniques will be described in quarterly reports or QAPP amendments if those techniques are needed.

B10 DATA MANAGEMENT AND HARDWARE/SOFTWARE CONFIGURATION

This project will have data coming from many non-directly measured sources and measured sources. In addition, that data will come in different formats determined by the organization from which the data was taken as well as the form in which the data is needed to be used in modeling and analysis. Thus, a clear understanding of what kind of data is expected (type, quality, and amount) as well as how that data is handled is vital at the front end of the project to make sure that mistakes are minimized, procedures are documented, and no data is lost over the life of the project.

The data will come in the form of binary files (WASP input, output, and configuration files), Excel spreadsheets, Access database files, geodatabase files, shapefiles, feature classes, and GIS map files. All efforts will be made to preserve data in its raw form so that it can be reassessed and mined for other purposes later in the project. The preservation of that data is important as well as the documentation of its source. To that end, a Central Data Record will be kept of all data sources used in the modeling portion of the project including information on amount, source, access period, use, and alteration (in terms of data values or data format).

Data will be reformatted according to its intended use, and all of that reformatting requires checking to make sure that it is done correctly. In the case of spatial data, all coordinates will be converted to latitude and longitude for use in GIS mapping. For modeling purposes, the software requires data to be in a certain read format as well as in the units used in the model. All data input into the WASP model will be checked against these requirements to avoid simple unit conversion errors or problems of reading incorrect rows (e.g. reading velocity value as flow values). This project is using the output from the RMA2 HSC model using for the Dioxin TMDL. In order to get that data into WASP, the HSCREAD interface is required. That interface was designed for the particular WASP model grid used in the Dioxin TMDL study. While the WASP grid will likely be very close to satisfactory for PCBs, it is likely that small changes will need. Thus, for the RMA2 output to be used as WASP input, it is likely that the HSCREAD interface code will need to be altered to ensure that it is going in the model correctly.

B10-1 Data Management

It is valuable to consider the specific data management procedures for the project in terms of the expected data products. Those products and their management are here explained.

Queried Raw Data Results: This class of data includes such examples as SWQM parameter data, rainfall data, and gauge flows. Nearly all of this type of data will be pulled from the internet or

ordered from an organization. That source will be tracked, and then that data will be stored in its original format in a common location. It will need to be manipulated for the purposes of database inclusion, statistical summaries, etc. Those activities will be documented in the Central Data Record.

Input Database Files: Files that need to be manipulated as text files or spreadsheets before they are placed in a database will be stored with that database. Information about the raw file that they were made from will be included with the file.

Model Input/Output/Configuration Files: These files will be kept with the model run that they belong in their original binary format. If multiple model runs use the same input or configuration files, those runs and their unique outputs will be stored together. Those model runs that are more critical to the project outcome (e.g. the TMDL scenario, the base scenario, anything asked for specifically by stakeholders, etc.) will be kept in two locations. One will be with all of the model runs, and the other will be a second folder that denotes these special runs. This will facilitate quick access to the important runs as well as duplication of critical project data. Also these special runs will be copied into a more readable format in MS Excel so that they may be more readable for later inspection. An MS Excel spreadsheet log (modeling log) will be kept with the modeling run files so that runs can be tracked in terms of parameters, date of the run, reason for the run, conclusion on the run, etc.

Excel Calculation Spreadsheets: Spreadsheet calculations for model input formatting and model output analysis will be required. These spreadsheets will be separated and stored as either model input or model post-processing. Written explanations of what each spreadsheet does will be kept in them as a separate workbook page.

Parameter Databases: Databases containing monitoring results (taken either by the project team or gotten elsewhere) will be kept so that queries can be run, statistics generated, etc. These databases will be stored with their input files. An effort will be made to provide information on the meaning of each field name given in tables. Also queries and tables will be given consistent file naming conventions to make them easier to use by others. All null values in any database will be denoted with some easily understood marker in order to avoid erroneous zeros.

Geodatabases: From parameter databases and other sources, geodatabases will be generated that ultimately will generate output for GIS software. While parameter databases may include spatial information, it is the goal of the data storage to keep all GIS file generating database tables and queries separate from pure data analysis and storage databases.

Geofiles (GIS maps, shapefiles, feature classes): These will be stored with the geodatabase that was used to generate them. It is desirable to keep these in a folder organization scheme that makes them easy to find and easy to place in new files. Ideally, these files will rarely be moved so that links made in GIS maps will not be broken. No central GIS server will be used, so this may be a challenge.

In general, all data used in the project will be tracked from the moment that they are received so that their source, use, and location may always be known. Files or situations not anticipated by the previous list will be handled according to this general philosophy.

B10-2 Migration/Transfer/Conversion

The modeling portion of this TMDL study will likely be primarily performed by one individual working on one particular computer. Thus, file transfers that occur will be in terms of raw data submitted to that one modeler, simple reformat or spreadsheet calculations performed by others and sent to the modeler, or processed output sent to other project members or the TCEQ Project Manager. Since the modeling efforts are then localized to one individual, a detailed file transfer infrastructure is not needed. Most files will be transferred by email or through CD/DVD mailouts, and a more detailed system will only be developed if the modeling tasks becomes more divided between personnel. If that does happen or a project team member needs to run the model on their own, the computer in which the model resides can be usually be accessed remotely. The remote access should also lower the amount of file transfer required.

B10-3 Information Dissemination

Project updates will be provided to the TMDL Project Manager in quarterly progress reports, periodic emails, and phone call meetings. The project information as it progresses will be made available at stakeholder meetings for the benefit of the TCEQ Project Manager, the stakeholders, and the general public. Input data and model outputs resulting from the project will be accessible to the general public by written request to the TCEQ.

B10-4 Hardware/Software configuration

Computers that will be used to develop the WASP model and analyze the results will be PCs running the Windows XP Professional operating system. The computer used to run the WASP model previously for the Dioxin TMDL ran with a processor of 5.32 GHz and RAM of 3 GB. The modeling computer will have that configuration or better and should provide adequate processing power for efficient model runs.

B10-5 Archives/Data Retention

Complete original data sets are archived on permanent media CD/DVDs and retained on-site by the University of Houston for a retention period specified in Table A9-1.

When the project is complete, a final report will be issued that should have most if not all of the files used in the modeling effort as a location of archival. The modeling computer will also retain the files from the project, and that retention will continue further by being transferred to another computer when the previous computer is discarded. That computer will likely always be housed at the Rifai research lab at UH Engineering. A former Schlumberger storage facility (University Business Park) containing all project data for projects at UH exists at 5000 Gulf

Freeway. This facility will house boxes of hardcopy data from the project, and electronic data will be included in those files on CDs and DVDs with information on their contents. Between these three archival sources, the data should be effectively protected. As it currently stands, the policy of the research group at UH is that data is retained indefinitely.

B10-6 Backup/Disaster Recovery

The modeling computer will be backed up weekly on an external hard drive. When the model is being altered more often, the backup frequency may be changed or manual backups can then be used. The modeler running that modeling computer will be responsible for making certain that this is happening. If the modeling computer suffers catastrophic failure, the backed up files on the external hard drive may be easily moved to other available computers and run with minimal loss of time and extra effort. Total systems recovery should be able to be performed within one week's time from the hardware failure.

SECTION C: ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

The following table presents types of assessments and response action for activities applicable to this QAPP.

Table C1-1. Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
General				
Status Monitoring, Oversight, etc.	Continuous	UH Project Manager	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of subcontractors peformance and data quality	Report to TCEQ in Quarterly/Monthly Report. Ensure project requirements are being fulfilled.
Technical Systems Audit	Dates to be determined by TCEQ	TCEQ QAS	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP	30 days to respond in writing to the TCEQ to address corrective actions
Data Quality				
RMA2 Hydrodynamic Output	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that it is correct and working properly in HSCREAD	adjust RMA2 model
Point Source Locations	Once before calibration/validation and once after	UH Project Manager, UH QAO	map and check xy coordinates	correct data
Channel Geography and Dimensions	Once before calibration/validation and once after	UH Project Manager, UH QAO	map and check xy coordinates, check z coordinates on depths, check calculation of areas	correct data
Gathered and Directly Monitored Parameters (∑PCB, TSS, solid OC frac, Salinity, Dissolved/Suspended Splits)	Once before calibration/validation and once after	UH Project Manager, UH QAO	check correct station-value associations, non-detect treatment consistency, null value treatment, outliers, erroneous results	correct data, extrapolate missing data, look for other data, log outliers
Input flows	Once before calibration/validation and once after	UH Project Manager, UH QAO	check for completeness and errors	correct data, log outliers
Model Setup				
Grid Scheme	Once before calibration/validation and once after	UH Project Manager, UH QAO	check representativeness of channel, check that all grid specification for each cell have been made	adjust the grid

Initial Conditions	Once before calibration/validation and once after	UH Project Manager, UH QAO	check data completeness, correct time span, and entry into model	correct as needed
Boundary Conditions	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that all boundaries have conditions, make certain cell assignments are correct	correct as needed
Input Parameters (Koc, decay, etc.)	Once before calibration/validation and once after	UH Project Manager, UH QAO	check reasonableness of parameter choice and how cell specific parameters need to be	correct as needed, search for other parameters
Time Step and Run Time	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that time step makes sense and that run time fits the prediction needs	adjust as needed
Hydrodynamic Linking	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that hydrodynamic inputs are going to correct cell assignments	correct as needed
Model Calibration				
Adjustable Coefficients	Once after calibration	UH Project Manager, UH QAO	check and maintain within min/max range	adjust as needed
Model Performance and Acceptance Criteria	Once after calibration	UH Project Manager, UH QAO	check that criteria are being applied correctly	adjust model coefficients
Model Validation				
Independence of data set	Once before validation	UH Project Manager, UH QAO	compare against calibration set	
Uniqueness of data set	Once before validation and once after	UH Project Manager, UH QAO	check that different conditions in channel were utilized as much as possible	
Time span of data set	Once before validation and once after	UH Project Manager, UH QAO	check against validation time span needs	
Model Performance and Acceptance Criteria	Once after validation	UH Project Manager, UH QAO	check that criteria are being applied correctly	review model coefficients
NPS and PS Load Allocation				
Runoff load	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that correct concentrations and flows used	correct as needed
Depositional load	Once before calibration/validation and once after	UH Project Manager, UH QAO	check time series of rainfall amounts and that correct concentrations used	correct as needed
Point source selection methodology	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that methodology is defensible	adjust methodology

Industry point source selection and quantitation	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that methodology is used and that point source estimations make sense	review methodology application and possibly apply it again
Sediment Transport				
Investigation	Once before calibration/validation	UH Project Manager, UH QAO	check that efforts were made to determine if transport is significant, especially at boundaries	make some level of investigation
Implementation into model	Once before calibration/validation and once after	UH Project Manager, UH QAO	check that any needed sediment transport into model is quantitatively and conceptual correct	rethink implementation and correct quantitation estimates/values
Tech. Memoranda and Reports				
Findings	After each new version of the model is produced, especially after the final version	UH Project Manager	review and approve; review and request changes	edit report(s) as needed
Conclusions	After each new version of the model is produced, especially after the final version	UH Project Manager	review and approve; review and request changes	edit report(s) as needed
TMDL Determination				
Tech. Credibility of Model	Once during the finalizing stages of model development	UH Project Manager, UH QAO	assess & certify model for TCEQ TMDL needs	
Updating				
Progress Reports	Quarterly	UH Project Manager	summarize efforts and identify problems and response to the problem	
Stakeholder Meetings	Quarterly	UH Project Manager	make sure all relevant information presented effectively at the meeting, address questions from stakeholders	

C1-1 Internal Assessment

Since the project is primarily a modeling endeavor, traditional performance and system audits are not appropriate. Instead, the data generated as part of the modeling results will be evaluated during the validation and model output interpretation processes. Modeling performance assessments will be made continually by the contractor and the TCEQ TMDL Program as

described in the validation and calibration processes, and by evaluation of tasks listed in Table C1-1.

Modeling data and project deliverables will be internally quality controlled by the TMDL Project Manager's in-house review. The Project Manager will maintain overall responsibility for examining the contracted work to ensure methodologies and processes are consistent with the procedures outlined in this QAPP.

What was given in the previous table is a list of very specific assessments that apply to this project. UH is the lead organization, and thus the UH Project Manager will be primarily responsible for all internal assessments. There are three broad assessments that cover the scope of everything shown in Table C1-1:

1) Surveillance Activities: To ensure that the technical aspects of the effort are being properly implemented, the status and progress of all work performed by the UH for the development of water quality model of the HSC will be closely monitored by the UH Project Manager. The UH Project Manager, in turn, will keep the Principal Investigators informed of the status of work during the course of the project. If, based on monitoring of the activities of the project, problems arise that could impact the ability of the project team to achieve the goals of the project, then appropriate corrective actions will be identified and implemented jointly by the UH Project Manager.

2) Data Acquisition: Data will be acquired for the project in its initial stages by way of data download and through the data collected from the Monitoring QAPP. As discussed in other portions of this QAPP, that data is needed for model input, configuration, calibration, and validation. The data will be run through the acceptance criteria given in the Data Quality Objectives of section A7. As data is brought in and organized, checks will be made to flag incomplete and erroneous data as well as data that need to have units converted for input into WASP. All conversions and other data manipulations (e.g. interpolating, averaging, truncating, etc.) will be documented. The various data sets will also be assessed to check the magnitudes and numerical ranges of the data to identify, and eliminate, any apparent outliers in the acquired data sets with appropriate consultation with project participants. Because many data sets used in building surface water models typically conform to a Gaussian (normal) distribution, outliers are defined as values determined to be less than, or greater than, the numerical range defined by three standard deviations from the mean value. No outlier data will be excluded from the input, or calibration and validation, data sets without due process. The TCEQ Project Manager will make final decisions related to the disposition of outlier data. As the final step in the assessment of data acquired for the project, georeferenced data (e.g., locations of monitoring stations or wastewater discharges), will be checked to ensure that the geographical position of the data is correctly located within the spatial domain of the hydrodynamic model. Corrections will be made, as needed, to assign the georeferenced data to the correct latitude and longitude position.

3) Model Calibration and Validation: During calibration and validation phases, assessments will be made as to the appropriateness of the range of values assigned to adjustable model parameters.

The assessor for this project will be the UH Project Leader. Project oversight will be provided by the TMDL Program of TCEQ. Others are available for technical assistance as requested, including project staff from UH, technical staff in the TCEQ TMDL Program and the TCEQ QA Officer. The TCEQ Project Manager has the ultimate authority to continue, or modify work, in a significant fashion, including issuance of a stop work order.

The UH Project Leader is responsible for modifying conditions to achieve results which she believes are realistic and supportable by actual conditions, and which would reflect probable results should future sampling be undertaken in attempts to develop a post-audit model of the water quality of the HSC. The UH Project Leader will maintain an electronic journal record (i.e., modeling log), such that input and output of computer analyses at various steps in the development of the model can be tracked and reproduced if necessary.

C1-2 Corrective Action

The UH Project Manager is responsible for implementing and tracking corrective action procedures as a result of audit findings. Records of audit findings and corrective actions are maintained by the TCEQ Project Manager and UH Quality Assurance Officer. Corrective action documentation will be submitted to the TCEQ TMDL Project Manager with the progress report.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work is specified in agreements or contracts between participating organizations.

The UH Project Manager and/or the UH Quality Assurance Officer is responsible for documenting deficiencies and nonconformities and reporting these to their management. A Corrective Action Report (CAR) must be completed and submitted to the TCEQ with the next progress report due after the deficiency and/or nonconformance occurred.

C2 REPORTS TO MANAGEMENT

C1-3 Reports to University of Houston Project Management

Reports to UH Project Management will happen on a weekly to biweekly basis, and be in the form of face-to-face meetings and emails. Project status will be presented in a discussion format as well as in hardcopy data output, summary, analysis formats as needed. Email will often be used for communication which will provide a written record of what has transpired, but individuals in the UH Project Team will also be encouraged to keep notes on meetings and other communications as well.

C1-4 Reports to TCEQ Project Management

Telephone calls, emails, and conference calls are the best way for the UH Project Manager to keep the TCEQ Project Manager apprised of progress and results on the goals of the modeling project. Formal deliverables that can be expected by the TCEQ Project Manager include:

1. This QAPP document (in its most recent format including formal amendments)
2. Quarterly Progress Reports (including CARs when appropriate)
3. WASP model input and output files
4. Current version of the WASP executable file
5. Draft report
6. Final report
7. Audit Report and Response

A more detailed explanation of some of these deliverables is given below.

Quarterly/Monthly Progress Report – Briefly details the University of Houston activities for each task; reports problems, delays, and corrective actions; and outlines the status of each task's deliverables. Reports should provide enough information so the TCEQ Project Manager can evaluate the modeling effort.

Corrective Action Report (CAR) – Identifies any deficiencies and nonconformances. The cause(s) and program impacts are discussed. The completed corrective actions are documented. Report is submitted to the TCEQ TMDL Project Manager with the first progress report occurring after the deficiencies and/or nonconformance was identified.

Audit Report and Response - Following any audit performed by the UH, a report of findings, recommendations and responses are sent to the TCEQ project manager in the quarterly/monthly progress report. Such reports will include model performance assessments, calibration, and validation performance determination.

C1-5 Reports by TCEQ Project Management

Contractor Evaluation - The UH is evaluated in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurements and Contracts Section.

SECTION D: DATA VALIDATION AND USABILITY

D1 DEPARTURES FROM VALIDATION CRITERIA

The UH Data Manager will be responsible for ensuring that all data are properly reviewed and verified, and submitted in the required format to the TCEQ Project Manager. The UH QAO is responsible for validating the data. Finally, the UH Project Manager, with the concurrence of the UH QAO, are responsible for validating that all data to be reported meet the objectives of the project and are suitable for reporting to TCEQ.

Section A7 describes a method to evaluate the model results using qualitative graphical methods and quantitative statistical methods. Both parts of this method have an appreciable amount of human judgment in them. The quantitative statistics are fairly objective though these statistics may be passed over if the model is still judged as valid. This area and the qualitative graphical analysis are both areas of subjectivity. To ensure that the model is still applied fairly and consistently, the UH QAO will make the judgment decision on the usability of the model in light of the acceptance criteria. The QAO will be under the oversight of the UH Data Manager while in this role. TCEQ project manager will also look at the criteria used for model approval and how it was applied to make a final acceptance decision so that results may be used for TMDL decision-making.

If the QAPP procedure for validation is not followed, then significant prediction errors can result. The main model output currently proposed is the total all congener PCB water concentration[1]. Model errors in validation or calibration can affect both model performance and model application. In areas of model performance, Table D1-1 shows the following consequences that may result from the validation criteria not being met. The list is not meant to be exhaustive but rather representative of possible model issues.

Table D1-1. Consequences of unmet model validation criteria

Model Issue	Source	Application Result
Model unable to deal with high point source loads	Calibration data set was too narrow in it's variety of point source conditions	Important load scenario cannot be considered.
Model unable to deal with high runoff loads	Calibration data set was too narrow in it's variety of rainfall conditions	High rainfall patterns cannot be considered using the model.

[1] Sediment and fish concentrations are important in the monitoring QAPP as well as in the final decision-making procedures in the TMDL. WASP, however, only predicts the water concentrations of PCBs as the model will currently be formulated. Sediment concentrations measured in the field will be used as inputs to this model while fish concentrations will be predicted from the model water concentrations. Thus, in the case of fish concentrations, the predicted water concentrations converted to predicted fish concentrations will be compared against actual measured fish concentrations.

Certain range of concentrations not predicted consistently	Calibration data set did not include that range of concentrations	That concentration range cannot be trusted when making decisions.
Unreasonably high suspended PCB concentrations	Scour velocity was calibrated at too high a value	The effects of sediment cannot be considered as completely.
PCB concentrations spatially invariant	Dispersive mixing was calibrated at too high a value	High PCB impact areas cannot truly be ascertained.

As can be seen, there are significant limitations on the use of the model when any of these or other issues occur. A problem involving inaccurate scenarios means that a TMDL decision might be considered more accurate under certain conditions than others. Inaccurate or questionable concentrations (especially when those errors are not quantifiable) create a situation where the project implementation of particular load reduction strategy might not have enough of an effect to meet the water quality standard. Errors in calibration mean that intrasystem transport interactions are not being modeled realistically. In the case of the unreasonably high suspended sediment concentrations, the bioavailable PCB concentration could be overestimated leading to an overestimation of the effect on fish and by extension an overestimation of human health risk.

A good understanding of the potential decision errors that can be made through improper application of validation acceptance criteria or through improper model performance issue analysis (i.e. not pursuing a model issue to its root cause) will give the project team an appreciation for the need to validate the model correctly. With that understanding, areas where the model is near out-of-compliance or barely out-of-compliance can be dealt with appropriately.

D2 VALIDATION METHODS

D2-1 Model Validation

Deviations in the model components will be determined through the calibration and validation process. Most of this process has already been described, but it will here be summarized in full form for conceptualization.

Input data, calibration data, and validation data will be collected either from previous records, literature, RMA2 modeling, or future sampling efforts. The compiled input parameters will be placed in the WASP7 module with geometries appropriate to describe the HSC. This geometry may need to be initially adjusted upon efforts to get the model to run. Once the model is running, the three parameters given in section B7 will be calibrated using the 2002-2003 PCB dataset taken from the Dioxin TMDL project. The monitoring data will then be used to validate the calibrated model. Hopefully, at least two datasets taken under different conditions will be generated for the validation runs. In both the calibration and validation steps, the acceptance criteria will be that given in section A7. Also both steps are subject to a certain level of optimization in calibration parameters to get the best parameterization possible.

The staff and management of the UH are responsible for the integrity, validation and verification of the data each task generates or handles throughout each process.

Verification, validation and integrity review of data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the manager of the task. The data to be verified are evaluated against project specifications (Section A7) and are checked for errors, especially errors in transcription, calculations, and data input. Duplication of data leading to independent data sets with potentially conflicting values will be eliminated by having a master copy of data kept on a computer at the UH. Data retrieval will be made from that machine, and the official data version will reside there with proper electronic backup. Potential outliers are identified by examination for unreasonable data, or identified using computer-based statistical software. If a question arises or an error or potential outlier is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues which can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork. If an issue cannot be corrected, the task manager consults with higher level project management to establish the appropriate course of action, or the data associated with the issue are rejected.

The UH Project Manager and QAO are each responsible for validating that the verified data are scientifically valid, legally defensible, of known precision, accuracy, integrity, meet the data quality objectives of the project, and are reportable to TCEQ. One element of the validation process involves evaluating the data again for anomalies. The UH QAO or Project Manager may designate other experienced water quality and/or modeling experts familiar with the water bodies under investigation to perform this evaluation. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data, before data validation can be completed.

A second element of the validation process is consideration of any findings identified during the monitoring systems audit conducted by the UH QAO or TCEQ QAS assigned to the project. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the UH Project Manager, with the concurrence of the QAO validates that the data meet the data quality objectives of the project and are suitable for reporting to TCEQ.

D3 RECONCILIATION WITH USER REQUIREMENTS

The results of the water quality monitoring study of the HSC will be review by the UH Project Leader to assess the usability of the model results, in light of any QA/QC issues identified, to provide water quality model results for determination of the TMDL load allocations that will be developed by TCEQ. Output data generated with the HSC model will be presented in the project deliverables as graphical comparisons of observed and model-generated water quality constituents. Model-data comparisons will be prepared as time series plots and as in-channel spatial plots in order to show both the model's ability to predict far out in time and the consistency with which it can predict over the whole portion of the HSC. The qualitative visual

evaluation of model performance will be complemented by a quantitative numerical evaluation of model evaluative statistics where model performance will be assessed based on filtering sub-sets of model results and observed data for the critical time period/season and low-flow and high-flow hydrologic conditions. The determination of model statistics based on filtered sub-sets of observations and model results will facilitate an evaluation of the usability of the model results for the TMDL process by separating out the effects of either low-flow or high-flow conditions and/or variations in seasonality (i.e., winter vs. summer, rainy vs. dry).

Using the qualitative-quantitative approach discussed in A7 Quality Objectives and Criteria for model inputs/outputs, a determination will be made of the overall technical credibility of the HSC model framework. If the visual comparison of model results with observations appears to be in reasonable agreement and the model statistics show that the model can meet the target criteria for a state variable for a range of flow, season, and rainfall conditions then the model will be considered to be technically defensible, and therefore useable, to provide water quality model results for determination of load allocations by TCEQ for a TMDL for PCBs in the HSC.

Potential limitations of the model would result mainly from small set of calibration/validation data. The model may be able to pass both the calibration and validation criteria with the data sets chosen. The range of pollutant loadings and hydrologic conditions (e.g. rainfall, tidal occurrences, boundary condition stream flows) that are present in those data sets will serve as a practical limitation to model usage. Also, the model may have limitations concerning more distant predictions in time from the validation data. These limitations could result from changes in actual HSC geometry caused by dredging or large flood events as well as the simple conceptual limitation of accepting model results far from any measured data point. Despite these potential limitations, the model may, in fact, be quite capable of reproducing observations quite well over a wider range of conditions and time than may be able to be tested during model development. In the absence of a comparison of model results to observations for an evaluation of model performance, such potential limitations on the use of the model results would be reported qualitatively in a narrative form to TCEQ.

If performance measures of the hydrodynamic and water quality model do not meet the project's requirements for Data Quality Objectives as outlined previously, the input data and the observed data sets used to construct the water quality model and the assignment of adjustable model parameters will be carefully reviewed and re-evaluated to determine the reasons for failure to meet the performance criteria. Decisions will be made by the UH Project Leader about the (a) validity of the input data and observed data used to construct the model and the (b) steps needed to complete development of the model to achieve satisfactory performance. If, after checking data used to build the model, satisfactory performance is not achieved then a discussion of the possible explanations for the poor performance of the model will be presented and discussed in the deliverable report. Assuming that the model may still be applied for a TMDL determination even though the model may not achieve the desired level of performance, then a higher margin of safety would be used to estimate load allocations to compensate for the poor performance.

No decisions will be made by the project team based on the model predictions. These data may be subsequently analyzed and used by the TCEQ for TMDL development, stream standards modifications, permit decisions, and water quality assessments.

SECTION E: REFERENCES

De Voogt, P., Brinkman, U.A., 1989. Production, properties and usage of polychlorinated biphenyls. In: Kimbrough, R., Jensen, A.A. (Eds.). Halogenated biphenyls, terphenyls, napthalenes, dibenzodioxins and related products. Elsevier Science, New York, NY, p. 536.

Mackay, D., Shiu, W.Y., Ma, K.-C., Lee, S.C., 2006. Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Second Edition on CD-ROM. CRC.

Rifai, H., 2006. Total Maximum Daily Loads for Dioxins in the Houston Ship Channel, Final Report October 2006. University of Houston, Houston, TX.

Rifai, H.S., 2007. Total Maximum Daily Loads for PCBs in the Houston Ship Channel System Segments 0901, 1001, 1005, 1006, 1007, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421: Quality Assurance Project Plan, Revision 1. The University of Houston, Houston, TX, p. 99.

APPENDIX A. EXAMPLE LETTER

TO: *(name)*
(organization)

FROM: *(name)*
(organization)

RE: TMDL Project Title

Please sign and return this form by (*date*) to:

(*address)*

I acknowledge receipt of the referenced document(s). I understand the document(s) describe quality assurance, quality control, data management and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria. My signature below indicates commitment to follow the procedures in this QAPP.

_____

Signature Date

APPENDIX B. MODEL ACCEPTANCE CRITERIA EXCERPT EXPLANATION FROM DIOXIN TMDL QUARTERLY REPORT OF MARCH 2006

In addition to the plots previously presented a variety of model statistics were calculated to measure model performance. These are discussed in Stow et al. (2003) and Legates and McCabe (1999) and include:

1. the correlation coefficient of model predictions and observations, *r*:

$$r = \frac{\sum_{i=1}^{n}(O_i - \overline{O})(P_i - \overline{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2 \sum_{i=1}^{n}(P_i - \overline{P})^2}} \tag{3.4}$$

2. the model efficiency, *MEF*:

$$MEF = \frac{\sum_{i=1}^{n}(O_i - \overline{O})^2 - \sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2} \tag{3.5}$$

3. the index of agreement, *d*:

$$d = 1.0 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(\left|P_i - \overline{O}\right| + \left|O_i - \overline{O}\right|)^2} \tag{3.6}$$

4. the root mean squared error, *RMSE*:

$$RMSE = \frac{\sqrt{\sum_{i=1}^{n}(P_i - O_i)^2}}{n} \tag{3.7}$$

where n=number of observations, O_i=ith of n observations, P_i=ith of n predictions, and $\overline{O}$ and $\overline{P}$ =observation and prediction averages, respectively.

The correlation coefficient, *r*, ranges from –1 to 1 and measures the tendency of the predicted and observed values to vary together linearly*. The model efficiency, *MEF*, measures how well a model predicts relative to the average of observations; a value close to 1 indicates a good match between observations and model predictions. The index of agreement, *d*, varies from 0 to 1, with higher values indicating better agreement between the model and observations. Finally, the root mean squared error, *RMSE*, measures the magnitude of the discrepancies between predicted and observed values, with values close to zero indicating a good match.

EXCERPT REFERENCES

Legates, D., McCabe, G., 1999. Evaluating the Use of "Goodness-of-fit" Measures in Hydrologic and Hydroclimatic Model Validation. Water Resour. Res. 35, 233-241.

Stow, C., Roessler, C., Borsuk, M., Bowen, J., Reckhow, K., 2003. Comparison of Estuarine Water Quality Model for Total Maximum Daily Load Development in Neuse River Estuary. Journal of Water Resources Planning and Management 129, 307-314.

* This parameter is equivalent to the square root of the coefficient of determination (r^2) of the best-fit-line.